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POLITZER'S TEXT-BOOK OF THE DISEASES OF THE EAR AND ADJACENT ORGANS

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DEAFMUTISM

AND THE

EDUCATION OF DEAF-MUTES BY LIP-READING AND ARTICULATION.

BY

DR. ARTHUR HARTMANN,

BERLIN;

WITH NUMEROUS AND IMPORTANT ADDITIONS WRITTEN BY HIM EXPRESSLY FOR THIS WORK,

AND

NINETEEN STATISTICAL TABLES.

TRANSLATED BY

JAMES PATTERSON CASSELLS, M.D., M.R.C.S. Eng.

CONTENTS.—Chap. I. On Deafmutism in General; II. Special Peculiarities of Deaf-mutes; III. The Recognition of Deafmutism: its Relation to Idiocy and Aphasia; IV. Statistics of Deafmutism; V. The Results of the General Statistics of Deafmutism; VI. The Results of Special Statistics regarding Congenital Deafmutism; VII. The Results of Special Statistics regarding Acquired Deafmutism; VIII. The Hearing-power of Deaf-mutes; IX. The Anatomical Changes upon which Deafmutism is based; X. The Curability of Deafmutism; XI. The Natural and Artificial Sign Languages; XII. The Education of Deaf-mutes at Home and at School; XIII. History of the Deaf and Dumb Instruction; XIV. Instruction of the Deaf and Dumb; XV. What is Achieved? XVI. The Deaf-mutes after they have left School; XVII. The Present State of the Education of the Deaf and Dumb; XVIII. Legal Relations of Deaf-mutes; XIX. Deafmutism and Blindness; Appendix, Index.

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THE

DISEASES OF THE EAR.

POLITZER'S TEXT-BOOK

OF THE

DISEASES OF THE EAR

AND

ADJACENT ORGANS.

FOR STUDENTS AND PRACTITIONERS.

TRANSLATED AT THE REQUEST OF PROFESSOR POLITZER,

AND EDITED BY

JAMES PATTERSON CASSELLS, M.D., M.R.C.S. Eng.,

AURAL SURGEON AND LECTURER ON AURAL SURGERY AT THE GLASGOW HOSPITAL AND DISPENSARY FOR THE DISEASES OF THE EAR.

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This Work is Dedicated to

HENRY ROSBOROUGH SWANZY, M.A, M.B., T.C.D.,

FELLOW OF THE ROYAL COLLEGE OF SURGEONS, IRELAND,

AND EXAMINER IN

OPHTHALMIC SURGERY TO THE COLLEGE,

BY

THE TRANSLATOR.

LETTER OF AUTHORIZATION.

(TRANSLATION.)

To Mr. JAMES PATTERSON CASSELLS, M.D., Lecturer, etc.

DEAR SIR,

You have had the goodness to send me a copy of the English translation of my *Lehrbuch der Ohrenheilkunde*, which you were authorized by me to translate. I have read it, and am very pleased with your translation of my work into English. Receive my thanks for the trouble and patience bestowed on it, and be assured of the esteem of

Yours sincerely,

(*Signed*) PROFESSOR DR. ADAM POLITZER.

PREFACE.

THIS translation of Professor Politzer's *Lehrbuch der Ohrenheilkunde* contains all the matter of that book, which was published in two volumes at Stuttgart (1878-82). It forms one volume complete in itself, and treats of the whole science of Otology in the fullest and most exhaustive manner.

I need not say that I value very highly the confidence Professor Politzer placed in me in requesting me to be his English translator. On that account it has been my endeavour to translate and edit his work to the best of my ability, in the hope that I would merit the distinguished author's approval, and also that of my medical brethren.

I beg to thank my friend Dr. Swanzy for the great interest he has taken in the preparation of this work.

J. P. C.

GLASGOW, *October*, 1882.

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ERRATA.

Page 16, line 9 from top, *for* 'saggital,' *read* 'sagittal.'
,, 19, ,, 2 from top, *for* '14, 15, and 16 *b*,' *read* '14 *b*, 15 *a*, and 16 *a*.'
,, 33, ,, 9 from foot, *for* 'fenestra rotunda,' *read* 'fenestræ rotundæ.'
,, 34, ,, 4 from top, *for* 'petroso,' *read* 'petrosus.'
,, 36, ,, 14 from top of small type, *for* 'spicula,' *read* 'spiculum.'
,, 49, ,, 7 from top, *for* 'FIG. 35,' *read* 'FIG. 34.'
,, 59, ,, 5 from foot, *for* 'sterno-mastoid,' *read* 'digastric.'
,, 83, ,, 14 from foot, *for* 'met,' *read* 'met with.'
,, 95, ,, 11 from foot, *for* 'inspect,' *read* 'inspecting.'
,, 185, ,, 22 from foot, *for* 'membrana,' *read* 'membranæ.'
,, 203, ,, 16 from foot, *for* 'hyoscyani,' *read* 'hyoscyami.'
,, 334, ,, 24 from top, *for* 'gobules,' *read* 'globules.'
,, 388, ,, 15 from top, *for* 'places,' *read* 'place.'
,, 404, ,, 23 from top, *for* 'carb.,' *read* 'bicarb.'
,, 439, FIG. 165 should have been turned through a right angle to the left.
,, 462, line 8 from foot, *for* 'carb.,' *read* 'bicarb.'
,, 477, ,, 7 from foot, *for* 'fungus,' *read* 'fungous.'
,, 484, ,, 3 from foot, *for* 'have,' *read* 'has.'
,, 538, ,, 13 from foot, *for* 'exophthalmus,' *read* 'exophthalmos.'
,, 539, ,, 15 ,, ,, ,, ,, ,,
,, 549, Fig. 196 inverted.
,, 582, line 5 from foot, *for* 'carbon,' *read* 'bicarbon.'
,, 588, ,, 10 from top, *for* '1·40,' *read* '1 in 40.'
,, 629, ,, 17 from foot, *for* '216,' *read* '217.'
,, 629, ,, 16 from foot, *for* '217,' *read* '216.'
,, 667, ,, 8 from foot, *for* 'Polypes,' *read* 'Polypus.'
,, 691, ,, 11 from top, *for* 'is,' *read* 'are.'
,, 720, ,, 14 from top, *for* 'ozæma,' *read* 'ozæna.'
,, 730, ,, 13 from top, *for* 'epithelioma,' *read* 'epitheliomata.'
,, 733, ,, 10 from foot, *for* 'acoustica,' *read* 'acousticus.'
,, 742, last line, *for* 'condition,' *read* 'conduction.'

RELATION OF METRICAL WEIGHTS AND MEASURES TO BRITISH.

Décigramme	=	1·543 grain.
Gramme	=	15·432 grains.

Centilitre	=	10	cubic centimetres	= 2 dr. 49 m.
Decilitre	=	100	,, ,,	= 3 oz. 4 dr. 10·3. m.
Litre	=	1000	,, ,,	= 1·76 pint.

Millimetre	=	·0394 inch.
Centimetre	=	·3937 inch.
Decimetre	=	3·9370 inches.
Metre	=	39·3707 inches.

*** All the therapeutical formulæ in this work are collected together in the Appendix.

ANATOMICAL DIVISION OF THE EAR.

THE sensations which we call perceptions of sound, reach our consciousness by the specific excitation of the nerve of hearing.

This excitation always results, when the medium which surrounds us is caused to vibrate by the oscillations of elastic bodies, the vibrations being transmitted to the nerve of hearing.

This perception of sound is principally brought about by the excitation of the peripheral expansion of the auditory nerve. The delicate terminations of this nerve lie upon membranous supports, which are surrounded by an aqueous fluid in a cavity partly formed by rigid walls. These membranous supports serve as a medium for the transfer of the waves of sound, which reach the auditory fluid from the outer world, to the extremities of the auditory nerve.

The most primitive form of auditory apparatus among the lower classes of animals consists of an expansion of the auditory nerve upon a small membranous vesicle, the auditory vesicle (or vestibular saccule). This simple hearing apparatus assumes in the higher animals a more complicated form, there being added to the vestibular saccule several membranous tubes (semicircular canals), generally three in number. In the most highly developed vertebrata, to these two parts of the labyrinth, the vestibular saccule and the semicircular canals, there is added a third, the cochlea, in which a portion of the auditory nerve is spread out upon a membranous lamella.

The vibrations of elastic bodies, however, do not reach the auditory nerve immediately, but are conveyed to it through a more or less complicated conducting apparatus.

In aquatic animals the waves of sound, proceeding through the water, are communicated to the hard parts of the head, and through those to the auditory fluid and the auditory nerve.

Animals living in the air possess a sound-conducting apparatus, adapted for the reception of atmospheric vibrations. The construction of this apparatus is the same in principle in all the separate classes of animals, but its form shows considerable variety.

In what degree the sound-conducting apparatus of the human ear possesses the property of receiving and of transmitting to the labyrinth the vibrations of bodies, so different in their quality, will be seen from the special description of the anatomical and physiological relations of the separate parts of the organ of hearing.

According to the above observations, the organ of hearing is divided into two principal parts, the sound-conducting and the sound-perceiving portions. As this classification is the only correct one from the pathological standpoint, we will adhere to it for the future, especially as the older anatomical divisions into *outer*, *middle*, and *inner ear* can be reconciled with it.

After dividing the organ of hearing, then, into two principal parts, as mentioned above, a further division takes place as follows:

1. *The sound-conducting apparatus*, in:
   - *a.* The external ear (auricle and external meatus).
   - *b.* The middle ear (the tympanic cavity with membrana tympani and ossicula, Eustachian tube and mastoid process).

2. *The sound-perceiving apparatus*, the so-called internal ear, divided into:
   - *a.* The origin of the auditory nerve in the brain.
   - *b.* The trunk of the auditory nerve.
   - *c.* Its expansion in the labyrinth.

After this division of the organ of hearing we will pass on to the special description of the anatomico-physiological relations of the human ear. As, however, the purpose of our observations is the knowledge and treatment of the disturbances of hearing, we will not confine ourselves to a simple description of the anatomical facts, but will put prominently forward the relations that exist between the organ of hearing in its normal state, and the pathological alterations of the tissues which impair its functions.

THE ANATOMY AND PHYSIOLOGY OF THE SOUND-CONDUCTING APPARATUS WITH REFERENCE TO THE DISEASES OF THE EAR.

I. THE EXTERNAL EAR.

A. The Auricle.

The auricle, the lateral part of the organ of hearing, which is externally visible, is seldom the seat of primary pathological alterations. Though it is therefore, in a practical sense, of only slight interest, we consider it better not totally to ignore its anatomy, because sometimes in cases of violent injuries a precise representation of the parts affected by the injury is required in a court of law.

The auricle presents in its outline a pyriform shape. Its normal position is between two horizontal lines, of which the superior touches the eyebrows, the inferior the tip of the nose (Henle, *Systematic Anatomy*, 1866). While it surrounds the external orifice of the ear, it is fastened on the lateral part of the head, midway between the forehead and the occiput, in such a manner that it forms with the lateral part of the head towards the occiput an acute angle, which is subject to manifold individual varieties.

In this position the concave surface of the auricle, turned forwards and outwards, shows a number of irregular elevations and depressions (Fig. 1). The outer margin of the cartilaginous plate is turned in towards the front, and forms the *helix* of the auricle (Fig. 1, *a*). The helix, commencing at the *crista helicis*, above the external orifice of the ear, in the most pronounced depression of the auricle (*concha*), extends from here along the margin of the auricle upwards and backwards, and ends above the posterior margin of the lobe.* In parallel direction with the

* On the superior part of the inverted margin of the helix, a more or less strongly pronounced knotty process is often found. According to Darwin, this is to be regarded as the remnant of the tip of the primitive ear, and is formed by the involution of the external margin of the helix.

posterior part of the helix, divided from its ledge by a depression, the so-called *scaphoid fossa*, there extends a second elevation, the *antihelix* (*b*). It commences above the crista helicis with two crura diverging forwards (*crura bifurcata*), and taking its course downwards, it passes with a slight curve forwards into a prominence of cartilage, the so-called *antitragus* (*d*). Opposite to the last-named part, and in front of the external orifice of the meatus, surmounting it a little, the cartilage of the ear forms a second nipple-like projection directed backwards, the *tragus* (*c*), which is separated from the antitragus by a notch (*incisura intertragica*). Below this notch, forming the inferior extremity of the auricle, is the lobe (*lobulus*, *e*) which shows numerous individual varieties, and in whose formation only the integument covering the auricle takes part. The subcutaneous connective tissue is highly developed in this place, its meshes containing globules of fat, but only a small number of bloodvessels and nerves.

FIG. 1.—AURICLE.

a, Helix; *b*, Antihelix; *c*, Tragus; *d*, Antitragus; *e*, Lobulus; *f*, Concha; *g*, Orifice of the external meatus.

The internal integument, covering the auricle, is fastened much more tightly to the perichondrium on the anterior than on the convex posterior surface, where the subcutaneous connective tissue is more strongly developed, and the skin therefore more easily movable.

The muscles supplying the auricle are divided into two groups. The first group acts in such a manner that it effects a movement of the whole auricle. The most important muscles belonging to this group are: 1. The *attollens auriculam*, a fan-shaped radiating muscle, which arises from the epicranial aponeurosis, and with its fibres converging in a downward direction, attaches itself to the convex surface of the auricle; it draws the auricle upwards. 2. The *attrahens auriculam*, which arises also from the epicranial aponeurosis in front of the auricle, above the zygomatic arch, and has its place of attachment on the crista helicis; it draws the auricle a little forwards and upwards. 3. The *retrahens auriculam*, which arises behind the auricle on the mastoid process, consists of several fasciculi, and extends to the convex surface of the concha; it is intended to draw the auricle a little backwards. The second group of muscles have their origin and place of attachment on the auricle itself. They effect an alteration in the form of the auricle, but only to a slight extent. The *tragicus*,

antitragicus, helicis major and *minor* lie on the concave surface, the *transversus* and *obliquus auriculæ* on the convex surface of the auricle.

In the cartilage of the ear, which belongs to the yellow or reticulated cartilages, there are sometimes to be found peculiar alterations, which are described by Parreidt (*Dissertatio inaugur. de Chondromalacia,* 1864), and Ludwig Meyer (*Virch. Arch.,* 1865) as softening enchondroma and vascular new-formation. The softening of the cartilaginous tissue is especially interesting and important on account of its rather frequent occurrence. It leads eventually to the formation of cavities filled with a gelatinous substance. Dr. J. Pollak, who has recently investigated this condition, has arrived at the conclusion that we have here to deal with retrogressive senile metamorphosis of the yellow cartilage, similar to that in other cartilages, for instance in the costal cartilage.

B. The External Meatus.

The external meatus is divided into two portions, viz., the cartilaginous and the osseous.

a. Its Cartilaginous Portion.

The cartilaginous meatus is a tubular continuation of the auricle directed inwards. This canal, however, is not cartilaginous in its whole extent, but consists of a cartilaginous channel, which is formed at its upper and back part into a tube by a membranous layer connected with the lining membrane of the meatus.

If this fibrous membrane is detached from the margin of the cartilaginous channel, the circumference of the latter (Fig. 2) appears largest at its outer extremity, while inwards the width of the cartilage decreases so steadily, that the inner extremity (*b*) appears as a narrow, rounded, cartilaginous point.

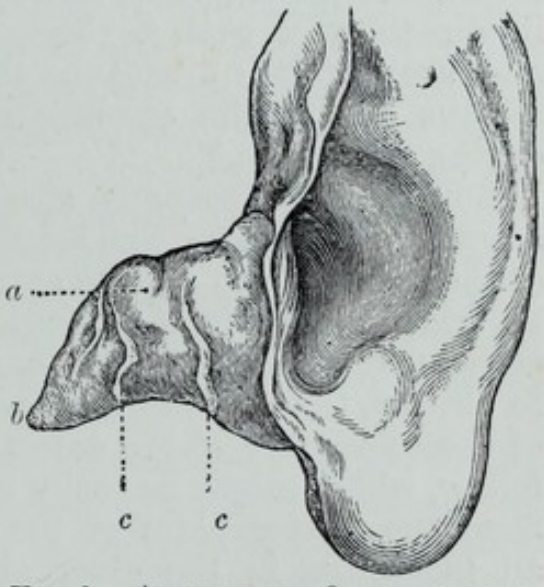

Fig. 2.—Auricle and Cartilaginous Meatus.

a, Cartilaginous meatus; *b*, Interior pointed extremity of the cartilaginous meatus; *c*, *c*, Fissures of Santorini (left ear).

This proportion of the cartilaginous channel to the membranous part of the passage can be shown in a simple manner by a section, which is made perpendicularly upon the axis of the detached cartilaginous meatus. In the cross section close behind the orifice of the external ear

(Fig. 3), the cartilaginous portion of the canal (*a*) greatly exceeds in size the fibrous part (*b*). In the middle of the cartilaginous meatus (Fig. 4) a decrease in the breadth of the cartilage (*a*) shows itself, while in the neighbourhood of the interior extremity (Fig. 5) the cartilaginous channel is visible in the section only as a narrow segment. We see, therefore, that the membranous portion (*b* in Figs. 3, 4, 5) increases in breadth towards the interior, while the cartilage decreases.

The channel of the cartilaginous portion of the meatus is traversed transversely by several fissures, the so-called fissures of Santorini (Fig. 2, *c*, *c*). As a rule two large fissures are

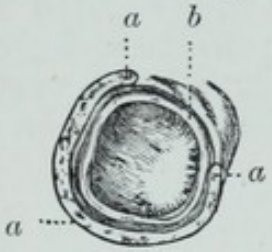

FIG. 3. — SECTION OF THE CARTILAGINOUS MEATUS CLOSE BEHIND THE ORIFICE OF THE EXTERNAL MEATUS.

a, *a*, *a*, Cartilaginous channel; *b*, Fibrous layer.

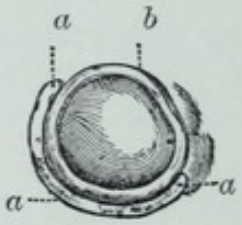

FIG. 4. SECTION THROUGH THE MIDDLE OF THE CARTILAGINOUS MEATUS.

a, *a*, *a*, Cartilaginous channel; *b*, Fibrous layer.

FIG. 5. SECTION IN THE NEIGHBOURHOOD OF THE INTERIOR EXTREMITY OF THE CARTILAGINOUS MEATUS.

a, Cartilage; *b*, Fibrous layer.

found. These are, however, by no means regular and constant in direction or extent. They are filled up by a fibrous tissue, and are important because they favour the straightening of the meatus during the examination of the membrana tympani and during operations.*

But in other respects also the fissures of Santorini possess a practical interest. The inferior wall of the cartilaginous channel of the meatus is to a great extent surrounded by the lobes of the parotid, so that in a parotitis, either primary or secondary, in consequence of an acute exanthema or typhus, and ending in abscess, the accumulated pus may force its way through one of these fissures into the external meatus. Thus an otorrhœa will follow, which might be easily mistaken for a suppuration issuing from the deeper parts of the organ. Again, in consequence of an ulceration in the external meatus, the suppurative process may extend through these fissures to the parotid gland.

The interior extremity of the cartilaginous meatus is fastened to the exterior margin of the osseous meatus by means of flexible connective tissue, in such a manner that the cartilaginous portion can be changed in position by traction on the auricle backwards and upwards. In conjunction with the mobility of the different

* The lateral fissure in the neighbourhood of the orifice of the external ear, which traverses the posterior circumference of the cartilaginous channel, gives to the several portions of the cartilaginous meatus the highest degree of mobility.

parts of the cartilaginous meatus, allowed by the fissures of Santorini, this fact is of considerable importance during the examination of the membrana tympani and during operations. The union of the intervening connective tissue with the osseous meatus is not immediate, but is effected by firm and compact connective tissue, containing elastic fibres tightly stretched like cartilage around the exterior margin of the osseous meatus. This consolidation, however, takes place only in that part of the external meatus formed by the tympanic portion of the temporal bone, which we have still to describe; therefore it belongs to the inferior and lateral margin of the canal (Fig. 8), while above, where the squamous portion curves at a right angle towards the superior wall, the fibrous portion of the cartilaginous meatus passes without interruption into the lining membrane of the superior wall of the osseous meatus.

b. Osseous Meatus.

1. *Its Development.*—The anatomical relations of the osseous meatus are essentially different in the new-born infant and in the adult. In the infant we find, instead of the osseous meatus, an osseous ring (*annulus tympanicus*) to the exterior margin of which a membranous canal (v. Tröltsch) is attached, forming one half of the whole meatus. This part ossifies from within outwards during the early years of life.

The formation of the osseous meatus is essentially connected with the development of the temporal bone. According to the examinations made by Arnold, the temporal bone is divided into three parts, which are separately developed. These are called the squamous, the tympanic, and the petrous portions of the temporal bone. When viewed from an evolutionist's standpoint, this division is the only correct one (Dr. Ludwig Joseph, *Osteological Contribution on the Temporal Bone and on the Apparatus of Hearing—Zeitschrift für rationelle Medicin*, part 18), for a clear insight has been gained through it into the formation of the osseous meatus.*

Comparing the temporal bone in the child with that in the adult, it will be seen that the osseous meatus consists of two different parts, and that principally the squamous and tympanic portions of the temporal bone are engaged in its formation.

The tympanic portion of the temporal bone in a child consists of a ring (annulus tympanicus) (Fig. 6) with an opening upwards and forwards, and is provided with a groove for the reception of

* In Du Verney's *Traité de l'Organe de l'Ouie*, 1731, plate iv., the perfect os tympanicum as principal constituent of the osseous meatus in the adult, will be found represented either in connection with the temporal bone, or by itself. In the same book, plate xv., there is a representation of the lately-discovered *sutura mastoideo-squamosa*.

the membrana tympani. This ring is attached by its free extremities (*b*, *b*) to the inferior part of the exterior surface of the squamous portion. The space between the two places of attachment of the tympanic portion to the squamous portion we shall

FIG. 6. — ANNULUS TYMPANICUS IN THE NEW-BORN INFANT.

a, Groove for the reception of the membrana tympani; *b*, *b*, Its free extremities, which are supported by the squamous portion.

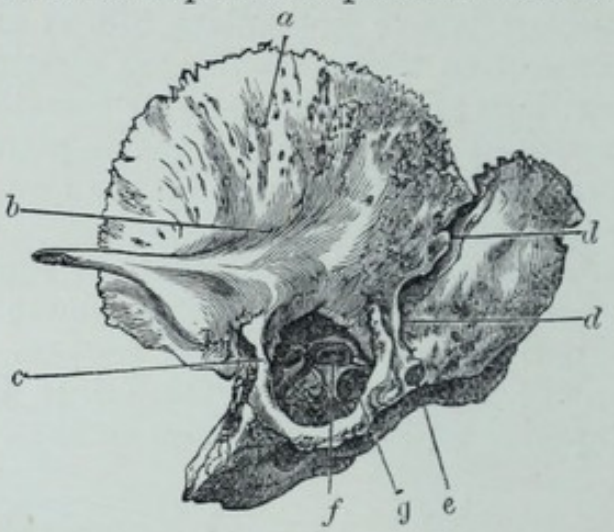

FIG. 7.—TEMPORAL BONE IN THE NEW-BORN INFANT.

a, Superior part of the squamous bone; *b*, Its inferior part below the line of the zygomatic process; *c*, Annulus tympanicus; *d*, *d*, The fissure between squamous portion and mastoid process, reaching to the foramen stylo-mastoideum; *e*, Foramen stylo-mastoideum; *f*, Foramen ovale; *g*, Foramen rotundum (left ear).

know by-and-by as the anterior superior grooveless segment of the tympanic ring (Rivinian segment).

With the progressing growth of the cranial bones in the early years of life, the following alterations take place in the squamous and tympanic portions. While (Fig. 7) the superior part of the squamous portion is placed on the lateral part of the cranium, its lower portion (*b*), which lies beneath the line of the zygomatic process, takes a more horizontal position, in such a way that in the completely developed temporal bone the superior part of the squamous portion (Fig. 9, *a*) is bent almost at a right angle to its inferior horizontal portion (*b*). This horizontal portion forms the superior wall of the osseous meatus, and in conjunction with the mastoid process it also forms a part of the posterior wall.

As mentioned above, an essential part in this formation of the osseous meatus is taken by the tympanic portion of the temporal bone. With its growth, through deposit of osseous substance on its exterior (ossification of the membranous part of the osseous meatus, v. Tröltsch), there arises an osseous groove (Fig. 8, *b*), the lateral walls of which reach so far up in a median direction near to the tympanic bone, that they also take part to a varying extent in the formation of the superior wall of the meatus.

In the perfect temporal bone, therefore, the groove-like tympanic portion (Fig. 8) appears as if pushed from below into the shallow sulcus (*a*) which, directed downwards, is formed by the horizontal part of the squamous bone and the mastoid process. The inferior and anterior walls of the meatus are therefore formed

by the tympanic portion, while in the formation of the posterior wall both squamous and tympanic portions participate.

In a number of temporal bones in my possession, the parts taken by the squamous and tympanic portions in the formation of the osseous meatus vary considerably. Sometimes the tympanic portion lies so close to the squamous portion and mastoid process, that their boundary lines appear almost effaced; sometimes the margin of the tympanic portion is prominently set off from the squamous portion and the mastoid process. Into the fissures thus formed prolongations of connective tissue descend, into which inflammatory and suppurative processes sometimes penetrate, causing caries of the wall of the meatus. On the other hand, in purulent affections of the meatus, I have seen the destructive process spread through these fissures from the inside outwards, in which case a loosening and detachment of the lining membrane of the posterior and superior walls of the meatus took place.

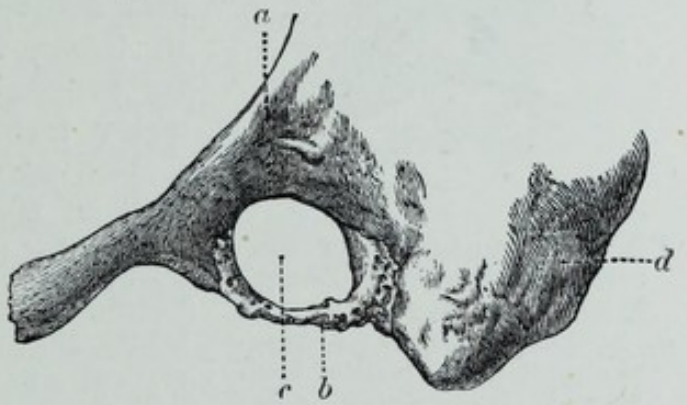

FIG. 8.—OSSEOUS MEATUS IN THE ADULT.

a, Horizontal part of the squamous bone (superior part of the meatus); *b*, Tympanic portion; *c*, Lumen of the meatus; *d*, Mastoid process (left ear).

2. *Construction of the Osseous Meatus.*—As we have seen, the osseous portion of the external meatus, which rests in the framework of the temporal bone, comes into connection with the cartilaginous meatus at its exterior margin, while at its interior, widened extremity, the membrana tympani is stretched out in a groove-like sulcus.

As the osseous portion forms the more important part of the external meatus, because of its relations to the neighbouring organs, which are often also affected in cases of disease of the organ of hearing, and on account of a number of important operations which take place within its range, we must enter into a detailed description of its anatomical relations.

Let us first observe, on a perpendicular section (front) from the adult, the relative positions of the superior and inferior walls to each other, and to the tympanic cavity. The strongly developed superior wall of the meatus (*b*) appears bent almost at a right angle to the squamous portion (*a*) of the temporal bone, and is formed by two osseous plates, the superior of which is turned towards the cranial cavity, and the inferior towards the lumen of the meatus.

Of these plates, the upper one meets at the *sutura petroso-squamosa* with the superior wall of the tympanic cavity, and

further back with the roof of the mastoid cells; the lower reaches to the boundary of the tympanic cavity, where it ends abruptly in a sharp grooveless edge (*margo tympanicus* of the temporal bone), directed inwards and downwards, into which the upper margin of the membrana tympani is inserted.

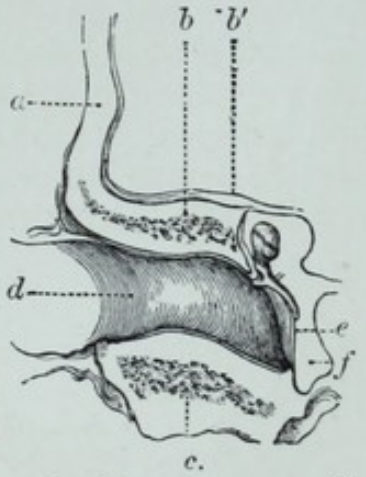

FIG. 9.—PERPENDICULAR SECTION (FRONT) THROUGH OSSEOUS MEATUS AND TYMPANIC CAVITY. *a*, Squamous portion; *b*, Superior wall of the osseous meatus; *b'*, Dura mater; *c*, Inferior wall of the osseous meatus; *d*, Meatus; *e*, Membrana tympani with the malleus; *f*, Tympanic cavity (left ear).

The cellular spaces (*b*) between the osseous lamellæ of the superior wall of the meatus vary in size and number. According to v. Tröltsch* they are in connection partly with the tympanic cavity, partly with the mastoid cells; and sometimes alterations are found in them, which have been produced by propagation of inflammatory processes from the middle ear.

The superior lamella of the upper wall of the meatus, which is formed partly by the temporal portion, partly by the lamella of the tegmen tympani being pushed outwards, belongs to the region of the middle cranial cavity, and is covered by the dura mater (*b'*). This relation of the superior wall of the meatus to the cranial cavity we consider worth mentioning, because in a few rare cases of otitis externa with affection of the bone, such as are principally caused by rough and violent attempts at removal of foreign bodies, the carious destruction of the superior wall of the meatus affects the dura mater, and produces fatal meningitis.

The inferior wall of the osseous meatus (*c*) appears thick and compact in the section. Its surface turned towards the meatus is convex from without inwards, the greatest convexity being on the borders of the inner third of the wall of the osseous meatus, from whence the surface inclines rather steeply towards the outside as well as towards the inside. In the neighbourhood of the membrana tympani the convexity is turned into a considerable concavity (Fig. 9), which deserves notice, because it, in conjunction with the membrana tympani, the latter placed obliquely to the axis of the meatus, forms a space (sinus of the external meatus, H. Meyer), in which small foreign bodies are often lodged.

A comparison of the lengths of the superior and inferior walls of the meatus shows that the superior wall extends farther outwards than the inferior, but that the inferior (*c*) extends from 6-8 mm. nearer the middle line of the body than the superior (*b*).

* *Lehrbuch der Ohrenheilkunde*, 5th Ed., 1873.

By this, as well as by the unequal lengths of the anterior and posterior walls, the oblique position of the membrana tympani to the axis of the meatus is caused: a fact which must be taken into consideration at the examination of the membrana tympani, as well as at operations.

In the horizontal section, the proportions of the anterior and posterior walls of the meatus are made clear. The anterior wall (Fig. 10, *a*), compared with the other, is thinner, and in its longitudinal direction, especially at the boundary of the inner third, is more or less strongly bulged out towards the lumen of the meatus. By this, as well as by the convexity of the inferior wall, a portion of the anterior inferior part of the membrana tympani is often hidden from view at its examination, and in some cases the bulging out of the anterior wall is so great, that even the greater part of the membrane cannot be seen, only a very small segment of the posterior quadrant being visible.

If a great number of temporal bones be examined, the anterior wall of the meatus will often be found pierced by a roundish or oval orifice, several lines in extent. This defect, near which several smaller orifices are often seen, is to be considered as the remains of that part of the osseous meatus, designated by Arnold and v. Tröltsch as defective in its ossification. V. Tröltsch gives an explanation of the origin of this gap, based upon the study of the process of ossification. 'For the ossification does not progress quite regularly from without inwards, but advances slowly in the centre, so that there remains a gap, which at first is a cavity open towards the outside, and later on roundish and closed only by connective tissue.'*

The superior portion of the anterior wall of the meatus adjoins the posterior part of the glenoid cavity, which is often separated from the cranial cavity only by a thin osseous lamella, and is situated higher than the lumen of the osseous meatus. The glenoid cavity extends, however, farther outwards than the anterior wall of the osseous meatus, and the posterior wall of the capsule of the joint comes therefore into contact with the osseous, as well as with the cartilaginous meatus, by means of an elastic connective tissue. Therefore, with every motion of the jaw, when the condyle protrudes from the bony cavity, an extensive motion of the anterior wall will follow, which can easily be ascertained by putting the finger into the meatus. The lumen of the canal will also be temporarily altered by this motion. Carious pro-

* According to Zuckerkandl, the growth of the tympanic bone progresses at first by the rapid enlargement of the *tubercul. ant.* and *post.*, visible on the tympanic ring of the new-born infant. As the osseous deposit on the inferior semicircular part of the annulus tympanicus progresses more slowly, a bridge is formed by the union with the bulging tubercle, which spans a gap in the ossification sometimes existing. According to the same authority, the meatus is most perfect between the ages of twenty and thirty; the gaps which appear after the thirtieth year he considers due to the pressure of the lower jaw.

cesses in the temporal bone very rarely extend to the maxillary joint.

As already mentioned, the posterior wall of the osseous meatus, the transverse diameter of which varies very much, is partly formed by the tympanic portion of the temporal bone, its exterior portion, however, being chiefly formed by the mastoid process. It extends farther outwards than the other walls, especially the inferior and anterior, but the anterior wall reaches 7-8 mm. farther inwards than the posterior (Fig. 10), on account of which the membrana tympani, stretched out at the inner extremity of the meatus, takes an oblique position, not only from above downwards, but also from behind forwards, which position will be discussed in detail during the description of the anatomy of the membrana tympani.

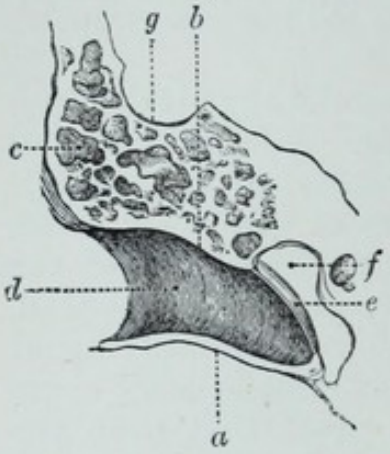

FIG. 10.—HORIZONTAL SECTION OF THE EXTERNAL MEATUS AND TYMPANIC CAVITY.

a, Anterior wall of the meatus; *b*, Posterior wall: *c*, Cells of the mastoid process; *d*, Meatus; *e*, Membrana tympani; *f*, Tympanic cavity; *g*, Sinus transversus.

During the growth of the temporal bone the cells of the mastoid process, which in the new-born infant are situated behind the tympanic cavity, extend outwards along with the greater mass of the cellular spaces by lying behind the meatus. Towards the front the mastoid cells are, therefore, immediately covered by the posterior wall of the osseous meatus, from which the important relation of this wall to the mastoid process can be understood, since caries in the latter often extends to the posterior wall, the necrosed cells being cast out through the external meatus. Less frequently the destructive process is observed to spread from the external meatus towards the mastoid cells.

c. The Lining Membrane of the External Meatus.

The lining membrane of the external meatus, a continuation of the external integument, is much stronger in the cartilaginous than in the osseous portion. In the latter the cutis generally becomes more delicate and thin as it gets nearer the sulcus of the membrana tympani; only on the superior wall a somewhat stronger band of the cutis extends towards the membrana tympani. The dermic layer of the cartilaginous portion, 1-2 mm. in thickness, is plentifully supplied with hairs, into the sacs of which grape-like sebaceous glands discharge themselves. Near these glands, embedded in the subcutaneous tissue, and closely applied to each other, are the so-called ceruminal glands (*glandulæ ceruminales*, sweat-glands of the ear, according to Ausspitz) of a

yellowish-brown colour, which in their formation belong to the tubular glands. Just as in the sweat-glands in other parts, the tube of these ceruminal glands is coiled up (Kölliker); it is 0·2 to 1 mm. in diameter, and discharges either directly into the meatus, or into the upper portion of the hair-sacs by means of a straight canal, 0·1 mm. wide (Henle). The orifices of the glands in the meatus can be observed with the naked eye as closely arranged small darkish points (Fig. 11, *a*, *b*, *c*).

According to former statements of anatomists, the glandular elements of the cutis are to be found only in the cartilaginous portion of the meatus, and not in the osseous. By the investigations of Buchanan and v. Tröltsch, however, it is proved that glands are to be found also in the osseous portion, and according to v. Tröltsch, the glandular layer extends from the posterior superior wall of the cartilaginous portion into the osseous meatus in the form of a triangular space, several mm. long (Fig. 11, the place between *b* and *c*), the point of which (*c*) is turned towards the membrana tympani. In the other parts of the osseous meatus the glandular elements are wanting, and the more delicate cutis, firmly united with the periosteum, forms linear-shaped papillæ (Gerlach), lying closely together, which often become hypertrophied in inflammatory affections, and form the foundation of large compact polypi.

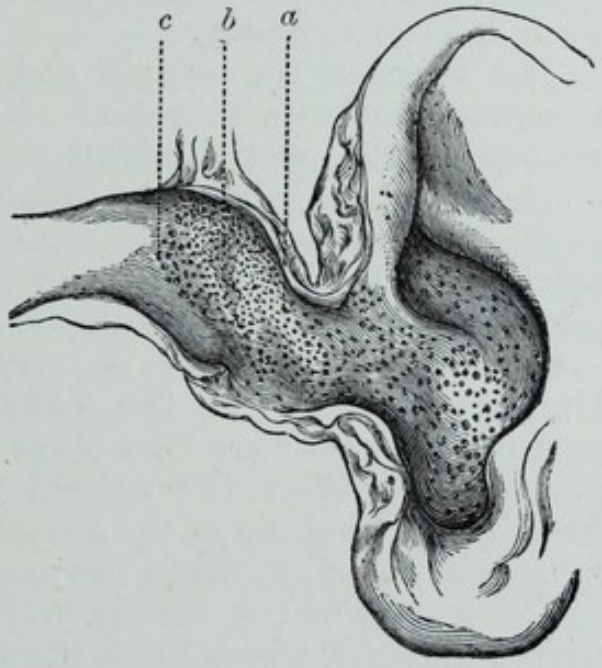

FIG. 11.—POSTERIOR WALL OF THE CARTILAGINOUS AND OSSEOUS MEATUS.

a, Orifices of glands on the cartilaginous portion; *b*, Boundary between cartilaginous and osseous meatus; *c*, Termination of the triangular space occupied by the orifices of the glands, which protrudes into the osseous meatus.

d. Vessels and Nerves of the Auricle and of the External Meatus.

The arteries of the auricle and of the external meatus spring from the temporal and internal maxillary arteries. The anterior surface of the auricle, as well as the exterior portion of the meatus, are supplied by the *art. auric. ant. sup.* and two to three *art. auric. anteriores inferiores*, springing from the *art. temporal. superf.* A branch of the *art. auric. posterior*, springing from the external carotid, ramifies on the posterior surface of the auricle. The blood-supply to the lower portions of the external meatus is provided by the *art. auric. profunda*, a branch of

the *art. maxillaris interna.* The smaller branches of the above-named arteries enter partly the intermediate membranous layer, bridging over the margins of the cartilaginous groove, partly the fissures of Santorini, and partly the fibrous connective tissue, by which the cartilaginous meatus is fastened to the osseous portion. They then ramify in the lining membrane of the external meatus, forming a fine capillary network on the perichondrium and around the glands of the hair-sacs and the sebaceous glands. A considerable vascular bundle extends along the superior wall of the meatus towards the upper margin of the membrana tympani, where it passes on to the membrane with a sheath of connective tissue, as will be described later on, extending along the posterior margin of the handle of the malleus to its inferior extremity.

The veins of the auricle and of the external meatus show numerous varieties in regard to their junction with the larger venous trunks on the lateral portions of the head. The *venæ auric. anteriores* and *profund.* unite chiefly with the *vena facialis posterior;* however, a portion of the veins coming from the meatus often unite with the *vena temporalis,* or, as *venæ posteriores,* immediately with the *vena jugularis externa.*

On the whole, there is very little known regarding the lymphatic vessels of the external meatus. It is, however, probable that they are very often connected with the lymphatic glands lying upon the parotid under the meatus, as there is frequently a swelling of the lateral cervical glands accompanying inflammatory affections in the meatus.

The nerves of the auricle and of the meatus come from the *nervus facialis,* which sends the *n. auric. post. profundus* to the posterior surface of the auricle; from the *trigeminus,* the third branch of which supplies the skin of the auricle and of the external meatus with some twigs of the *n. auriculo-temporalis;* from the *plexus cervicalis,* which takes part through the *n. auricularis magnus* in the supply of the external ear; from the *n. vagus,* which assists in the supply of the external meatus through the *ramus auricularis vagi,* discovered by Arnold, coming from the *ganglion jugulare,* entering the posterior wall of the meatus as a considerable branch, and supplying the lining membrane of the meatus. A large nervous branch extends from the superior wall of the meatus to the membrana tympani.

e. Size and Direction of the External Meatus.

Closely connected with the above-described anatomical relations of the meatus are also some of its properties, which deserve a detailed description on account of their practical importance. These are the comparative capacity of the meatus in its different parts, the length and the direction of the whole passage.

The capacity of the external meatus* in the adult is subject to many individual variations. The cartilaginous portion is often so wide that the little finger can be inserted without trouble as far as the osseous portion; in others, again, the lumen is found narrowed to the diameter of a goose-quill. The lumen of the cartilaginous meatus, which, inside the orifice of the external ear, gradually becomes wider as it passes inwards, shows again a moderate narrowing towards the place of union with the osseous portion. In childhood it is narrower than in the adult, and therefore examinations and operations are generally more difficult. On the other hand, in old persons a slit-like narrowing of the orifice of the external meatus often takes place in consequence of atrophy and shrinking of the cartilage, which reaches such a high degree that the anterior and posterior margins of the orifice of the ear completely touch, and the latter, therefore, seems closed up.

The capacity of the osseous meatus also presents many individual varieties. Its calibre becomes gradually less in passing from its external orifice (Fig. 9) inwards, is least at the margin of the inner third of the osseous portion (*isthmus*), and again increases considerably in size from this point towards the insertion of the membrana tympani. In the section the lumen of the meatus is somewhat rounded in appearance towards the outside, and in the lower portion till above the isthmus more elliptic in form (Fig. 12), the diameter of the ellipse not being perpendicular, but a little inclined forwards. It follows from this, that the isthmus is in that part of the meatus where the anterior and inferior walls display the greatest convexity towards the lumen. As this is the place where foreign bodies become wedged in, and where, if they penetrate lower still, the greatest obstacle is offered to their extraction, it is important to know that the distance of the isthmus (front) from the anterior margin of the membrana tympani amounts to 7-8 mm.; from the posterior margin however (on the posterior wall), only to 1-2 mm. In case of attempts at extraction the instrument can, therefore, be inserted along the superior and posterior walls only with great caution, so as to avoid injuring

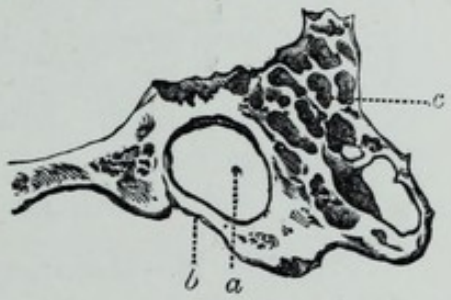

FIG. 12.—SECTION OF THE EXTERNAL MEATUS.

a, Lumen of the meatus; *b*, Anterior wall; c, Mastoid cells.

* According to the examinations of Zaufal, in the new-born infant the lumen is wanting in the inmost part of the meatus, as the membrana tympani lies with its whole surface on the inferior wall of the canal. This condition, according to v. Tröltsch, is also favoured, on the one hand, by the meatus passing abruptly outwards and upwards, on the other hand, by the strongly developed epidermic layers on the membrana tympani and the meatus.

the membrana tympani (v. Tröltsch). The transverse diameter of the osseous meatus amounts at the isthmus to 6 mm.; at the interior and exterior extremities to 9-10 mm.

Not less important is the knowledge of the length of the meatus. As the inner extremity forms an oblique truncated surface, the lengths of the different walls from the external orifice of the ear to the insertion of the membrana tympani will be unequal. V. Tröltsch in his measurements assumes as the exterior boundary of the meatus a saggital plane, passing through the posterior margin of the orifice, and according to him the length of the superior wall amounts to 21 mm., that of the inferior to 26 mm., that of the anterior to 27 mm., and that of the posterior wall to 22 mm. On an average the length of the

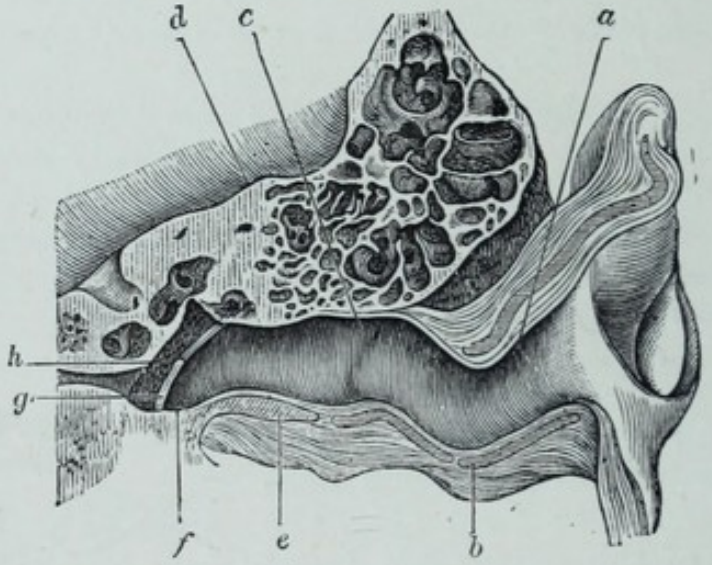

FIG. 13.—HORIZONTAL SECTION OF THE EXTERNAL MEATUS.

a, Concha; *b*, Tragus; *c*, Place of attachment of the cartilaginous portion; *d*, Mastoid process; *e*, Anterior wall of the meatus; *f*, Sin. meat. audit. extern.; *g*, Membrana tympani; *h*, Tympanic cavity.

whole meatus is 24 mm., of which more than one-third is taken up by the cartilaginous portion.

The meatus in its course from the external orifice to the membrana tympani displays several curves, which deserve full consideration in regard to examinations of the membrana tympani, as well as in respect of operations in the meatus. Although there are also numerous variations here, it may on the whole be assumed that the cartilaginous portion in passing inwards turns backwards and upwards, the osseous portion forwards and downwards.*

The longitudinal axes of the two portions of the meatus therefore form an open angle forwards and downwards, and as the meatus from the place of union of the two portions slopes both

* Henle (*Handbuch der systematischen Anatomie des Menschen*, vol. ii. p. 731) remarks that the curves in the external meatus are of two different kinds; a very constant one in the horizontal section, and a variable one in the vertical section.

outwards and inwards, the inferior part of the external orifice and of the membrana tympani must lie lower than the other parts of the meatus. It is therefore only in a very small number of persons, whose meatus is very wide and straight, that one is able to see the membrana tympani without further manipulation of the auricle. In most cases the membrane can be seen only when the angle formed by the longitudinal axes of the two parts is obliterated, by drawing the auricle backwards. The important influence exerted by the many individual differences in the direction of the meatus upon the performance of operations, will be discussed at length in the special division.

To the description of the anatomical relations of the two portions of the meatus, we must add a few remarks upon the topographical position of the cartilaginous portion to the osseous. The cartilaginous meatus is partly covered over by the walls of the osseous portion. The superior osseous wall completely roofs, as far as the external orifice, the membranous portion of the cartilaginous meatus, the latter being attached by an elastic connective tissue to the former. The exterior portion of the posterior wall of the osseous meatus also extends over the cartilaginous portion. Close by the orifice the osseous walls can therefore be felt through the cartilage upwards and backwards, and this explains the occurrence of exostoses in the external orifice of the ear. These growths mostly originate in the superior and posterior walls of the osseous meatus, and protrude into the lumen of the cartilaginous portion. Of the inferior and longest wall of the cartilaginous portion only the exterior part is free and can be felt, the interior part being covered by the parotid. The anterior cartilaginous wall is in part in contact with the posterior surface of the capsule of the joint of the lower jaw.

II. THE MIDDLE EAR.

The middle ear, to which belong the tympanic cavity, the Eustachian tube and the cells of the mastoid process, forms the most important part of the ear from a pathological point of view, because in most cases the pathological foundation of the disturbance of function has its seat there. As the pathological changes in the middle ear mostly appear as obstacles to the conduction of sound in the tympanic cavity and in the ossicula, we shall in the first instance describe the anatomical relations of the tympanic cavity, and let its description be followed by that of the Eustachian tube and the mastoid process.

A. The Tympanic Cavity.

The tympanic cavity is an irregular, trilateral, prismatic (Henle) cavity (Fig. 9 *f*) compressed from without inwards, in which the diameters from above downwards, and from before backwards,

are greater than from without inwards. Although the walls forming the cavity are in some places not sharply defined, it is necessary for a clear representation of the anatomical facts to describe these different parts as walls of the tympanic cavity. We will therefore commence with a description of its exterior wall, and the first subject for our attention will be the membrana tympani, which forms the greater part of this wall, and must be looked upon as an integral part of the middle ear on account of its close physiological connection with the ossicular chain.

The names of the walls of the tympanic cavity—exterior, interior, superior, and inferior—are not in keeping with their actual positions, as the direction of the cavity from above downwards is not perpendicular, but extends in an oblique direction downwards and inwards (towards the middle line). If we adhere to the old names it is necessary, owing to the important practical significance of these relations, never to lose sight of the fact, that in the normal position of the head the exterior wall becomes an exterior inferior by its inclination; the interior wall, which completely roofs the exterior wall, an interior superior; the inferior wall an inferior interior; and the superior wall a superior exterior.

a. The Membrana Tympani.

The membrana tympani, which, in conjunction with the ossicular chain, serves for the reception and conduction of the waves of sound reaching the ear from the external air, is stretched out as an irregularly-rounded concave membrane at the inner extremity of the osseous meatus, placed obliquely to its longitudinal axis, so that the plane of the membrane forms an obtuse angle with the superior wall of the meatus, and an acute angle with the inferior.

The margin of the membrane is embedded in a groove-like sulcus (*sulcus tympanicus*), situated at the inner end of the meatus. This sulcus belongs to the tympanic ring (Fig. 6) already mentioned, and exists on the perfect temporal bone (Fig. 14) only to the extent of the part taken by that ring in the formation of that bone (*vide* 'Development of the Osseous Meatus,' p. 8). In front and above, however, at the so-called Rivinian segment, the sulcus is wanting altogether, and here the membrana tympani is united partly with the grooveless margo tympanicus, partly with the lining membrane of the osseous meatus.

Form of the Membrana Tympani.—The form of the membrana tympani is dependent on the shape of the periphery of the inner end of the meatus. This varies between the elliptic, the irregularly oval, and the heart-shaped forms, according to the greater or less prominence of the lateral parts of the osseous ring. Especially at two places the membrane is bulged out towards the periphery, viz., behind and above, into a large segment of a

circle (Fig. 14), and also as the Rivinian segment at the anterior superior pole (Figs. 14, 15, and 16, *b*) of the membrane above the short process of the malleus. This segment is marked off from the remaining periphery of the sulcus of the membrane by two more or less sharply-defined angular projections (Figs. 14 and 16), the distance of which from each other at the base amounts to $2\frac{1}{2}$-3 mm., the height of the rounded protuberance being about 2 mm. (compare Prussak, *Arch. für Ohrenheilkunde*, vol. iii. p. 258).

Size of the Membrana Tympani.—The size of the membrana tympani depends on the circumference of the inner extremity of the meatus, which presents more or less noteworthy deviations in different individuals. From numerous measurements taken by me, it appears that the greatest longitudinal diameter from the point of the *spina tympanica post.* to the lowest point of the inferior margin of the membrane amounts to $9\frac{1}{2}$-10 mm., the greatest transverse diameter from the anterior to the posterior margin measures $8\frac{1}{2}$-9 mm., while the thickness of the membrane between the handle and the tendinous ring, according to Henle, amounts to 0·10 mm.

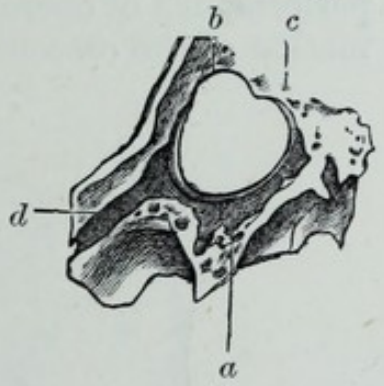

FIG. 14.—SULCUS OF THE MEMBRANA TYMPANI AT THE INNER EXTREMITY OF THE MEATUS.

a. Sulcus; *b*, Anterior superior grooveless bulging out of the periphery of the membrana tympani (margo tympanicus) or Rivinian segment; *c*, Osseous wall of the tympanic cavity behind the membrana tympani; *d*, Exterior wall of the cavity extending into the Eustachian tube. (Right ear.)

The Inclination of the Membrana Tympani.—The inclination of the membrana tympani depends on its relations to the walls of the external meatus, and in the adult it follows the inclination of the sulcus tympanicus towards the axis of the meatus. The inclination of the plane of the sulcus, which represents the oblique truncated surface of the external meatus, is subject to many varieties, and will of course be greater the farther the anterior and inferior walls of the meatus reach inwards beyond the posterior and superior walls (Figs. 9 and 10). The measurements which have been taken in this direction apparently vary, because the different investigators started from different standpoints. Hyrtl gives the angle of inclination of the plane of the membrane to the inferior wall of the meatus at 50°; but this cannot be taken as a constant measurement, since the inferior wall of the meatus is hollowed out near the membrane in different individuals to a different degree. Huschke denotes the oblique position of the membrane by an angle of 130°, at which the planes of the two membranes, prolonged inwards and downwards, would intersect. V. Tröltsch places the angle which the plane of the

membrane forms with the superior wall of the meatus at an average of 140°.

Until now the position of the membrane tympani of the infant has been described as nearly horizontal. Dr. J. Pollak, however, proved by numerous measurements that this assumption is erroneous, as there is no perceptible difference between the inclination of the membrane in the new-born infant and in the adult.

The oblique position of the membrane to the longitudinal axis of the meatus has an important influence, not only upon the estimation of the condition of the membrane, but also upon the performance of operations. Of course, in the first place, the formation of the osseous meatus has here to be taken into conside-

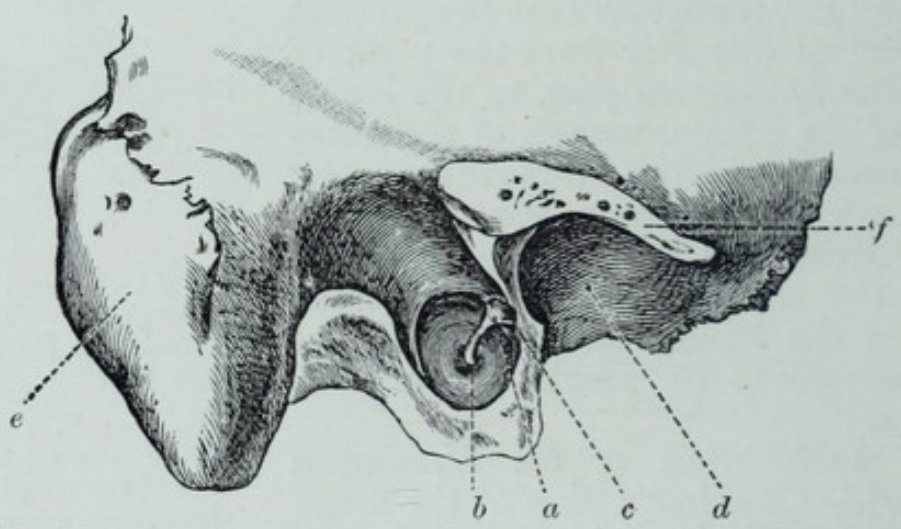

FIG. 15.—EXTERNAL SURFACE OF THE MEMBRANA TYMPANI (NATURAL SIZE).

a, Short process of the malleus; *b*, Inferior extremity of the handle of the malleus (umbo); *c*, Membrana flaccida Shrapnelli; *d*, Cavitas glenoidalis; *e*, Mastoid process; *f*, Section of the zygomatic process. (Right ear.)

ration, for the difficulty of operating upon the anterior portion of the membrane is considerably augmented by the curvature of the anterior inferior wall of the meatus, while the posterior wall, which is more even, offers no obstacle to operations on the posterior part of the membrana tympani.

Curvature of the Membrana Tympani. — In the above-described oblique position the membrana tympani is not stretched out as a plane surface, but is curved in such a manner that it turns its concavity outwards, and its convexity towards the interior of the tympanic cavity (Fig. 9, *e*). The deepest part of the curvature, the so-called *umbo*, corresponds with the inferior extremity of the handle of the malleus, which is enclosed in the layers of the membrana tympani. By the traction of this handle inwards the membrane appears hollowed out in a funnel-shaped manner. The interior convexity is common to the membrana tympani as a whole, but on closer observation it is seen that the

anterior and inferior portions of the membrane, extending from the umbo towards the periphery, show a slight curvature with external convexity (Fig. 9). This partial bulging out, as opposed to the curvature of the membrane, is due partly to the drawing inwards of the membrane by the traction of the handle of the malleus, partly to the action of the circular fibres upon the radiating fibrous layers (Helmholtz). The arches, which the radiating fibres form in the above manner, are of importance to the mechanical action of the membrana tympani. That portion of the membrane which is situated behind the handle of the malleus appears more relaxed, and shows a less regular curvature than its anterior and inferior portions.

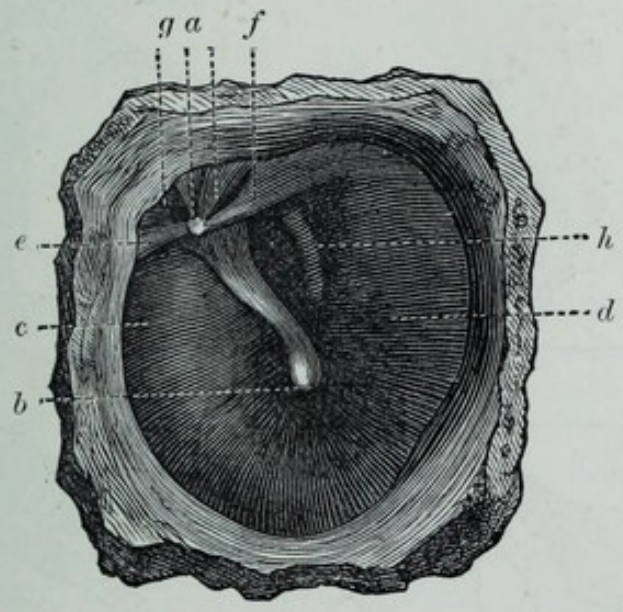

FIG. 16.—EXTERNAL SURFACE OF THE LEFT MEMBRANA TYMPANI, SEVERAL TIME ENLARGED.

a, Short process of the malleus; *b*, Inferior extremity of its handle (umbo); *c*, Anterior portion; *d*, Posterior portion of the membrana tympani; *e*, Anterior fold; *f*, Posterior fold of the membrana tympani; *g*, Membrana Shrapnelli; *h*, Long process of the incus shining through.

The malleus, which is in close relation with the membrana tympani, transfers the waves of sound which strike the membrane to the incus and the stapes. The shaft-like handle of the malleus (Figs. 15 and 16), intimately united with the layers of the membrane, and strongly inclined inwards, extends in an oblique direction from the front and above, backwards and downwards, and ends at the umbo in a flattened extremity.

The handle of the malleus, which divides the membrana tympani into two unequal portions, a lesser anterior one and a larger posterior one, extends forwards and upwards to the short process of the same bone (Figs. 15 and 16, *a*). This short process is recognisable on the membrane by a strongly-marked, partially-pointed projection at its anterior superior pole. Before and behind this pole are two folds, due to the partial bulging for-

wards of the membrane. These folds (Fig. 16, *e*, *f*) are of a more or less decided character, and when the membrane is abnormally concave they often have the appearance of grey, tendinous bands. We will show their important diagnostic significance in describing the pathological conditions of the membrana tympani.

At the anterior superior pole of the membrana tympani, near the folds and above them, there are also to be found two short, tightly-stretched striæ, which take origin in the corners of the

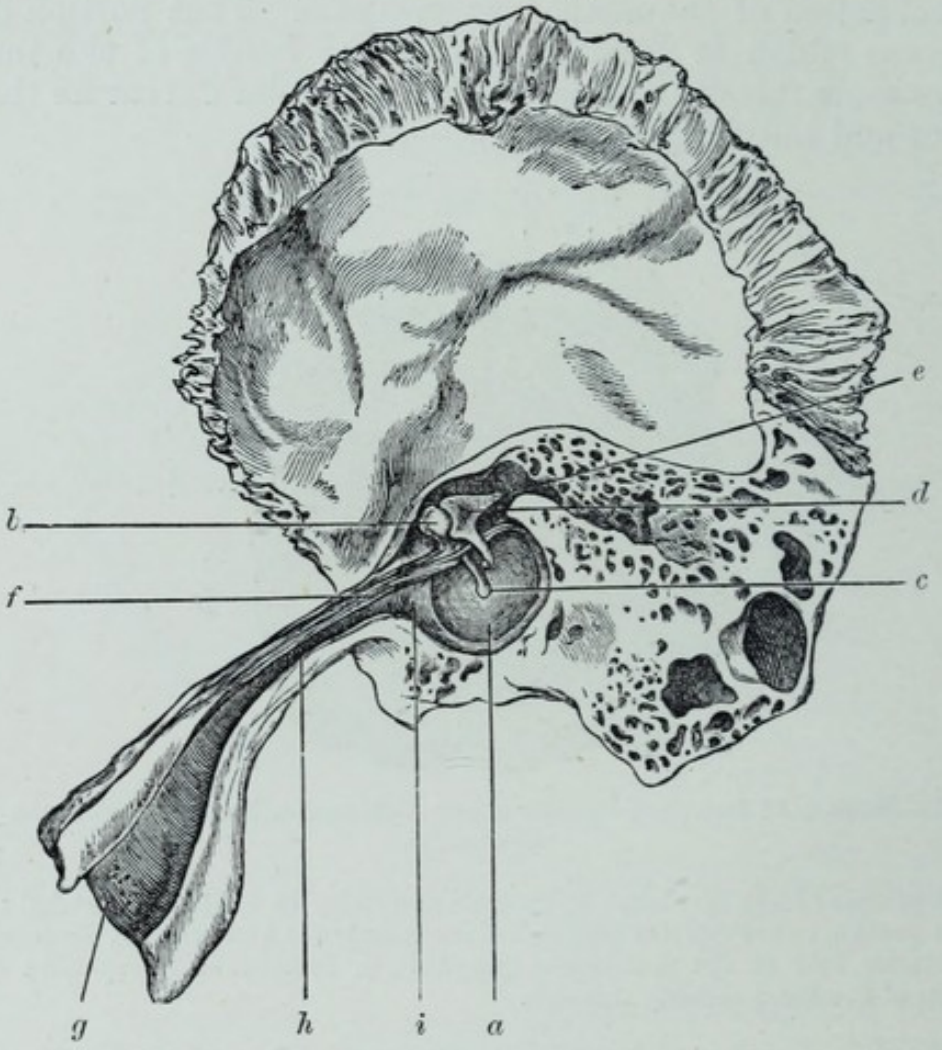

FIG. 17.—INTERNAL SURFACE OF THE MEMBRANA TYMPANI.

a, Membrana tympani ; *b*, Head of the malleus ; *c*, Inferior extremity of the handle of the malleus ; *d*, Incus ; *e*, Short process of the incus ; *f*, Musc. tensor tympani ; *g*, Ostium pharyngeum tubæ : *h*, Isthmus tubæ : *i*, Ostium tympanicum tubæ. (Right ear.)

segment of Rivini, and extend, converging towards each other, to the point of the short process. These striæ, which were first described by Prussak, and which in examinations made during life are often visible as marked white lines, appear somewhat sunken in dried preparations.* The portion of the membrane (*vide* Fig. 16) which is bounded by these striæ and the grooveless fissure, is generally called the *membrana flaccida Shrapnelli*. It is much thinner and less tense than the other parts of the

* Superior striæ for the attachment of the membrana tympani (Helmholtz).

membrana tympani, and it appears therefore above the short process as a small, pit-like depression, and forms the outer wall of a small space, communicating with the tympanic cavity, which Prussak calls the superior pouch of the membrane. Shrapnell's membrane consists of delicate, loose prolongations of connective tissue, which cross each other in an irregular manner, and are covered by a thin dermic layer. Bloodvessels which enter the membrane here form a partial anastomosis between the vessels of the external meatus and of the tympanic cavity.

As regards the interior surface of the membrana tympani, the rounded head of the malleus (Fig. 17, *b*), and the incus (*d*) connected with it by a joint, come first into view above the membrane. Below the head of the malleus is the neck, from which proceeds downwards and backwards the handle (Figs. 17 and 18). The latter is closely connected with the membrane (*a*); indeed the bulk of the handle bulges out over the surface of the membrane, so that it appears as if it were lying on it. The posterior surface of the head of the malleus is articulated with the incus (*d*), the short process of which (*e*) is pointed backwards towards the entrance into the mastoid process, while its long process (Fig. 18, *i*) passes nearly parallel to the handle of the malleus downwards and backwards. On separating the incus from the malleus, besides the chorda tympani (Fig. 18, *f*), which stretches from behind above the neck of the malleus to the Glaserian fissure, there will be found a fold on the posterior segment of the membrane, which has been described by v. Tröltsch. It begins at the posterior superior margin of the tendinous ring, is closely connected above with the posterior grey stria, visible on the exterior surface of the membrane, and extends from the angular projection of the annulus tympanicus to the short process (Prussak), and from there forwards, till it fastens itself to the posterior surface of the handle of the malleus. Standing out from the membrana tympani with a free inferior margin, this fold forms with the surface of the membrane the posterior pouch of the membrana tympani (v. Tröltsch, Fig. 18, *f*), in contrast to the smaller anterior pouch. This latter is enclosed by an osseous projection from the neck of the malleus, the ligamentous and osseous remains of the long process of the malleus; by the chorda tympani, the *arter. tymp. inf.* and the lining membrane. The superior boundary of the anterior pouch is formed by the grey stria visible on the exterior surface of the membrane, and extending from the short process to the anterior angular projection of the annulus tympanicus (Prussak).*

* The aperture at the superior anterior pole of the membrana tympani, described by Rivinus (1689), was put down as constantly occurring by Bochdalek (*Prager Vierteljahrschrift*, i. 1866). He described it as an oblique delicate canal, extending through the lamellæ of the membrana tympani, and lined with an epithelium. Although Kölliker found his assertions confirmed by some of the preparations shown him by Bochdalek, the constant occurrence of the foramen Rivini is by no means to be considered as a positive fact.

Microscopic Anatomy of the Membrana Tympani.—As was known to older investigators (Lincke), the membrana tympani consists essentially of three principal layers, a middle fibrous layer, the *lamina propria*, an external dermic layer, and an internal layer of mucous membrane, the two last named being the coverings which the lamina propria receives from the lining membrane of the external meatus and of the tympanic cavity. The dermic layer may be easily detached from the fibrous, but the internal layer is so closely connected with the fibrous, that it is not possible to separate them.

The dermic layer is a continuation of the lining membrane of

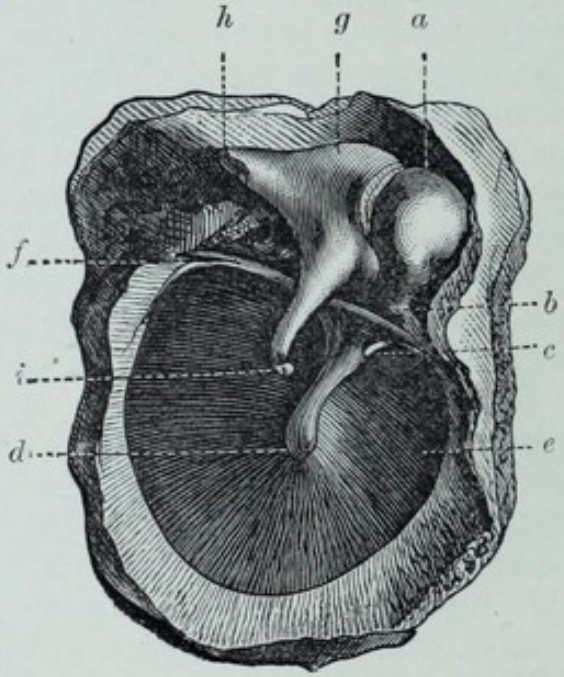

FIG. 18.—INTERNAL SURFACE OF THE LEFT MEMBRANA TYMPANI (ENLARGED).

a, Head of the malleus; *b*, Neck of the malleus; *c*, Tendon of the m. tensor tympani and anterior fold of the membrana tympani; *d*, Inferior extremity of the handle of the malleus; *e*, Anterior portion of the membrana tympani; *f*, Posterior fold of the membrana tympani and chorda tympani; *g*, Incus; *h*, Short process of the incus; *i*, Long process of the incus.

the external meatus. It consists of several strata of pavement epithelium with a malpighian mucous layer, but possesses only a very slight stratum of connective tissue, which differs in its arrangement from the fibres of the lamina propria, and seems to sustain a communication with the vessels and nerves in the external covering.

We have already mentioned that, especially in the new-born infant, a strongly developed cutaneous band extends from the superior wall of the external meatus to the membrana tympani and behind the handle of the malleus, so that between the handle and the cutaneous band there is left a triangular transparent space, directed with its apex towards the extremity of the handle; with this cutaneous band, consisting of connective tissue and elastic fibres (Prussak's descending fibres), there also extend

vessels and nerves from the meatus to the membrana tympani. At the inferior and widened extremity of the handle of the malleus, the ligamentous fibres of this bundle radiate towards the periphery, and partly unite with the fibres of the *substantia propria*.

The middle fibrous layer consists of two separable lamellæ, an external radiating layer, and an internal circular layer. The pale, filamentous and delicately defined fibres of these two layers form a tissue, which, according to Gerlach, is, so to say, midway between the usual fibrillated and the homogeneous connective tissue of Reichert. According to Helmholtz, these fibres are very similar to tendinous fibres, with which they also agree as regards their conduct towards chemical reagents. The radiating fibres spring from the marginal tendinous ring, and are attached, in conjunction with the circular fibres (Prussak), to the spatular extremity in the inferior segment; but in the superior segment, to the anterior edge of the handle of the malleus. They become at the same time more dense towards the centre, partly because they multiply by splitting of the fibres, and partly because they thicken at the umbo by accumulation in the limited space (v. Tröltsch).

The inner lamella consists of fibres which, from their circular arrangement, cross the direction of the radiating fibres. At the margin it is closely connected with the origin of the radiating layer; both layers, however, are easily separable from each other from this point to the handle of the malleus. The fibres of the circular layer, which can be traced to the tendinous ring, are wanting on the external margin of the membrana tympani. They collect themselves and are most dense within the tendinous ring, which consists of compact fibrous connective tissue, while they become more sparse towards the centre. At the handle of the malleus, the fibres of both layers amalgamate, and attach themselves to it, surrounding its inferior third on all sides, that being the portion most closely connected with the fibres of the membrana tympani. Between the fibres of the two layers, the corpuscles of connective tissue, called Tröltsch's corpuscles after their discoverer, are seen spindle-shaped in the longitudinal sections, and star-like in the transverse. They are very similar to the corpuscles of the cornea, their delicate processes anastomosing with each other, and spreading on either side towards the vascular cutaneous layer and the layer of lining membrane, to draw from them their nutrition. According to v. Tröltsch, the cells of the epithelial surface of the lining membrane are connected by processes with the corpuscles of the membrana tympani; Prussak has confirmed the occurrence of the spindle-shaped fibres in the membrane (organic muscular fibres) described by Everard Home.

The inner layer, a continuation of the lining membrane of the

tympanic cavity, is closely united with the circular fibrous layer, and consists of a very scanty stratum of connective tissue with a covering of non-ciliated pavement epithelium. Gerlach has found on the lining membrane of the membrana tympani in not inconsiderable quantities projections, sometimes globular like the papillæ of the tongue, sometimes finger-shaped like the shaggy villi of the intestine. The globular projections attain such a size, that with sufficient light they are visible to the naked eye. In the central portion they consist of ordinary, on the margin rather of homogeneous connective tissue, covered with a layer of flattened cells, and they contain one or more capillary clusters, but no demonstrable nerves. They occur in greatest numbers on the membrana tympani of the new-born

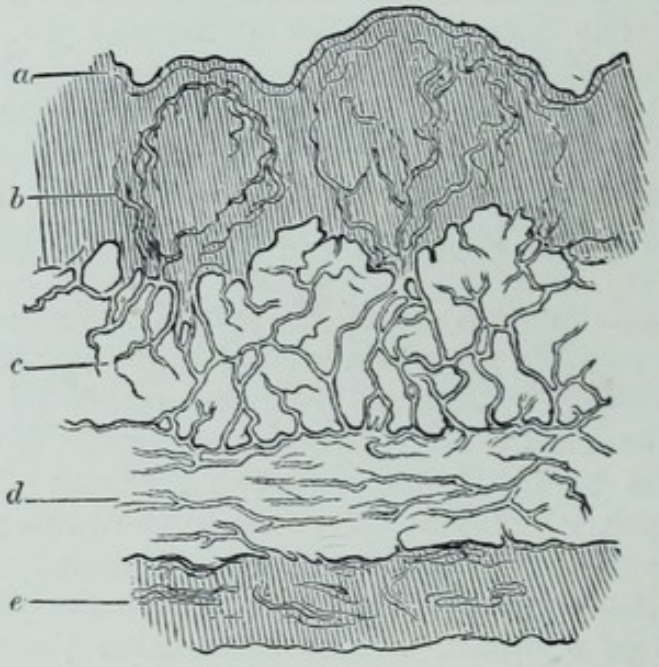

FIG. 19.—SECTION OF THE MEMBRANA TYMPANI IN THE NEW-BORN INFANT.

a, Epidermic layer; *b*, Cutaneous layer; *c*, Radiated fibrous layer, with the star-like corpuscles of the membrana tympani; *d*, Circular fibrous layer; *e*, Layer of lining membrane.

infant, and as some of them are connected with the lining membrane only by a stalk, Gerlach declares them to be villi of the membrana tympani.

The membrana tympani possesses two vascular networks, separated by the substantia propria, and anastomosing with each other at the periphery, the outer one belonging to the connective tissue of the cutis, the inner to the mucous membrane.

The vascular network of the cutis comes from the arteria auriculæ profunda, which sends a branch to the centre of the membrana tympani. This branch lies between two venous branches, which form a plexus here and there, and descends to the umbo from the superior posterior wall of the meatus, behind

the handle of the malleus. These vessels do not lie immediately behind the handle, but at some distance from it, in such a way that between them and the bone a portion of the membrana tympani is visible, its point directed downwards. At the centre of the membrane the arteries as well as the veins communicate by numerous radiating branches with a vascular zone, situated at the periphery of the membrane, and through this also with the vessels of the tympanic cavity. According to the investigations of Prussak,* the veins are in greatest numbers at the handle of the malleus, as well as at the periphery. The arterial branches which run along the handle of the malleus, partly enter at once into the venous plexus in the neighbourhood, and partly pass across the membrana tympani to the marginal venous zone. Which course the blood takes during life, whether it takes the shorter way to the venous plexus at the handle of the malleus, or the longer way to the plexus at the periphery of the membrane, will evidently depend upon the nature of the obstacles lying in its way in the veins. Burnett found vascular loops always present on the membrana tympani of the ox, the cat, and the goat.

The veins of the cutaneous layer of the membrana tympani are connected partly with the veins in the external meatus, partly, on the periphery of the membrana tympani, with the vessels in the tympanic cavity through apertures sometimes of considerable size.

The vascular network on the surface of the lining membrane springs from the vessels of the tympanic cavity, and presents a rather closely meshed capillary system, developed from an artery which runs parallel to the handle of the malleus, on the inner side of the membrana tympani. The lymphatic vessels of the membrane, according to Kessel (Stricker's *Handbuch der Lehre von den Geweben*, 1870), are, like the bloodvessels, arranged in three layers anastomosing with each other. If the epithelium of the lining membrane be brushed off, with a low microscopic power a fibrous framework (designated by Gruber dentritic formation) will be found lying upon the substantia propria, which is often spread over the whole membrane, but is especially developed on that part situated behind the handle of the malleus.

From the membranous expansion of this fibrous framework, which is interrupted here and there (Fig. 20, *a*) by large and small interspaces, there radiate towards the handle of the malleus, as well as towards the peripheral tendinous ring, processes which form curves of different sizes. These processes strike deep, partly amalgamating with the fibres of the substantia propria, and partly forming a second framework between the

* *Zur Physiologie und Anatomie des Blutstroms in der Trommelhöhle* (Experiments on Dogs). Presented by C. Ludwig at the session of the Royal Saxon Society of Sciences, May 9th, 1868.

radiating and the circular fibrous layers. Hence arises in the membrana tympani a system of empty spaces which are lined by an epithelium, and which in their construction are analogous to the lymph-sacs of frogs. The polygonal epithelium which lines the inner surface of the membrana tympani in some places contains rounded orifices, which lead into the system of interspaces previously described.

Through the interspaces in the framework the blood and lymphatic vessels of the tympanic surface are connected with those of the external surface of the membrana tympani. The

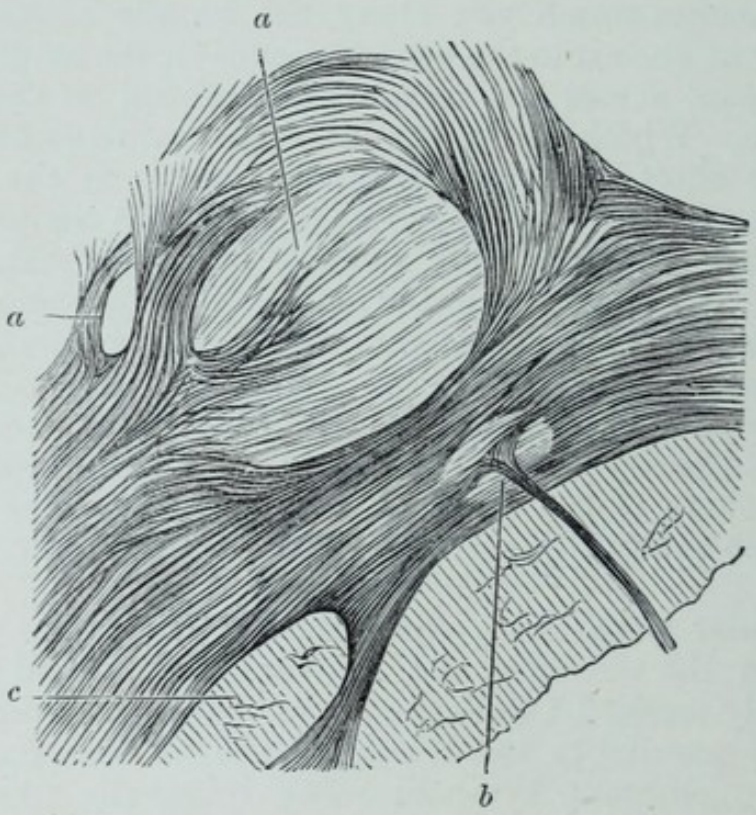

FIG. 20.—FIBROUS FRAMEWORK OF THE POSTERIOR SEGMENT OF THE INTERIOR SURFACE OF THE MEMBRANA TYMPANI IN THE ADULT.

a, Great interspace in the framework; *b*, Small interspace, through which a thin process passes; *c*, Arch formed by radiating processes.

lymphatic vessels of the mucous membrane, entering through the interspaces of the framework into the system of cavities, form in that place sac-like dilatations and globular enlargements. Kessel further describes a system of lymphatic canals in the mucous layer of the membrana tympani, extending over its whole surface, but most strongly developed along the handle of the malleus and towards the peripheral tendinous ring.

The nerves of the membrana tympani, which, according to Arnold, spring from the *nervus temporalis superficialis* of the *trigeminus*, but which were minutely examined for the first time by v. Tröltsch, are spread out on the external layer, parallel with the vessels, in the form of three or four very delicate, ill-defined branches, the terminations of which are, so far, unknown. Kessel

says that he has sometimes observed round the vessels and between their meshes a large nervous plexus and gangliar swellings on the nerve-fibres. In the *rete Malpighii* there is a second plexus supplied with multipolar cells. The nerve-fibres of the cutis, while regularly dividing dichotomously, penetrate the substantia propria and come into connection with the nervous plexus of the lining membrane. Gerlach observed delicate fibres without any marks in the covering of the lining membrane.

b. Superior Wall of the Tympanic Cavity.

The superior wall, or roof, of the tympanic cavity is formed by an osseous plate, continuous with the superior surface of the pyramid. This plate extends beyond the boundaries of the tympanic cavity, forming not only a part of the superior lamella of the osseous meatus, but also the upper wall of the cells of the mastoid process, and the roof of the canal for the tensor tympani, and of the osseous portion of the Eustachian tube.

In the ear of the infant, on the upper wall of the tympanic cavity will be found a suture (*sutura petroso-squamosa*), which is formed by the meeting of the roof of the tympanic cavity with the inner lamella of the squamous portion of the temporal bone. Through this suture, in the new-born infant, processes of connective tissue, containing bloodvessels, pass from the dura mater into the tympanic cavity. This explains why children suffering from acute tympanitis often exhibit symptoms of meningeal irritation, the hyperæmia in the tympanic cavity spreading by means of these vascular connections to the dura mater.

In the adult this suture is firmly closed, and with the exception of a few traces, the connective tissue processes have disappeared. It is indicated on the macerated bone by a jagged furrow, and is not situated above the tympanic cavity, but for the most part above the osseous meatus.

The width of the superior wall of the tympanic cavity varies in different individuals, and at different parts. On an average, above the head of the malleus, it amounts to 5-6 mm. Sometimes the roof is formed by a thin osseous plate, but often it is thickened by a cellular osseous substance; it is, however, much thinner than the superior wall of the meatus, as the accompanying drawing shows (Fig. 21). Now, the space due to the difference in thickness of the superior wall of the osseous meatus and the superior wall of the tympanic cavity, and in which the head of the malleus and the body of the incus are situated, is called the upper space of the tympanic cavity.

An examination of a large number of macerated crania will often show that the delicate transparent osseous plate of the roof of the tympanic cavity is defective, being pierced by one or more

irregular apertures, and that sometimes a great part of the roof of the tympanic cavity may be wanting.*

What we have said before about the possibility of a carious affection of the superior wall of the meatus giving rise to meningitis, holds good still more as regards the superior wall of the tympanic cavity, partly because the purulent processes which cause the development of caries are disproportionately more frequent in that cavity than in the external meatus, and partly because the extension of the affection to the cranial cavity is favoured by the superior wall of the tympanic cavity being much thinner.†

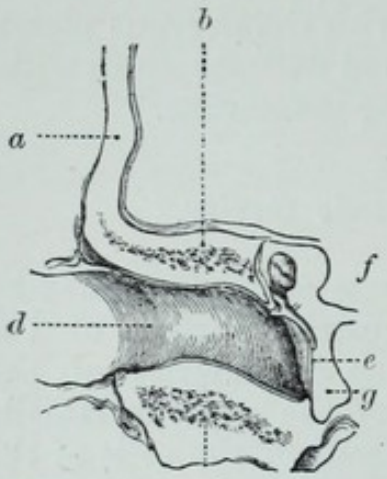

FIG. 21. — PERPENDICULAR (FRONTAL) SECTION OF THE OSSEOUS MEATUS AND THE TYMPANIC CAVITY.

a, Squamous portion; *b*, Superior wall of the osseous meatus; *c*, Inferior wall; *d*, Meatus; *e*, Membrana tympani; *f*, Superior wall of the tympanic cavity; *g*, tympanic cavity.

c. Inferior Wall of the Tympanic Cavity.

The inferior wall of the tympanic cavity (Fig. 21) is narrower than the superior. It is limited behind by the posterior wall, and before by that gentle elevation of the inferior wall towards the anterior, which is situated below the ostium tympanicum tubæ. Its surface usually presents ridges and hollows,‡ but is often smooth and bulged forward towards the tympanic cavity by the adjoining fossa jugularis. Its thickness varies in the same manner as that of the superior wall.

The proximity of the inferior wall of the tympanic cavity to the fossa jugularis is worthy of remark, because a fatal phlebitis with thrombosis in the bulbus venæ jugularis is often brought about by caries of this wall. We must however differ from the view, according to which this wall is especially exposed to the corroding influence of stagnant secretions in the middle ear. For as the inferior wall of the tympanic cavity is not horizontal, but inclined from the inside obliquely outwards and downwards, the pressure of the secretion must therefore fall more upon the strongly-inclined membrana tympani. In consequence of this strong inclination, in cases where the inferior half of the membrana tympani is destroyed, the ridges and depressions of the inferior wall of the tympanic cavity often lie bare to a great extent.

* This anomaly, which is designated by Hyrtl as spontaneous dehiscence of the tegmen tympani, is probably due to arrested development. In two specimens in my collection the dehiscence is to be found on both sides.

† Such an occurrence is favoured still more in those cases in which there is a defect in the osseous tegmen tympani, the lining membrane of the tympanum and the dura mater being then in contact.

‡ In this wall also dehiscences have been observed similar to those in the superior wall (Friedlowsky).

d. Posterior Wall of the Tympanic Cavity.

The height of the posterior wall, rising abruptly from the floor of the tympanic cavity (Fig. 22), amounts to several millimetres. Above it there is a great triangular aperture, which is the means of communication between the tympanic cavity and the mastoid process. In the inferior angle of this aperture a saddle-shaped notch will be found, in which rests the short process of the incus. From the surface of the posterior wall there arises a small osseous projection, directed forwards, on the pointed extremity of which a delicate and rounded aperture is visible. This is the *eminentia*

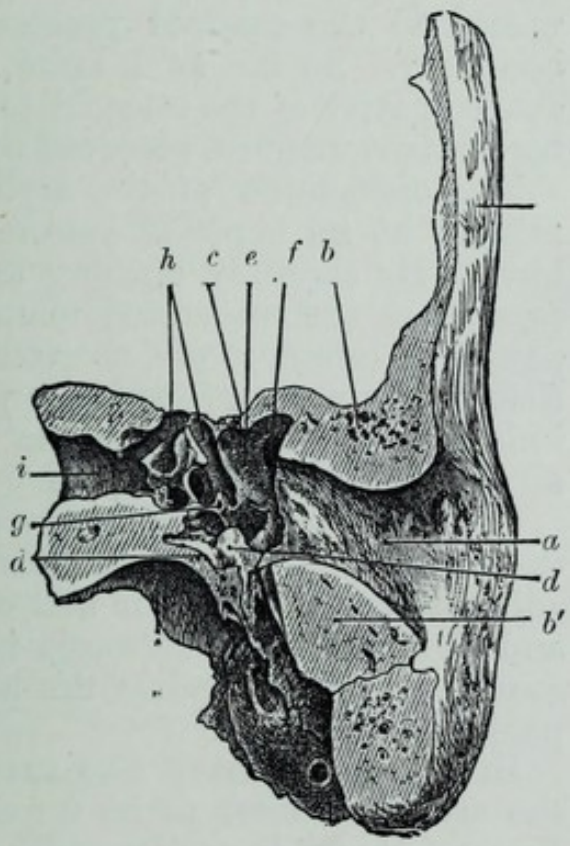

FIG. 22.—VIEW OF THE POSTERIOR WALL OF THE TYMPANIC CAVITY.

a, Meatus; *b*, *b′*, Superior and inferior walls of the meatus; *c*, Superior wall of the tympanic cavity; *d*, Protuberance underneath the eminentia stapedii, caused by the superior extremity of the styloid process; *e*, Posterior wall; *f*, Entrance into the mastoid process; *g*, Eminentia stapedii; *h*, Canalis Fallopiæ; *i*, interior meatus.

pyramidalis (*g*), which is connected with the Fallopian canal by one or more fissures, and which encloses the muscle of the stapes, the tendon of which passes through the rounded aperture to the capitulum of the stapes.

Below the eminentia stapedii very often a more or less pronounced irregular protuberance (*d*) will be seen, which, as I was the first to prove,* is caused by the bulging out of the superior extremity of the styloid process. This process, which according

* *Arch. f. Ohrenheilk*, vol. x.

to the investigations of Reichert originates from the second branchial arch, is mostly quite cartilaginous after birth, and ossifies only in the course of the first year. As first described by me, the shape of its superior portion in the new-born infant (Fig. 23) is that of a club, the upper knobby extremity of which is located underneath the eminentia stapedii. The rounded extremity of the club (*b*) is pointed backwards, and rests in a cup-shaped depression of the mastoid cells, directed forwards. This small cavity ($\frac{1}{2}$ mm. in diameter) on the anterior portion of the mastoid cells I have found at different times in the macerated temporal bones of new-born infants, the superior extremity of the styloid process not yet having been ossified or united to the mastoid process on its posterior boundary. So far as I know, this small, cup-shaped cavity of the mastoid process in the new-born infant was first observed by me.

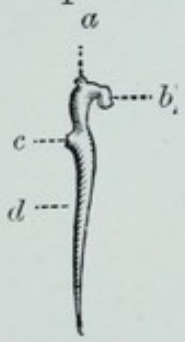

FIG. 23.—STYLOID PROCESS IN THE NEW-BORN INFANT.

a, Superior extremity pointed towards the posterior wall of the tympanic cavity; *b*, Club-like extremity pointing backwards; *c*, Short cartilaginous process; *d*, Inferior extremity.

The ossification of the styloid process commences at its superior extremity, often before birth. By carefully opening the sheath of this process in the macerated temporal bone of the new-born infant, it will therefore often be found that its uppermost ossified portion is firmly united with the bone at the place where the above small cavity is situated.

The projection on the superior extremity of the styloid process, which is directed forwards, is adjacent to the posterior wall of the tympanum, and often presses it forwards in the shape of a rounded swelling against the lumen of the tympanic cavity.

In the adult I have also succeeded in tracing the styloid process to its uppermost extremity. In carefully made sections (Fig. 24), I found the cortical substance of the styloid process closely united with the surrounding osseous tissue; and I could trace the medullary space (*b*) to its superior extremity, bordering on the posterior wall of the tympanic cavity.

e. Anterior Wall of the Tympanic Cavity.

The anterior wall of the tympanic cavity is formed only by the short, ridgy, and oblique plane which rises at the anterior boundary of the inferior wall (Fig. 25). Above this plane, on the same level as the entrance into the mastoid process, a large irregular aperture, the ostium tympanicum tubæ, leads into the osseous Eustachian tube, which lies immediately below the canal for the tensor tympani. The ridgy, sometimes dehiscent, anterior wall of the tympanic cavity is closely applied to the carotid canal.

According to a number of observations, a sudden fatal hæmorrhage may occur from caries of this wall opening the carotid artery. The walls of the carotid artery do not, however, lie close to the osseous canal, as they are surrounded by a venous sinus, which is connected with the sinus cavernosus, as first proved by Rektorzik (*Wiener Acad. Sitzungsberichte*, 1858). According to v. Tröltsch, full attention should therefore be given at anatomical examinations, in cases of chronic suppuration of the middle ear, to the pathological alterations of the venous sinus, hitherto so little regarded.

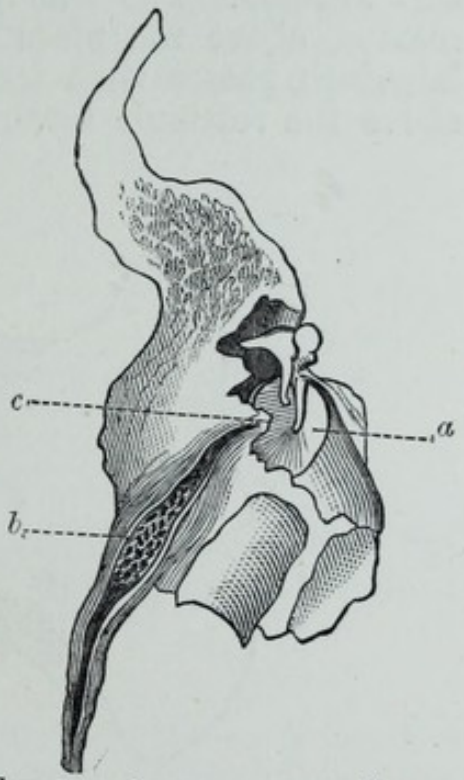

FIG. 24.—SECTION OF THE STYLOID PROCESS IN THE ADULT.

a, Membrana tympani; *b*, Medullary cavity of the styloid process; *c*, Its superior extremity with the protuberance on the posterior wall of the tympanic cavity.

f. Inner Wall of the Tympanic Cavity.

The relations of the inner wall, or labyrinth wall, of the tympanic cavity (Fig. 25) are more complicated. In it there are two fenestræ, closed by elastic plates, and leading to the labyrinth, the great importance of which in the physiology and pathology of the ear we will see later on. The oval or bean-shaped fenestra (*a*), which leads to the vestibule of the labyrinth, and is situated at the extremity of a deep niche, receives the foot-plate of the stapes, the edge of which is fastened to the margin of the fenestra ovalis by means of a fibro-elastic annular ligament. The greatest diameter of the aperture (4 mm.) extends from before backwards and downwards; the height from without inwards and downwards is 1½ mm. The plane of the fenestra ovalis is therefore strongly inclined towards the axis of the ear.

Below the fenestra ovalis (at a distance of 3-4 mm.), the entrance to the niche of the fenestra rotunda (Fig. 25, *b*) will be seen, directed backwards. In an obliquely-placed groove at its base, a small, delicate membrane (*membrana fenestra rotunda sive memb. tymp. secundaria Scarpæ*), somewhat concave towards the membrana tympani, is stretched out, which shuts out the cochlear canal from the tympanum. Thickening of the lining membrane of the latter, and the closing up of the niche by a firm exudation, or by proliferation of connective tissue, often cause serious functional disturbances.

Between and a little in front of the two fenestræ, the wall of the tympanum is strongly bulged out towards the cavity; this is

due to the projection of the first whorl of the cochlea, and is called the promontory. Vertically above it, in an open or covered groove, extends Jacobson's nerve, which connects the jugular ganglion with the n. petroso. superf. minor.

Above and slightly behind the fenestra ovalis there is seen a portion of the Fallopian canal, containing the facial nerve. This canal, in cases of suppuration in the middle ear, is sometimes also affected. The Fallopian canal commences in the internal meatus, above the place where the auditory nerve enters the labyrinth, passes then into the substance of the petrous bone above the vestibule towards the outer side, and, arrived at the

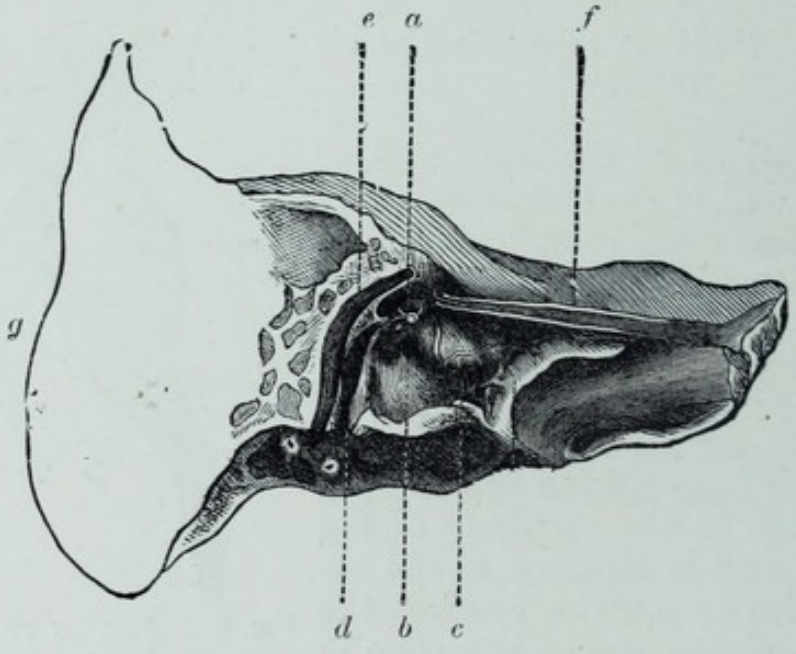

FIG. 25.—INNER WALL OF THE TYMPANIC CAVITY.

a, Fenestra ovalis with the stapes; *b*, Fenestra rotunda; *c*, Promontory; *d*, Musc. stapedius; *e*, Canalis Fallopiæ; *f*, Canal for the tensor tympani; *g*, Mastoid process.

inner wall of the tympanic cavity, forms a knee-like bend (Fig. 22), from which the canal continues backwards along the inner wall of the tympanic cavity above the fenestra ovalis, and extends farther along the boundary between the posterior and the interior walls of the tympanum, with an abrupt bend downwards to the stylo-mastoid foramen.

On the portion of the Fallopian canal extending above the fenestra ovalis, there is an elevation projecting backwards towards the tympanic cavity; this is the wall of the horizontal semicircular canal, which in some rare cases of destructive purulent affection of the middle ear is eroded and opened.

The parts so far enumerated are situated in the posterior and middle portions of the inner wall of the tympanic cavity. At the anterior portion the promontory becomes flatter, and at the same time narrower, as it is confined between the anterior wall, rising obliquely towards the ostium tympanicum, and the canal

for the tensor tympani. This muscular canal commences at the anterior portion of the temporal bone in the triangular segment, which is formed by the point of the pyramid and the anterior margin of the squamous portion. It lies (Fig. 25, *f*) above the osseous portion of the Eustachian tube, from which it is usually incompletely, but often completely, separated by a thin, osseous lamella. The canal in the tympanic cavity lies on the border between the interior and superior walls, and at the level of the middle portion of the Fallopian canal, in front of and above the fenestra ovalis, ending in a spoon-shaped process, which is pointed

FIG. 26.—MALLEUS.

a, Head; *b*, Neck; *c*, Handle; *d*, Long process; *e*, Articular surface.

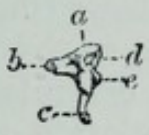

FIG. 27.—INCUS.

a, Body; *b*, Short process; *c*, Long process; *d*, Articular surface; *e*, Inferior toothed process.

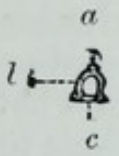

FIG. 28.—STAPES.

a, Head; *b*, Crus; *c*, Foot-plate.

outwards (*rostrum cochleare*), and above which the tendon of the tensor tympani passes across the tympanic cavity to the handle of the malleus (Fig. 29).

g. Ossicula.

Having described in the preceding part the walls enclosing the tympanic cavity, and their relations to the neighbouring organs, we must now consider more closely the ossicula, or small bones of the ear.

An exact knowledge of their position in the tympanic cavity, as well as of their relations to its various walls, is of great importance, because the functional disturbances that accompany the diseases of the tympanum are very often called forth by products of disease which interfere with the mobility, and thereby also with the power of vibration, of the ossicula.

The ossicula form an articulated chain, which extends from the membrana tympani (Fig. 29) through the tympanic cavity to the fenestra ovalis. They serve for the conduction of the waves of sound from the membrana tympani to the labyrinth. On the first of these, THE MALLEUS (Fig. 26), which is club-shaped, may be observed the oval head (*a*) with its articular surface directed backwards (*e*), the constricted neck (*b*), the pointed handle connected with the membrana tympani (*c*), the long process inserted into the Glaserian fissure (*d*), and the short process directed towards the external meatus (Fig. 29, *o*).* THE

* The longitudinal axis of the malleus is not straight, the head being bent to the handle at an obtuse angle. On the back of the rounded head there is an articular surface, bounded by a slight projection of bone, and extending in an oblique direc-

INCUS (Fig. 27), the body of which (*a*) resembles the crown of a molar tooth, has two processes, the short (*b*), which points backwards towards the entrance into the mastoid process, and the long (*c*), which, slightly bent in a direction almost parallel with the handle of the malleus, points downwards and backwards. On the long process (*c*) there is the processus lenticularis (*ossiculum lenticulare Sylvii*), which unites the long process of the incus to the capitulum of the stapes. The third ossiculum, THE STAPES (Fig. 28), shows many varieties of form. On its capitulum (*a*) a hollowed articular surface for the reception of the lenticular process will be seen. The foremost of its two crura is generally a little shorter than the other; the foot-plate (*c*) presents the same bean-shaped appearance as the fenestra ovalis.

Now, in what way are the ossicula applied to each other, and what is their topographical relation to the walls of the tympanic cavity? First, as regards the malleus; its handle (Fig. 26), as we have seen in the description of the membrana tympani, is surrounded by the fibres of that structure. Its short process (*a*) is turned outwards towards the lumen of the meatus, and is

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tion from above and outwards, inwards and downwards. This is formed by two oblique planes, of which the lower is described by Helmholtz as the 'cog' of the malleus.

The neck of the malleus extends on the inside to the broad rhomboidal surface of the handle. On the external surface of the neck a ledge, wound in spiral form, parallel with the edge of the 'cog,' will be seen, from which the strong check-band of the malleus extends to the outer wall of the tympanic cavity.

On the border between the neck and handle, and from the foremost angle of the interior rhomboidal surface of the bone, the long process of the malleus commences as a small, flattened, and slightly bent, flexible, osseous lamella, which lies in the Glaserian fissure, and is easily seen only in the new-born infant. In the adult this process has partially disappeared, and is replaced by a tight ligamentous band, extending from the Glaserian fissure to the malleus.

The handle of the malleus is an angular spicula of bone. The uppermost part develops outwards into a pointed tubercle of considerable size (short process of the malleus), on the extremity of which is visible, in the macerated preparation, a small rough depression, which is the position of the cartilaginous short process. From the short process the exterior edge of the handle, firmly connected with the membrana tympani, extends backwards and downwards, and merges into its spade-like termination. The internal edge of the handle is pointed towards the interior wall of the tympanic cavity, and is divided upwards into two crura, which form the lower half of the interior rhomboidal surface of the handle. Between the external and internal edges of the handle there are two surfaces elevated above the level of the membrana tympani, of which the one points forwards and inwards, and the other backwards and outwards. (On the proportions of size of the ossicula, compare Urbantschitsch, *A. f. O.*, vol. xi. p. 1.)

In the embryonic condition the malleus is cartilaginous, and not only in the new-born infant will the central part be found still unossified (Moos), but even in the adult cartilaginous cells will be observed (Prussak, *l.c.*). The greater part of the short process consists of hyaline cartilage, and is to be considered as the unossified remnant of the embryonic cartilaginous malleus. The assertion of Gruber, however, that the short process of the malleus has a cartilaginous covering, which is articulated with a corresponding cartilaginous surface on the membrana tympani, covered by an epithelium, has been proved to be erroneous by repeated observation; besides, Moos, Prussak (*l. c.*), and Brunner (*Beiträge zur Anat. u. Hystol. d. mittl. Ohres*, 1870) have satisfactorily proved, that there is neither a cartilage separated from the malleus, nor an articular connection between the membrana tympani and the handle.

visible in the living ear as a small white protuberance on the anterior superior pole of the membrana tympani. Its neck is lodged in that little pouch on the anterior superior margin of the tympanic ring (Fig. 14), already described, but contact of the malleus with the osseous edges of this notch does not take place. The head of the malleus (Fig. 29, *f*) is situated in the upper space of the tympanic cavity, its distance from the superior wall of which varies so considerably that, while in some cases the upper surface of the head nearly touches the wall of the tympanic cavity, in others the distance from the same amounts to above 1½ mm.* These variations are not without influence in the production of important structural alterations in the middle ear, which impair the functions of the organ of hearing. As experience shows that in consequence of adhesive processes in the tympanic cavity, the head of the malleus sometimes becomes anchylosed to the superior wall, it stands to reason that this union will take place sooner in those cases where the distance of the head of the malleus from the superior wall of the tympanic cavity is very small, and where, therefore, the diseased parts come more easily into contact.

The second link of the chain, the incus, is connected with the head of the malleus by a joint, which allows to both bones a considerable degree of mobility. The outer surface of its body is directed towards that part of the outer wall of the tympanic cavity which is above the posterior superior margin of the tympanic ring (*vide* Fig. 14, *c*). At this point it will sometimes be found that anchylosis has taken place with the outer surface of the body of the incus, in consequence of chronic inflammation of the lining membrane of the middle ear. Also the saddle-shaped notch on the posterior wall of the tympanic cavity, to which, as we have seen, the end of the short process of the incus is fastened in a movable manner by means of a little band, is sometimes the seat of an adhesive inflammation attacking the mucous covering of the tympanic cavity, by which means the short process of the incus becomes attached at that place to the bone. The long process of the incus may also form a close union with the posterior wall of the tympanic cavity, as can be seen from a preparation in my collection, in which the malleus and the stapes are perfectly movable.

The stapes, as the terminal member of the apparatus for the conduction of sound, is the most important formation in the tympanic cavity, because trifling alterations in its vicinity suffice to impede its mobility, and thereby to impair to a considerable degree its function. This bone is articulated by means of the processus lenticularis with the long process of the incus, and stands with its longitudinal axis almost perpendicular (Fig. 29)

* On the superior wall of the tympanic cavity a small osseous projection, pointed towards the head of the malleus, will very often be found.

to the longitudinal axis of the malleus and the incus, while its two crura lie in a plane in such a manner that in a front view of the tympanic cavity the anterior crus of the stapes alone can be seen.

The relation of the stapes to the fenestra ovalis is of considerable importance in connection with the occurrence of pathological alterations, which impede its mobility. For the fenestra ovalis lies at the end of a grooved depression, like a short canal, in the interior wall of the tympanic cavity (Fig. 29), so that the crura of the stapes are hardly $\frac{1}{4}$-$\frac{1}{8}$ mm. distant from the walls of this depression. Now in this small space adhesions between the crura of the stapes and the canal leading to the fenestra ovalis

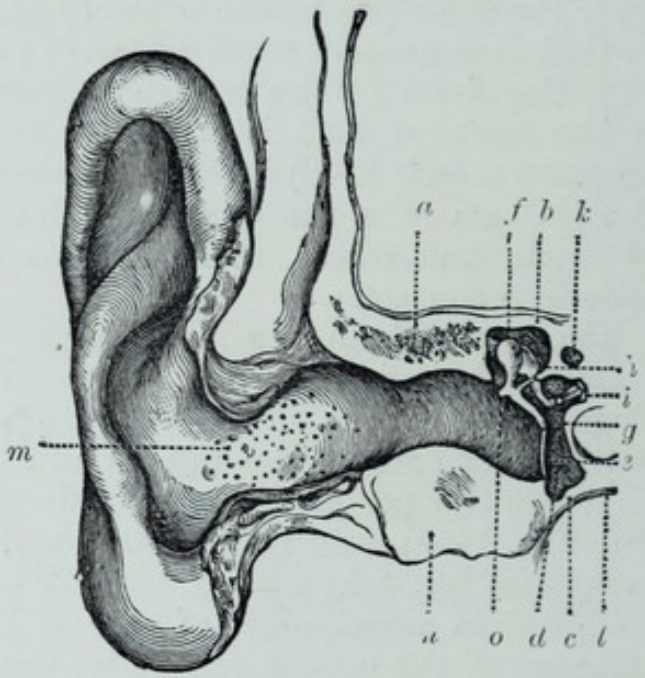

FIG. 29.—VERTICAL SECTION OF THE EXTERNAL MEATUS, MEMBRANA TYMPANI, AND TYMPANIC CAVITY.

a, Cellular spaces in the superior wall of the meatus connected with the middle ear; *b*, Roof of the tympanic cavity; *c*, Inferior wall; *d*, Tympanic cavity; *e*, Membrana tympani; *f*, Head of the malleus; *g*, Handle of the malleus; *h*, Incus; *i*, Stapes; *k*, Fallopian canal; *l*, Fossa jugularis; *m*, Apertures of glands in the external meatus. (Right ear.)

often take place, which firmly fix the stapes, and deprive it of its power of vibration. According to my observations, anchylosis of the stapes is favoured by a congenital narrowness of the niche of the fenestra ovalis.

h. Articulation of the Ossicula.

The union of the ossicula takes place by means of articulations which connect them movably together. The articulations of the ossicula are as follows:

1. *Articulation of Malleus and Incus.*—On the posterior surface of the head of the malleus there is an oblong, articular surface, which extends in spiral form from above downwards and

inwards to the boundary of the neck. It consists of two surfaces, which meet in an almost vertical edge. Corresponding with this, the incus possesses an articular surface, composed of two parts; its superior portion (Fig. 27, *d*) is directed inwards, its inferior (*e*) outwards. These articular surfaces are covered by a thin layer of hyaline cartilage. The articulation of the two ossicula is effected by a capsular ligament, which is fastened to the somewhat depressed margins of the articular surfaces, and permits of considerable mobility of the bones. From the inner wall of the capsule a fold, first described by Pappenheim (*Specielle Gewebelehre des Gehörorgans*, 1840), and recently confirmed by Rüdinger, projects in the form of a wedge-shaped meniscus* into the cavity of the joint (Fig. 30).

The mechanism of the articulation of the malleus and incus is compared by Helmholtz to the check-contrivance inside the key

FIG. 30.—SECTION OF THE ARTICULATION OF MALLEUS AND INCUS.

a, Malleus; *b*, Incus; *c*, Capsular ligament with the wedge-shaped meniscus. (Prepared with hyper-osmic acid.)

usually supplied with Geneva watches. With the motion of the handle of the malleus inwards, the inferior 'cog' of the malleus (Fig. 26, *e*) catches the inferior cog of the incus (Fig. 27, *e*), causing the long process of the incus to follow the motion of the handle of the malleus inwards. On the other hand, with the motion of the handle of the malleus outwards, a strong movement of the articular surfaces will follow, the inferior cog of the malleus will recede from that of the incus, the incus will therefore follow only to a slight degree the motion of the malleus outwards.

2. *Articulation of Incus and Stapes.*—This joint is formed by the convex, globular surface of the processus lenticularis of the long process of the incus, and by the correspondingly concave articular surface of the capitulum of the stapes. The mode of union of the articular surfaces, which are covered with hyaline cartilage, does not admit of much separation of the bones from

* I obtained this wedge-shaped meniscus best in sections of the bones, which had first been placed in hyper-osmic acid, and had afterwards been decalcified by muriatic acid.

each other, but allows them to move sideways to a greater extent. The capsular ligament, which unites the articular extremities, is composed of numerous elastic fibres. According to Eisell (*A. f. O.*, vol. v.), the connection of the incus with the stapes is to be considered as a real joint provided with a cavity, while Brunner declares the articulation to be a synchondrosis.

3. *Stapedio-vestibular Articulation.*—The joint between the stapes and the margin of the fenestra ovalis has recently been examined microscopically by Eisell (*A. f. O.*, vol. v.), Dr. Buck, (*A. f. O. u. A.*, vol. i.), and Brunner. These examinations have shown that the tissue connecting the margin of the fenestra ovalis with the margin of the foot-plate of the stapes, consists of elastic fibres, which extend in a radiating direction, converging towards the margin of the foot-plate. This ligament, not equally broad at all parts, is composed of a layer of periosteum of the osseous portion bordering the fenestra ovalis, and takes upon

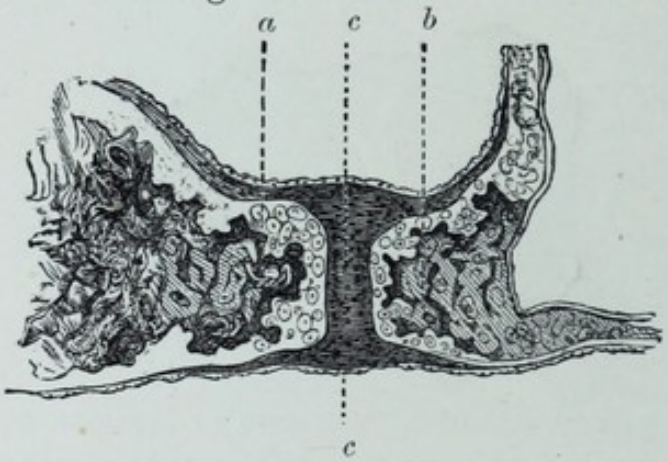

FIG. 31.—SECTION OF THE STAPEDIO-VESTIBULAR ARTICULATION.

a, Margin of the fenestra ovalis covered with a cartilaginous layer; *b*, Margin of the foot-plate of the stapes covered with a cartilaginous layer; *c*, *c*, Section of the ligament. orbic. stapedis.

itself the functions of the periosteum from the place where the foot-plate of the stapes is situated. According to Rüdinger, the fibrous tissue extending from the fenestra ovalis to the foot-plate of the stapes, contains small, irregular spaces filled with liquid. From numerous sections made by me, I cannot confirm this statement. As Toynbee and Magnus have already proved, the margin of the foot-plate of the stapes, as well as that of the fenestra ovalis, are covered with a thin layer of cartilaginous tissue, which, according to Eisell, lines the vestibular surface of the stapes, and encloses in the shape of a heel the margin of the foot-plate, while Voltolini denies the presence of cartilaginous elements on the stapedio-vestibular articulation.

i. Ligaments of the Ossicula.

Besides the above-described capsular ligaments, which connect the articular extremities of the ossicula, there are also to be

enumerated some ligamentous ties between the walls of the tympanic cavity and the ossicula, which hold the latter in their position, and act as check-bands in case of too great excursion of these bones. 1. The *superior ligament of the malleus*, a rounded band, which extends from the superior exterior wall of the tympanic cavity to the head of the malleus; it prevents the handle of the malleus from being turned too much outwards. 2. The *anterior ligament of the malleus*, which, according to Henle, passes from the spina angularis of the sphenoid bone through the fissure of Glaser to the head of the malleus. According to Helmholtz it is a short and very broad fibrous ligament, which, encircling the stump of the long process of the malleus, is inserted into the parts of the head and neck of the malleus, which are directed forwards. Dr. Verga describes a ligamentum malleomaxillare, which extends from the malleus through the Glaserian fissure to the lower jaw. 3. *External ligament of the malleus* (Helmholtz). This forms, according to Prussak, the superior boundary of the so-called superior pouch of the membrana tympani, and is stretched out between the crista capitis mallei and the exterior wall of the tympanic cavity. It is also useful in preventing the handle of the malleus from being turned too much outwards. Helmholtz calls the posterior strands of this ligament the posterior ligaments of the malleus. A line passing through the latter, if prolonged through the malleus, would intersect the middle fibrous prolongations of the anterior ligament, and as the axis on which the malleus turns passes through these two fibrous prolongations, Helmholtz calls them the ligaments of the axis of the malleus. 4. *Posterior ligament of the incus.* The short process of the incus, covered with a thin layer of fibrous cartilage, leans on the saddle-shaped depression of the posterior wall of the tympanic cavity, at the entrance of the mastoid process. Of the fibrous prolongations, which connect the short process with the osseous wall, the fibrous bundle extending between the short process and the exterior wall of the fissure is especially strongly developed. This union, called the incu-tympanic articulation, is, according to Henle, an amphiarthrosis.

In the ligamentous apparatus, extending from the external wall of the tympanic cavity to the malleus, I found a system of cavities (*Wien. med. Wochenschrift*, No. 16, 1870), the disposition of which is rendered plain by the annexed drawing (Fig 32). It is taken from the section of the membrana tympani of an infant. We see towards the inside of the intersected osseous parts the malleus with its head (*a*), its slighter neck, and the short process (*h*) projecting strongly outwards. Opposite the head of the malleus appears the section of the superior portion of the exterior wall of the tympanic cavity, the rounded point of which (*e*) represents the grooveless margo tympanicus.

From the inferior surface of this osseous margin, and therefore from the superior wall of the meatus, we see its covering merge into the membrana flaccida (*g*), which extends downwards to the short process (*h*) and the handle of the malleus. From the middle of the interior surface of the membr. flacc. (near *g*) a membranous fold branches off, which extends with a semicircular curvature towards the neck of the malleus. Thus a considerable hollow space (*c*) above the short process is formed.

Above this space exists a system of cavities (*f*), bounded on the outside by the superior part of the membr. flacc., above by a membrane which extends downwards and inwards to the neck of the malleus as a continuation of the lining membrane of the exterior wall of the tympanic cavity. The osseous margin of the Rivinian segment projects into the system of cavities. This is composed of large and small cavities, with a rounded or oval margin, which are lined with an epithelium, in the same manner as the larger cavity (*c*) above the short process. The contents of the smaller cavities very often consist of a yellowish, transparent, lymph-like fluid. Their number is very variable, and, especially in preparations from adults, I found only very few of them; in some of them they were wanting altogether. Near *d*, *d*, folds of the lining membrane will be seen, which do not regularly occur; they extend from the external wall of the tympanic cavity to the head of the malleus; higher up the regular superior ligament of the malleus will be noticed.

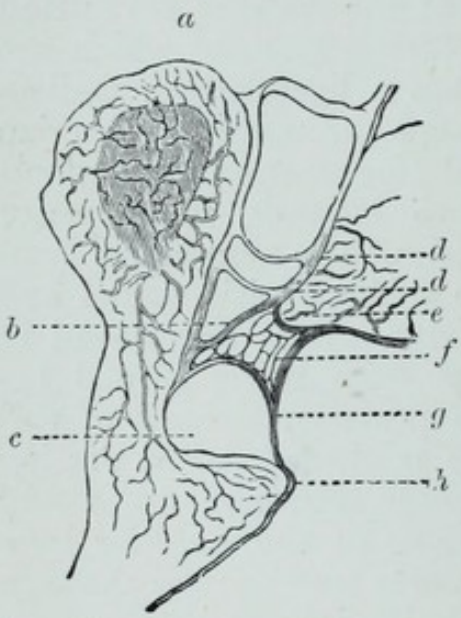

FIG. 32.—SYSTEM OF CAVITIES BETWEEN THE MEMBRANA TYMPANI AND THE NECK OF THE MALLEUS.

k. Intra-tympanic Muscles.

Two muscles have been mentioned above, which, lying in osseous canals, have their tendons inserted into the ossicular chain. They are the *musculus tensor tympani* and the *musculus stapedius*.

The tensor tympani arises in front of the anterior orifice of the *canalis pro tens. tymp.* on the osseous wall of the pyramid adjacent to the carotid canal, and from the cartilaginous Eustachian tube. The rounded tendon of this penniform muscle leaves the canal at the rostrum cochleare, extends in a direction almost at right angles to the belly of the muscle across the tympanic cavity (Fig. 33), and is inserted on the inner margin of the

handle of the malleus, at the anterior edge of the rhomboidal surface, in an oblique direction to the longitudinal axis of the malleus.

According to Helmholtz, the short fibres lying in the muscular canal arise from the periosteum of the superior surface of the canal; the tendon, which can be traced far into the canal, lies on the inferior side of the muscle, and its free surface is turned towards the smooth periosteum. The sheath of the tendon, covered by mucous membrane, described by Toynbee as the tensor ligament, is considered by Helmholtz as the continuation of the periosteum lining the canal. Henle found this sheath connected with the tendon by considerable prolongations of connective tissue. Sometimes, but by no means constantly, the anterior portion of the tensor tympani is connected with the tensor veli palatini, either immediately or by tendinous tissue (v. Tröltsch, L. Meyer, Urbantschitsch).

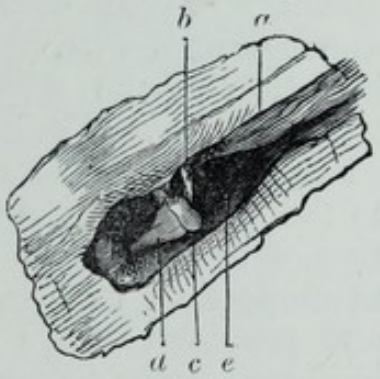

FIG. 33.—MUSCULUS TENSOR TYMPANI.

a, Tensor tympani; *b*, Tendon of the muscle; *c*, Head of the malleus; *d*, Body of the incus; *e*, Ostium tymp. tubæ.

The stapedius muscle has its origin in the eminentia pyramidalis (Fig. 25, *d*), situated on the posterior wall of the tympanic cavity (*c*). This muscle appears in longitudinal sections generally pyriform, in transverse sections generally trilateral or prismatic, and with rounded angles. The bundles, arising from the muscular sheath, extend from the floor and the lateral walls of the cavity upwards and towards the middle of the muscle, and merge into the tendon of the stapedius, the tissue of which can often be traced beyond the middle of the muscle. This thin tendon passes through the aperture situated at the point of the eminentia pyramidalis, and is inserted into a point between the capitulum and the posterior axis of the stapes.

The examinations which I have made with reference to the relation of the stapedius to the facial nerve,* have resulted as follows. In the new-born infant there is found an immediate communication between the inferior portion of the muscular cavity and the facial canal; in adults either one or more oblong fissures between the eminentia stapedii and the canalis facialis will be found, where the fibrous coverings of connective tissue of the muscle and the nerve come into contact and amalgamate. The nerve of the stapedius passes either through one of these fissures, or through a separate small aperture, on its way from the facial nerve to the muscle.

My own experiments regarding the innervation of the intra-tympanic muscles of the ear.—Since the discovery of the otic ganglion by Arnold, the branch extending from this ganglion to

* *A. f. O.*, vol. ix.

the tensor tympani has also been known. It being a disputed point whether its motor-elements belong to the facial (Longet) or to the trigeminus (Luschka),* I was led, on account of its being impossible to find the origin of the fibres by dissection, to execute a number of experiments in the laboratory of Prof. Ludwig, which I will briefly sum up here for those to whom the *Academy Reports*† are less known.

The head of a dog, which had just been killed, was quickly severed from the body, and after entering the osseous cavity on the inferior surface of the head, the cavum tympani was opened. Then the brain was removed from the opened cranium, and the stumps of the trigeminus, facial, glosso-pharyngeal, vagus and spinal accessory nerves were isolated, and one after the other were irritated with the electrodes of Neef's battery. With every irritation of the trigeminus, a motion of the malleus in the tympanic cavity was apparent, which became specially evident when the membrana tympani was separated from its attachments to the periphery. A second experiment, by which the contraction of the tensor tympani was proved, was made by inserting a manometrical tube into the external meatus, fitted in air-tight, and provided with a small drop of coloured fluid. With every irritation of the trigeminus, the drop in the tube was drawn inside the meatus. By irritating the other nervous stems in the cranial cavity, no motion of the drop of fluid inwards was perceptible.

These experiments show that the tensor tympani is supplied by the motor portion of the fifth nerve.‡

As regards the nerve supply of the stapedius, it is well known that it receives a small branch from the facial. As, however, the small twig branches off at the angle after the anastomosis of the facial with the nerv. petrosus superficialis major et minor, coming from the trigeminus, it was doubtful whether the motor fibres of the stapedius came from the trigeminus or from the facial. The experiments, which I executed as above, showed that with the irritation of the facial stem alone in the cranial cavity, a motion of the stapes backwards followed, while with the irritation of other nervous stems, the capitulum of the stapes remained unmoved.

* *Ueber die willkürliche Bewegung des Trommelfells. Archiv für physiologische Heilkunde*, 1850, vol. ix. pp. 80-85. Luschka is of opinion that the small branch extending from the n. pterygoid. int. to the muscle, is the cause of the spontaneous motion, the small twig from the ganglion oticum of the involuntary motion.

† Report of session of the Vienna Academy, 14th March, 1861.

‡ In vol. lxv. of Virchow's *Archiv*, Voltolini has made the assertion, that the tensor tympani is supplied by the trigeminus as well as by the facial. In vol. lxviii. of the same *Archiv*, I have, however, proved by Voltolini's own experiments, that by not observing the rudiments of experimental physiology, he was compelled to arrive at a wrong conclusion. For he made use, as he specially points out, not of weak electric currents—the application of which he designates as the origin of the mistake in my experiments—but only of strong currents, during the application of which he doubtlessly observed in ten out of twenty-five experiments contractions of the tensor on the irritation of the facial, through the production of disturbing currents.

This experiment shows that the central fibres of the stapedius are under the control of the facial nerve.

l. Lining Membrane of the Tympanic Cavity.

The lining membrane of the tympanic cavity in the adult appears as a thin transparent pellicle, which in some parts is connected closely with the osseous walls, in others is more easily detached from them. The epithelium of the lining membrane in

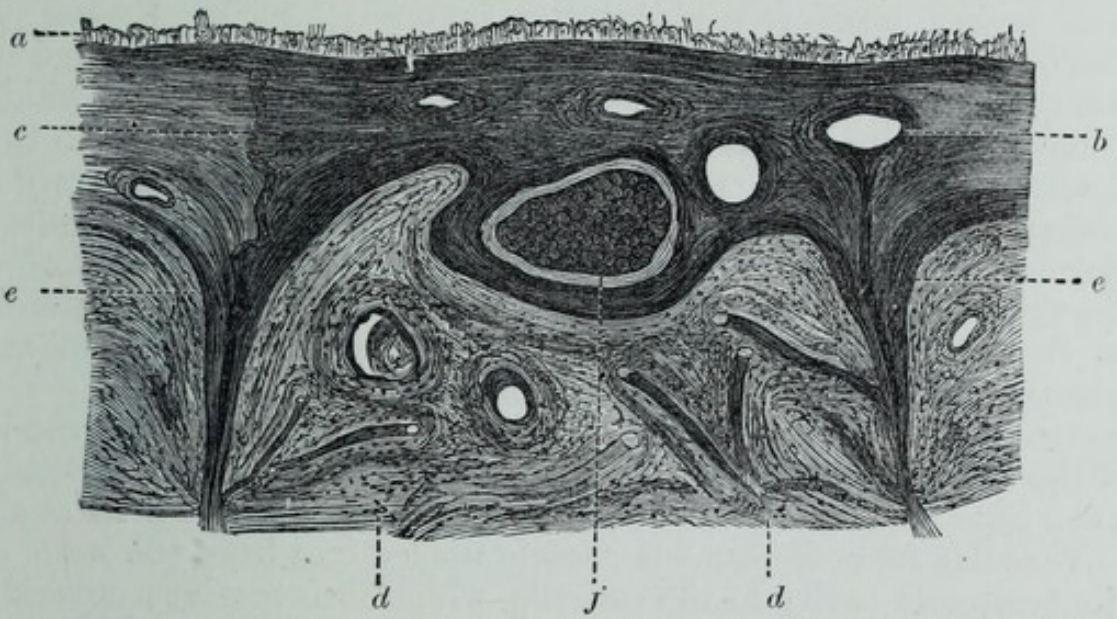

FIG. 34.—SECTION OF THE LINING MEMBRANE OF THE ANTERIOR WALL OF THE TYMPANIC CAVITY.

(Decalcified and prepared with osmic acid.)

a, Epithelium ; *b*, Section of a bloodvessel in the stratum of connective tissue, from which a branch penetrates into the funnel-shaped depressions of the bone ; *c*, Bloodvessel on the surface, penetrating into the bone ; *d*, *d*, Osseous wall ; *e*,*e*, Funnel-shaped depressions in the bone, into which the stratum of connective tissue of the lining membrane penetrates ; *f*, Section of a large, nervous stem in the stratum of connective tissue of the lining membrane.

the inferior portion of the tympanic cavity is ciliated and cylindrical, but in passing upwards it gradually changes into the ciliated pavement variety. According to Kessel (*l. c.*), the cells of the epithelium are connected with the tissue of the lining membrane by processes.

According to Prussak (*l. c.*), the stratum of connective tissue of the lining membrane of the tympanic cavity (Fig. 34), in which the bloodvessels, lymphatic vessels, and nerves ramify, is composed of two layers, of which the inferior must be considered as the periosteum of the osseous wall. At certain places, especially at the ridgy inferior and anterior wall, I found (*A. f. O.*, vol. v.), in the upper layer of the connective-tissue stratum, networks of fibres similar to the framework of the membrana tympani ; therefore, to regard it as peculiar to the membrana tympani is inadmissible. According to Kessel (*l. c.*), who says that he has traced this framework everywhere on the lining

membrane of the tympanic cavity, it forms the round or oval orifices of channels through which blood and lymphatic vessels pass in and out.

The question whether the lining membrane of the tympanic cavity is a mucous or a serous membrane has up to this time been a matter of controversy. I believe that there can be no doubt that it is to be considered as a mucous membrane. For not only is it known to be an immediate continuation of the mucous membrane of the pharynx and of the Eustachian tube, but also it has been proved by the investigations of Krause, v. Tröltsch (*l. c.*) and Wendt, that mucous glands are to be found in the tympanic cavity. In a considerable number of the ears which I have examined, there were glandular elements only in the anterior part of the tympanic cavity. Neither in horizontal preparations, nor in vertical sections, did I succeed in finding glands either on the promontory or on the covering of the roof of the tympanum, or on its posterior part. The presence of glands in the anterior portion of this cavity is, however, by no means constant, and their number varies very much. In only a few instances did I find them in great numbers in the neighbourhood of the tympanic orifice of the Eustachian tube, but most commonly a few isolated glands only are to be seen, and sometimes none at all.

Vascular folds of mucous membrane extend from the walls of the tympanic cavity to the ossicula, which thus receive a covering from the lining membrane of that cavity. These folds are the means of connecting the vessels in the coverings of the ossicula and those in the walls of the cavity. The most prominent of these folds are the following: a membrane extending from the superior exterior wall to the head of the malleus and to the superior margin of the body of the incus, also a fold (not constant) passing from the incus to the inner wall of the tympanic cavity (v. Tröltsch, Urbantschitsch), and lastly the fold of the stapes, which between the crura of the stapes (lig. obturat. stapedis) is spread over the posterior crus and the tendon of the stapedius.

Besides the above-named folds of mucous membrane, I found in the tympanic cavity a number of inconstant prolongations of connective tissue, which have formerly been considered as pathological products, but which I was the first to prove to be (*Beleuchtungsbilder des Trommelfells*, 1865) a residuum of the gelatinous connective tissue which fills the middle ear in the fœtal state. Upon these connective tissue structures I discovered with the microscope peculiar formations, previously unknown. These formations (Fig. 35) are usually oval, sometimes a little constricted in one or more places (*c*), pyriform, and in rarer cases triangular; occasionally both these shapes are combined in one specimen. These small bodies are covered with epithelium, and have, superficially as well as in section, a fibrous

structure, arranged in layers parallel with the exterior outline. Between the layers, spindle-shaped bodies are to be seen.

A fibrous stalk (*a*) of varying size arises with a broad base from the membranous surface below, enters into the rounded extremity of this body, and traversing it, issues at the other extremity and is inserted into a membrane or into the osseous wall opposite. Sometimes one stalk traverses several of these bodies, or is divided into two stalks when issuing. The size of these bodies varies between 0·1-0·9 mm. and upwards.* These bodies, which are considered by Wendt, Krause, and myself, as formations of connective tissue, I found mostly in the posterior portion of the tympanic cavity, in the antrum mastoideum, also in the upper tympanic space, and once on the membrana tympani.

The lining membrane of the tympanum in the new-born infant is remarkable for an abundance of vessels, as also for great tumefaction of the tissue (Brunner). In places which are perfectly smooth in the adult, for instance on the promontory, are often found densely packed papillæ of the same structure as those described as occurring on the membrana tympani (p. 26).

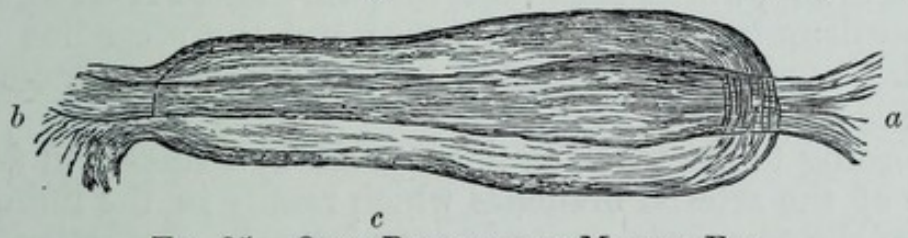

FIG. 35.—OVAL BODY IN THE MIDDLE EAR.

a, Entrance of the stalk; *b*, Exit of the stalk; *c*, Constricted part of the body.

The great swelling and vascularity are connected with the evolutional processes which take place in the middle ear in the fœtal state and after birth. For the fœtal tympanic cavity is filled with a gelatinous mass, which on microscopic examination presents the characters of undeveloped connective tissue, spindle-shaped cells in a structureless, gelatinous, fundamental substance. This tissue, designated by v. Tröltsch as a proliferation of the mucous lining of the wall of the labyrinth, often displays, even before birth, the appearance of incipient decay, fatty degeneration having already commenced in the epithelium of the lining membrane of the middle ear and in this gelatinous tissue. After birth a rapid degeneration of the gelatinous substance into a yellowish-green, thickish fluid is caused by the entrance of air

* The existence of these formations, which I was the first to describe (*Wiener med. Wochenschrift*, Nov. 20, 1869), was confirmed six weeks later by Kessel (*Centralblatt f. d. med. Wissensch*, 1869). The pedunculated bodies, observed by v. Tröltsch (Virchow's *Archiv*, vol. xvii.) in the ear of a woman, seventy-one years of age, who had suffered from deafness for many years, are hardly to be considered as identical with those described by me, as the formations seen by v. Tröltsch consisted of bladders containing a thickish fluid, like pedunculated cysts. The peduncle, moreover, did not traverse his formations, while the passage of the stalk through the body was a characteristic feature in those observed by me.

into the tympanic cavity. This fluid contains fat and pus corpuscles. As the investigations of v. Tröltsch and Wreden have shown, in the great majority of new-born infants there is found in the tympanic cavity a pus-like substance, which is reabsorbed in a few weeks after birth by the highly vascular mucous membrane.

m. Vessels and Nerves of the Tympanic Cavity.

The arteries which supply the lining membrane and the structures in the tympanic cavity spring from various vessels. The anterior and middle portions of the tympanic cavity are supplied (1) by the branches of the ascending pharyngeal artery (from the external carotid), (2) by branches of the middle meningeal artery, which penetrate through the *hiatus canalis Fallopiæ* and the fissura petroso-squamosa into the tympanic cavity, and (3) by the internal carotid, which sends a few small branches through minute vascular orifices of the carotid canal in the petrous bone into the tympanic cavity. The stylo-mastoid artery, which penetrates into the Fallopian canal, supplies the neurilemma of the facial nerve and the stapedius muscle, and also sends small branches to the lining membrane of the tympanic cavity.

According to the investigations made by Prussak on dogs, the calibre of the arterial branches which ramify in the lining membrane of the tympanic cavity is very large in proportion to that of the trunk from which they arise, and the arteries often pass into the veins without the intervention of capillaries. The veins of the lining membrane are very tortuous, and show here and there considerable pouch-like dilatations of their lumen.

The relation of the bloodvessels of the mucous membrane to the osseous walls of the tympanic cavity is only hinted at in the work of Prussak, previously quoted. He says that fibres extend from the deeper periosteal layer of the mucous membrane to the tunica adventitia of the osseous vessels. I undertook lately a series of anatomical examinations,* which led to the result that vascular connections are kept up between the middle ear and the labyrinth through the osseous wall separating them.

In microscopic sections of the wall of the labyrinth, prepared with osmic acid and decalcified, the bloodvessels of the middle ear can be seen proceeding from the deeper layers of the lining membrane, accompanied by numerous prolongations of connective tissue, penetrating almost perpendicularly into the osseous substance. The bloodvessels of the middle ear enter into the funnel-shaped mouths of the canals of the osseous wall. The prolongations of connective tissue (Fig. 34) appear at their origin

* *Ueber Anastomosen zwischen den Gefässbezirken des Mittelohrs und des Labyrinths*, *A. f. O.*, vol. xi.

mostly of a broad triangular shape, and as they rapidly get narrower, extend either in a straight line or winding a little, to the bottom of the osseous wall, where they form a connection with other prolongations of connective tissue. I have observed that not only the bloodvessels of the deeper layer, but also those of the superficial layers of the mucous membrane, enter the osseous wall (Fig. 35). If the inner wall of the tympanic cavity, prepared with osmic acid, is closely scrutinized, even with the naked eye small black dots will frequently be found, either single or in greater numbers, between the ramifications of the nerves and the vessels, which on closer examination appear as the culminating points of a number of vessels, of which several enter deep into the bone. The vessels of the osseous wall, then, form a connection on the one hand with the bloodvessels of the lining membrane of the middle ear, on the other with the vessels of that of the labyrinth.

This relation of the lining membrane of the tympanic cavity and its bloodvessels to the osseous wall is frequently of considerable importance in regard to the pathological condition of the middle ear. At different times I have proved, in cases of chronic suppuration in the middle ear, that inflammatory processes similar to those present in the mucous membrane were to be found in the prolongations of connective tissue entering the osseous wall; and it is probable that if these inflammatory processes attain a high degree, they may cause disturbances of nutrition in the bone, which may lead to caries. From pathological and clinical observations, there can be no doubt but that hyperæmia and congestion of the vessels of the middle ear, accompanied with inflammation, owing to these anastomoses, sometimes extends to the vascular regions of the labyrinth, causing there temporary or permanent disturbances of nutrition.

According to the investigations of Kessel, the lymphatic vessels of the mucous membrane of the tympanic cavity are arranged similarly to those on the membrana tympani. He regards the spaces, which are enclosed by the fibrous framework already referred to, as lymph-sacs, similar to those of the frog.

Besides the sensory fibres of the trigeminus, the sympathetic and the glosso-pharyngeal nerves take part in the supply of the lining membrane of the middle ear. Of these three, the branch of the latter nerve to the tympanic cavity is the one most highly developed. From the jugular fossa it enters the tympanic cavity through an orifice in the inferior wall, and extends upwards in the groove on the promontory to unite with the nerv. petros. superf. minor. In this, called Jacobson's nerve, Pappenheim, Kölliker, and Krause (*Zeitschrift f. rat. Medicin*, 1866, p. 92) have traced ganglion cells inserted at intervals. W. Krause found a moderately large branch passing from the tympanic

plexus to the cartilaginous Eustachian tube; and I saw several times such a branch pass directly from Jacobson's nerve.*

The sympathetic nerves of the lining membrane of the middle ear spring from the sympathetic plexus, which accompanies the carotid artery in its canal. By means of orifices in the canal several small branches of this plexus enter the tympanic cavity as nervi carotico-tymp., to form in its anterior portion, together with the ramifications of Jacobson's nerve and the n. petros. superf. minor, the plexus tympanicus. From this proceed the finer nerves for the whole lining membrane of the middle ear. These can be seen to best advantage under the microscope by preparing the lining membrane, after detaching it from the bone, with gold chloride or osmic acid. The elements can be seen in such preparations sharply defined as strong nervous bundles, consisting of a number of fibres, and spreading either by themselves or along a bloodvessel. On the promontory, especially near the fenestra ovalis, clusters of ganglion cells are inserted in these nervous bundles. Besides the latter, a delicately ramifying network of nerve-fibres is seen, which spreads partly above and partly below the vessels, and forms ganglionic swellings at places where several fibres meet. I saw these relations very clearly on the mucous membrane of the Eustachian tube, prepared with chloride of gold. The important influence exerted by the sympathetic nerves upon the vessels of the tympanic cavity is shown by Prussak's (*l. c.*) experiments on dogs. The tympanum was opened, and while the portion of the sympathetic in the neck was galvanized, the vessels of the promontory and of the membrana tympani were examined by a magnifying glass. Shortly after the commencement of the irritation, the vessels became smaller, diminishing so as to be almost invisible; when the irritation ceased, a considerable expansion of the vessels took place.

n. Topographical Relation of the Membrana Tympani to the Interior Wall of the Tympanic Cavity.

The knowledge of the topographical relation of the membrana tympani to the interior wall of the tympanic cavity is of great importance to the practitioner for the proper understanding of pathological alterations in the different portions of the tympanic cavity, as well on account of operations in that cavity and on the membrana tympani. It is especially important to know the distance of the different portions of the membrane from the interior and opposite wall of the cavity, so as to avoid injuring either it or the articulation of the stapes and incus, in case of paracentesis or of excision of a portion of the membrane. If a

* Compare Bischoff, jun., *Mikroskopische Analyse der Anastomosen der Kopfnerven*, München, 1865.

number of ears be examined, considerable differences in the dimensions of the transverse diameters of the tympanic cavity will be observed. The clearest conception of the position of the membrana tympani with regard to the inner wall of the tympanic cavity will be obtained from vertical and horizontal sections of the cavity, as they are represented in the annexed drawings (Figs. 36 and 37).

The part of the membrana tympani nearest to the inner wall of the tympanum is the umbilical depression which corresponds with the inferior extremity of the handle of the malleus

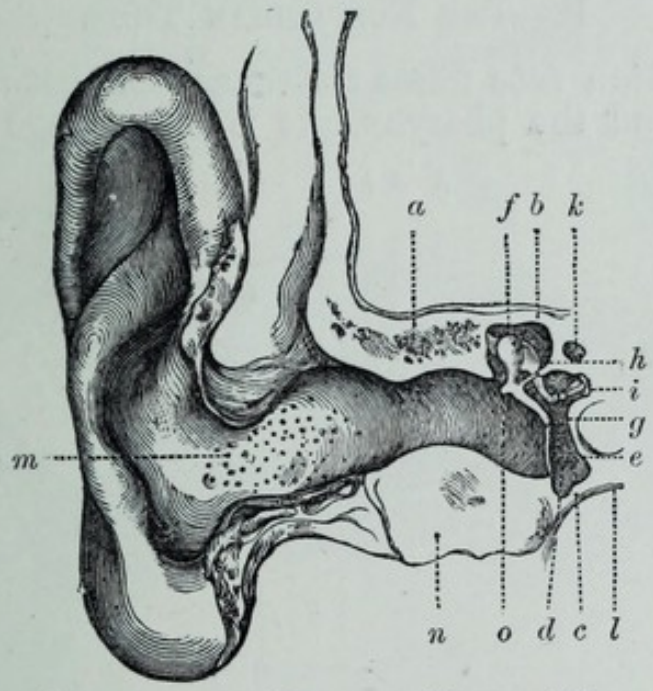

FIG. 36.—VERTICAL SECTION OF THE EXTERNAL MEATUS, MEMBRANA TYMPANI, AND TYMPANIC CAVITY.

a, Cellular spaces in the superior wall of the meatus, connected with the middle ear; *b*, Roof of the tympanic cavity; *c*, Inferior wall; *d*, Tympanic cavity; *e*, Membrana tympani; *f*, Head of the malleus; *g*, Handle of the malleus; *h*, Incus; *i*, Stapes; *k*, Canalis Fallopiæ; *l*, Fossa jugularis; *m*, Glandular orifices in the external meatus. (Right Ear.)

(Fig. 36). The distance of the membrane from the promontory amounts here on an average to 2 mm., and it is this part which often becomes adherent to the interior wall of the tympanic cavity. Below this place, at a distance of 1-1½ mm., is that part of the promontory which curves most strongly outwards. The distance from this point to the membrana tympani is 2½ mm. and more. The space between the posterior portion of the membrane and the interior wall varies, according to Schwartze, between 2½ and 4 mm. The posterior superior quadrant of the membrane has important relations with the incus and the stapes. The long process of the incus is distant from the membrane 1½-2 mm., the capitulum of the stapes 2½-3 mm. The inferior portion of the long process of the former, and the posterior crus of the latter ossiculum will therefore be visible when the mem-

brane is very transparent, and will be exposed to view behind the handle of the malleus, when the posterior portion of the membrane is destroyed. This portion of the membrane will also frequently come into contact with the above-named parts of the ossicula, or anchylose with them, when the membrana tympani approaches the interior wall of the tympanic cavity, in consequence of atrophy or cicatricial formation. These anatomical relations will also have to be borne in mind, in case of operations on the posterior superior segment of the membrane, so as to avoid injury to the articulation of the incus and the stapes.

B.—The Eustachian Tube.

The *Eustachian tube* forms the connection between the tympanic cavity and the pharynx. It is the passage by which an

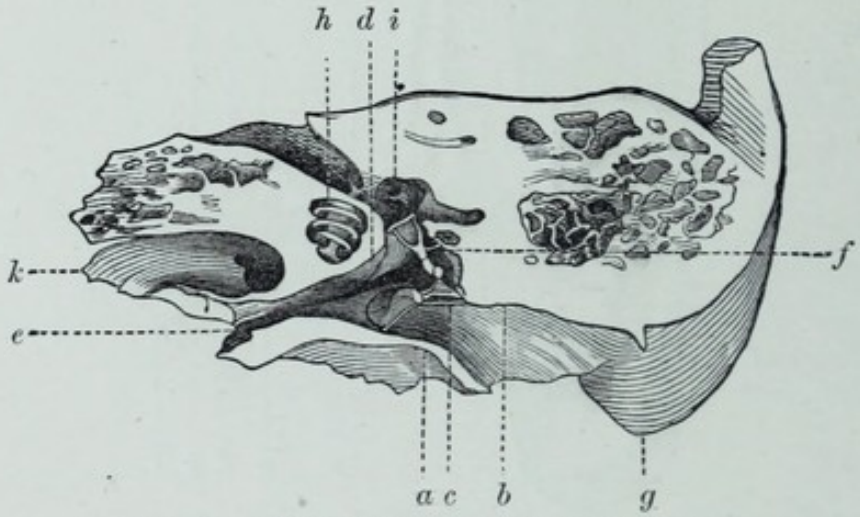

Fig. 37.—Horizontal Section of the Ear.

a, Anterior wall of the osseous meatus; *b*, Its posterior wall; *c*, Section of the membrana tympani, of the handle of the malleus, and of the posterior pouch; *d*, Promontory; *e*, Ostium tymp. tubæ; *f*, Stapes in connection with the inferior extremity of the long process of the incus and of the tendon of the stapedius; *g*, Mastoid process; *h*, Cochlea; *i*, Vestibule; *k*, Carotid canal.

exchange of air takes place between the external atmosphere and the tympanic cavity. This canal is of great importance functionally, the diseases which interfere with its permeability causing more or less considerable derangement in the hearing by producing abnormal tension in the tympanic cavity. From a practical aspect, the Eustachian tube is of quite as great importance, for, in cases of disease of the middle ear, it affords us not only a means of investigating the pathological state of that part, but also a channel for the introduction of remedies.

The Eustachian tube consists of an osseous and a cartilaginous portion. Its position is oblique, having, according to Henle, a direction almost exactly diagonal between the horizontal and the vertical, the axis of the tube forming an angle of 135° with the horizontal axis of the meatus, and one of 40° with the horizon.

The length of the whole canal can only be determined approximately, because the commencement of its osseous portion in the tympanic cavity is not sharply defined; it amounts generally to 34-36 mm., of which the cartilaginous portion forms two-thirds. The narrowest part, the *Isthmus tubæ*, which is situated in the

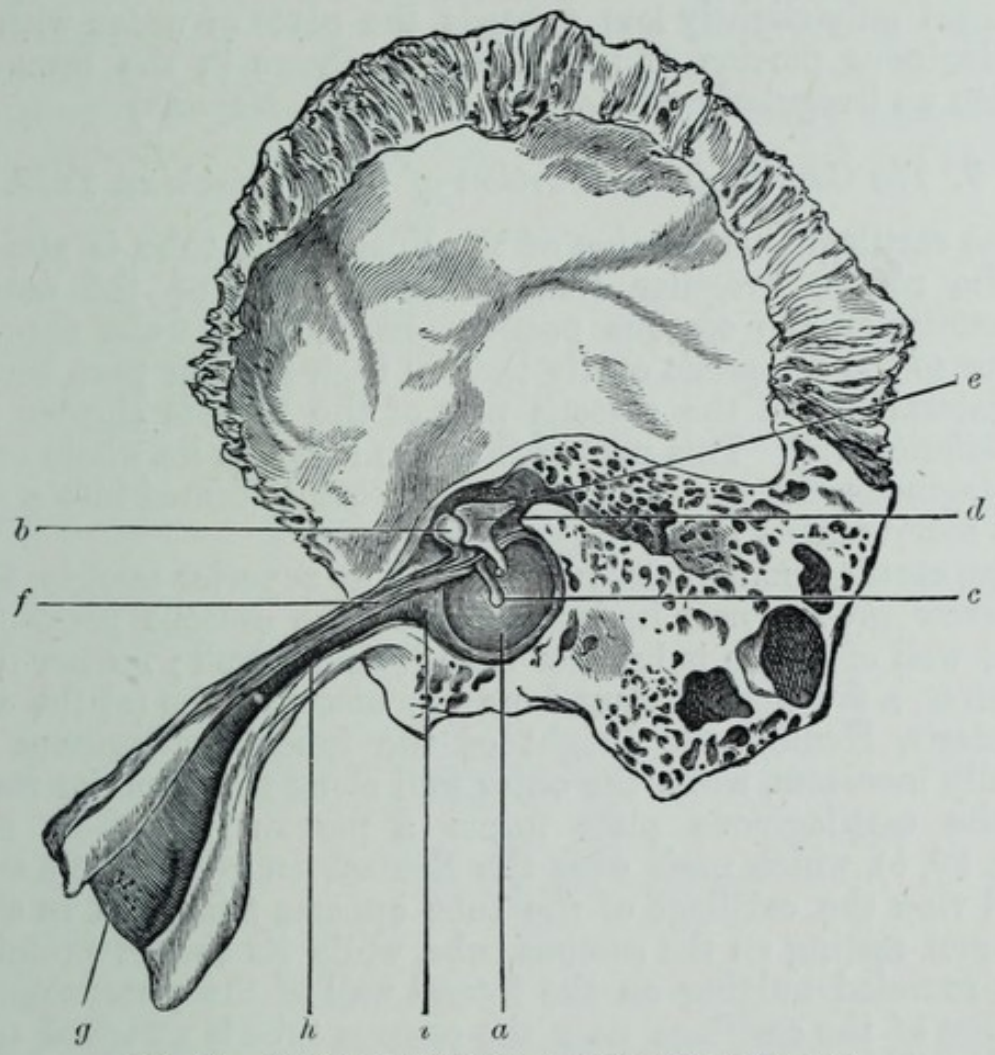

FIG. 38.—EUSTACHIAN TUBE AND TYMPANIC CAVITY.

a, Membrana tympani; *b*, Head of the malleus; *c*, Lower end of the handle of the malleus; *d*, Body of the incus; *e*, Short process of the incus; *f*, Tensor tympani; *g*, Ostium pharyngeum tubæ; *h*, Isthmus tubæ; *i*, Ostium tympanicum tubæ. (Right Ear.)

cartilaginous section in front of its point of union with the osseous portion, measures in height $1\frac{1}{2}$-2 mm., in width $\frac{1}{2}$-$\frac{3}{4}$ mm.

a. The Osseous Portion of the Eustachian Tube.

The osseous portion of the Eustachian tube, bounded above by the canal of the tensor tympani, and below and towards the middle by the carotid canal, is a prolongation of the anterior portion of the tympanic cavity directed inwards. The boundary between the tube and the cavity, however, is not a very marked one, because the superior and lateral walls of the latter merge without interruption into the former. On the under-side the boundary is better defined, especially where the obliquely rising

anterior wall of the tympanic cavity curves towards the inferior wall of the osseous tube (Fig. 38, *i*). Above this place is situated the *ostium tympanicum tubæ Eustachii*, irregularly defined and inconstant in size. Its height measures, according to v. Tröltsch, 5 mm.; its width 3 mm. The lumen of the osseous canal, the diameter of which, according to Henle, amounts to about 2 mm., becomes only slightly less towards the place of union with the cartilaginous portion of the tube, and shows in the transverse section an irregularly trilateral outline. (L. Mayer.*)

b. The Cartilaginous Portion of the Eustachian Tube.

The cartilaginous portion of the Eustachian tube is attached to the rough, irregular, and oblique margin of the anterior extremity of the osseous portion; laterally its walls approach nearer to the tympanic cavity than in their inferior part, because the lateral wall of the osseous part of the tube is shorter than the inferior wall. This part of the tube is not in its whole extent cartilaginous, the groove-like cartilage being formed into a canal by a membranous plate.

The cartilaginous plate, turned in at its superior margin, forms a narrow groove near its insertion into the osseous portion, the outer wall of which is broader than its inner wall; farther down, however, a few lines distant from the osseous tube (at the spina angularis, Henle), the height of the inner cartilaginous wall rapidly increases, while the outer wall along the superior margin of the cartilaginous plate forms a narrow turned-in stripe (Fig. 39, *b*), which roofs over the Eustachian tube. At a superficial view the cartilage of the tube appears triangular in shape, its apex resting on the osseous tube, while its base is prominent as a rounded bulging on the lateral wall of the pharynx. The portion of the cartilage near the osseous tube is attached to the basilar fibro-cartilage, and is less movable than the inferior broader portion standing out from the base of the skull. The cartilage itself, composed on the surface of hyaline, and in the deeper layers of a fibrous fundamental substance, shows very often a number of irregular fissures, clefts, and sometimes disruption of the cartilage of the tube into several separate pieces (Zuckerkandl;† Urbantschitsch‡).

The Eustachian canal in the child differs considerably as regards length, width, and direction from that in the adult. Its tympanic orifice is comparatively large, and lies somewhat lower; on the other hand, the pharyngeal orifice is indicated only by a slight depression or fissure, and the posterior prominent portion of the tube forms a hardly noticeable projection on the wall of

* *Studien über die Anatomie des Canalis Eustachii*, 1866.

† *Zur Anatomie und Physiologie der Tuba Eust. Monatschrift f. Ohrenheilk.*, 1873.

‡ *Zur Anatomie der Tuba Eust. beim Menschen. Wiener medicinische Jahrbücher*, 1875.

the pharynx. The tube in the child is also shorter and wider, a condition which is of practical importance in so far as obstacles in it, caused by the products of disease, can with greater facility be removed by a current of air.

The relation of the membranous portion to the cartilaginous plate is most clearly shown by transverse sections of the tube. Examining the anatomical relations of the cartilaginous tube by this method, v. Tröltsch, Moos, Henle, Rüdinger, and L. Mayer have brought to light a number of very interesting anatomical facts. In such a transverse section (Fig. 39) we see in the first

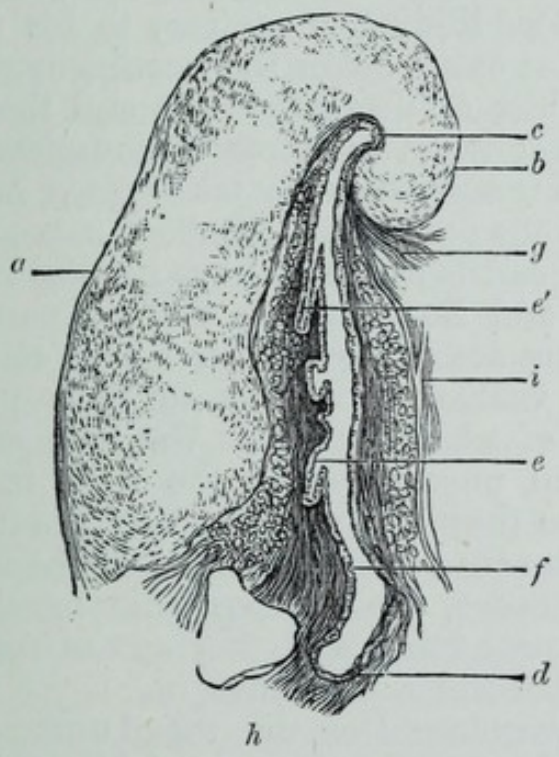

FIG. 39.—TRANSVERSE SECTION OF THE CARTILAGINOUS EUSTACHIAN TUBE.

a, Central cartilaginous plate; *b*, Cartilaginous hook: *c*, Space below the cartilaginous hook; *d*, Base of the Eustachian tube; *e*, *e'*, Folds of mucous membrane; *f*, Cylindrical epithelium; *g*, Musc. tensor palat. mollis; *h*, Musc. levator palat. mollis.

instance the central cartilaginous plate (*a*), twisted round like a hook (*b*) at its superior margin. At the end of this hook commences the membranous portion of the tube, delicate and thin near the cartilage, increasing, however, in thickness downwards, and mostly supported by an abundant adipose and glandular layer. The membranous portion, which merges below into the salpingo-pharyngeal fascia, according to v. Tröltsch forms the smaller half of the circumference of the Eustachian tube, and constitutes, together with the cartilaginous hook, the lateral wall of the cartilaginous portion of the tube (*i*), and also its base (*d*).

By reason of this hook-like twist of the cartilage, a space is formed below it, the proportions of which vary in the several portions of the Eustachian tube. In transverse sections of hardened preparations in the superior portions near the osseous

part a small space will be found below the curvature of the hook, the walls of which do not come into contact with each other. In the middle portion, however, the central and lateral walls of the tube are completely in contact, and only near the ostium pharyngeum do the walls again diverge a little. From numerous sections of the cartilaginous Eustachian tube I have been able to convince myself of the correctness of the statements on this subject by v. Tröltsch (*Beiträge zur vergleichenden Anatomie der Ohrtrompete, Arch. f. Ohrenh.* vol. ii.) and Moos (*Arch. f. Augen- und Ohrenheilk.*, vol. i., and *Beiträge zur normalen und pathologischen Anatomie und Physiologie der Eust. Röhre*, Wiesbaden, 1874). Rüdinger, contrary to his former assertions that an open space exists below the cartilaginous hook along the whole length of the cartilaginous tube, and that therefore without exception a constant and free communication between the pharynx and the tympanic cavity takes place, has now also given his adherence to the opinion of the above-named authors.

The islands of cartilage, which have been specially commented upon by Moos and Zuckerkandl, deserve particular attention. Moos divides them according to their size as microscopically and macroscopically visible; according to their position into five different kinds, of which those at the base and the sides are histologically and physiologically the most important. Histologically, because they always consist of fibrous cartilage; and physiologically, because in consequence of their connection with the submucous tissue, the salpingo-pharyngeal fascia, and the tendon of the tensor veli palati, they act as real sesamoid cartilages in the mechanism of the tube.

The mucous membrane of the membranous portion of the Eustachian tube has an abundance of folds in its lower portion. According to communications from Moos, which I received in 1868, these folds of the membranous portion form a bulging immediately behind the ostium pharyngeum, which closes the tube in this place, when at rest. Above, the abundance of folds gradually decreases.

Lining Membrane of the Eustachian Tube.—The walls of the Eustachian tube are covered by a glandular mucous membrane with a ciliated cylindrical epithelium. The lining membrane of the osseous tube is smooth and closely united with the periosteum. The mucous membrane of the cartilaginous plate is more strongly developed, and a great number of acinose glands discharge on its surface (Fig. 39, *i*, *e*). These glands extend to the neighbourhood of the perichondrium, but sometimes, especially near the orifice in the pharynx, they can be traced through fissures in the cartilage of the tube, into the connective tissue outside the tube. These glandular elements are most numerous near the orifice of the tube in the pharynx, while in the osseous portion, especially towards the tympanic cavity, they are much less abun-

dant. Besides this, Gerlach found in the mucous membrane of the child sebaceous glands, the walls of which consist of a diffuse conglomerate glandular substance, and which occur in great numbers in the whole cartilaginous portion of the tube. Gerlach proposes to name these sebaceous glands tonsils of the tube, as analogous to the pharyngeal tonsils of Luschka.

Muscles of the Eustachian Tube.—The lumen of the Eustachian tube, the walls of which are in contact with each other, sometimes more, sometimes less intimately, is temporarily opened by a muscular apparatus. The normal condition of the tube is therefore opposed to the free passage of air from the pharynx to the tympanum; hence, the Eustachian tube being closed, the air-tension in the tympanic cavity undergoes a change, by which the tension of the membrana tympani and of the ossicula becomes altered. Through the temporary opening of the Eustachian tube a considerable exchange of air takes place between the tympanic cavity and the pharynx, and the equilibrium between the external pressure and that in the tympanum is thereby maintained. The muscles of the tube, which, as v. Tröltsch correctly remarks, were formerly, without regard to their important relations to the Eustachian tube, classed as muscles of the soft palate, are the levator and tensor palati mollis.

The first of these, the levator palati mollis (*petro-salpingo-staphylinus*), arises from the surface of the petrous bone next the carotid canal. Its rounded belly extends parallel to the Eustachian tube, is closely applied partly to the membranous portion (Fig. 39, *h*), which forms the base of the tube, partly to the cartilaginous plate, and is inserted in a radiating manner into the soft palate below the orifice of the tube in the pharynx. None of its fibrous bundles arise, as was formerly believed, from the Eustachian tube, for it is only attached to it by a short band of connective tissue. The action of the levator palati mollis is not confined to the velum palati alone, for the base of the Eustachian tube is raised at every contraction of the muscle, by which the orifice of the tube is made smaller, but the resistance in the tube is lessened owing to the shortening and widening of its aperture.

The tens. palat. moll. (*spheno-salpingo-staphylinus s. circumflexus palat.*) has its origin at the inferior surface of the sphenoid bone; a great number of its bundles, however, come from the short, hook-like part of the lateral cartilaginous wall (Fig. 39, *g*), and from the membranous part of the cartilaginous portion of the tube. In its downward course its flat belly lies close to the lateral wall of the membranous portion of the tube, and is rather firmly attached to it. The direction of the fibres of the belly, the tendon of which is coiled round the hamulus pterygoideus, and radiates in the fibrous prolongation of the hard palate

(Henle), forms an acute angle with the direction of the cartilaginous portion of the tube. The tendon of the muscle is attached so tightly to the hamulus pterygoideus, that the effect of the muscular contraction is greater in the Eustachian tube than in the soft palate. By the contraction of this muscle the cartilaginous hook is slightly unfolded, the membranous portion of the tube is lifted up a little from the cartilaginous portion, and the lumen of the tube is opened. V. Tröltsch, who first drew attention to the importance of the anatomical relations to the physiological function of the Eustachian tube,* proposes the name

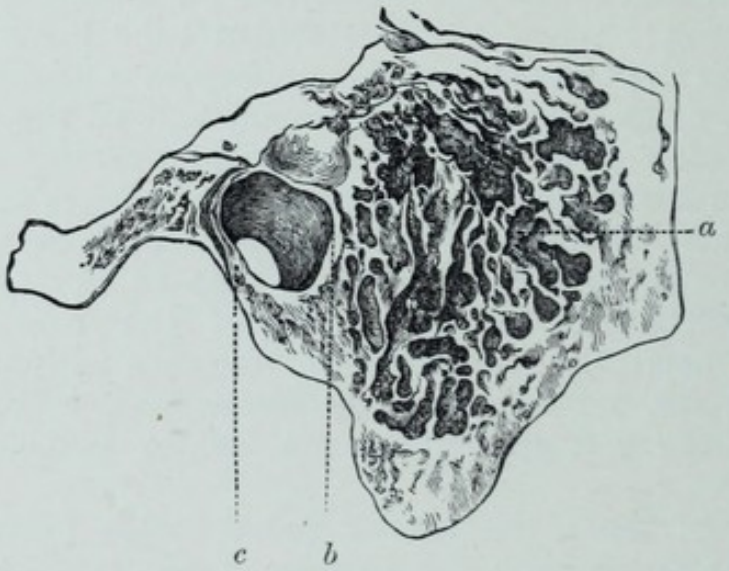

FIG. 40.—VERTICAL SECTION OF THE MASTOID PROCESS AND THE OSSEOUS MEATUS.
a, Mastoid cells; *b*, Posterior wall of the osseous meatus; *c*, Anterior wall of the osseous meatus.

'abductor' or 'dilatator tubæ' instead of the hitherto current tensor palati mollis.

C. THE MASTOID PROCESS.

The tympanic cavity is essentially increased in capacity by the cellular spaces of the mastoid process. In the new-born infant they are composed of a spongy, osseous tissue, consisting of small cells, which surround an empty space, 4-5 mm. in size, communicating with the tympanic cavity, the future antrum mastoideum.

The development of the mastoid process is only complete at the age of puberty, and anatomists divide the perfect process into two portions: the horizontal portion (*antrum mastoideum*), a large empty space, situated below the roof of the process, to which immediate entry is obtained by an orifice on the posterior wall of the tympanic cavity, and the proper cellular or vertical portion. The cellular spaces, bounding the antrum mastoideum,

* *Beiträge zur anatom. und physiol. Würdigung der Tuben- und Gaumen-muskulatur. A. f. O.*, vol. i.

are formed by osseous lamellæ (Fig. 40), which cross each other in different directions; their number and size is exceedingly variable, and they are in connection with each other and with the antrum mastoideum. The walls of the spaces are covered by a delicate membrane, a continuation of the lining membrane of the tympanic cavity, which is closely united to the periosteum, and has a non-ciliated layer of epithelium. In the antrum mastoideum, as well as in the larger cellular spaces, connective tissue membranes and bands are often seen, in which frequently the pedunculated structures (Fig. 35, p. 47), recently described and discovered by me, are to be found.

As regards the position of the mastoid cells and their relation to those parts of the organ of hearing and of the cranial cavity which are contiguous to them, it is to be noted that they are situated behind the tympanic cavity, mostly, however, behind the osseous meatus, the posterior wall of which adjoins these spaces in front (Fig. 41; compare formation of the osseous meatus, p. 12). The mastoid process is therefore bounded in front by the osseous meatus and the tympanic cavity, and also by those cellular spaces which surround the semicircular canals. The outer wall is formed by the convex osseous plate (Fig. 40) which can be felt behind the auricle, and which varies very much in extent of surface and thickness.* Posteriorly the empty spaces are contiguous to the cells of the diploe, which still belong to the mastoid portion of the temporal bone, and only rarely do they extend beyond the boundaries of the temporal bone to the occipital (pneumatic occipital bones, Hyrtl). At the base of the mastoid process, which narrows to a blunt point, is the more or less pronounced fossa for the point of attachment of the sterno-mastoid muscle, while the roof belongs to the osseous lamella, which forms the superior surface of the pyramid of the petrous bone, the roof of the tympanic cavity, and partly the superior wall of the osseous meatus.

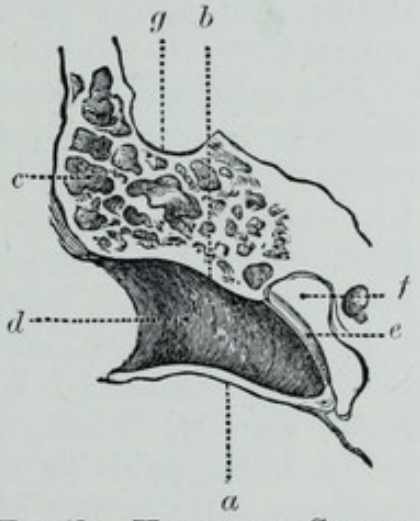

FIG. 41.—HORIZONTAL SECTION OF THE EXTERNAL MEATUS AND THE TYMPANIC CAVITY.

a, Anterior wall of the meatus; *b*, Posterior; *c*, Cells of the mastoid process; *d*, Meatus; *e*, Membrana tympani; *f*, Tympanic cavity; *g*, Fossa sigmoidea. (Right Ear.)

* Dehiscence of the exterior osseous plate of the mastoid process has hitherto been seldom observed: it is important in so far as the skin overlying the defect in the bone will be pushed out in case of great condensation of air in the middle ear (Schwartze, *Mittheilung in der Section für Ohrenheilk.* in Hamburg, 1876); by rupture of the subcutaneous connective tissue an extensive emphysema of the skin will often be caused (Schmitt, Inaugural dissertation, *Ueber emphysematöse Geschwülste am Schädel*, Würzburg, 1871; und Wernher, *Deutsche Zeitschrift für Chirurgie*, vol. iii.).

The inner border of the mastoid process is especially interesting. On the osseous lamella, which shuts off the mastoid cells from the cranial cavity, is the sigmoid fossa of variable width and depth, which contains the transverse sinus. This fossa originates at the eminentia cruciata interna of the occipital bone, passes over the inner surface of the mastoid process, and arrives at the foramen jugulare (*lacerum posticum*), and then rises with an abrupt curvature towards the inferior wall of the pyramid, where it forms the sinus for the bulbus venæ jugularis. The osseous lamella, which divides the cells of the mastoid process from the venous sinus, is sometimes very strong, in some cases, however, very thin, here and there even dehiscent,* so that the venous wall and the lining membrane of the mastoid cells come into immediate contact.

The relations between the mastoid process and the transverse sinus, mentioned above, are of great importance, because in the event of suppuration in the mastoid process producing caries of the osseous tissue, the destruction may extend to the sigmoid fossa, causing consecutive phlebitis, and, as a consequence, thrombosis, pyæmia, embolism and death.

Since the indications for operations on the mastoid process were lately supplemented by v. Tröltsch, Forget, Meyer, Schwartze, Eisel, Jacoby, Roosa, and Buck, greater attention has necessarily been paid to the anatomical relations of the mastoid process. The works of Albert Buck, Bezold and Arthur Hartmann have furnished important results on this subject. Hartmann especially has tried by the examination of a hundred preparations to determine the relation of the antrum mastoideum to that place on the external osseous plate of the mastoid bone where an opening into this antrum should be made; also the position of this place to the sigmoid fossa and to the middle cranial cavity. He found that in a hundred cases, through the variable position of the sigmoid fossa, which appears to be shifted forwards to a considerable extent in many cases, as also through the middle cranial cavity lying lower than usual, the transverse sinus was injured twice, and the middle cranial cavity three times, at the opening of the antrum mastoideum from without. It is therefore necessary to keep these relations always in view during operations on the antrum mastoideum.

* In my collection is a preparation described by Arthur Hartmann, where a dehiscence 6-7 mm. in size is visible on the exterior cranial surface behind the external meatus, which leads immediately into the sigmoid fossa.

PHYSIOLOGY OF THE SOUND-CONDUCTING APPARATUS.

A. AURICLE.

THE auricle is of less importance to the functions of the human ear than has been generally supposed by older authors. Each of the depressions of its anterior surface, as well as the dimension of the angle it forms with the lateral surface of the head, has been supposed to play an important part in the reflection of sound. On the other hand, the auricle has been represented as an accessory formation of no importance to the conduction of sound to the membrana tympani. The latter view has been based upon the fact, that no noticeable disturbance of hearing has been observed in individuals who had lost the auricle from frost-bite or by mechanical injury.

But there can be no doubt that the auricle plays a considerable part in the conduction of sound to the membrana tympani, although not to the same degree in man as in some animals. The concha, that large recess on the auricle already described, is the principal depression on the exterior surface, collecting a portion of the waves of sound that strike the ear, and reflecting them into the meatus. Schneider has proved that a decrease in the power of hearing takes place if this depression is filled up with wax. To test the influence of the auricle upon the reflection of sound, I experimented on individuals who were hard of hearing, because in such persons the distance of hearing for continuous sound is much more sharply defined than in persons whose ears are normal. Now, the head of the patient being placed in a fixed position, and the hearing-distance being ascertained by a metronome, which is then placed somewhat within the boundary of the hearing distance, the sound of the instrument will at once be lost to the patient, when the concha is covered by a stiff piece of paper. In this experiment the external orifice of the ear must remain free. No alteration in the hearing-distance will take place if the other depressions on the auricle are covered.

That the size of the auricle and its angle to the head have an influence upon the reflection of sound into the meatus will be seen from the fact that persons of normal hearing, as well as those who are hard of hearing, will hear more distinctly and more fully, if they bend the auricle forward by pressure upon its posterior surface, or if they augment the surface of the auricle by the hollow of the hand. Therefore, although the loss of the auricle will not have defective hearing as its consequence, the sound will certainly not be perceived so distinctly and fully as if the auricle were in its place.

As the result of examinations made by me, I must consider the tragus of great importance for the reflection of waves of sound which strike the auricle. In front and slightly overlapping the external orifice of the ear, the tragus appears as a nipple-like projection directed backwards, and by this means a considerable space is formed opposite the concha and the orifice of the external meatus. In this space the waves of sound reflected by the auricle (concha) are collected, and are thrown into the external orifice of the ear.

The importance of the space formed by the tragus can be tested by modifying the above-described experiment, by putting cotton-wool steeped in oil into the recess opposite the concha. By this means the sound of the metronome will either be weakened or will totally disappear. On the other hand, the sound will be heard considerably increased if the surface of the tragus is enlarged backwards by placing a small firm plate against it.

It is therefore beyond doubt that the auricle intensifies the perception of sound considerably by reflecting the waves of sound into the external meatus.*

The muscles which are inserted into the cartilage of the ear have only a subordinate influence upon the position of the auricle in man during the act of hearing. On the whole, spontaneous movements of the cartilage of the ear are rare. On the other hand, I observed frequently during the testing of the hearing-distance reflex motions of the auricle, of which the patient knew nothing, and which were visible sometimes in different portions and sometimes over the whole auricle.

B. Conduction of Sound in the External Meatus.

The waves of sound which advance in the column of air in the external meatus are reflected several times by its many curvatures. This refers, however, only to those waves of sound which are reflected into the meatus by the auricle, or which strike the walls of the meatus perpendicularly. For waves of sound also reach the membrana tympani, which proceed through the meatus without reflection.

In the reflection of waves of sound from the walls of the meatus upon the membrana tympani, two places in the external meatus must be mentioned as of great importance; one is the trough-shaped depression on the posterior wall of the cartilaginous meatus, which commences immediately inside the external meatus, and extends along the posterior superior wall to the middle of the canal. It is situated opposite the cavity formed by the tragus, and collects the waves of sound which are

* Küpper, *A. f. O.* vol. viii., and Mach, *ibid.* vol. ix., wholly deny that the auricle exerts any influence on the collection and reflection of the waves of sound.

thrown back from this place, to reflect them again upon the anterior inferior wall of the osseous meatus.

Here we meet with the concavity, already (p. 10) described, which extends over the inner portion of the anterior and inferior wall of the osseous meatus, and is roofed by the membrana tympani placed obliquely upon the axis of the meatus. This concavity has a parabolical curvature, and the waves of sound which are collected here will strike the membrane very powerfully, as the latter is situated opposite to it.

The waves of sound, however, as is well known, lose their intensity by repeated reflection; therefore a portion of those entering the ear must be destroyed by the walls of the meatus. It is therefore probable that the sound, which penetrates the ear, strikes the membrana tympani slightly modified in its intensity.

The width of the meatus has only a slight influence upon the intensity of perception of sound, as can be proved by pushing a little ball of wax towards the middle of the canal, so as to diminish its lumen to a small fissure, after having previously exactly fixed the hearing-distance for the ticking of a watch. The hearing-distance will be very little altered in this case, and the strength of the ticking will seem hardly diminished. In people of normal hearing, a ceruminal plug will often be found occupying the middle portion of the meatus, and causing no detriment to the functions of the ear. A hardly visible space between the mass and the wall of the meatus suffices for the passage of the waves of sound to the membrana tympani.

C. Propagation of Sound through the Membrana Tympani, and through the Ossicula.

a. Application of the Results to the Pathology of the Ear.

The waves of sound, proceeding through the meatus, throw into vibration the membrana tympani, which is stretched out at its extremity. This small membrane is provided with an extraordinary capacity for the reception and conduction of sound, more than can be produced in a physical membrane.

For if a physical membrane is stretched across a ring, and is thrown into vibration by a blow, a tone will be produced, which will vary according to the degree of tension, and which is called the key-note of the membrane.* Such a membrane will vibrate most strongly if a tone is produced near it which corresponds with its key-note; tones which come near the key-note of the membrane will cause lively vibrations, but these will continually decrease as the tone diverges in the scale from the key-note of the membrane.

The membrana tympani possesses the property of transmitting

* Membranes do not possess a distinctly defined key-note like tense strings.

tones of the most various durations of vibration, not only one after the other, but also simultaneously, so as to be uniformly perceptible. It must not, however, be looked upon as an elastic membrane; from the anatomical arrangement of its fibres it is rather a stiff membrane of little elasticity, a quality which is of importance in so far as it prevents after-vibrations, which would impair the distinctness of the perception of sound. The cause of this remarkable property of the membrana tympani was formerly explained by the irregularity in the density of its different portions, by means of which a simultaneous vibration of the membrane to different tones has been thought possible. Besides that, the alteration in the tension of the anterior and posterior portions of the membrane, produced by the strain of the handle of the malleus, has been considered as the cause of its extraordinary power of vibration, as it was believed that the anterior portion was brought into vibration especially by high tones, the posterior portion by low tones.

As opposed to these assertions, the theory advanced by Helmholtz is of great importance. Helmholtz* has established, upon mathematical and experimental bases, the fact that the power of resonance of curved membranes is incomparably greater than that of flatly-stretched membranes. He conducted the tones of a stretched string by means of a wooden pin to a curved membrane stretched across a glass cylinder, and found that its resonance extended over a great part of the scale, and that the curved membrane was also brought into intense vibrations, when high and low tones were produced, by elongating or shortening the string. Mach and Kessel† have observed the motions of the vibrating membrana tympani by means of the stroboscopic method. They found, that during the phase of rarefaction of the wave of sound, an annular fold proceeds from the umbo towards the periphery of the membrana tympani, which recedes again from the periphery to the umbo during the phase of condensation. They further observed, that in the living the excursions of the posterior segment of the membrane are far more considerable than those of its other portions.

As has been already said, the membrane, besides its inward curvature, has also a curvature in the opposite direction from the umbo towards the periphery facing the meatus (p. 21). The radiating fibres, which are stretched out from the periphery to the handle of the malleus, represent a system of stretched strings, with the handle of the malleus as its movable bridge. Through the semicircular curvature outwards, the radiating fibres offer a favourable point of contact for the waves of sound to strike the

* *Die Mechanik der Gehörknöchelchen und des Trommelfells.* Pflüger's *Archiv*, vol. i.

† *Beiträge zur Topographie und Mechanik des Mittelohres. Reports of Vienna Acad. Session*, April, 1874.

membrane, as Helmholtz asserts. This investigator has further proved that only a slight motion of the point of the handle of the malleus takes place, in proportion to a relatively great excursion of the membrane, and that, on the other hand, the membrane executes a great excursion with only slight motions of the handle of the malleus.

In my investigation upon this subject,* I have made experiments with an apparatus in which the membrana tympani (6 cm.), and the malleus (5½ cm.), were imitated on a large scale. The metallic drum, representing the tympanic cavity (10 cm. diameter, 16 cm. length), was provided at its posterior perforated extremity with an auscultation-tube, by means of which the experimenter could perceive the alteration of the tones conducted to the membrane. In this manner it could be seen that tones of the tuning-fork, pitched high and low, which were only slightly heard with a flat membrane, became at once more distinct when the membrane received a curved shape by tension of the malleus. This increase in the sound was of the same intensity whether the membrane was curved concavely or convexly towards the direction of the sound.

Fick asserts that, in consequence of the oblique plane of the membrana tympani, the waves of sound strike the ear in a less favourable manner than if the membrane were placed perpendicularly upon the axis of the meatus. As, however, the waves of sound advance with a spherical wave-front, and on the other hand the membrane is also curved, great importance must by no means be attached to the inclination of the membrane as regards the reception of the waves of sound.

The ossicula form a system of sensitive levers, through which the vibrations of the membrana tympani are transmitted to the labyrinth. In some books the opinion will still be found expressed, that the sound, striking the membrana tympani, is transmitted only in a slight measure by the ossicular chain, being conducted through the air in the tympanic cavity, and through the fenestra rotunda to the labyrinth. The physiologists who assumed that the propagation of sound was principally effected by the ossicula, could not agree as to whether only a mutual movement of the separate molecules of the ossicula towards each other took place, or whether the separate portions of the chain, malleus, incus and stapes, vibrated as whole bodies with extensive oscillations.

I was the first to furnish the experimental proof that the ossicula vibrate as whole bodies with extensive oscillations under the influence of the waves of sound which strike the membrana tympani.

After removal of the tegmen tympani and of the inner or

* *Zur physiologischen Acustik und deren Anwendung auf die Pathologie des Gehörorgans, A. f. O.* vol. vi.

labyrinthine wall, fine threads of glass, 10-12 cm. in length, with the fibre of a feather attached to their point, were fastened by means of resin one after the other to the malleus, incus and the foot-plate of the stapes, and the tones of organ-pipes of different height were conducted through the external meatus to the membrana tympani.

The vibrations of the ossicula were rendered considerably more perceptible by the sensitive glass levers which were fastened to them, and were plainly visible to the naked eye. The vibrations may, however, be most distinctly traced if the ossicula are made to register them themselves. For this purpose a brass drum is used, which revolves round its longitudinal axis and moves forward, is covered with paper and blackened by the smoke of a turpentine lamp. If the point of the vibrating thread of glass is brought into contact with the blackened surface of the cylinder quickly rotating, regular spiral lines will be produced upon it.

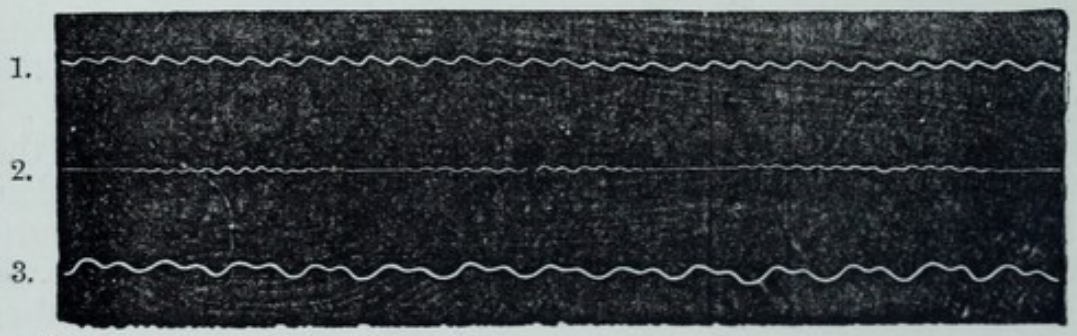

FIG. 42.—SELF-REGISTERED TRACINGS OF THE VIBRATIONS OF THE OSSICULA.

These experiments have been made with simple and compound notes. With simple notes regular spiral lines were traced (Fig. 42, 1); with compound notes, however, vibrations were created by the interference of the waves of sound, which were visible upon the surface of the cylinder as regularly recurring straight-lined places between the spiral lines (Fig. 42, 2). The most regular drawing of this interference was obtained by the notes of two organ-pipes, which were exactly an octave apart; in each great spiral curve of the deeper octave, the smaller curve of the higher octave was inserted (Fig. 42, 3).

The proportion of the vibration of the ossicula depends principally on the mechanism of the joints. In 1862, I discovered by experiment (*Wiener Med. Wochenschrift*, Nos. 13 and 14) that every time the air is condensed in the tympanic cavity, a considerable excursion of the membrana tympani with the handle of the malleus outwards towards the meatus, and a distinct motion of the articular surfaces of the malleus and incus, are visible, while the excursions of the long process of the incus are very trifling. This is plainly a foreshadowing of Helmholtz's very recent description of the mechanism of the articulation of the malleus and incus. As already mentioned, he compares that

articulation with the mechanism of the catch-contrivance inside a watch-key. With the excursion inwards, the cog of the malleus catches exactly in that of the body of the incus, causing the latter bone to follow the motion. With the motion outwards, however, the cog of the malleus unhooks itself from that of the incus, and the malleus principally is moved outwards, the incus being so only in slight degree.

The relative range of the motion of the separate bones may be ascertained by the method indicated by me, in the following manner. Threads of glass of equal length are fastened to the malleus, incus and stapes, and the membrana tympani is brought into motion by condensation and rarefaction of air in the external meatus. It will then be seen that the sensitive glass lever on the malleus executes much greater excursions than that on the incus, and that the excursions of the thread of glass fastened to the stapes are the slightest. By the same method I have also proved* that the axes of the ossicula are not fixed, but movable; and I have made the statement, that in transmitting the waves of sound from the membrana tympani to the labyrinth, the vibrations of the malleus are greater than those of the incus, while those of the latter are again greater than those of the stapes.

These assertions have been confirmed by Schmiedekam.† Dr. Buck of New York afterwards made use of another method to trace the vibrations of the ossicula. It is on the principle of Lissajous, based upon the optical examination of the vibration of bodies.‡ Buck fastened starch granules to the ossicula, and examined their vibrations by means of a microscope supplied with a micrometer. The starch corpuscle, which was fixed under the microscope, and which appeared as a whitish spot when at rest, expanded during the vibration of the membrana tympani and the ossicula into a line, the length of which for each of the bones could be measured by the micrometer. Buck has proved by this method, which has the advantage that the ossicula are not weighted during the experiment, that the vibrations of the malleus are twice as strong as those of the incus, and four times as strong as those of the stapes. According to Helmholtz, the greatest excursions of the stapes amount to $\frac{1}{18}$-$\frac{1}{14}$ mm. These measurements are, however, only to be assumed in the case of extensive excursions of the ossicula, when they are brought into

* *Wochenblatt der Gesellschaft der Aerzte*, No. viii. 1868.

† *Experimentelle Studien zur Physiologie des Gehörorgans.* Inaugural Dissertation. Kiel, 1868.

‡ Mach and Kessel (*l. c.*) made use of the same method to ascertain the axes of the ossicula during vibrations caused by the sound. They found that the stapes performed no piston-like motion in the fenestra ovalis, but that it revolved round an axis situated near the inferior margin of the foot-plate of the stapes, so that the superior margin penetrates deeper towards the vestibule than the inferior margin.

motion by alternate condensation and rarefaction of the air in the external meatus or in the tympanic cavity. During vibrations caused by sound, however, the excursions of the stapes are very trifling, and Riemann correctly remarks, that with weak, but still plainly perceptible notes, they must be so slight as not to be discernible even with the most powerful microscope.

The motion in the sound-conducting apparatus is compared by Helmholtz to that of an unequal lever, which executes great excursions at one side, and small ones at the other. If, according to the foregoing, the excursion of the vibrations is decreased as the waves of sound progress through the ossicula owing to the bulging in the membrana tympani, their intensity is by no means lessened.

By the mode of articulation of the malleus and the incus, the organ of hearing is protected from violent concussions acting upon the membrana tympani. When, by a sudden condensation of the column of air in the meatus, the membrane with the whole ossicular chain is rapidly forced inwards, the violent shock which would fall upon the labyrinth is prevented by the outwardly convex arches formed by its radiate fibres. For the shock falling upon the convexity of these arches serves to straighten them, and in this way the handle of the malleus is arrested in its excursion inwards, before it has exerted much force on the incus.

The labyrinth is also protected against excessive variations ot pressure, due to the sudden entrance of air into the tympanum, because, as already mentioned, the membrana tympani with the handle of the malleus is moved outwards to a considerable extent, while the incus and the stapes follow this motion only in a slight degree.

The resistance to the vibration of the ossicula is caused partly by their articular ligaments, partly by the fibrous ligaments and folds of mucous membrane which extend from the walls of the tympanic cavity to them. These obstacles are of the greatest importance in favouring the uniform reception and conduction of the waves of sound, which vary in the duration of their vibration (Riemann, Helmholtz). They give the ossicular chain a sufficient amount of stability, by which the necessary proportion between the tension of the membrana tympani and that of the ossicula is effected.

The anomalies which arise between the tension of the membrana tympani and that of the ossicula owing to pathological changes must impair the propagation of sound. In cases of closure of the Eustachian tube an increased tension of the membrana tympani arises by rarefaction of air in the tympanic cavity, which will be followed by increased tension of the ossicula. The result of this is an abnormal increase in the obstacles and a hindrance in the conduction of sound to the

labyrinth. Cases will also occur where the membrana tympani gets thinned and atrophied by being overweighted on one side for a long time, or by extensive cicatricial formation, whereby it loses its normal degree of tension. Here also the anomaly between the tension of the membrane and that of the ossicula will cause a disturbance of the functions. This also holds good with regard to those pathological processes in the middle ear, where the tension of the membrana tympani is not altered, but where obstacles are created by diseased products at the joints of the ossicula, or in places where they come in contact with the walls of the tympanic cavity, which produce a hindrance to the conduction of sound.

The principle of Lissajous, made use of by Buck, I have applied in a number of experiments, the results of which are of importance in the explanation of functional disturbances, observed in consequence of pathological obstacles to the conduction of sound in the middle ear. As a point on the ossicula, if fixed by a microscope, appears as a line during their vibration, the intensity of the vibrations was measured during these experiments by the alteration in the length of this line. The results of these experiments, published by me in 1871 (*A. f. O.* vol. vi.), are as follows:

1. If the tones of a harmonium are conducted by means of a tube to the membrana tympani of an anatomical preparation of the ear, it is found, that with equally intense tones the intensity of the vibrations of the ossicula is less with deep tones than with high ones above the middle range, while with very high tones the intensity decreases again.

2. If words are spoken into the meatus through a hearing-trumpet, the ossicula exhibit as many oscillations as there are syllables in the word. The greatest excursion of the oscillation coincides with the vowel of the syllable.

3. If some portions of the membrana tympani are weighted with a small ball of wax or a little rod, the intensity of the vibrations of the ossicula decreases only in a slight degree; but if the malleus or other ossiculum is weighted in the same manner, and an obstacle to the conduction of sound is thereby created, similar to the exudations and adhesions which have arisen from disease of the middle ear, the excursion of the vibration is considerably diminished.

4. If deep or high tones act upon the membrana tympani while the ossicula are weighted as above, a comparatively greater vibration will be observed with high than with deep tones. The vibrations will also be notably less during the speaking of words into the meatus, than during the impact of musical tones.

These results agree with the disturbances of hearing observed in patients. Alterations on the membrana tympani, as cicatrices,

calcifications and perforations, will impair the power of hearing less than pathological products (adhesions, anchylosis) in the ossicula, which diminish their power of vibration. It will also be seen, that in such cases high tones are mostly heard better than deep ones, and that the perception of speech is more affected than that of musical tones.

5. If the membrane is artificially destroyed, the vibrations of the malleus become less; but if an artificial membrana tympani is inserted, and its india-rubber plate is brought into contact with the handle of the malleus, the vibrations will again become stronger.

6. The jingling sounds in the ear, observed by Helmholtz after intense concussions, are in my opinion not caused by the striking against each other of the cogs of the articulation of the malleus and the incus, but, as my experiments have shown, by the whizzing of the membranes and ligaments of the ossicula; for these jingling tones can be produced in the ear of a dead body by the tone of an organ-pipe, even if the articulation of the malleus and the incus has been artificially anchylosed.

D. Physiology of the Eustachian Tube.

It is well known that when the mouth and the nose are closed, air can be forced into the tympanic cavity by means of a powerful act of expiration, by which the membrana tympani will be somewhat forced outwards. This is called the Valsalvian experiment. By the condensation of air in the tympanic cavity, which results from this experiment, a sensation of fulness and tingling in the ear, and a slight degree of hardness of hearing, especially for deep tones, are brought about.

A similar sensation will be perceived if the act of swallowing is performed when the mouth and nose are closed. But in this case the air in the tympanic cavity is not condensed (Toynbee), but, as I was the first to prove, rarefied, as part of the air in the pharynx is swallowed, and the rarefaction of air extends from the pharynx through the tube to the tympanic cavity.

If the nasal orifices are opened again after the act of swallowing, the sensation of tension in the ear nevertheless remains; it will only disappear when the act of swallowing is repeated with the nasal orifices unclosed.

This can be simply explained. The Eustachian tube is opened wide, during the act of swallowing, by the action of its muscles, and the rarefaction of air, arising in the pharynx, extends to the tympanic cavity. Immediately after the act of swallowing, however, the walls of the tube lie again close together, and the air in the tympanic cavity remains rarefied, while the atmospheric pressure again prevails in the pharynx. As there is now a difference in the pressure of air in the tympanic cavity and in

the pharynx, the membranous wall of the tube is pressed closer to the cartilaginous wall by means of the external pressure of air, so that the closure of the Eustachian tube is more complete than it is in ordinary circumstances. If now another act of swallowing be performed, the tube will again be opened, and the pressure of air in the tympanic cavity and in the pharynx will be equalised.

These results followed from a number of experiments, performed by me in 1860, in the laboratory of C. Ludwig. I made use of a small glass tube, 2-3 mm. wide, fitted into an india-rubber stopper (ear-manometer, Fig. 43), and furnished with a drop of coloured fluid. This tube was hermetically sealed into the external meatus. During the Valsalvian experiment, the fluid in the manometer was seen to rise. If an act of swallowing were performed with the closed mouth and nose, during the first stage of this act a slight rise (positive fluctuation) of the fluid in the manometer took place, followed, however, during the second stage of the act of deglutition, by a considerable fall (negative fluctuation), as the air in the tympanic cavity is rarefied and the membrana tympani is pressed inwards. The fluid will now remain in the place where it fell to after the act of swallowing, and will return to its former place only when the closed Eustachian tube is reopened by another act of swallowing with open nostrils. In many cases, and even in the same individual, slight fluctuations of the fluid in the manometer will be observed even with quiet respiration, corresponding with the respiratory movements; these fluctuations will be greater the more quickly the air is allowed to pass through the nose, and when a greater obstacle is presented to the passage of air by closure of one of the nostrils.

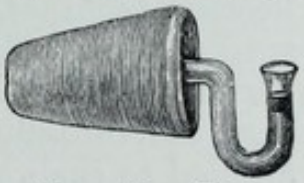

FIG. 43.—EAR-MANOMETER.

The opening of the Eustachian tube during the act of swallowing can also be proved by another simple experiment, which was first performed by me in 1869. If a vibrating tuning-fork is held in front of the nostrils, a uniformly weak sound will be heard in both ears; during an act of swallowing, however, the tone of the tuning-fork will be perceived in both ears greatly increased, as its vibrations penetrate unchecked into the tympanic cavity through the open Eustachian tube.

It has already been pointed out, that the surfaces of the mucous membrane in the middle portion of the Eustachian tube come on all sides into contact with each other. This portion of the cartilaginous tube is sometimes large and sometimes very short, as I have observed in a number of preparations, which explains the normal individual differences observed in regard to the amount of hindrance to the passage of air along the tube from the pharynx. According to Mach and Kessel, the closure of the

Eustachian tube in the normal state is an important condition in the production of extensive vibrations of the membrana tympani.

The oft-discussed question, whether we can hear through the Eustachian tube, and especially whether we can understand speech, when the conduction of sound by means of the external meatus and the membrana tympani is excluded (Voltolini declaring such a possibility as a fable in vol. lxv. of Virchow's *Arch.*), will be decided in a positive sense by the following experiment. An individual of normal hearing, whose meatuses are so firmly closed by means of the moistened fingers that he cannot understand speech at a distance of one meter, has the ear-piece of a hearing-trumpet of the same length inserted into the orifice of the nose, and the nostrils are closed round it by another person. The person experimented on will now at once distinctly hear speech, which he could not understand before, if it is spoken into the hearing-trumpet. That many persons can understand whispered speech, while others only understand loud speech during this experiment, is due to the fact that the walls of the Eustachian tube vary individually in respect to the closeness with which they are applied to each other. But from this fact the conclusion can by no means be drawn that the tube is open, as speech can also be understood through an india-rubber tube, the walls of which lie loosely together for a short distance.

These anatomical observations and experiments give the following results:

1. The Eustachian tube is not constantly gaping; its permeability varies individually, as in a number of cases a current of air from the pharynx towards the tympanic cavity takes place even during quiet respiration, while in other cases an act of deglutition, or a powerful expiration with opened or closed nostrils, is necessary to make the tube passable for the current of air.*

2. The Eustachian tube is opened during the act of swallowing chiefly by the action of its muscles, especially the abductor tubæ (v. Tröltsch),† as is proved by the experiments of Toynbee‡ and myself.

3. When the air-pressure in the tympanum exceeds that in the pharynx, or *vice versâ*, equalization of the pressure will be brought about by the passage of air from the one cavity to the other; but the passage of air from the former to the latter takes place more readily than from the latter to the former.

* Confirmed by Mach and Kessel: *Die Function der Trommelhöhle und der Tuba Eustachii, Vienna Acad. Reports*, 1872.

† During experiments on vivisected dogs I have succeeded in observing a widening of the fissure of the tube in the wall of the pharynx by the irritation of the trigeminus in the cranial cavity. The dissection showed that the widening was caused by the tensor palat. moll. *Ueber eine Beziehung des Trigeminus zur Eust. Ohrtrompete. Würzburger naturwissenschaftliche Zeitschrift*, 1861.

‡ *Diseases of the Ear.*

These views, which in the main were advanced by me in 1861 (*l. c.*), are now generally acknowledged as correct.

E. Application to the Pathology of the Ear.

In regard to the pathology of the ear, the following considerations result from the above physiological facts:

1. The permeability of the Eustachian tube is of great importance for the functions of the organ of hearing. If the tube becomes impermeable by swelling of the mucous membrane, or by accumulation of secretion, the consequences of the interruption to the exchange of air between the external atmosphere and the tympanic cavity will shortly become apparent. By exclusion of the air from the tympanum, and consequent rarefaction of the air in that cavity, congestion of its tissues and exudation into it will often follow; and as the external pressure of air preponderates, the membrana tympani and the ossicular chain become tensely stretched and forced inwards by it, and partially deprived of their power of vibration.

2. By the opening of the Eustachian tube during the act of swallowing, the resistance which is opposed to the current of air from the pharynx to the tympanic cavity is considerably lessened. Where it is necessary, therefore, in disease of the middle ear, to render the tube permeable, and to employ the action of a strong current of air into the tympanic cavity, the effect will be materially increased if during the inflation an act of swallowing is performed.

F. On the Influence of the Variations of the Air-pressure in the Tympanic Cavity upon the Tension of the Contents of the Labyrinth.

By condensation of air in the tympanic cavity during the Valsalvian experiment, and also by rarefaction of air in the cavity, as mentioned above, a sensation of fulness or tension in the ear arises, as well as tingling, and a slight degree of hardness of hearing. These anomalies in the function of hearing, caused by variations of air-pressure in the tympanic cavity, have, since the time of J. Müller, been attributed to altered tension of the membrana tympani. To the same cause, especially as it is a well-known physical law that tightly-stretched membranes are brought into vibrations chiefly by high tones, was attributed the fact, that under the same circumstances hardness of hearing, principally for deep tones, takes place, high tones being still well perceived. In this explanation, seemingly so very plausible, a very simple physical law was however lost sight of, namely, that the pressure of aeriform or fluid substances cannot act unilaterally in a cavity, but must act uniformly in all directions upon the walls of the cavity. The simultaneous pressure upon the elastic membrane of

the fenestra rotunda and upon the foot-plate of the stapes and the membrane bordering it, consequently also upon the whole contents of the labyrinth, remained disregarded. To prove that, as I supposed, an alteration in the amount of tension of the contents of the labyrinth would take place with increased or decreased pressure in the tympanic cavity, I instituted a number of manometrical experiments on fresh human ears (in Prof. Ludwig's laboratory), during which (Fig. 44), the condensation and rarefaction of air in the tympanic cavity were produced by an air-pump connected with the Eustachian tube (*c*). A manometrical tube, partly filled with a solution of carmine (*h*), was introduced into the opened superior semicircular canal, and fastened hermetically. Now, when the air in the tympanic cavity was con-

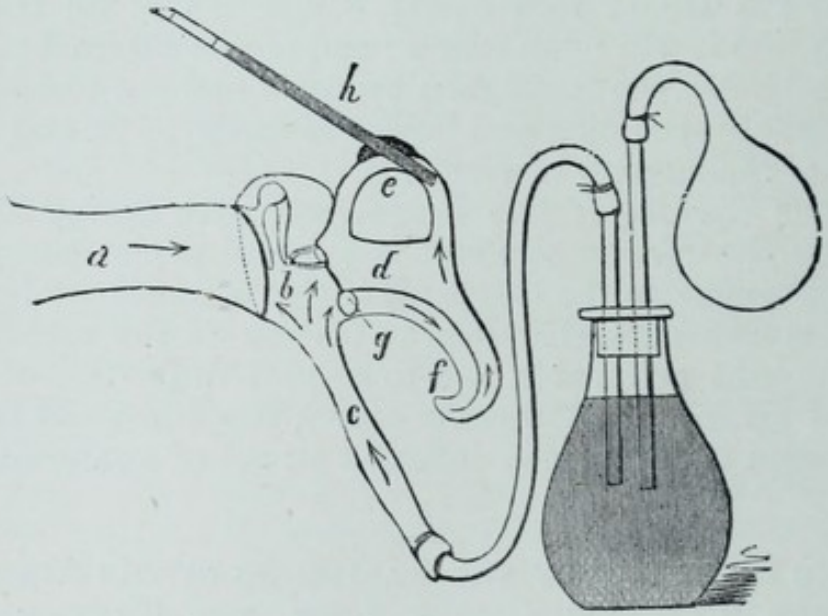

FIG. 44.

a, External meatus; *b*, Tympanic cavity; *c*, Eustachian tube; *d*, Vestibule of the labyrinth; *e*, The superior semicircular canal with the manometrical tube introduced into it; *f*, The cochlea with the scala vestibuli and tympani; *g*, Fenestra rotunda.

densed by compression of the balloon, an outward curvature of the membrana tympani and also a rising of the fluid in the manometrical tube in the labyrinth (*h*)—positive fluctuation of 1½-3 mm.—were observed, while during rarefaction a distinct fall of the fluid in the manometer was noticed. If the fenestra rotunda is closed by wax, a decrease in the fluctuation of the fluid in the manometrical tube will take place during condensation of air in the tympanic cavity. If the articulation of the stapes and incus is severed, an increase in the fluctuation of the fluid to the extent of ½-1½ mm. results in consequence of the resistance, which was formerly opposed to the motion inwards of the stapes being removed.

From these experiments it results:

1. That by condensation of air in the tympanic cavity, not only

does an alteration in the tension of the membrana tympani take place, but by simultaneous action on the membrane of the fenestra rotunda and on the movable foot-plate of the stapes, the pressure on the contents of the labyrinth is considerably increased. The extremities of the auditory nerve, surrounded by the auditory fluid, are mechanically irritated by this increased pressure, which will cause subjective sensations of sound. The slight degree of hardness of hearing can be explained in a similar manner to the disappearance of the perception of light when a moderate pressure is exerted by the finger on the eyeball. The fact that in this case hardness of hearing for deep tones especially occurs, while high tones can still be heard comparatively well, has to be attributed to the altered tension of the membrana tympani ; but it must not be lost sight of, that at the same time also the structures of the labyrinth (lamina spiralis membranacea and membranous saccules) are more tightly stretched, and that they will vibrate with greater difficulty in response to deep tones.

2. That in the above experiment an explanation is to be found for the subjective noises and disturbances of the function of hearing, which so often accompany those diseases of the ear in which, by accumulation of serous or mucous exudations, or by the new formation of connective tissue in the tympanic cavity, the two fenestræ of the labyrinth are abnormally weighted, or in which the membrana tympani and the ossicula are pressed inwards, the tension in the labyrinth being abnormally increased by the excessive pressure of the foot-plate of the stapes inwards.

G. Function of the Intra-tympanic Muscles.

Our knowledge hitherto concerning the action of the intra-tympanic muscles relates to the mechanism of the increase and decrease in the tension of the membrana tympani, and also to the regulation of the intra-tympanic pressure. Concerning the influence of the tension of the membrana tympani upon the perception of tones, I have proved (*A. f. O.* vol. i.) by experiments on human ears, as well as on preparations of the same organs of dogs, which had just been killed, in which the tensor was made to contract by electrical irritation of the trigeminus in the cranial cavity, that, especially during testing with deep tones (tuning-forks), a softening down of the key-note and a greater distinctness of the upper notes is observable.

I have experimentally proved that the action of the tensor is not confined only to the membrana tympani, but that it extends also to the labyrinth, as I observed a motion of the fluid in the labyrinth on electrical irritation of the trigeminus in the cranial cavity. The tensor tympani increases, therefore, the pressure in the labyrinth. In a number of other experiments I have proved that the stapedius acts antagonistically to the tensor tympani, as

it decreases the tension of the membrana tympani and lessens the pressure in the labyrinth (*Wiener Medicinal-Halle*, 1867). From examinations conducted hitherto, we can at present only state that it is one of the principal functions of the intra-tympanic muscles to remove the alterations in the position and tension of the ossicular chain and of the contents of the labyrinth, which are caused by the variable fluctuations in the air-pressure: in fact, to regulate the degree of tension of the hearing-apparatus.

I was the first to state, upon the basis of observations on myself and on aural patients, the view (*A. f. O.* vol. iv.) that the deafness which occurs during yawning is brought about by a simultaneous motion of the tensor tympani. This view was confirmed by Helmholtz (*l. c.*).

Concerning the spontaneous contractions of the tensor tympani, Luschka and I advanced at the same time the opinion, that the cracking noises in the ear, which many persons can cause spontaneously, arise by the contraction of the abductor tubæ. The observations of spontaneous contractions of the tensor tympani have only recently been made (Schwartze, *A. f. O.* vol. ii.; and Lucæ, *ibid.* vol. iii.). In a case described by me (*A. f. O.* vol. iv.), involuntary as well as spontaneous contractions of the tensor were observed in both ears.

THE DISEASES OF THE CONDUCTING APPARATUS.

I.—THE DISEASES OF THE MIDDLE EAR.

General Division.

a. A Survey of the Pathological Anatomy of the Middle Ear.

Pathological examinations of the ear have brought to light an important result during the last few years. While formerly diseases of the labyrinth and the auditory nerve were considered as the most frequent cause of deafness, it is now an established fact, that in the majority of aural cases the site of the primary pathological changes which disturb the function is in the middle ear, and that primary diseases of the auditory nerve are, on the whole, rare. Affections of the middle ear are, therefore, the diseases which chiefly interest the practitioner; and from this point of view—contrary to the formerly current arrangement—we will commence our study of the diseases of the ear with a description of those affections.

The diseases of the middle ear have their origin and seat in its lining membrane. In it commence all those pathological changes which often not only impair the function of hearing, but also endanger the life of the individual by extension to vital organs in its vicinity. The knowledge of these changes is, therefore, of very great importance, because it forms the basis of the diagnosis and treatment of these affections.

The pathological changes in the middle ear are caused by inflammation of its lining membrane. As this is a continuation of the mucous membrane of the pharynx, inflammatory processes in the middle ear and their results will, therefore, bear the character of inflammations of mucous membranes generally, with this difference, that in the middle ear condensation of the tissue and adhesion of the diseased surfaces to each other take place much more frequently. We find, therefore, hyperæmia and œdema, loosening and excessive swelling of the tissues, due to their infiltration with exudation; effusion of free exudation on the surface of the diseased membrane in the form of serous, mucous or purulent secretion; and lastly, as secondary products,

organized new formations of connective tissue, developed in the course of the disease as thickenings and proliferations of the mucous membrane or bands of connective tissue in the middle ear.

Anatomically as well as clinically this inflammatory process displays great variety. Its course is either acute, subacute, or chronic; and it may terminate either in complete cure and recovery of the normal power of hearing, or in functional disturbances of different degrees of severity owing to permanent pathological changes.

An attempt has been made to arrange the different forms of inflammation in the middle ear by taking as the basis of classification either the ætiology, the aggregate of clinical symptoms, or the pathological condition. However, none of these classifications is even tolerably practical; because the clinical symptoms often change while the pathological condition remains the same, and because, very often, transitions from one form of inflammation to another are observed. The opinion, even now held by some, that these different forms of inflammation should only be regarded as different degrees of *one* process, is based upon the last-mentioned fact. The results of pathological examinations as well as clinical experience, however, contradict this assumption. For, as we will see later on, certain forms of inflammation of the middle ear show from their commencement so singular a character in regard to the clinical cause and result, that that assumption seems quite inadmissible.

Although, as may be seen from the foregoing, there are great difficulties in the way of a strict classification of the forms of the middle ear inflammation, still it is necessary for practical purposes, especially as regards prognosis and treatment, to arrange the affections of the middle ear in groups in which the pathological changes have a prominent place, while each group is represented by a typical clinical picture.

While referring the reader for information on the classification of the forms of inflammation of the middle ear to the special chapter on the subject, it appears of importance for a due understanding of the pathological changes and their results, which have to be described next, to mention that from a clinical standpoint inflammations of the middle ear are divided into two great groups. In the first the continuity of the membrana tympani is not disturbed during the pathological process, while in the second, which is characterized by suppuration in the middle ear, the membrane is perforated. Experience certainly teaches that there are transition-forms between these two groups; but the clinical picture and the pathological state are so peculiar in each that this division of these affections seems justified. It also serves practical purposes, since the modes of treatment vary considerably in these two groups. It must also be specially noted

here that the inflammations of the middle ear, which are not accompanied by a disturbance of the continuity of the membrana tympani, appear in two essentially different forms, the distinction between which is of equal importance for the prognosis and for the treatment. One of these forms, which I call the exudatory and resoluble inflammation of the middle ear, is characterized by effusion of serum or mucus into the tympanum; while in the other, the so-called sclerotizing form of inflammation, abnormal anchylosis of the ossicula to the walls of the tympanic cavity or anchylosis of the ossicular articulations is generally developed. Even although the last-named form originates not unfrequently in an exudatory inflammation, it exhibits in a number of cases from its commencement a peculiarly insidious course, while without previous effusion it results in condensation of the connective tissue stratum, and gradual fixing of the ossicula, chiefly of the stapes. The distinction of these two forms is important to the practitioner in so far as the prognosis is favourable in the exudatory forms and unfavourable in the sclerotizing forms, while their treatment differs in many respects.

A. Changes in the Structure of the Diseased Lining Membrane of the Middle Ear.

a. Changes in the Epithelial Layer.

The epithelial layer of the lining membrane undergoes many changes in disease of the middle ear; its condition being different in acute and in chronic inflammation. In acute inflammation the epithelium will often be found partly raised off its base by exudation, and here and there quite detached; the contents of its cells are opaque and finely granular, and their outlines indistinct or obliterated by swelling.

In chronic inflammation, accompanied by free effusion into the tympanum, a slight increase in the bulk of the epithelium, and a great number of finely granular epithelial cells will be observed lying free. In insidious, adhesive inflammation, however, I found the epithelium for the most part unchanged.

Most striking are the changes of the epithelial layer in purulent perforating otitis media. In this case the epithelium not unfrequently loses its ciliated character; and often, especially in the course of chronic suppuration, such a considerable increase in the bulk of this layer takes place in consequence of excessive growth of the epithelial cells, that its thickness is several times greater than that of the other layers of the mucous membrane. These epithelial growths, which can be torn off in the form of a pellicle or in thick shreds, are composed of many strata of irregular flat cells, or they bear the character of the inferior cylindrical epithelium, while the deeper cells are irregularly rounded or pyriform. A minute examination of the cells will show that

they are often filled with a finely granular substance, mixed with roundish, highly refractive, fat-globules. In chronic affections cholesterine crystals are often present in the proliferating epithelial layer, as well as finely granular pigment, which latter is deposited partly in the epithelial cells, and partly between them.

The changes in the subepithelial tissue occur mostly in the vessels and in the connective tissue elements of the lining membrane.

b. Changes in the Vessels of the Lining Membrane of the Middle Ear.

During acute inflammation of the middle ear the bloodvessels of the lining membrane are affected similarly to those of other

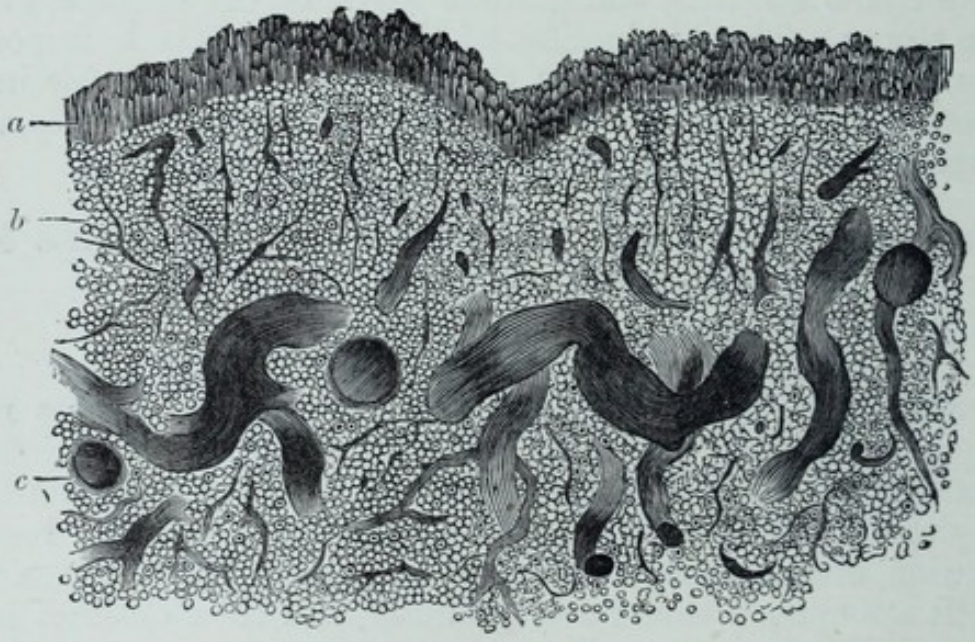

FIG. 45.—SECTION OF THE TUMEFIED MUCOUS MEMBRANE OF THE POSTERIOR WALL OF THE TYMPANIC CAVITY IN THE RIGHT EAR OF A GIRL, 19 YEARS OF AGE, WHO SUFFERED SINCE CHILDHOOD FROM PURULENT INFLAMMATION OF THE MIDDLE EAR ON BOTH SIDES, AND WHO DIED OF ENCEPHALO-MENINGITIS BY EXTENSION OF THE SUPPURATION FROM THE LEFT EAR TO THE CRANIAL CAVITY.

a, Proliferation of the epithelial layer; *b*, Sub-epithelial layer of mucous membrane interspersed with lymphoid corpuscles with few ramifications of bloodvessels; *c*, Deeper layer of the mucous membrane interspersed with highly dilated bloodvessels (Hartnack, Obj. 7).

mucous membranes when inflamed; they seem injected and widened, the large branches are much twisted, here and there bulged out and densely packed with blood-corpuscles. In purulent perforating inflammation the pathological alterations in the bloodvessels are most striking. The veins are in this case much more affected than the arterial branches, of which there are only a small number. Some of the veins have a calibre many times as great as their normal, and, especially along the great nervous trunks, display a highly tortuous course, with here and there varicose expansions. Especially with a highly tumefied state of the

lining membrane, they form a dense vascular network, which is strongly developed, either in all the layers of the mucous membrane or only in its deeper ones (Fig. 45). This vascular network arises in the first instance from the branches existing in the mucous membrane; but there can be no doubt that in cases of chronic inflammation it is often increased by newly-formed vessels.

The walls of the bloodvessels often show changes in structure. They are opaque and thickened, interspersed and pigmented with

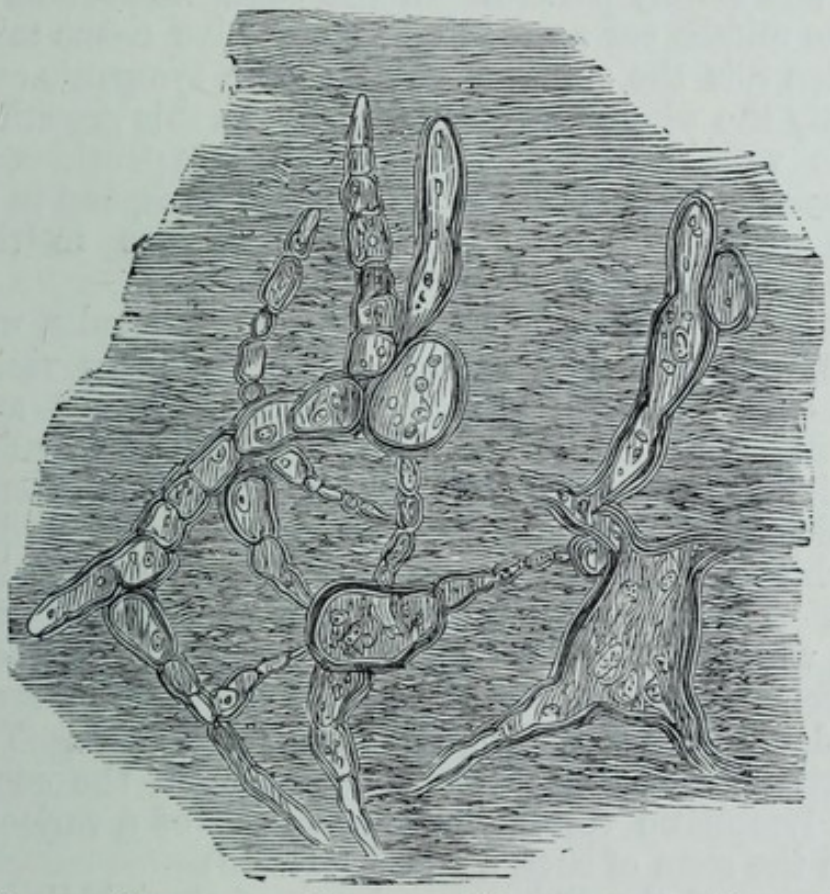

FIG. 46.—DILATED NETWORK OF LYMPHATIC VESSELS IN THE DEEPER LAYERS OF THE COVERING OF THE PROMONTORY IN A PHTHISICAL PERSON, 27 YEARS OLD, WHO HAD OTORRHŒA SINCE CHILDHOOD. (RIGHT EAR.) (Hartnack, Obj. 7.)

granular exudation or nuclear proliferations, and are often covered by lymphoid corpuscles.

The pathological changes of the lymphatic vessels of the lining membrane of the middle ear are principally observed in chronic perforating inflammations. I found them mostly in the deeper layers of the mucous membrane as varicose, constricted, vascular formations, provided with lateral cul-de-sacs, the stems of which either inter-cross or form an anastomosing network (Fig. 46). When highly magnified, it will be observed that the inner wall of these pouch-like passages is covered by an endothelium, the sharply-defined cells of which are here and there clear and transparent, in other places obscured by a finely granular molecular substance. The lumen of the lymphatic vessels is in some places

without any contents, while in others large quantities of roundish, granular lymph-corpuscles are visible.

Besides these varicose vascular formations, round or oval cystic spaces are often found, the walls of which display a hyaline or fibrous structure, and which contain roundish cells similar to the lymph-corpuscles. Their size varies from $\frac{1}{4}$-$\frac{1}{2}$ mm., and upwards. I found them either singly in the tumefied lining membrane, chiefly near the dilated stems of the lymphatic vessels, or in case of excessive hypertrophy of the mucous membrane,* in greater numbers and closely packed. In the course of chronic suppuration of the middle ear a growth of connective tissue takes place, which often fills the superior space of the tympanic cavity, and more rarely the whole tympanum itself. In this growth enlarged lymphatic vessels with lateral, knob-like expansions, and also cystic spaces, are very often found, which correspond in form and structure with the above-described formations in the lining membrane of the middle ear.†

The question whether, as regards the above results, we have to deal here with pathologically altered, pre-existing vascular formations, or with newly-formed lymphatic vessels and cystic spaces, will have to be answered as follows: The vascular formations, which occur in the deeper layers of the lining membrane of the middle ear, are pathologically altered, pre-existing lymphatic vessels, which are not only excessively enlarged, but are also altered in shape. The cystic formations, on the contrary, as well as the passages, which according to my observations occur so often in the proliferating mucous membrane of the middle ear, have to be considered as newly-formed lymphatic vessels. The cystic spaces originate either from a constriction in the course of an enlarged lymphatic vessel, or by separation of a varicose expansion from the stem of such a vessel (Heschl).

The nerves of the lining membrane of the middle ear appear often unchanged, even in cases of long-standing disease. However, in chronic inflammation, accompanied by suppuration, the nerve-bundles are infiltrated with exudation, and are rendered opaque and of a brownish colour, and their contents become crumbling, granular, or fatty. The complete absence of the medulla of the nerve, its outlines only being visible, is very seldom observed.

c. Pathological Changes in the Connective Tissue Layer of the Lining Membrane of the Middle Ear.

The connective-tissue elements in the lining of the middle ear are affected in different ways by inflammation. In *acute in-*

* The occurrence of these cystic formations in the diseased lining membrane of the middle ear was first described by me (*Wiener med. Zeitung*, 1873, No. 9), and was confirmed later by Wendt (*A. f. Heilk.* vol. xiv.).

† Compare my treatise *Zur pathologischen Histologie der Mittelohr-auskleidung*, *A. f. O.* vol. xi.

flammation the exudation penetrates into the connective tissue, the fibrillæ of which are separated so as to form a network (Wendt). The interstitial exudation appears in this case either as a clear fluid with scanty cellular elements and red blood-corpuscles, the latter especially abundant near the vessels, or else the whole stratum of connective tissue will be found infiltrated with quantities of lymphoid cells, red blood-corpuscles and a finely granular exudation, with here and there some small fat-globules.

The increase in bulk of the connective-tissue elements is one of the most important changes of the lining membrane of the middle ear, because obstacles to the conduction of sound are frequently produced by it, causing permanent disturbance of function. It appears in numerous forms, either extending over a great portion of the middle ear, or circumscribed.

The inflammatory affection of the lining membrane often leads to new formation of connective tissue and to hypertrophy and condensation of that already existing. In consequence of the increase in bulk caused thereby, which is accompanied either by new formation of permanent vessels, or by atrophy of the existing and of the newly-formed vessels, the previously delicate and easily displaced mucous membrane becomes very much tumefied or firm and inflexible through contraction of the newly-formed connective tissue, and in this way more firmly adherent to its osseous base.

Proliferation of the connective-tissue elements in the diseased lining membrane may occur in all forms of inflammation. It is, however, most extreme in purulent perforating inflammation of the middle ear. The lining membrane appears in this case many times its normal thickness and swollen up either throughout its whole extent, or only in circumscribed patches, so that it either partially or completely (rarely) fills the tympanic cavity. In this way the recess of the fenestra rotunda as well as the depression leading to the fenestra ovalis are closed up, and the stapes is embedded in the sodden tissues. Just as often this tumefaction is met in the superior portion of the tympanic cavity, where malleus, incus and stapes are enveloped by the proliferated mucous membrane, and fixed. This inflammatory growth of connective tissue often leads to the development of pedunculated new formations, which extend in the form of polypi and granulations, and often pass into the external meatus through the defective membrana tympani.

Microscopic examination of this tumefied and hypertrophied membrane shows, in addition to the changes in the blood and lymphatic vessels already described, an excessive growth of round cells, such as are often found in many polypi or in the granulation tissue. These are either in isolated groups in the fibrous stratum of connective tissue (Wendt), or they form almost the whole intervascular tissue (Fig. 47).

In a few cases I found the growth of round cells chiefly in the superficial layers of the mucous membrane, in the deeper layers fibrous connective tissue being predominant. The surface of the mucous membrane, therefore, was smooth, here and there without epithelium, or covered by a layer of epithelium several times stratified; or it received a finely granular papillous appearance (Wendt's polypous hypertrophy) from numerous villous or fungiform elevations (Fig. 47, c, c′), the tissue of which consisted of the same round cells.

The excessive growth of round cells mostly occurs with hyper-

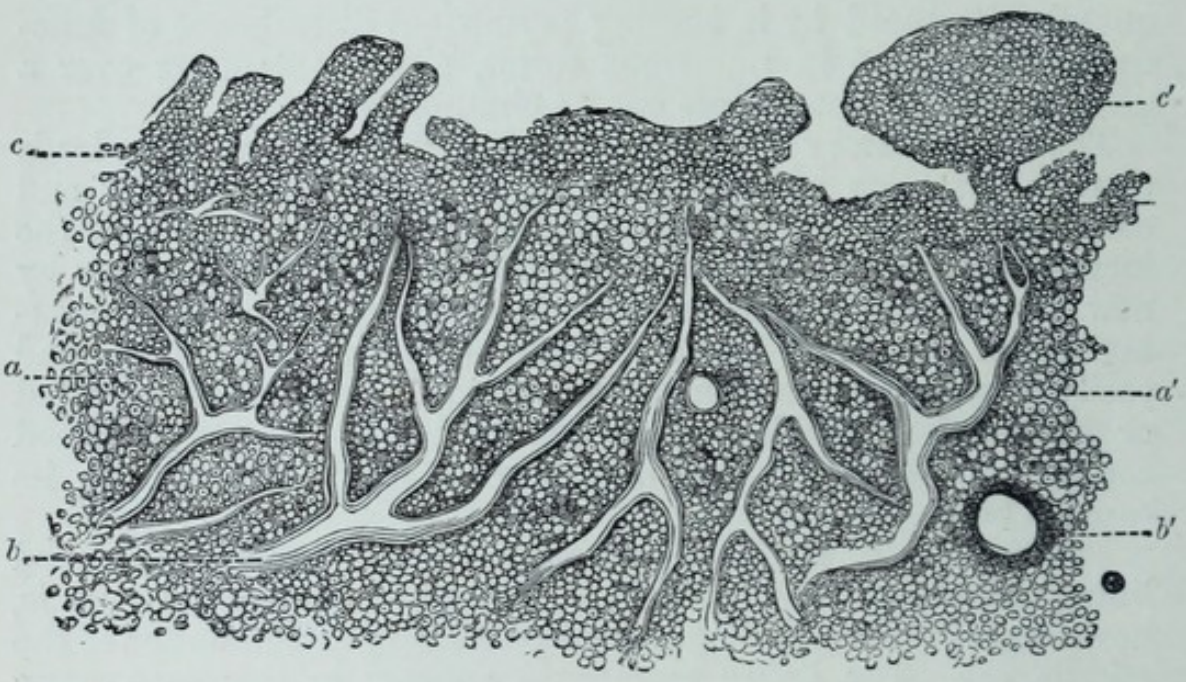

FIG. 47.—UPPER HALF OF A SECTION OF THE HYPERTROPHIED MUCOUS MEMBRANE OF THE SUPERIOR WALL OF THE TYMPANIC CAVITY OF THE RIGHT EAR, 4 MM. THICK, FROM A MAN 42 YEARS OF AGE, WHO DIED OF PULMONARY PHTHISIS, AND WHO HAD SUFFERED SINCE CHILDHOOD FROM PURULENT INFLAMMATION OF THE MIDDLE EAR.

a, *a′* Closely packed round cells, of which the whole tissue between the bloodvessels consists; *b*, *b′*, Longitudinal and transverse sections of bloodvessels; *c*, Villous elevations of the hypertrophied mucous membrane; *c′*, A fungiform protuberance (Hartnack, Obj. 7).

trophy and tumefaction of the diseased mucous membrane in the course of chronic suppuration of the middle ear, as long as the purulent process lasts. In cases, however, where hypertrophy and thickening of the mucous membrane remain after the suppuration has ceased, the round cells are more scanty, and the stratum of connective tissue is hypertrophied and condensed, partly by increase in bulk of the normal connective tissue, partly by transformation of those round cells into fibrous connective tissue. The connective tissue is also here and there interspersed with enlarged or contracted bloodvessels, with enlarged lymphatic canals and cystic spaces, and sometimes coloured in circumscribed areas by blackish-brown, granular, star-shaped or flaky pigment.

Of special importance in the causation of permanent disturbances of the function of hearing is the development of bands and bridges of connective tissue, by which the membrana tympani and the ossicula are connected in an abnormal manner with each other and with the walls of the tympanic cavity, whereby the sound-conducting apparatus must partially lose its power of vibration.

These newly-formed bridges and pseudo-membranes are developed mostly by mutual contact and adhesion of the proliferating growths of connective tissue, especially if the surfaces which are in contact are stripped of their epithelial layer. They must be distinguished from those ligamentous bridges of connective tissue which, as I was the first to prove, are often found more or less highly developed extending in the normal condition between the membrana tympani, the ossicula and the inner wall of the tympanic cavity, and which are to be considered as the residuum of the gelatinous connective tissue filling the tympanic cavity during the fœtal state. On the other hand, however, it is probable that many highly-developed, striated structures in diseased tympana have been produced only by inflammatory increase in bulk of those prolongations of connective tissue, which often occur in the normal state.

Not less significant in the causation of important disturbances of the function is the increase in bulk and condensation of the connective tissue in the mucous membrane covering the inner wall of the tympanic cavity. For in this case either in extensive inflammation of the middle ear, but oftener in circumscribed inflammation, confined to the immediate neighbourhood of the fenestræ of the labyrinth, condensation and contraction of the connective-tissue layer take place, and in the periosteal layer of the mucous membrane there is often a transformation of the fibrillous connective tissue into bright bands, similar to the fibres of the membrana tympani, which is considered by Wendt, in agreement with Virchow, as sclerosed connective tissue. In these cases the connective tissue is mostly impregnated with calcareous salts, stiff and inflexible. These changes frequently lead to anchylosis of the crura of the stapes with the niche of the fenestra ovalis, of the margin of the stapes with the margin of the fenestra ovalis and in rarer cases to condensation of the covering of the membrana tympani secundaria. Moreover the condensation of the connective tissue at the points of contact of the ossicula with the walls of the tympanic cavity, as well as in the covering of the articulations of the ossicula, leads to their abnormal fixture and decrease in their power of vibration.

More rarely inflammations of the lining membrane of the middle ear result in (1) calcification, developed in the course of chronic affections; (2) transformation into osteoid tissue, and (3) ossification of the condensed mucous membrane (Wendt); also

(4) tuberculosis of the lining membrane, when it decays into a cheesy substance, consisting of fragments of tissue, molecular detritus and fat-globules; (5) ulceration; and lastly (6), phthisis of the mucous membrane, its tissue being completely wasted away and large tracts of the osseous wall of the cavity being laid quite bare. This change I found in a few cases of chronic suppuration of the middle ear in the course of advanced pulmonary phthisis.

Lastly, attention must be drawn to some pathological changes in the tympanic cavity, hitherto but little regarded. They consist of union and eventual anchylosis of the ossicular articulations, caused by chronic inflammation. They arise either in the course of an inflammation of the middle ear, accompanied by condensation of the mucous membrane (Zaufal); or sometimes without any traceable signs of a pathological process having taken place in the lining membrane. Thus I found several times an anchylosis of the articular surfaces of the malleus and incus, without other change in the middle ear, to be the cause of a considerable disturbance in the function of hearing. The rare cases of anchylosis of the articulation of the incus and the stapes, however, were only observed after chronic purulent inflammations of the middle ear. But most frequently pathological alterations take place in the stapedio-vestibular articulation in the course of chronic inflammations of the middle ear, sometimes also with a perfectly normal state of the lining membrane. For the fibrous ligament (lig. orbiculare stapedis, *vide* p. 40), which connects the margin of the foot-plate of the stapes with the margin of the fenestra ovalis, becomes stiff and firm by deposit of calcareous salts, by which the stapes loses its mobility and power of vibration in the fenestra ovalis either partially or completely.*

We are indebted to Moos for exact details regarding the histological alterations in cases of chronic swelling of the Eustachian tube (*A. F. A. u. O.* vol. v.). Their essence is, that all the folds of mucous membrane are partially or completely levelled, with the exception of those of the median wall. The epithelium becomes more liable to decay; the submucous and interacinous connective tissue is hypertrophied, and their prolongations form a connection with the extremities of the fascia salpingo-pharyngea, which are also hypertrophied, and with the perichondrium. The walls of the gland-cavities become thicker, and their form changed; dilatation of their canals occurs as a rule only near their apertures. Part of the gland-substance is displaced and atrophied by the tendinous extremity of the hypertrophied abductor tubae; in other respects, however, no new formation of acini takes place.

* Wendt observed a case where proliferation of the cartilaginous layer, covering the margin of the fenestra ovalis, was the cause of a secondary alteration in the stapedio-vestibular articulation (*Arch. f. Heilk.* vol. xiv. p. 286).

In several ears examined by me, where during life a chronic suppurative inflammation of the middle ear had existed, I found in sections that the mucous membrane of the cartilaginous part of the Eustachian tube was covered by an opaque and fatty epithelium, stratified several times, the lumen of the dilated gland canals was filled with a crumbling substance, consisting of secretion and dead epithelial cells, the closed follicles of the so-called tonsils of the tube were dilated, the interstitial connective tissue greatly hypertrophied, the cartilage cells of the tube fatty and partly stained of a brownish colour by a finely granular pigment.

The inflammatory changes in the lining membrane of the mastoid cells are, on the whole, the same as those of the lining membrane of the tympanic cavity. The swelling, tumefaction and proliferation of the lining membrane of the cells often attain such a high degree, that the cellular spaces are completely filled by them. The cells often contain serous, gelatinous, or purulent secretion, or thickened cheesy retention-products.

d. Free Exudation in the Middle Ear.

Inflammatory processes in the lining membrane of the middle ear often lead to the effusion of free exudations into that cavity. According to the degree and the character of the inflammation, the exudations present differences with regard to consistence, colour and morphological composition, the knowledge of which is important as regards both diagnosis and treatment. They appear :

(1.) As a thin, serous, yellowish fluid, containing only a very few pus-corpuscles and exfoliated epithelial cells ;

(2.) As a thick, colloid, syrupy or tough and viscid mucous substance of a yellowish colour, in which pus and mucous corpuscles and exfoliated and fatty epithelial cells are in somewhat greater abundance than in the serous exudation ;

(3.) As a purulent, yellowish-green, creamy fluid, which is principally composed of pus-corpuscles ;

(4.) As muco-purulent exudation, consisting of a tough and cloudy mucous substance with a great quantity of pus-cells ;

(5.) As fibrinous, hæmorrhagic exudation, but seldom croupous.

Besides the above, the exudations frequently contain coloured blood-corpuscles, due either to extravasation through the vascular wall, or to rupture of a bloodvessel, also amorphous flakes of pigment, cholesterine crystals, vibriones and fungus-spores.

The two first forms, the serous and the colloid or mucous effusions, occur chiefly in inflammations which pass away without inflammatory phenomena of reaction ; the purulent and the muco-purulent exudations mostly in acute reactive inflammation and in perforating otitis media.

B. Review of the Pathological Basis of the Obstacles to the Conduction of Sound in the Middle Ear.

If we review the tissue changes of the lining membrane of the middle ear, it will be seen that inflammatory processes are either resolved without new formation of tissue, or they leave behind them organized, permanent, inflammatory products. In the first case the function of hearing will again become normal on the disappearance of the inflammatory process (curable inflammation of the middle ear); in the second case, however, the disturbance of hearing will be the greater, the more serious the obstacle to the conduction of sound produced by the inflammatory products, *i.e.*, the more firmly the sound-conducting structures are united to each other, and to the walls of the tympanic cavity.

The membrana tympani also is often affected by disease of the lining membrane of the middle ear. Even if its pathological alterations, to be described more fully further on, are of less account as regards functional disorders in general than those products of disease which impair the mobility of the ossicula, yet they are of great importance, an ocular inspection of the membrana tympani permitting in many cases a conclusion to be drawn as to the anatomical changes in the middle ear.

The pathological alterations which take place in the middle ear may be tabulated as follows:

a. Obstacles to the Conduction of Sound by Pathological Changes in the Membrana Tympani.

These are caused by:

1. Increase in bulk of the membrana tympani produced by—(*a*) serous infiltration of the membrane; (*b*) effusion in its layers, ending in the formation of abscesses, calcification and ossification; (*c*) formation of granulations, polypous growths or interstitial new formation of connective tissue with condensation of the membrane.

2. Anomalies of tension of the membrana tympani, the tension being either increased or decreased. The membrane may be too tense, (*a*) in consequence of the impermeability of the Eustachian tube, the membrane being forced inwards by atmospheric pressure; (*b*) by retraction of the tendon of the tensor tympani; (*c*) by abnormal adhesions of the membrana tympani with the ossicula or with the inner wall of the tympanic cavity; (*d*) by accumulation of interstitial exudations, and by deposits on the membrana tympani.

The tension of the membrane is lessened—(*a*) by inflammatory softening; (*b*) by disturbance of its connections, by rupture, perforation and losses of substance; (*c*) by total or partial atrophy of its layers, especially of the substantia propria; (*d*) by cicatricial formations; (*e*) by detachment of the membrane from the handle

of the malleus, by severing the articulations of the ossicula or the tendon of the tensor tympani.

b. Pathological Changes as Obstacles to the Conduction of Sound in the Ossicular Chain.

1. In the malleus: the obstacles to the conduction of sound in the malleus arise in consequence of—(*a*) membranous or osseous union with the superior wall of the tympanic cavity; (*b*) anchylosis of the articulation of malleus and incus; (*c*) anchylosis of the handle of the malleus with the long crus of the incus or with the stapes; (*d*) adhesions of the inferior extremity of the handle of the malleus with the inner wall of the tympanic cavity; (*e*) thickening and rigidity of its axial ligament and of its check-bands; (*f*) retraction of the tendon of the tensor tympani; (*g*) increase in bulk of the malleus; (*h*) fracture, detachment from the membrana tympani and dislocation.

2. In the incus: in consequence of—(*a*) anchylosis of the outer surface of the body of the incus with the outer wall of the tympanic cavity, or the superior margin of the roof; (*b*) fixture of the short process of the incus to the saddle-shaped depression at the inferior angle of the entrance into the mastoid process; (*c*) anchylosis of the long crus of the incus to the membrana tympani or to the posterior wall of the tympanic cavity, more rarely to the inner wall; (*d*) ossification of the connection between the long crus of the incus and the capitulum of the stapes (articulation of stapes and incus); (*e*) dislocation from its articulation and its partial destruction.

3. In the stapes: in consequence of—(*a*) ligamentous or osseous union of its long crus with the walls of the niche of the fenestra ovalis (anchylosis of the crus of the stapes); (*b*) rigidity of the covering of the tympanic cavity of the foot-plate of the stapes; (*c*) osseous anchylosis of the margin of the foot-plate of the stapes to the margin of the fenestra ovalis (anchylosis of the foot-plate of the stapes); (*d*) loosening and dislocation of the stapes, and destruction of its crura; (*e*) retraction of the tendon of the stapedius.

Besides these pathological changes there have still to be mentioned as obstacles to the conduction of sound in the middle ear—(*a*) the serous, mucous or purulent exudations into the tympanum, or cheesy and cholesterine masses, which impair or suspend the power of vibration of the membrana tympani and of the ossicula by clogging them; (*b*) growths of connective tissue, which lie on the membrana tympani or unite with it, and which partly or completely envelop and fix the ossicula; (*c*) anomalies of tension of the ossicular chain: and these are amongst the most frequent obstacles in disease of the middle ear. Very often the excessive tension of the chain is a consequence of an

abnormal tension of the membrana tympani, whether this has arisen by decrease in the pressure of air in the tympanic cavity or by pathological changes of the membrane, or by adhesions of the same. Often, however, the abnormal tension of the ossicular chain is caused by tightness and rigidity of its articulations, by stiffness of the check-bands and folds of mucous membrane, or by abnormal adhesions. The tension of the chain will be diminished by inflammatory, ulcerative or traumatic loosening or separation of its articulations, and also by partial or total carious destruction and necrosis of one or more of the ossicula.

It has been pointed out in the beginning of this chapter, that inflammations of the middle ear cause not only the tissue changes already described, and thereby disorders of hearing of different degrees, but also sometimes inflammation of neighbouring vital organs. We reserve our detailed description of the affections of vital organs, consecutive to disease of the meatus, and will here only mention caries of the osseous walls of the middle ear, where the suppuration penetrates towards the cranial cavity and causes fatal meningitis or encephalo-meningitis; also inflammation of the veins in the cranial cavity, not due to caries, especially phlebitis and thrombosis of the lateral sinus with their consequences; as well as those destructive processes in which fatal pyæmia results from erosion of the transverse sinus; and lastly, the very rare erosion of the carotid canal and of the transverse sinus, with fatal hæmorrhage from the ear.*

II.—THE PHYSICAL METHODS OF EXAMINING THE ORGAN OF HEARING.

A. The Examination of the External Meatus and of the Membrana Tympani.

Examination of the external meatus and of the membrana tympani is indispensable to the knowledge of pathological changes in the organ of hearing. The membrana tympani, being covered on the outside by the cutis of the external meatus, and

* J. Toynbee, *A Descriptive Catalogue of Preparations Illustrative of the Diseases of the Ear*, London, 1857. The same, *The Diseases of the Ear*, London, 1860. V. Tröltsch, *Anatomische Beiträge zur Ohrenheilkunde*, Virchow's *Arch.*, vol. xvii. Wendt, *Beiträge zur pathol. Anatomie des Ohres*, *Arch. f. Heilk.*, vol. xi.; *Ueber das Verhalten des Gehörorgans und Nasenrachenraums bei Variola*, *ibid.* vol. xii.; *Secundäre Veränderungen, besonders der Schleimhaut im Mittelohre*, *ibid.* vol. xiv.; *Polypöse Hypertrophie der Schleimhaut des Mittelohrs*, *ibid.* Zaufal, *Die pathologisch-anatom. Untersuchung des Gehörorgans*, *Wien. med. Wochenschrift*, 1866. *Ueber das Vorkommen seröser Flüssigkeit in der Paukenhöhle*, *A. f. O.* vol. v. S. Moos, *Beiträge zur normalen und pathologischen Anatomie und zur Physiologie der Eustachschen Röhre*, Wiesbaden, 1874. The same, *Sectionsergebnisse von Ohrenkranken*, *Arch. f. A. u. O.* vol. iii. A. Politzer, *Studien uber Gefässveränderungen in der erkrankten Mittelohrauskleidung*, *A. f. O.* vol. vii. *Zur pathol. Histologie der Mittelohrauskleidung*, *ibid.* vol. ix.

on the inside by the mucous membrane of the tympanic cavity, is in intimate relation to the affections both of the external meatus and of the middle ear. The processes of disease going on in them cause changes in the membrana tympani, which may be recognized by ocular inspection, and enable conclusions to be drawn as to the pathological state of the external and middle ears. Now, experience shows that the diseases of the middle ear most frequently form the basis of functional disturbance in this organ, and since these affections are often combined with changes in the membrana tympani, it will be seen that the state of the latter is of great importance in the diagnosis of affections of the former. It must, however, be distinctly noted, that alterations in the membrana tympani are observed in a considerable number of persons of normal hearing, without the least disturbance of function. These alterations are to be considered as inherent anomalies, or as the residue of some pathological process which had ended in complete cure. On the other hand, the membrana tympani is perfectly normal in a considerable number of persons whose hearing is disordered to a high degree. Even though such a negative examination is not of the same value as one that shows characteristic changes in the membrana tympani, yet it supplies the valuable information that the cause of the disorder is situated in such cases not near the membrana tympani, but in the deeper portion of the organ, either in the inner wall of the tympanum, or in the labyrinth.

Although, as has been said, we can often recognise the nature of the pathological changes in the middle ear by the alterations in the membrana tympani, we are never able to draw a conclusion as to the degree of functional disturbance from the extent of the visible alterations in the membrane; for extensive tissue changes in it, such as perforations, cicatrices and calcifications, are often accompanied only by a trifling disturbance of hearing, while on the contrary, with slight deviations from the normal state of the membrana tympani, a high degree of deafness is often observed. As already mentioned, disturbances of the function in the case of diseases of the middle ear are most frequently caused by those products of disease which diminish the mobility and power of vibration of the ossicula.

From the oblique position of the membrane, it follows that we see it in perspective during ocular examination, and that, therefore, its pathological alterations will appear somewhat different from what they in reality are. For this reason, the result of the post-mortem examination sometimes does not agree with the state of the membrane as observed in life, because our estimate of the anomaly of curvature and of the extent of the pathological alterations must necessarily lose in precision by its oblique position. But it must not be forgotten that this disagreement often has a different cause; for after death the state of the mem-

brane frequently appears considerably changed by alterations of its blood-contents, by its greater dryness, or by maceration.

The considerable progress in the diagnosis of the diseases of the ear which has lately been made, is owing not only to pathological investigations, but also to recent improvements in the methods of examining the membrane. Itard's bivalve ear-specula, formerly in use, and still employed by many surgeons, have justly been laid aside on account of their defectiveness in comparison with the more recent and more reliable instruments.

The most practical method, which is now generally in use, is v. Tröltsch's examination with the conical speculum and a concave mirror which serves as reflector. These ear-specula, invented by Dr. Jgnaz Gruber, and modified in shape and size by

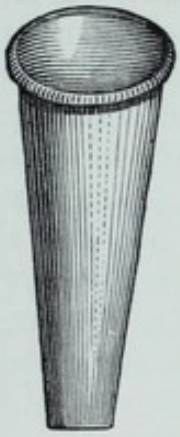

FIG. 48.—WILDE'S SPECULUM.

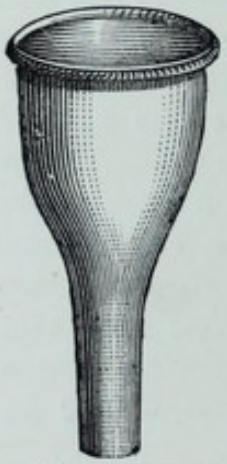

FIG. 49.—ERHARD'S SPECULUM.

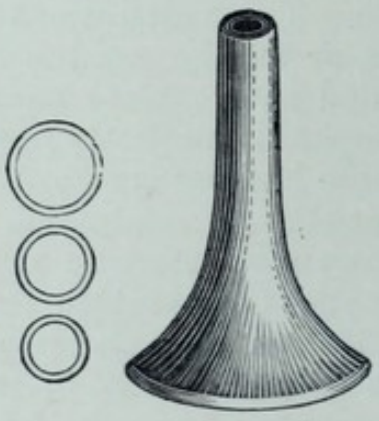

FIG. 50.—THE AUTHOR'S SPECULUM OF VULCANITE.

Arlt, Toynbee, Wilde (Fig. 48), and Erhard (Fig. 49), consist of metal, with a polished and blackened interior. They are either funnel-shaped or like a truncated cone, and have a round or oval aperture at their extremity; but this, as well as the shape of the speculum, is of little importance.

Some years ago I proposed the employment of vulcanite instead of metal in the manufacture of the speculum. These vulcanite specula (Fig. 50) have the advantage of being considerably lighter—so that they remain in the required position—than those of metal, and also of not producing the unpleasant chilly sensation of the polished metal speculum. Their black interior serves to render the surface of the membrane more distinct by contrast, and with judicious illumination the view of the membrane will therefore appear clearer than with the same light reflected from a polished metal speculum. Besides, injury to the lining membrane of the meatus will not take place so easily, even with a careless manipulation of the vulcanite speculum, as with the sharp-edged metal one.

The different sizes, 8, 6, and 4 mm. in diameter at the aperture (Fig. 50), are constructed to suit various meatuses.

These specula, combined with a reflecting concave mirror

perforated in the centre, 7-8 cm. in diameter and of 10-15 cm. focal distance, give, with sufficient light, an accurate view of the membrana tympani, from which the eye of the observer is only at a moderate distance; while during examination with the bivalve specula, the eye must remain at too great a distance from the object, so as to avoid obstructing the light by the head.

Refractive anomalies of the eye, which sometimes occur, often necessitate the application of corrective lenses to obtain a distinct view of the membrana tympani. Persons of normal sight and people short-sighted to a moderate degree do not require these lenses. But persons with presbyopia or hypermetropia must positively use convex lenses, as I have found out by experience in my classes, for most of them can see the membrane only very indistinctly without a corrective lens, while with one suitable to the degree of the refractive anomaly they not only see the membrane distinctly, but also somewhat magnified. These lenses are best fixed by a contrivance on the back of the mirror, constructed similarly to that in Stellwags' ophthalmoscope. It consists of a semicircle of vulcanite, furnished with a groove for the reception of the corrective lens, and capable of being removed from the aperture of the mirror by means of a joint fixed to the upper extremity of the handle.

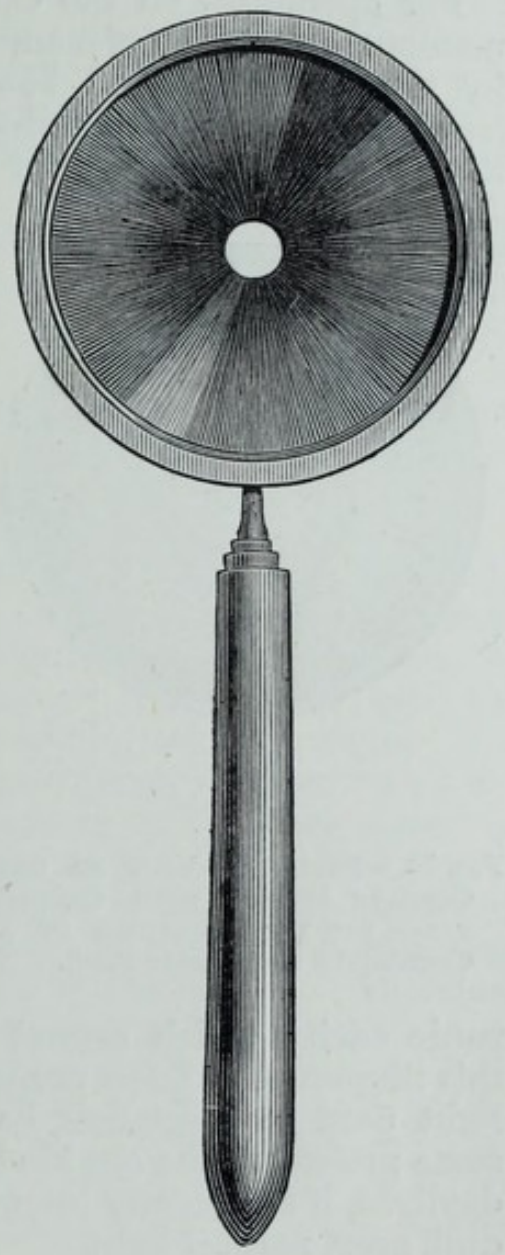

Fig. 51.—Concave Mirror perforated in the Centre, with Handle (half Size).

For the production of a magnified image of the membrana tympani bi-convex lenses are used, which by means of a simple contrivance, designed by Dr. Auerbach of Hamburg, are fixed obliquely at the entrance of the speculum. The most distinct enlargements can be obtained by lenses with a focal distance of 6·5-7·5 cm. Moderate enlargements can also be obtained by convex lenses of greater focal distance, which are fixed as above on the posterior surface of the mirror. By magnifying the membrana tympani many changes, especially vascular ramifications,

small deposits, projections and depressions, movable exudation and air-bubbles in the tympanic cavity, come distinctly into view. Such enlargements are of value chiefly to persons with hypermetropia or presbyopia, while short-sighted people can do without them.*

For operations on the ear, where both hands are required for manipulation, the best manner of fixing the mirror to the head is by Semeleder's frontal band, to which the concave mirror is fastened by means of a ball-and-socket joint in front of the eye of the observer. Every mirror can be so constructed that it can be used with a handle as well as with a frontal band. (To be obtained from Leiter, in Vienna.)

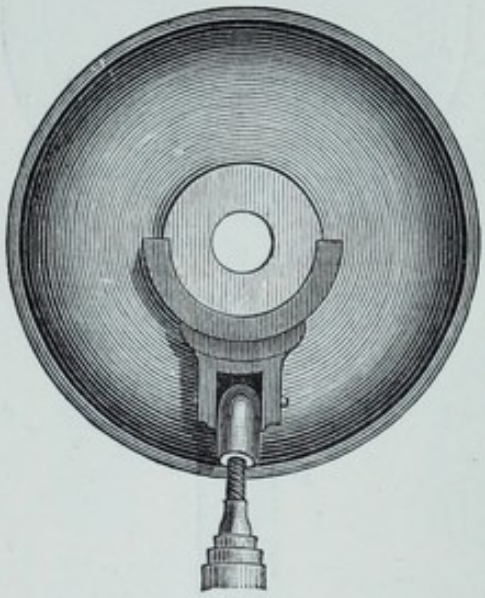

FIG. 52.—POSTERIOR VIEW OF THE CONCAVE MIRROR WITH CONTRIVANCE FOR THE RECEPTION OF A CORRECTIVE LENS (HALF SIZE).

The illumination of the membrana tympani is effected either by ordinary daylight or by artificial light. The disadvantage of the latter, especially if reddish-yellow, is that the colour of the membrane is more or less altered by it. Ordinary daylight, by which the shades of colour are perceived in the most natural manner, is to be preferred to all other kinds of light, the best form of it being that reflected from a white cloud, that from a blue sky being too dull. Illumination by direct sunlight, however, is too glaring, but is sometimes useful in showing exudations in the tympanic cavity which cannot be perceived by ordinary light; in this illumination Lucæ proposes the use of a plane mirror. The light used by specialists, however, is greatly a matter of habit, some preferring the one kind, some the other. Personally I prefer daylight, if sufficiently intense, but use an artificial rather than a dull, grey, natural light.

The position of the patient during the examination is of importance. The ear which is to be examined must be turned from the light, so that the rays, falling upon the concave mirror at an angle of 45°, are reflected directly into the lumen of the external meatus.

To insert the speculum into the meatus, it is necessary with the left fore and middle fingers to draw the auricle a little backwards and upwards, as also towards the observer, so that the axes of the osseous and cartilaginous portions of the meatus, which

* Brunton's ear-speculum, used especially by English military surgeons, is much more troublesome, on account of the difficulty of concentrating the descending light upon the membrana tympani, than the conical speculum and the concave mirror.

form an angle in their natural position, are brought into a straight line, thus rendering a free view of the membrana tympani possible.

Then the speculum, slightly warmed, is inserted into the cartilaginous meatus with a slight rotatory movement by means of the thumb and forefinger of the right hand, so far that the hairs which obstruct the view are completely turned aside. If the instrument has penetrated to the osseous meatus, which can easily be noticed by the slight resistance, any attempt to push it farther must be avoided, owing to the violent pain caused by pressure upon the nerves of this part.* The mirror, held in the right hand, slightly reclining on the glabella, is brought so near the ear that the rays of light, reflected through the speculum, are focussed almost at the membrana tympani. It is, however, seldom possible to view the meatus and the membrana tympani at once; to view their separate portions one after the other it is therefore necessary to move with the unoccupied thumb the speculum as well as the mirror in all directions, which the observer's eye must also follow through the central aperture.†

In spite of the exact observance of these instructions we get in some cases only an imperfect view of the membrane, in consequence of various obstructions, which occur sometimes in the cartilaginous, sometimes in the osseous meatus, and bear the character either of normal or of pathological formations. The abundant growth of hair in the cartilaginous meatus, which extends into the osseous portion, obstructs in the first place the examination, in so far as the pushing aside of the hair by the speculum in the deeper lying portions is not easily achieved. This impediment is removed most easily by waxing the projecting hairs and pressing them to the wall of the meatus. Abundant ceruminal deposits are also obstructive, as they either act as plugs, or are laid on the walls of the meatus in such thick layers that they narrow its lumen considerably. The removal of this abnormal deposit is effected by soaking and syringing, or by the use of a vulcanite ear-scoop, or of one of the blades of Guye's fenestrated forceps. Detached epidermic scales and whitish, mother-of-pearl-like, epidermic layers, hanging down like mem-

* The introduction of the speculum, especially in old persons, often causes a troublesome reflex cough by irritation of the n. auric. vagi.

† The observer must get used to keeping both eyes open during the examination, and always to inspect the membrana tympani with that eye before which the mirror is held. E. de Rossi has constructed a binocular otoscope, which consists of a plane glass plate, fixed to a frontal band, from which the rays of the sun are reflected into the meatus. Eysell recommends for binocular inspection two prisms of a small refractive angle (3°-5°), which are inserted between the reflector and the speculum. By this contrivance the observer gets a transverse double view, which after some practice will melt into one. The binocular inspection of the membrane is, however, of little advantage to the expert, while difficulties are created for the inexperienced observer by the great distance from the object with De Rossi's instrument, and by having to combine the transverse views of the membrane obtained with Eysell's prisms into one image.

branes or strings, and mostly to be found in the osseous meatus, are best removed with a bent forceps.

The forceps which I have used for this purpose for years (Fig. 53) has cross blades, and its narrow spoon-shaped extremities are grooved on their inner surface. It is to be preferred to forceps without cross blades, because opening of the blades in the meatus is less interfered with by the speculum.

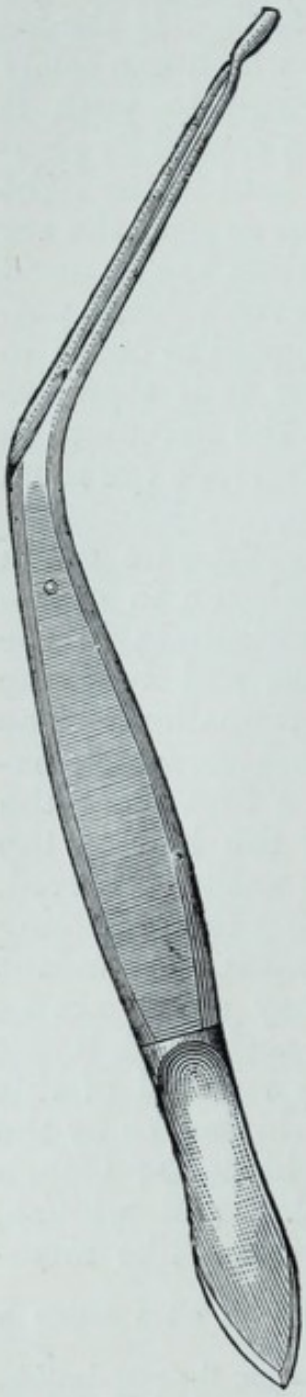

FIG. 53.—BENT FORCEPS WITH CROSS BLADES.

More important, because their removal is impossible, are the hindrances to examination which arise from inherent narrowness of the meatus, or from the abnormal bulging forward of the anterior wall of the osseous portion. This constriction has as its consequence an insufficient illumination of the range of view, while the more or less pronounced bulging out interferes with the inspection of the whole membrane so much, that the portion before the handle of the malleus is completely hidden, and sometimes even the handle of the malleus can only partly be seen.

Among the pathological changes which render the membrana tympani temporarily or permanently inaccessible for examination, are specially to be noted inflammatory affections of the lining membrane of the meatus with stricture, accumulation of pus and mucus, granulations, polypi and exostoses.

Normal State of the Membrana Tympani.—When the membrana tympani is seen perfectly and distinctly with proper illumination, its colour, transparency, lustre, inclination and curvature, as well as the position of the handle of the malleus and of its short process, have separately to be considered, as the relations of these to each other collectively constitute the characteristic appearance of the normal, as well as of the pathologically altered membrane.

Concerning the *colour* of the normal membrana tympani, it must be remembered that this membrane is a more or less transparent medium which reflects a portion of the light thrown upon it, while it permits of another portion passing through it to illuminate the tympanic cavity, from the opposite inferior wall of which a portion of this light is reflected back through the membrane, and reaches the observer's eye. The colour of the membrane, as seen, is therefore composite, and depends upon its intrinsic colour, the kind of light

employed, and the quantity and colour of the rays reflected back from the promontory.

The true colour of the membrane cannot be exactly made out during life, as the kind of light and the surroundings have a very great influence upon it; and in the dead body, where the natural colour suffers by maceration of the epidermic layers, or by evaporation, the change is such, that no approximately correct conclusion as to the real colour can be drawn. The kind of light used during examination has always a considerable influence on its colour. This can easily be confirmed by examining as above the same membrane with the light of a clear blue sky, and then with the light of an oil-lamp; the delicately blue tinge of the membrane will be unmistakable in the first case, and in the second it will assume a reddish-yellow colour. The quantity and the colour of the light reflected from the promontory are dependent, first, on the degree of transparency of the membrane; secondly, on its distance from the promontory; and, lastly, on the angle of inclination to the axis of the meatus; for the more oblique the position of the membrane the thicker is the substance through which the rays of light which are reflected by the promontory must pass to reach the eye, and their intensity must therefore also be less.

As the distance of the different portions of the membrane from the inner wall of the tympanic cavity varies considerably, the membrane will present in its different parts various colours with the same kind of light.

The normal colour of the membrana tympani is best described as a neutral or pearly grey, with a slight tinge of light brownish-yellow. The grey is darkest in the anterior portion, in the angle between the handle of the malleus and the cone of light, and lighter in the posterior portion. The colour of the latter part is in many cases modified at the superior boundary by v. Tröltsch's pouch, situated on the inner surface of the membrane, which in transparent membranes shines through as a whitish-grey opacity, extending from the handle of the malleus backwards. Behind the handle in the posterior superior quadrant, the lower portion of the illuminated long crus of the incus (Figs. 54 and 55) is often, and the posterior crus of the stapes less frequently, plainly visible if the membrane be transparent. The membrane is also slightly yellowish-grey behind and a little above the inferior extremity of the handle of the malleus, which is caused by the bone-yellow rays reflected by the promontory. To this colour is often added a glimmering lustre, due to the light reflected from a moist and smooth spot on the mucous membrane of the promontory. A pronounced dark spot in the posterior inferior quadrant corresponds with the niche of the fenestra rotunda.

Besides these varieties in the colour of the normal membrane, there are also some which depend upon age. In childhood the membrane often appears greyish, opaque, and dim, but not un-

frequently transparent and lustrous; in children, however, the grey colour of the membrane is often much darker, and the promontory is much more frequently seen shining through it. There are just as often changes in old age, which are characterized by a uniformly grey and often lustreless appearance of the membrane.

At the inspection of the membrana tympani the short process of the malleus, which is visible at the anterior superior pole as a white, pointed protuberance, catches the eye first (Figs. 54 and 55). It is continuous with the handle, which, imbedded in the membrane as a yellowish-white stria, extends backwards and downwards, ending at the umbo in a greyish, spatular expansion.

In my *Beleuchtungsbilder des Trommelfells* (1865) I have given as the cause of this umbilical opacity the thickening of the membrane due to the convergence of the radiate fibres at this point. Trautmann has tried to prove that this grey opacity, described by him as the 'yellow spot' on the membrane, is caused by the anterior surface of the handle of the malleus being rotated on its axis at an angle of 45°. But that this is incorrect can easily be proved by comparing the extent of the umbilical opacity in life with its appearance in the dried preparation, and with the extremity of the handle in the macerated malleus. If the explanations given by Trautmann were correct, the umbilical opacity must have the same extent as well on the dried and macerated membrana tympani, as in the living. This is, however, not the case; for it is generally several times wider than the osseous extremity of the handle of the malleus. After a number of examinations during the last few years, I have come to the conclusion that this opacity is caused partly by the radiate descending fibres of Prussak at the umbo, mainly, however, by the deposit of small cartilaginous cells round the inferior extremity of the handle of the malleus, and that the extent of the opacity depends on the size of the area in which this cartilaginous deposit takes place. Besides that one often finds at the anterior periphery of the membrane a tendinous-grey opacity, corresponding with the annulus tendineus, which is not unlike the arcus senilis of the cornea.

The *lustre* of the membrana tympani is of importance in estimating its condition in so far as in many cases, during movements of the membrane, we can draw conclusions from the alteration of the shape and size of the spot designated 'the cone of light,' not only as to the state of the membrane itself, but also as to the permeability of the Eustachian tube. This sharply-defined and usually triangular spot of light, which exists in addition to the delicate lustre spread over the whole surface (v. Tröltsch), is situated in the inferior quadrant of the membrane (Figs. 54 and 55); it commences with its apex in front of the umbo, and extends forwards and downwards, so that it forms an obtuse

angle forwards with the direction of the handle of the malleus, and this angle is greater, the slighter the inclination of the membrane to the meatus. The shape of this bright spot varies greatly, partly on account of differences in the inclination of the membrane, partly on account of variations in its curvature. It is often interrupted in its continuity, so that between its apex and its base there is a portion without reflection; sometimes it seems divided into two parts in its longitudinal direction, or delicately striped. It seldom extends to the periphery of the membrane; and often the anterior portion of the reflection is effaced, and only its apex is visible in front of the umbo, as a small, irregular, lustrous spot. The knowledge of all these varieties in the normal state is of importance, because they might give rise to erroneous interpretations of pathological changes.

FIG. 54.—NORMAL MEMBRANA TYMPANI OF THE RIGHT EAR.

FIG. 55.—NORMAL MEMBRANA TYMPANI OF THE LEFT EAR.

(Double size.)

Authors are greatly divided as to the origin of this spot of light. Wilde thinks that it is caused by the external convexity of the membrane. Although undoubtedly the curvature of the membrane exerts an influence upon the size and form of this spot, it is of minor importance for its production in this place. The principal cause is the inclination of the membrane to the axis of the meatus, in connection with the concavity of the membrane, produced by the handle of the malleus, as the examinations (*A. f. O.* vol. i.) made by me have shown.

In a carefully-dried preparation of the normal ear we observe during illumination of the membrana tympani the triangular reflection of light in the same spot as in the living ear; by moving the eye in different directions this reflection, just as in the living, will alter its position very little, because the axis of the meatus, therefore nearly the axis of our eye, can change very little in respect to the inclination of the membrane. If we remove the meatus from the membrana tympani in such a manner that the latter simply remains in the osseous groove, we will, by turning the membrane so that other portions are placed in the position of the original spot, perceive in all these positions

a reflection of light which retains almost the same form and position as the original cone of light, but which generally appears large, irregular, and ill-defined in the portions behind the handle, on account of the great difference in the curvature of this part as compared with that of the anterior portion.

Now comes the question, What causes this spot of light? If the membrana tympani were a plane surface, no reflection of light would arise by its inclination to the meatus, as all the light thrown upon it, according to the law of reflection, would be reflected back against the anterior inferior wall of the meatus. In consequence of the inward curvature of the membrane by the traction of the handle of the malleus, the different portions of the membrane are so altered in their inclination that the anterior portion comes to be exactly opposite the axis of our eye, and therefore the light which is thrown upon this place is reflected into our eye. The correctness of this view can be tested by stretching a lustrous animal membrane over a large ring, giving it the inclination of the membrana tympani; no reflection will be perceived if the membrane is viewed with the mirror in the same direction in which the membrana tympani is observed, but a reflection will at once take place at the spot where the reflection of light appears on the membrana tympani, if the central portion of the animal membrane is drawn or pressed inwards.*

The form and size of the cone of light undergo many changes in the diseases of the membrana tympani and of the middle ear, which are of special diagnostic value, if we have an opportunity of observing them during the course of the disease. On the whole, however, these changes of the cone only aid the diagnosis in conjunction with other symptoms, as similar alterations of the cone are often observed in persons of normal hearing (Duplay).

Of most importance in diagnosis are those changes in its form which arise by variation of the pressure of air in the tympanic cavity, and which in many cases can be used in determining the permeability of the Eustachian tube. For if air is pressed into the tympanic cavity by means of the Valsalvian experiment, or the air in the tympanic cavity is rarefied during an act of swallowing with closed nostrils, a change in the form of the reflection of light will be observed on inspection of the membrana tympani, as necessarily the curvature of the membrane must be altered by these rapid variations in the pressure of air. If we therefore perceive an alteration in the spot of light during the above-named manipulations, we can say with certainty that the tube is permeable. But we can by no means infer the contrary from an absence of change in its form or size, for often not the slightest motion of the membrana tympani, even in the normal state, is visible with very rapid and great changes in the pressure of air, as for

* This explanation was offered by me in *A. f. O.* vol. i., and has been confirmed by Trautmann, *A. f. O.* vols. viii., ix. and x.

instance, during catheterization, while a manometrical tube, inserted into the meatus, undoubtedly indicates the presence of a change in the curvature.

Besides this cone of light, there are reflections also at other places on the membrana tympani in its normal state; especially a faint lustre on the posterior superior portion, and here and there a small reflection of light in the depression of Shrapnell's membrane.

The influence of the inclination of the membrane upon the estimation of its state has been prominently put forward above. We have here only to add, that our judgment of the degree of the inclination during the inspection of the membrane is altogether very uncertain, as we generally estimate it to be much less than the examination of anatomical preparations show it to be. But generally the extent of surface of the membrane will appear less, the stronger the membrana tympani inclines to the axis of the meatus, on account of the perspective diminution in which we see the membrane. Besides, our judgment as to the inclination of the membrane is often influenced by the width of the osseous meatus in such a way, that with a wide meatus the membrane seems to be placed more perpendicularly than with a narrow meatus.

The curvature of the membrane has also an influence upon our ability to judge of its pathological state. It varies in different individuals in the same manner as the inclination, and our judgment as to the degree of curvature at the inspection in the living is also apt to be faulty, as it appears to us less curved inward than it is in reality.

According to my examinations, the transparency of the membrane exercises an important influence upon the judgment of its curvature. The more transparent the membrane, the less it seems curved; the more opaque the membrane, the more the funnel-shaped concavity of the external surface seems to project. This can easily be proved by the experiment of examining, in a dried preparation of the organ of hearing, first the transparent membrane by means of a mirror, just as in the living; then the interior surface of the membrane is painted with a thin coat of white paint, and again inspected by means of the mirror from the external meatus.

This fact is of importance, for I am convinced that in cases of slight opacity even specialists diagnose retraction of the membrana tympani, when such a condition does not exist. The most important factor in the diagnosis of a pronounced anomaly of curvature of the membrane is, however, the position of the handle of the malleus; we generally infer increased inward curvature, the more the inferior extremity of the handle is moved inwards, and the shorter it appears. But this cannot be laid down as a rule for all cases, as will be seen by-and-by.

If we take a general survey of the foregoing, the following normal appearance of the membrana tympani results. At the anterior superior pole of the membrane (Figs. 54 and 55) there is seen a whitish projecting spot, *the short process of the malleus*, from which there extends backwards, downwards, and towards the centre of the membrane a whitish or yellowish process, expanding like a spatula at its inferior extremity, *the handle of the malleus*. In front of and below the extremity of this handle there is a triangular spot of light, *the cone of light*, with its apex at the umbo and its base directed forwards and downwards towards the periphery. The portion of the membrana tympani between the handle of the malleus, the light spot, and the anterior wall of the meatus, generally of a darker grey than the rest of the membrane, is seldom visible as far as the periphery; the portion behind the handle, which is separated from the posterior superior wall of the meatus by a lightish-coloured line, more or less pronounced, appears much larger and lighter in its colour, the latter being modified as above described (see p. 97).

The examination of the membrana tympani with Siegle's pneumatic speculum has still to be described. This instrument (Fig. 56), which is of importance in the diagnosis of the affections of the middle ear, differs from the ordinary speculum in having its wide extremity closed by an obliquely inserted thin plate of glass, and a small nipple, projecting on the side to which is fastened an india-rubber tube, furnished with a small balloon. By putting a small piece of india-rubber tubing on the end of the speculum, the instrument can be hermetically fixed in the external meatus.

To examine the membrane, the speculum, inserted into the meatus, is fixed with the left hand, so that reflection from the glass plate does not interfere with the examination. Then the membrana tympani is illuminated by means of the concave mirror, and the air in the external meatus is alternately condensed and rarefied by the balloon, by compressing it slightly with two fingers of the right hand, quickly releasing it after each pressure. Condensation of air by blowing into the speculum with the mouth is unsuitable, as the inner surface of the glass is dimmed by the condensed breath.

In the normal state, during this method of examination, considerable motions of the membrana tympani are observed, greatest midway between the malleus and the periphery. The most striking sign of the motion is the change in the form of the cone of light, which becomes considerably smaller during condensation.

But on close inspection of the handle of the malleus a very distinct motion in it is also visible, for during condensation either its inferior extremity moves downwards and inwards, or the whole handle moves in this direction. This mobility of the handle of

the malleus undergoes many changes in disease of the middle ear, being lost either partially or completely by thickening and inflexibility of the membrana tympani, or by rigidity and anchylosis of the articulation of malleus and incus, or lastly, by abnormal adhesion of the head of the malleus to the adjacent walls of the tympanic cavity.

As Siegle has mentioned, the pneumatic speculum is used with most success in cases where it is required to ascertain whether the membrana tympani or some of its parts be adherent to the inner wall of the tympanic cavity. The examination shows that those portions of the membrane which are united with the opposite wall of the tympanic cavity remain unmoved during

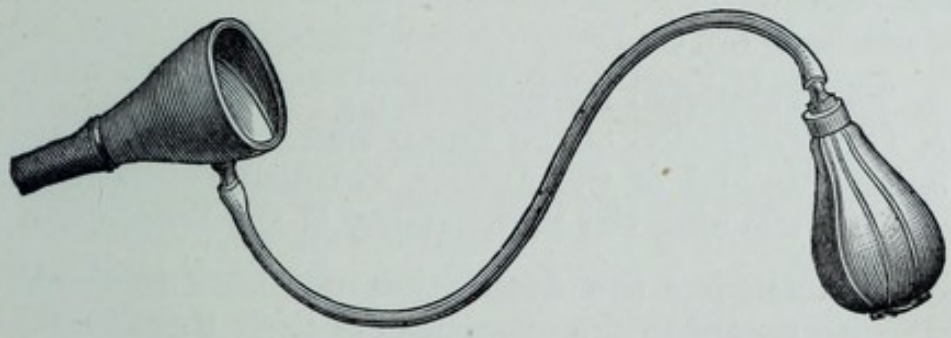

FIG. 56.—PNEUMATIC EAR-SPECULUM OF SIEGLE.
(Speculum $\frac{1}{2}$ size, balloon $\frac{1}{4}$ size.)

condensation and rarefaction of air with this instrument, while the portions which are not adherent exhibit a distinct motion. In cases of closure of the Eustachian tube, where the membrana tympani is strongly drawn inwards by the rarefaction of air in the tympanic cavity, I also found the mobility of the membrane reduced to a minimum, a symptom to which reference will be made in detail in the description of the pathological changes in the Eustachian tube.

The behaviour of the bloodvessels in the membrana tympani and in the external meatus during this mode of examination is, according to my observations, of special interest. For if these vessels are strongly injected, that injection will partly or altogether disappear during the condensation of air with the pneumatic speculum; as soon, however, as the condensation of air ceases, the bloodvessels quickly fill again.*

* Fabricius Hildanus, inventor of the aural speculum; *Opera, quæ extant omnia*, Francof. 1646. W. Kramer, *Die Erkenntniss und Heilung der Ohrenkrankheiten*, Berlin, 1849. C. G. Lincke, *Handbuch der theoret. und pract. Ohrenheilkunde*, Leipzig, 1837. J. M. G. Itard, *Traité des Maladies de l'Oreille et de l'Audition*, Paris, 1821. W. R. Wilde, *Practical Observations on Aural Surgery*, London, 1853. W. Rau, *Lehrbuch der Ohrenheilkunde*, Berlin, 1856. J. Toynbee, *The Diseases of the Ear*, London, 1860. V. Tröltsch, *Die Untersuchung des äusseren Gehörgangs und des Trommelfells, Deutsche Klinik*, 1860. S. Moos, *Klinik der Ohrenkrankheiten*, Wien. 1866. A. Politzer, *Die Beleuchtungsbilder des Trommelfells*, Wien. 1865. E. de Rossi, *Le Malattie dell' Orecchio*, Genova, 1871. St. John Roosa, *A Practical Treatise on the Diseases of the Ear*, New York, 1873. S. Duplay, *Traité de Pathologie externe par Follin et Duplay*, Paris, 1874.

B. Methods of Examination of the Middle Ear.

Among the methods of examination of the organ of hearing, the various means for examining the state of the Eustachian tube and of the tympanic cavity hold a prominent place. By their aid we are often able to obtain information with regard not only to the permeability of the Eustachian tube, but also to the presence of diseased products in the middle ear, and to the state of the membrana tympani. But these methods are of still greater importance in the treatment of the affections of the middle ear, as they supply us with the means of conducting therapeutic agents in the form of compressed air, gases, vapours or fluids into the tympanic cavity.

These methods are :

a. The Valsalvian Experiment.
b. Catheterization of the Eustachian Tube.
c. The Method of the Author, so called Politzer's Method, for effecting the Permeability of the Eustachian Tube.

Before commencing the description of these methods, it is advisable, with regard to the estimation of their therapeutic value, to make a few remarks about the mechanical action of compressed air in diseases of the middle ear.

On the Mechanical Action, in the Diseases of the Middle Ear, of Currents of Air introduced into the Tympanum.

The main purpose of the methods of examination now about to be described is to effect the permeability of the Eustachian tube, and to conduct compressed air into the middle ear to remove or lessen the obstacles to the conduction of sound, which disturb the function of hearing.

The first effect of a current of air conducted from the pharynx to the middle ear is produced in the Eustachian tube, the walls of which, lying against each other in the normal state, are forced asunder, and its lumen widened. If the tube is obstructed by swelling and œdema of its membrane, or by accumulation of secretion, so that the entrance of the tube cannot be made to gape by an act of swallowing, the permeability of the canal and the communication between the air in the tympanic cavity and that in the pharynx are re-established by the introduction of a current of air. By the action of this current that part of the secretion which is deposited near the pharyngeal orifice is forced into the pharynx, while that in the superior portion of the tube is forced towards the tympanic cavity, as experiments on the dead body have shown.

The effect of such a current of air upon the Eustachian tube is by no means momentary or temporary, as many assert; for

experience shows that the constricted tube is often mechanically dilated by the pressure of the air on its walls, and the tumefaction of the hyperæmic and swollen mucous membrane is lessened or quite removed by the action of the air-current, because the blood is gradually displaced from the dilated vessels.

The current of air which penetrates into the tympanic cavity through the tube will in the first instance act upon the inner surface of the flexible membrana tympani, bulging it out towards the lumen of the external meatus. As we have already seen, the malleus, connected with the membrane, and in a less degree also the incus and the stapes, will follow this outward movement. Therefore, as in diseases of the middle ear, the membrana tympani with the ossicular chain is very often abnormally tightly stretched inwards, and the propagation of sound thereby much hindered, the membrana tympani and the ossicula are forced back into their normal position by the introduction of a current of air, if applied with sufficient force, and by thus removing the abnormal tension of the sound-conducting apparatus, its power of vibration is partially or totally re-established.

Indeed experience shows, that in cases where the membrana tympani and the ossicula are forced inwards by the external pressure of air, and where hardness of hearing exists in consequence of the closure of the Eustachian tube and the rarefaction in the middle ear caused thereby, a striking improvement in the hearing will take place immediately after the propulsion of air into the middle ear. The abnormal tension of the hearing-apparatus, which is caused by tightness of the ligaments of the ossicula, by retraction of the tendon of the tensor tympani and by newly formed bands of connective tissue, stretched out between the membrana tympani, the ossicula and the walls of the tympanic cavity, is often decreased by the pressure and the jerking rush of the air into the middle ear. For, as the membrana tympani and the ossicula move outwards, the tendon of the tensor, which is on the stretch, and also those tight ligaments and bands, are lengthened, thus producing an increase in the mobility and power of vibration of the ossicular chain, and a decrease of the obstacles to the conduction of sound.*

I have already pointed out in the physiological division, as the result of a number of my experiments (p. 73), that the current of air entering into the tympanic cavity, exercises pressure not only upon the inner surface of the membrana tympani, but at the same time upon the fenestræ rotunda and ovalis. If, therefore, the tissues closing these fenestræ have become inflexible through inflammatory thickening, they will become relaxed and more mobile by

* The tearing and separation of the newly formed bands in the tympanic cavity by the sudden increase of pressure in the middle ear is an exceedingly rare occurrence. I have generally observed a disturbance in the continuity of newly formed membranes, which were stretched out in front of the ostium tymp. tubæ, and which were, therefore, exposed to the first shock of the entering current of air.

the repeated action of the compressed air, and consequently the waves of sound will be more readily propagated.

Of course the increased pressure of air in the tympanic cavity will also have an important influence upon the relative pressure in the labyrinth (*vide* p. 74). For the inflammatory affections of the middle ear are very frequently associated with increased pressure in the labyrinth, partly in consequence of its two fenestræ being clogged with exudation, partly in consequence of the abnormally increased tension of the sound-conducting apparatus, by which the stapes is pushed in too strongly towards the vestibule. If this abnormal tension is removed by a current of air, and the foot-plate of the stapes is moved outwards, the abnormally increased pressure in the labyrinth, and the subjective noises and disturbances of hearing which often accompany it, will be lessened or totally removed.

The air-douche is also of considerable importance in the removal of exudation from the middle ear. But the mechanical action of the compressed air in this instance must be closely examined in regard to its effects upon exudative accumulations both with and without perforation of the membrana tympani. Concerning the action of the current of air upon an exudation accumulated in the middle ear with an intact membrana tympani, the opinion was formerly current that improvement in hearing was due to the removal of the exudation, which was supposed to be driven by the current of air from the tympanic cavity into the pharynx. Experiments on human ears, which I undertook with a view to the elucidation of this question,* have however considerably modified the above opinion. The current certainly effects a displacement of the exudation in the Eustachian tube and in the tympanic cavity, and this alone may result in an increase in the power of hearing; if, for instance, some portions of tenacious matter deposited at one of the labyrinthine fenestræ, or at the articulation of the malleus and the incus, are removed to a place where they do not obstruct the conduction of sound. But from my experiments it cannot be assumed that, with a normal position of the head and an intact membrana tympani, considerable quantities of exudation in the Eustachian tube and in the tympanic cavity are forced into the pharynx by the current of air. The greater portion of the exudation, especially if it is very tenacious, remains in the tympanic cavity even with very powerful inflations, and the improvement in the hearing, which occurs immediately after the entrance of the current of air, is to a great extent due to the moving outwards of the membrana tympani and of the ossicular chain into their normal position, as also to the partial removal of the abnormal tension in the tympanic cavity. Fluid exudation in the middle ear is however often partially or completely removed by inflation of air, if the head is

* *Ueber bewegliche Exsudate in der Trommelhöhle, Wiener Med. Presse,* 1869.

much inclined forwards and sideways during the operation. The position of the tube is thus changed, so that the ostium tymp. tubæ is directed exactly upwards, and the ostium pharyngeum exactly downwards, and thus, when the tube is opened, fluid can gravitate from the tympanic cavity into the naso-pharynx.

If, then, a cure is effected by the frequent propulsion of air in a number of cases, where the exudation cannot be mechanically removed by the current, it is simply due to the absorption of the secretion in consequence of the re-establishment of the normal pressure of air in the tympanic cavity. For, as already mentioned, the air is rarefied in the tympanic cavity by the closure of the Eustachian tube in affections of the middle ear, combined with swelling and hyper-secretion. Hence the blood and lymphatic vessels of the mucous membrane of the cavity will be under a subnormal pressure of air, a condition which is favourable to the exudation of fluid from the vessels into the tympanic cavity. Zaufal, who confirms this opinion, first advanced by me,* correctly describes this process as in a number of cases *hydrops ex vacuo.*

I am of opinion that by propelling air into the tympanic cavity in these cases, the circulation in the blood and lymphatic vessels again becomes normal on the re-establishment of the normal air-pressure, and thus the absorption of the secretion is effected. I formed this opinion from the observation of cases where an acute inflammation of the middle ear, accompanied by marked injection and opacity of the membrana tympani, had already lasted for several weeks or months, and where no increase in the hearing-distance was observed previous to the treatment. If in such cases a current of air is conducted into the middle ear, not only will a considerable improvement in the hearing immediately take place, but also a noticeable change in the membrana tympani will be observed during the following days, while the improvement in the hearing makes still further progress after the repeated introduction of air. First the injected radiating vessels disappear, and then the peripheral vascular wreath; the membrane becomes more transparent, its lustre returns, and with the removal of the hardness of hearing the membrana tympani has, as a rule, regained its normal appearance.

It is sufficiently clear from these observations that the exudations lying in the tympanic cavity in cases of closure of the tube, together with the abnormally decreased air-pressure, keep up the hyperæmia in the middle ear, as the dilated vessels of the external surface of the membrana tympani prove. The speedy disappearance of a hyperæmia which has existed for some time, and of hardness of hearing after air has been injected several times into the tympanic cavity, demonstrate the favourable effect of the air-

* *Wochenblatt der Ges. d. Aerzte*, November 17, 1869, No. 46.

douche in bringing about a re-establishment of the circulation in the middle ear and the absorption of the exudation.

The effect of the propulsion of air into the middle ear with a perforated membrana tympani is essentially different from the results hitherto discussed. For, as the current of air, entering through the Eustachian tube, escapes through the perforation, the secretion deposited in the tube and in the tympanic cavity will be forced immediately through the aperture in the membrane into the external meatus, and pus and mucus are in this manner removed from the middle ear. The current of air has the same effect in cases of exudation in the middle ear, where the membrana tympani has been artificially perforated.

In cases of perforation of the membrane, the current of air which is caused to rush through the middle ear and the external meatus is not without influence on the position of the ossicula, in spite of its escape through the aperture. For very often in perforating inflammation of the middle ear the ossicular chain is forced inwards, and the conduction of sound is thereby impeded, chiefly by the stapes. Even if the air, which rushes through the Eustachian tube, escapes into the external meatus, the current acts also at the same time upon the internal surface of the remnant of the membrane, and forces it and the ossicula outward into an approximately normal position.

Some time ago the assertion was made that in perforating inflammation of the middle ear, the current of air, penetrating into the tympanic cavity, propelled the purulent secretion into the mastoid cells. Dr. Michael (*A. f. O.* vol. xi.) has proved by numerous experiments on the dead body, that, especially with the application of strong currents of air, the secretion in the tympanic cavity is always propelled into the external meatus, and never into the mastoid process.*

a. The Valsalvian Experiment.

The Valsalvian experiment consists in condensing the air in the naso-pharynx by a strong act of expiration, performed with closed mouth and nostrils. By this means the walls of the

* Joseph Gruber made the assertion that in perforating inflammation of the middle ear the pus was propelled from the tympanic cavity into the mastoid cells, and that caries of the mastoid process was the consequence. This assertion, which is refuted by Michael's experiments, is, however, antagonistic to our knowledge of aural pathology ; for it has been proved by pathological examinations, that the mastoid cells are not normal while suppuration is going on in the tympanic cavity, but that almost without exception they contain inflammatory products, due to participation of the mastoid process in the inflammation, partly also to leakage from the tympanic cavity into the cells during the recumbent position of the patient. This constant occurrence of inflammatory products in the mastoid cells, and the comparatively rare combination of suppuration in the middle ear with caries of the mastoid process, will demonstrate satisfactorily that the presence of pus in the mastoid cells does not of itself cause caries.

Eustachian tube are forced asunder, and the condensed air is propelled into the tympanic cavity.

To estimate the diagnostic and therapeutic value of this experiment, it is necessary first to make a few remarks about the range of its pressure, as measured by the manometer, and also about the obstructions which oppose the entrance of air into the middle ear.

In the first place, it is important to mention that the manometrical pressure effected by the Valsalvian experiment varies according to the age of the individual, and according to the individual power of the expiratory muscles. Hence the pressure will be far less in children than in adults, and also considerably less in weakly persons than in robust individuals. Waldenburg's experiments prove also that there is a considerable difference in the amount of the expiratory pressure in the two sexes, as in males it amounts on an average to 100-130 mm., in females to 70-110 mm., as indicated by the quicksilver column.

During the execution of the Valsalvian experiment the obstructions opposed to the entrance of air into the tympanum of a normal ear are situated partly in the Eustachian tube, partly in the membrana tympani. It has already been pointed out, in the physiological division, that the walls of the Eustachian tube in the normal state are closely applied to each other, to a different degree in different individuals. The expiratory pressure necessary to force the air through the tube into the tympanic cavity must, therefore, be greater the closer the walls of the tube are in contact, while the muscles of the tube are at rest. A considerable hindrance to the current of air is the membrana tympani itself, and the pressure which is required to overcome the tension of the membrane and to bulge it forwards towards the meatus is, in my opinion, not inconsiderable. For this assumption is especially supported by the observation of those cases in which rupture of the membrane occurs from a box on the ear. As I have elsewhere* pointed out, a decidedly less expiratory pressure during the Valsalvian experiment will in such cases suffice to force air into the middle ear than in cases with an intact membrane, because the resistance of the membrane is removed by the gap which has been made in it.

A. Hartmann says† that by experimenting on a considerable number of persons of normal hearing, he has ascertained by the manometer the amount of pressure which is required during the Valsalvian experiment to bulge forward the membrana tympani. He finds that on an average a pressure of 20-40 mm. Hg. suffices for this purpose. Accordingly, it might be assumed that

* Compare my treatise, *Ueber traumatische Trommelfellrupturen*, *Wien. Med. Wochenschrift*, 1872.

† *Ueber die Luftdouche und ihre Anwendung in der Ohrenheilkunde*, *Virchow's Arch.*, vol. lxx.

the Valsalvian experiment in a normal organ of hearing should succeed without exception with less than the minimum expiratory pressure. But experience shows that the Valsalvian experiment does not succeed in many individuals with normal ears. The reason of this lies partly in the fact that the expiratory pressure produced is insufficient to force the air into the middle ear, but principally in the inability of many persons, especially children and old people, to execute the Valsalvian experiment at all.

The entrance of air into the tympanic cavity during the Valsalvian experiment can be proved by inspection of the membrana tympani as well as by auscultation. If the membrane of a normal ear be inspected during the Valsalvian experiment, an outward curvature of the portions situated between the handle of the malleus and the periphery will be seen. The change in the form of the cone of light will specially attract attention; as a rule it is shortened and narrowed, and in some rare cases even disappears (Moos). This change in the form of the cone of light during this experiment warrants the conclusion that air has penetrated into the tympanic cavity, but we are by no means justified in drawing further conclusions from this as to the state and the degree of permeability of the Eustachian tube.

The air which penetrates into the tympanic cavity produces a noise in the middle ear, which can be perceived either by placing the auricle immediately to the concha of the person being examined, or in a more practical manner by the auscultation tube (otoscope) designed by Toynbee. It consists of an india-rubber tube 80 cm. in length, furnished at its ends with tubular olive-shaped nozzles for insertion into the meatuses. As a precaution, the surgeon will do well to mark the nozzle which is intended for his own ear, and every time to cleanse, or even change, the nozzle which has been inserted into the meatus of the patient, remembering that purulent secretions, especially from persons with general syphilis, are infectious.

The auscultation tube is indispensable in all cases where examination of the middle ear and treatment of its affections are necessary. It serves not only to indicate whether air or fluid has entered the middle ear, but also not unfrequently to determine, by attention to a series of sounds caused by the entering air, the degree of permeability of the Eustachian tube, the presence of pathological products in the middle ear, and the state of the membrana tympani.

The rush of air into the tympanic cavity during the Valsalvian experiment produces a short puffing sound, similar to that which is caused by forcing asunder the moderately compressed lips by a forced expiration. This sound, which is often preceded by a slight murmur caused by the friction of the air in the Eustachian tube, which is generally called the sound of the concussion of the air on the membrana tympani, is produced by the rapid outward

movement of the portions of the membrane situated between the handle of the malleus and the periphery, as I have ascertained by numerous experiments made on fresh ears. The sound is therefore caused by the movement of the membrane itself, and not by its concussion by the air, and it should for this reason be more correctly described as the sound caused by the bulging out of the membrane.

While the Valsalvian experiment in normal ears often fails to effect the entrance of air into the middle ear, it does so still more frequently in abnormal ears. Hartmann found that with a slight swelling of the mucous membrane of the Eustachian tube, with no disturbance of hearing, as often occurs with naso-pharyngeal catarrhs, the manometrical pressure (averaging in the normal state 20-40 mm.) was increased to 100-120 before the Valsalvian experiment was successful. A still more considerable increase in the pressure is required in cases of disease, especially in the affections of the middle ear accompanied by swelling and secretion. As they are generally combined with a tumid state of the mucous membrane of the tube, and therefore with stricture of the isthmus tubæ, such an obstruction to the entering current of air is offered as is often incapable of being overcome by the greatest expiratory pressure.

This is especially the case in that group of affections of the middle ear which run their course without perforation of the membrana tympani. In this group other obstructions besides the resistance offered by the swollen and narrowed Eustachian tube will exist to prevent the entrance of the current of air into the middle ear during the Valsalvian experiment. These consist principally of accumulated secretion in the middle ear, great tension of the membrana tympani, and the greater adhesion of the walls of the Eustachian tubes, caused by rarefaction of air in the tympanic cavity.

For special mention has already been made of the fact, that the air in the middle ear is rarefied in consequence of the impermeability of the tube, and of the interruption to the communication between the pharynx and the tympanum. Hence, on the one hand, the membrana tympani is pressed inwards by the external air as far as the elasticity of the fibrous layers of the membrane permits; on the other hand, the membranous portion of the tube is, for the same reason, pressed closely to its cartilaginous portion from the direction of the pharynx, and the resistance in the tube is thereby considerably increased.

However, in that group of the affections of the middle ear where the membrana tympani is perforated, the Valsalvian experiment may be much more frequently used as a means of diagnosis. For here the resistance of the membrane has ceased; a counter-opening has been made into the tympanic cavity, which considerably facilitates the entrance of a current of air through the

tube into the tympanum. But although in such cases the hissing noise made by the exit of the air from the tympanum is often heard during the Valsalvian experiment, there is a considerable number of cases where, in spite of the existence of a perforation, the air cannot be pressed into the ear even with forced expiration. This is specially the case where the mucous membrane of the Eustachian tube is much swollen, or where obstructions are created by granulations and inspissated secretion in the tympanic cavity or in the external meatus. Therefore, if no hissing noise is heard, it must not be inferred that the membrana tympani is not perforated.

From this description of the mechanical action of the Valsalvian experiment it will be seen that it is insufficient as a means of diagnosis in cases of great resistance in the middle ear; to this there are exceptions. There are some cases in which both catheterism and my method fail to effect the entrance of air into the tympanum, while the Valsalvian experiment, a much weaker force, succeeds. Hartmann is of opinion that the obstacle presented to the passage of air by an accumulated secretion in the Eustachian tube will be greater during an act of swallowing than during the Valsalvian experiment, when the muscles of the tube are at rest. This, however, does not suffice to explain the above fact; for much more generally, in cases of evident accumulation of secretion in the tube, the Valsalvian experiment fails, while my method succeeds. We must therefore assume that in those rare cases other agencies, which we cannot at present define, work together in such a way that the permeability of the Eustachian tube is more easily re-established by a weak air-pressure, gradually increasing, than by currents of air of greater force.

To sum up, it will be found that the Valsalvian experiment as a means of diagnosis is certainly of limited value, but, nevertheless, it can be used in a great number of cases. If it give a positive result, we may, generally speaking, infer that the mechanical obstruction in the Eustachian tube is slight; if, however, it give a negative result, we may assume that the membrana tympani being intact, or even perforated, a greater obstacle exists in the Eustachian tube or elsewhere in the middle ear. From my experience, these results are of no slight importance in prognosis, for in inflammations of the middle ear, accompanied by swelling and secretion, the prognosis in regard to speedy removal of the pathological changes will on the whole be more favourable in those cases where the permeability of the tube can be effected by the Valsalvian experiment, than in those in which the application of the catheter or of my method is necessary. The examination of the middle ear should therefore always be commenced with the Valsalvian experiment, to be followed by my method and by catheterism.

The therapeutic value of the Valsalvian experiment will be

discussed in the division in which the effects of the methods enumerated at the commencement of this division are compared.

A method remains to be mentioned which was recommended by Toynbee as a diagnostic expedient, and is called Toynbee's experiment. According to Toynbee, the act of swallowing with closed nostrils causes a feeling of fulness in the ear, referred by him to condensation of air in the tympanum. I have experimentally proved (compare p. 71) that this procedure causes a considerable rarefaction of air in the middle ear, preceded at the beginning only of the act of swallowing by a moderate condensation.

If a normal ear be auscultated during the execution of this experiment, a peculiar cracking sound will certainly often be heard, which is not generally perceived when the Eustachian tube is impermeable; however, the diagnostic value of this sign is considerably lessened by the fact that this cracking is often imperceptible in people with sound ears, while, on the other hand, it is audible with an impassable tube.

The inspection of the membrana tympani is also of little use in diagnosing the permeability of the Eustachian tube during this experiment. In the normal ear an inward movement of the anterior portion of the membrana tympani and a change in the form of the cone of light will be frequently observed; often, however, not the slightest movement of the membrane will be perceptible. But in pathological states, permeability of the tube must by no means be inferred from a motion of the membrana tympani, especially if its tension is decreased, or if secretion is deposited in the middle ear, because, as I was the first to prove (*Beleuchtungsbilder des Trommelfells*, 1865, p. 140), the change in the position of the Eustachian tube during the act of swallowing is of itself sufficient to create a motion of the air, and a locomotion of the secretion in the tympanic cavity, as also a movement of the pathologically changed membrane, without the Eustachian canal having been opened.

b. Catheterism of the Eustachian Tube.

Catheterism of the Eustachian tube consists in the introduction of a Eustachian catheter through the nose, or more rarely through the mouth, into the tube. This is one of the most important operations performed in the diseases of the ear. For not only does the catheter give more reliable information as to the state of the middle ear than the other methods of examination, but it is also quite indispensable as a means of conducting gaseous or fluid agents into the middle ear for remedial purposes.

The execution of this operation requires an exact knowledge of the topographical relations of the ostium pharyngeum tubæ.

We will, therefore, describe the anatomical relations of the naso-pharynx, which have to be considered during catheterism, before entering on the details of the method.

1. *Topographical Relations of the Pharyngeal Orifice of the Eustachian Tube.*

The pharyngeal orifice of the Eustachian tube (Fig. 57) is situated in the lateral wall of the pharynx, on a level with the horizontal prolongation of the inferior spongy bone. It presents an oval depression, pointing obliquely downwards, which is bordered in front by an ill-defined swelling; above and behind, however, by a strong, firm lip, projecting towards the pharynx.

Between the posterior lip and the posterior wall of the pharynx there is a depression, Rosenmüller's cavity (*g*), which is rich in glandular tissue, and subject to great individual variations in size. In consequence of chronic pharyngeal catarrh, a cystic hypertrophy of the closed mucous glands, their amalgamation with the originally existing depressions of the mucous membrane in this place, and formation of extensive gaps and bridge-like bands often occur, by which the operation of catheterism is sometimes rendered difficult, especially when the operator allows the beak of the catheter to become entangled in these bands.

The distance of the orifice of the tube from the posterior pharyngeal wall will, therefore, not only vary in different individuals (according to L. Mayer it amounts on an average to 1·8 cm.), but it will also depend on the degree of swelling of the mucous membrane of the pharynx. For this reason it is impossible to employ the distance between the orifice of the tube and the posterior wall of the pharynx as a safe guide in the introduction of the catheter.

Below the orifice of the tube is the velum palati (*e*), which in the living arches upwards above the level of the hard palate. The muscles which enter it from the tube and from the palatine arches give to it a considerable degree of mobility. Every movement of the velum palati has associated with it a movement in the Eustachian tube, and the posterior extremity of a catheter undergoes a perceptible change of position at every motion of the soft palate, if the catheter either come into contact with the velum or be introduced into the tube.

The velum palati has a high degree of tension and power of resistance owing to the muscles of the Eustachian tube and the pharynx, and the beak of the catheter meets with some opposition at the soft palate during its rotation. This resistance is much greater during respiration through the nose, when the velum is elevated, than during respiration through the mouth, when it lies considerably lower. During catheterism the patient

should, therefore, always breathe through the mouth, because the contact of the catheter with the elevated soft palate causes an unpleasant sensation.

In the nasal cavity, lying in front of the Eustachian tube, the three spongy bones on the outer wall and the nasal septum merit description. The superior spongy bone (*c*) is short and narrow, while the middle (*b*), and especially the inferior (*a*) spongy bones, project more into the nasal cavity. Hence there arise below these curved bones the three nasal meatuses, of which the lower is of special importance in catheterism.

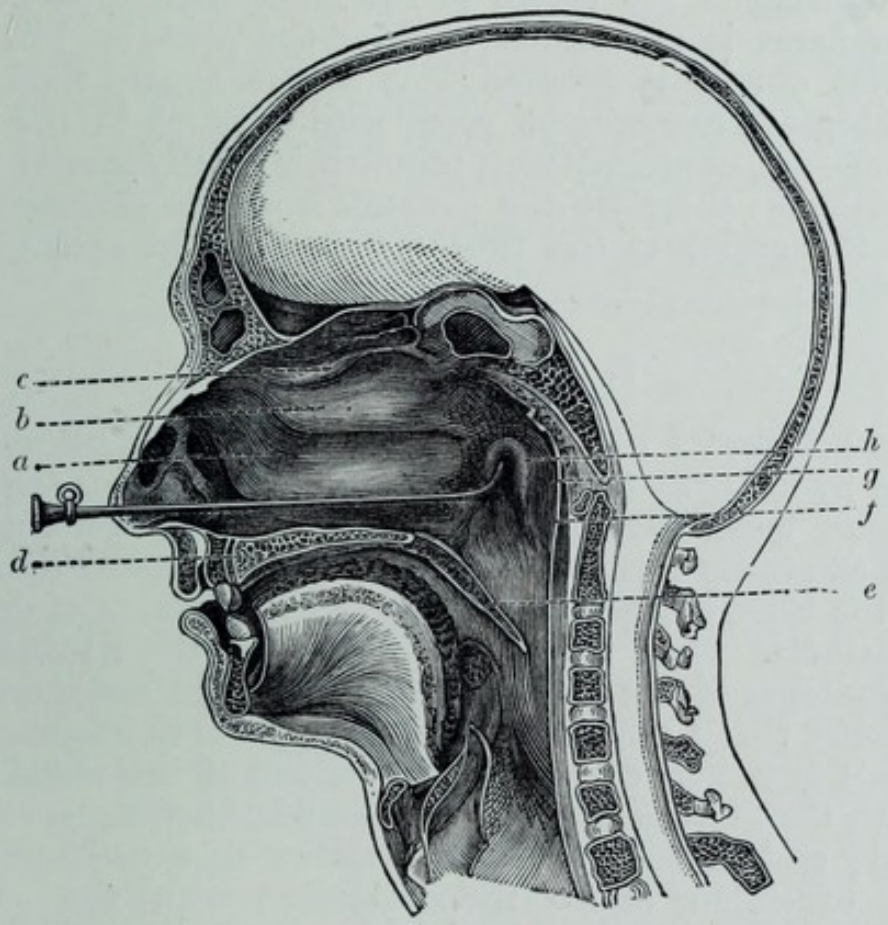

FIG. 57.—VERTICAL SECTION OF THE NASO-PHARYNX WITH THE CATHETER INTRODUCED INTO THE EUSTACHIAN TUBE.

a, Inferior spongy bone; *b*, Middle spongy bone; *c*, Superior spongy bone; *d*, Hard palate; *e*, Velum palati; *f*, Posterior pharyngeal wall; *g*, Rosenmüller's cavity; *h*, Posterior lip of the orifice of the Eustachian tube.

In the performance of catheterism of the Eustachian tube, besides the obstacles produced by pathological processes which will be described later on, there have to be considered the frequent congenital deformities of the nasal septum and of the spongy bones. For if a considerable collection of crania be examined, it will be found that the septum of the nose seldom represents a perpendicular plane, but that it is more or less bulged out, sometimes to one side and sometimes to the other (more frequently towards the left side), by which one half of the

nose is greatly narrowed, while the other is proportionately more spacious.* By excessive development of the middle, but more often of the inferior, spongy bone, the permeability of the nose is often impaired, and the contraction will reach a higher degree if an enlargement of the spongy bones is combined with a bulging out of the nasal septum towards the same side. A frequent obstacle to the introduction of the catheter is an insufficiently moist condition of the pituitary membrane; it is therefore advisable to let the patient blow his nose before catheterism, as the instrument will then more easily glide along the moistened membrane.

The distance of the orifice of the Eustachian tube from the posterior nares is as variable as from the posterior pharyngeal wall. Not only is it generally less in the female than in the male, but great fluctuations occur with varieties in the cranial formation—*e.g.*, in prognathous people it is mostly greater than in orthognathous: therefore the distance from the entrance of the nose to the orifice of the tube cannot be used as a guide in catheterism.

2. *Choice of Catheter.*

For catheterism I use instruments made of vulcanite, as first proposed by me (Fig. 58). Their length is 13-16 cm., the length of the beak being 2-2½ cm. A metal ring fixed to the posterior widened extremity corresponds with the concavity of the curvature of the beak, and serves to indicate the direction of the point of the catheter when the instrument is in the naso-pharynx. The advantages of the vulcanite over the metal catheters are so considerable, that I now almost exclusively use the former. The unpleasant sensation caused by the contact of the metal instrument with the mucous membrane is not felt when these catheters are used; and, indeed, experience shows that patients almost without exception prefer the treatment with the vulcanite catheter to that with the metal instrument, a fact which is not to be undervalued in practice. The metal catheters also cause pain by pressure upon the inflexible walls of the nasal passages, while the vulcanite ones more easily follow the curvatures of the nasal cavity on account of their elasticity. This moderate degree of elasticity, however, by no means impairs the firmness of the instrument, which is required in order to feel the sliding of its beak over the posterior lip of the tube, or the resistance at the posterior margin of the nasal septum.

The objection that vulcanite catheters might easily be broken in meeting obstacles in the nose, is met by the fact that forced catheterism is inadmissible in cases of stricture in the nasal

* In rare cases I found both halves of the nose diminished in capacity, because the lamellæ of the septum were bulged out equally both to the right and to the left.

cavity, because by such a proceeding not only the mucous membrane but also the spongy bones might be injured, of whatever material the catheter be made.

Vulcanite catheters have also the advantage of not being acted on by acid or saline solutions, thus rendering it possible to dip the catheter after use into strong alkaline solutions, in order to destroy the mucous particles which adhere to the instrument. The metal catheters, however, which contain a certain amount of copper, are attacked by weak acid solutions and by solutions of metallic salts, which are often used for injections into the tympanic cavity, as copper salts are produced on the inner surface of the instrument, and its wall is at last so thinned by the action of the chemical agents, that with a weak lateral pressure the catheter breaks more easily than a vulcanite one.*

Individual differences in the capacity of the nasal passages, congenital anomalies and strictures caused by pathological processes, necessitate the use of instruments of different calibres. I use catheters of three different sizes, the thickest $3\frac{1}{2}$ mm., the middle size $2\frac{1}{2}$ mm., which is oftenest used, and the thinnest $1\frac{1}{2}$ mm. in diameter; the thickness of the wall of the catheter is $\frac{1}{2}$ mm.

Not less important in the performance of the operations is the length and the curvature of the beak of the catheter. As a rule, a length of 2-$2\frac{1}{2}$ cm., and a curvature of the beak of the catheter of 145°, will completely answer the purpose. But catheters with long, strongly curved beaks will only with difficulty pass through the nasal cavity even where slight obstacles are present, and the rotation of the instrument towards the orifice of the tube is either quite impossible, or produces great pain. Their frequent use may be decidedly detrimental to the course of the disease in many cases, for in inflammatory swelling of the tube, whether primary or secondary to catarrh of the pharynx or of the tympanic cavity, it increases the swelling by repeatedly penetrating to the narrow portion of the tube, causing irritation there, and consequent aggravation of the pathological state.

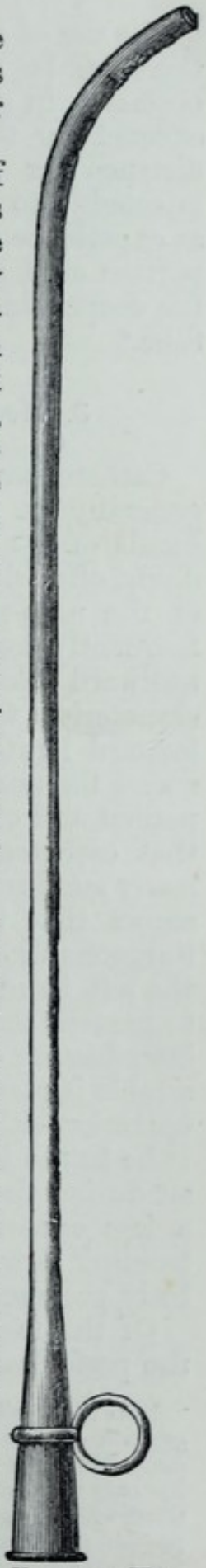

FIG. 58.—VULCANITE CATHETER OF MEDIUM THICKNESS.

* The elastic catheters, recommended by Bonnafont, which are constructed after the manner of the English vesical catheters, have proved unsuitable, as the sliding of the instrument over the lip of the tube cannot be felt, and because during the application of strong currents of air the point of the instrument is lifted out of the tube by the recoil.

The use of instruments with a long, strongly curved beak must therefore be confined to those cases where, along with great obstacles in the Eustachian tube, its permeability cannot be effected by the use of ordinary catheters, inserted the usual distance; or where considerable quantities of fluid are to be injected into the tympanic cavity by means of the catheter, as experience shows that air and fluid pass through the narrowest portion of the tube into the tympanic cavity with more certainty, the deeper the point of the catheter is inserted into the Eustachian tube.*

3. *Mode of Catheterizing the Eustachian Tube.*

Catheterism of the Eustachian tube, although not painful, is generally an unpleasant operation for the patient even in the hands of a skilful operator. The degree of unpleasantness no doubt often depends on the sensibility of the mucous membrane of the naso-pharynx peculiar to the individual; much more frequently, however, the operation is positively painful owing to awkward manipulation. The surgeon must therefore perform catheterism with the greatest possible care, push the instrument forward lightly and gently, and especially avoid force in cases where the nose is obstructed. With regard to the position of the patient and of the surgeon during this operation, it may be stated that catheterism while the patient is standing, as practised by many aural surgeons, is not to be recommended, because experience shows that it is much less unpleasant in a sitting posture. Surgeons who are not sufficiently expert in fixing the head with the left hand had better seat the patient in a high-backed chair, to prevent the head from moving too far backwards during the introduction of the catheter. The surgeon, at whose right hand a table is placed with the necessary instruments, may perform the operation either standing or sitting according to his convenience. If he has to treat a number of patients, it will be better for him to sit during the operation, as he will get fatigued by standing, and a less experienced surgeon should always do this, because in bending forwards he might easily cause pain by the weight of his body pressing on the catheter.

Of the numerous methods which have been recommended for the performance of this operation, two specially deserve a detailed

* As the possibility of inoculating syphilis by means of the catheter is admitted, the greatest caution must be exercised to prevent such a disaster occurring, when the same catheter is used for more than one patient. It is the duty of every practitioner not only to provide for the absolute safety of the patient, but also to remove everything which might inspire fear of possible infection. To this end it is prudent to provide every patient with a small drinking glass, a catheter, and a point to affix to the Politzer bag which is in common use by the surgeon. But where this is not practicable, it is necessary to wash the catheter after use with great care, both without and within, and for this purpose the solution of permanganate of potash or of carbolic acid is of great service.

description, because according to my experience they have proved to be the safest methods for the practitioner, and because they supplement one another. The many methods described are mostly unimportant modifications of the same procedures, and doubtless answer the purpose more or less perfectly. But for the aural surgeon a special method is only of value in exceptional cases, as it would be difficult for any specialist *not* to get into the Eustachian tube with the catheter. The non-specialist, however, will only use those methods with advantage in which certain anatomical relations serve as guides for the introduction of the catheter into the tube. These guides, which form the basis of the following two methods, are the posterior lip of the tube,* and the posterior margin of the septum of the nose.

First Method.—Feeling the point of the catheter glide from Rosenmüller's cavity over the posterior lip of the tube is the guide for the introduction of the catheter. The details of the method are the following: To introduce the catheter with as little unpleasantness as possible to the patient, the point of the nose is first tilted up with the thumb of the left hand, and the head is steadied by placing the other four fingers against the forehead. Then the posterior extremity of the catheter is taken between the thumb, forefinger, and middle finger of the right hand like a pen, and is slightly depressed while the beak is introduced into the nasal cavity.

The point of the beak is now lowered to the floor of the nasal cavity, the posterior extremity of the catheter is lifted up until the instrument is in a horizontal position; it is then moved backwards, the beak being constantly in contact with the nasal floor. In a normal nasal cavity the catheter passes between the spongy bones and the nasal septum (more rarely in the space formed by the inferior spongy bone) backwards along the osseous floor, without noticeable change in the direction of its beak, and then glides across the superior surface of the soft palate to the posterior wall of the pharynx. When this is reached, a circumstance which will be known by the check given to the catheter, its beak is then turned obliquely outwards, but not quite horizontally, in which position it would be forced into Rosenmüller's cavity. While its posterior extremity is somewhat raised, the catheter is retracted with moderate rapidity, during which movement the beak of the catheter will be felt to slip over the bulging lip of the tube, projecting from the lateral wall of the pharynx.

After the point of the catheter has thus passed the posterior lip, it has arrived at the pharyngeal orifice of the Eustachian tube.

* According to P. H. Wolf (*Handbuch der theor. und pract. Ohrenheilkunde von Lincke*, vol. iii. p. 360), first proposed by Kuh.

To insert the beak into the tube it is now sufficient to turn the instrument so far outwards, that the metal ring fastened to its posterior extremity is pointed towards the outer canthus of the eye of the same side. This direction of the beak corresponds as a rule with the axis of the Eustachian tube.

After the catheter has been introduced into the tube in this manner, it is fixed outside the nose. For this purpose Kramer's frontal band or Rau's spectacles were formerly used, and are still employed by many specialists. With both instruments the catheter is fixed by means of calipers, which are not only insufficient during the introduction of gaseous or fluid substances, but also are often most unpleasant to the patient.

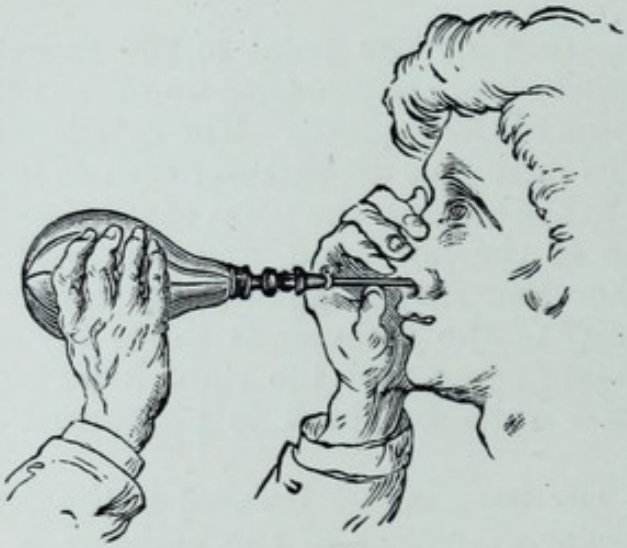

FIG. 59.—FIXING OF THE CATHETER INTRODUCED INTO THE EUSTACHIAN TUBE WITH THE LEFT HAND.

The fixing of the catheter with the fingers is just as simple as it is practical, especially in such cases as require air or fluid to be conducted into the tympanic cavity. After the catheter has been introduced in the above manner, the instrument is seized close in front of the point of the nose with the left thumb and forefinger, and to fix it safely in this position, the other three fingers of the left hand are laid upon the bridge of the nose, and the instrument is in this way readily fixed (Fig. 59).

Only when the catheter has to remain a considerable time in the Eustachian tube for the introduction of vapours into the middle ear, or of bougies into the tube, do I make use of Bonnafont's nose-pinchers (Fig. 60), the arms of which press the alæ to the septum of the nose, and thereby also hold the catheter in position. A simple and useful nose-pincher, designed lately by the Belgian aural surgeon Delstanche *fils*, consists of a whalebone rod, which after being dipped into hot water is bent to the shape of an M, so that the long crura squeeze the alæ of the nose together and fix the catheter.

Second Method.—In the second modification of catheterism of the Eustachian tube, the posterior margin of the septum of the nose is used as the anatomical guide. It forms a semicircle, directed downwards and backwards, rising from the posterior margin of the hard palate towards the superior wall of the pharynx. The distance from the orifice of the tube to that part of the above-named semicircular margin, which in a horizontal plane is on a level with the ostium pharyng. tubæ, gives an average measurement of 2-2½ cm., a distance which corresponds with the length of the beak of the catheters in common use.

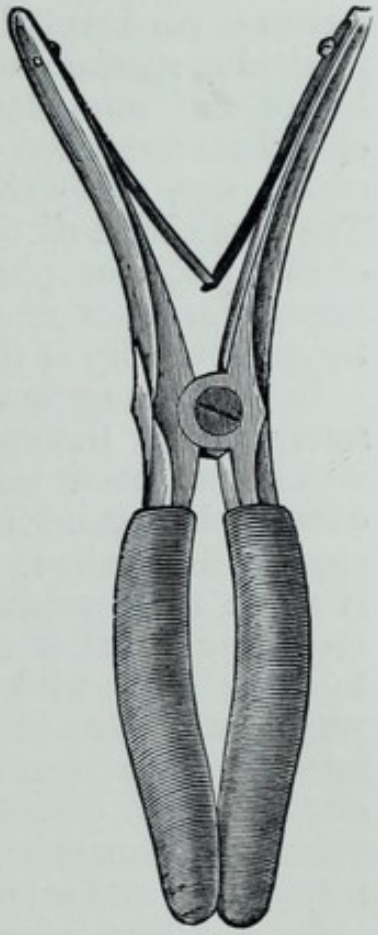

FIG. 60.—BONNAFONT'S NOSE-PINCHERS.

Concerning the details of this method, the fixing of the head, the lifting up of the point of the nose, and the introduction of the catheter through the nasal cavity into the posterior pharynx, are accomplished just as in the previous method. After the catheter has been introduced as far as the posterior wall of the pharynx, its point is not turned outwards, as in the former method, but inwards, towards the orifice of the other Eustachian tube, and is brought into a horizontal position, as ascertained by the position of the metal ring on its end. The outer end of the catheter is then moved slightly outwards, and gradually drawn back until the beak has reached the posterior margin of the nasal septum. During moderate traction a noticeable resistance will be felt at this place, which prevents the catheter from being drawn further back, because its hoop-shaped, curved beak grasps the posterior margin of the nasal septum. Drawing the catheter too strongly against this moderate resistance is apt to interfere with the success of this method. The catheter is now moved towards the septum of the nose, taken hold of with the left forefinger and thumb close to the point of the nose, and its beak rotated downwards, and the instrument turned on its long axis 180°. The point of the beak is inserted in this manner into the pharyngeal orifice of the Eustachian tube, provided that the catheter during the last rotation was not displaced either forwards or backwards, and that no deformities exist in the posterior portion of the naso-pharynx or near the orifice of the tube. Sometimes the tightly stretched velum palati offers great resistance to the rotation of the catheter downwards, whereby the

point of the instrument is forced backwards, and its introduction into the orifice of the tube is prevented. If the point of the catheter has got into the orifice, the instrument is brought into the proper position and fixed exactly as in the previous method. This procedure was first described by Giampietro, and afterwards modified by Loewenberg.*

Though in the majority of cases the introduction of the catheter into the Eustachian tube is effected in normally formed nasal cavities as easily by the first method as by the Giampietro-Loewenberg procedure, cases often enough occur where catheterism is possible only after one of these two methods. The first method is specially unsuited for such cases as have the posterior lip of the tube flattened or levelled either by ulceration, by cicatricial formation on the lateral pharyngeal wall, by the atrophy of old age, or by shrivelling in consequence of chronic catarrh. The application of this method is just as difficult if great œdema of the posterior pharynx or the existence of granulations and adenoid growths in that cavity offer obstacles to the finding of the posterior lip of the tube.

In such cases our object will be effected more quickly and safely by the Giampietro-Loewenberg method. This procedure, which has been made use of by Loewenberg only in some exceptional cases,† I have found to be an excellent and generally applicable method, and the necessary skill for its execution is much more readily acquired than for other methods. But on the other hand, it must not be forgotten that it is impossible in many cases, with a normal state of the naso-pharynx as well as with obstructions in its posterior portion, to introduce the catheter into the Eustachian tube by this method, while it is effected without the least difficulty by the first-described procedure. The value of these two methods lies principally in the fact that in many cases one supplements the other.

In the largely used method of Kramer, according to the description of v. Tröltsch (*l. c.* p. 202‡), the catheter, pushed forward to the posterior pharyngeal wall, is drawn back 2-2½ cm. (¾-1 inch), and its beak, directed downwards, is then rotated outwards and upwards through an angle of 135°, whereby it is supposed to get into the orifice of the tube. But here all anatomical guidance for the finding of the orifice is wanting, and the inefficiency of this method is best characterized by the assertion of v. Tröltsch, that the instrument is often drawn back either too far or too little, in which latter case Rosenmüller's cavity instead of the Eustachian tube will be reached. According

* *Archiv für Ohrenheilkunde*, vol. ii. p. 127.

† *Zur Technik des Catheterismus der Ohrtrompete*, *Wiener Med. Presse*, 1872.

‡ This differs from the description in Kramer's *Die Erkenntniss und Heilung der Ohrenkrankheiten*, 1849, p. 484, in so far as in it mention is also made of the sliding over the lip of the tube.

to the same author the above mistake is often made, not only by beginners, but even by surgeons who have frequent practice in the use of the catheter. This is explained partly by the fact that no exact measurement can be given as to the distance that the catheter is to be drawn back again from the posterior pharyngeal wall.

In case of great irritability of the soft palate and of the mucous membrane of the pharynx, catheterism after the above methods often produces spasmodic coughing and vomiting, which impede the execution of the operation. The following method can here be recommended as the most useful. The catheter, introduced into the nasal cavity, and sliding with its point over the base, is gradually turned outwards, before it leaves the hard palate, in such a manner that the metal ring at the posterior extremity is placed in an oblique position, directed outwards and downwards. If in this position the instrument is pushed backwards, its point, without touching the soft palate, will get into the orifice of the tube, while the posterior lip of the tube prevents the instrument from reaching Rosenmüller's cavity. I apply this modification very often in a quite normal state of the naso-pharynx.

Lastly, we will mention another modification of catheterism, which some years ago was asserted to be a new one, but which had already been described in old works (Lincke, vol. iii. p. 359, and Rau, p. 117). It consists of drawing back the catheter with its point directed downwards, after the instrument has been pushed forward to the posterior pharyngeal wall, until it meets with resistance at the palate, when by a quarter turn the catheter is supposed to get into the orifice of the tube. With this modification, just as with any other method, it will be often possible to perform catheterism after long practice, but it does not afford the same certainty to the less experienced surgeon as the first-described methods, because the position of the soft palate varies very much, and because it often yields more or less to the pressure of the beak of the catheter; the sure anatomical guidance is therefore also wanting in this method.

4. *Mistakes in Catheterism.*

If the above-mentioned precautions are observed, the surgeon will with some practice soon succeed in executing catheterism of the Eustachian tube without difficulty. It is, however, not out of place here to draw attention to some mistakes which happen even in a normal state of the passages, and which prevent the success of the operation. These are:

1. The point of the catheter is during its introduction not laid upon the floor of the nasal cavity, but pushed towards the upper portion of the nose; the instrument will then, as a rule, get into

the middle nasal meatus, and be detained there, and so the beak cannot be turned towards the pharyngeal orifice.

2. The catheter is correctly pushed forward to the posterior wall of the pharynx, but the posterior extremity of the instrument is not tilted up sufficiently; in this way the point of the catheter, instead of slipping over the lip of the tube, passes above its pharyngeal orifice.

3. The instrument reaches the posterior pharyngeal wall, but its beak is turned too little outwards towards Rosenmüller's cavity, so that when drawing back the instrument, the sensation of gliding over the lip of the tube is wanting.

4. The point of the catheter is in Rosenmüller's cavity. But while drawing it back, the posterior lip of the tube offers such a great resistance, that it might lead to the belief that the instrument is detained in the tube.

5. The beak of the catheter is drawn over the posterior lip of the tube, but instead of performing the rotation of the instrument, which is necessary for its entrance into the tube immediately after the point has slid over the lip, it is drawn still farther outwards. In this case the point of the catheter is often detained by the protuberance at the posterior extremity of the inferior spongy bone, which may also give rise to the erroneous assumption that the instrument is detained in the Eustachian tube.

6. The instrument, in being drawn back, is turned too little towards the Eustachian tube after it has passed its posterior lip, so that the point is in the orifice, while the direction of the beak does not correspond with that of the tube. It may also happen that the catheter, if its beak has not penetrated sufficiently far into the canal, slips out again by its being turned too much outwards and upwards. The point of the instrument is then directed towards the superior pharyngeal wall, which can be seen by the vertical position of the metal ring at its outer end.

5. *Obstacles during Catheterism, and the Modifications of the Operation required in consequence.*

Besides the congenital anomalies which impede the introduction of the catheter, or even make it impossible, obstacles in the naso-pharynx are often met with, due to diseased conditions. The most prominent are the following: The deformities due to traumatic affections of the septum of the nose and of the spongy bones; strictures of the nasal cavity from ulceration and caries; hyperostosis of the upper jaw (Moos); polypous formations; cancer; sarcoma, and adenoid vegetations in the naso-pharynx; and lastly, often excessive swelling and relaxation of the mucous membrane of the naso-pharynx.

The possibility of introducing the catheter into the Eustachian

tube in the presence of such anomalies depends in the first place on the degree of the stricture in the nasal cavity. If during the introduction of a thick catheter into the nasal cavity an obstacle is encountered which cannot be overcome by turning the instrument slightly to the side, a smaller catheter must be employed. If this also cannot be pushed forward, the operation must be attempted with a catheter, the beak of which is less curved. Arrived at the place of obstruction, it is not at all advisable to press the instrument forward by force, as not only is unnecessary pain caused, but the nasal walls may also be injured. To evade the obstacle, it is better to turn the beak of the catheter outwards (more rarely inwards) when arrived at the point of obstruction, and at the same time to push the instrument gently backwards. During this manipulation the catheter will often execute a complete rotation round its axis; indeed, cases frequently occur where two rotations of the instrument are necessary to effect a passage through a nose obstructed at several points, and to reach the posterior pharynx. The cases where the introduction of the catheter has to be modified in the above manner are by no means rare. If the obstruction is in the anterior portion of the nose, it can easily be discovered by lifting up the tip of the nose with the left thumb, and by illuminating with the concave mirror first one side of the nose and then the other. It will then often be perceived that the septum of the nose, bulged out strongly at one side, is in contact with the spongy bones. The strictures thus caused exist generally only on one side, while the other is more roomy than in ordinary cases. Tumours and polypous growths in the anterior and middle portions of the nasal cavity can often also be seen from the front by this illumination. In cases, however, where the narrowing is situated in the deeper portions which cannot be immediately viewed, information regarding the cause and extent of the obstacle may be obtained by Zaufal's specula, by the rhinoscope, or by digital examination.

In case of absolute impermeability of one of the sides of the nose, it has been recommended to effect catheterism of the corresponding Eustachian tube from the other nasal meatus; and where both sides are impermeable, from the cavity of the mouth. These modifications of catheterism can be quite dispensed with in many cases since the invention of my method, as by this procedure almost the same result is obtained as by catheterism. The above modifications will therefore be used only in exceptional cases where the permeability of the Eustachian tube can be effected neither by the Valsalvian experiment nor by my method, or where the injection of fluids into the middle ear or the introduction of bougies into the Eustachian tube are advisable.

Catheterism of the Eustachian tube from the opposite nasal passage, which was first proposed by Deleau,* was for a long time

* *Revue médicale*, 1827.

thought very difficult, by many even impracticable. Cerutti,* who speaks of this operation as being easily performed, recommends it as a generally applicable method to save the patient the unpleasantness of the introduction of the catheter through both nasal passages. If, according to Cerutti, the operation is performed with an ordinary metal catheter having a long and strongly curved beak, the point of the instrument may certainly get into the orifice of the tube, but by no means so far inside the tube as by catheterism from the same side. He therefore proposes the use of a double catheter with an elastic inner cannula, which can be pushed forward through the external metal cannula. V. Tröltsch uses a catheter with a long beak, strongly curved, such as is often necessary also for catheterism from the same side; and I agree with his assertion, that the finding of the orifice of the tube from the opposite side is not so simple and so safe, and that delicate auscultation has often to be dispensed with.

I consider the application of a double catheter as superfluous, but I have convinced myself by numerous experiments that the employment of my vulcanite catheters effects the purpose oftener and more safely than the metal ones, because they can be more easily pushed into the tube on account of their elasticity. As the cavity of the superior pharynx varies in size, it is often possible, in the case of a narrow pharynx, to get into the tube with an ordinary catheter; in other cases, however, catheters with a beak 20-25 mm. long are necessary for this purpose.†

The method of procedure in this modification is the following: The catheter is carried as before to the posterior pharyngeal wall, and its point is turned towards the opposite Rosenmüller's cavity, which places the metal ring in a horizontal position. The point of the catheter is then pushed into Rosenmüller's cavity by drawing the outer extremity of the instrument away from the septum of the nose towards the external wall of the nasal cavity; it is conducted into the orifice of the tube by traction over the hard lip of the tube, and is then pushed into the Eustachian canal by a moderate movement backwards.

If during this procedure the instrument is not distinctly felt to glide over the posterior lip of the tube, an entrance into its orifice may often be effected by drawing back the horizontally placed beak of the catheter to the posterior margin of the nasal septum, and by drawing the outer end of the instrument towards the external wall of the nasal cavity. The point of the catheter,

* *Nuova osservazione di Cateterismo della tuba Eust. destra dalla narice opposta. Gaz. med. italiana Stati Sardi*, 1858.

† The vulcanite catheters can be made very soft by warming them over a flame or in hot water for a few seconds, and they get hard again so quickly, that the beak of the instrument can be lengthened or curved at will in a very short time—a considerable advantage in comparison with the stiff inflexible metal instruments.

which by this means enters the orifice of the tube, is pushed into the canal by a slight movement backwards.

Fixing the instrument in position, in case of catheterism from the opposite side, is accomplished most easily with the thumb and forefinger of the left hand, the other fingers being laid upon the bridge of the nose. The instruments for fixing the catheter, which have been previously described, are insufficient for catheterism by this method.

The indications for catheterism from the cavity of the mouth are still more rare than those for the above modification. This operation is only performed when both nasal canals are impermeable to the catheter, or when with impermeability of the one canal catheterism from the other side is not possible. I also use this modification, which lately has again been recommended by Störk, Pomeroy, and Kessel, in cases of deficiency of the hard and soft palate, whether the orifice of the tube is visible through the gap or not. As the destructive processes in the palate are mostly combined with ulcerations and deformities in the nasal cavity, the tube will generally more easily be reached from the cavity of the mouth through the gap in the palate than through the nose.

The catheters used for this modification are of somewhat thicker calibre. The ordinary curvature of the beak will generally suffice in case of a defect in the palate; with an intact palate, however, it is advisable, as proposed by Störk and Kessel, to bend the point of the catheter towards the orifice of the tube and somewhat backwards, by which the aperture in the point of the instrument is brought more into the direction of the Eustachian tube. The introduction of the instrument is effected by placing the catheter flat upon the tongue (which is at the same time pressed down by the instrument), carrying it to the posterior pharyngeal wall and then turning its point upwards and towards Rosenmüller's cavity on the lateral wall of the pharynx. The instrument is at this stage withdrawn till its point arrives at the orifice of the tube, which event is recognized by its being felt to glide over the posterior lip. By a slight movement forwards the beak of the catheter is forced into the Eustachian canal.

But even though it is possible sometimes to perform catheterism in this manner, cases are by no means rare in which the operation is impeded and often rendered quite impossible by continuous choking and vomiting from irritability of the throat, or in which the irritability of the œsophageal muscles is only overcome after repeated attempts. This method is much more simple in cases of defective palate, because irritation of the muscles of the tongue and of the palate does not then occur, and the entrance of the point of the catheter into the canal can be directly seen.

In spite of the frequent congenital or acquired anomalies in the naso-pharynx, the cases where catheterism through the nose

is absolutely impracticable, in consequence of mechanical obstructions, are on the whole rare. The insuperable difficulties which occur sometimes in the execution of this operation, even with a normal condition of the naso-pharynx, are much more frequently due to other causes. Thus, for instance, the great majority of children offer a most energetic resistance; and although some specialists maintain the possibility of success in the operation even with children, these assertions, which are based upon isolated cases, are of no value in practice.

But resistance is met with in the adult also, for not only nervous and old persons but even strong men have an obstinate aversion to this operation, against which all the remonstrances of the surgeon are often powerless. Continued feverishness, weakness, and irritability during the convalescence of sick people of course contra-indicate catheterism.

We will lastly point out a number of unpleasant incidents which may occur during the execution of catheterism, and render success either very difficult or impossible. These are mostly vomiting and a sense of choking in the throat, which occur when the soft palate is touched, but which subside as soon as the catheter is introduced into the Eustachian tube. It happens, however, not frequently, that even with the catheter in correct position in the tube, an attack of vomiting is excited, which necessitates the removal of the instrument from the nose; this occurs especially on each occasion that air or fluid is injected into the tympanum. Such choking sensations are most commonly met with in old people, who on the whole do not stand catheterism well, and often do not permit it to be repeated. The rarer incidents by which the operation is interrupted are: continuous sneezing, which ceases only after the removal of the instrument; convulsive attacks of coughing during the introduction of the beak of the catheter into the Eustachian tube; and bleeding from the nose, which occurs, even though the catheter is carefully introduced, in persons predisposed to it.

6. *Methods of Propelling Air into the Middle Ear by the Catheter for Diagnostic and Therapeutic Purposes.*

Results of Auscultation in the Normal and Pathological Conditions of the Middle Ear.—The importance of the employment of currents of air introduced into the middle ear in cases of disease has already been insisted on in the commencement of this section. To Deleau is due the credit of first having made extensive use of this procedure for purposes of diagnosis, but principally in the treatment of the diseases of the ear. He it was who utilized the results of Laënnec's investigations, and, applying them practically, thereby made an important advance in the treatment of ear-diseases.

For the purpose of propelling air into the middle ear, a pyriform india-rubber balloon (capable of holding 300-350 grammes fluid) is generally used, a force-pump being rarely employed. The air-douche by means of the balloon is executed in the following manner: After the catheter, which has been introduced into the Eustachian tube, is fixed with the fingers of the left hand, and the corresponding ear of the patient has been connected with that of the surgeon by means of the auscultation-tube, the india-rubber balloon is seized with the right hand in the manner represented in Fig. 61, and is inserted into the outer extremity of the catheter, which fits it exactly, and the air is propelled into the middle ear by compression.

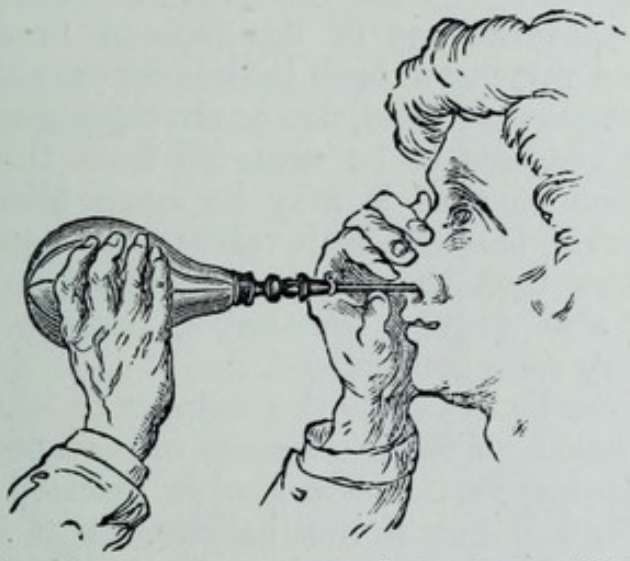

FIG. 61.—AIR-DOUCHE WITH THE INDIA-RUBBER BALLOON.

The following precautions have to be observed: The first compressions of the balloon must not be made too rapidly nor with too much force, as otherwise most unpleasant consequences might follow should the catheter be incorrectly placed. Such consequences are most commonly due to a faulty manipulation of the catheter, whereby its point is pressed against the walls of the pharynx or of the tube. In this way the mucous membrane, at the point against which the catheter presses, is injured either by the instrument itself or by the too powerful current of air; the air then penetrates into the cellular tissue of the pharyngeal mucous membrane, and an emphysema results which is mostly confined to the pharynx, but sometimes also extends to the entrance into the larynx, as well as to the submucous connective tissue of the lateral region of the neck and face.*

* The submucous emphysema in the pharynx generally disappears after a few days. It is most troublesome during the act of swallowing, and respiration is somewhat impeded only when the swelling is of considerable extent. Often a continuous, troublesome tickling and itching in the pharynx will arise, which cause the patient to clear the throat repeatedly, whereby the emphysema frequently increases in extent, because by the forced acts of expiration air is driven below the mucous membrane at the injured point. It is therefore important to recommend patients, after the occurrence

If, therefore, great resistance is felt during the first compression of the balloon, instead of repeating the compression, it is advisable to draw back the instrument a little, whereby the orifice at its point is relieved, so that the air can penetrate unchecked into the canal. If this is not sufficient, the catheter must be removed from the tube and re-inserted.

It is a matter of importance to have the catheter firmly fixed while air is being blown into the ear. If it is not so, the instrument may be driven backwards, perforating the pharyngeal mucous membrane, and giving rise to emphysema. In order to avoid this accident, the balloon may be connected with the catheter by a short piece of india-rubber tubing.

The air being heard to enter the tympanic cavity, several quick and powerful compressions of the balloon may be made, the number of these varying in each individual case according to the degree of resistance presented, five or six times generally sufficing.

The balloon requires to be removed from the catheter after each compression, so that it may be again filled with air. To avoid this removal, balloons with valves have been proposed, but experience shows that they soon get out of order; perforated balloons have also proved unsuitable, because the orifice by frequent use very soon gets dilated.

Attention must be drawn to the manner in which the balloon is to be compressed, as having a most important bearing on the effect of the air-douche. I have always asserted that the most powerful pressure is got if the balloon, as in Fig. 61, is compressed from the side, between the hollow of the hand and the tips of the fingers, the pressure obtained being considerably less when the fingers are applied round the neck and the balloon is compressed by the thumb laid on its base. This statement has been confirmed by the experiments of A. Hartmann, who obtained a pressure of 380 mm. Hg. by the former method, and only 260 mm. Hg. by the latter.

Although this mode of inflation suffices in the majority of cases requiring the air-douche, it not unfrequently occurs, however, that the resistance in the Eustachian tube and in the tympanic cavity cannot be overcome by it; or, if the air enters into the middle ear, the current is so weak that the mechanical obstacles to the conduction of sound are not overcome by it. In such cases it is necessary to use a force-pump.

My force-pump (Fig. 62) consists of a globular metal receptacle,

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of emphysema, to suppress as far as possible the clearing of the throat and the act of swallowing. If the swelling assumes such an extent that it produces difficulty in breathing, an exit for the air may be made by tearing the pharyngeal mucous membrane with the nail of the forefinger, or, according to Guye, by cutting the soft palate with scissors. In cases of emphysema affecting the cheeks and the neck, friction of the parts has been recommended—but is not, in my opinion, a good method of treatment, for it drives the air towards the pharynx, rather increasing the disorder.

14 cm. in diameter (*e*), in which the air is condensed by a piston, working in a tube (*d*). The difference of this pump from its predecessors is, that its manipulation does not require the least exertion, that the compression of air in the pump to the necessary degree can be accomplished in a very short time and with only one hand, and that the strength of the escaping current can be exactly regulated. A double-acting valve renders it possible, by a rapid upward and downward motion of the piston, to increase the pressure to $\frac{2}{3}$ atmosphere in the space of 15 seconds. Considerable advantage is gained in this pump by the lever-valve (*b*) fitted on the escape-pipe. By it the strength of

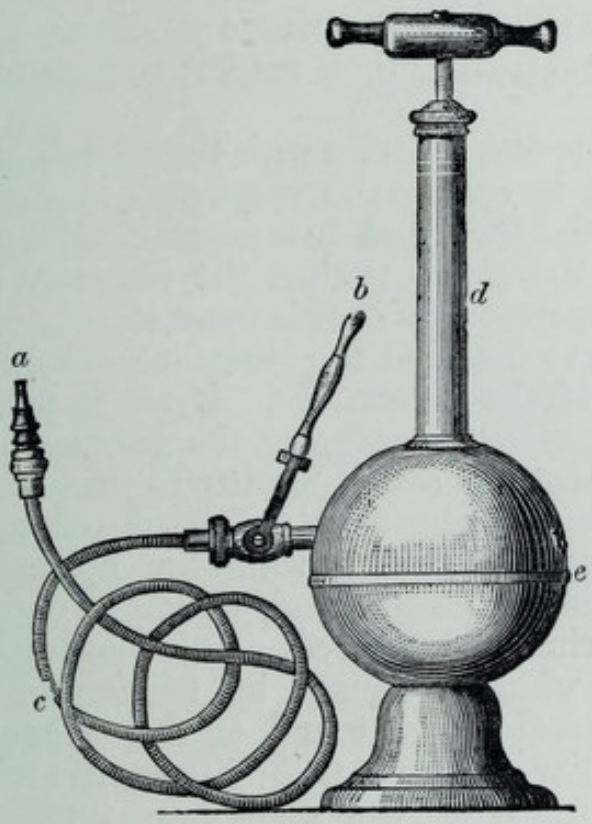

FIG. 62.—FORCE-PUMP.

the current of air can be fixed according to the size of the angle formed by the lever with the vertical; also, if a powerful current of air, of short duration, is to be applied, it can be instantaneously interrupted by a rapid backward and forward movement of the lever. The india-rubber tube (*c*), connected with the escape-pipe, is furnished with a conical nozzle (*a*), which is fitted into the outer extremity of the catheter.

To determine the pressure of air in the pump, an open or closed quicksilver manometer, or a spring one, may be connected with the escape-pipe behind the valve. In force-pumps not provided with a manometer, the pressure may be measured by testing with a manometer the number of motions of the piston required to produce $\frac{1}{4}$, $\frac{2}{5}$, $\frac{1}{2}$, and 1 atmospheric pressure.

Before the compressed air is allowed to pass through the

catheter into the tympanic cavity, it is necessary to ascertain by the use of the balloon that the catheter is correctly placed in the Eustachian tube. If this precaution is disregarded, serious accidents may happen, as the mucous membrane of the tube or of the naso-pharynx may be injured by the rapid entrance of a current of air, giving rise to extensive emphysema of these parts. For besides the pain, choking sensations in the throat, and dyspnœa, suffocative attacks may occur if the emphysema spreads downwards to the entrance to the larynx.*

The bellows of Richardson's spray apparatus, recommended several years ago by Lucae, and lately again by Schwartze, not only cannot replace the use of the force-pump, but are even inferior in their effect to the single pyriform balloon. This is easily tested by comparing their respective pressures as measured by a manometer.

Blowing air into the catheter with the mouth, still practised by many specialists, is only to be employed in exceptional cases; for, apart from the fact that the expiration-force is mostly too weak to be of therapeutic value, the majority of patients are reluctant to be operated on in this manner,

We have now to describe the auscultation-sound produced by the application of the air-douche. If air is propelled into the normal middle ear by the catheter, the listener will hear a large, dry, protracted, blowing sound, similar to that which is produced if the tongue is brought near the hard palate and the act of expiration is performed quickly while the lips are almost closed. But rarely is the flapping sound, which is noticed during the Valsalvian experiment, perceived. This blowing sound (Deleau's *bruit de pluie*), which is caused by friction of the air on the walls of the Eustachian tube and of the tympanic cavity, and receives its peculiar character mainly from the friction of the air on the inner surface of the membrana tympani, has various degrees of strength and distinctness, which are dependent on the varying width of the Eustachian canal in different individuals.

The calibre of the catheter, the size of the orifice at its point, and its position with regard to the walls of the Eustachian tube, exercise a considerable influence on the pitch and the intensity of the auscultation-sounds, in the normal as well as in the diseased ear.

By using slender catheters, a higher and shriller sound will generally be heard than by propelling air through a catheter with a wider lumen. A change of the auscultation-sound may also occur during catheterism, if the orifice in the beak of the catheter is relatively narrowed by lying against the wall of the tube through a change in the position of the instrument.

* In two cases of Turnbull's of London, where sudden death occurred during the application of the force-pump, the fatal cause remained unexplained. It is quite probable that the entrance of the larynx was closed up by a considerable submucous emphysema, and that death from suffocation ensued.

It has already been insisted on, in the pathological division, that the Eustachian tube is widened by the act of swallowing so that it gapes. Thus the air propelled through the catheter during the act of swallowing is heard to enter the tympanum with a much louder noise. But the correctness of the position of the catheter can by no means be inferred from the fact that the entrance of air into the tympanic cavity is not heard at all, or only very slightly, without deglutition, but plainly perceived during an act of swallowing. For it occurs not unfrequently that the sound caused by the entering air is distinctly heard, although the point of the catheter is situated outside the tube, in front of or behind its orifice. This is easily explained; for a slight condensation of air near the orifice of the tube may extend to the tympanic cavity if the tube is made to gape by an act of swallowing.

A misleading auscultation-sound deserves to be mentioned here. It occurs as well in normal as in pathological states of the ear, mostly when the catheter is incorrectly placed, though sometimes when it is in correct position. This is a sound caused by the reflux of the injected air from the narrowest part of the Eustachian tube back into the pharynx, the air never having reached the tympanic cavity. This sound is somewhat similar to that of the air entering the tympanic cavity, and may therefore easily be mistaken for it. The difference, however, is that the former is much weaker and softer, and seems far more distant than the latter, which is heard as if it arose immediately under the ear of the examiner.

In some rare cases, the air entering the tympanic cavity through the catheter causes no sound, even in normal states, though more frequently in pathological conditions. To ascertain in such cases whether air has entered the tympanic cavity, I use the ear-manometer (see page 71) designed by me, which is inserted hermetically into the external meatus. Every time the inflating-bag is compressed and air enters into the tympanic cavity, the drop of fluid with which it is supplied will rise, owing to the bulging forward of the membrana tympani.

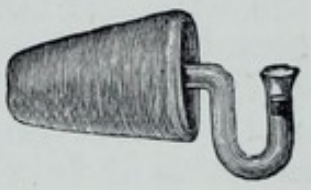

FIG. 63.—EAR-MANOMETER.

The auscultation-sound caused by the use of the air-douche is subject to many changes in diseased states of the middle ear. To estimate the value of these abnormal sounds, we must bear in mind that we have to deal generally with a combination of sounds, caused partly by free exudation in the middle ear, partly by swelling of the lining membrane of the middle ear and stricture of the Eustachian tube, and partly by morbid changes in the membrana tympani. That the strength of the air-current influences the quality of the sounds need hardly be mentioned.

There is generally a considerable difference between the auscul-

tation-sounds produced in cases of perforate membrana tympani and those in cases in which the membrane is intact. When the membrane is not perforated, the sounds heard on auscultation vary directly with the amount of swelling and secretion in the middle ear. In cases of accumulation of secretion in the middle ear, rattling noises, differing in quality, will frequently be heard whilst the air-douche is being used. These rattling noises originate most frequently in the Eustachian tube, especially when it contains rather fluid secretion. These sounds, however, have by no means that diagnostic importance which some specialists attach to them, for clinical experience and experiments on the dead body show that the rattling sounds which arise in the Eustachian tube often cannot be distinguished from those which are due to accumulation of mucus or serum in the tympanic cavity, and that therefore it can only rarely be inferred from the quality of the sounds in which of these two places the secretion is deposited. These rattling sounds are less frequently due to the passage of the air through accumulations of secretion in the tympanic cavity. But if a considerable quantity of fluid secretion has collected, such sounds, in rapid succession, will often arise, may even be heard without the auscultation-tube, and frequently continue for some time after the inflation; while, with a scantier secretion, the presence of which can be proved by inspection of the membrana tympani, if the air passes above the level of the fluid, without mixing with it, frequently no such sounds will be heard. Seldom have I observed a marked rattling noise with tough, thready, coherent mucous masses in the tube and in the tympanic cavity, but generally a rough, grating or friction sound.

The character of the râles originating in the Eustachian tube and in the tympanic cavity is manifold. In the case of a secretion of fluid consistence there is generally heard a râle of a fine bubbling character; on the other hand, in the case of thick, tenacious secretions, the sound has a larger, uniform, and more interrupted bubbling character, the interruption sometimes having the character of a rough friction-sound, caused by a simultaneous swelling of the mucous membrane of the tube and an alteration in the tension of the membrana tympani. A distinct râle is often heard only at the commencement of the inflation, soon followed by a rough or freer inflation-sound. This is the case if the secretion lodged in the tube has been removed by the first inflation of air, or if during the introduction of the catheter mucous secretion from the naso-pharynx has stuck to its point and got into the tube with the beak of the instrument. This occurs frequently, and might give rise to mistakes, because the rattling sounds so caused might be looked on as a consequence of hyper-secretion of the mucous membrane of the tube.

The rattling sounds produced by mucus in Rosenmüller's

cavity or near the orifice of the tube, when the catheter is incorrectly placed, must be distinguished from those already described. As has long been known, it differs from the sounds produced in the middle ear in that it resembles the bursting of large bubbles, and is heard as if distant from the ear. Grating sounds also are observed in the pharynx during the application of the air-douche, caused partly by vibrations of the membranous wall of the tube, partly by the vibration of the soft palate when the air is returning.

The auscultation-sounds pathognomonic of the secretive forms of inflammation of the middle ear are produced chiefly by stricture of the Eustachian tube and by the abnormal tension of the membrana tympani. Stricture of the tube is most frequently due to swelling of its mucous membrane, more rarely to new formation of connective tissue in the submucous layer (organic strictures). When the mucous membrane of the tube is swollen, the auscultation-sound, in consequence of the increased resistance to and greater friction of the air, will have an uneven, shrill, and high-pitched character, sometimes jerking, rugged and cracking, sometimes combined with mucous rattling. In organic strictures of the tube, however, such as arise sometimes after suppurative inflammations of the middle ear, and lastly, in consequence of ulcerative processes in the naso-pharynx, the auscultation-sound is mostly weak and indistinct, or quite wanting, and scarcely altered during deglutition; sometimes, however, a high-pitched, thin hissing or whistling sound will be perceived, as the air passes through the stricture.

It has already been pointed out that the friction of the air on the inner surface of the membrana tympani gives to the auscultation-sound its character. This is proved not only by experiments on the dead body, but also by comparing these with observations made on patients. I have shown by a number of experiments that if, in a preparation of the normal ear, the membrana tympani is either stretched too tightly or too loosely, the normal auscultation-sound will be altered thereby, because the vibrations of the membrane from the friction of the air will be changed in consequence of its altered tension. The shrill and high-pitched sound produced by the entering air, which, as already mentioned, is observed in cases of great swelling in the Eustachian tube, receives its character therefore partly from the altered tension of the membrana tympani, a condition which, as we know, is almost always combined with impermeability of the Eustachian tube. But that anomalies of tension of the membrane can alone change the auscultation-sound will be seen from the fact that with cicatrices in the membrane, with relaxation of it in consequence of atrophy, with cicatricial adhesions between the membrane and the inner wall of the tympanic cavity, and also with stiffness of the membrane, even if the Eustachian tube is normally permeable,

shrill, high-pitched, and vibrating auscultation-sounds will often be heard. These often appear so near the ear of the auscultator that they might easily be mistaken for the auscultation-sounds heard in cases of perforated membrane. Although, after some practice, those can generally be distinguished from the sounds caused by perforation, yet isolated cases occur where no certain information can be obtained by auscultation. By the employment of the ear-manometer these cases can be distinguished with the greatest certainty; for with an intact membrana tympani there is observed only a rise of the fluid, while with perforation the fluid will be thrown out altogether.

In inflammations of the middle ear without swelling or secretion the auscultation-sounds vary. If the tube and the membrane are not affected, as is the case in the circumscribed inflammations of the middle ear, which cause stiffness of the ossicular articulations, but more commonly anchylosis of the stapes, the normal blowing-sound will always be heard. In cases of condensation of the mucous membrane of the middle ear, however, where the membrana tympani is also drawn inwards, there will be heard only a weak, dry, thin sound, or sometimes a high, shrill or whistling one.

The character of the auscultation-sound in a case of perforated membrane depends on the presence and quantity of secretion in the middle ear, on the degree of stricture of the Eustachian tube, and also on the size of the perforation. Either a hissing sound, perceptible even without the auscultation-tube, and combined with a rattling sound, or, where there is no secretion but a stricture in the tube, a high-pitched whistling or hissing sound without any rattling is heard. But if the tube is dilated, which occurs after suppurative inflammation of the middle ear, a blowing puffing sound will be perceived, even if the perforation in the membrane is small. As the air which comes through a perforation passes into our ears through the auscultation-tube, these sounds will be heard as intensely as if they had their origin in our own organ. In cases where the margins of the perforation lie closely together, where also inspissated purulent masses, growths of mucous membrane in the tympanic cavity, or adhesions closing the tympanic orifice of the Eustachian tube cause such obstruction in the tympanum that the air cannot escape through the perforation, no distinct sound of the air hissing through will be heard, but either only a weak, indistinct râle, caused by the entrance of the air, or an interrupted clacking noise, mingled with rattling, will be perceived, or there will be no auscultation-sound at all.

Concerning the auscultation of the mastoid process, Laënnec* has already proved that the air entering into the middle ear produces a sound in the mastoid process, plainly perceptible

* *Sur l'Auscultation médiate*, 1835, p. 57.

by auscultation, and that also rattling sounds in the middle ear are heard by auscultation at the base of the mastoid process, and that the locality of their origin can be distinguished. Dr. Michael, of Hamburg,* has lately investigated these auscultation phenomena by experiments on the dead body and on the living, employing for this purpose an otoscope fitted with an ear-speculum for application to the mastoid process. His results are briefly as follows: If a blowing auscultation-sound is heard in the mastoid process of the living, it can be positively asserted that the mastoid cells are filled with air and are therefore free from any pathological products. When the permeability of the Eustachian tube is much impaired, as well as when there is perforation of the membrana tympani, no sound whatever will be perceived in the mastoid process. If these two conditions can be excluded and the sound be absent, a diseased state of the mastoid cells may be inferred (*e.g.*, exudation, cheesy masses, growths of mucous membrane, sclerosis).

The importance of auscultation in the diagnosis of the affections of the middle ear has been both over- and under-estimated. It cannot be denied that although auscultation often furnishes a negative and uncertain result, it may nevertheless often suffice to decide the diagnosis of an affection of the middle ear in a given case. And though the diagnostic value of auscultation by itself is on the whole but limited, yet it is of importance in connection with other symptoms, for by completing the objective group of symptoms it contributes considerably to the recognition of the pathological alterations in the middle ear.

7. *Methods of Injection of Fluid and of the Introduction of Vapours into the Middle Ear through the Catheter.*

Injections of fluid through the catheter are employed in the different forms of disease of the middle ear. Their purpose is: (1) in swelling and hyper-secretion, by the immediate action of the medicated fluid upon the diseased mucous membrane, to lessen the secretion, and to cause a decrease in the swelling of the lining membrane; (2) in that form of disease in which, in consequence of condensation of the mucous membrane, a firm union of the ossicula between themselves and with the walls of the tympanic cavity exists, to effect an irritation and loosening of the rigid mucous membrane, and thereby a greater mobility of the ossicula, by the injection of slightly irritating fluids; (3) in accumulation of inspissated secretions, to bring about their removal by liquefying them.

The injection of medicated fluid into the middle ear through the Eustachian tube by means of the catheter is imperfect in so

* *Arch. für Ohrenheilkunde*, vol. xi. p. 46.

far as one can never ascertain what quantity of the fluid intended for injection reaches the tympanic cavity. The first reason for this is the funnel-shaped form of the Eustachian tube in its cartilaginous portion, the walls of which therefore appear as oblique planes. Now if the fluid is squirted out of the point of the catheter, introduced into the cartilaginous portion, only the central part of the fluid jet will pass through the tube, and penetrate into the tympanic cavity, while the lateral diverging portions of the jet will light upon the oblique planes of the cartilaginous tube, and to a great extent flow off into the pharynx.

The quantity of the fluid penetrating into the tympanic cavity is the greater the farther the point of the catheter is pushed towards the isthmus tubæ, and the more exactly the orifice of the instrument corresponds with the direction of the Eustachian tube. As the direction of the tube also varies considerably in different individuals, and its cartilaginous and osseous portions form an obtuse angle, opening downwards, the partial escape of the fluid into the pharynx cannot be prevented, even though the injection is correctly performed.

The details of the method of injection of small quantities of fluid into the middle ear, as at present in use for purposes of treatment, are the following: After the catheter has been introduced into the Eustachian tube, air is injected two or three times into the tympanic cavity by means of the inflating-bag to remove secretion, which might be deposited in the tube, and would obstruct the entrance of the fluid.

Next 8-10 drops of the slightly warmed medicated fluid are put into the catheter by means of Pravaz's syringe, or by means of a drop-glass (de Rossi), then the fluid is blown into the middle ear by the balloon. If there is great resistance in the Eustachian tube, the entrance of the fluid may be facilitated by causing the patient to swallow during the injection, by which means the tube is rendered more patent. Care must be taken that the head of the patient remains in the erect position, because if the head is inclined backwards, the fluid in the catheter will escape into the pharynx before the propulsion into the middle ear has taken place.

The phenomena observed during and after the injection of small quantities of fluid into the middle ear vary very much when the membrana tympani is intact. When the Eustachian tube is normally open or only slightly narrowed, the auscultator hears a shrill sound, caused by the entrance of the fluid, accompanied by a rattling sound, as if small bubbles were blown, which is often perceptible for some time after the injection. With great swelling of the mucous membrane of the tube, as well as with abnormal tension of the membrane, the rattling sound appears to be much higher in pitch, rougher, and more penetrating. The inspection of the membrana tympani will show either an un-

altered state of the membrane, or a more or less marked injection of the vessels of the handle of the malleus, and great congestion of the neighbouring portions of the superior and posterior walls of the meatus; this occurs not only with the application of irritating injections, but also sometimes with the employment of quite indifferent fluids. Small quantities of fluid are seldom seen after injection to shine through the membrana tympani; large quantities of fluid will, however, be seen to shine through, especially when the membrane is transparent, and the fluid is coloured.

The subjective symptoms which occur after inflation consist mostly of a sensation of fulness and warmth, sometimes of burning, more rarely of acute pain in the ear. Great reaction with subsequent inflammation in the middle ear I have seldom observed, and never an inflammation with suppuration in the tympanic cavity, and perforation of the membrana tympani. Much more frequently the escape of a portion of the fluid into the pharynx causes an unpleasant itching, hawking, and cough, which can be most quickly removed by gargling with cold water. Acute pain in the ear after the injection is removed, either by rubbing the region of the external ear, by simply breathing into the ear, or by pouring lukewarm water into the external meatus.*

For the injection of larger quantities of fluid into the middle ear a thicker catheter with a longer beak is used, and is pushed as far as possible into the Eustachian tube. By this means the point of the catheter is more firmly enclosed by the walls of the tube, and the outflow of the injected fluid into the pharynx is lessened. The injection is effected by a vulcanite syringe, made to contain 80-100 grammes, the nozzle of which can be fitted hermetically into the outer extremity of the catheter. The greater the resistance in the middle ear, the more difficult is the injection of fluid into the tympanic cavity; indeed, even with a permeable tube and a perforated membrane, and with the point of the catheter well pushed in, only a portion of the injected fluid will escape at the external meatus, the greater portion making its way into the pharynx or the nose.

But it is not always possible to inject fluid into the middle ear by the catheter in the above manner, especially if the tympanic cavity is partially or wholly filled by inspissated mucus or by proliferation of the mucous membrane. In case of such obstacles it will not be possible for the fluid to penetrate into the tympanic cavity, and it will flow back from the tube into the pharynx. It is then advisable to use the elastic tympanic catheter, which has been recommended by Weber-Liel for sucking exudation out of the tympanic cavity, and for injection of

* After the successful injection of different fluids into the tympanic cavity, Moos has observed temporary gustatory sensations in some of his patients.

Fig. 64. Elastic Tympanic Catheter.

medicated fluids into the tympanum. In my work *Ueber die Anwendung des Paukenröhrchens.** I have made the assertion, based upon a considerable experience, that the tympanic catheter can generally be dispensed with in those conditions of the middle ear for which it is recommended by Weber-Liel, but that in certain other diseases of the middle ear, of the external meatus, and of the mastoid process, it proves an invaluable instrument.

The tympanic catheter (Fig. 64) consists of a small flexible tube, funnel-shaped at its outer extremity, 17 cm. long, and 1-1¼ mm. thick, with a small aperture at its point (or on its side) for the exit of air or fluid.

The introduction of this tube into the tympanic cavity is effected in the following manner: a moderately thick vulcanite catheter, 12 cm. long, through which the small catheter can easily be pushed, is first introduced into the Eustachian tube. After the correct position of the catheter has been ascertained, it is fastened to the nose by means of Bonnafont's clamp, and the little elastic catheter is pushed through it into the Eustachian tube and into the tympanic cavity. The point of the small catheter will be in the tympanum, when it has been pushed 2½-3 cm. beyond the point of the catheter, as indicated by a mark previously made on its outer extremity.

According as a smaller or larger quantity of fluid is to be injected, either Pravaz's graduated syringe or a larger one is used, and its nozzle must fit into the funnel-like widened extremity of the tympanic catheter. As the friction of the fluid in the latter is very great, a considerable amount of pressure has to be employed during the injection; this pressure must be increased only gradually, because if outflow into the external meatus is prevented, violent pain and giddiness may arise from the suddenly increased pressure of the injected fluid upon the walls of the tympanum.

When the fluid injected either by the catheter alone or by aid of the tympanic tube is entering the tympanic cavity, a dull rushing sound will be heard similar to that which is perceived when one listens over an india-rubber tube through which fluid is flowing. When a considerable quantity of fluid is injected, although the tympanic catheter has been used, a large portion will flow into the naso-pharynx, while the portion injected into the tympanic cavity will escape mostly by drops into the external meatus.

The injection of large quantities of fluid into the middle

* *Wiener med. Wochenschrift*, Nos. 15, 16, 1875.

ear by the catheter as well as by the tympanic tube I consider applicable only in those affections of the ear where a perforation of the membrana tympani exists, and where, therefore, the fluid injected into the tympanic cavity may escape again through the external meatus. Referring to the special division for the indications for this method, we will here only mention that injections of warm water are specially serviceable where there is violent inflammation in the middle ear in consequence of inspissated secretion, and where, therefore, liquefaction and removal of the inspissated exudation have to be effected. They are also successfully employed in those cases where, in the course of chronic suppuration of the middle ear, even without retention of secretion, an acute inflammation, accompanied by violent pain and with or without an osseous affection, is intercurrent.

We must, however, disapprove of such injections in those affections of the middle ear in which the membrana tympani is not perforated. Deleau,* and Bonnafont,† speaking from considerable experience, have already pointed out the injurious consequences in the middle ear which follow the injection of large quantities of fluid when the membrana tympani is intact. We can fully confirm their statements, for, after the introduction of a large quantity of fluid into the middle ear, there is not unfrequently a most violent reaction, accompanied by the development of a very painful suppurative inflammation of the middle ear, with perforation of the membrana tympani, which may lead to fatal complications.

These unfavourable incidents are, however, not brought about by injections with the catheter only, but, as will be seen from the description in the next division, they are developed with still greater intensity when those methods of injection are employed in which the use of the catheter is dispensed with.

The introduction of medicated substances in the form of vapour in the treatment of the diseases of the middle ear was formerly practised more frequently than now. It was thought that vapours acted more uniformly on the diseased mucous membrane than medicines injected in a fluid form.

The volatilizers proposed by Itard, Kramer, Lincke, Wolf, Rau, and others, have almost all gone out of use, and need not be described. At present, in the rare cases in which vapours are introduced into the middle ear, more simple instruments are employed, of which the one designed by v. Tröltsch is the most practical, on account of its compendious form and easy production. This apparatus, represented in Fig. 65 in a somewhat modified form, consists of a glass bottle with a wide neck, closed by a stopper of vulcanized india-rubber pierced with three holes, and fixed on a stand. Into the middle orifice is inserted a ther-

* *Traité du Cathétérisme de la Trompe d'Eustache*, p. 53.
† *Traité théorique et practique des Maladies d'Oreille*, 1860, p. 77.

mometer to ascertain the temperature of the vapours, in the lateral orifices two curved glass tubes; the one (*d*) serves for the conduction of the compressed air, and the other (*f*) for the introduction of the vapour into the tympanic cavity.

To utilize the apparatus for different kinds of vapours, small tin vessels, fastened to a wire, serve for the reception of the drugs. At the bottom of the glass bottle is a layer of sand, which is heated by the flame of a spirit-lamp, and soon causes the medicated substance in the metal vessel to evaporate. The propulsion

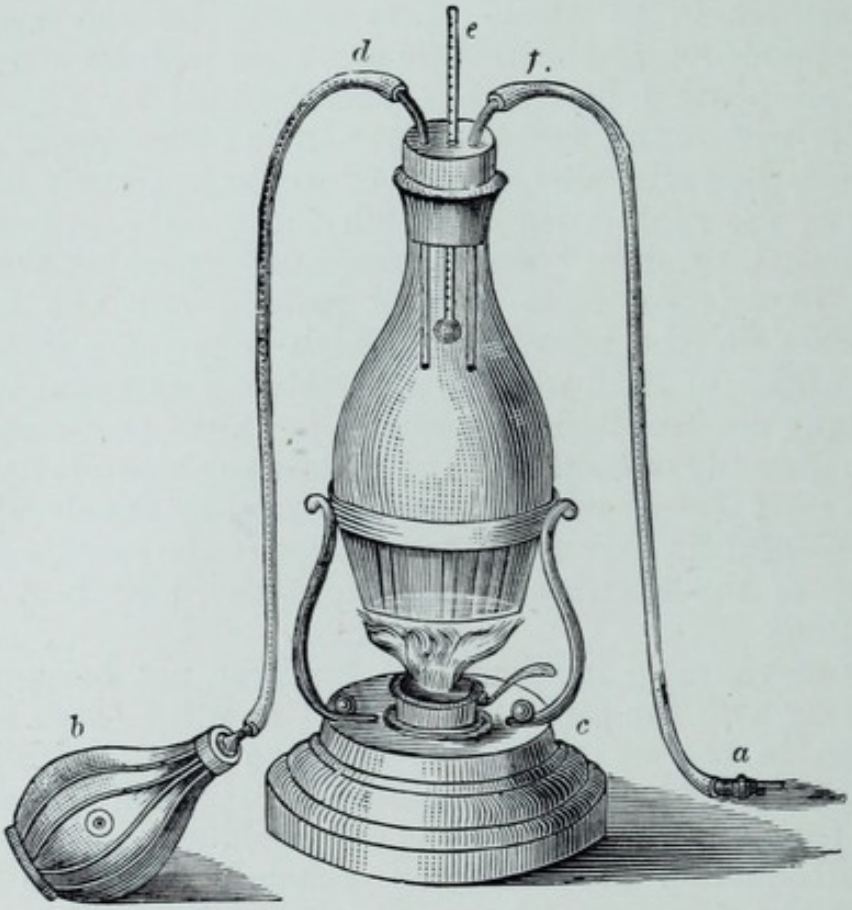

FIG. 65.—VOLATILIZATION APPARATUS.

of air may commence when vapours become visible at the point of both glass tubes.

The vapours which are developed in the bottle are propelled by a compression apparatus connected with the conducting-tube (*d*) into the tube (*f*), and from there through the catheter into the middle ear. The choice of the compression apparatus depends on the air-pressure by which the vapours are to be propelled into the tympanic cavity. If only a slight pressure is required, Richardson's bellows, consisting of a double balloon, the effect of which can be heightened by an occasional compression of the escape-pipe, will suffice. According to Miot, a single pyriform balloon with a lateral orifice (Fig. 65, *b*) is more useful; the orifice is closed by the middle finger of the compressing

hand, and permits the re-entrance of air after the compression has taken place.

When employing either a single or double balloon, the pressure, measured at the escape-pipe of the glass bottle, will be less than the manometrical pressure at the point of the balloon itself, because a great portion of the pressure gets lost in the bottle as well as in the conducting-tubes leading into the catheter. The air, impregnated with vapours, will therefore flow from the point of the catheter with only a slight force, reaching the tympanic cavity with a slighter pressure when the Eustachian tube is permeable.* But when the Eustachian tube is much swollen, as also when there is considerable obstruction in the tympanic cavity, the balloon is insufficient as a compression apparatus, and in such cases it will be necessary to effect the propulsion of vapours into the middle ear by means of a force-pump (*vide* Fig. 62, p. 131), connected with the tube (*d*) of the volatilizer.

When applying rapidly evaporating fluids, such as chloroform, sulphuric ether, acetic ether, turpentine, amylnitrite, a volatilization apparatus is not required. It is enough to put a few drops of the fluid into the balloon, and to press the developing vapours through the catheter into the tympanic cavity; or the vapours may be collected by placing the point of the compressed balloon into the neck of the small bottle which contains the medicated fluid, and then gradually relaxing the pressure.

Concerning the precautions which have to be observed in the application of vapours to the tympanic cavity, in the first instance one must have ascertained that the catheter has been correctly placed in the tube. The introduction of vapours has, therefore, to be preceded by the air-douche with the balloon to determine the permeability of the Eustachian tube, and to remove secretion deposited in the canal. The fixture of the catheter during the introduction of vapours is most easily effected by Bonnafont's clamp, or by Delstanche *fils*' pinchers (*vide* p. 120). The temperature of the vapour depends on the drug employed, many evaporating at a low temperature, while others require a high one. The duration of the application also depends on the nature of the drug and on the amount of irritation which is developed during the action of the vapour in the ear or in the pharynx. Generally the duration of the application is three, five, or ten minutes.

The phenomena observed during and after the introduction of vapours into the middle ear are usually a feeling of warmth and fulness in the ear. Great burning in the ear, with at the same time injection of the vessels of the handle of the malleus, most frequently occurs after the action of ammonia vapours. The most marked reactive phenomena occur, however, in the naso-

* The older aural surgeons used commonly a slight pressure in the introduction of vapours into the middle ear.

pharynx, as the escape of vapours into that cavity often causes great itching, hawking with cough, congestion and swelling of the mucous membrane, and increased secretion.

When I first employed this highly recommended method of treatment, at the beginning of my career as a practitioner, I asked myself the question whether the vapours really reached the middle ear in such quantities as was generally supposed. I undertook, therefore, a number of experiments on human organs of hearing to ascertain the manner in which the vapours entered into the middle ear. The experiments with different kinds of vapours gave different results. Of simple or medicated steam, which was so frequently used, only a very trifling quantity reached the tympanic cavity in the form of vapour, as a portion of the steam is condensed even in the conducting-tube and in the catheter, while another portion is so during the outflow from the point of the catheter at the narrowest place of the Eustachian tube. Of the condensed steam only a part will, therefore, be propelled into the middle ear by the current of air in a fluid form, while the greater portion runs off into the naso-pharynx. Sal-ammoniac vapour will also be condensed at the narrowest place in the Eustachian tube, and only small quantities of it will reach the tympanic cavity in vapour form. Of easily condensed vapours very little, or nothing, will reach the tympanic cavity, especially when the lining membrane of the tube is greatly relaxed, and a considerable portion of the canal is narrowed. However, the subtle vapours of chloroform, of sulphuric ether, of the various ethereal oils, of acetic ether, of turpentine, and of iodine, can be propelled in greater quantities into the tympanic cavity even where there are considerable obstacles in the Eustachian tube. Of the different kinds of gases, carbonic acid especially was formerly frequently applied. The apparatuses designed by Ruete and Rau (*Lehrbuch der Ohrenheilkunde,* p. 143) for the development of this gas are, however, much too complicated. The simplest manner of effecting the development of carbonic acid, and its introduction into the middle ear, is to collect in the pyriform india-rubber balloon the carbonic acid, which is developed in a good-sized bottle, half filled with a solution of soda, by the addition of tartaric acid, and to press it through the catheter into the middle ear.

Loewenberg* has recently recommended, instead of atmospheric air, the application of hydrogen gas or breathed air, collected in a bladder for the air-douche. The statement of Loewenberg, that the effected increase in the hearing will last longer when breathed air is applied than when atmospheric air is used, I cannot confirm after repeated experiments.

* *Académie des Sciences*, 1876.

c. The Author's Method of making the Eustachian Tube Permeable. (Politzer's Method.)

The method of making the Eustachian tube permeable, which I published in 1863,* is based upon the fact that condensed air can be blown through the Eustachian tube into the middle ear during an act of swallowing, the naso-pharynx being closed on all sides. The essential novelty of this method, by which it is distinguished from catheterism of the Eustachian tube, lies in the fact that the nozzle of the instrument to be used for condensation of air is introduced only into the anterior portion of the nasal cavity, and thereby introduction of the catheter into the Eustachian tube, which is sometimes impracticable and often disagreeable, is avoided. The closure of the naso-pharynx in this method is effected, behind by the soft palate being closely applied to the posterior pharyngeal wall, and in front by compression of the alæ of the nose. At the same time the resistance in the tube is lessened by the act of swallowing, by which the influx of the condensed air into the tympanic cavity is materially facilitated.†

The most serviceable instrument for my method is a pyriform balloon (Fig. 66), about the size of the doubled fist, which is furnished with a slightly curved tubular nozzle. To avoid bleeding, which is frequently produced by the immediate impact of the stiff nozzle upon the pituitary membrane, the connection between the balloon and the nozzle is effected by the insertion of a short elastic india-rubber tube.

The details of the method are the following: The patient, seated in a chair, takes a little water into his mouth, which he is required to swallow when told.‡ The surgeon, standing on the patient's right, introduces the nozzle of the Politzer-bag one cm.

* *Wiener med. Wochenschrift*, 1863, No. 6.

† This method was suggested by a number of experiments made in reference to the fluctuations in the pressure of air in the tympanic cavity. I quote here the second experiment (*W. med. W.*, 1863, v. 6), which I demonstrated to Professor v. Tröltsch in 1861. If I introduce the extremity of the escape-pipe of a force-pump into the nose, half an inch deep, and compress the alæ round it, and then perform an act of swallowing while the compressed air rushes into the nasal cavity, I feel the air at the same moment entering with force into both tympanic cavities, while the drop of fluid in a manometer, inserted into the external meatus, moves outwards.

‡ The use of water is by no means absolutely necessary in all cases during the application of my method, which I often perform during a simple act of swallowing, the effect of an energetic act of deglutition being the same as that of drinking water. Sometimes, however, the simple act of swallowing is less powerful, and not only is deglutition in such cases materially facilitated by drinking water, but the lumen of the Eustachian tube is also more widened by the powerful contraction of the naso-pharyngeal muscles, and the effect of the injected air is increased. Miot gives the patient a small piece of sugar instead of water, by which salivation is produced, facilitating the act of swallowing.

into the corresponding orifice, and then compresses with the left thumb and forefinger the alæ of the nose closely round the instrument. The patient is next told to perform an act of swallowing, and at the same moment the surgeon expels the air from the inflating-bag with his right hand. By the condensation of air, produced in the naso-pharynx in this manner, the closure effected by the soft palate is forced open, and its vibrations give rise to a dull gurgling noise which frequently, if not always, may be taken as an indication that the air has entered into the middle ear. The majority of patients experience at the same time the sub-

FIG. 66.—POLITZER'S METHOD.

jective sensation of a stream of air entering both tympanic cavities.* If this sensation of air streaming into the tympanic cavity is more pronounced on one side, it is in many cases due to the difference in the permeability of the tubes; but if this sensation be quite absent it must by no means be concluded that the air has not reached the middle ear, as not unfrequently the sensibility of the mucous membrane of the tympanic cavity in aural patients has become so diminished that even during catheterism the current of air in the middle ear is not felt.

The changes in the membrana tympani during the application of this method, as observed on inspection, are analogous to those seen during catheterism. There is a noticeable alteration in the form of the cone of light and outward bulging of the membrane between the handle of the malleus and the periphery, sometimes

* Pagenstecher's statement (*A. f. O.* vol. ii.) that the sudden lifting of the hands towards the ears, while air is propelled, is in children to be accepted as a safe indication of the entrance of air into the middle ear, I can confirm from experience.

even in cases where these phenomena were wanting during catheterism or during the Valsalvian experiment. The vessels of the handle also are often injected just as after catheterism; but the most striking changes take place in cases of anomalies of curvature of the membrane such as where either the whole membrane or portions of it are drawn inwards towards the inner wall of the tympanic cavity, for after the inflation of the middle ear by my method either the whole membrane or the circumscribed depressions are strongly bulged outwards, and are sometimes even pressed forwards like bullæ.

Inspection of the membrana tympani during my method does not, however, always furnish a positive result, as is also the case with catheterism; but in such cases the entrance of air into the tympanic cavity may be ascertained by the insertion of the ear-manometer into the external meatus, when the slightest, even invisible, changes in the curvature of the membrane will be indicated by the drop of fluid.

Concerning the results of auscultation during my method, I stated in my first publication that in most cases no decided result could be obtained because the loud vibrating noise of the soft palate drowns the auscultation-sounds in the Eustachian tube and in the tympanic cavity; and that only with a perforated membrana tympani, either with the unaided ear or more intensely with the otoscope, a distinct hissing noise is perceived, which is also heard by the patient. After the experience of many years I must, however, modify these statements, because very often even with an intact membrana tympani, in spite of the gurgling noises in the pharynx, the sounds which have been produced in the middle ear can be plainly distinguished, as by continued practice we are enabled to disregard the more distant pharyngeal noises, and to concentrate our attention upon those nearer ones.

During the application of my method we will therefore often hear the bulging-out noise of the membrana tympani (Moos) and the abnormal auscultation-sounds which were mentioned during the description of the operation of catheterism. While, however, during catheterism the noise appears modified by the friction of the air in the catheter and by its escape from the point of the instrument, the auscultation-sound during the application of my method, where these disturbances are absent, is comparatively often more clearly heard.

The air, condensed in the naso-pharynx by my method, will as a rule enter into both tympanic cavities, more powerfully, however, on the side where the resistance in the tube and in the tympanic cavity is feebler.* Therefore to concentrate the effect

* It frequently happens that the current of air penetrates more powerfully into the middle ear of that side which is opposite to the nasal orifice into which the air is propelled (Hinton).

of the current of air upon the diseased ear, and to limit the entrance of air into the normal one as much as possible, it is necessary to create an artificial resistance in the latter by hermetically closing its meatus with the finger. By this means the air condensed in the meatus of the normal ear will exert such a pressure upon the external surface of the membrana tympani that it cannot bulge outwards, and the condensed air in the naso-pharynx can therefore at the opening of the Eustachian tube penetrate into the normal middle ear only to a slight extent. For the same reason, in cases in which both ears are affected, the same measure must be adopted; as for instance when, owing either to perforation of the membrane or to diminished resistance in the Eustachian tube, the entrance of air into one ear takes place more readily than into the other. In such cases, where we wish to inflate the latter more powerfully, the meatus of the former must be hermetically closed with the finger. Indeed where both ears are affected, and the current of air penetrates equally strongly into both cavities, the mechanical and therefore also the therapeutic effect of inflation can be increased by closing the meatuses alternately, to allow the full power of the air-current to act separately upon each tympanic cavity.

The strength of the air-current to be employed depends generally on the amount of resistance in the middle ear, on the presence of inflammatory phenomena, and also sometimes on the pathological changes in the membrana tympani. In the case of slight obstacles, which may be assumed when the hearing-power has not been much diminished, as also in acute inflammations of the middle ear, where the reactive phenomena, especially the pain, have not completely disappeared, currents of slight pressure are advisable. For this purpose the introduction of air may be effected either by the mouth by blowing through the nozzle of the rubber balloon, or through a short india-rubber pipe, or by the balloon, in the application of which the pressure of the hand can be so regulated as to propel currents of air with very slight or very great force into the tympanic cavity.* In cases of great resistance, however, the permeability of the Eustachian tube must be effected by powerful and rapid compressions of the balloon, and in some cases, when this does not suffice, by the use of the force-pump (*vide* p. 131), the tube of which is connected with the nozzle of the balloon or with a short india-rubber tube.

The effect of inflating with air after my method depends on the nature of the pathological changes which impair the function of hearing. In those affections of the middle ear where, in

* The proposal of Zaufal to increase the pressure in the balloon gradually by compressing it with two, three, four, and five fingers is very good, especially if the operator has not had sufficient practice in regulating the pressure with the whole hand.

consequence of swelling and accumulation of secretion, and of the abnormal tension of the membrana tympani and of the ossicula combined with it, a high degree of deafness often exists, a striking improvement in the hearing will generally follow the application of my method; where, however, in the course of inflammatory processes in the middle ear a development of newly formed connective tissue, and thereby abnormal anchylosis of the ossicula with each other and with the walls of the tympanic cavity have taken place (*vide* p. 89), either no improvement in the hearing or only a slight one is effected by this method. The feeling of improvement in the hearing will often correspond with a demonstrable increase in the hearing-distance; however, cases are not unfrequent where the patients complain after the application of my method of a feeling of numbness in the ear, while by testing a considerable increase in the hearing-distance is ascertained.*

My method has in the course of years been modified, partly by myself and partly by others, and the original indications have been increased. It is worthy of special notice that the effect of this method is not confined to the middle ear alone, but that secretion in the naso-pharynx, also even indeed in the cavities adjoining the nose, is removed by the air-current (Hartmann). The modifications refer partly to an alteration in the form of the instrument, partly to the closure of the soft palate.

The modifications of the form of the instrument have for the most part proved impracticable. One of them is the employment of an olive-shaped nozzle for the balloon, by which one of the nasal orifices is filled, while the other is compressed, so as to avoid the necessity of compressing the alæ nasi round the instrument. But apart from the fact that the width of the nasal orifices is subject to very great variations, an objection to this modification is the fact that there is a reflux of air from the nose, and therefore a decreased effect upon the middle ear, even when the olive-shaped nozzle is closely fitted into the nose. Still less useful was the application to both nasal orifices of a plate pierced with two holes, as proposed by Allen. The substitution for the hard nozzle of a short india-rubber tube (Loewenberg), however, appears to me very serviceable, because the painful sensation which is produced by the compression of the nasal wings round the hard nozzle as well as the occurrence of bleeding from the nose are avoided.† In my practice I use at present, without exception, this elastic front-piece, consisting of a piece of grey india-

* The sensation of pressure in the region of the stomach, which sometimes occurs immediately after the employment of my method, is chiefly observed as the result of considerable pressure applied by means of the force-pump. This sensation is caused by the abrupt entrance of air into the inferior portion of the œsophagus, but it can very quickly be removed by the patient's taking a deep breath several times in succession.

† The employment of a short elastic nozzle is also recommended on the ground of

rubber tube, 3 cm. long and 0·5 cm. in diameter, in which is inserted half-way the short nozzle of the inflating-bag. The management of this elastic tube requires, however, some practice, because when compressing the nasal wings we have to avoid complete closure of the tube, and at the same time escape of air through the nasal orifices outside of the tube.*

Regarding the various proposed modifications of the method of closing the soft palate, it was first proved by Schwartze† that, especially in children, air can penetrate to the middle ear by applying my method even without the act of swallowing. The reason for this is to be found partly in the narrowness of the naso-pharynx and in the shortness of the Eustachian tube in the child, partly in the fact that the soft palate is reflexly lifted up by the action of the current of air on its upper surface, is applied to the posterior pharyngeal wall, and closes the naso-pharynx downwards. Moos‡ found that even in adults not unfrequently the entrance of air into the tympanic cavity can be perceived before the act of swallowing, and Loewenberg§ has proved that the act of swallowing during the application of my method may be replaced by a simple lifting of the soft palate, such as produces the well-known hawking noise, since by this, as well as by every movement of the palatine muscles, the resistance in the Eustachian tube is lessened. I observed myself, when the act of swallowing was performed too soon (and the patient told me this at the same moment as the balloon was compressed), that not unfrequently during speaking the air compressed in the naso-pharynx penetrated into the tympanic cavity. It has also been long known that by phonation of the vowels, as well as of the consonants, the soft palate is applied to the posterior pharyngeal wall, and closes the naso-pharynx downwards, the experimental proof of which was given by Czermak and Brücke (*Vorlesungen über Physiologie*, 1873, vol. i. p. 510). Upon these facts is based Lucae's proposal (*Virch. Arch.* vol. lxiv. 1875) to substitute the phonation of the vowel *ā* for the act of swallowing in my method, a proposal which in character is similar to Loewenberg's communication. That all these proposals are unimportant modi-

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cleanliness, as each patient can be furnished with a separate tube, thus excluding completely the possibility of infection.

* The proposal of Dragumis (*A. f. O.* 1875) to propel air into the tympanic cavity by compressing the inflated cheeks while the nostrils are closed is worthless. Blowing air one's self through a tube introduced into the nose, which was proposed by Roustan (*Bulletin de la Société de Chirurgie*, 1876), is also of no value, because it is identical with the Valsalvian experiment, entailing even greater exertion and congestion. Levi's statement (*Annales des Maladies de l'Oreille*, etc., 1877) that air can be propelled into the tympanic cavity with the same force as by my method by a powerful expiration towards the naso-pharynx while the nostrils are closed and the mouth kept open, I cannot confirm after repeated experiments.

† Behrend's *Journal für Kinderkrankheiten*, 1864.

‡ *Klinik der Ohrenkrankheiten*, 1866, p. 144.

§ *Centralblatt für die med. Wissenschaft*, 1865.

fications of the closure of the soft palate, which do not at all replace the closure according to my method, is a matter of course, as the point of my method is to avoid catheterism and to replace it efficiently in most cases.

Concerning the practical value of these modifications in the position of the palate during the application of my method, simply blowing air into the naso-pharynx (Schwartze) may for previously stated reasons be used in children, who cannot be induced to perform an act of swallowing. The entrance of air into the middle ear will in that case succeed much more easily when the child cries, because the simultaneous violent expirations, and the decrease in the resistance of the Eustachian tube due to the lifting up of the soft palate, will favour the entrance of air into the tympanic cavity. If the closure of the palate is effected by phonation of a vowel, the air will very frequently not enter the middle ear at all, or only with very slight force, because the weak pharyngeal closure can be easily forced open by the current of air, and on the other hand, because by the lifting up of the soft palate during phonation the resistance in the Eustachian tube is only slightly lessened. The same holds good also of the closure of the palate by phonation of the consonants *g* (*German pronunciation*) and *k*. For although the power of resistance of the elevated soft palate against the penetrating current of air is increased by application of the tongue to the palate, observations by Zaufal, Jacoby, and myself have proved that in cases where the air enters the middle ear at all during phonation this takes place as often during phonation of vowels as of consonants. The reason for this is that during phonation of the vowels the palate is closed as long as the intonation of the vowel lasts, and that therefore the period of compression of air coincides more accurately with the closure of the palate, while during the phonation of consonants the period of propulsion of air does not coincide so accurately with the closure of the pharynx, because many patients are not able to retain the soft palate in its elevated position and allow the palate to open again immediately after the consonants *g* (*German*) and *k* have been formed. It is different with the closure of the palate by the act of swallowing. For not only is a firmer closure of the palate effected by the simultaneous action of the constrictores pharyngis, but also a considerable and demonstrable widening of the Eustachian tube will follow, such as is not produced by any other motion of the palatine muscles. This can be proved in the simplest manner by the already described experiment of holding a vibrating tuning-fork before the nasal orifices (p. 71), first made by me. Its sound will not in any way be increased by phonation of vowels or of consonants; during an act of swallowing, however, a considerable increase in the sound of the tuning-fork will be

perceived in both ears.* The dilatation of the Eustachian tube by the application of my method is—as late experiments of Hartmann's (*l. c.*) have placed beyond doubt—of the greatest importance in a practical aspect, for in the diseases of the middle ear combined with great resistance in the tube, where currents of air prove effective only when they act powerfully upon the walls of the middle ear, the entrance of air is chiefly rendered possible by the material widening of the Eustachian tube during an act of swallowing.

Indeed, it has been shown that even in cases in which air cannot be propelled into the tympanic cavity, when the closure of the palate is effected by phonation of vowels or consonants, a striking improvement in the hearing will immediately follow if my method is applied with the act of swallowing. But even in those cases in which a certain increase in the hearing-distance takes place by inflation during the phonation of vowels and consonants, a still more considerable improvement in the hearing will generally follow if afterwards my method is applied during the act of swallowing. A very little experience convinces one that the various proposed modifications of the method of closing the soft palate are inferior to that which I originally proposed.†

I have previously mentioned the fact observed by me that the condensed air in the naso-pharynx not unfrequently also enters the tympanic cavity during speaking. This occurs, as I have since convinced myself, much oftener than during the simple closure by means of vowels or consonants. For while speaking the palate is not only closed, but the base of the Eustachian tube is elevated more strongly and more continuously, as ascertained by immediate inspection with Zaufal's speculum. If, therefore, during the propulsion of air the patient pronounces a word of several syllables—for instance, the words *vaarix, maatrix, König*—the influx of air into the tympanic cavity will occur much more frequently than during the simple closure by means of vowels or consonants. The cause of this is that the closure, while speaking, on the one hand is firmer than during phonation of a vowel, and on the other hand lasts longer than the utterance of a consonant. In a number of cases this modification of the closure of the palate, proposed by me, is to be considered as practically the best among all the modifications hitherto mentioned, and will have the same effect as propelling air by the application of my original method; very often, however, this

* That the current of air towards the tympanic cavity is not temporary in the application of my method, but that it lasts longer than the act of swallowing, will be seen from the fact that in case of a perforated membrana tympani the hissing noise, caused by the exit of air into the external meatus, will often last as long as the inflating-bag is compressed.

† See the communications of Zaufal (*A. f. O.*); Hartmann, *Virch. Arch.* vol. lxx.; Levi, *Annal. des Maladies de l'Oreille*, May, 1877, p. 81.

modification also proves insufficient in comparison with the effect produced by my original method or with catheterism.*

It has been stated by opponents of my method that it frequently causes rupture of the membrana tympani. From this it would seem that rupture, caused by the increased pressure of air in the tympanic cavity, is a characteristic of my method, that it occurs very frequently, and that it is to be considered as an unfavourable incident to the patient. But these statements are refuted by the following facts: (1) Ruptures of the membrane are observed not only during the application of my method, but also during the Valsalvian experiment (Toynbee) and during catheterism of the Eustachian tube.† (2) That ruptures of the membrane occur only very seldom, will be seen from the fact that during thirteen years altogether fourteen cases are known—a very small number considering how largely my method is in use. (3) That these ruptures of the membrane are not accompanied by injurious consequences will be seen from the description of the cases in literature. For in almost all the cases published by Pagenstecher (*l. c.*), Schwartze (*l. c.*), Lucae (*Deutsche Klinik* 8, 1866), van Hoeck (*Nederlandsch Tijdschrift vor Heelen Verloskunde*, 1866), and by myself (*Wien. med. Presse*, 1868), a considerable and in most cases permanent increase in the hearing-distance took place after the rupture.

The causes of this rupture are partly the decreased power of resistance of the membrane, partly the excessive width of the Eustachian tube.‡ Most frequently rupture has been observed to take place in membranes thinned by cicatrization and calcified, and not only during the application of great pressure, but also during careful catheterism, and while using only a slight pressure in the application of my method. Phonation during the latter is also no preventive against rupture, for ruptures have repeatedly taken place during phonation. We must add here that in all cases where the above-mentioned changes in the membrana tympani exist, and where it is desirable to prevent

* In some very rare cases, where propelling air during an act of swallowing does not succeed, the air will enter the middle ear when my method is applied during phonation. But a similar exceptional effect has also been observed during the Valsalvian experiment, and yet there is only one opinion as regards its slight therapeutic value (p. 112). V. Tröltsch is of opinion that in such cases a considerable swelling at the ostium pharyng. tubæ has taken place, and that the entrance of the air is still more impeded by the additional narrowing of the orifice of the tube during the act of swallowing; but his statement is refuted by the fact that it is specially common in cases of excessive relaxation of the tissues of the naso-pharynx, and swelling of the entrance of the Eustachian tube, as proved by the rhinoscope, to find the most striking improvement in hearing to follow the application of my method during the act of swallowing, while propulsion of air during phonation remains without result.

† S. G. Cerruti, *Del Cateterismo della tuba Eust.*, 1857; Pagenstecher (*A. f. O.* vol. vi.); Schwartze, *Die Paracentese des Trommelfells*, 1865.

‡ In the case of a normal membrana tympani a pressure of 3-4 atmospheres is required to cause rupture; in treatment, however, we apply only a pressure of about half an atmosphere.

rupture, this can be effected most safely by firmly closing the external meatus with the finger.

1. *On the Therapeutic Value of the Author's Method (Politzerizing) as compared with the Valsalvian Experiment, and Catheterism.*

The importance of injecting air into the middle ear in the treatment of its affections has already been dwelt on in the description of the mechanical effects of currents of air introduced into the tympanum. In my former writings on this subject it has been pointed out that when treating diseases of the middle ear by injecting air it is essential not only that the air should enter the tympanic cavity, but that it should enter with force and with a jerky action. In the application of treatment, therefore, not only should the degree of force and jerky action of the current be considered, but also its rapidity. For if a given quantity of condensed air be injected into the tympanic cavity the effect will vary according as the current penetrates slowly or rapidly. In the first case no improvement in the hearing, or only a slight one, will take place, while in the same patient the hearing-distance will increase to a considerable extent after the action of a rapid current.

This fact, ascertained by clinical experience, is explained by the results of a number of experiments which I performed on human ears. As we know, the outward motion of the membrana tympani is followed by a movement of the articulation of the malleus with the incus, by which the handle of the malleus is turned strongly outwards, while the incus and the stapes follow this motion only to a slight extent (*vide* pp. 39, 66). Now if, in an ear in which the membrana tympani and the ossicula have been drawn inwards for a length of time, the membrane is forced outwards by a current of air entering the tympanic cavity, the pressure of which is gradually increased, the incus and the stapes will follow the motion of the malleus only slightly; but the ossicula will move outwards more freely if the current of air passes into the tympanic cavity with a rapidly-increased pressure. Again, the position of the ossicula in the affections of the middle ear is of great importance in the conduction of sound, and therefore also as regards disturbance in function; the more tightly the ossicular chain is drawn inwards the greater is the hindrance to the conduction of sound, the improvement in the hearing will therefore also be more considerable and more permanent the more completely the ossicula have returned to their normal position.

We have considered it necessary to premise these observations to the following discussion of the therapeutic value of my method in comparison with that of the Valsalvian experiment and of catheterism.

Regarding the Valsalvian experiment, we have already drawn attention to the fact (p. 111) that in the normal state the entrance of air into the tympanic cavity takes place chiefly at an expiratory pressure of about 40 mm. Hg., but that in a case of slight swelling of the Eustachian tube, caused by cold, without any noticeable disturbance of hearing, the expiratory pressure required for forcing air into the tympanic cavity must be increased to 100-120 mm. Hg. If therefore in the case of a slight swelling of the Eustachian tube a certain exertion is necessary to force asunder the closely-applied walls of the tube, and to press the air into the tympanic cavity, this is required in a still greater measure in those affections of the middle ear in which the tube has become contracted by great tumefaction of its mucous membrane and by impassable accumulation of tough exudation. The obstruction in the tube thus caused, which is often increased by accumulation of secretion in the tympanic cavity (Moos) and by great tension of the membrana tympani, can either not be overcome at all by the Valsalvian experiment, or, if the current of air enters into the tympanic cavity, it will only do so with a considerable loss of its original force, as most of it will have been spent in overcoming the resistance in the Eustachian tube.

The injection of air by my method has a different result. In the first place the resistance in the tubes is considerably lessened by the act of swallowing (in a much slighter degree by phonation), and the current of air enters the tympanic cavity with only a trifling loss of force, acting therefore more powerfully upon its walls, especially upon the inner surface of the membrana tympani. These statements have been experimentally confirmed by Hartmann (*l. c.*). In a number of persons of normal hearing he observed the entrance of air into the middle ear during the Valsalvian experiment with an expiratory pressure of 20-40 mm. Hg., while during the application of my method in the same cases he ascertained that the entrance of air took place at a pressure of 20 mm. Hg. and less. Still more remarkable is the difference in the effect of the Valsalvian experiment and of my method in cases of disease in which during the Valsalvian experiment the air very often either does not penetrate into the tympanic cavity at all, or does so only under a very high expiratory pressure, while in the same cases by my method the entrance of air into the middle ear frequently takes place with much less pressure than that which was applied in the Valsalvian experiment.

The difference in the effect of the two methods is most striking if the Valsalvian experiment is followed by the application of my method in the same individual. For if in a case of acute or chronic affection of the middle ear, combined with swelling and impermeability of the Eustachian tube, it has been possible to force air into the tympanic cavity by means of the experiment

of Valsalva, a slight bulging forwards of the membrana tympani will be observed, but only a trifling increase in the hearing-distance. If now a current of air of the same pressure be conducted into the middle ear after my method, a great bulging forwards of the membrane and considerable increase in the hearing-distance for the watch, for the universal acoumeter, and for speech, will take place. Another and not less important distinction between this experiment and my method is the difference in the air-pressure which can be obtained. For while, as we have just seen, the permeability of the Eustachian tube can be re-established with my method by currents of air of the same or even of less pressure than that employed during a Valsalvian experiment which has failed to effect the entrance of air into the tympanic cavity, yet the expiratory pressure, as used with my method by blowing the air in simply with the mouth (*vide* p. 148), proves very often insufficient, and in such cases currents of air must therefore be employed, the pressure of which exceeds the highest possible expiratory pressure. These can be best produced by the inflating-bag. For with this contrivance we are able not only to produce a current of air of a pressure more than twice as great as the expiratory pressure, but, by a greater or less powerful compression of the balloon by the hand, to create currents of air of different pressure and rapidity, in proportion to the resistance existing in the middle ear.

The amount of pressure produced in the naso-pharynx by compressing the inflating-bag will be greater the more powerful the flexors of the fore-arm of the operator's hand are developed, the larger the balloon or the compressed volume of air (Hartmann), and the smaller the capacity of the naso-pharynx of the individual. A current of air at a given pressure will therefore have a much greater effect upon the naso-pharynx and the middle ear of a child than upon those of an adult.

The pressure required for the application of my method in practice varies as a rule between 0·1 (76 mm. Hg.), 0·2 (152 mm. Hg.), and 0·4 (304 mm. Hg.) atmospheres, a pressure which can easily be produced by compression of a pyriform india-rubber bag capable of holding 300-350 grammes fluid (10 to 12 oz.) Only in a few cases is it necessary to apply a still greater pressure by means of a force-pump.

But if the current of air enters the middle ear with only a slight pressure, it by no means always follows that the therapeutic purpose is effected. For instance, by employing a pressure of 0·1 atmosphere, the air may penetrate into the middle ear without effecting a noticeable increase in the hearing-distance, while in the same case a striking improvement may take place after the application of a pressure of 0·2, 0·3, or 0·4 atmospheres. From this it will be seen that, especially in cases of great swelling and anomalies of tension in the middle ear, the air must be

propelled by rapid and powerful compressions of the balloon; and if this is not sufficient, by means of the force-pump.

My method has also the important advantage over the Valsalvian experiment, that the congestion of the vessels of the head which occurs during the latter is avoided. V. Tröltsch has already pointed out the injurious effect of Valsalva's experiment in old people, insisting on the fact that congestion of the head in case of fatty degeneration of the cerebral vessels might lead to apoplexy. From my experience I must also, for other reasons which will be dwelt on hereafter, pronounce against the employment of this experiment for diagnostic and therapeutic purposes. I will here only briefly mention, that the venous congestion in the head which arises during forced expiration is not confined to certain parts of the head, but extends also to the ears, as is proved by the frequent injection of the vessels of the membrana tympani during the Valsalvian experiment. The repetition of such congestion will necessarily create a permanent hyperæmia in the ear, by which not only is the inflammatory process already existing in the middle ear increased, but also disturbances of nutrition are caused in the labyrinth. In my method, however, congestion of the vessels is completely avoided, as no action of the muscles of the thorax is required.

To form a correct opinion as to the value of my method as compared with catheterism, it is necessary to premise a few remarks about injecting air through the catheter. First of all, it must be pointed out that the current of air passing through the catheter cannot exert its full force on the middle ear, because the point of the instrument is not closely grasped by the Eustachian tube, thus allowing a partial reflux of the air into the pharynx, and because the effect of the current of air is also dependent on the calibre of the catheter, and partly on the position and direction of its beak in the tube. When a catheter with a small calibre is employed, in consequence of the great friction in the instrument the air will pass from the point of its beak with a great loss of force and will therefore have a less effect than when a catheter with a greater calibre is used. On the other hand, however, it must be mentioned that currents of air propelled through a catheter of a very wide ($2\frac{1}{2}$-3 mm.) diameter, with the application of a medium pressure, such as is produced by compressing the inflating-bag with the hand, will not act as powerfully as such currents forced through a catheter of medium size with a diameter of 1·5-2 mm., because, with equal pressure, the rapidity of a current of air will decrease just as much if the tube be too wide as if it be too narrow.* The same obstacles, also, which arise in

* To diminish the adhesion and the friction of air in the catheter as much as possible, and thereby to increase the jerky action of the current, I lately ordered conical catheters, similar to Itard's, of different sizes. A wide tube and a narrow orifice of exit are essential to the production of the greatest possible velocity of the current of air from a balloon of a certain volume.

the case of injections of fluid through the catheter from the incorrect position of its point in the Eustachian tube, or from individual varieties in the direction of the tube obstructing the entrance of fluid into the middle ear (p. 138), make themselves felt when propelling air through the catheter, although to a less extent. The more the point of the catheter is directed towards the wall of the tube rather than towards the lumen of the canal, the more the force of the current of air is impaired, and its effect upon the tympanic cavity weakened.

To some extent these considerations do not apply to my method, for the current of air entering from the pharynx into the Eustachian tube with a stronger, jerky action, will produce a uniform pressure in all directions, and will therefore frequently penetrate more safely and with greater effect into the tympanic cavity than during catheterism. Indeed, experience also shows that in many cases, where only a moderate increase in the hearing-distance is observable after the air-douche through the catheter, a considerable improvement will take place when air is propelled into the middle ear after my method. On the other hand, there are cases in which the resistance in the Eustachian tube is not overcome by Politzerizing, while the air-douche with the catheter is completely successful. This more favourable effect of catheterism is observed, but not very frequently, in cases of considerable resistance in the tympanic cavity, as also in those affections of the middle ear where, in consequence of excessive swelling of the mucous membrane of the Eustachian tube, and great adhesion of its walls, an extensive portion of the canal, from the ostium pharyngeum to past the isthmus tubæ, is closed. In this case, by the introduction of the catheter into the tube, the beak of the instrument will force asunder the adhering walls for some distance, and the resistance in the upper portions of the canal is overcome by the current of air being directed immediately against the obstacle.*

As regards therapeutic value, my method of inflating the tympanic cavity is rarely less effective than the air-douche with the catheter, and is frequently even more so, possessing considerable advantages over catheterism. They are:

* The experiments of Arthur Hartmann (*A. f. O.* vol. xiii.), of great value in the solution of this question, have shown that in the normal state a smaller pressure of air is required during catheterism than during the Valsalvian experiment. As a rule, the difference in the amount of pressure required for propelling air by the Valsalvian experiment, my method, and catheterism, is most considerable in cases of stricture of the Eustachian tube. In one case, related by Hartmann, the air entered the tympanic cavity during catheterism at a pressure of 10-20 mm. Hg., while it did not enter at all during the Valsalvian experiment at a pressure of 130 mm. Hg.; and during Politzerizing the entrance of air took place at a pressure of 80-100 mm. Hartmann assumes that a stricture of the tube has its seat at the ostium pharyngeum, if a great pressure is required to force air into the tympanic cavity during the Valsalvian experiment, or during the application of my method, while during catheterism the air penetrates with a slight pressure.

1. The simplicity of its application, which enables the practitioner who is not familiar with catheterism to effect, in many cases, the permeability of the Eustachian tube, and to treat with success a number of affections of the middle ear.

2. The possibility of injecting air into the middle ear in the treatment of many cases in which catheterism of the Eustachian tube is very difficult or impossible. The application of my method of inflation is specially serviceable in the case of children who suffer very frequently from great dulness of hearing in the course of acute or chronic naso-pharyngeal catarrhs, with hypertrophy of the tonsils, owing to consecutive swelling of the mucous membrane of the Eustachian tube and effusion in the tympanic cavity. The method can also be applied in the congenital or acquired deformities and diseases of the naso-pharynx (*vide* pp. 113, 124) which prevent the introduction of the catheter. But even when the nasal cavity is normal, this method will be exclusively employed for effecting the permeability of the Eustachian tube in persons who object to the introduction of the catheter, in nervous individuals, in aged people, and in convalescents from severe illness, in whose cases the permeability of the Eustachian tube requires to be established on account of accumulation of secretion in the middle ear, but whose weakness and irritability do not allow of the use of the catheter.

3. The application of my method in all those cases in which catheterism of the Eustachian tube can be dispensed with. If it is, therefore, necessary to effect the permeability of the tube by a current of air, this method is always to be preferred to catheterism, because thus the unpleasant sensation caused by the latter proceeding is avoided, because the local irritation of the mucous membrane of the tube by immediate contact with the catheter does not take place; and lastly, because the permeability of both Eustachian tubes can be effected simultaneously. But I must repeat here most emphatically, that it frequently happens that catheterism of the tube, as a diagnostic and as a therapeutic agent, cannot be replaced by any other method, especially if the catheter is required as a conducting-tube for the injection of fluids and for the introduction of bougies into the middle ear.

4. My method has also the advantage that on account of its easy application it is well adapted for self-treatment, especially in those chronic affections of the middle ear in which, after the surgical treatment has terminated, inflation of the middle ear is from time to time necessary to retain the improvement effected in the hearing and to prevent a relapse.

The introduction of vapours into the middle ear by means of my method was first proposed by Professor Hagen of Leipzig. For this purpose the previously (p. 142) described volatilizer serves, the front-piece of which (*a*) with a small india-rubber tube is inserted into the anterior portion of the nose. The pyriform balloon is,

however, quite sufficient for rapidly-evaporating drugs, such as sulphuric ether, acetic ether, chloroform, turpentine and iodine, as either a small quantity of the drug is put into the balloon, or the vapours in the vial containing the drug are collected in the balloon by aspiration. By this method only a small quantity of the vapour reaches the middle ear, and hence the operation has to be repeated several times if it is required to inject a considerable quantity of vapour.

In conclusion, I will mention a modification of my method which has been recommended for injection of fluid into the middle ear. For if, according to the proposal of Saemann,* the india-rubber balloon is filled with fluid instead of air, and this is injected with closed nostrils during an act of swallowing or without one into the naso-pharynx, the fluid will penetrate into the middle ear with varying force. The original proposal to inject fluid into the middle ear without the aid of the catheter was therefore made by Saemann, and the method of injection—introduced a year later† by Joseph Gruber as a new method—in which the injection is made during the closure of the palate with a syringe instead of with the balloon, is only a modification of Saemann's water-douche.

As to the value of injections as a method of treating chronic affections of the middle ear, I have already pointed out in the section on the injection of fluid through the catheter (*vide* p. 141) the accidents observed by the older aural surgeons to arise owing to the entrance of considerable quantities of fluid into the middle ear when the membrana tympani was intact. Still more frequently and in a much greater degree will dangerous effects ensue if, as is so often done, a considerable quantity of fluid is forced into the middle ear by Saemann's modification. Seldom does the fluid passing from the naso-pharynx into the middle ear give rise to no irritation; generally it causes a feeling of fulness and uneasiness, giddiness, numbness in the head, a sensation of warmth or a slight burning in the ear. But also, either immediately or shortly after the injection, fits of vomiting accompanied by most violent pain in the ear will take place, symptoms which indicate a rapidly developing suppurative inflammation of the middle ear. The artificially produced suppurative inflammation may either pass away without further consequences or it may become chronic, and in its course may lead to destruction of the membrana tympani and of the ossicula, and to caries of the mastoid process and of the petrous bone.

Besides these results of Saemann's water-douche or of Gruber's modification of it, I have frequently observed cases in which treatment by injection into the middle ear for the cure of chronic

* *Die Wasserdouche der Eustach'schen Ohrtrompete, eine Modification des Politzer'schen Verfahrens. Deutsche Klinik*, 1864.

† *Deutsche Klinik*, 1865.

inflammation has been accompanied or followed by an increase in the deafness and in the subjective noises. A steadily and rapidly progressing aggravation was most strikingly apparent in those cases in which, after the injection of the fluid, pain in the ear was felt, and where considerable engorgement of the vessels of the membrana tympani was observable. It is probable that the pathological changes leading to anchylosis of the ossicula are aggravated by the irritating action of the injection on the lining membrane of the middle ear, and that the union of the ossicula with the walls of the tympanic cavity is only accelerated thereby.

This method of injection leads, especially in affections of one ear only, to very grave consequences, because not infrequently the fluid injected into the naso-pharynx penetrates chiefly into the normal ear on account of the slighter resistance offered to it, and produces a reaction there which is much greater than that produced by the fluid in a diseased ear. I have frequently seen patients, previously affected on one side only, who during treatment after this method were seized with an incurable affection of the middle ear on the other side. From these facts, which have been often corroborated, an opinion may be formed as to the therapeutic value of this method of injection. Anyone who has in a few cases observed the sudden appearance of these dangerous symptoms will certainly for the future abstain from employing a mode of injection which is just as unreliable as it is incalculable as to its consequences; the more so as the patient will with justice ascribe the injurious consequences to the treatment on account of their occurring immediately after the injection.

The occurrence of violent irritation in the middle ear is observed much less frequently after the application of this method when the membrana tympani is perforated, because the fluid entering into the middle ear can flow off into the external meatus. Nevertheless it is ill suited for the treatment of purulent, perforating inflammation of the middle ear. Apart from the facts that the fluid sometimes does not reach the middle ear at all, and that in the case of a one-sided affection it may enter the normal ear in spite of the inclination of the head towards the diseased side, causing an acute inflammation there, these injections, in respect to their therapeutic effect as well as the simplicity of the procedure, are far inferior to the method of introducing medicated fluids into the middle ear* invented by me, and described in the special division. Saemann's injections, modified by Gruber, possess also the decided disadvantage that their application is unpleasant to most patients, as, even more frequently than with Weber's nasal douche, there occur pain in the forehead, in the occiput, and not unfrequently also in the upper jaw, lasting several hours; an unpleasant burning

* Wittelshöfer's *T. f. C.* 1864; and R. Chimani, *W. med. W.* 1867.

sensation in the pituitary membrane, tickling and choking in the throat. Besides I have observed after the injection, especially in children, great inflammation of the pituitary membrane and erysipelatous swelling of the skin of the face on the same side as that on which the injection had been made.*

C. Tests for Hearing.

The tests for hearing are of the greatest importance in the diagnosis of the diseases of the ear; for they serve not only to determine the extent of the disturbance of hearing, but not unfrequently also to localize the affection, inasmuch as in cases in which the other objective methods of examination give a negative result, we are enabled to judge whether the anatomical cause of the functional disturbance has its seat in the apparatus for the conduction of sound or in the nerve apparatus. But they are also of special value because by means of them, while the patient is under observation, we can note the course of the disease, and also the result of treatment.

As our ear perceives not only the waves of sound, transferred immediately from the air to the sound-conducting apparatus, but also the vibrations transmitted through the cranial bones, the power of perception of waves transmitted in both ways must be tested separately for diagnostic purposes.

* *Machines et Inventions approuvées par l'Académie Royale des Sciences*, Paris, 1735, vol. iv. (Catheterism through the mouth: the method of Guyot, the inventor of catheterism); Archibald Cleland, *Philosophical Transactions*, vol. xli. London, 1744: (Catheterism through the nose); Jonathan Wathen, *Philosophical Transactions*, London, 1756; J. M. G. Itard, *Traité des Maladies de l'Oreille et de l'Audition*, Paris, 1821; J. A. Saissy, *Essai sur les Maladies de l'Oreille interne*, Paris, 1827; Westrumb, *Rust's Magazin f. d. ges. Heilk.* vol. xxxv. 1831; Kuh, *ibid.* vol. xxxviii. 1832; J. H. Curtis, *A Treatise on the Physiology and Pathology of the Ear*, 1836; Deleau, *Traité de Cathéterisme de la Trompe d'Eustache et de l'emploi de l'Air atmosphérique dans les Maladies de l'Oreille moyenne*, Paris, 1838; J. Williams, *Treatise on the Ear*, London, 1840; Lincke, *Handbuch der theoret. und pract. Ohrenheilkunde*, 3 vols. 1845; W. Kramer, *Die Erkenntniss und Heilung der Ohrenkrankheiten*, Berlin, 1849; W. R. Wilde, *Practical Observations on Aural Surgery*, etc. 1853 (German by Haselberg, 1855); Rau, *Lehrbuch der Ohrenheilkunde*, 1856; Bonnafont, *Traité théorique et pratique des Malad. de l'Oreille*, 1860; J. Toynbee, *Diseases of the Ear*, London, 1860; V. Tröltsch, *Die Krankheiten des Ohres*, in Pitha and Billroth's *Chirurgie*, vol. iii., (1) *Abth.* and (2) *Heft*, and *Lehrbuch der Ohrenheilkunde*, 1877; *ibid.*, *Das Politzer'sche Verfahren in seiner Bedeutung für die Ohrenheilkunde*, *A. f. O.* vol. i.; S. Moos, *Klinik der Ohrenkrankheiten*, Wien. 1866; E. de Rossi, *Le Malattie dell' Orecchio*, Genova, 1871; C. Miot, *Traité pratique des Maladies de l'Oreille*, Paris, 1871; Lawrence Turnbull, *A Clinical Manual of the Diseases of the Ear*, Philadelphia, 1872; A. Magnus, *Verhalten des Gehörorgans in comprimirter Luft*, *A. f. O.* vol. i.; H. Schwartze, *Ueber die Stärke des bei der Luftdouche erforderlichen Luftdruckes*, *A. f. O.* vol. x.; Wreden, *Ueber flüssige Einspritzungen in das Mittelohr*, *Petersburger med. Zeitschr.*, 1871; O. D. Pomeroy, *A Faucial Eustachian Catheter*, *Transactions of the Americ. Ot. Soc.*, 1872; Henry D. Noyes, *Form of the Eustachian Cathether, especially when introduced by the Opposite Nostril*, *ibid.* 1870; St. J. Roosa, *A Practical Treatise on the Diseases of the Ear*, New York, 1873; S. Duplay, *Traité de Pathologie externe*, par Follin et Duplay, Paris, 1874; E. Morpurgo, *Rivista Otojatrica, Giornale veneto di Scienze mediche*, vol. xxiii. ser. 3; Hartmann, *Ueber die Luftdouche und ihre Anwendung in der Ohrenheilkunde*, *Virch. Arch.* vol. lxx. 1877.

a. Testing the Acuteness of the Perception of Sound-waves transmitted through the Air to the Membrana Tympani.

1. *Testing the Sharpness of Hearing for Simple Tones.*

The expedients hitherto in use for testing the function of hearing, the watch, the tuning-fork, and speech, have, as compared with the type- and colour-tests of the ophthalmologists, proved to be incomplete. Many attempts have indeed been made to construct acoumeters for the production of a certain tone, and for testing the power of perception of different scales of tones; but all the more or less complicated instruments as yet invented are useless for the precise estimation of the degree of functional disturbance, and are therefore now only of historical interest.*

To test the acuteness of hearing for simple tones the watch† has until very recently been used for the production of sound. As, however, different watches vary considerably as to the pitch and intensity of their sound, it is clear that the results of testing with different watches must also be different, and that they are therefore not suitable for a precise indication of the acuteness of hearing.‡

These imperfections, as well as the importance of a universal acoumeter, giving a definite volume of sound of general application, have lately induced me to attempt the construction of a new acoumeter, intended as a substitute for the watch as a test of hearing.§

This acoumeter (Fig. 67, actual size) consists of a horizontal steel cylinder (*c*), 28 mm. long and 4·5 mm. thick, connected by means of a tightly-fitting screw with the perpendicular vulcanite column (*h, f*). Above the place of attachment of the cylinder the percussion-hammer (*k, e*), which can be turned round its axis,

* Itard (*Traité des Maladies de l'Oreille et de l'Audition*, 1821) used a simple copper hoop, struck by a small metal staff, furnished with a metal ball: the elevation of the staff, indicated by a sextant, being the measurement of the volume of sound employed. But according to Hartmann, Wolke had already constructed a wooden acoumeter after the same principle previous to Itard.

The acoumeter proposed by Conta (*A. f. O.* vol. i.) and improved by Magnus (*ibid.* vol. v.), which is based upon the principle of testing the power of hearing not as to distance, but as to the length of time during which the tone of a vibrating tuning-fork is perceived, did not come into favour with practitioners, because the manner of examination is much too troublesome, and takes up too much time, and also because the statements of patients are unreliable.

† As Oscar Wolf quite correctly remarks, the ticking of a watch is not a noise but a sound having a distinct pitch.

‡ To express the relative acuteness of hearing in numbers, the average hearing-distance, ascertained with a certain watch in a number of persons of normal hearing, has been accepted as the unit with which the hearing-distance of the deaf individual is compared. But this kind of estimation of the acuteness of hearing has no claim to general acceptance, as the numerical values for the relative acuteness of hearing arrived at with different watches in the same individual do not agree.

§ *A. f. O.* vol. xii.

is fastened in an oval orifice of the vulcanite column, and produces the tone by falling upon the steel cylinder.

As the intensity of the sound depends on the height from which the percussion-hammer falls, to produce in all instruments an equal height, a small piece of vulcanite (*d*) furnished with a soft india-rubber plate is fixed at the posterior periphery of the column as a check, upon which the posterior short lever of the hammer is pressed. At the superior and inferior extremities of the column are two flat semicircles (*b*, *a*), with which two fingers may grasp the instrument, the superior semicircle for the forefinger and the inferior for the thumb. Below the superior semicircle, parallel with the axis of the percussion-hammer, there is a

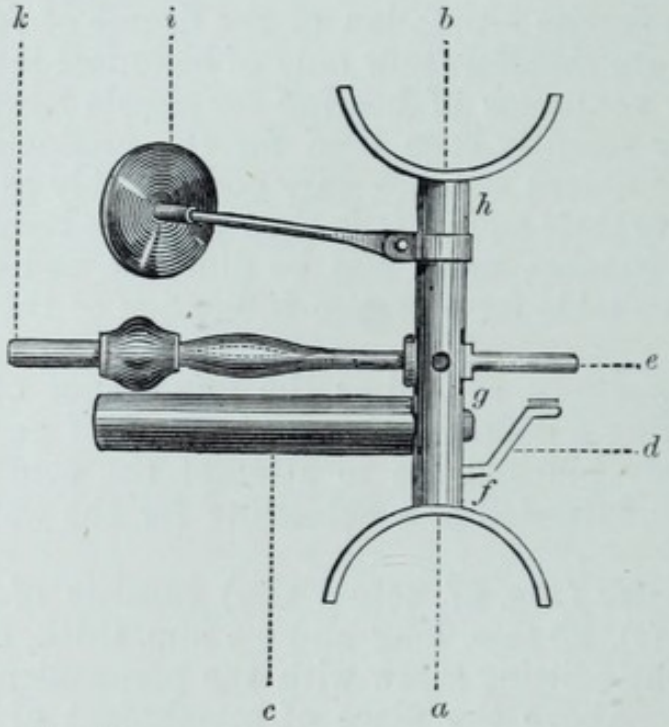

FIG. 67.—THE UNIVERSAL ACOUMETER DESIGNED BY THE AUTHOR.

ring on the vulcanite column, into which a pin, to which a round metal plate is attached (*i*), can be inserted. This last contrivance is for testing the perception of the cranial bones by bringing the metal plate into contact with the temple or with the mastoid process while the meatuses are closed. In the same manner, in cases where the tone of the acoumeter is not heard even on the closest proximity, the round metal plate is brought into contact with the orifice of the external meatus, to find out whether the tone of the acoumeter is perceived by contact.

To produce a number of instruments of exactly the same quality of tone all the portions of the acoumeter must correspond in regard to size, shape, and weight, and this even is not generally sufficient on account of the inequality of the material; hence every instrument must besides be tuned by carefully filing the cylinder. In this manner I have succeeded in having con-

structed a number of instruments the tones of which agree completely, as the cylinders were carefully tuned to the note C.

The tone produced by the hammer striking the cylinder may be compared to the ticking of a loud watch, but exceeds it considerably in intensity. Its higher notes, vibrating along with its key-note, are so slight that they exercise no influence upon the hearing-distance, as comparative experiments with different instruments on the same individual have shown.

This instrument is very easily used. It is taken hold of by the forefinger and thumb of the right hand, while the rise and fall of the percussion-hammer upon the cylinder are effected by alternately pressing down and releasing the posterior lever of the hammer. While testing the hearing, just as with the watch, the direction of the instrument to the external orifice of the ear must be considered, as the acuteness of hearing is materially modified by the position of the origin of sound to the ear. As a rule the tone will be heard more intensely and also at a greater distance if the line connecting the external orifice of the ear and the acoumeter does not lie perpendicularly upon the lateral portion of the head, but is directed more forwards. In case of repeated testing the acoumeter should therefore always be moved and fixed in that direction.

To estimate the acuteness of hearing exactly, a centimeter-measure is used, which is held horizontally and is laid on the lateral surface of the head immediately below the lobe of the ear; but care must be taken to avoid contact of the acoumeter with the measure, on account of the immediate conduction of the vibrations to the cranial bones. In every consulting-room, moreover, either on the floor or on the wall, a meter-scale should be marked off so as to be able to estimate exactly the acuteness of hearing for greater distances as well.

Each ear must be separately tested in regard to the acuteness of hearing; for which purpose, during the examination of one ear the meatus of the other is closed with the moistened finger. The hearing-distance is measured by gradually bringing the instrument nearer to the ear in the direction of the measure, until the patient states that he commences to perceive its tone.* To check the statements as to the perception of the tone the patient is requested to cover the eye with the hand of the same side, so that he cannot see the place from which the sound proceeds,

When testing the acuteness of hearing with the acoumeter or with the watch, differences in the distance will be frequently observed according as the instrument is brought nearer to the ear from without the boundary of perception, or is farther removed from the ear after the first perception of the tone. In the latter case the hearing-distance is almost always greater than in

* Hartmann requests the patients to state the number of strokes of the acoumeter.

the former. The cause of this, in my opinion, is that by approaching the ear with the instrument not heard as yet, the extremities of the auditory nerve, which are at rest, require a greater amount of sound to disturb their equilibrium, and that therefore the origin of sound must be brought nearer to the ear to irritate the auditory nerve; while by withdrawing the origin of an already perceptible sound from the ear the auditory nerve, being in a state of irritation, is still kept irritated by vibrations of lesser intensity, and the sound is perceived at a greater distance.

It is therefore important while fixing the acuteness of hearing always to approach the ear from a distance beyond the boundary of perception, because by alternate testing in both directions an increase or decrease in the acuteness of hearing might be ascertained, which in fact does not exist.

The advantages of my acoumeter over others are:

1. That the tone of all instruments constructed upon the same principle can be made exactly uniform, and this acoumeter is therefore suitable in every respect for the observation of the acuteness of hearing—*i.e.*, the degree of acuteness of perception of an exactly uniform tone at a certain distance—and for expressing it in figures in such a manner that every examiner is obliged to arrive at the same result under the same circumstances. This universal acoumeter enables us to put into practice the proposal of Prout and Knapp to designate the degree of hardness of hearing as a fraction of the normal acuteness of hearing, a proposal which has hitherto been impossible with the watch-test. We have only to compare the ascertained hearing-distance with the accepted normal hearing-distance, to fix the relative acuteness of hearing.

The fixing of the average normal distance at which my acoumeter is heard is very difficult. Not only will a considerable difference in the acuteness of hearing be found in different individuals, but also noticeable fluctuations in the same person even if the testing is repeated at short intervals. The cause of this is not only the fluctuating power of perception of the auditory nerve for weak vibrations of sound (Urbantschitsch), but is also to be looked for in external circumstances, of which especially the continually changing noises of the outer world, and variations in the direction of the acoumeter or in the position of the head, must be mentioned.* Similar fluctuations I also observed in persons hard of hearing; but, as Conta has already pointed out, the differences are slighter the greater the degree of dulness. The observations made by Hartmann and myself on a considerable number of persons of normal hearing in localities

* Fechner found that in individuals of normal hearing, the acuteness of hearing of the left ear is greater than that of the right.

as noiseless as possible, gave as their result a distance of 15 meters* as the average normal distance of hearing for my acoumeter. At a distance of 1 meter, therefore, the relative acuteness of hearing is expressed as $\frac{1}{15}$, of 10 ctm. as $\frac{0{\cdot}1}{15}$, of 3 ctm. as $\frac{0{\cdot}03}{15}$ of the normal acuteness of hearing accepted for this acoumeter.

2. That by being able to originate the tone at our pleasure we can easily satisfy ourselves as to whether the statements of the patient respecting the perception of tone are erroneous or not, while the continuous ticking of the watch renders this control very difficult, if the ticking is not interrupted by a special check-contrivance (Bing).

3. That the intensity of tone of my instrument is considerably greater than the loudest ticking of a watch, whence it is possible to fix the degree of acuteness of hearing of a considerable number of persons who would not perceive the ticking of a watch at all. Experience also shows that the result obtained by testing with the acoumeter, in consequence of its greater intensity, allows of a more decided comparison with the result of whispered speech than is the case when testing with the watch; therefore, from the increase in the hearing-distance for the tone of the acoumeter, we can with greater certainty infer a corresponding increase in the hearing-distance for speech than from testing with the watch.

4. The handy form of the instrument and the simplicity of its construction, thus avoiding the frequent repairs required by the complicated acoumeters, as also its comparatively trifling cost.†

Examination by the tuning-fork is of little value in testing the perception of sounds transmitted through the air. I use a tuning-fork, constructed by König, of 512 vibrations in the second (C^3), which is made to sound by striking one of its prongs against the left hand or against a soft piece of wood covered with leather. In cases where one ear is affected, the vibrating tuning-fork, held before the orifice of the meatus, is heard better in the normal ear, and, as a rule, where both ears are affected, but to a different degree, it will be heard better in the less-affected ear.‡ There is still to be mentioned an alteration in the perception of the tone of the tuning-fork, which is not unfrequently observed in cases of great tension of the membrana tympani, especially in musical patients. This is a change in the pitch of its tone, which is heard by the affected ear $\frac{1}{4}$, $\frac{1}{2}$, rarely a whole note higher than by the normal ear.

Testing with a number of musical tones is best effected by a harmonium, the casing of which is furnished with an opening

* Chimani's testings with a smaller number of persons resulted in a somewhat greater distance.

† 5½ fl. ö. W. at Gottlieb's in Vienna.

‡ It rarely happens that a patient declares that he hears the tuning-fork louder in that ear which has been proved by the acoumeter and by speech to have a greater hearing-distance than the other.

for the insertion of an auscultation-tube. By inserting its olive-shaped nozzle into the meatus of the ear to be examined, the tones of the harmonium will be conducted immediately to the membrana tympani. I use this method of examination principally in those affections of the ear in which examination leads to the assumption of a primary or secondary disease of the auditory nerve, to test the power of perception for different tones of the musical scale, and to ascertain if there be any non-perception of tones, a rare occurrence indeed.* Kessel uses as a test a reed-instrument of six octaves; Blake (*Transactions of the American Otological Society*, 1873), a series of König's cylinders of 20,000 to 100,000 vibrations per second, with intervals of 5,000 vibrations. Comparative experiments which Blake undertook with persons of normal and defective hearing gave interesting results, which are valuable in the diagnosis of anomalies of tension.†

2. *Testing the Hearing-power for Speech.*

Fixing the hearing-distance for speech with a view of estimating the amount of disturbance of hearing is more difficult than testing the hearing-distance for a constant sound.

During a careful observation of this method of testing, it strikes us at once that the vowels are generally perceived more surely and at a greater distance than the consonants. For this reason patients frequently hear only the vowels of a word of several syllables, and when repeating what they have heard pronounce another word which contains the same vowels but different consonants (for instance 'Vater' instead of 'Wasser;' 'Gabel' instead of 'Tafel'). It is also observed that those words in which vowels of a clear sound, A, E and I, occur are more easily perceived than those which contain the more or less dull vowels O and U. But some of the consonants also, as the R lingual, B, H, F, S and Z, are heard with more difficulty than the other consonants.

The recognition of separate words at a certain distance depends also on the arrangement of the vowels and consonants, as also on the rhythm and cadence of the syllables, so that many words are heard and understood at a disproportionately greater distance than others.

* Moos found in chronic catarrhs decreased or imperfect perception of high tones; H. Burnett (*Transactions of the American Otological Society*, 1873) observed in a case, in which otherwise the function of hearing was normal, hardness of hearing for deep tones.

† In the Physiological Society of Berlin (Discussions of Jan. 11, 1878), Arthur Hartmann demonstrated a new method of testing the hearing. It is possible to graduate a sound created in the telephone with an exactitude hitherto unapproached, as the electric flashes transmitted to the telephone can be altered in a precisely definable manner by the interpolation of different kinds of resistance. It may be expected that many questions regarding the perceptions of the ear, which are still unexplained, will be brought nearer to solution by this important discovery.

The mutual relations of speech and hearing have been rendered more intelligible by the investigations of Oscar Wolf.*

Human speech is composed of a large number of sounds and tones of the most different pitch, intensity and quality. Therefore, if the examiner wishes to arrive at diagnostic results by testing with speech, he must always bear in mind its acoustic properties, judging the amount of disturbance of hearing by the manner in which the diseased ear mistakes this or that sound or does not perceive it at all.

Oscar Wolf undertook to ascertain, by numerous and thorough investigations, the pitch of the key-note of the different sounds of speech, as also the distance at which these sounds can be distinguished. Referring the reader to Wolf's original works as regards the pitch of the different sounds,† we here reproduce his results as regards the distance at which the sounds of speech can be distinguished, a matter of great practical importance.

For the distinction of vowels and consonants the following hearing-distances in meters (1 pace = 0·7 meter) were ascertained:

A = 252. O = 245. Ei, and Ai = 238. E = 231.
I = 210. Eu = 203. Au = 199·5. U = 19·6.
Sch = 140. S = 122·5. G soft and Ch soft = 91.
Ch harsh and R uvular = 63. F (F and V) = 48·9.
K (K and hard G) = 44·1. T (T and D) = 44·1.
R lingual (without any tone) = 28·7. B (B and P) = 12·6.
H (as an aspirate) = 8·4.‡

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* *Sprache und Ohr; Acustisch-physiologische und pathologische Studien* (Braunschweig, 1871), and *Neue Untersuchungen über Hörprüfung und Hörstörungen; A. f. Augen- und Ohrenheilk.* vol. iii.

† According to O. Wolf, the range of the pitch of the tones of speech extends from the R, pronounced with the tip of the tongue (R lingual), the deepest sound with 16 vibrations per second, to the S-sound with about 4,032 vibrations; it therefore comprises nearly 8 octaves.

‡ *Note by Translator.*—The vowels and consonants here enumerated by the author have in most cases a sound different from that in the English language. When pronounced singly, they sound in German as follows:

A,	like the English a		in *hart,*	not like that in			*hare.*
E,	„	„	e	„ *end,*	„	„	*even.*
I,	„	„	i	„ *inch,*	„	„	*iron.*
O,	„	„	o.				
U,	„	„	u	„ *hunt,*	„	„	*use.*
Ei,	„	„	i	„ *rise,*	„	ei	*eight.*
Ai,	„	„	ai	„ *aisle,*	„	ai	*air.*
Au,	„	„	ow	„ *now,*	„	au	*August*
Eu,	„	„	oi	„ *oil,*	„	eu	*Europe.*
G soft,	„	„	g	„ *ring.*			
G hard	„	„	g	„ *great,*	„	g	*general.*
K,	„	„	ca	„ *can,*	„	k	*Kate.*
B,	„	„	be	„ *before,*	„	b	*beetle.*
P,	„	„	pe	„ *petition,*	„	p	*Peter.*
D,	„	„	de	„ *debate,*	„	d	*deep.*
T,	„	„	te	„ *temerity*	„	t	*tedious.*
H,	„	„	ha	„ *hand,*	„	h	*hate.*
F,	„	„	f.				
V,	„	„	f.				

The vowel A possesses the greatest power of tone and richest sound, and H the least. The letters R lingual, B, K, T, F, S, Sch, and G (soft), are called self-sounding, in contrast with L, M, N, and W, which borrow their sound, because the former possess a key-note which can be independently articulated and musically defined by the mouth, while the latter possess no sound without the aid of sounding vibrations of the ligaments of the glottis; they must, so to say, borrow a little sound from the subsequent or preceding vowel to be distinguished.

From the preceding it will be seen that the vowels greatly exceed the consonants in strength of tone, which furnishes an explanation to the fact mentioned at the commencement of this division, that vowels occurring in words are perceived more surely and at a greater distance than the consonants.* Experience also teaches that frequently very deaf persons, with whom it is possible to converse only by means of a speaking-trumpet, and indeed even many deaf and dumb individuals, can distinguish the vowels A, E, I, O, U, at a moderate distance. Therefore, according to Wolf, the vowels and loud speech are much less suitable as delicate tests of hearing, than whispered speech and the self-sounding consonants.

In spite of the various imperfections thus seen to be associated with the testing of hearing by speech, we yet look upon it as an indispensable test in the estimation of the disturbance of function and of the results of treatment. If the hearing-distance for simple tones were definitely proportioned to that for speech, testing hearing by speech would be superfluous. Observations show, however, that there often exists a striking disproportion between the hearing-distance for simple tones and for speech, and that not unfrequently during the treatment of aural patients the hearing-distance for simple tones increases to a considerable extent, while the distance for the understanding of speech has only slightly increased, and *vice versâ*. This shows that results obtained by testing the hearing with the watch, or other origin of sound, do not indicate the degree of the functional disturbance for speech. But as our endeavour in the treatment of functional

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L, like the English l.
M, „ „ m.
N, „ „ n.
W, „ „ ve in *vehement*, not like w in *well*.
Z, „ „ cet „ *lancet*, „ z „ *zeal*.
S, „ „ s.
Sch, „ „ sh „ *shine*.
Ch, „ „ ch „ *loch*, „ ch „ *cheese*.
Ch hard, „ ch „ *chronic*.

* Compare my experimental investigations on this subject in the physiological division, p. 69, second experiment. If words are spoken into the meatus through a speaking-trumpet, the ossicula exhibit as many vibrations as there are syllables in the word. The greatest excursion of the vibration corresponds with the vowel of the syllable.

disturbances is mainly centred in the re-establishment or improvement of the power of hearing speech, the application of speech as a means of testing cannot under any circumstances be dispensed with.

To ascertain the hearing-distance, whispered speech is more frequently employed than loud speech. A considerable drawback in the application of the latter is found in the fact that it is impossible to employ a uniformly strong voice on different days. For even if we succeed by continued practice in training our voice and speech apparatus to a uniformly strong pronunciation, the clearness of our voice will on many days be temporarily altered by trifling changes in the larynx and in the ligaments of the glottis. But loud speech is also badly suited for testing the hearing, on account of the differences in the volume of sound of the vowels and of the consonants, and in the material difference in the hearing-distance of single words resulting therefrom.

But testing by whispered speech is much more reliable. The speaker, by subduing the vowels, transmits to the ear in this form of speech waves of sound differing from each other much less in volume than those of loud speech, and therefore testing by whispered speech results in a distinctly less difference in the distance for single words than in loud speech.*

In cases of slight or moderate deafness, therefore, considering the limited space which is as a rule at our disposal during our examinations, whispered speech is mostly employed. In cases of great deafness, however, when the hearing-distance for whispered speech is less than a meter, or when whispering is not understood at all, testing by loud speech is advisable, because the increase in the hearing-distance is more markedly observable in the course of treatment in such cases when using loud speech than by employing whispered speech.

Fixing the normal distance of hearing for speech is subject to the same difficulties as we have already pointed out when describing testing by simple tones. Besides the material individual variations, the more or less great noise in the daytime, in or out of the house, has to be taken into consideration, having a particularly disturbing influence upon the testing of hearing in diseased conditions. According to Hartmann, the average normal hearing-distance for whispered speech in a room as noiseless as possible amounts to 25 meters, during the ordinary noise of the day to about 20 meters, a distance which agrees with that (60 Frankfort feet) stated by Wolf (*l. c.*). R. Chimani found it in a quiet hall of the Vienna Garrison Hospital to be a distance of 21 meters.

When testing the acuteness of hearing for speech, special care

* As the intensity of whispered speech, as Teuber and Zwicke correctly remark, is very variable, the result of testing the hearing by whispered speech cannot be of absolute, but only of relative value.

must be taken that the spoken words are not read by the movement of the mouth, as many patients, especially those who have been hard of hearing since childhood, possess a particular skill in reading the lips.

Each of the ears must be separately tested, the one being turned directly towards the speaker, while the other is closed as completely as possible with the moistened finger-tip. In cases of one-sided deafness, special care must be taken to close the normal ear as hermetically as possible, because moderately loudly spoken words in the neighbourhood of the diseased ear may be easily heard by the normal one if insufficiently closed, and in this manner mistakes may take place. In such cases, speaking loudly in the neighbourhood of the patient must therefore be avoided, and it is advisable, in cases in which it is desirable to ascertain that the patient has really heard the speech with the diseased and not with the normal ear, to test the hearing with both meatuses closed. If after the diseased ear has also been closed, speech is still heard at the same distance as before, it may be assumed with certainty that the sound enters into the normal ear; if speech is not heard, there can be no doubt that it had been heard by the diseased ear before it was closed.* Testing the distance at which speech is understood, is effected by pronouncing with an intensity† as uniform as possible at a certain distance different words, which the patient is requested to repeat. Testing with whole sentences is not advisable, because the patients will very often guess the sense of a whole sentence from understanding some of the words, and in this manner by combination also repeat the words they have not heard. Just as unsuitable is the pronouncing of single figures, because by frequently testing in this manner the figure will easily be guessed by hearing the vowels which occur.

Testing the hearing by the use of the same words on different days must also be avoided, because by repeatedly hearing the same word its perception is materially facilitated, and therefore an increase in the hearing-distance might erroneously be inferred.

The part which the intellect of the patient plays when testing the understanding of speech will be seen from the fact that words which are often heard in everyday life, and which are easily comprehended by the patient, are perceived at a much greater distance than words which are less frequently heard. The con-

* Compare the observations of H. Donnert in reference to this (*A. f. O.* vols. x. and xiii.).

† On the supposition that the intensity of speech corresponds with the expiratory pressure employed, Lucae (*A. f. O.* vol. xii. p. 282), in order to fix the intensity of speech, constructed, after the principle of Scott's phonautograph, a maximum phonometer, by means of which the degree of the expiratory pressure, and therefore also the loudness of the speech employed, is ascertained. The apparatus, however, is of little practical value; because the supposition that the intensity of speech corresponds with the degree of expiratory pressure is not correct, and because the impulse on the membrane must be different according to the different vowels and consonants.

trast in the perception of frequently and unfrequently used words is still more markedly shown when the patient is requested to repeat, besides words that are known to him, words also of a language unknown to him. The hearing-distance for foreign words often hardly amounts to the fifth or sixth part of the distance for words of his own language, and the difficulty of hearing the consonants will then become specially prominent in the case of deaf people. This shows that testing with an unknown language should give the most reliable result as regards the relative distance of hearing, as it would simply test the function of hearing in the abstract, the influence of the intellect being withdrawn. But as we endeavour in the treatment of the patient to improve his understanding of his own language, testing with a foreign language is of no practical value.*

In estimating the result of treatment in the case of children, it is very important to test their power of hearing speech, because, on account of the difficulty of fixing their attention, it is very difficult, or even impossible, to determine the distance at which they hear the acoumeter or the watch. It is also necessary to choose words which the child can comprehend, and to use no more than four or five words every time the hearing is tested, because when the examination is prolonged, children very soon become impatient and inattentive, and do not listen to the words pronounced for them.

b. Testing the Perception of the Waves of Sound conducted to the Ear through the Cranial Bones.

1. *Testing with the Watch and the Acoumeter.*

While the methods of testing described in the previous division are chiefly intended to determine the acuteness of hearing, the manner of testing now to be described is meant to ascertain the conduct of the organ of hearing towards vibrations of sound conveyed to the labyrinth through the solid parts of the head.

If a vibrating body is brought into contact with the cranial bones, the vibrations will be communicated to all parts of them, and therefore also to the ear. These vibrations reach the labyrinth in two different ways, viz. (1), by immediate conduction from the solid parts to the labyrinth, and (2), by transmission from the cranial bones to the membrana tympani and the ossicula, to be conducted by them to the labyrinth (E. H. Weber, Lucae).

The perception of the waves of sound, conducted from the solid parts of the head to the ear, is modified in many ways by

* Dr. Buck, of New York, has lately proposed to group together a number of unconnected words for testing hearing, and to fix the hearing-distance by ascertaining the distance for these words. To have a reliable test of the hearing-distance on different days, it is advisable to note, besides the ascertained distance, the word which was used for testing (Lucae).

morbid changes in the organ of hearing. Clinical experience sufficiently confirms this, and attempts have often been made to utilize these changes for diagnostic purposes. But apart from the intrinsic obstacles to its use, utilizing this method of testing as a means of diagnosis is rendered still more difficult by patients' statements as to subjective sensations being frequently unreliable. Nevertheless, testing the conduction through the cranial bones must not be omitted, for if not in all, at least in a great number of cases, important indications as to diagnosis and prognosis can be obtained by it.

For testing the perception of sound through the cranial bones the watch and the tuning-fork have hitherto been used. The imperfections of the watch as an expedient for testing are here still greater than when employed in the fixing of the acuteness of hearing (conduction of sound through the air). As the perceptive power of the auditory nerve is decreased in different degrees in disease, we would have to employ a considerable number of watches, the tick of which varies in intensity, to ascertain the amount of diminution in the power of perception, and to fix the limit at which perception ceases. But such testing takes up too much time, and is by no means suitable for practical purposes. For cases not unfrequently occur in which even a loudly ticking watch is insufficient to indicate the presence or the absence of perception through the cranial bones. Even if a negative result is obtained by testing with loudly ticking watches in cases of disease, we are by no means justified in concluding the absence of perception; for frequently the employment of a louder instrument will show that though perception is impaired it is not extinct, which will lead to our prognosis being modified. We have such an instrument in my universal acoumeter, which in many cases in which the ticking of the watch is not perceived gives a positive result. The acoumeter is therefore suitable for use as a test in a much greater number of cases than the watch (A. Hartmann).

But testing with the watch, as a weaker instrument, cannot be dispensed with in cases in which it is required, not only to ascertain whether vibrations are perceived through the cranial bones at all, but also to find out the extent of the decrease in perception. It is therefore to be recommended that besides testing with my acoumeter, use should also be made of a low-ticking watch. If such a watch is perceived, an intact, or under certain conditions a very trifling decrease in the perception may be inferred, and testing with my acoumeter is then superfluous. If the watch is not perceived, while the acoumeter is heard distinctly, a decrease in the power of perception may be inferred; if even the strokes of the acoumeter are not at all noticed, a severe affection of the perceptive apparatus may be assumed.

Testing with the watch is effected, after the meatuses have

been closed by the patient, by pressing it first to the temples, then to the mastoid processes, and when there is a negative result at these places, by the patient taking the watch between the teeth. At this point the watch is heard loudest, less loudly at the forehead, the parietal bone, and the occiput. In the same manner testing with the acoumeter is carried out by bringing its metal plate into contact with the above-mentioned points.*

As is well known, the power of perception through the cranial bones of the ticking of the watch, and often also of the tuning-fork, is diminished in old age. This is not due, as was previously supposed, to the decreased conduction of the cranial bones, but chiefly to the material changes which the auditory nerve undergoes through senile degeneration. The age at which this occurs is very variable. After the fiftieth year cases are not infrequent in which a low-ticking watch is not heard through the cranial bones; after the sixtieth year the cases are rare in which it is still heard. But I have seen several cases in which after the seventieth year the watch was still heard on the temple, although the power of hearing for speech was impaired. On the whole it may therefore be said that in the normal state the power of perception through the cranial bones for weak vibrations is as a rule in existence until the fiftieth year, and that in aural patients over that age, and who do not perceive sound through the cranial bones, the same importance cannot be attached to those imperfections as in younger individuals.

We will refer to the utilization of this method of testing as regards diagnosis and prognosis in the discussion of the several forms of disease. We will here only mention in a general way that some little time ago it was thought that the watch was a means of differential diagnosis by which the diseases of the sound-conducting apparatus could with certainty be distinguished from those of the labyrinth, as in cases in which the ticking of the watch was heard through the cranial bones, the cause of the functional disturbance was supposed to be in the sound-conducting apparatus, while, when the perception was wanting, disease of the labyrinth was inferred. Clinical experience, however, has proved that such an assumption is erroneous, for very frequently in cases in which affections of the middle ear may be proved objectively it will be found that perception of the ticking of a watch through the cranial bones is completely wanting; and on the other hand, in cases of slight affection of the labyrinth a loudly ticking watch may be perceived through the cranial

* Among the peculiarities of a one-sided affection is the sharply defined, often linear, boundary in the middle line of the parietal bone and the forehead, where the perception of the normal side suddenly ceases as soon as the watch has reached the other or diseased side of the head. But not unfrequently, if the perception on one side is quite absent, by pressing the watch to the corresponding temple, the sound is yet perceived on the other side, whatever part of the head the watch is applied to, and when the normal ear is closed.

bones. Nevertheless, I consider this mode of testing, lately pronounced as of no practical value, of importance both in diagnosis and prognosis in so far as in affections of the middle ear, capable of objective proof, a simultaneous affection of the labyrinth may be inferred from the decrease or complete absence of perception of the ticking of a watch through the cranial bones. For experience teaches that in the exudative forms of inflammation of the middle ear, with or without perforation of the membrana tympani, perception of the ticking of the watch through the cranial bones is generally preserved, and very seldom completely disappears, while in the insidious inflammations of the middle ear, accompanied by condensation of the mucous membrane, such perception very often becomes extinct. In such cases it is quite justifiable to assume the existence of a simultaneous disease of the labyrinth from the want of perception through the cranial bones, because the other accompanying symptoms, especially the continuous subjective noises and the rapidly progressing impairment of hearing, point to a simultaneous affection of the expansion of the auditory nerve.

On the whole it may, therefore, be said that in those diseases of the middle ear in which perception through the cranial bones even for a weakly ticking watch exists, the labyrinth is intact, and the prognosis will, therefore, *ceteris paribus* be more favourable than in similar cases in which the perception through the cranial bones is decreased or completely extinct. This mode of testing is, however, also of prognostic importance in another respect. For experience shows that in those chronic affections of the middle ear, accompanied by thickening of the mucous membrane, in which, even after a long duration of the disease, perception through the cranial bones for watch and acoumeter is preserved, the decrease in the power of hearing does not occur so quickly in the further course of the disease as in those cases in which, after a short duration, perception of sound through the cranial bones disappears.

In my opinion the existence of the perception of the ticking of the watch through the cranial bones is of diagnostic importance in those cases in which the acuteness of hearing for watch and acoumeter as well as for speech has decreased in a considerable degree. For we may assume in such cases with great probability that the functional disturbance is caused by a hindrance to the conduction of sound and not by an affection of the labyrinth.

The perception of the ticking of the watch through the cranial bones disappears, as I was the first to observe, sometimes even in acute inflammations of the middle ear, partly in consequence of the pressure which the exudation exercises on the fenestræ of the labyrinth, partly owing to simultaneous hyperæmia and exudation in the labyrinth. If in the course of the pathological process

perception returns again, it must be taken as a favourable sign as regards the restoration of the power of hearing. The same holds good of those paralytic conditions of the labyrinth caused by mechanical action (shot, stroke, fall), and of those labyrinthine diseases produced by general syphilis, where such a return of perception is also a favourable prognostic sign.

In conclusion we will mention the rarely observed intermittent perception through the cranial bones. The phenomenon that on some days the watch is heard well through the cranial bones, while on others the perception is completely wanting, occurs in acute as well as also, and much more frequently, in chronic affections of the middle ear. In such cases the fluctuations in the power of perception of the auditory nerve are produced partly by already existing anatomical changes, partly by an alteration of the tension in the tympanic cavity, and by its secondary influence upon the labyrinth.

2. *Testing with the Tuning-fork.*

The application of the tuning-fork to test perception through the cranial bones has become of considerable importance in the diagnosis of the diseases of the ear. For by its means we are frequently able, in cases in which objective examination of the membrana tympani and of the Eustachian tube gives a negative result, to ascertain whether the functional disturbance has its seat in the tympanic cavity or in the labyrinth. But even in cases in which the examination of the membrana tympani and of the Eustachian tube proves with certainty the existence of an affection of the middle ear, information is often obtained by the tuning-fork as to whether the auditory nerve is intact or already secondarily affected.

E. H. Weber was the first to show that a vibrating tuning-fork brought into contact with the cranial bones will chiefly be heard by that ear, the meatus of which is closed with the finger. This fact remained long unexplained, until recently Mach on theoretical grounds gave the opinion that it was caused by the hindrance to the dispersion of the waves of sound from the ear. A considerable number of experiments which I made on human ears* proved that this increased sensation of sound by closure of the external meatus is caused (1) by increased resonance of the external meatus, and by reflection of the waves of sound transferred through the cranial bones to the air in the external meatus upon the membrana tympani and the ossicula; (2) by the altered tension of the membrana tympani and of the ossicula; and (3) by prevention of the dispersion of the waves of sound from the ear which reached the labyrinth and the tympanic cavity through the cranial bones (Mach).

* *Ueber Schallleitung durch die Kopfknochen*, *A. f. O.* vol. i. p. 318.

Upon this theory is based the utilization of the tuning-fork for diagnostic purposes in the diseases of the ear. For it is generally acknowledged that in all those cases in which sound is prevented from reaching the labyrinth by pathological changes in the external meatus or in the middle ear, the tuning-fork, brought into contact with the cranial bones, is heard principally and most loudly with the affected ear, always supposing that the labyrinth is not simultaneously affected to such a degree that the perception of the vibrations of the tuning-fork by the auditory nerve is not quite impossible. This holds good not only in cases in which one ear alone is diseased, but also when both ears are affected, though in different degrees. The same pathological changes which hinder the conduction of the waves of sound produced in the air form at the same time an obstacle to the dispersion of the waves of sound from the ear if they are conducted directly to the organ of hearing through the cranial bones.*

To test the perception of sound through the cranial bones tuning-forks of large size (low-toned forks) are most useful, because the vibrations last a considerable time, thus enabling the patient to state more exactly in which ear the sound is best heard. High-toned forks of smaller size are generally not suitable for such examinations, because the sound ceases too quickly. But I use the latter also to test the perception of high tones as well, and sometimes a more positive result is obtained by them than by low-toned forks.

The tuning-fork which I use is the quadrilateral prismatic fork $\bar{C} = 512$ vibrations per second (Fig. 68), manufactured by König of Paris. If the tuning-fork is made to sound by striking its prongs against an object, two kinds of tones will simultaneously be heard: a deep tone, the key-note of the tuning-fork, which is especially prominent if the fork is held close in front of the ear, and a higher sound, created by the upper tones of the key-note, which becomes distinct a little distance from the ear. In cases of one-sided affection, as also when both ears are affected to a different degree, the seat of the functional disturbance being in the sound-conducting apparatus, upon placing the vibrating fork upon the parietal bone the key-note as well as the upper tones will frequently be perceived with the dull ear; but it very often happens that the key-note is heard with the dull ear and the upper tones with the normal or less affected ear. This is not unfrequently a disturbing element during the examination; for, as we have to deal here with subjective statements of the patient, it often occurs that when the patient is asked which ear best

* That the tuning-fork in cases of affection of one ear is heard louder through the cranial bones with the affected ear, was known to the older aural surgeons; but it was then considered a symptom of the obstruction of the meatus, of the tympanic cavity, and of the labyrinth (E. Schmalz, *Erfahrungen über die Krankheiten des Gehörs*, Leipzig, 1846).

perceived the tuning-fork placed upon the parietal bone he will point out that ear which perceives the upper tones, because as a fine and clear sound they will engage his attention more than the low key-note. In this way an incorrect statement is received if the patient does not say himself, without having had his attention drawn to it, that he hears the droning (key-note) better with the dull ear, and the sounding (over-tones) better with the normal or less affected ear. These over-tones are, as I proved, to a great extent removed by weighting the tuning-fork with two great brass clamps which clasp the prongs (Fig. 68). These clamps must be perfectly fixed by means of strong screws, because otherwise a clattering noise will arise when the tuning-fork is struck against anything. The efficiency of this modification is easily proved, if in a number of aural patients the tuning-fork is alternately employed with and without the clamps. During examination with the simple tuning-fork the statements of the patients as to the ear in which the sound is louder are often variable, while much more decided statements will be made during the testing with a tuning-fork provided with clamps. But by fixing clamps to the prongs of the tuning-fork the pitch of its note will also undergo a noticeable alteration, for a tone will be produced which is several notes lower in the scale. If, according to König's proposal, the clamps are moved downwards the tone will become higher the lower they are fixed. The raising of the tone amounts to a whole octave. By this means we are able to test the hearing with different tones by the same tuning-fork, which is important for the practitioner because he does not now need to possess a whole series of high and low pitched tuning-forks.

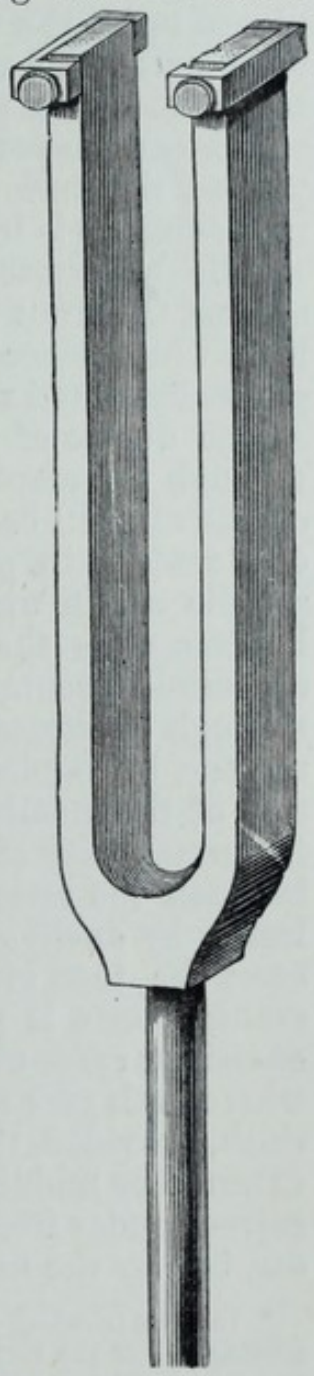

Fig. 68. — Prismatic Tuning-fork with Clamps* (half-size).

The examination with the tuning-fork is effected in the most simple manner by taking hold of it and striking it against a soft piece of wood, or against the hand, and then placing the extremity of its handle upon the middle line of the parietal bone. In case of one-sided deafness, or deafness of both ears differing in degree, the patient will generally give a decided answer when he is questioned as to the predominance of the perception of the tone in one or other ear. If the difference in the degree of deaf-

* Price at Leiter's in Vienna, 4 fl. ö. W.

ness in the two ears is not considerable, the patient will generally state that the sound is equally well perceived in both ears. It also frequently occurs in cases of one-sided deafness that the patient, biassed by the idea that he ought to hear better with the sound ear, immediately states that he perceives the tuning-fork, placed upon the vertex cranii, better with the normal ear. But such statements will at once become more reliable if the patient is requested to pay close attention, so as to be able to say in which ear the perception of sound predominates. As testing by placing the tuning-fork upon the vertex frequently gives no definite result, it is in such cases advisable that the extremity of its handle be pressed either upon the middle line of the upper lip against the front teeth, or upon the median line of the lower jaw, from which places the site of the increased perception of tone is generally stated more correctly than from the vertex.*

The degree of perception of the vibrations of the tuning-fork through the cranial bones in the diseases of the different portions of the ear will be discussed in the special division. We will here only remark in general, that in the diseases of the external and middle ear in which the disturbance of hearing is caused by a hindrance to the conduction of sound—as by ceruminal and epidermic accumulations, by polypous formations, by stricture through exostoses, by inflammatory or cicatricial stricture of the meatus, by exudations in the middle ear with or without perforation of the membrana tympani, by anomalies of tension through impermeability of the Eustachian tube, by abnormal connections between the ossicula and the walls of the tympanic cavity, and lastly, by anchylosis of the ossicula—in the majority of these cases the tone of the tuning-fork, brought into contact with the cranial bones, is perceived more distinctly by the affected ear in one-sided cases of disease, and by the most affected ear in cases where both ears are diseased.† But in the diseases of the labyrinth, provided they are not combined with an affection of the external or middle ear, the vibrating tuning-fork will not be perceived louder from the middle line of the cranium by the affected ear, but by the normal or better hearing ear.

* In cases in which the patients, after repeatedly placing the tuning-fork upon the median line of the vertex and of the upper and lower jaws, have not been able to say exactly in which ear the sound prevails, it will often be distinctly perceived if the extremities of an otoscope are inserted into both meatuses. If this is also unsuccessful, it is advisable, according to Hassenstein (*Berl. kl. Wochenschr.* 1871, No. 9), to place the tuning-fork upon the angle of an instrument similar to that for the measurement of the pelvis, the blunt extremities of which are placed upon the mastoid processes.

† An interesting phenomenon in cases of one-sided hindrances to the conduction of sound in the external meatus and in the middle ear, to which I was the first to draw attention, may here be mentioned. If in such cases the external meatus of the normal ear is closed by the finger, the increased perception of the tone of the vibrating tuning-fork will frequently be transferred from the dull to the sound ear, and return again to the dull ear after removal of the finger from the meatus. This shows that the preponderance of the perception of sound in one ear can dislodge the perception of sound in the other ear, although the supply is equally great in both ears.

That the tuning-fork is heard better through the cranial bones with the affected ear in diseases of the external and middle ear may be set down as a rule, to which, however, there are exceptions. These exceptions, however, by no means detract from the value of the instrument as a test. If we ascertain in a given case that the tuning-fork is heard from the vertex better with the affected ear, we infer the presence of a hindrance to the conduction of sound; if, however, it is heard better through the cranial bones with the normal or less affected ear, it does not entitle us to diagnose disease of the labyrinth, because it might be one of those exceptional cases to which we have just now referred. This shows that testing with the tuning-fork is only of diagnostic value in those cases in which we have the positive statement of the patient that the instrument is heard better with the affected ear, while a contrary statement only permits the inference of disease of the labyrinth, provided a number of other symptoms, to which we will refer in the course of this division, point to such an affection. The result of testing with the tuning-fork is specially important in those frequently occurring, insidious inflammations of the middle ear, leading to rigidity of the ossicular chain, in which the membrana tympani presents quite a normal appearance, and examination of the Eustachian tube shows it also to be normal. In the absence of other objective symptoms in these cases, the positive statement of the patient that the deep-toned fork is heard better through the cranial bones with the affected ear, will of itself be decisive of an affection of the middle ear, while with a negative result the diagnosis between an affection of the middle ear and disease of the labyrinth often remains undecided.

The results obtained by testing with the watch and with the tuning-fork frequently agree, but very often they do not, as it may happen that on the side on which the tuning-fork, placed on the vertex, is better heard, the watch, pressed to the temple of the same side, is either not heard at all, or is perceived much weaker than with the other ear. This, I think, is due to the difference in the volume of sound of the watch and of the tuning-fork, the opinion being based upon the following facts: We have seen that the waves of sound transmitted through the cranial bones reach the labyrinth partly through the membrana tympani and the ossicula; it is therefore evident that a decrease in the power of vibration of the membrana tympani and of the ossicula must diminish the supply of sound to the labyrinth. Clinical experience and pathological investigations have also demonstrated that in a great number of chronic affections of the middle ear the labyrinth is secondarily diseased; for we find not unfrequently, besides changes in the tympanic cavity, deposits of pigment, fatty, and colloid degeneration of the expansion of the auditory nerve in the labyrinth. That the power of perception of

the auditory nerve is decreased by these changes is certain, and it is probable that in a number of cases the decrease or complete absence of perception of ticking of the watch from the temple is produced not only by the pathological changes in the membrana tympani and in the ossicula, but also by the above-mentioned changes in the labyrinth. For in these circumstances, where the effect of the hindrance to perception through the cranial bones outweighs that of the hindrances to the dispersion of sound, the watch-tick is too weak to effect any increase in its perception. It is different with the vibrations of the tuning-fork. Through these a great volume of sound is conducted to the diseased ear, and even if a portion of it is lost owing to decreased mobility, and is also perceived less strongly in consequence of the decreased power of perception of the labyrinth, yet the quantity of sound which is detained in the ear through the hindrance to the conduction of sound is so much greater, that the perception in the diseased ear is better than in the normal ear, from which dispersion takes place without hindrance.

By numerous experiments with powerful clock-work, I have been led to the conclusion that when testing the perception of sound through the cranial bones by means of the watch and the tuning-fork, the difference in the intensity of the vibrations is of considerable importance as regards the difference in the perception. I employ when testing the hearing in cases of severe deafness, in which the acoumeter even is only heard when in contact with the auricle or not at all, a metronome-like clock-work, the strokes of which are of about the strength of those of a common German clock ; the difference in the hearing-distance previous to and during treatment in cases of very great deafness can be much more easily ascertained with this instrument than with a weaker source of sound. In many cases, therefore, in which the watch and the acoumeter are heard weaker from the temple of the diseased side than from the normal side, the tuning-fork is perceived stronger from the vertex with the diseased ear, this metronome clock-work, placed upon the vertex, will also be heard better with the diseased ear. During this test it is necessary, in order to avoid mistakes which might arise from the transmission of the vibrations from the clock-work through the air to the external meatus and the membrana tympani, to keep these vibrations from the ear, not, however, by closing the meatuses with the fingers, because perception through the cranial bones is often reversed by it, but by the insertion of the extremities of the auscultation-tube into both meatuses.

If the vibrations of the tuning-fork* are perceived better through the cranial bones with the diseased ear, the presence of a hindrance to the conduction of sound is indicated. But this does not by any means justify us in excluding a secondary disease

* I speak here of testing with deep-toned forks.

of the labyrinth, because it follows from the above that in a secondary affection of the labyrinth, not far advanced, the perception of the vibrations through the cranial bones may be better in the diseased ear if a great quantity of sound is detained in the ear by the hindrance to the conduction of sound in the tympanic cavity. It is otherwise when the affection of the labyrinth has reached such an extent that the power of perception of the expansion of the auditory nerve has been greatly reduced. In such a case the tuning-fork will, of course, not be heard better through the cranial bones with the diseased ear, but with the normal or less affected ear.

The degree of perception of the vibrations of the tuning-fork through the cranial bones is of great importance in the diagnosis of those affections of the ear in which the external meatus and the middle ear are intact, and the functional disturbance arises primarily from the labyrinth. Here, in slight cases in which the acuteness of hearing for the watch or the acoumeter and for speech has not been materially reduced, the watch and the acoumeter are heard less loudly, or not at all, from the temple of the diseased side, and the tuning-fork is also not heard by the diseased ear, but distinctly by the normal or better hearing ear. I observed this in cases in which marked one-sided deafness, tinnitus, and unsteady gait had occurred; the examination which was made shortly after the appearance of the affection showed no changes in the membrana tympani or in the middle ear, and neither irritative nor paralytic symptoms were to be found in any nerve-region except the acoustic. In this instance a rapid exudation or extravasation in the labyrinth could with probability be assumed. Cases of one-sided affection of this kind are, however, less frequent than disease in both ears, in which the tone of the tuning-fork is not perceived at all through the cranial bones. The same holds good of those forms of deafness, occurring suddenly in the course of constitutional syphilis, in which by objective examination no alteration in the middle ear is discovered, and the watch, pressed to the temple or to the mastoid process, is not perceived. As of prognostic importance I should like to mention the fact, that if during the treatment of a case of constitutional syphilis the previously absent perception of the ticking of the watch or of the vibrations of the tuning-fork through the cranial bones returns again, it may be considered as a favourable sign.*

* Testing with the tuning-fork furnishes also in carious processes in the petrous bone an important guide for the estimation of the state of the labyrinth. For if the tuning-fork is perceived better through the cranial bones by the normal than by the affected ear, it may with probability be concluded that the labyrinth is also affected by the carious process. But we cannot by any means agree with Lucae's opinion, that as long as the tuning-fork, brought into contact with the cranial bones, is heard better with the diseased ear, a serious affection of the ear and the extension of the disease

Some forms of disease of the labyrinth have still to be enumerated, in which in case of one-sided affection the tuning-fork is also not perceived from the vertex cranii by the diseased ear. These are temporary or permanent pareses of the expansion of the auditory nerve, caused by concussion (blow or fall) or by violent action of sound (explosion in the neighbourhood of the ear). The hardness of hearing, which in this instance is, as a rule, associated with subjective noises, is sometimes of a high degree, sometimes, however, inconsiderable; and concussion of the expansion of the auditory nerve may justly be assumed in cases in which shortly after the appearance of the deafness no changes in the membrana tympani or in the Eustachian tube are to be found, in which propulsion of air into the middle ear has no effect upon the hearing-distance, and the watch as well as the tuning-fork is perceived through the cranial bones by the better-hearing ear. We must attach considerable importance to a phenomenon which we have observed in cases of this kind in which the hardness of hearing was not of a high degree. If in a case in which the presence of all the above-named phenomena point to paresis of the auditory nerve, in which, therefore, the tuning-fork is plainly perceived from the vertex with the normal or better hearing ear and not at all with the diseased ear, the meatus of the diseased ear is closed with the finger during the testing, the increased perception of tone is immediately transferred to the diseased ear, and returns to the other ear after the removal of the finger. This observation essentially forms the basis of our opinion, already expressed in the description of the affections of the middle ear, that in cases of an affection of the tympanic cavity the labyrinth may be secondarily affected to a certain degree although the vibrations of the tuning-fork are heard louder with the affected ear if a great quantity of sound is detained in the ear by an impediment to the conduction of sound.

In conclusion, a few remarks about the understanding of speech through the cranial bones should here be made. Years ago (*A. f. O.* vol. i. p. 350) I proved that when both meatuses are filled with glycerine and closed by an india-rubber plug, and the mouth and the nose are also firmly shut, loudly spoken sentences will still be heard at a distance of 0·5 meter plainly enough, although the sound be very dull. The pathology of the affections of the middle ear, especially anchylosis of the stapes, proves indeed that when the vibrations of the membrana tympani and of the ossicula are completely wanting, articulate tones may still be heard. That in such cases the waves of sound reach the

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to the brain may with probability be excluded, as the carious process may break through from the tympanic cavity towards the cranial cavity in different parts of the temporal bone, without the labyrinth itself being affected.

labyrinth through the cranial bones, and not by transmission of the vibrations of the air in the tympanic cavity upon the membrana tymp. sec., is proved by those cases of great deafness in which words spoken through the hearing-trumpet are not understood, while the patient still understands words spoken loudly close to him without the use of that instrument.

That the understanding of speech as well as the perception of musical tones in cases of obstruction to the conduction of sound in the tympanic cavity is brought about by means of the cranial bones and other solid parts of the body, has already been proved by cases related in the older literature of otology. This refers to those deaf people who hear a succession of musical tones in a confused and disconnected manner, while if in contact with the origin of sound (for example a piano with a staff held between the teeth) they perceive whole melodies as distinctly and clearly as when their hearing was normal. I have observed several patients afflicted with very marked deafness in consequence of chronic thickening of the lining membrane of the middle ear, who with their eyes closed understood speech only when the hand of the speaker was laid upon their head or shoulder.

The method of examination with an auscultation-tube furnished with three branches for testing the condition of tension of the conducting apparatus proposed by me, as well as the interference-otoscope proposed by Lucae for the same purpose, might here be mentioned. As even in people of normal hearing the two membrana tympani reflect the sound with unequal intensity, an effect of course more frequently met with in cases where tension is altered by disease, this method of examination is only of limited value in diagnosis. Other conditions also, such as different widths of the meatuses, dissimilar positions of the end-pieces of the tubes in the orifices of the ears, etc., interfere with the result of this examination. For the detailed description of this subject I refer the reader to my treatise *On Conduction of Sound through the Cranial Bones* (*A. f. O.* vol. i.), and to the treatise of Lucæ (*ibid.* vol. iii. p. 186).

Dr. Bing has lately proposed a diagnostic expedient for the examination of individuals hard of hearing, which he calls the entotic application of the hearing-trumpet. He means by this that words are spoken into the bell-mouth of a speaking-trumpet, the other end of which communicates directly with the tympanic cavity by being inserted into the posterior orifice of a catheter the beak of which is introduced into the Eustachian tube. By this means the waves of sound proceed through the hearing-tube, the catheter, and the Eustachian tube into the tympanic cavity, where they reach the foot-plate of the stapes, and are transmitted by it immediately to the auditory fluid and to the auditory nerve. In a case in which speech cannot be understood at all

by the ordinary application of an ear-trumpet, but is distinctly heard by its entotic application, it may be inferred that there is a hindrance to the conduction of sound in the malleus or the incus, and also that the mobility of the foot-plate of the stapes in the fenestra ovalis is unimpaired.*

* Besides the already enumerated works on otology by Itard, Lincke, Kramer, Wilde, Rau, Toynbee, Bonnafont, v. Tröltsch, Moos, Erhard, de Rossi, Roosa, L. Turnbull, Duplay, and the special treatises, already mentioned in the text, of O. Wolf, v. Conta, Magnus, Lucae, Dennert, Knapp, and myself, there remain to be mentioned—A. Hartmann, *Ueber Hörprüfung und Politzer's einheitlichen Hörmesser, A. f. A. und O.* vol. vi. ; Garrigou-Desarènes, *Recherches sur la Transmission à l'Oreille*, etc., *Gaz. d. Hôp.*, 1867 ; Prout, *Boston Medical and Surgical Journal*, 1872 ; A. H. Buck, *Test-Sentences for Determining the Hearing Power—Report of the First Congress of the Intern. Otolog. Society ;* Urbantschitsch, *Ueber die von der Höhe des Stimmgabeltones und von der Applicationsstelle abhängige Schallleitung durch die Kopfknochen, A. f. O.* vol. xii. ; E. Morpurgo, *Rivista otojatrica—Giornale Veneto di Scienze mediche*, vol. xxiii. ser. 3 ; E. Schurig, *Bericht über die Leistungen in der Ohrenheilkunde*, 1875 and 1877.

THE DISEASES OF THE CONDUCTING APPARATUS.

Introduction to the Special Division.

General Remarks regarding the Etiology, Duration, and Course of the Diseases of the Ear, with Special Reference to the Examination of Patients.

a. Analysis of the most Important Symptoms of these Diseases.

Having in the previous division described the methods of examination of the ear, we will now discuss the most important points which have to be considered during the examination of the patient, and their importance as regards diagnosis and prognosis. While in certain cases the diagnosis may be made without a detailed record of the history by means of the objective examination of the patient, it is in the majority of cases absolutely necessary to take into consideration the history of the pathological changes, as it is only by it, in connection with the objective results, that a diagnosis of the affection as well as a prognosis is rendered possible. Contrary to those specialists who attach only slight practical value to this record, we consider it in many cases as one of the most important factors in the determination of the course of the disease.

When inquiring into the history of a case, it is specially important from a prognostic point of view to find out the duration of the ear-disease, as the prognosis will be generally the more favourable the shorter its duration. In cases in which disease of the ear has been suddenly developed without any previous affection of this organ with striking subjective symptoms, or with suddenly occurring deafness, we generally receive reliable statements regarding the commencement of the disease, but many patients are not even able to fix the date of the beginning of their disease approximately. The latter happens especially in those cases of unilateral insidious affections of the ear, which are developed without striking subjective phenomena, without pain or subjective noises, and unnoticed by the patient. These are

generally dated only from the time when during the closure of the normal ear the functional disturbance of the diseased ear has been accidentally found out. But also in such cases affecting both ears the functional disturbance will be noticed only when it has reached such a degree as to interfere with conversation, especially in persons whose position or calling makes no great demands upon their hearing, and who therefore hardly notice any trifling impairment. The commencement of a disturbance of hearing, which has already existed unnoticed for a long time, may also be dated from the appearance of the subjective noises; indeed not unfrequently patients are examined who state that their ears have been affected for only a short time, while objective examination shows extensive losses of substance, chalky deposits and cicatricial formations, which have existed for a long time without the person in question having the least idea of any affection of the ear.

Of no less importance in the prognosis is the determination of the course of the affection. Although we are obliged to confine ourselves to the statements of the patient, which are not always to be trusted, it is not unfrequently possible to find out the course of the disease by minute examination of the condition. Some aural surgeons, holding the opinion that the pathological changes alone must form the basis of the treatment to be applied, neglect altogether the investigation of the exciting and other causes. We shall see by-and-by, however, that with objectively analogous changes in the ear the prognosis and the treatment differ materially, as, for instance, in uncomplicated ear-disease, and in affections of the ear produced by scarlatina, syphilis, and other general diseases.

Among the etiological data of aural affections are those detrimental influences which act directly, or by continuity, upon the ear, and which are to be taken into consideration apart from those caused by a general affection or by disease of other organs.

Of the causes which directly set up mischief in the ear, we must in the first instance consider injuries, whether they implicate the ear directly or other portions of the cranium; the excessive action of sound upon the organ of hearing; also scalds, burns, and frost-bite; and lastly, vegetable parasites (aspergillus), which sometimes give rise to violent inflammatory phenomena.

Of the causes which come into play by means of continuity and contiguity of tissue, due prominence must be given to the acute and chronic naso-pharyngeal affections which cause functional disturbances of varying extent by spreading to the middle ear. Less frequently is the ear affected by external disease, as, for instance, by erysipelas and eczema of the skin of the face and head.

Among the immediate causes, even if not always demonstrable, we must count the atmospheric influences which are commonly

called 'colds.' Even if we admit cold to be a cause, we cannot by any means assume this so frequently as is so often done. The question put to the patient during the examination regarding the supposed cause of his affection is certainly frequently answered by the statement that it has probably been produced by a cold. But experience shows that this statement must generally be considered as a term in common use for a cause which is unknown to the patient, and which he only conjectures. But we are certainly justified in assuming a cold to be the cause of the affection of the ear if it has arisen shortly after exposure to cold. If, for instance, one states that during a cold wind the diseased ear was for a considerable time exposed to the current of air, and if soon afterwards a severe inflammation of the membrana tympani or of the lining membrane of the middle ear, with violent stinging pain, comes on, or if these phenomena are developed after a cold bath, or shortly after a wetting or a chill, we do not hesitate to assume cold to be the cause of the ear-affection.

Affections of the ear are also developed sometimes in the course of general diseases or diseases of special organs. To the former class belong scarlatina, measles, small-pox, typhus, syphilis, tuberculosis, scrofula, acute rheumatism, and gout; to the latter, pneumonia, puerperal processes, Bright's disease, and a number of affections of the circulation, such as are caused by valvular defects, aneurism, struma, and attacks of hooping-cough. Besides, intra-cranial processes, meningitis simplex, meningitis cerebro-spinalis epidemica, hydrocephalus acutus and chronicus, apoplexy, encephalitis, sclerosis of the brain, and tumours of the brain (Benedikt); also tabes dorsalis (Rosenthal), and hysteria, are the cause of disturbances of hearing of different degrees, partly by the extension of the pathological processes to the ear itself, partly by affecting the trunk of the auditory nerve. In conclusion, we must mention certain drugs, like quinine, salicylic acid, and others, which when taken internally produce temporary or permanent disturbances of hearing, as also chronic poisoning, occurring in various industries, from lead, arsenic, phosphorus, etc.

Another important cause has to be added to those already enumerated, viz., hereditary predisposition. As is well known, hardness of hearing is hereditary in many families to the extent that either all the members, or several of them, are afflicted with it. The affection appears either in the immediate descendants, or, according to my experience, more frequently in the second generation. But we are only justified in assuming hereditary predisposition as the cause of the aural affection, when in several members of the same family the disease of the ear has developed with similar symptoms and without other demonstrable cause. It would be going too far to assume in a given case a hereditary tendency—which under all circumstances makes the prognosis

more unfavourable—as the cause, if one member of the ancestors, or one of the brothers or sisters, had a disease of the ear, as of course, considering the frequency of the occurrence of affections of the ear, several members of one family may be afflicted with ear disease without hereditary disposition.

If, according to the foregoing, we are often enough in a position to trace the causes of the affection of the ear to one of the above-named sources, we must, on the other hand, confess that very frequently the cause is not to be defined. This refers not only to a number of acute inflammations of the external and middle ear, accompanied with free exudation, but especially to those insidious affections of the middle ear which are developed without striking symptoms and with a gradually progressing functional disturbance. But this is by no means surprising if we consider that medical science is still generally in darkness regarding pathogeny and the determination of the causes of disease, especially chronic affections.

Another point to be considered during the examination of the patient is his calling and occupation. Just as in the diseases of other organs, pathological processes in the ear may be affected in an unfavourable manner by injurious influences due to the calling and occupation of the patient. Experience also shows that in the curable forms of acute and chronic inflammations of the middle ear, the chances of complete recovery are much smaller in persons who are obliged to expose themselves during the course of the disease to unfavourable influences connected with their occupation, than in those who are in a position to avoid any external disadvantage.

The unfavourable influence of occupation upon affections of the ear is especially prevalent among certain classes; for instance, coachmen, masons, tanners, fishermen, sailors, soldiers in the field, etc—in a word, among persons who are continually exposed to all the vicissitudes of the weather. It is just as certain that the affections of the ear, associated with subjective sensations and an irritated or paralytic state of the auditory nerve, are influenced in a detrimental manner by noises in certain occupations continually acting upon the organ of hearing. We observe, for instance, in locksmiths, blacksmiths, millers, coopers, workers in noisy factories, and so on, in consequence of the excessive irritation of the auditory nerve, an obstinate continuance of the subjective noises, and an increase of the same, as well as of the deafness. In this instance the detrimental action of loud noises upon the diseased auditory nerve is as apparent as that of glaring light upon the diseased retina.* That climate, the condi-

* That occupations which are associated with continuous noise not only act unfavourably upon already existing affections of the ear, but cause ear-disease, is beyond doubt. In the investigation which I undertook in regard to this with different tradesmen, I found that, next to the locksmiths, coppersmiths and coopers were most

tion of the dwelling, the mode of life of the patient, the excessive indulgence in spirits, etc., influence the course of affections of the ear, requires no further proof.

A few remarks may here be made from a prognostic point of view regarding the frequency of the diseases of the ear at different ages, and the influence of age upon the course and issue of the disease. There is no doubt that the origin of many affections of the ear dates from the period of intra-uterine life. Soon after birth, the transformation-process in the middle ear, the rapid formation of mucous membrane there, and the action of external injurious agencies upon the hyperæmic mucous membrane of this cavity, favour the origin of inflammations. In childhood the acute exanthemata and naso-pharyngeal affections are the chief diseases which frequently become the source of affections of the ear. While the frequency of ear-diseases decreases in the prime of life, it presents again a noticeable increase in advanced age, not only in consequence of retrograde changes in the ear similar to those in the other organs of special sense, weakening the power of the auditory nerve, but also frequently owing to the development of chronic insidious inflammations of the middle ear, leading to thickening of the lining membrane of the tympanic cavity, and to rigidity of the articulations of the ossicula. The influence of age upon the course and issue of diseases of the ear is the same as in diseases of other organs, and our methods of treatment, therefore, have a far less favourable effect on old people than on the young.

It is also important to note the mode of development and the course of an affection of the ear, as they not unfrequently permit of a conclusion as to the nature of the disease. It is, therefore, necessary to find out in every case whether the disease has arisen with acute inflammatory phenomena, or without them, with rapid decrease of the function of hearing; or whether the disease has taken a slower, insidious course, with gradually increasing deafness; whether, also, a number of symptoms, such as subjective noises, giddiness, pain, pressure in the ear (which will be more fully discussed hereafter), have existed during the course of the affection, or are still in existence; and lastly, whether there has been, either temporarily or permanently, a purulent discharge from the ear.

We must likewise learn whether the power of hearing varies to any considerable extent or not. For experience teaches that great fluctuations in the hearing-distance are generally observed in temporary closure of the Eustachian tube, in swellings and accumulation of secretion in the middle ear, and also in affections

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afflicted by disturbance of hearing. Upon the latter especially, according to their own statement, the so-called hollow stroke when hooping the casks is said to have such a deafening effect, that most of them, if they remain at their trade, become hard of hearing in time.

of this cavity capable of resolution; but that in the insidious inflammations of the middle ear, unaccompanied by swelling and secretion, which cause permanent disturbances of hearing by the fixture of the ossicula, the power of hearing is subject to only very slight fluctuations. Considerable fluctuations in the hearing-distance may therefore generally be accepted as a favourable prognostic sign. But it must be added here that sometimes fluctuations in the hearing-distance may be produced by alterations of the auditory nerve itself, not only in primary but also in secondary diseases of the labyrinth which are developed in the course of acute or chronic affections of the middle ear, and in affections of the auditory nerve which have been caused by diseases of the brain. Such fluctuations are, however, seldom so considerable as those which are observed in swelling of the Eustachian tube and of the tympanic cavity.

We will now describe a series of subjective symptoms, the importance of which in diagnosis and prognosis must not be undervalued.

The Subjective Sensations of the Ear.—Among the subjective phenomena which accompany the diseases of the ear, the subjective sensations in the ear hold a prominent place, not only on account of their great frequency but also on account of their character, being so exquisitely distressing as to undermine often both the physical and the moral powers of the individual, and in some cases even to lead to suicide. The importance of this subject will therefore justify the following detailed description.

The subjective noises in the ear, which are always caused by some irritation of the auditory nerve, arise either from disease of the ear itself or by reflex transmission from the cerebral and spinal nerves to the auditory nerve. From these subjective sensations the so-called intra-tympanic noises have to be distinguished. These are the noises which are objectively perceptible to the patient and to the examiner, being produced by various pathological conditions in the interior of the ear (muscular noises, vascular noises, mucous rattling).

In the diseases of the eye the subjective sensations of sight are with only few exceptions projected outwards; the muscæ volitantes, the sparks and flames, the coloured rings and spots, which occur in diseases of the eye, are always seen by the patient outside the eye. It is different with the subjective sensations of the ear. These in the great majority of cases are perceived in the ear itself, in many cases in the interior of the head, in the occiput, in the region of the temple and at the parietal bone. Only rarely is this sensation of hearing referred outside, and this generally happens at the commencement only of the subjective noises; the strangeness and unwontedness of the sensation may in this instance easily lead to deceptions without its being justifiable to call them hearing-hallucinations. I saw a

female patient, in whom a blowing noise suddenly came on, which she at first mistook for a draught in the chimney, until she convinced herself that it was a subjective sensation of hearing. In other cases rumbling noises are mistaken for the rattling of a waggon in the street, and in this way the sensations of hearing, according to their variety, may in the beginning give rise to erroneous imaginations, which, however, cease as soon as the faculty of judgment controls the phenomena and corrects the imagination. Hallucinations of hearing do not, on the whole, occur frequently in aural patients without the conjunction of an altered state of the brain.*

But with subjective noises of longer standing the sensation may also be referred to the outside, in which case, however, the patient is not under a false impression, but knows that he has to deal with a subjective sensation. There are patients who state that they hear a humming or a rushing sound close in front of the ear, or at a few centimeters distant, or the roaring of a waterfall, or ringing of bells some distance from them. I observed a patient who, besides the most varied noises in the ear, stated that he also heard even inarticulate human voices, and the barking of a dog in the street.

If a considerable number of aural patients are tested in regard to the kind of noises they hear, very varying statements will be received. Certainly all the statements are not correct, for what the one takes for rushing, the other will possibly call hissing or whizzing, and many patients openly confess that they are not able to compare their subjective sensation with any known objective noise.

Most frequently hissing noises of different intensity are stated to be heard; next most common are, a noise similar to that of boiling water, the rushing and roaring of a waterfall, the humming of a swarm of bees or of a shell held before the ear, the noise of leaves in the wood, when the wind blows through them, the sensation of ringing of bells, and either the sharply defined tone of a small bell, or the humming reverberation of a large bell, metallic tinkling of different intensity, droning and whistling in the ear, the rumbling noise of a railway train, the chirping of crickets, the twittering of birds.

Besides these phenomena the strangest noises are often perceived, for instance inarticulate human voices, the barking of a dog, the smashing of panes of glass, grinding of scissors, the breaking of beams in the head, the sound of a trumpet, the tone of a low or high pitched violin-string, chaotic musical tones, crashing and crackling in the ear, pistol-shots, clattering, the sensation of wind rushing out of the ear, the knocking of a hammer, the noise of a mill, the croaking of frogs, etc.

Each of these subjective sensations may remain constant and

* Compare Köppe, *A. f. O.* vol. ix.

unchanged, or several kinds of noises may be perceived simultaneously even in the same ear, being plainly distinguishable, or single noises change alternately, or one replaces the other more permanently. I have seen patients who heard whizzing, ringing, hissing and droning simultaneously, and even barking as of a dog and inarticulate human voices in the street. Sometimes very intense permanent noises cease during the so-called 'ringing in the ears,' which also occurs in people of normal hearing, but they return again immediately after its disappearance with the former intensity.

Subjective noises in the ear arise, as already mentioned, from diseases in the organ of hearing, sometimes through causes situated outside the ear. It will be seen from the special description of the different diseases of the ear that the affections of the external meatus, and more frequently the diseases of the middle ear, are accompanied by subjective noises. Of special importance to the practitioner are the subjective sensations of hearing which occur in the affections of the middle ear, and which are produced not unfrequently by simultaneous pathological changes, but often by an abnormal increase of pressure in the labyrinth. This increase of pressure is caused either by the clogging of its fenestræ with masses of exudation, or by anomalies of tension of the ossicula; and later on the reader will learn the data by which the subjective sensations of hearing, emanating from the middle ear and produced by increase of pressure, are distinguished from those subjective noises which are caused by pathological changes of the labyrinth itself. This distinction is specially important from a practical aspect, as experience shows that the subjective noises, caused by increase of pressure, may frequently be made to disappear altogether.

The subjective noises are either continuous or intermittent. On the whole, it may be said that they are much more frequently continuous in affections of the middle ear without perforation of the membrana tympani than in purulent perforating inflammations.

If the noises are continuous, their intensity is rarely uniform; indeed fluctuations in intensity occur which have their cause in the pathological process itself, but more frequently in the action of external influences, and in changes in the general health of the patient.

Of external influences which produce an increase of the subjective noises must be mentioned—change of weather and temperature; in rainy weather, and often even a little time before it, the tinnitus generally increases; great heat causes an increase in the noises more frequently than great cold; in many persons they are aggravated to a considerable extent by the entrance of cold air into a warm room; and generally most people perceive the noises less in the open air than in a closed room. Diversion and

occupation often make the patient forget considerable noises, and many of them, therefore, do not notice the tinnitus during the day, while in a quiet room, in the evening before going to sleep, and while reading (Wilde, Rau), it is perceived more distinctly. Loud objective noises frequently completely mask the subjective ones, so that persons in a carriage, in a railway train, and in noisy localities, do not perceive a loud tinnitus; while they hear it so much the louder when everything is quiet again. I have, however, seen persons who heard their subjective noises in the midst of the greatest tumult; a lady with perforation of the membrana tympani stated that she heard subjectively the tone of a bell in the theatre, when the whole orchestra played, just as well as when everything was quiet.

In some cases in which no continuous noises occur, subjective sensations of hearing are frequently produced by certain kinds of objective noises, the tinnitus lasting either only as long as the objective noise, or much longer than it. In some patients tinnitus was principally caused by the striking of a pendulum-clock; many heard the strokes resound in the interior of the ears, others perceived at the moment the clock struck a confused tinnitus, which was either of short or long duration; similar phenomena have also been produced by the twittering of birds, by rustling of paper, or by the patient's own voice. The inability of a patient to perceive an objective noise similar to his subjective sensation is worth mention. Thus many patients state during examination that they cannot judge whether they hear the ticking of a watch, if they perceive a subjective noise similar to that ticking. A patient with a pronounced catarrh of the Eustachian tubes and tympana, who stated that he almost always heard the chirping of a cricket outside his ear, said that he could not recognize the chirping which was imitated by the mouth in his neighbourhood as an objective 'noise,' although his deafness was only of a slight degree.

Subjective noises are just as frequently produced or increased by temporary changes in the organism, *e.g.* bodily and mental exertion, remaining for some time in a bent position, much speaking, coughing and sneezing, often by the act of mastication only, by the turning and shaking of the head, waking through the night, or too long-continued sleep, the use of spirits, especially of wine, overloading the stomach; in fact, causes which produce an irritation of the nervous system will mostly induce a marked increase in the noises in the ear.

Not less frequently an aggravation of the subjective noises occurs, if the individual is taken ill, or seized with any indisposition; also if the emotions are excited, as well as during menstruation, pregnancy, and the puerperal state. When the body is well and the mind at ease, when cheerfully disposed, in fine, clear weather, the subjective noises are felt less intensely.

The change in the subjective noises which occurs when pressure is made with the finger upon the mastoid process or upon the first cervical vertebra, is of special interest. This fact was observed first by Türck (*vide* his *Spinalirritation*), but the phenomenon was not taken notice of any further. Benedikt has recently drawn attention to it, and I can also confirm Türck's statements after much experience. In cases in which pathological changes in the middle ear had been proved by examination, as also in those cases in which the diagnosis was undecided as to whether or not there existed disease of the middle ear or of the labyrinth, I observed often a decrease, less frequently an increase, of the tinnitus, as long as the pressure upon the mastoid process continued. It is not generally necessary to ask the patients about this change in the tinnitus, as they state themselves that it decreases or increases, or, as I have sometimes observed, that the noise during the pressure (hissing and whistling) moves upwards or ceases altogether.

A change in the intensity of the noises is also produced by closing the external meatus with the finger. Noises which are often so weak that they are hardly perceived by the patient, will at once be noticed if the meatus is closed. This can be explained partly by the change of pressure in the labyrinth when pressing the finger into the meatus, partly by the fact that by excluding the external objective noises the subjective sensations become more prominent. A remarkable phenomenon, which we cannot at present explain, often occurs in people hard of hearing on one side; it is that by closing the normal ear with the finger, a subjective noise will arise in the diseased ear, which, according to the patient's statement, is frequently of very great intensity, but disappears again immediately on the normal ear being opened.

We have still something to add regarding the importance of subjective noises in the prognosis of the diseases of the ear. In this connection it is most important to learn whether the patient suffers only temporarily from subjective noises, or whether they continue uninterruptedly. For experience shows that, even in otherwise analogous cases, the prognosis is more favourable if no subjective noises, or only temporary ones, exist, while the prognosis is generally more unfavourable if the subjective sensations are continuous. If in a case of chronic affection of the middle ear with constant tinnitus a striking improvement in the hearing is brought about without the subjective noises being changed by the treatment, it may with great probability be assumed that the result will not be lasting, but that a relapse and a decrease in the acuteness of hearing will again take place. The prognosis will also be unfavourable in those cases in which the affection of the ear commences with slight continuous subjective noises, which steadily increase in course of time, and in which the power of hearing has only gradually decreased after years to such an extent that the understanding of speech close by is difficult. In such

instances, also, either no improvement in the hearing, or only an inconsiderable one, will be effected by treatment.

Hyperæsthesia acoustica must now be described.

Hyperæsthesia Acoustica.—This is an unpleasant, painful sensation in the ear, produced by tones or noises. On the whole, we may say that the highest tones capable of being produced create a painful sensation in almost every individual with sound ears.* The degree of sensibility for certain tones varies in different individuals, but it also changes in the same individual under the most diverse bodily conditions, by which the whole nervous system is brought into a state of irritation. Observations which I have collected on this subject in regard to individuals with sound ears have shown, on the whole, that weakly, easily excitable, nervous, and anæmic persons, are more frequently unpleasantly affected by certain tones and noises than strong and healthy individuals. In some this sensitiveness only occurs temporarily, and that more frequently in the evening, when the nervous system is specially relaxed by mental work, or in the morning after a sleepless night. Bodily indisposition often increases the sensitiveness considerably in persons who are otherwise only moderately sensitive to tones.

Hyperæsthesia of the auditory nerve occurs sometimes in a high degree in those affections of the organism in which the nervous system has been specially attacked. Even in severe congestion of the head sensitiveness to loud noises is often observed. Acute hyperæsthesia I have also observed several times in the beginning of meningitis, accompanied by photophobia, in encephalitis, at the commencement as well as also during convalescence, in some cases of basal or cerebral tumours, and in spinal affections. The sensitiveness to noises was not less pronounced in some forms of neuralgia of the trigeminus, and during convalescence from severe illnesses. In megrim, this hyperæsthesia does not often reach a high degree.

Most frequently such hyperæsthesia is observed in the diseases of the ear itself. The inflammatory affections of the external meatus only very rarely produce hyperæsthesia of the auditory nerve, which in that case is caused by hyperæmia spreading to the deeper portions of the auditory apparatus, or by reflection from the expansion of the nerves in the meatus to the auditory nerve.†

It is, however, the diseases of the tympanic cavity which most frequently give rise to this nervous symptom. The acute inflam-

* Appun and Preyer produced as their highest note the E of 40,960 vibrations by small tuning-forks, upon which they played with a violin-bow. These tones are stated to be very painful and unpleasant. A similar height of tone can be produced by König's sounding staffs (tuned steel cylinders).

† Compare my treatise, *Ueber subjective Gehörsempfindungen*, *Wiener med. Wochenschrift*, 1865.

mations of the membrana tympani are rarely accompanied by hyperæsthesia. In cases in which it does occur the affection is seldom confined to the membrane, but is combined with swelling and hyperæmia in the tympanum, and consecutively with hyperæmia in the labyrinth. But it is in rupture of the membrane by a blow on the ear that I have most frequently observed hyperæsthesia. It is certain, however, that the rupture of the membrane is not the cause of this phenomenon, but the concussion of the expansion of the auditory nerve in the labyrinth, caused by the blow on the ear, by which the nerve is irritated.

In the acute affections of the tympanum, very often in the beginning of the disease, but most frequently in the course of chronic adhesive inflammations of the middle ear, I have observed hyperæsthesia acoustica. It is remarkable in this latter form of disease that the symptom of hyperæsthesia frequently appears only at its commencement, when as yet none or only slight hardness of hearing has come on, and only a slight tinnitus is perceived; but frequently it arises only when the hardness of hearing is advanced, so that such patients often protest against too loud speech, and even avoid the use of the ear-trumpet because the sound causes a troublesome and painful sensation.

The cause of the frequent occurrence of hyperæsthesia in chronic affections of the middle ear is to be looked for in the secondary changes which are produced in the labyrinth by these processes, and the insidious changes in the middle ear which end in anchylosis of the stapes are specially frequently accompanied by thickening or atrophy of the membranous labyrinth, by a large deposit of calcareous salts, by a copious discharge of amorphous pigment, and by hyperæsthesia of the auditory nerve.

The painful sensation caused by tones or noises does not, however, always remain confined to the ear, but it causes, not unfrequently, a number of reflex phenomena. Patients often complain of a simultaneously occurring uneasiness and trembling; they avoid noisy streets, noisy meetings, and loudly instrumented operas and concerts. Many complain of numbness in the head, headache, and nervous excitement if the sound which created the unpleasant sensation lasted for some time.

Hyperæsthesia acoustica has no connection with the subjective noises in the ear. They may occur simultaneously, but frequently no sign of hyperæsthesia is to be found with loud subjective noises, or it takes place without simultaneous subjective hearing-sensations.

But hyperæsthesia acoustica may also occur in cases of complete deafness, as I have observed. To explain this fact, perhaps the assumption would not be unjustified that the auditory nerve principally consists of fibres, the irritation of which by waves of sound effects the perception of sound; but that besides these it possesses another kind of fibre, which is also only irri-

tated by sound, while it does not give rise to the perception of sound, but to a peculiar sensation of pain.

Of the symptoms accompanying the diseases of the ear we have still to mention pain, the sensation of pressure, fulness and numbness of the ear, and the feeling of stupor and of giddiness.

We will discuss the symptom of *pain* in the ear more in detail when describing the separate diseases of the organ of hearing. It is well known that pain occurs mostly as a symptom of acute, more rarely of chronic, inflammation in the external and middle ear; also that it is sometimes the symptom of neuralgia in the external meatus or of the plexus tympanicus, both as an independent neuralgia, and as a part of neuralgia of the trigeminus. It often radiates in the same manner as in caries of the teeth or in affections of the larynx and pharynx. The pain accompanying inflammation of the external meatus, but especially of the middle ear, is only rarely limited to the region of the ear; it radiates generally towards the parietal bone, sometimes also downwards on the lateral portions of the neck to the shoulder, or towards the occiput and the teeth. The pain is exceedingly intense in acute inflammation of the membrana tympani and of the middle ear in childhood, in acute purulent inflammations of the middle ear before perforation of the membrane, and lastly in carious processes in the temporal bone. Pain is, however, by no means a constant symptom of inflammatory affections of the ear, nor is its intensity in proportion to the degree and extent of the pathological process. For not unfrequently in purulent affections of the middle ear an extensive destruction of the membrana tympani, with partial erosion of the ossicula, is observed, without the patient ever having felt the slightest pain in the ear. In cases of protracted suppuration of the middle ear also, a circumscribed softening of the osseous tissue surrounding the middle ear may take place without the least pain during its whole course.

Abnormal sensations, which the patient calls pressure, fulness, heaviness, and numbness of the ear, are by no means constant symptoms of inflammatory and exudative processes in the ear.

In some cases the feeling of fulness and numbness in the ear is caused by closure of the external meatus or of the Eustachian tube by an accumulation of exudation in the middle ear, or by abnormal tension of the membrana tympani and of the ossicula. But in the majority of the cases enumerated here, the phenomena of pressure and fulness in the ear are completely wanting. I was the first to point out that the sensation of fulness and numbness is frequently perceived by patients in whom the Eustachian tube is only very slightly swollen, and no considerable accumulation in the middle ear has taken place, while when the Eustachian tube is impermeable through great swelling of its mucous membrane, or when fluid has copiously accumulated in the tym-

panic cavity, the sensation of numbness is much more trifling, or is completely absent.

The sensation of giddiness which is sometimes observed will be produced by affections of the labyrinth, by hyperæmia, exudations, and extravasations. Not unfrequently, however, temporary, or somewhat lasting, attacks of giddiness occur in diseases of the sound-conducting apparatus, as an extensive increase of pressure in the labyrinth is caused by abnormal tension in the middle ear, or by pathological products.

To the symptoms enumerated here we will add the description of a group of disturbances of hearing which sometimes make their appearance in company with symptoms of the most various forms of ear-disease, and which principally engage the attention of the specialist on account of their peculiarities. They are paracusis loci, paracusis Willisiana, and diplacusis.

Paracusis Loci.—Paracusis loci, or localis, means the inability to point out the locality and the direction from which sound has come. Even with normal ears we possess only in an imperfect degree the faculty of judging the direction of sound, as this distinction is not an act of the perception itself, but a result of our judgment produced by experience. We believe the origin of sound to be in this or that direction according as the sound strikes louder the one ear or the other; but our judgment regarding the direction of sound will become quite uncertain if both ears hold the same position with regard to the site of the origin of sound. The observation of this phenomenon in aural patients who were not only unable to state the direction of the origin of sound, but who frequently enough believed it to be in an exactly opposite direction, induced me to institute a series of experiments with a considerable number of persons of normal hearing, and with others of defective hearing, which serve to afford an explanation of paracusis loci in aural patients.*

If a loudly ticking watch is moved backwards and forwards in the plane of the vertex cranii above the head of a person of normal hearing while the eyes are closed, he will not be able to state exactly whether the watch is before, above, or behind him; but as soon as one ear is closed, the ticking of the watch is at once referred to the side of the open ear; indeed, the ticking is also projected in the direction of the unclosed ear, if the place where the watch is held in the plane of the vertex is seen by the person experimented upon. If, the eyes being closed, the watch is moved from the front backwards in the horizontal plane in a semicircle, its ticking, if held in front of the forehead, will still be heard towards the side of the open ear if the watch is moved a little distance towards the closed ear; but the nearer it gets to the line of direction of the closed meatus, the more uncertain will be the statements, and the more will they approach the

* Compare my *Studien über Paracusis loci*, *A. f. O.* vol. xi.

nature of guesses. The statements of many persons increase in certainty after a protracted test (Chimani).

These experiments show that our judgment regarding the direction of the sound is principally effected by hearing with both ears, and even if, as we have previously remarked, this judgment is not completely certain in the normal state, all the certainty we possess in the judgment of the direction of the sound is dependent on hearing with both ears.

Similar observations to those with closure of one meatus are made in a certain group of aural patients, who not only are unable to state the direction of the sound, but frequently enough also erroneously believe the origin of sound to be in an exactly opposite direction. Formerly it was thought that this anomaly was produced by disease of the labyrinth, and specially of the semicircular canals, which were supposed to be enabled by their position to make the direction of the sound perceptible. But this assumption is justified neither by experiment nor by observation, and cases are not infrequent in which with decided affection of the labyrinth this faculty exists, while in cases in which the disease has its seat in the sound-conducting apparatus, and in which the auditory nerve has been proved to be intact by functional tests, the capability of judgment as to the direction of the origin of sound is very frequently lost.

Paracusis loci is more frequent in patients than is generally supposed, but it is a symptom seldom stated spontaneously, generally only in reply to the surgeon's question. In cases in which it occurs in a pronounced degree, the deception is much more striking when the patient is surprised by a sound, and when the origin of sound is on the side of the hard-hearing ear. But there are also patients who, with the greatest attention, are unable to find out the direction of the origin of sound until they are informed of it by the object producing the sound becoming visible, or by turning the head several times. I have observed this most strikingly in sportsmen, who have stated that even with the closest attention they frequently perceived the noise of game, or the call of a woodcock, in the opposite direction, and generally more frequently when the dull ear was turned towards the place from whence the noise came. On the other hand, there are patients who never observed in themselves the phenomenon of paracusis loci, although the above experiment with the watch, and with speech, made upon them, showed that they deceived themselves remarkably regarding the direction of the sound.

Paracusis loci chiefly occurs in cases of obstruction to the conduction of sound without a simultaneous affection of the labyrinth, as in cases of exostoses or polypi in the external meatus, in affections of the middle ear, with or without perforation of the membrana tympani, more rarely in diseases of the labyrinth. Although I found this anomaly chiefly in cases of

one-sided deafness, I have often enough observed it in disease of both ears when there was no great difference in the disturbance of their hearing.

In conclusion, we should like to draw the attention of military surgeons to a practical aspect of this subject. The regulations of those countries which exclude from active service an individual afflicted with one-sided deafness would be justified by what has been said about paracusis loci. For in outpost service during the night, so important in war, when it is the duty of the advanced sentry to observe any movements in the direction of the enemy's camp which can only be perceived by the sense of hearing, ill-consequences might easily arise in case of one-sided dulness of hearing of the sentry by his forming an erroneous judgment as to the direction of the sound.

Paracusis Willisii.—This is an appellation for a remarkable improvement in the hearing of very deaf persons, which occurs during the action of loud noises. This improvement is chiefly observed while driving in loudly rattling carriages or in a railway train, in noisy factories and workshops, while listening to music loudly instrumented, etc., and is the more striking that the patients can understand speech during such noises much easier and at a much greater distance than people of normal hearing. The peculiar symptom was known to the older otologists, and in literature a considerable number of striking examples may be found which illustrate paracusis Willisiana.*

An attempt has been made to explain this phenomenon, by saying that the patients in question understand speech better during noise, because during it people speak louder. But I cannot admit this explanation, after having experimented on a number of such cases in a carriage and in a railway train. I found that not only speech, but also the strokes of my acoumeter, the perception of which, as I have already mentioned, can be exactly controlled, were perceived at a greater distance by such patients; indeed, I have even occasionally observed that whispered speech was understood at a greater distance while riding, than loud speech when at rest. V. Tröltsch is of opinion that in such cases we have possibly to deal with some slight interruption to the conduction of sound in the tympanic cavity, for instance, with a separation of the stapes from the incus, and that loud noises certainly would press the membrana tympani inwards, and throw these bones into distinct vibrations, whereby the ossicula would also come nearer to each other. As I have chiefly observed paracusis Willisiana in adhesive inflammation of the middle ear, it is, in my opinion, probable that the improvement in hearing during noise is produced by concussion of the ossicula, the articulations of which have become rigid, as the ossicula,

* Compare v. Tröltsch, *Lehrbuch der Ohrenheilkunde*, 1877, p. 253.

having lost their equipoise through the concussion, become more serviceable for the conduction of sound.

The occurrence of this form of paracusis is of great importance as regards the prognosis, because I have noticed this symptom almost exclusively in the incurable forms of the affections of the middle ear.

Paracusis Duplicata.—Paracusis duplicata, or diplacusis, is an anomaly of hearing of rare occurrence, in which either every sound or only certain tones and sounds are heard double. I have as yet observed this disturbance in the hearing but three times, once in an acute inflammation of the middle ear without perforation, once in the course of chronic suppuration of the middle ear with perforation of the membrana tympani, and once in a chronic inflammation of the middle ear, accompanied by free effusion. In all these three cases the symptom was only temporary; in the two first, tones as well as speech were said to be heard double; in the last case, it was rather a weak echo which the patient stated that he heard.

Diplacusis was known to the older aural surgeons, and such cases have been communicated by Itard, Sauvages, Beck, Wittich, Moos, and Knapp, who also tried to explain this phenomenon. Bressler* reports an interesting case of diplacusis, which Gumpert had observed in himself. After an exhausted inflammatory affection of the ear, not more fully described, double hearing took place. He heard spoken words in such a manner, that they seemed to come from two different directions. Both words were perceived without interval; the second was, therefore, no echo of the first, and he could distinguish them only by their difference in tone. That he heard double with the diseased ear alone, could plainly be proved by hermetically closing the meatus of the sound ear. After applying oleum hyoscyani coct. the diplacusis is said to have disappeared altogether.

b. A Survey of the Mode of Procedure in the Examination and Inspection of Patients.

An estimation of the facts of the patient's history, already described, as also of the most important symptoms of disease, taken in connection with the results of the objective examination, should in most cases enable one to form a judgment as to the nature of the affection of the ear and its prognosis in any given case. It is now only required to survey, in regard to the methods of examination already discussed, the order of procedure in the examination and inspection of patients, as also the most important facts which are to be taken into consideration.

The mode of procedure in the examination of patients is, as a rule, the following: First, the age and the occupation of the patient, the duration of the disease, and the probable causes

* *Die Krankheiten des Gehörorgans*, 1840.

(colds, naso-pharyngeal catarrhs, general diseases, hereditary tendencies), are ascertained; then the first symptoms, those during the course of the affection and at the time of examination, are inquired into. The manner of the occurrence of the gradual increase or decrease of the hardness of hearing, of the tinnitus, of pain, and of other subjective symptoms, are to be considered; also, under what influences and at what periods the alterations came on. We must further learn whether a discharge from the ear previously existed; if so, how long it lasted, and what was its character; whether swelling of the external region of the ear, or of the mastoid process, took place, and whether treatment has already been tried, and if so, of what kind.

The objective inspection of the patient commences with the auricle, the external meatus, and the membrana tympani. The neighbourhood of the external orifice of the ear and that portion of the external meatus visible without the speculum must be examined before the introduction of this instrument, because certain changes, confined to this region, are covered by the speculum, and might thus be easily overlooked. After the insertion of the speculum the meatus is examined as to its capacity and curvature, character of its secretion and vascularity; and the nature of existing obstacles, such as are caused by a natural or abnormal secretion of cerumen, by fungi, polypous growths, exostoses, or other pathological processes, leading to the stricture of the meatus, is ascertained by inspection, and eventually by probing.

If the inspection of the membrana tympani is not prevented, the different portions of the membrane are examined in regard to colour, lustre, transparency, and curvature, by slightly moving the speculum. The degree and extent of the vascular injection, the size and colour of existing opacities and chalky deposits, the form, position and extent of perforations, of cicatrices and atrophied places, are ascertained, and the presence of general or partial outward curvature, which may be caused by infiltration, serous and purulent formations, as also by granulations and polypous growths, is discovered. General or partial inward curvatures of the membrane, and their relation to the articulation of the stapes and to the inner wall of the tympanic cavity, must also be taken into consideration.

The position and inclination of the malleus, the size and outward curvature of the short process and of the posterior fold of the membrane, the form and extent of the triangular cone of light, the pathological changes in the tympanic cavity, the colour and extent of exudation shining through, and the reddish promontory, and in case of a perforation, the state of the visible inner wall of the tympanum, must be ascertained. In many cases of decided anomalies of curvature of the membrane, examination

with Siegle's speculum, to ascertain the tension and mobility of the membrana tympani, must not be omitted.

After ascertaining the state of the membrana tympani, the function of hearing has to be tested by first finding out the acuteness of hearing for the acoumeter and the watch, the distance of hearing for speech, and then the power of perception through the cranial bones by means of the watch, the acoumeter, and the tuning-fork.

Then follows the examination of the Eustachian tube and of the tympanic cavity, by the Valsalvian experiment, by propelling air by means of my method, and if these procedures give no positive result, by means of the catheter. Here the auscultation-sounds in the middle ear, and the changes in the membrana tympani, perceptible after inflation, especially the change of colour and curvature of the membrane, and the position of the handle of the malleus, must be observed.

After examining the middle ear, testing the hearing is repeated in the above manner to ascertain the difference in the power of hearing before and after inflation. This is of the greatest importance as regards both diagnosis and prognosis. For generally, if a considerable increase in the hearing-distance takes place, it may be inferred that the changes are such as to warrant a favourable prognosis (swelling and secretion in the middle ear, anomalies of tension, etc.), while in cases in which no improvement in the hearing, or only a slight one takes place after inflation, the prognosis will be more unfavourable, because it may with probability be assumed that the disturbance of hearing is due to some organized and irremovable pathological change in the middle ear, or in the labyrinth.

In inflammation of the middle ear, especially in acute and chronic suppuration, examination of the region of the mastoid process is absolutely necessary, because inflammations which have extended to that part produce palpable changes by involving the external osseous wall, the periosteum, or the integument, changes which it is very important to discover in time for treatment to be applied. By a moderate pressure with the tip of the finger it may be ascertained whether there is any enlargement of the bone, any infiltration of the periosteum and of the skin, and whether fluctuation is present ; also whether, and to what extent, pressure upon the bone causes pain, in what part of the mastoid process the greatest pain during pressure is felt, and whether or not a fistulous opening or cicatrix exists. As in inflammation of the external meatus and of the middle ear, especially in purulent affections, the cervical glands and the lymphatic gland on the mastoid process are often swollen and infiltrated, they have also from time to time to be examined, as a decrease in the infiltration may generally be considered as a favourable sign.

After this follows the examination of the naso-pharynx in re-

gard to congestion, swelling, secretion, growths of mucous membrane, ulcerations, and principally in regard to the state of the orifices of the tubes. Referring to the special division on the naso-pharyngeal affections for the details of the examination, we will only remark here that rhinoscopic inspection must be made, especially when the collective symptoms (changes in the portions of the visible naso-pharyngeal structures, increased secretion, palpable obstacles in the naso-pharynx, and difficulty in breathing through the nose) make the instrumental examination advisable. In case of obstacles to the current of air through the nose, our attention is often drawn to the presence of a naso-pharyngeal affection by a peculiar, one might say imbecile, expression of the face of the patient, which arises from breathing through the widely opened mouth.

But while the result of the objective inspection of the ear and the neighbouring parts, together with the history of the case, generally suffices for prognosis and treatment, it is often necessary also to consider the state of the general health. We cannot, however, by any means agree to the proposal of those specialists who urge a minute examination of the organs of respiration, circulation, etc., in every aural patient. Considering the amount of time which is spent in a minute examination of the patient, and in a thorough objective testing of the ear, such an examination of the other organs, undertaken without a special cause, would only be an unnecessary loss of time. The examination will therefore be extended to other organs in those cases only in which either the patient's history (*e.g.*, frequent occurrence of pulmonary catarrh, hæmoptysis, palpitation of the heart, syphilis), or his appearance, etc., makes a general investigation appear necessary.

Before closing this division, which is intended to serve the practical surgeon as an introduction to the special division, and to facilitate its comprehension, I must state that it is of special importance to note down the results of the examination, the objective result as well as the result of the hearing-test, so as to be able to ascertain at the next visit of the patient with the greatest possible exactness the changes which have occurred. The most practical way of noting down these memoranda is to make use of a special printed form, and I will here annex the one which I employ. It is reproduced here somewhat changed in shape (about 4½ cm. narrower and 3 cm. longer than the original form), and each page in the octavo shape contains two forms.* When abbreviations, initial letters, and certain signs† are employed, which everyone may construct according to his own convenience, the history of a case can be completely inserted into the given space,

* The German lithographed forms can be had in the shape of a book, firmly bound, from Rosner, Wien, at the price of 1½ fl. ö. W. per 1000 forms.

† Compare the abbreviations and signs proposed by Zaufal in No. 25 of the *Prager med. Wochenschrift*, 1876.

No. of Journal. Date	Name, Age, Occupation, Residence.	Diagnosis.

History		Duration	Cause	Course	Tinnitus	Pain	Otorrhœa	Remarks
	Right							
	Left							

Present Condition		Meatus	Membrana Tympani	Eustachian Tube	Naso-pharynx	Hearing-Distance				Conduction through the Cranial Bones		Hearing-distance after propelling air.	
	Right					Acoumeter		Speech		Watch		Acoumeter	
						Speech				Acoumeter		Speech	
										Tuning-fork			
	Left					Acoumeter		Speech		Watch		Acoumeter	
						Speech				Acoumeter		Speech	
										Tuning-fork			

Treatment		Hearing-distance when Dismissed			
		Right	Acoumeter		
			Speech		
		Left	Acoumeter		
			Speech		

Course and Result :

and can be used not only as a guide during the course of the disease, but also for scientific communications.*

* J. T. Schenk, *Dissertatio inaug. de tinnitu aurium*, 1669; Du Verney, *Traité de l'Organe de l'Ouie, etc.*, 1683; J. H. Hofmeister, *Diss. inaug. de organo auditus et ejus vitiis*, 1741; J. Haas, *De audit. vitiis, surditatem et difficilem auditum producentibus*, 1782; E. Dann, *Commentatio de paracusi s. de auditus hallucinationibus*, 1830; C. G. Lincke, *Sammlung auserlesener Abhandlungen, etc.*, 1836. The text-books and manuals of Itard, Lincke, Kramer, Wilde, Rau, Toynbee, Triquet, Bonnafont, v. Tröltsch, Moos, de Rossi, Roosa, L. Turnbull, Miot. A. Politzer, *Ueber subjective Gehörsempfindungen, Wiener med. Wochenschrift*, 1865; Schwartze, *Ueber subjective Gehörsempfindungen, Berliner klinische Wochenschrift*, 1866; Ch. Delestanche fils, *Etude sur le Bourdonnement de l'Oreille, Bruxelles*, 1872; A. Politzer, *Zur Theorie der Hyperästhesia acustica, A. f. O.* vol. v.; ibid., *Studien über Paracusis loci, ibid.* vol. xi.; Brunner, *Ueber den bei Krankheiten des Gehörorgans vorkommenden Schwindel, A. f. A. und O.* vol. ii.; W. Kroll, *Ueber Schwindelzufälle bei Ohrenkrankheiten, Inaugural-Dissertation, Halle*, 1872; Knapp, *Fall von Doppelthören bei Otit. med. purul., A. f. A. und O.* vol. ii.

II.—THE DISEASES OF THE MIDDLE EAR.

Special Division.

a. The Diseases of the Membrana Tympani.

The state of dependence of the membrana tympani on the external and middle ears in regard to its vascular supply, and the importance of this relation in the diagnosis of its conditions, have already been stated in the general division (pp. 26, 91). Although in the great majority of cases the pathological changes of the membrana tympani arise secondarily by spreading from the external and middle ears, the occurrence of independent, primary diseases of the membrane has been ascertained by clinical observations. We will first give a general survey of the most important histological changes of the membrane; and in the following division we will chiefly discuss its primary affections, while the secondary changes will be considered in the description of the diseases of the external and middle ear.*

1. *Survey of the Histological Changes in the Membrana Tympani.*

Although the pathological changes in the membrana tympani are not unfrequently confined to some of its layers only, the division of the histological changes according to their occurrence in the separate layers is not strictly practicable, as the latter, being so closely connected with each other by their nutrition, can hardly be conceived as separated from each other, and every layer must therefore be more or less affected by any disturbance in the nutrition of its neighbouring layers. If, then, we describe the disorders of nutrition in the membrana tympani according to its layers, we do so to render the description more clear. We shall therefore discuss the changes in the epidermic layer, the cutis, the substantia propria, and the layer of mucous membrane,

* The anomalies in the structure of the membrana tympani will be discussed together with those of the whole organ of hearing in a special division on the anatomical basis of deaf-mutism.

remembering at the same time the connection between the pathological changes in all the layers.

(i.) *Changes in the Epidermic Layer of the Membrana Tympani.*

The epidermic layer of the membrana tympani is subject to many changes. In acute inflammations the delicate, transparent layer of epithelium is loosened by being saturated with and macerated in serum, becomes opaque and non-transparent, and is sometimes raised in the form of blisters by a rapid effusion of serous fluid on the superficial dermic layer. The macerated epidermis is detached in the form of shreds, plates or scales, and reproduction of the epithelial layer takes place shortly after the inflammation has ceased.

In chronic inflammations of the membrane an abundant growth of epithelial cells very frequently occurs, not uncommonly producing an abnormal thickening of this layer. This increase in bulk rarely takes place independently; it is generally a consequence of diseased processes in the external meatus, which spread to the external layer of the membrane. Most frequently, however, increase in bulk of the epidermic layer is observed during or after suppurative, perforating inflammations of the middle ear, in which the membrana tympani is also constantly affected (otitis desquamativa, Buck). The detached epidermic masses consist of intact, swollen, and fatty epidermic cells, of free fat-globules and debris, with considerable quantities of cholestearin crystals in cases of chronic growth in the epidermis, especially if it adheres to the membrana tympani for a long time.

I have in some rare cases observed that circumscribed hypertrophy and cornification of the epidermic layer takes place. I found in a syphilitic woman, 45 years of age, who was suffering from a chronic inflammation of the middle ear, behind the umbo, a pointed, horny growth, about 2 millimeters high, with a crater-like depression at its point, which could be removed neither by dropping softening fluids upon it, nor by a vigorous use of the probe.

The epithelial growths on the membrana tympani, which were first observed by Urbantschitsch,* are amongst the rare formations in the epidermic layer. They are formed on the membrana tympani and in the external meatus either single or multiple, and develop as a rule in the course of chronic inflammations of the middle ear as little round protuberances, which disappear again spontaneously. While this author in two cases found only epithelial cells in them, and therefore called these formations epithelial growths, I found in one case that they contained principally cholestearin crystals and molecular debris. In this case eight pearly balls (Fig. 69) of the size of a pin-head, and of a

* *A. f. O.* vol. x.

bright lustre, applied to each other in the form of a semicircle with its concavity downwards, and which, when probed, proved to be firmly seated, solid globules, were to be seen in the posterior portion of the membrane. Otherwise the membrane was grey, and in the anterior inferior quadrant a small black orifice, as if pierced by a needle, was visible. These pearly growths had developed in the course of suppuration in the middle ear, which had existed for a year, and which had ceased only a short time before the examination.

Desquamation and condensation of the epidermic layer of the membrana tympani are as a rule associated with great opacity of the membrane. These opacities can be distinguished from those caused by the mucous layer, since in the latter the handle of the malleus is distinctly visible, while it is very indistinct in cases of slight epidermic thickening, and invisible in cases of great thickening. As a matter of course with deposits of that kind, anomalies in the curvature and in the extent of the visible surface of the membrane will also be combined, and the membrane will be found to be either flat or uneven and rough, the boundary between it and the meatus being obliterated.

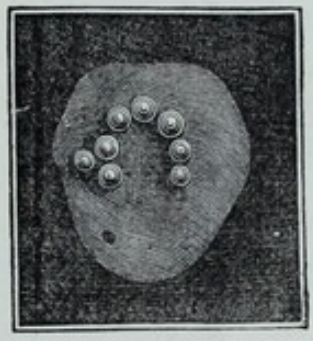

FIG. 69.—GLOBULAR PEARLY GROWTHS ON THE LEFT MEMBRANA TYMPANI OF A YOUNG MAN, WHO HAD HAD AN AFFECTION OF THE EAR FOR A YEAR.

(ii.) *Changes in the Dermic Layer of the Membrana Tympani.*

Hyperæmia and Hæmorrhage of the Dermic Layer.—In spite of the dense vascular network of the dermic and mucous layers of the membrane, its vessels are not visible in the normal ear. But an increased supply of blood, due to irritation or inflammation, renders the widely spread vascular ramifications plainly visible, sometimes in patches, sometimes over the whole membrane. Even by mechanical irritation of the membrane, such as a lengthened inspection with speculum and mirror (v. Tröltsch), or by irritation of the meatus with hard bodies, great hyperæmia may be produced in the normal membrane. In disease the excessive supply of blood to the membrane is frequently combined with hyperæmia of the lining membrane of the external meatus, more frequently still with a similar condition in that of the tympanic cavity; and rarely is it the consequence of a local inflammatory irritation of the membrana tympani itself.*

* The observations of Moos (*Die Blutgefässe und der Blutkreislauf des Trommelfells und des Hammergriffs, Arch. f. A. und O.* vol. vi.) have shown that numerous capillary anastomoses exist between the different vascular regions of the membrana tympani. We also know from the examinations of Prussak and Moos that the

Hyperæmia of the membrana tympani always commences with an overfilling of the bloodvessels of the handle of the malleus, which extend as light or dark-red striæ along the posterior margin of the handle to the umbo, and are at the upper boundary of the membrane either distinct from or in connection with the hyperæmic vessels of the superior wall of the meatus. In the latter case the handle may be either still plainly visible in front of the vascular bundle, or so completely covered by the bloodvessels that its locality and direction are only recognizable by the injected vascular bundle. Closely applied to the handle of the malleus, the vascular bundle, as it passes upwards, turns somewhat away from it, becoming separated into distinct large vascular stems, which anastomose with the vessels of the superior wall of the meatus, so that a small triangular space, with its apex directed downwards, is formed between the handle and the vascular bundle. In many cases the handle appears bounded by a vessel as by a sharply defined red outline, or traversed by a large vessel, extending across it.* If the excessive supply of blood increases, an injection of the circular vascular wreath situated near the periphery of the membrane will also take place, from which radiating branches extend towards the centre of the membrane, and come into connection with the bloodvessels of the handle of the malleus. In still more intense hyperæmia the capillary meshes of the dermic and mucous layers become so injected that the membrane appears uniformly light-red, purple, or copper-coloured.

Hyperæmia of the handle of the malleus occurs in those who, in consequence of cerebral hyperæmia, suffer from time to time from attacks of giddiness and subjective noises, also permanently in certain forms of chronic inflammation of the middle ear, and in chronic inflammations and hyperæmia of the external meatus. Extensive hyperæmia is a consequence of acute and chronic inflammation of the membrana tympani and of the tympanic cavity, and will be discussed more in detail in the special division.

Ecchymoses in the membrana tympani take place by rupture of the dermic vessels, either through mechanical contact with hard bodies, or through concussion from sudden condensation of air in the external meatus, in acute myringitis and acute otitis media, and in inflammations in the course of typhus, scurvy, variola (Wendt). They appear on the more or less hyperæmic membrane, sometimes as sharply defined, sometimes as indistinct,

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venous blood of the different layers of the membrane may return to the general circulation in many various ways. This explains why in the normal state disturbances in the circulation are capable of rapid removal, and on the other hand why hyperæmia of the membrana tympani arises so easily from the action of external interferences, and from irritative occurrences of any kind.

* Compare my *Beleuchtungsbilder des Trommelfells*, 1865.

blackish-brown, irregular spots, lying especially upon the handle of the malleus and behind it, sometimes coincident with ecchymoses in the meatus.

The ecchymoses migrate, as was first observed by v. Tröltsch, from the place of their origin into the external meatus; those behind the handle generally backwards and upwards, and those below and in front of the handle forwards and downwards, but sometimes also backwards and upwards. This migration is, in my opinion, connected with the eccentric growth of the membrane, an opinion confirmed by the migration backwards and upwards to the periphery of the membrane of a vulcanite eyelet, which was inserted by me into an orifice in the membrane below the handle of the malleus.

Inflammation of the Dermic Layer.—The dermic layer of the membrana tympani is frequently the seat of inflammation in primary as well as in secondary myringitis. In acute

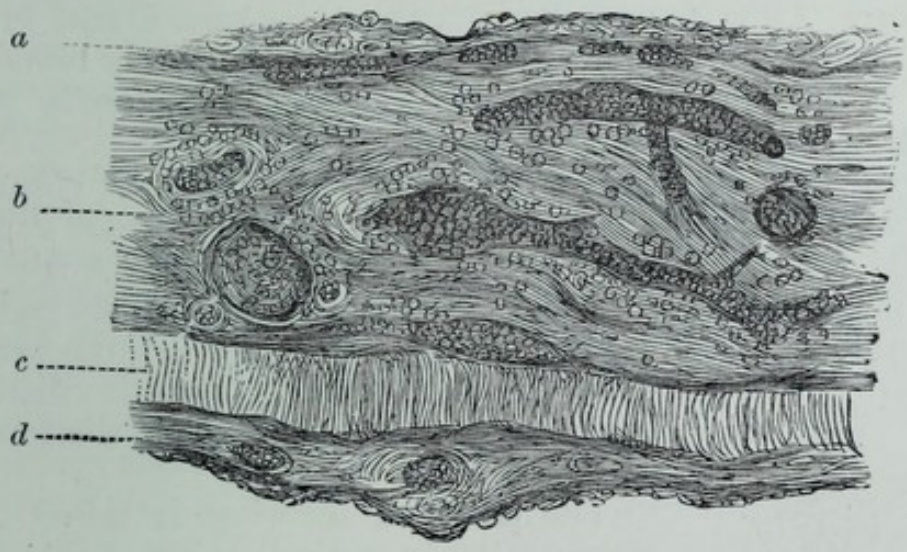

FIG. 70.—SECTION OF THE INFLAMED MEMBRANA TYMPANI OF A WOMAN, WHO DIED OF PUERPERAL FEVER, DURING WHICH SHE SUFFERED FROM OTIT. MEDIA ACUTA WITHOUT PERFORATION OF THE MEMBRANE.

a, Epidermic layer; *b*, Dermic layer greatly loosened, and traversed by large blood-vessels and pus-cells; *c*, Substantia propria hardly altered; *d*, Layer of mucous membrane moderately infiltrated, and irregularly swollen.

inflammation great hyperæmia leads to exudation on the surface and into the tissue accompanying the vessels and nerves. In a superficial inflammation the exudation is discharged below the rete Malpighii, as a clear or yellowish fluid, or as a hæmorrhage (Bing), by which the epidermic layer is raised in blisters. Only rarely does a fibrinous exudation upon the surface of the membrana tympani take place in the form of easily removable pseudo-membranes with numerous clusters of micrococci, a form of disease which is called by Bezold* croupous inflammation of the membrana tympani. When the whole dermic layer is inflamed the

* *Virchow's Arch.*, vol. lxx.

interstitial tissue is loosened by infiltration with serous fluid and round cells. In the microscopic examination of such membranes, five or six times as thick as in the normal state, it will be found, as I have already pointed out in my *Beleuchtungsbilder des Trommelfells* (p. 43), that the increase in bulk (Fig. 70) is chiefly caused by loosening and thickening of the dermic layer (*b*), while the substantia propria (*c*) is almost unaltered, and the mucous layer (*d*) only slightly so. The increase in bulk of the cutis is caused partly by the great dilatation of the vessels engorged with blood, partly by swelling of the tissue and by infiltration with round cells, which are for the most part accumulated near the vascular walls.

As the inflammation does not commonly affect the dermic layer uniformly, bulging forward takes place where the infiltration is greatest, and partial forward curvatures also occur when abscesses on the membrana tympani are formed.

These change in the dermic layer are capable of complete resolution. After acute inflammation, thickenings and opacities caused by new formation of connective tissue rarely remain, and usually with simultaneous changes in the substantia propria. Perforating ulceration is very uncommon.

The pathological changes of the dermic layer in chronic inflammations are of greater importance. The increase in bulk of the cutis, accompanied by secretion, leads to uniform thickening of the membrane, or to the formation of granulations and papillary excrescences, covered with a pavement epithelium, with new formation of vessels (myringitis villosa, Nassiloff), or in some rare cases to the formation of polypi.

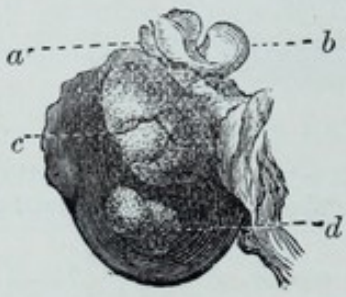

FIG. 71.—GLOBULAR, LOBULATED POLYPI ON THE EXTERNAL SURFACE OF THE MEMBRANA TYMPANI OF A GIRL, 19 YEARS OF AGE, WHO DIED OF CONSECUTIVE MENINGITIS.

The annexed drawing is taken from a preparation in my collection of the ear of a girl, 19 years of age, who had suffered since childhood from chronic suppuration of the middle ear on both sides, and who died of encephalo-meningitis by extension of the inflammation from the left ear to the cranial cavity. Besides multiple polypous growths in the tympanic cavity, which grew into the meatus through the space previously occupied by the membrane of Shrapnell, which was destroyed, and several small knob-like polypi (*a*) on the head of the malleus (*b*), two lobulated roundish polypi will be found on the external surface of the membrane, of which the larger (*c*) originates somewhere near the upper extremity of the handle of the malleus, and the smaller (*d*) with a broad base below its handle. The inner surface of the membrane is smooth, normal in curvature, and the handle is plainly visible.

(iii.) *Changes in the Substantia Propria.*

Pathological changes in the substantia propria of the membrana tympani must generally be regarded as secondary alterations, produced by disease of the dermic and mucous layers. In chronic affections of the middle ear and of the labyrinth, and also in advanced age, changes in this tissue may take place, such as deposits of fat-globules and molecules of calcareous salts, without coincident alterations of the external and middle layers; but this is rare. The occurrence of such changes, confined to the substantia propria, is not now considered so remarkable as formerly, when it was believed to be devoid of vessels, it having been ascertained by the investigations of Moos (*l. c.*) that vessels exist in that layer.

The secondary exudations in the substantia propria, due to inflammation of the dermic and mucous layers, present many varieties, according to the intensity and the stage of the process. In acute inflammations of the membrana tympani the tissue of the middle layer is loosened and decayed, and between the fibres granules, or round cells, are deposited. Sometimes, however, the structure is only slightly altered.

The tissue-changes are greater in chronic inflammations, especially in the suppurative affections of the middle ear. In these cases a large amount of exudation is effused by the adjacent inflamed layers into the substantia propria, seldom, however, uniformly, more commonly as irregular, yellowish patches, somewhat faint while the secretion lasts, but after suppuration has ceased appearing as greyish-white, chalky, sharply defined spots. Only seldom, and that when the membrane is extensively adherent to the inner wall of the tympanic cavity after suppuration in the middle ear, is the substantia propria in its whole extent interspersed with a fine granular substance, and thickened by new formations of connective tissue, the membrana tympani appearing rigid, and several times as thick as normal, by hypertrophy of its dermic and mucous layers, not unlike a thin leather or cartilaginous plate.[1]

Exudation into the substantia propria may be completely reabsorbed, but, owing to the vascular poverty of this layer, there often remain, especially in chronic inflammations, traces of exudation which undergo calcareous metamorphosis. These calcareous concretions in the membrana tympani, known to Cassebohm,* and which have recently been investigated in a more detailed manner in regard to development, histological relation, and diagnostic importance by Wilde, Toynbee, v. Tröltsch, Moos, Schwartze, de Rossi, Chimani, and myself, are frequently observed. They occur most commonly in the course of chronic suppuration in the middle ear, more rarely, as Moos first stated, in chronic inflammations of the middle ear, unaccompanied by

* *Tractatus quatuor anatomici de aure humana*, Halae, 1734.

suppuration. For clinical information on this subject the special division may be referred to. I will here only mention the histological changes as seen in microscopic sections. When the thickness of the calcareous deposits is only slight, this change is confined to the substantia propria, but when it is considerable, the external and internal layers of the membrana tympani take part in the process of calcification. In extreme cases of this kind, as seen in several preparations in my collection, the thickness of the membrana tympani is increased several times, the external surface of the membrane is smooth, while the internal is uneven, and appears as if covered with a mass of plaster of Paris. These kinds of deposits are generally found near perforations, and extend, spreading almost over the whole remainder of the membrane, nearly to the periphery on the one side, and to the handle of the malleus on the other. Such membranes, when touched with the probe, are found to be non-elastic and hard, like an egg-shell.

Microscopically these calcareous deposits prove to consist of minute, amorphous, granular masses, deposited partly between the fibres of the membrana tympani, partly, as v. Tröltsch has observed, in the corpuscles of the membrane. The fibres of the membrane undergo various changes in and around the calcified places. When calcareous salts are only scantily deposited, the ligamentous fibres of the substantia propria are frequently quite unchanged. When, however, the membrana tympani is considerably thickened, the fibres are infiltrated with minute fat-globules and granules, here and there completely replaced, and so unrecognizable that, even in sections from which those salts have been removed by acetic acid, the three layers can no longer be distinguished from each other. V. Tröltsch found in one case crystallized calcareous deposits; Bauer, in the membrane of hemicephalic individuals, found crystals of phosphate of lime. In the calcified portions a black, or blackish-brown, pigment (Toynbee) will also sometimes be found, in roundish masses or striæ, or in spindle or star-shaped cells, and fat-globules are everywhere present in different proportions.

Besides the calcareous deposits, a real osseous new-formation in the membrana tympani has in some rare cases been found. The occurrence of such osseous formations in the human membrane was first ascertained and described* by me, and was afterwards confirmed by Wendt. In one case observed by me during the last few years, I found in the calcified membrana tympani of a young man who had died from tuberculosis, and who had suffered for some time from discharge from the ear, a true osseous formation. Besides a circular perforation in the anterior inferior quadrant, I found behind the handle of the malleus, in the

* Compare my treatise, *Zur pathologischen Anatomie der Trommelfelltrübungen und deren Bedeutung für die Diagnostik der Gehörkrankheiten. Oesterr. Zeitschrift f. pr. Heilk.*, 1862.

midst of an extensive calcified portion, a circumscribed irregular place 0·5 mm. in size, which offered great resistance when making sections. In a section of the membrana tympani at this point (Fig. 72), in the substantia propria is perceived an oblong, ill-defined, but circumscribed lighter part, in which both dark and transparent bone-corpuscles with delicate processes are seen. Besides these, a number of oblong or irregularly formed dark corpuscles will be found, in which, however, the delicate processes are wanting.

The rare occurrence of cholesteatoma in the membrana tympani must here be mentioned. Wendt found it on the inner surface of a perforated membrane as a reddish, uneven protuberance, with a golden lustre, which had developed from the substantia propria, and, according to Wendt, from the endothelial

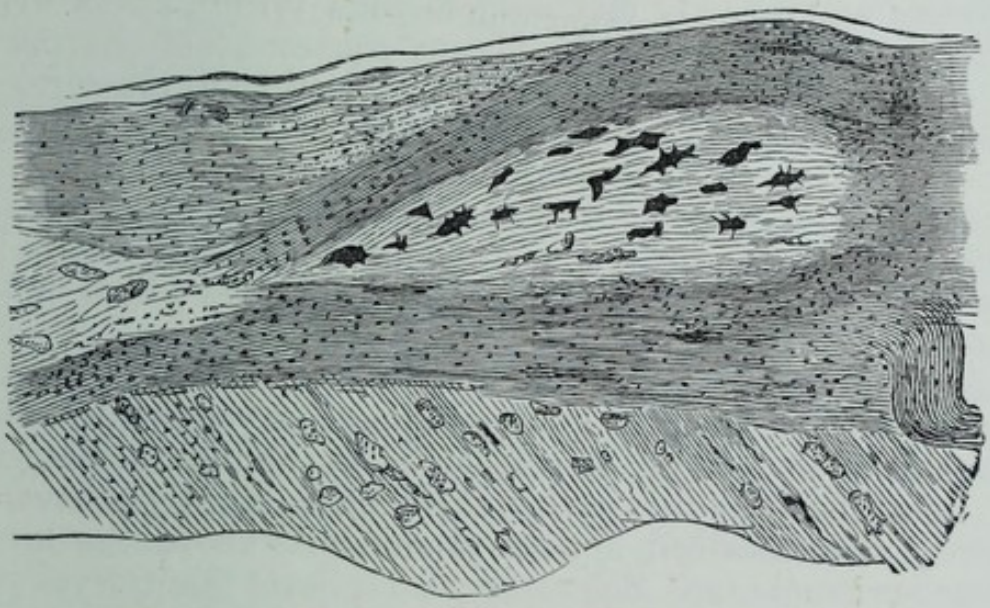

FIG. 72.—OSSEOUS NEW-FORMATION IN THE MEMBRANA TYMPANI OF A YOUNG MAN WHO DIED OF PULMONARY TUBERCULOSIS.

sheaths of its striæ. A. H. Buck* observed in one case an interlamellar cyst in the membrana tympani.

(iv.) *Changes in the Mucous Layer of the Membrana Tympani.*

The mucous layer of the membrana tympani suffers many alterations in the diseases of the middle ear. Hyperæmia of the dense vascular network of the internal layer in acute inflammations is rare, and only for a short time unaccompanied by hyperæmia of the dermic layer. Ecchymoses in the mucous layer are less frequent than in the dermic layer, and occur more rarely in primary, acute affections than in intercurrent, acute inflammations in the course of chronic affections of the middle ear, and in cases of concussion of the membrana tympani. They may completely disappear, or their pigment may remain.† Dilated,

* *Med. Record*, vol. vii., and Roosa's *Diseases of the Ear*, p. 222.

† Wendt observed in patients afflicted with smallpox the occurrence of small hæmatomata in the mucous membrane of the membrana tympani.

varicose, lymphatic vessels with saccular expansions, such as I was the first to describe, in the deeper layers of the mucous membrane of the middle ear (p. 81), I have seen in two preparations of the membrana tympani (chronic perforating inflammation of the middle ear).

The exceedingly thin layer of connective tissue in the mucous membrane, inseparable from the substantia propria, may become hypertrophied by proliferation, growth of round cells, and new-formation of connective tissue to such an extent that the membrane is enlarged to several times its normal thickness. The increase of bulk of the mucous layer, especially in cases of chronic suppuration in the middle ear, leads to adhesion of the membrane to the inner wall of the tympanic cavity, or without adhesion to thickening and opacity of the membrana tympani. In several preparations I found only the fibrous framework of the mucous layer (*vide* p. 28) hypertrophied and projecting in the form of a ridge above the level of the inner surface of the membrane. In addition, and especially in perforating inflammations, there may be developed in circumscribed parts papillary excrescences, considerable polypous growths, pedunculated cysts of microscopic size, and also diffused and circumscribed deposits which undergo calcareous metamorphosis.*

According to Schwartze,† in children with miliary tuberculosis, tubercles in the membrana tympani appear as yellowish-red spots of the size of a pin-head, or still larger, in the intermediate zone. Seen from the tympanic cavity, these spots, slightly convex and distinctly circumscribed, appear prominently above the level of the mucous membrane. Schwartze also believes that the yellowish, slightly prominent and hardish spots which he observed in cases of chronic pulmonary tuberculosis on the membrana tympani of adults during life, and which were quickly followed by ulcerative decay of the membrane, may be regarded as tubercles on the membrana tympani.

The anomalies in transparency and colour, the disturbances in the continuity, and the methods of healing of the perforations of the membrana tympani and its anomalies of curvature, will be discussed in detail in the description of the different forms of disease of the middle ear in which these changes of the membrane are developed.

2. *Inflammation of the Membrana Tympani.*

(i.) *Primary Acute Inflammation of the Membrana Tympani (Myringitis Acuta).*

Acute inflammation of the membrana tympani affects this structure in its whole extent, or in part only. The signs of the

* Lucae found in a case of chronic catarrh of the middle ear carbonate of lime crystals in the thickened epidermis of the mucous layer.

† *Handbuch der path. Anat.* v. E. Klebs, 1878.

inflammation are generally most marked in the posterior part of the membrane; only rarely does the immediately adjoining portion of the superior wall of the meatus participate in the affection. The cause of primary myringitis cannot always be discovered; it has been proved that it sometimes develops after the action of a cold wind upon the ear, after a cold-bath (v. Tröltsch), after sea-bathing (de Rossi), or in the course of acute naso-pharyngeal catarrhs.

FIG. 73.—A BLISTER OF THE SIZE OF A HEMP-SEED IN FRONT OF THE UMBO. FROM A MAN, 24 YEARS OF AGE, WHO FOR 2 DAYS HAD HAD AN INFLAMMATION OF THE MEMBRANA TYMPANI. ON THE THIRD DAY OF THE DISEASE THE BLISTER HAD DISAPPEARED, THE DIM MEMBRANA TYMPANI WAS COVERED HERE AND THERE WITH BLACK ECCHYMOTIC SPOTS; ON THE FOURTH DAY THE POWER OF HEARING, WHICH WAS ONLY SLIGHTLY LESSENED DURING THE EXISTENCE OF THE BLISTER, WAS AGAIN COMPLETELY NORMAL.

FIG. 74. — TRANSPARENT PEARLY BLISTER IN THE POSTERIOR INFERIOR QUADRANT OF THE MEMBRANA TYMPANI OF A YOUNG MAN, WHO HAD AN INFLAMMATION FOR 18 HOURS. HEARING-DISTANCE ONLY SLIGHTLY DECREASED. ON THE NEXT DAY THE BLISTER HAD DISAPPEARED.

FIG. 75. — DARK-RED HÆMORRHAGIC BLISTER UPON THE POSTERIOR FOLD OF THE MEMBRANA TYMPANI OF A MAN 60 YEARS OF AGE, WHO SUFFERED FROM INFLAMMATION FOR 24 HOURS. ON THE THIRD DAY A DRY ECCHYMOSIS WAS VISIBLE ON THE SITE OF THE BLISTER.

Appearance of the Membrana Tympani.—Acute myringitis commences with great hyperæmia of the external layer of the membrane, generally followed in a very short time by effusion into its tissue.

In the slighter degrees of myringitis, situated in the superficial strata of the dermic layer, there occurs simply a serous saturation of this layer along with scattered, irregular ecchymoses; or one or more transparent blisters of the size of a hemp-seed, filled with serous fluid, are formed, the lustre and transparency of which gives them the appearance of fine mother-of-pearl (myringitis bullosa) (Figs. 73 and 74). These blisters are readily distinguished from the yellowish-green, opaque abscesses of the membrane by their transparent, pearly-grey or vinous-yellow colour. The occurrence

of hæmorrhagic blisters on the membrane (Bing) is rare. In a case observed by me (Fig. 75), the dark-red, oval blister was situated upon the posterior fold of the membrane.

These blisters last as a rule only a short time, and frequently burst a few hours after they have risen; or they disappear again by rapid reabsorption of their contents. In the former case, a small quantity of watery or sanious fluid flows from the external meatus for a short time, and the next day, at the place where the blister was visible, the membrana tympani will be found to be covered by a layer of cracked epidermis, pale-grey in colour, the hyperæmia at and along the handle of the malleus will be decreased, and small ecchymotic spots will be seen near the point where the blister had been.

FIG. 76.—TENSE, YELLOWISH, TRANSPARENT, LUSTROUS BLISTER, INVOLVING THE POSTERIOR SUPERIOR PORTION OF THE MEMBRANA TYMPANI. FROM A MAN 21 YEARS OF AGE, WHO HAD MYRINGITIS FOR 36 HOURS. TWO DAYS AFTER THE FIRST OBSERVATION THE BLISTER HAD DISAPPEARED WITHOUT HAVING BURST. THE HEARING-DISTANCE, WHICH HAD BEEN SLIGHTLY LESSENED, WAS AGAIN NORMAL AFTER A SHORT TIME.

While we have to deal here with a markedly superficial inflammation of the dermic layer of the membrane, in which, by the discharge of serum below the epidermis, the latter is partially lifted off, and blisters are formed, in the more severe forms of inflammation, blisters of considerable size, and abscesses which have their seat in the deeper strata of the dermic layer, will be formed.

When inspecting the membrana tympani in such cases, there may be observed a swelling of the size of a small pea, extending over the posterior superior portion of the membrane, the appearance of which depends on the character of the exudation, and on the depth of the site. In the case of serous exudation the swelling (Fig. 76) is like a large transparent pearl of a yellowish lustre; in the case of a purulent effusion, it is like a lustrous, non-transparent, yellowish-green blister; and if a more diffuse exudation takes place in the deeper strata of the dermic layer, the latter will be bulged forward in the form of a bluish-red lustrous tumour, or as a tumour covered with a slightly torn and sodden epidermic layer, which at first sight is very like a polypous growth.

In the course of acute myringitis, abscess more rarely occurs than in acute otitis media. Wilde observed in two cases circumscribed suppuration in the membrana tympani, and when an opening was made, the pus was discharged into the external meatus. V. Tröltsch saw in a case of acute myringitis at the posterior superior margin of the membrane, a yellowish swelling the size of a hemp-seed, of a doughy character when felt with the probe, which gradually decreased as the disease lessened.

Schwartze observed that abscesses were produced by painting the membrana tympani with nitrate of silver and tincture of iodine. Wreden has in two cases seen small abscesses between the layers of the membrana tympani. From the excellent description by O. Boeck (*A. f. O.* vol. ii.) of a few cases of abscesses in the membrana tympani, it must be concluded that in the cases in question it was not an acute primary myringitis with abscess-formation that had to be dealt with, but a secondary formation of blisters and abscesses in the membrana tympani, occurring in the course of acute or chronic affections of the middle ear.

In the primary abscesses which I have observed, and also in the case of large blisters, the posterior superior quadrant of the membrana tympani was the seat of the affection; only once did I see small abscesses on the posterior inferior quadrant, and once on the anterior half of the membrane. They appear as semi-globular, pus-green, lustrous, but non-transparent tumours, or as small, pointed, greenish prominences, with a livid, sodden, or ecchymosed base, and a small drop of pus will ooze out on their being opened with a needle.

The blisters and abscesses which arise in the posterior superior portion of the field of view mostly spread over a great portion of it, so that the handle of the malleus, as far as the short process, and partly also the anterior portion of the membrana tympani, are over-arched and covered by them. The short process of the malleus generally remains visible as a white knob in front of and above the swelling, with an intensely red, ecchymosed base, not unlike a pustule surrounded by an areola. The simultaneous occurrence of blisters and abscesses is rare. In one case I observed in an inflamed membrana tympani a blister and an abscess beside each other. In the ear of a young surgeon, who stated that he had never suffered from any aural affection, two globular swellings developed, accompanied by violent pain; of these the anterior one, covering Shrapnell's membrane and the short process, of the size of a hemp-seed, was like a lustrous, bluish-transparent pearl, while the larger and posterior one, covering the posterior superior portion of the membrane, protruded above its level as a greenish-yellow lustrous, non-transparent swelling (Fig. 77). The inferior portion of the abscess, as well as the umbo of the membrane, were ecchymosed, the hearing-distance for the acoumeter was only slightly decreased, and for whispered speech not at all. On the third day the blister was not visible, on the fourth day the abscess had also disappeared, and only a blackish ecchy-

FIG. 77.—BLISTER AND ABSCESS ON THE RIGHT MEMBRANA TYMPANI OF A YOUNG MAN, WHO HAD HAD AN INFLAMMATION OF THE MEMBRANE FOR 24 HOURS.

mosis was to be seen in its place; towards the front an old calcareous spot was visible; hearing-distance normal.

These appearances of the membrana tympani are sometimes also observed, although not in quite so striking a manner, in the acute inflammations of the middle ear, in which the membrane is secondarily affected by the inflammatory process. *Per se* they are therefore not characteristic indications of primary myringitis, and for this reason the diagnosis as to whether it is primary acute myringitis, or acute inflammation of the middle ear, will be rendered possible only by hearing-tests, and by a consideration of the course of the affection; and as we will see later on, in many cases the diagnosis remains undecided. Before we indicate the facts which distinguish myringitis from otitis media, we must first briefly describe the symptoms and the course of myringitis.

Acute myringitis, especially at its onset, is accompanied by violent stinging, piercing pain, radiating towards the parietal bone and the lateral region of the neck, sometimes also by subjective noises and pulsation. In a superficial inflammation, the pain generally lasts only a short time, and ceases when the blisters appear on the membrana tympani. If, however, exudation takes place in the deeper layers of the membrane, and the latter is bulged forward towards the meatus as a bluish-red swelling, or if an abscess is formed, the pain, especially by night, will be very severe, and will often last for several days without intermission, until the inflammation subsides. I have never observed the formation of painless acute abscesses in primary myringitis (Boeck). Feeling of fulness in the ear, of pressure and of uneasiness, is rarely complained of; on the other hand, I have several times observed great hyperæsthesia in regard to noises. Slight pyrexia occurs only in children.

The functional disturbance accompanying myringitis is not proportionate to the changes in the membrane. For if the hearing is tested at the stage when the symptoms of the exudation are most pronounced, generally only a moderate decrease in the acuteness of hearing for the tone of the acoumeter and for whispered speech will be found. The power of hearing is rarely much affected in inflammations of the membrana tympani, which by their future progress are proved to be of a primary nature. I could not ascertain any change in the power of hearing on inclining the head (Boeck).

The course of acute myringitis confined to the membrane, and causing no considerable swelling and exudation in the middle ear, is distinguished from that of acute otitis media by the more rapid decrease in the inflammatory phenomena, and by the much shorter duration of the process preceding complete return to the normal state. For although in some cases the inflammation runs a protracted course, and cure takes place only after several weeks,

I have generally observed complete cure after three or four days. The effused exudation is either rapidly reabsorbed, or is discharged into the meatus by bursting of the epidermic layer. In the latter case, the place where the blister was situated is covered by a grey, macerated epidermic layer, the vessels of the malleus are injected, and the base of the blister is sometimes ecchymosed. After the blister has burst, a slight decrease in the power of hearing is generally observed, caused by a simultaneous slight swelling in the Eustachian tube, which, however, soon disappears after inflation with air several times. Bursting of the abscess inwards is very rare. In one case I was led to believe that this had occurred from the rapid disappearance of the abscess with a consequent rapid decrease in the hearing-distance, and from the sudden bulging outward of the collapsed swelling after the application of my method. The communication of the swelling with the cavity of the abscess was placed beyond doubt through the sharp definition of the exudation from the inflated air.*

But although inflammation of the membrana tympani frequently remains confined to the membrane itself, without spreading any further, I have often observed that, just as the membrana tympani is also usually affected in cases of acute inflammation of the middle ear, so in the course of primary myringitis, especially if the exudation takes place in the deeper layers of the membrane, the inflammatory irritation with swelling and effusion spreads to the lining membrane of the tympanic cavity, and to the Eustachian tube. If, therefore, the patient come under observation at this stage of the process, it will hardly be possible to ascertain whether the inflammation arose originally in the membrana tympani, or in the lining membrane of the middle ear. This shows the difficulty in many cases of deciding whether the primary disease had been acute inflammation of the membrana tympani, or acute otitis media. We will be justified in assuming a primary inflammation of the membrana tympani only when its appearance, as above described, is disproportionate to the degree of functional disturbance, *i.e.* when, in spite of the bulging outwards of the membrane, the hearing-distance is not noticeably decreased. For in those forms of acute otitis media, in which the inflammatory phenomena in the membrana tympani are as pronounced as we have described them here, we know from experience that such a copious effusion of exudation into the tympanic cavity will have taken place, that by it, as well as by the coincident swelling of the mucous membrane of the tympanum and of the Eustachian tube, the power of hearing will be decreased to a more considerable extent.

The result of acute myringitis is in most cases recovery; only

* Compare my treatise, *Ueber Blasenbildung und Exsudatsäke im Trommelfell*, *W. m. W.* 1872.

rarely does chronic inflammation and suppuration on the external surface of the membrane develop from it, while more frequently, as already mentioned, an inflammatory swelling of the lining membrane of the middle ear results, which, however, runs a definite course, and very seldom becomes chronic. After the cure of the myringitis, slight hyperæmia, radiating vascular injection, and opacity of the membrana tympani with continuous shedding of the epidermic layer (myringitis sicca, de Rossi), may continue for some time longer; seldom do changes in the membrane remain, such as occur in the affections of the membrana tympani complicated with inflammation of the middle ear. These latter are streaky, grey opacities, more rarely circumscribed calcareous spots or atrophied cicatricial-like thinnings of the tissue of the membrane.

Treatment.—The treatment of acute inflammation of the membrana tympani during the stage of reaction is palliative, and in the beginning of the process is not different from that of acute inflammation of the middle ear. We therefore refer the reader, as regards the application of local bleeding, narcotic embrocations, and other remedies recommended for the removal of pain, to the special section of this book. In those cases in which the formation of a yellowish-green abscess in the membrana tympani, accompanied by continuous violent pain, is observed, the abscess must be opened with a lancet,* so that the pus may discharge outwards. This operation, which is a very easy one, is advisable in the case of abscesses of the membrana tympani, situated in its deeper layers, because it prevents the pus from penetrating towards the tympanic cavity. But in the case of globular blisters of a pearly-grey lustre, transparent, and filled with serous fluid, especially if they are observed after the pain has ceased, the artificial opening is unnecessary, because, according to my experience, these blisters either quickly subside, or burst spontaneously very soon after they have risen, and discharge their contents into the external meatus. In inflammations in the deeper layers of the membrana tympani, in which the membrane appears bulged forward in the form of a bluish-red swelling, incisions with the lancet, or with a narrow knife like a tenotomy-knife, are advisable only in those cases in which, on account of violent pain, a diminution of tension in the infiltrated portions of the membrane is rendered necessary. In this instance, as well as when opening abscesses, care must be taken that not more than one half of the lancet is inserted into the membrana tympani, because all the layers of the membrane will be severed if the lancet penetrates more deeply, and so the inflammation will spread to the tympanic cavity, and suppuration will be set up, by which the otherwise

* The details of the operation of paracentesis of the membrana tympani will be given in the section on 'Treatment of Free Exudation in the Tympanum.'

rapid cure might be postponed for a long time. Bonnafont and Schwartze also recommend incision in acute myringitis.

As long as the inflammation remains confined to the membrana tympani, and the power of hearing is not materially altered by the inflammatory process, inflation of the middle ear with air is unnecessary, especially as the air-current in many cases produces temporary pain. But if, in the further course of the case, a rapid decrease in the hearing-power takes place, after the pain has disappeared, from which an additional swelling and secretion in the middle ear may be inferred, it is advisable to apply my method in order to make the Eustachian tube permeable; it is applied first with a slight, and afterwards with a greater pressure, to act upon the additional exudation in the middle ear. Regarding the precautions to be observed, reference must be made to a later section dealing with the treatment of acute otitis media.

(ii.) *Chronic Inflammation of the Membrana Tympani (Myringitis Chronica).*

Chronic inflammation of the membrana tympani, in which the inflammation is confined to the membrane alone, is among the rare diseases of the ear. It occurs as the result of primary acute myringitis, generally after an inflammation of the whole dermic layer, which has been followed, especially in scrofulous and cachectic people, by continued suppuration on the external surface of the membrane. Sometimes it occurs insidiously, without previous reactive phenomena. More frequently, however, chronic myringitis is a sequela of a previous otitis externa or of a perforating inflammation of the middle ear. For I observed repeatedly in diffuse acute and chronic inflammation of the external meatus, in which the external surface of the membrana tympani was also affected, inflammation and secretion continuing on the membrane after the inflammatory signs on the walls of the meatus had completely disappeared. I have also seen the signs of a chronic inflammation remain in the membrana tympani after the cessation of suppuration in the middle ear, and after the closure of the perforation in the membrane. The latter forms cannot be classed among the primary inflammations, but after the disappearance of their cause they must be considered as independent affections.

Chronic myringitis affects usually the whole surface of the membrane; sometimes, however, it is limited, most frequently to the posterior superior portion, and next in frequency to the region of Shrapnell's membrane. The last-named forms are, however, but rarely confined to the membrane; generally a limited portion of the posterior or superior wall of the osseous meatus, immediately adjoining, is involved.

The appearance of the membrana tympani in chronic myringitis presents many varieties. In the slighter degrees of diffuse inflammation the membrane appears of a moist lustre

covered with secretion, and of a gray colour with faint yellowish-white spots; the red vascular bundle of the handle of the malleus can still be plainly seen through the thin layer of secretion. In the case of proliferation and thickening of the epidermic layer, however, the membrane is covered by a whitish-yellow, non-transparent layer, which hides the malleus, and which can only with difficulty be detached from its base by syringing. If in such cases there is a great desquamation of the dermic layer, after peeling off of the epidermis the membrane appears intensely congested, flattened, velvety, with irregular reflections of light scattered over it; and when the epidermic layer is partially detached, the congested places, deprived of their exterior layer, may be mistaken for ulcers on the membrana tympani.

FIG. 78.—GRANULATIONS ON THE MEMBRANA TYMPANI OF A YOUNG GIRL, WHO SUFFERED FOR SEVERAL YEARS FROM DISCHARGE FROM THE EAR; REMOVAL OF THE GROWTHS BY TOUCHING THEM WITH LIQ. FERRI SESQUICHLOR.

Chronic myringitis leads in some rare cases to the formation of papillary excrescences (*vide* p. 214). They appear as light-red papillæ of the size of a pin-head, singly or in groups (Fig. 78), or in greater numbers spread over the whole surface of the membrane. In the latter cases the membrane has the appearance of a purple raspberry with numerous dots of light sprinkled over it. In one case an isolated growth occurred exactly at the point of the short process, in another, above it upon Shrapnell's membrane. In two cases the papillary formation extended over from the posterior superior quadrant of the membrana tympani a few millimeters upon the posterior superior wall of the osseous meatus.

The changes produced by condensation of air in the tympanic cavity, as seen during inspection, are important in the diagnosis of primary chronic myringitis. Upon employing the Valsalvian experiment, or my method, the membrane plainly becomes curved outwards, without air passing through it into the meatus. In this respect chronic myringitis is different from chronic suppurative inflammations of the middle ear accompanied by inflammation of the membrana tympani. This fact, however, must not be considered as pathognomonic of chronic myringitis at the first examination, because, as we shall see later on, in chronic perforating suppuration of the middle ear a temporary closure of the margins of the perforation may take place. It is only when, by observing the further course of the disease, the presence of a perforation is excluded, when no swelling or secretion in the middle ear is demonstrable by auscultation, and when the hearing-distance is but slightly decreased, that the diagnosis of chronic myringitis may be made. However, I have also repeatedly observed cases in which, along with chronic swelling and secretion in the middle

ear without perforation of the membrane, there existed a chronic secretion on its external surface.

The symptoms which accompany chronic myringitis rarely trouble the patient much. The inflammation either runs a quite painless course, or is only now and then accompanied by fleeting, lancinating pains in the ear. Subjective noises are on the whole rare, and generally intermittent; and equally seldom is the feeling of fulness and pressure in the ear complained of. The most troublesome symptom, which is frequently the sole reason for the patient's applying for surgical treatment, is the offensive smell from the ear, caused by decomposition of the cerumen mixed with pus.

The result of the inflammation, which often lasts for years, is complete recovery, when the secretion ceases; or it may terminate in a moderate thickening of the membrana tympani with a trifling disturbance of the hearing. Excessive thickenings of the membrane, as described by v. Tröltsch and de Rossi, I have not observed. After the secretion has ceased, a great desquamation of the epidermic layer, or incrustation on the membrana tympani, sometimes goes on for a considerable time. In myringitis granulosa suppuration is maintained by the papillæ which are developed, and a cure will result after their removal by treatment still to be described.

Treatment.—The treatment of chronic myringitis depends on the changes that have occurred in the membrana tympani. If the secretion is accompanied only by a slight desquamation of the dermic layer, it will in most cases be removed by the application of astringent fluids, dropped into the ear. To permit the astringent solution to act immediately upon the diseased dermic layer, it is necessary previously to remove the secretion from the ear by syringing it with tepid water. It is best to commence with weak solutions of zinc (zinc sulph. 0·2, aq. dest. 20·0; sig. 10 drops, tepid, to be poured into the ear); and only if the secretion does not cease after treatment for eight or ten days, to resort to solutions of lead, (plumbi acetat. 0·2, aq. dest. 20·0), applied in the same manner as the solutions of zinc. If the secretion is only slight, one application daily is sufficient; but if the discharge be abundant, the application must be made twice a day, and the fluid must remain in the ear for at least ten minutes. But if after the application of the lead solution for several weeks the discharge has not ceased, it is advisable to touch the inflamed membrane with concentrated nitrate of silver (nitr. arg. cr. 0·8, aq. dest. 10·0). After removal of the secretion by syringing, the membrane is either painted with a brush dipped into the solution, or 10 to 15 drops of the solution are dropped into the meatus by means of a teaspoon, and are left in it for ten minutes. After the action of the silver solution upon the membrana tympani the excess of the caustic is removed from the ear by syringing. To avoid staining the skin with the silver, the region of the external orifice is

washed immediately after the application of the remedy with a weak solution of iodide of potassium, and is lightly dried. A repetition of this treatment must be made only after the slough has peeled off; and as a rule cauterization three times a week, carried on for three or four weeks, will suffice to remove the diseased discharge from the membrana tympani.

If granular formations have taken place on the membrana tympani in consequence of growth of the dermic layer, the above treatment will not suffice to cause the growths to shrink. To remove them quickly it is therefore advisable to destroy them at once by means of liq. ferr. perchlor., either by applying the remedy to the growths in small drops by means of a probe dipped into the fluid, or by painting them with a small brush. These cauterizations are performed every third day, and are continued until the membrana tympani is smooth and dry.

Cauterization with chloride of iron is decidedly to be preferred to that with nitrate of silver, on account of the more rapid destruction of the growths, and because it produces less pain. If solid growths do not shrink after a lengthened application of chloride of iron, the galvano-cautery will have to be applied, by which the growths will be destroyed in the surest manner. If a surgeon possesses a galvano-cautery, it is advisable to use it at once, not only because the duration of the treatment is much shorter than in the application of the above cauterization, but also because the pain which is caused by the procedure ceases immediately after removal of the cautery. When applying the galvano-cautery, a simple platinum point should be used; the circuit must be closed only when the point of the electrode touches the growth; each cauterization, applied at one sitting in 5-6 different parts of the membrane, must last only 2-3 seconds; the electrode must be removed immediately after every cauterization, and the hot vapours, developed in the meatus, may be removed by blowing into it with the mouth.

3. *Traumatic Lesions of the Membrana Tympani.*

The traumatic injuries of the membrana tympani are produced: (1) by direct penetration of a foreign body into the membrana tympani; (2) by the extension of a fracture of the cranial bones to the membrane; and (3) by a sudden condensation of air in the external meatus or in the tympanic cavity, more rarely by a rapid rarefaction of the external air.

According to my observations, the direct injuries of the membrane occur for the most part in persons who scratch the meatus with different objects on account of an unpleasant itching, and by an accidental push pierce the membrane with the instrument employed for scratching, such as ear-picks, hair-pins, tooth-picks, matches, pieces of straw, pencils, etc. They may also be caused by the careless manipulation of syringes with long, pointed

nozzles, by coarse attempts at extraction of foreign bodies, by splinters of wood flying into the meatus, or by thorns entering the meatus while passing through a thicket.

The site, the size, and the form of these injuries are very various, depending, according to Zaufal's experiments on the dead body (*A. f. O.* vol. viii.), on the character of the instrument, whether its penetrating end is sharp, blunt, pointed, rigid, or flexible, smooth or rough, and also on the force with which it was introduced.

Regarding the locality of the direct injuries, my experience agrees with that of Zaufal (who in seven experiments on the dead body observed six times rupture in the anterior half of the membrane), in so far as I have also more frequently seen ruptures in front of the handle of the malleus than in the posterior half of the membrane. I also quite agree with Zaufal's statement that the instrument slides off from the obliquely placed posterior portion of the membrane, and the latter is therefore less frequently injured than the more vertical anterior half.

The appearance of the membrane varies according to the extent of the destruction, and the time at which the inspection of it is made. Shortly after an injury with a thin, pointed instrument, one finds openings more or less round in shape, the margins and surroundings of which are covered with blackish-red extravasated blood. In the case of extensive, irregular ruptures, the shape of the gap is not recognizable, on account of the extravasated blood covering the membrane, and effused into the external meatus. After a short time, nothing but a dark surface with one or more pulsating reflections of light will be seen as a sign of the beginning of the traumatic inflammation of the membrana tympani and of the middle ear. But when suppuration commences, and the extravasations are removed, it is sometimes possible after syringing to see the extent of the destruction.

At the moment of the occurrence of the injury, a loud report is heard, and a piercing pain is felt, followed either by fainting, or by reeling, giddiness, and great tinnitus. After several hours relief will take place, but the numbness of the head and the subjective noises will still continue for a considerable time. At the commencement of the reactive inflammation, the pain and the noises will again increase in intensity, and the latter especially continue long after the subsidence of the inflammation and the suppuration, as is also shown by Zaufal's observations.

The injuries produced by direct action are rarely cured without inflammation and suppuration. In cases of extensive, irregular ruptures especially, but sometimes also in cases of smaller perforations, a painful suppuration of the middle ear occurs, which lasts for weeks and months, and in consequence of which inflammations in the mastoid process and in the external meatus may become developed. After the subsidence of the suppuration, permanent gaps or cicatricial formations not unfrequently remain

in the membrana tympani, which often adhere to the inner wall of the tympanic cavity, generally causing great and lasting deafness. In regard to the treatment to be employed here, reference must be made to the treatment of the acute and perforating inflammations of the middle ear.

In the case of ruptures of the membrane, caused by the extension of a fracture of the cranial bones, the membrane generally presents a fissure of more or less extent stretching from the superior wall of the meatus. The copious bleeding from the ear which usually takes place is due to the vessels, partly of the membrana tympani, and partly of the diploe of the fractured bones. In such cases the rupture of the membrane is of less significance than the injury to the cranium. If death does not ensue, profuse suppuration, proliferation of the inflamed membrana tympani, and of the mucous membrane of the middle ear, and adhesion of the remains of the membrana tympani to the inner wall of the tympanum will take place. What sort of changes may be produced in the ear by excessive concussion of the cranium, the following case will show.

In my collection there is a preparation of the right ear of a man in the prime of life, who died of typhus in the general infirmary. In his youth, after a fall upon the head from a height, a violent bleeding from the right ear, and unconsciousness, lasting several days, took place, and were followed by intense headache, which kept the patient in bed for several weeks. A few days after the injury, acute suppuration in the ear occurred, which lasted several years, and after it had ceased, that ear was completely deaf. On objective examination, there was found a great retraction of the posterior portion of the membrana tympani, caused by adhesion to the inner wall of the tympanum, with the handle of the malleus greatly drawn backwards, and complete deafness for the watch, speech, and tuning-fork. The post-mortem examination showed a pigmented, slate-grey bridge of connective tissue, which extended from the inner surface of the posterior half of the membrana tympani to the inner wall of the tympanum, almost separating the tympanic cavity into two portions. The malleus was preserved on the anterior, thickened portion of the membrana tympani; the incus and the stapes, however, were wanting, probably lost during the suppurative process. The examination of the labyrinth revealed complete obliteration of the cavity, as the vestibule, the semicircular canals, and the cochlea were all filled by a calcareous, whitish-yellow substance, firmly connected with the bone, and consisting of amorphous calcareous salts.

We will now describe ruptures of the membrana tympani, caused by sudden condensation of air in the external meatus. These are due mostly to blows or falls upon the ear, or to explosions in its near neighbourhood; as, for example, the report of a cannon (Orne, Green, Bonnafont). As the ruptures of the mem-

brane, caused by a blow upon the region of the ear, claim the interest of the practitioner from a forensic point of view, it seems important to discuss these first in detail.

At the moment of the occurrence of the blow, and of the resulting injury, many perceive a violent report in the ear, others a great pain. The patient is further frequently seized with staggering, giddiness, and great tinnitus, so that he is unable to stand upright. The latter symptoms decrease in intensity after a few hours, but often a feeling of stupor remains for several days, and in some cases tinnitus for a long time.

The objective examination of the membrana tympani is of the greatest importance. The appearance of the membrane is so characteristic in the first days after the injury, that we are enabled to ascertain from it whether the perforation in the membrane is caused by an injury or by a pathological process.

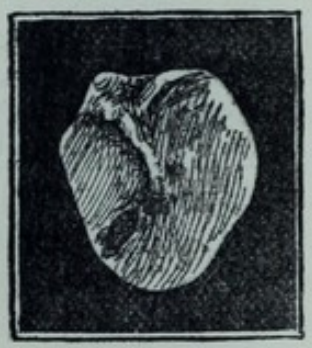

FIG. 79.—RUPTURE IN THE ANTERIOR INFERIOR HALF OF THE MEMBRANE OF A BOY AFTER A BOX ON THE EAR.

FIG. 80.—DOUBLE RUPTURE OF THE MEMBRANE OF A WOMAN, 30 YEARS OF AGE, CAUSED BY A FALL UPON THE EAR; APPEARANCE ON THE THIRD DAY AFTER IT HAD TAKEN PLACE.

FIG. 81.—ROUND RUPTURE IN THE ANTERIOR SUPERIOR QUADRANT OF THE MEMBRANE OF A GIRL, WHICH WAS CAUSED BY A LARGE BOX FALLING UPON HER EAR.

The assertion has been made that, in the case of injuries of the membrana tympani caused by sudden condensation of air, the rupture appears as a linear gap (Toynbee), which extends behind or below the handle of the malleus, and the margins of which are applied to each other, and are only forced asunder by the Valsalvian experiment, or in the form of the letter T, as Hubert-Valleroux avers. According to my observations, this form seems to be a rare one, for in the cases seen by me, the rupture presented always a gaping orifice, or a hole, through which the inner wall of the tympanic cavity could be plainly seen.

The situation of the rupture in the membrane is very various. I have observed it often in the anterior portion, at a point corresponding with the cone of light (Fig. 79), but still more frequently in the posterior portion of the membrane. There is generally only one rupture in the membrane. Only in one case did I observe two ruptures, the one in the anterior, the other in the

posterior quadrant of the membrane (Fig. 80); they occurred in a woman, who slipped and fell upon the right ear.* The perforation is generally situated midway between the handle and the tendinous ring; only rarely does it extend from close in front of the handle of the malleus to the tendinous ring.

The shape of the rupture may be round (Fig. 81), as if a piece of the membrane had been punched out, but it is generally oblong, oval, with pointed (Figs. 79 and 80) or rounded extremities, and the longitudinal axis of the oval is parallel with the direction of the radiating fibres. From this it may be concluded with probability that in the case of ruptures by condensation of air, it is mostly the fibres of the circular layer that are torn. As the elastic fibres are separated, they retract in opposite directions, and thereby cause the rupture to be gaping. According to the observations of Zaufal and Wendt, sometimes also a flap is torn in the membrane, and is turned either outwards or inwards.

The margins of the rupture are sharply defined, and are covered, either in their whole extent or only here and there, with reddish-black coagulated blood; sometimes ecchymosed spots will be found near the rupture, or even in more distant parts (Figs. 79 and 81), especially at the posterior margin of the handle; the remainder of the membrane is not pathologically changed, but the vessels of the handle of the malleus are sometimes considerably injected. The larger the orifice in the membrane, the plainer the inner wall of the tympanic cavity will be seen as a bone-yellow surface of a moist lustre, without noticeable vascular injection.

The degree of the disturbance of hearing caused by traumatic ruptures is very various. The deafness is much more considerable if, besides the rupture, there has also been concussion of the labyrinth, caused by a blow upon the ear. For a blow upon the region of the ear, by which the air in the external meatus is suddenly condensed, may have two different effects.

In a number of cases the force of the blow is exhausted on the membrana tympani, tearing its elastic fibres; these are the more favourable forms, because in them the labyrinth as a rule remains intact. The power of hearing is in these cases generally but slightly lessened, the hearing-distance for the watch and for the acoumeter, as well as for whispered speech, often amounting to several meters. The perception of sound from the temple of the injured side persists; the tone of the tuning-fork, placed upon the parietal bone, is perceived better by the injured ear. The two last-named phenomena are of great importance in the estimation of the injury.

In other cases, however, the membrane remains intact. These are decidedly more unfavourable forms, as the force of the con-

* Bonnafont saw a multiple, cribriform perforation of the membrana tympani, due to an explosion of gas.

densation of air produced by the blow is not exhausted at the membrana tympani, but produces a concussion of the expansion of the auditory nerve in the labyrinth by suddenly propelling the ossicular chain inwards.

In such cases the high degree of the functional disturbance and the loud subjective noises indicate that by the great concussion of the labyrinthine fluid the delicate expansions of the auditory nerve have lost their equilibrium, and are partially paralyzed, or put into a state of abnormal irritation by which the subjective noises are produced.*

Cases are less frequent in which a rupture of the membrane is combined with a concussion of the labyrinth. In this instance the deafness is of a high degree, and the affection is generally accompanied by subjective noises. In these cases, as well as in those of concussion of the labyrinth without rupture of the membrane, the examination with the tuning-fork is of great importance. For while in cases of traumatic rupture of the membrane without an affection of the labyrinth, as we have seen above, the tuning-fork is perceived from the cranial bones louder by the injured ear, we find in the traumatic affections of the ear complicated with concussion of the labyrinth, that when the vibrating tuning-fork is in contact with the cranial bones, the perception of its tone exists only in the normal ear, while it is wanting in the affected ear.

Another symptom, important in deciding whether a traumatic rupture of the membrane has taken place, is the auscultation sound of the air rushing through the orifice of the rupture when the Valsalvian experiment is being performed. For while in the case of perforations produced by diseases of the middle ear the air, pressed through the Eustachian tube into that cavity, escapes from the ear, even when there has been great loss of substance, with a sharp, hissing noise, the air rushes from the ear with a very broad, deep, breathing-sound in cases of traumatic rupture of the membrane, if the injury has befallen a normal ear. It will further be observed that while in the former cases a more or less considerable amount of exertion is required to press air through the tube into the middle ear by means of the Valsalvian experiment, only a very slight exertion is necessary to effect this in the latter cases.

This observation shows that the Eustachian tube, permeable in the normal state, is as a rule also affected in inflammations of the lining membrane of the tympanic cavity, for not only does the mucous membrane of the tube appear swollen coincidently with swelling of the mucous membrane of the tympanum, but also a

* Compare the opinion expressed in Friedreich's *Blättern für gerichtl. Med.* 1876, by the Munich medical committee, concerning an individual who became suddenly deaf through repeatedly knocking his head against a door; neither rupture of the membrana tympani nor a cerebral affection could be proved, and simulation had also to be excluded (E. Hofmann, *Gerichtl. Med.* p. 473).

certain degree of stricture in the tube commonly remains after the swelling in the middle ear has disappeared.

The course of ruptures of the membrana tympani, not complicated with concussion of the labyrinth, is as a rule a favourable one, as the gaping orifice in the membrane is closed again without any marked phenomena. Observation of the process of cicatrization furnishes a number of interesting data regarding the process of nutrition in the membrana tympani. It is only rarely that a diminution of the rupture takes place by simultaneous growth of all the layers of the membrane; contrary to Zaufal's opinion, that the cicatrization originates from the dermic layer, I found that the inner layer of the membrane generally effects the closure of the rupture.

For several days after the rupture has been produced, the formation of a greyish-yellow thin pellicle will be observed, which gives the impression as if it were pushed across the rupture from the inside. Even after complete closure of the orifice, the former margins of the rupture can be seen in the dermic layer, and only after several weeks does the membrane resume its normal appearance, it being impossible at a later date to discover the place where the rupture had been. The coagulated blood adhering to the margins of the rupture either falls off or migrates from the centre towards the periphery of the membrane, and is pushed into the osseous meatus.

A rare consequence of traumatic ruptures of the membrana tympani is the development of inflammation of the membrane and of the lining membrane of the middle ear with suppuration (Hassenstein). The cause of this inflammation is generally improper treatment of the rupture, or by instillation of irritating oils or other medicated solutions an inflammation of the mucous membrane of the tympanum and of the membrane is produced.

The occurrence of suppuration in the middle ear does not prevent a complete cure, for after several days, but sometimes only after several weeks, the secretion ceases, the swelling of the mucous membrane disappears, and the perforation is closed, without leaving any disturbance in the power of hearing.

In some cases, however, the suppuration in the middle ear becomes chronic, the orifice in the membrane increasing in size by softening of its tissue, granulations developing themselves on the membrane as well as in the tympanic cavity; or after months or years, when the suppuration has ceased, a persistent gap in the membrane (Roosa) will be found, or adhesions between the membrane and the promontory (Burnett).

In most cases, disturbances of hearing caused by traumatic ruptures disappear completely, so that the function becomes normal again. It is only in those cases in which permanent changes in the middle ear are developed in consequence of sup-

puration having taken place, or in which the rupture of the membrane is combined with concussion of the labyrinth, that disturbances of hearing of different degrees remain. In those cases also in which by a blow upon the region of the ear a concussion of the labyrinth without an injury to the membrane, and associated with tinnitus and hardness of hearing, has been produced, the function of hearing may again become quite normal after several days or weeks; more frequently, however, a disturbance in the hearing will remain for life.

In the treatment of ruptures of the membrane I consider it best to avoid all local applications, as by instillations or injections the cure is not only not promoted, but even retarded. But when in the open air, especially during damp and cold weather, the patient must close the meatus with cotton wool to protect the exposed mucous lining of the tympanic cavity from atmospheric influences. In cases of concussion of the labyrinth I have sometimes observed after the application of a constant electric current an increase in the hearing-distance and a decrease of the subjective noises.

We will now discuss the traumatic ruptures of the membrana tympani from a forensic point of view. If a surgeon is asked to state whether a rupture is of a traumatic nature, it is above all necessary that the patient be examined during the first few days after the injury has taken place; for if the examination take place only a considerable time after the infliction of the injury, the surgeon, owing to cicatrization of the rupture, may not be able to ascertain whether rupture has taken place at all, and whether the existing functional disturbance has really been produced by an injury.

A medical jurist cannot discover that a case is of traumatic origin if at the time of his first examination a suppurative inflammatory process has already taken place in the membrana tympani and in the middle ear, as the appearance of the membrane in such a case cannot be distinguished from that in a primary suppurative process of the middle ear. He will therefore be justified in concluding a rupture of the membrane to be traumatic only if, after having discovered the almost characteristic appearance of the membrana tympani above described, cicatrization of the rupture take place in the space of several weeks under his observation. The latter is of special importance, because a persistent gap, produced by a previous purulent process, may be present, and might be mistaken, on account of the sharp definitions of its margins and of the other appearance of the membrane, for a traumatic rupture. Such a mistake will not, however, occur if the surgeon bear in mind that a gap caused by a previous suppuration, as soon as its margins are healed over (and this is mostly the case with those orifices which do not soon cicatrize after the suppuration has

ceased), will not be closed at all. Traumatic ruptures, however, according to my observations, have only two results: either cicatrization takes place during the first weeks or suppurative inflammation occurs.

If the traumatic nature of the affection of the membrana tympani has been ascertained by the surgeon, another question will have to be answered, viz., whether the injury is to be considered as a slight one or as a severe one.

An injury of the membrana tympani is to be called a slight one if it is not complicated with concussion of the labyrinth (*i.e.*, if the watch is perceived from the temple of the injured side, and the tone of the tuning-fork is heard from the cranial bones best in the affected ear), and if after cicatrization of the rupture, apart from the duration of the process of cicatrization, the function of hearing returns to its normal state.

An injury of the membrana tympani must, however, be considered as severe if by a blow upon the ear concussion of the labyrinth has taken place (*i.e.*, if the perception of the watch and the tuning-fork from the cranial bones is wanting in the affected ear), and if, even after cicatrization has taken place, a disturbance in the hearing can be proved by observations carried on over several months.

An injury of the membrana tympani will also be a severe one if, a traumatic rupture having been ascertained, it is aggravated by suppuration; and changes in the middle ear (adhesions, granulations) are produced by it which cause a permanent disturbance in the hearing.

This will show that the medical jurist is not always able on his first examination to form a judgment as to the character of an injury, but that in a number of cases a lengthened observation, extending over at least three months, is required; for concussion of the labyrinth may exist after an injury of the ear, the consequences of which will not permanently remain, as the function of hearing sometimes becomes normal again only after some weeks, or indeed even after two or three months or more. In the same manner a suppurative process, which aggravates a rupture of the membrane, may end without leaving any changes in the middle ear, and in the complete return of the power of hearing.

In the case of functional disturbances, produced by a blow upon the region of the ear, and caused by concussion of the labyrinth without any injury to the membrana tympani, the surgeon cannot form an opinion as to whether in a given case the disturbance of hearing was caused by an injury or not, as the objective appearance of the membrana tympani and other characteristic indications are wanting as data. The surgeon must therefore in such cases always bear in mind the possibility of the existence of a chronic affection of the labyrinth or of the middle ear, which the alleged injured person may make use of to sue his

opponent after a quarrel. If, however, the surgeon finds, shortly after the alleged injury is supposed to have taken place, calcification and cicatricial formations on the membrana tympani, he may conclude with certainty that it is a chronic process in the middle ear, because changes of this kind cannot develop in a few days, but require a considerable time.

Paragraph 156 of the Austrian Penal Code, which enumerates the permanent consequences of injuries, the presence of which entails the highest measure of punishment (hard labour for between five and ten years), includes the loss or the lasting defect of the hearing-power among 'aggravating circumstances.' E. Hoffmann* makes the following remarks about this: 'Although it cannot be doubted that the loss or a great disturbance of hearing on one side causes a decrease in the power of hearing, the same importance cannot be ascribed to such a loss as to the loss of the power of vision in one eye. The legislator clearly thought of the sense as a whole, and in the new (Austrian) draft, as well as in the German Penal Code, hearing in general is only spoken of, but no difference is made between the hearing in one or both ears, as was done regarding the power of vision. We must also bear in mind that it is only a considerable disturbance of hearing, which may be set down as a defect of the hearing in the sense of the law, and that it is advisable, just as in the case of weakness of vision, that we should confine ourselves in doubtful cases only to the explanation of the nature and of the degree of the functional disturbance, and leave it to the judge and to the jury to say whether after such an explanation they will recognize the case as coming under clause *a* of paragraph 156 or not.' To this argument I should like to add the remark that although the loss of hearing on one side causes no notable disturbance of hearing in ordinary intercourse, the fact should not be lost sight of, that according to experience, in cases of one-sided deafness, the sound ear becomes very frequently sympathetically affected, and that such an affection, as a rule, causes a rapidly increasing hardness of hearing.

In conclusion we will draw attention to the ruptures of the membrana tympani observed in those whose death was caused by hanging. As I have no experience myself in regard to this, I must refer to the cases communicated by Wilde, Ogston, and Littré. According to the statements of Zaufal, such ruptures seem more frequent in those who have been executed than in suicides, as in a number of suicides by hanging, which he had the opportunity of examining, he could not find a single rupture of the membrana tympani. How the rupture occurs is not very clear, and I am myself in doubt about this matter. The fact that in the case described by Ogston the torn patch of the membrane was turned outwards, would show that the mechanical force (ex-

* *Lehrbuch der gerichtlichen Medicin. Wien*, 1878.

cessive condensation of air) must have acted from the direction of the tympanic cavity.

Brigade-Surgeon Chimani, chief of the aural section in the garrison-hospital No. 1 in Vienna, had the kindness to give me a brief account of his experience of ruptures of the membrana tympani, gained in the above-mentioned aural section from 1867 to 1877. Among 5,041 aural patients treated, 54 cases of rupture of the membrana tympani were observed. They were caused in 38 cases by boxes on the ear, in 6 cases by falls upon the head, in 3 cases by a kick from a horse on the head, in 2 cases by strokes upon the head with wooden clubs, in 2 cases by the playing of brass instruments (signal trumpet and helicon), in 2 cases by the report of a loaded gun in the immediate neighbourhood of the ear, and in 1 case by a fall into the water from a considerable height.

The ruptures caused by boxes on the ear were in 36 cases in the left and only twice in the right ear; the rupture was in 27 cases in the posterior inferior quadrant of the membrana tympani, in 9 cases in front of and somewhat below the extremity of the handle of the malleus, and twice in the superior posterior portion of the membrane, almost on a level with the short process. The rupture was never linear in form, but was generally ragged, roundish, or oval. The bleeding was in no case so considerable as to be perceived by the patient. During the first days giddiness, tinnitus, and considerable functional disturbance generally took place. In 34 cases perfect recovery without any functional disturbance resulted; in 4 cases no complete cure was effected; indeed, in 2 of them, in which the patients had been repeatedly subjected to blows on the ear when the rupture already existed, and which came under treatment only on the 8th and 14th days respectively after the occurrence, a purulent inflammation of the middle ear, with perforation of the membrane and a superficial necrosis on the mastoid process, set in. The perforation extended over the posterior inferior and central portions, and could not be made to close by treatment. The acuteness of hearing had considerably diminished.

The ruptures caused by falling upon the head were 4 times in the anterior inferior quadrant, once in the centre of the posterior portion of the membrana tympani, and once in the region of the short process of the malleus. The bleeding was in 3 cases so considerable that the patients had their attention drawn to the injury of the ear only by the blood flowing from it. In 2 cases, in spite of the perforation being healed, a considerable hardness of hearing, and in one case a labyrinthine affection, remained.

The ruptures produced by the kick of a horse on the head were all in the right ear and the posterior inferior quadrant (flap-wounds); one case was accompanied by extravasation of blood on the membrane and on the lining membrane of the meatus. In all

cases recovery without any functional disturbance took place after suppuration had ceased.

In the same manner the ruptures caused by blows upon the head, and by the report of a loaded gun, ended in cure by suppuration. In the one case in which the rupture of the membrane was produced by a fall into water from a considerable height (attempted suicide), the membrana tympani was torn in its whole extent. The injury, which healed up after a lengthened suppuration, left behind considerable functional disturbance.

No rupture of the membrana tympani was seen in artillerymen due to the firing of cannons; indeed, the percentage of ear disease was no higher than in men of other arms. The fact that formerly ruptures of the membrane frequently occurred in artillerymen of the Vienna garrison, while they are now scarcely met with at all, may be explained by the mode of service of the cannons being changed in 1860-61, with the introduction of the rifled gun. Formerly a man had to remain, even during the firing, one pace to the side of the mouth of the cannon, therefore nearly within the focus of the sound, and was liable to be affected by the dreaded so-called 'stitch.' This name was given to a peculiar shrill (stinging) sound, which was produced by the direct friction of the iron ball on the metal of the cannon, and was heard loudest just as the shot came from the cannon's mouth. Since the introduction of breechloaders the serving party withdraws a distance of about twelve paces, with the exception of one man who attends to the firing, but also from a considerable distance, by which means they are protected from the action of the most intense sound.*

* Besides the above-mentioned manuals of Wilde, Rau, Bonnafont, Toynbee, v. Tröltsch, Moos, de Rossi and Roosa, there have to be enumerated: A. Politzer, *Die Beleuchtungsbilder des Trommelfells*, Wien, 1865; Kessel, *Zur Myringitis villosa*, *A. f. O.* vol. v.; Urbantschitsch, *Ueber eine eigenthümliche Form von Epithelialauflagerung am Trommelfelle und im äusseren Gehörgange*, *A. f. O.* vol. x.; Wendt, *Ueber ein endotheliales Cholesteatom des Trommelfells*, *Arch. f. Heilk.* vol. xv.; Hinton, *Sebaceous Tumour*, etc., Guy's Hospital Reports, 1863; Lucae, *Aragonitkrystalle in der verdickten Epidermis eines menschlichen Trommelfells*, Virchow's *Arch.* vol. xxxvi.; Buck, *Cavernöses Angiom des Trommelfells*, *A. f. A. und O.* vol. ii.; Hassenstein, *Gerichtsärztliche Würdigung der Läsionen des Gehörorganes durch Schlag*, *Ber. Kl. Wochenschrift*, 1871, No. 9; Herz, *Ueber traumatische Rupturen des Trommelfells*, Inaugural Dissert., 1873; Zaufal, *Casuistische Beiträge zu den traumatischen Verletzungen des Trommelfells*, *A. f. O.* vols. vii. and viii.; Parreidt, *Fall von traumatischer Ruptur des Trommelfells mit Symptomen der Labyrinthreizung*, *A. f. O.* vol. ix.; A. Politzer, *Ueber traumatische Trommelfellrupturen*, *Wien med. Wochenschrift*, 1872, and *Ueber Blasenbildungen und Exsudatsäcke im Trommelfelle*, *ibid.*, 1872.

b. The Diseases of the Tympanic Cavity, the Eustachian Tube, and the Mastoid Process.

General Preliminary Observations.

In the general division I have pointed out in the survey of the pathological changes in the middle ear, that its lining membrane is liable to suffer from an inflammation similar to that of mucous membranes; that this inflammation presents various degrees of severity, such as simple hyperæmia, catarrhal swelling and secretion, severe inflammation accompanied by suppuration; and that these changes may completely subside, or may, by cellular proliferation and new-formation of connective tissue, cause permanent hindrances to the conduction of sound. I have also stated that the inflammations of the middle ear present many varieties in their anatomical as well as in their clinical aspects, and I have mentioned the difficulties in the way of a classification of the forms of inflammation of the middle ear, in pointing out the numerous transition forms, and finally I explained the impossibility of any strict division upon an ætiological and pathological basis.

The difficulty of classifying the inflammations of the middle ear will be most readily seen from the very divergent views of different authors on this subject. Indeed, in the present state of our science, every attempt at a classification of the affections of the middle ear which would answer equally from an anatomical as well as from a clinical point of view, is confronted with considerable difficulties, and much progress in our pathological knowledge is yet necessary in order that an objective strictly scientific division may be made.

An attempt has lately been made, but without scientific basis, to represent the various inflammations of the mucous membrane of the middle ear as the same process. Such a position, however, convenient and simple as it appears, is opposed by the results of anatomical investigation as well as by clinical experience. For although one kind of inflammation may be transformed into another, and may go through different grades of development, it has been ascertained beyond dispute by clinical experience that certain forms of inflammation of the middle ear, from their commencement and during their whole course, preserve peculiarities which give them a clinically typical character. Now these peculiarities are, as will be seen from the special description of the affections of the middle ear, of the greatest importance from a clinical point of view, because in many cases prognosis and treatment are determined by them alone.*

* What has been affirmed hypothetically as regards inflammation of the connective tissues does not positively hold good as regards imflammation of the mucous mem-

From what has been said so far, it will be seen that, considering the difficulty of meeting all requirements, a classification on a clinical basis seems at present to be the best, because description according to clinical types not only facilitates the survey of the many forms of inflammation, but serves also as a guide in every single case, as it supplies the practitioner with indications for diagnosis, prognosis, and treatment.

If we consider the inflammations of the middle ear in a general way, according to their leading clinical features, in respect to the degree of their intensity, we meet in the first instance principally with a great group called catarrhs of the middle ear, in which the inflammation, accompanied by hyperæmia and swelling of the mucous membrane, is characterized by the discharge of a serous, or of a tough, colloid mucous secretion. This form of inflammation of the mucous membrane generally runs its course without notable phenomena or lesion of the membrana tympani, the functional disturbance being produced by swelling, accumulation of secretion, and by abnormal tension of the membrana tympani and of the ossicula. It may either completely subside, or it may give rise to various changes, such as adhesions between the ossicula and the walls of the tympanic cavity, with permanent hearing disturbances taking place during its course, in consequence of the growth of connective tissue in the mucous membrane, and of the formation of bands of tissue.

Next in order to these adhesive processes among the consequences of the above-described catarrhs, is a kindred inflammatory form, clinically different, however, in many respects, in which, without any demonstrable secretion, the ossicula, but most frequently the stapes, become fixed, owing to the gradual shrivelling and induration of the mucous membrane and of the ligamentous apparatus.*

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brane of the middle ear. When therefore Prof. Jos. Gruber, borrowing his view from v. Stellwag's text-book, says: 'I consider the most various inflammations of the mucous membrane of the middle ear to be the same process, the course of which is only modified by coincident internal and external conditions,' and, 'for only in this manner can it be explained how the most diverse forms are so often combined, and present also many points of similarity in their course,' the last statement is certainly correct and well known, but the inference that therefore all the inflammations of the middle ear must be considered as the same process is just as untenable as if one were to assert that catarrhal-pneumonia and pulmonary tuberculosis, because they develop in succession, must be considered as the same process, the course of which is only modified by internal and external conditions.

* I refer here to those insidious forms, mostly accompanied by subjective noises, which so frequently come under observation, in which hearing-disturbances of high degree are often developed without demonstrable secretion or other phenomena of inflammatory reaction, in which by the objective inspection of the membrana tympani and of the Eustachian tube pathological change can be but rarely proved, and in which the labyrinth is generally also affected. The placing of this form of inflammation (called 'dry catarrh,' 'otitis med. catarrh. sicca') among the true catarrhs is rather arbitrary, as its peculiar course, and especially its frequent complication with an affection of the labyrinth—a rare occurrence in the true catarrhs—indicate a special

Another group of inflammations of the middle ear includes those forms which develop with acute and more or less violent inflammatory phenomena and sudden effusion of a purulent or muco-purulent exudation, in which, as a rule, the membrana tympani is also affected by the inflammatory process. If we take a general survey of this group, we may say that the course of the affections comprised in it is such that either the inflammation quickly reaches its climax, and the whole process subsides after a short period without lesion of the membrana tympani (acute inflammation of the middle ear), or in still more severe forms perforation of the membrana tympani, with effusion of purulent or muco-purulent secretion (acute perforating or suppurative inflammation of the middle ear)* takes place, in consequence of a copious effusion with ulceration of the membrana tympani. The latter form of inflammation may also after a short time subside with cicatrization of the perforation and restoration of hearing, or it may lead to chronic suppuration of the middle ear (chronic perforating or suppurative inflammation of the middle ear), which may also subside, but which frequently causes permanent disturbances of hearing in consequence of ulceration of the membrana tympani, exfoliation of the ossicula, polypous formations, granulation and shrinking of the mucous membrane, with anchylosis of the ossicula; or it may even have a fatal issue by extension of the suppuration to the cranial cavity and to the adjoining sinuses.

These general remarks will indicate the manner in which the affections of the middle ear will be described in this work. If it deviate somewhat from the form at present current in otology, it may be justified by the endeavour to define more clearly certain forms of inflammation of the middle ear, on account of their practical importance.

Far from considering this manner of description and the terms employed as faultless, I would like to observe how desirable it would be, in the interest of the student and of the practitioner, if a general understanding were arrived at regarding the names to be employed for the different forms of inflammation of the lining membrane of the middle ear. In otology, which must be

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character. I quite agree with v. Tröltsch, who points out the possibility of this group of affections of the ear being independently classed when our pathological knowledge becomes more extended.

* That acute inflammation of the middle ear and its perforating form, although they originally represent the same pathological process differing only in intensity, are not classed as one form, would seem justified by the facts that the disease runs a different course after perforation has taken place, and that our treatment undergoes a change. This supports the statement which I made above as to the clinical difference of the affections of the middle ear taking their course with or without perforation of the membrana tympani. The separate description of acute inflammation of the middle ear in this book was made with regard to the sequence hitherto observed in otology. But it would be advisable in future, on account of the relations of the two forms, to discuss it after the sero-mucous catarrhs, and immediately before acute otitis med. purulent. seu perforat.

considered as a new science to most medical practitioners, this is much more important in order to avoid mistakes than in other sciences, in which many designations, which are not quite correct, have become so familiar that they are understood by everyone. In this way an endeavour should be made to establish such a nomenclature as would more clearly define the anatomical processes than that at present in use, depending as it does on the character of the exudations. The names of the older authors—'Periostitis of the tympanic cavity,' 'Phlegmonous inflammation of the middle ear,' 'Otitis interna,' etc.—are antiquated and have justly become obsolete. Lately the appellation 'catarrh,' or 'catarrhal inflammation,' has been almost generally adopted, but the designation used by different authors for the same inflammatory form varies (for instance, v. Tröltsch 'acute simple catarrh,' de Rossi 'hyperæmia acuta,' and so on), so that the student will only find out their identity by comparing the full descriptions. In the same way authors differ as to the meaning of the appellation 'Otitis media catarrhalis.' For while Zaufal and Schwartze apply it only to the mucous catarrh, to be distinguished from the serous and purulent catarrhs, the mucous catarrh of v. Tröltsch comprises all the inflammatory forms, whether accompanied by serous or by mucous exudation. But if the name 'catarrh' is used for all the inflammations of the middle ear, otitis media catarrhalis would be the general term for all inflammatory forms, and otitis media catarrhalis serosa, mucosa, or purulenta, would have to be distinguished with a view to a clearer definition of the exudation. As the terms 'catarrh' and 'inflammation of the mucous membrane' are synonymous, names like 'purulent catarrh of the middle ear,' or 'purulent inflammation of the middle ear,' can be used for the same purpose. For practical purposes, however, it would be advisable to call those forms which run their course without significant inflammatory phenomena, and with a discharge of sero-mucous exudation, 'catarrhs,' and those forms which are accompanied by violent inflammatory phenomena, by formation of muco-purulent or simply purulent secretion 'inflammation.' Certain designations, as otitis media serosa, hæmorrhagica, crouposa, diphtheritica, etc., are in so far justifiable, as they indicate in a certain case some peculiarity of the process, a more distinct clinical definition of the disease being intended by it. An appellation, however, like otitis media hypertrophica (a mistaken analogy with the hypertrophic catarrh of the conjunctiva of Stellwag), such as Jos. Gruber has proposed for the sclerotizing inflammation of the middle ear, is to be discarded as positively incorrect, because the most excessive growths and hypertrophies of the mucous membrane do not occur in sclerotizing inflammation, but chiefly in chronic otitis media suppurativa.

1. *Acute Inflammation of the Middle Ear (Otitis Media Acuta).*

Syn.: Acuter einfacher Mittelohrcatarrh (v. Tröltsch); Otite aigue de la caisse (Bonnafont); Iperæmia acuta dell' orecchio medio (de Rossi); Acute catarrhal inflammation of the middle ear (I. Roosa).

Acute inflammation of the lining membrane of the middle ear is characterized by the rapid development of an effusion with more or less violent inflammatory symptoms, and exudation of a muco-purulent or purulent fluid into the middle ear, by a simultaneous secondary inflammation of the membrana tympani, and by its almost typical, definite course of generally short duration. The anatomical changes are characterized at the commencement of the disease by excessive hyperæmia, which is soon followed by exudation partly into the tissue of the diseased mucous membrane, and partly also into the tympanic cavity. In the rare cases in which there is an opportunity for a post-mortem examination, as in cases of typhus fever and puerperal diseases, the mucous membrane is found much swollen, in consequence of the interstitial serous effusion mixed with exudation cells, and it is sometimes ecchymosed: the fibrillæ of the connective tissue stratum are forced asunder in the form of a network by the exudation (Wendt), the epithelium is opaque and swollen, and in places raised up and peeled off.

These changes are not confined to the tympanic cavity alone, but also spread to the covering of the ossicula, and are almost always combined to a greater or less extent with great hyperæmia and swelling of the Eustachian tube, and with hyperæmia of and exudation into the lining membrane of the mastoid cells.

The free effusion into the middle ear consists of a thick, opaque fluid, mucus, and pus cells, and, by the tearing of blood-vessels in the case of very sudden exudation, a great number of red blood corpuscles are sometimes present; but the effusion is frequently composed almost entirely of pus cells with only a slight admixture of mucus. The exudation is not always fluid, but sometimes firm and tough. I have been able to convince myself of this in the post-mortem examination of persons who had died of puerperal fever, and who during their illness were affected by an acute inflammation of the middle ear. The muco-purulent secretion tinged with blood, which filled the tympanic cavity, was so firm that it could only be removed in coherent masses.

Ætiology.—Acute inflammation of the middle ear is caused by the action of atmospheric influences (sudden fluctuations in the temperature, stormy weather, dampness), by exposure to wet, or by a cold-bath; more frequently, however, it is caused by the

extension of an acute or chronic inflammation from the neighbouring mucous membrane of the naso-pharynx, especially in people who, during the course of an acute cold in the head, have been exposed for some time to the action of moist and cold weather. It also develops in the course of general diseases, especially in the acute exanthemata, most frequently in scarlatina, less frequently in measles and variola; also in the course of typhus, pneumonia, bronchial catarrh, tuberculosis, puerperal fever, and an intercurrent acute attack in the course of chronic (sero-mucous) catarrhs of the middle ear. That acute inflammation of the middle ear may be due to the application of Weber's nasal douche, as Roosa was the first to prove,* and also of Saemann's water-douche (*vide* p. 160), has been sufficiently proved. This disease occurs much more frequently in children than in adults, and in our climate oftener in spring and autumn than in summer and winter. Generally only one ear is affected, more rarely both, either simultaneously or the one after the other.

Appearance of the Membrana Tympani.—The objective symptoms in acute inflammation of the middle ear present many varieties, according to the intensity of the process. The cartilaginous meatus is generally normal, only rarely, and that in children, slightly swollen and tender; but in the osseous portion of the meatus, especially near the membrana tympani, more or less pronounced uniform congestion will be seen, passing without interruption along the superior wall on to the membrana tympani.

Inspection of the membrana tympani in the slighter forms of inflammation will discover great injection, especially on the periphery, in the neighbourhood of the short process and along the handle of the malleus, while the portions of the membrane situated between the handle and the periphery are lustreless and grey, or, owing to saturation with serum, they present small, sometimes pulsating reflections of light, like punctures. It is only rarely that a radiating arrangement of the bloodvessels can be distinguished. In the more severe forms the congestion extends over the whole surface of the membrane, which is of a uniform scarlet or livid colour, or, when there is intense injection of its mucous membrane, and increased lustre of its external layer, its colour resembles that of a burnished copper plate. The last-described appearance is observed, however, for a short time only at the commencement of the acute inflammation, because the membrane loses its lustre owing to the rapid progress of the exudation and of the saturation of the epidermis. Through swelling of its epidermic layer the colour of the membrane undergoes many changes, from a dirty ashy grey to dark grey, which receives a violet-red tinge, owing to the congested mucous membrane of the tympanic cavity shining through. In case of rapid exuda-

* *A. f. A. und O.* vol. i.

tion the epidermis is not unfrequently cracked, and the greyish-red surface appears divided into irregular patches by numerous dark fissures crossing each other. In this instance the handle of the malleus is almost always covered by the infiltrated dermic layer, and is invisible, while the short process can sometimes still be distinguished as a red or yellowish-white protuberance on the anterior superior pole of the membrane.

The inflammatory infiltration of the membrana tympani is not, however, always uniform; for it is frequently confined to the posterior superior portion, which, as in Fig. 82, is bulged forward towards the meatus, in the form of a blueish-red, globular swelling, covering the handle of the malleus, while the anterior grey, or greyish-red, frequently lustrous portion of the membrane, recedes as compared with the bulging parts.

FIG. 82. — BLUEISH-RED, GLOBULAR SWELLINGS ON THE POSTERIOR SUPERIOR QUADRANT OF THE MEMBRANA TYMPANI—ECCHYMOSES. APPEARANCE IN A MAN, 47 YEARS OF AGE, 15 HOURS AFTER THE COMMENCEMENT OF THE INFLAMMATION; HEIGHT OF INFLAMMATION AND SUBSIDENCE OF THE SWELLING ON THE SIXTH DAY. CURED AFTER 14 DAYS.

Besides the above-described appearances of the membrana tympani in acute inflammation of the middle ear, there is sometimes a condition observed, more or less resembling it, which is found in myringitis. At the commencement one or more blisters are formed, which burst after a short time, and pour out a serous or reddish fluid into the meatus; or interlamellar abscesses may form (Eysell), but these are met with less frequently in such cases than at the beginning of a very severe acute perforative inflammation of the middle ear. In some rare cases, in which the membrana tympani is only slightly affected by the inflammatory process, the greyish yellow exudation, just as in hypopyon, may be seen deposited in the lower part of the tympanic cavity.

Bulgings and exudation-sacs on the membrana tympani, communicating with the tympanic cavity, are among those rarer occurrences in acute inflammations of the middle ear which have hitherto been little noticed. According to my observation, they are situated on the posterior superior portion of the membrana tympani, and are distinguished from the blisters occurring in acute myringitis, or from the blister-shaped, pale yellow swellings (Schwartze) containing serous or transparent mucous exudation, observed in recent catarrhs, by their being not tense like them, but loosely bag-shaped (Figs. 83 and 84), also by their being not transparent, but of a greenish or yellowish-grey colour, according to the fluid they contain, whether purulent or opaque mucous, and by the portions which are not bulged out showing great congestion, swelling, and infiltration. That these sacs are in

connection with the tympanic cavity is proved by the fact that during the Valsalvian experiment, or after injecting air into the tympanic cavity, the sac bulges strongly forward and changes its form, air or exudation, or both, being forced into it from the tympanic cavity. A remarkable change of colour will then be observed in the rapidly increasing swelling. For while the superior portion appears grey and transparent, in the inferior portion of the blister or of the sac may be seen a yellowish-green exudation, which, as in Figs. 83 and 84, is demarcated by a sharp line from the air-filled upper portions of the swellings.

I have seen these saccular swellings on the membrana tympani communicating with the tympanic cavity more frequently

FIG. 83.—GLOBULAR SAC ON THE POSTERIOR SUPERIOR QUADRANT OF THE MEMBRANA TYMPANI; AT THE BASE OF THE SWELLING A YELLOWISH-GREEN EXUDATION, DEFINED BY A CURVED LINE WITH ITS CONCAVITY UPWARDS. FROM A WOMAN 30 YEARS OF AGE, WHO WAS TAKEN INTO THE AURAL CLINIC 2 DAYS AFTER THE COMMENCEMENT OF A PAINFUL INFLAMMATION. AFTER THE INFLAMMATION HAD PASSED AWAY THE POSTERIOR PORTION OF THE MEMBRANE REMAINED THINNED.

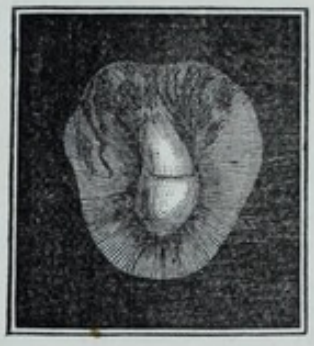

FIG. 84. — BAG-SHAPED, BULGED-OUT SWELLING COVERING THE HANDLE OF THE MALLEUS, COMMENCING AT THE POSTERIOR SUPERIOR PORTION OF THE MEMBRANE. THE INFERIOR PORTION OF THE BAG CONTAINED A YELLOWISH-GREEN OPAQUE EXUDATION AFTER INFLATION. APPEARANCE IN A YOUNG MAN ON THE THIRD DAY AFTER THE COMMENCEMENT OF INFLAMMATION. CURE IN 3 WEEKS.

in adults than in children. They develop often very rapidly, with pain, hardness of hearing, and tinnitus, and either subside completely, without any trace of these changes being visible on the membrane, or an atrophy of the posterior portion of the membrane remains, after the acute inflammation has passed away. With regard to the origin of the sacs, it may be assumed from observations on patients either that they are produced by the entrance of exudation from the tympanic cavity into the tissue of the membrana tympani, by which the fibres of the substantia propria are forced asunder and the dermic layer is bulged out, or that the entire posterior portion of the membrane, having become distensible owing to the inflammation, is forced outwards by the exudation.

Subjective Symptoms.—The symptoms of acute inflammation of the middle ear vary with the intensity of the process. The

disease commences as a rule with a stinging, jerking pain in the ear, which is sometimes preceded, especially when the affection has spread from the naso-pharynx, by a feeling of numbness and fulness in the ear or by violent headache. In adults the pain rarely reaches such a degree of severity as in children, in whom so-called otalgia is very frequently nothing less than the accompanying symptom of an acute inflammation of the middle ear. The pain is seldom continuous, but it intermits, so that in the evening and during the night it is most severe, while during the day it diminishes. This intermission is specially complete in children, so that after violent paroxysms of pain, during which the little patients writhe with agony, pauses of several hours will follow, in which the children's cheerfulness and brightness completely return. The pain, which is increased by coughing, clearing of the throat, and swallowing, is seldom confined to the ear, but frequently radiates in flying stitches upwards towards the parietal bone or downwards towards the shoulder; in some cases the pain also shoots forward towards the teeth.* Pressure upon the external region of the ear and upon the mastoid process rarely causes pain in adults, more frequently in children; but the region corresponding with the Eustachian tube in the angle between the mastoid process and the ascending ramus of the lower jaw is exceedingly tender on pressure.

Acute inflammation of the middle ear is frequently, but not constantly, accompanied by subjective sensations of hearing, such as ringing, hissing, whistling, and rushing. The noises frequently assume a pulsating character; in which case they temporarily cease if the carotid is compressed with the finger. This feeling of pulsation sometimes corresponds, as I was the first to prove on the intact membrana tympani, with a visible pulsating motion of the membrane, on which either single spots of light, or a considerable portion of the bulging membrane (Roosa) show motions synchronous with the contractions of the heart. The subjective noises are caused either by coincident hyperæmia and effusion in the labyrinth,† or by the clogging of the fenestræ of the labyrinth by the effused exudation. Their speedy disappearance in the course of the inflammation is to be considered as a favourable sign, and their uninterrupted continuance after the inflammation has ended as an unfavourable one.

A frequent symptom in acute inflammation of the middle ear is the feeling of heaviness and numbness of the head, and the resonance of the patient's own voice, a sensation similar to that which is felt when in the normal state the meatus is closed with the finger during speech. This troublesome phenomenon fre-

* Toothache may very rarely be the forerunner of the whole affection. Compare Moos, *Ueber den Zusammenhang zwischen Krankheiten des Gehörorgans und solchen des Nervus Trigeminus*, Virchow's *Arch.* vol. lxviii.

† Compare my communications on anastomoses between the vascular regions of the middle ear and of the labyrinth (p. 48).

quently lasts until the inflammation has completely subsided. Urbantschitsch observed an alteration in the sensation of taste on that half of the tongue corresponding with the diseased ear.

Acute purulent inflammation of the middle ear is sometimes accompanied by fever at its commencement and during its progress. High fever is met with most frequently in children in whom—though less frequently than in severe acute perforative inflammation — delirium, and even convulsions, may also be observed.

Disturbances of Hearing.—The disturbances of hearing which occur in the course of acute inflammation of the middle ear present many varieties in the different phases of the disease. In the first stage of the inflammation, in which the pain reaches its climax, with the exception of the cases in which an early and rapid exudation takes place, the decrease in hearing is mostly slight, because in this stage of the inflammation the anatomical changes principally consist of great hyperæmia, by which the conduction of sound is scarcely altered. Next, in the stage of exudation, in which the pain gradually disappears, and a decrease of the hyperæmia in the membrana tympani is observed, the hardness of hearing increases to a considerable extent, partly in consequence of the accumulation of exudation in the tympanic cavity, partly by swelling and infiltration of the covering of the ossicula and of the two labyrinthine fenestræ, partly by swelling and closure of the Eustachian tube, and by the alteration of tension of the membrana tympani and of the ossicula (compare p. 105) caused thereby. The extent of deafness does not, however, always depend on the quantity of the exudation secreted, but on the locality in which it is deposited. In a man forty years of age, who died of phthisis pulmonalis, who only became hard of hearing during the last few weeks of life, and who especially complained of pain and violent rustling in the left ear, in which the hearing-distance for speech hardly amounted to half a meter, I found at the post-mortem examination a reddish, opaque secretion in the inferior portion of the tympanic cavity and also in the mastoid cells. In the niche of the fenestra rotunda a tough, firmly-adherent, muco-purulent plug was discovered, which could only be removed with a fine forceps after repeated attempts; the niche of the fenestra ovalis was also filled with a tough lump, so that only the capitulum of the stapes was visible. The cause of the great deafness, therefore, in this case was clogging of the two fenestræ with tough plugs of trifling size.

Testing the power of perception through the cranial bones will, as a rule, show a normal state of the auditory nerve. The watch and the acoumeter are inaudible from the temples in very exceptional cases only, and they are cases of genuine inflammations when the affection of the middle ear is complicated with

great hyperæmia and serous saturation of the labyrinth, also in secondary syphilis, and in consumptive and decrepit individuals. The same holds good of testing with the tuning-fork, which, with few exceptions, is perceived in unilateral inflammations better from the vertex of the affected ear.

The auscultation-sounds, regarding which we refer the reader to the detailed description in the general division (p. 133), vary according to the character of the secretion and to the degree of the swelling in the Eustachian tube. The more liquid the exudation, the more distinctly will the rattling noises be perceived; they may be quite wanting with tough or viscid exudation; the greater the swelling in the Eustachian tube, the rougher, sharper, and more irregular will be the noise produced by the entering air.

Course, Duration, and Result.—The course and the duration of acute inflammation of the middle ear depend on the intensity of the process, on its cause, and on the general condition of the patient. In simple inflammations occurring in a healthy constitution the duration of the congestion, combined with pain, varies from a few hours to eight days and more. In most cases the pain has reached its climax on the third or fourth day, when with the appearance of the exudation a considerable increase of the hardness of hearing results, which is subject to more or less remarkable fluctuations in the subsequent course, until the function is again normal.

With the decrease of pain as a rule the disappearance of the diffuse hyperæmia in the membrana tympani also commences, and that at first in those parts situated between the malleus and the periphery; the swelling of the membrane subsides, it receives a yellowish or leaden-grey appearance, the short process of the malleus is more plainly visible, while the handle is covered by a red streak, widening upwards, produced by the persistent hyperæmia of its vascular bundle. Simultaneously with the disappearance of the general congestion, a number of sharply defined vascular branches appear on the membrana tympani, as will be seen in Figs. 85 and 86, and extend as slightly tortuous twigs from the periphery towards the centre and towards the handle of the malleus. These undoubtedly venous vascular branches of the cutis are sometimes more strongly developed in the anterior (Fig. 85), in other cases in the posterior half (Fig. 86) of the membrana tympani; sometimes only one or two extensive branches are visible, which extend to the malleus, while a number of smaller branches are visible on the boundary between the external meatus and the membrana tympani.

The dilatation of the vessels of the membrana tympani may exist for weeks if the exudation discharged into the tympanic cavity remains there, and does not become reabsorbed. According, however, as the absorption of the exudation takes place, the blood-vessels quickly decrease, and disappear altogether, the lustre of

the membrane returns again, the handle becomes visible, the leaden or dirty grey opaque membrane again becomes clear, and as a rule regains its former normal appearance, with the restitution of the hearing-power. Sometimes during the course of the inflammation the uppermost epidermic layer peels off in the form of a dirty yellow scale.

Even although in most cases in which before the appearance of the inflammation the membrana tympani was normal, acute inflammation of the middle ear runs its course without leaving traces on the membrane, it will, nevertheless, be found, especially after frequent relapses of the inflammation, that partial and diffuse opacities, calcareous spots, and frequently circumscribed atrophies

FIG. 85.—RADIATE VASCULAR DEVELOPMENT ON THE POSTERIOR HALF OF THE MEMBRANA TYMPANI. APPEARANCE IN A MAN ON THE EIGHTH DAY AFTER THE COMMENCEMENT OF THE INFLAMMATION; COLOUR OF THE MEMBRANE YELLOWISH-GREY; HARDNESS OF HEARING OF A HIGH DEGREE; IMMEDIATELY AFTER THE APPLICATION OF MY METHOD CONSIDERABLE IMPROVEMENT IN THE HEARING. DISAPPEARANCE OF THE OPACITY OF THE MEMBRANE, AND RETURN TO THE NORMAL STATE IN THE FOURTH WEEK.

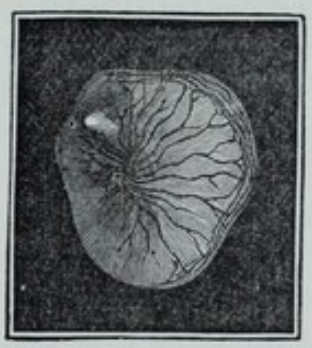

FIG. 86.—RADIATE VASCULAR INJECTION OF THE MEMBRANA TYMPANI. APPEARANCE IN A WOMAN 33 YEARS OF AGE, ON THE NINTH DAY AFTER THE COMMENCEMENT OF THE INFLAMMATION; MEMBRANE NORMAL AT THE END OF THE FOURTH WEEK.

of the membrane, with partial retractions and contact with the inner wall of the tympanic cavity, remain.

The duration of acute inflammation of the middle ear until a completely normal state is regained varies in the normal course from a few days to three weeks and more. In simple inflammations the duration not only depends on the intensity of the process, but also on many other facts. In strong healthy individuals, in persons who can avoid the noxious influences of the weather, when a rational diet is observed, the inflammation will run a more rapid course than in weakly, reduced individuals, in people who expose themselves to sudden changes of temperature, and who increase the determination of blood towards the head and the ears by a bad diet, especially by the excessive use of alcohol. The course of the disease will also be more favourable in summer than

in autumn or in winter, during which relapses of the inflammation more frequently occur. However, even under otherwise normal and favourable conditions, exacerbations of the process during its course not unfrequently take place. After the pain has disappeared for several days, and the hyperæmia of the membrana tympani has subsided, often all at once, without a demonstrable cause, the pain returns, accompanied by an increasing excessive supply of blood in the membrane, and aggravation of the hardness of hearing. Relapses of that kind may recur several times, and in this inflammatory form I wish to attach special importance to the disappearance and to the recurrence of the pain, because only with the decrease of the pain may a decided lessening of the inflammation be expected, while the return of the pain almost always points to an increase of the inflammatory process.

Acute inflammation of the middle ear runs an irregular protracted course if it appears during exanthemata, typhus, in scrofulous, tuberculous, and cachectic individuals, or if pathological changes have already previously existed in the middle ear. According to these data the prognosis is generally also determined. Not only does the stage of inflammatory reaction last much longer in such cases, but relapses during the subsidence of the inflammation are also more frequent. The cure often occurs only after several months, or a chronic swelling and discharge into the middle ear may be established with all its consequences, which will be described among the chronic catarrhs of the middle ear. Lastly, by increase of the inflammatory process a copious production of purulent and muco-purulent exudation and inflammatory softening, ulceration and perforation of the membrana tympani may take place, an inflammatory form which we describe as the acute purulent or perforative otitis media, and which may be considered as a higher grade of the inflammation of the middle ear just described, but with an essentially altered clinical character.

After inflammation has been cured, a disposition to relapses will generally remain for a considerable time. In children especially, the inflammation frequently recurs for several years almost regularly in spring and in autumn, during a severe cold in the head or a sore throat. Such relapses may again end in cure; frequently, however, a growth of connective tissue in the mucous membrane of the middle ear is caused by the recurring inflammation, which impairs the power of vibration of the ossicula, and hearing-disturbances of a slight degree will then remain, which, as v. Tröltsch correctly remarks, will be the more considerable, the more frequently the relapses occur.

Before commencing the description of the treatment to be employed in acute inflammation of the middle ear, we must premise that this disease may subside spontaneously, without leaving functional disturbances; but, from experience, it may be

positively asserted that by rational treatment the duration of the disease is not only abbreviated, but also functional disturbances remain more rarely than when the pathological process is left to itself, a fact which finds its explanation in the mechanical action of currents of air introduced into the middle ear, as described in the general division (p. 107).

Treatment.—The treatment of acute inflammation of the middle ear in the beginning of the disease, and as long as the congestion and the active symptoms last, is palliative. The main duty of the practitioner at this time consists in the removal or alleviation of pain, and only in the subsequent course of the disease does the indication for the treatment of the pathological process and of the functional disturbance appear.

In the more intense degrees of inflammation in which the pain becomes very severe, and great hyperæmia and infiltration of the membrana tympani and engorgement in the osseous meatus point to an excessive supply of blood in the mucous membrane of the tympanic cavity and in its periosteum, the pain is sometimes removed or materially alleviated by local blood-letting.

In painful inflammations of the middle ear, blood-letting from the mastoid process was formerly resorted to without regard to the locality of the inflammation. According to Wilde and v. Tröltsch, however, local bleeding can exert an influence upon the blood supply of the tympanic cavity only when the operation is performed in the anterior region of the ear, close in front of the tragus, because the veins which perforate the membrana tympani extend in the lining membrane of the external meatus along its anterior superior wall, and discharge in front of the tragus into the anterior facial vein. Bleeding in this locality will also effect a depletion of the venous network situated in the cavity of the maxillary joint and its neighbourhood, the importance of which Zuckerkandl was the first to point out, the supply of blood in the vessels of the tympanic cavity which are in communication with these vessels being thus lessened.

Bleeding from the mastoid process is to be recommended when in the course of the inflammation violent pain is felt in the region behind the ear, pain which is much increased by pressure on the mastoid process, in which case it may be assumed with probability that the inflammation has spread to the lining membrane of the mastoid cells. As the vessels of these cells anastomose through numerous passages in the exterior osseous wall with the vessels of the integument, there can be no doubt that by local bleeding behind the ear a temporary depletion of the vessels of the mastoid cells and also of those of the tympanic cavity anastomosing with them will be effected. I must, however, remark that in this form of inflammation of the middle ear the pain in the region of the mastoid process rarely reaches so high a degree as it does in the acute purulent perforative form, and

that local bleeding must, therefore, much less frequently be resorted to than in the latter form.

Local bleeding is effected either by leeches or by Heurteloup's artificial leech. The number of leeches to be applied depends not only on the violence of the pain, but also on the age and constitution of the patient. While three to five leeches may be applied in adults and strong people, only one to two should be applied in the case of weakly anæmic patients, and in children rarely more than one leech. As unpleasant mistakes frequently occur in practice, a few hints on the application of leeches may not be out of place. If the surgeon is compelled to entrust the friends of the patient with the application, he must mark with care the spots where the leeches are to be applied immediately in front of the tragus, because otherwise the bites of the leeches will be found so far in front of the tragus as to render it improbable that the depletion of blood which has taken place has affected the tympanic cavity. The meatus also must be closed with cotton wool before the leeches are applied, in order to prevent them from creeping and blood from flowing into it.

After the leeches have fallen off, the bleeding must be allowed to continue for from a few minutes to a quarter of an hour, when it is to be arrested. If a large vein has been opened, and the bleeding cannot be easily stopped, it will be necessary either to cauterize the leech-bite with nitrate of silver, or to stanch the bleeding by applying chloride of iron. Heurteloup's apparatus is always to be preferred to leeches in cases in which a rapid depletion is required, and the quantity of blood to be withdrawn is to be exactly controlled.

The opinions of specialists regarding the effect of local bleeding are very divided; while on the one hand an important influence upon the inflammatory process is ascribed to local blood-letting, it is on the other hand regarded as entirely superfluous. Although it can be said with certainty that the inflammation is not materially altered or reduced by local bleeding, in spite of all theoretical objection it cannot be denied that, if not always, at least very frequently, the pain is materially lessened by it; but it must be remarked that sometimes the pain even increases in intensity after the blood-letting, especially in weakly, nervous people.

If the pain is continuous, and disturbs the patient's sleep, it is advisable to prescribe a narcotic for internal administration at night, such as 0·005 gramme doses of acetate of morphia two or three times repeated, or, if this does not agree well with the patient, 1·50 to 2·50 gramme of chloral hydrate in solution. In this form of inflammation I have very seldom been compelled to administer subcutaneous injections of morphia (in the neck or in the arm of the diseased side) (Laurence Turnbull).

It is necessary here to make a few remarks on the effect of

cold and warm applications to the region of the ear in painful inflammations of the middle ear. While we must admit that in many cases very violent pain is quickly alleviated by the application of cold, experience teaches us that on the whole in inflammatory affections of the ear, cold applied to the region of the ear has a bad effect, as the pain is frequently only increased after its action. Cold, therefore, must only be resorted to experimentally in isolated cases, in which the pain pertinaciously continues in spite of treatment, and must immediately be discontinued if the pain increases after its repeated application. Regarding the instillation of cold water, recently recommended, our experience is still too scanty to form a judgment. But in relation to this I would remind the reader of Schmiedekam's experiment, who observed in individuals with healthy organs of hearing, convulsive pain in the ear and violent giddiness after an injection of cold water into the external meatus. I must also pronounce against the application of warm poultices, because, although frequently they may temporarily alleviate the pain, they increase the inflammation and the pain by aggravating the hyperæmia in the ear (v. Tröltsch). And besides, in inflammation the formation of pus is favoured by the action of warmth, so that a purulent, perforative inflammation of the ear may develop the more easily, because by the action of the warmth the inflamed membrana tympani is softened, and gives way to the pressure of the exudation. For the same reason, the introduction of hot vapours into the external meatus by means of paper funnels, which is often practised by laymen, must be entirely discarded, because by the immediate action of the hot vapours upon the membrana tympani the exudation may burst outwards still more easily than when fomentations are applied.

Moist, warm fomentations to the region of the ear, however, prove very effective; a light piece of linen of the size of a dinner-plate, folded several times and dipped into tepid water or in a tepid solution of tinct. opii (2 parts to 200 parts of water), if applied to the region of the ear, covered with oiled silk, tied up with a dry handkerchief, and changed three or four times during the day, is often of excellent service. Besides that, in my practice I frequently order in cases in which the pain obstinately continues, and that not only in acute otitis media, but also in all inflammatory affections of the ear accompanied by pain, the whole head to be wrapped up in a linen cloth, dipped in warm water, to be changed after two or three hours, and this often has an exceedingly good effect.

Instillations of narcotic solutions and oils into the meatus, as recommended in several quarters, certainly sometimes temporarily alleviate the pain, but I cannot recommend them, because they not only irritate the membrana tympani, but also cover it with a fatty layer, which becomes rancid, and which is only got

rid of after a long time. I employ the very effective instillations of warm water (ear baths) recommended by v. Tröltsch only in cases in which the exudation reaches such a high degree that, to judge by the appearance of the membrana tympani (yellowish-green discolouration at the upper part of the livid swelling), perforation of the membrane is probable. In cases, however, in which the phenomena do not reach that intensity, their application may rather act detrimentally, because by maceration of the inflamed membrane, its softening and perforation from the inside towards the outside are assisted. The pain is frequently quickly alleviated by the insertion into the external meatus of a plug of cotton-wool, of the size of a hazel nut, dipped into warm water, which may be hourly changed if the patient is relieved by it.

In inflammations of a slighter degree, which are accompanied by moderate, not continuous pain, local bleeding or poultices are not required; narcotic embrocations in the region of the ear, repeated every two or three hours, generally suffice to remove the pain; if it is paroxysmal it will be removed in the quickest manner by dipping a plug of cotton-wool into five or six drops of a warm narcotic oil,* and inserting it into the external orifice of the ear. To rapidly alleviate attacks of pain I also apply a mixture of olive oil and chloroform in equal proportions, of which twenty to thirty drops are dropped upon a piece of wadding of the size of the palm of the hand, covering the region of the ear. Embrocations of oil and chloroform must be avoided, because they frequently produce a violent acute eczema in the external region of the ear.

Besides local medication for the removal of the pain, during the course of the disease hygienic considerations must not be overlooked. In damp, cold, and stormy weather, which, according to experience, produces severe relapses—indeed throughout the cold time of the year, the patient must be enjoined not to leave his room until the reactive phenomena have completely disappeared. If the inflammation is combined with feverishness it is advisable for the patient to remain in bed, because by the perspiration in the uniform warmth of the bed not only will the general condition be improved, but the pain also will more speedily abate. To assist the perspiration a cup of tea or a decoction of lime-blossoms is ordered, the action of which is increased by adding a spoonful of spirit. mindereri. (℞. Infus. flor. tiliæ 10·0, aqu. dest. s. 150·0, spirit. mindereri 5·0, syr. cort. aurant. 40·0. Sig. Take two table-spoonfuls hourly.) A restriction of the diet is also advisable in the active stage in cases with elevated temperature and increased quickness of the pulse; alcoholic liquors, by which the hyperæmia of the head is aggravated, and smoking, by which the mucous membrane of the pharynx and of

* Ol. olivarum 10·0, acet. morph. 0·2; or ol. hyoscyam. press. 10·0, extr. laud. aquos. 0·8.

the Eustachian tubes is irritated, must be specially forbidden. In case of sore throat the use of an astringent gargle (decoction of marsh mallow with alum and addition of tinct. opii) is advisable. I have repeatedly observed an increase of the pain after warm baths, which are recommended by others.

We will now describe the treatment of the disturbances of hearing which develop in the course of acute inflammation of the middle ear, and will first discuss the employment of inflation. I have already remarked that at the commencement of the inflammation, in the case of great congestion and violent irritative phenomena, there is frequently only a moderate degree of deafness, and that often the hardness of hearing rapidly increases only when the active symptoms decrease, this being due partly to the effusion which then takes place, and partly to changes in the tension, which are produced by impermeability of the Eustachian tube. In the commencement of the disease, therefore, no indication for propelling air into the tympanic cavity exists. And I cannot subscribe to v. Tröltsch's proposal to commence propelling air as early as possible in this inflammatory form, because in the active stage, according to experience, the pain and the irritation are mostly increased by a sudden increase of pressure in the tympanic cavity, such as is produced by sneezing, blowing of the nose, and eructation. This, however, only holds good for the beginning of the inflammation, by no means for the later stage of secretion. From my experience I can affirm that it is inadvisable to inflate as long as there is great pain in the ear, and that it is only after the active phenomena have ceased and a rapid decrease in the hearing has taken place that the introduction of currents of air into the middle ear is advisable to effect the permeability of the Eustachian tube and the removal or re-absorption of the secretion. But in cases in which at the first onset a rapid and considerable hardness of hearing exists in consequence of sudden effusion, gentle inflations with the mouth may be employed during the first days, and after them sometimes even a decrease of the pain is observed.

With regard to the method of inflation to be employed, I must, for previously stated reasons (p. 157), pronounce against the performance of the Valsalvian experiment; the more so, because in consequence of the acute swelling of the mucous membrane of the Eustachian tube, the resistance in the canal can rarely be overcome by this experiment, and also because the already existing hyperæmia and inflammation of the middle ear may be increased by the congestion of the vessels of the head, which is a consequence of the expiratory effort.

In the great majority of cases of acute inflammation of the middle ear under treatment the absorption of the discharged exudation and the improvement and complete re-establishment of the power of hearing are effected by inflation by my method,

taking for granted that no changes in the middle ear have existed before the appearance of the inflammation, or that the cure is not prevented by conditions previously enumerated. It is only in exceedingly rare cases that it is necessary to make the Eustachian tube permeable by catheterism, the resistance in the canal caused by the swelling being so considerable that my method does not suffice to overcome the obstruction. In those cases, however, in which air is propelled into the tympanic cavity with sufficient force by the application of my method, catheterism is to be avoided, because by the immediate contact of the instrument with the inflamed mucous membrane the swelling is increased, and the inflammatory state of the tympanic cavity is aggravated by the spread of the irritation from the Eustachian tube to the tympanum.

It is of importance to determine the air-pressure which should be applied by means of my method in this inflammation. As already mentioned, the reaction in the tympanic cavity may be increased by a sudden additional pressure, and therefore, especially at the beginning of the local treatment, only weak currents of air must be applied. In a former treatise (*Wien. Med. Wochenschr.*, 1869) I made a statement to this effect: 'Moreover, I inflate air with the mouth also in the acute catarrhs of the tympanic cavity, if the inflammatory phenomena, especially the pain, have relaxed, and the power of hearing, which was only slightly lessened in the beginning of the affection, rapidly decreases in consequence of the effusion. At this stage currents of air, propelled with great pressure into the tympanic cavity, are not advisable, because, in consequence of the dragging to which the membrana tympani is subjected by the powerful current of air, sometimes the inflammatory phenomena which had already disappeared return.'* My subsequent experience has hardly altered my views on this subject, even though I must now assume that it is not always the case that the pain in the ear, arising after powerful inflation, is the consequence of an increase in the inflammation.

Shortly after the pain has ceased it is therefore advisable to inflate either with the mouth or with the inflating-bag, increasing the pressure gradually by compressing it with two, three, four, and finally five fingers (Zaufal). With children it frequently suffices simply to blow air into the nose (Schwartze), or the modification of my method, proposed by me, to close the pharynx downwards by pronouncing a word of several syllables, as *König* or *Vaarix*, while air is propelled, instead of having an act of swallowing performed. When there is only slight swelling of the tube the permeability of the canal may also be effected in adults by this modification. In cases where the tube is greatly swollen, and

* I have here quoted verbally this view, expressed by me nine years ago, because recently exactly the same has been published as something new, and alleged to be opposed to my opinion.

there is a copious accumulation of secretion in the tympanic cavity, this modification does not suffice even with children, for the air will enter the tympanum with the necessary force only during the act of swallowing, effecting a striking improvement in the hearing, which was not observable during phonation. According to Hartmann, my method with a slight pressure is the mildest form of the air-douche; and in acute inflammation of the middle ear, when the tubes are only moderately swollen, even a very low pressure, which can be exactly measured by Hartmann's compression apparatus, will suffice to effect the entrance of air through the tubes.*

Injections of medicated solutions through the Eustachian tube into the tympanic cavity are, according to my experience, positively injurious in the inflammatory form; they not only retard the subsidence of the inflammation, but frequently cause an increase of the inflammatory process.

The striking improvement in hearing which is often observed immediately after air has been propelled for the first time partially disappears again the next day, when the secretion continues unabated. Only when the increase in the hearing-distance, which has been effected by inflation, remains almost constant after twenty-four hours, or, indeed, even increases, are we justified in concluding that the exudation is decidedly decreasing; and while at first air was propelled daily, from the time that the improvement in the hearing becomes permanent, my method must be applied only every other day, then only every third day, and at last for some time only once a week; but the application must not be suspended altogether until a complete return to the normal state has been ascertained by testing the hearing. The effect of inflation is, however, not confined to the removal of deafness alone, the other subjective symptoms also, the heaviness and fulness in the ear, the subjective noises, and the numbness of the head disappearing more or less rapidly; sometimes even after a complete return to the normal state an unpleasant smacking noise in the ear when swallowing will remain.

In conclusion, I will refer here to paracentesis of the membrana tympani, as recommended by some aural surgeons in inflammations of the middle ear, accompanied by congestion and swelling of the membrane.

My experience is decidedly against the frequent performance of this operation in these forms of inflammation of the middle ear, for I have repeatedly observed in a bilateral affection that a lingering muco-purulent discharge took place from the ear which was operated on, while in the other ear, in which paracentesis was not performed, the cure and complete re-establishment of the hearing-power were effected much more speedily by inflation according to my method.

* *A. f. O.* vol. xiii. p. 10.

Paracentesis is only to be recommended in those cases* in which the appearance of the membrana tympani indicates that perforation is likely to occur; therefore when a yellowish-green discolouration of the membrane has taken place at the point where it is most bulged forward, also when a livid red swelling has appeared on the membrane, when the pain has become very severe, and has not been removed by the above-mentioned applications. After the incision the pain often abates at once, but frequently soon returns again with its former violence; in other cases, however, it is permanently removed. If the swollen dermic layer alone is incised, a slight serous, sanious discharge takes place, and on the following days a moderate secretion of purulent matter on the membrana tympani, after the speedy disappearance of which dry epidermic scales will be observed to peel off the membrane. Only in a very few instances have I seen no suppuration come on after incision of the membrane. If all the layers of the membrane have been severed, a muco-purulent or purulent discharge soon commences, and the secretion can be removed from the tympanic cavity into the external meatus through the orifice in the membrane by means of inflation. But when the exudation is very tenacious no discharge will be observable after paracentesis, and none will be forced through the incision even by inflation, which moreover is very difficult in such cases, until, after a day or two, the exudation becomes more fluid. Paracentesis gives unfavourable results in scrofulous, weak patients, in whom, according to my experience, a very lingering chronic suppuration of the middle ear, with its consequences, frequently develops after the operation.

2. *Catarrh of the Middle Ear* (*Otitis Media Catarrhalis*).

The inflammatory affections of the middle ear, which are clinically comprised in the appellation 'catarrhs of the middle ear,' are characterized anatomically by more or less pronounced hyperæmia, swelling and desquamation of the mucous membrane of the middle ear, and by the secretion of a clear, serous fluid, or of a viscid, sticky, mucous exudation into that cavity. They mostly run their course without marked active symptoms, and without disturbance of the continuity of the membrana tympani, and end in a cure by subsidence of the changes,† or in the development of

* The details of the operation of paracentesis of the membrana tympani will be discussed in the next division, at the description of the treatment employed in cases of accumulation of sero-mucous exudation.

† The term 'subsidence' has here reference only to the changes affecting the power of vibration of the sound-conducting apparatus. For daily experience teaches us sufficiently that, after catarrhs have ended in complete restitution of the hearing-function, the changes in the membrana tympani frequently do not disappear, but that opacities, calcareous spots, and partial thinning remain. In several cases, examined in the General Infirmary, in which the power of hearing was normal, while great opacities existed on the membrana tympani, I found at the post-mortem exam-

permanent inflammatory products, which lead to rigidity of the articulations of the ossicula, to abnormal adhesions, and to their fixation with permanent hearing disturbances. From a practical point of view, especially in regard to the difference in the modes of treatment, I have considered it best to describe first the catarrhs which are accompanied by demonstrable secretion and swelling, and then those adhesive processes which either develop independently or as a sequel to the catarrhs just mentioned.

The causes of the catarrhs of the middle ear with discharge of serous or mucous exudation are atmospheric influences, influenza, the acute exanthemata, and syphilis; but most frequently they are due to the extension of acute or chronic catarrhs of the naso-pharynx.

The exudation into the middle ear is caused in the first instance by the inflammatory process in the mucous membrane; as, however, these catarrhs are always combined with a more or less considerable swelling of the mucous membrane of the Eustachian tube and impermeability of this canal, the exudation is without doubt materially favoured by the closure of the tube and the consequent rarefaction of air in the tympanic cavity. That serous transudation may arise from impermeability of the tube (Hydrops ex vacuo, Zaufal) I have already (p. 107) mentioned; on the other hand, however, I have also stated that the rarefaction of air in the middle ear caused by the closure of the tube does not always produce a transudation of serous fluid into the tympanic cavity.

The sero-mucous catarrhs of the middle ear are generally called chronic catarrhs of the middle ear, without regard to their duration. These forms of inflammation of the mucous membrane of the middle ear have certainly a markedly protracted course; but yet it is scarcely correct to class as 'chronic' those frequent catarrhs which chiefly arise in the course of an acute swelling of the mucous membrane of the naso-pharynx, and in which the sero-mucous exudation in the middle ear has evidently existed for only a few days. While, therefore, the phenomena which characterize the sero-mucous catarrhs at their commencement agree in many instances with the symptoms of catarrhs of longer duration, it is important, in regard both to prognosis and treatment, to take into consideration in any given case, whether it is a recent or a chronic catarrh that has to be dealt with.

The time after which catarrh of the middle ear may be considered as chronic, cannot be exactly fixed, as this inflammation

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ination on the promontory and near the ostium tymp. tubæ, circumscribed, tendinous opacities of the mucous membrane, the remains doubtless of former catarrhs, situated in places in which such pathological changes could not impair the conduction of sound.

does not run a typical course, such as is the case with acute otitis media. But the catarrhal condition may be considered as chronic if the exudation has existed for several months, or if, by repeated relapses, such changes on the membrana tympani have already developed, as are observed only in catarrhs of long duration.

In the sero-mucous catarrhs, the affection of the mucous membrane does not always extend over the whole surface of the middle ear; but the swelling and hypersecretion may remain confined to the lower portion of the Eustachian tube without alteration of the mucous membrane of the tympanic cavity during the whole course of the affection when not of long duration. The occurrence of such affections of the middle ear, commonly called catarrhs of the tube, has been ascertained by experience. In them there is generally more or less swelling, with increased secretion, which occur in the course of acute or chronic naso-pharyngeal catarrhs (less frequently primarily), at the ostium pharyngeum tubæ, and spread for some distance into the canal. We know that many persons are affected with a slight catarrh of the inferior extremity of the cartilaginous tube every time they have a violent cold in the head, and that they have an exceedingly unpleasant sensation of fulness and pressure, as well as of a violent gurgling (rattling in the tube) in the ear, when they blow their nose, phenomena which are mostly unaccompanied by any noticeable deafness or changes in the membrana tympani, and which disappear again when the cold in the head passes off. But even a greater swelling in the cartilaginous portion of the Eustachian tube, combined with impermeability of the canal and considerable deafness, may continue, without simultaneous disease of the mucous membrane of the tympanic cavity, though it generally leads after a lengthened duration to pathological alterations in the latter.

In the affections, however, which are accompanied by great hardness of hearing, impermeability of the Eustachian tube and a great concavity of the membrana tympani, and which are generally called ‘chronic catarrhs of the tube,’ especially common in childhood, the disease is by no means confined to that portion of the tube, but is, as a rule, spread over the whole mucous membrane of the middle ear. The so-called ‘chronic catarrhs of the tube,’ therefore, cannot be separated from the chronic catarrhs of the middle ear, and this term can only be employed if in a given case it is intended to denote great swelling and impermeability of the tube.

Appearance of the Membrana Tympani.—The appearance of the membrana tympani in the sero-mucous catarrhs of the middle ear presents many varieties, which depend partly on the duration of the affection, partly on the transparency of the membrane, and again on the degree and the duration of the impermeability

of the Eustachian tube, on the quantity, character, and colour of the exudation, and on the amount of blood-supply in the mucous membrane of the tympanic cavity.

When the membrana tympani is transparent, the accumulation of serous or mucous exudation in the tympanic cavity, as I first observed and described,* can be distinguished by a peculiar appearance of the membrane. For the fluid can be seen through the membrane in the dependent portions of the tympanic cavity, its level being sharply defined from the air-filled part of the tympanum by a line on the membrane.

The line of demarcation, which is sometimes dark-grey or black, like a hair stretched across the membrane, sometimes shining white (Fig. 87), extends either in a curve, slightly concave upwards, passing from before backwards, or is stretched straight

FIG. 87.—ACCUMULATION OF FLUID EFFUSION IN THE INFERIOR PORTION OF THE TYMPANIC CAVITY, MARKED BY A BRIGHT LINE. IN A YOUNG WOMAN IN THE COURSE OF A SEVERE COLD IN THE HEAD. CURE BY POLITZERIZATION.

FIG. 88.—ACCUMULATION OF EFFUSION IN THE INFERIOR PORTION OF THE TYMPANIC CAVITY. THE LINE OF THE FLUID LEVEL IS CURVED AND WAVY. IN A WOMAN 40 YEARS OF AGE AND SYPHILITIC. REMOVAL OF THE EXUDATION BY PARACENTESIS.

across the membrane, or is convex upwards, or irregularly curved and wavy (Fig. 88); or the fluid may be bounded by two lines, which, commencing at the inferior extremity of the handle of the malleus, diverge downwards with a slight curvature (Fig. 90), an appearance which is principally observed when there is only a slight quantity of fluid in the tympanic cavity. Frequently the line of fluid level is visible only in front of the handle (Fig. 91) or only behind it, or it may be that it is seen only under a certain light. The colour of the membrana tympani below the level of the fluid is dark and yellowish, above this line much lighter and grey.

If such lines can be observed on the membrana tympani, the diagnosis of accumulation of secretion is materially supported by the change in the position of the line, if the head is inclined

* *Diagnose und Therapie der Ansammlung seröser Flüssigkeit in der Trommelhöhle. W. med. Wochenschr.* 1867; *Ueber bewegliche exsudate in der Trommelhöhle. W. med. Presse*, 1869.

either forwards or backwards. Especially when the secretion is liquid, the change in the position of the line will be very rapid, as the fluid, when the position of the head is changed, flows towards the deepest portions of the tympanic cavity (Fig. 89) just as in the water-level. If the exudation is tough and mucous, the line as a rule changes its position either very slowly or not at all.

If the level of the exudation reaches the superior portion of the tympanic cavity, the line of demarcation will be wanting, because in that case the fluid covers the whole inner surface of the membrana tympani, and the exudation can only be distin-

FIG. 89. — CHANGE OF POSITION OF THE LINE OF THE FLUID LEVEL OF THE EXUDATION BY INCLINING THE HEAD BACKWARDS. IN THE SAME WOMAN.

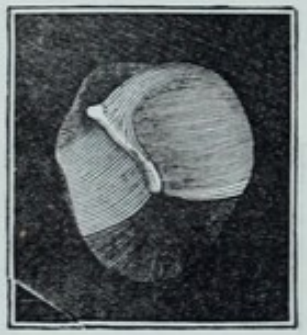

FIG. 90.—ACCUMULATION OF A SLIGHT QUANTITY OF EXUDATION IN THE INFERIOR PORTION OF THE TYMPANIC CAVITY. THE LEVEL OF THE EXUDATION IS BOUNDED BY 2 LINES MEETING AT THE HANDLE OF THE MALLEUS. IN A MAN WITH AN ACUTE CATARRH OF THE NASOPHARYNX. CURE IN 3 DAYS AFTER THE APPLICATION OF MY METHOD.

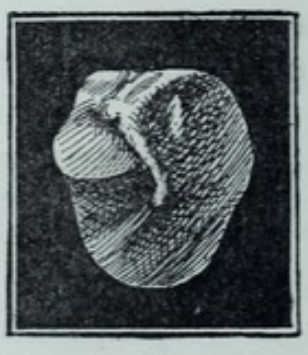

FIG. 91.—ACCUMULATION OF A CONSIDERABLE QUANTITY OF EXUDATION. THE LINE OF THE FLUID LEVEL IS ONLY VISIBLE IN FRONT OF THE HANDLE OF THE MALLEUS. IN A MAN WITH A CHRONIC CATARRH OF THE NASOPHARYNX. REMOVAL OF THE EXUDATION BY PARACENTESIS OF THE MEMBRANA TYMPANI.

guished by the peculiar colour of the membrane. For the normal tint of the membrane appears in this instance more pronounced and deeper, and its grey colour has more or less of a greenish-yellow hue.* This reflection, which is caused by the yellow-wine colour of the exudation, is most strongly pronounced behind the umbo, in the region of the promontory, and it is so decidedly different from the appearance of the normal membrane that from it alone the diagnosis of accumulation of serous

* The yellowish-green hue of the secretion will be noticed particularly plainly if the membrana tympani is illuminated by the light of the sun (Lucae) or that of a petroleum lamp. The line of the level of the fluid as well as the grey and light outlines of the air-bubbles can very distinctly be seen, if the illuminated membrane is magnified by a lens fastened behind the reflecting mirror, or if it is examined with Brunton's ear speculum, modified by Hassenstein (manufactured by J. Leiter in Vienna), or with Auerbach's speculum (p. 93).

or gelatinous mucous masses in the tympanic cavity may be made.*

If the mucous membrane of the promontory is very hyperæmic, to the yellow colour of the exudation will be added a reddish hue, and hence the membrana tympani will sometimes have a brick-red appearance. In all these instances the lustre of the membrane is greatly increased, and the handle of the malleus is much more sharply defined than in the normal state.

The changes which are observed in the above appearances of

FIG. 92.—FROTHY SECRETION IN THE TYMPANIC CAVITY AFTER INFLATION IN A CASE OF ACCUMULATION OF SEROUS FLUID. IN A PATIENT WITH AN ACUTE CATARRH OF THE NASO-PHARYNX.

FIG. 93.—HEMISPHERICAL BULGING-OUT OF THE POSTERIOR SUPERIOR PORTION OF THE MEMBRANA TYMPANI BY YELLOWISH EXUDATION. IN A MAN WHO DURING A COLD IN THE HEAD WITH SLIGHT INFLAMMATORY SYMPTOMS CONTRACTED A CATARRHAL DISCHARGE IN THE MIDDLE EAR. CURE IN 2 WEEKS BY POLITZERIZATION.

the membrana tympani immediately after inflation are very interesting. If the exudation is serous, and the membrane remains transparent after the air has entered the tympanic cavity, the froth produced by the current of air can be plainly seen through the membrane, a number of dark or lustrous well-defined rings becoming visible, which change their locality when they are observed for some time, and are in lively motion immediately after air has been propelled (Fig. 92). Sometimes at the anterior inferior margin of the field of view, one or more air-bubbles will be seen to enter, which slowly or more rapidly pass upwards out of sight.†

The air-bubbles which have appeared in the secretion are, however, only visible if the membrana tympani retains its trans-

* The yellow hue is wanting in those rare cases in which the exudation is completely colourless.

† The occurrence of visible mucous bubbles, such as were first described by v. Tröltsch, I have frequently observed, especially in children suffering from catarrh of the middle ear due to a severe cold in the head or to inflammation of the tonsils, and in whom the secretion had probably assumed its frothy character in consequence of the entrance of air into the tympanic cavity while blowing the nose.

parency after inflation. Frequently, however, the membrane, forced and stretched inwards by the closure of the tube, looks wrinkled, yellow or blueish-grey, somewhat like crumpled tissue-paper, dull and untransparent, thus causing the exudation deposited in the tympanic cavity to be invisible.

But, on the other hand, not unfrequently, in cases in which the signs of accumulation of secretion were not distinctly pronounced, the characteristic appearance of an exudation will be plainly seen only after inflation. For the line of fluid level, which was formerly invisible, often comes immediately into view, or the yellow colour of the membrane becomes more pronounced, or instead of the dark-yellow appearance, a light sulphur colour prevails in cases of mucous or sero-mucous secretion; or lastly, the posterior superior quadrant of the membrana tympani, thinned and elastic in consequence of continued stretching, is bulged forward hemispherically, and the yellowish exudation, shining through the bulged-out portion, becomes plainly visible.

Even though in cases of accumulation of serous or mucous exudation in the middle ear, the membrana tympani generally presents no material change of curvature, or appears forced inwards, there are other rare cases in which the membrane is partially bulged forward by the accumulated exudation. It is as a rule the posterior half of the membrane which is bulged out as a blister-like or semi-globular, pale-yellow swelling (Fig. 93), (Schwartze, Zaufal). The communication of these swellings with the tympanic cavity may be inferred from the rapid enlargement of the outward curvature after inflation, when the air and the exudation can be plainly distinguished by the contrast of their grey and yellow colours. Since there are many cases of copious accumulation of secretion in the tympanic cavity which do not cause a bulging of the membrana tympani, an inflammatory condition of the membrane and disintegration of its tissue must be looked upon as factors, over and above mere pressure, in the causation of these bulgings. This is confirmed by the fact that such conditions are usually accompanied during their development by moderately active symptoms, which are as a rule wanting in the more common accumulation of secretion.*

* Such bubble-shaped bulgings, which in their development are generally accompanied by more or less acute symptoms, occur not only in recent but also frequently in chronic catarrhs, if an acute inflammation with increased discharge is intercurrent. These transition forms between sero-mucous catarrh and acute otitis media and *vice versâ*, occur most frequently in children in whom the phenomena of an acute inflammation not unfrequently exist at the outset; after which the symptoms are analogous to those of sero-mucous catarrh. For this reason acute otitis media is in many books described along with recent sero-mucous catarrhs as pathological forms of a similar kind. An examination of the principal points of distinction between recent catarrh and otitis media shows that in the former the membrana tympani is only slightly changed, transparent, and with little or no injection of its vessels; the mucous membrane of the tympanic cavity is moderately congested; the exudation is a clear serous fluid, or a transparent colloid mucous mass; acute symptoms are either absent or slight; the disease runs a slow course, and the exudation is absorbed with

The above-described variations in the appearance of the membrana tympani are seen with special clearness when the membrane is transparent. Frequently, however, even in cases of copious accumulation of exudation none of these conditions will be found, the membrane having become opaque and non-transparent after a long-continued catarrh. In the slighter degrees of opacity, it is sometimes possible to illuminate the membrane by intense light, so that the exudation can be distinguished by its yellowish hue, or by the dark or lustrous line of its level becoming visible; in cases of greater opacities, however, the presence of free exudation in the middle ear cannot be ascertained by inspection. The statement, that in such cases even slight quantities of exudation in the middle ear may be recognized by auscultation, we can, however, by no means confirm; for, on the one hand, the rattling noises originating in the Eustachian tube are heard as distinctly as if they had taken origin in the tympanic cavity, and, on the other hand, no rattling noises may be heard, if tough, viscid mucus has accumulated in that cavity. The results of auscultation, therefore, will only render the presence of free exudation in the middle ear probable when taken in connection with other symptoms, such as great swelling of the mucous membrane of the naso-pharynx and of the Eustachian tube, great fluctuations in the hearing-distance, a striking improvement in the hearing after inflation, etc.; positive proof can, however, only be given by paracentesis. That in the course of chronic catarrhs, opacities of various degrees become developed, and circumscribed calcareous deposits on the membrane take place, which remain after a cure has been effected, has already been mentioned. More frequently, however, opacities, either circumscribed or extending over the whole membrane, occur in the adhesive processes which are developed from chronic catarrhs, and are accompanied by permanent hearing-disturbances; the appearances of the membrana tympani in this form we will describe in detail in the next division.

With regard to the curvature of the membrana tympani and the position of the handle of the malleus, it will frequently be found, especially in recent cases, that no noticeable deviation from the normal state exists; but after the catarrh has persisted for a long time, when the Eustachian tube is impermeable, the membrane is forced inwards by the excess of the external air-

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difficulty; while in the latter there are intense hyperæmia, inflammation and exudation on the membrane, with complete opacity; the mucous membrane of the tympanic cavity is much congested; the exudation consists of an opaque mucus mixed with large quantities of pus-cells or is quite purulent; the symptoms are acute and violent; the inflammation runs a rapid course, and the exudation is readily absorbed, especially after the Eustachian tube has been rendered permeable. Such distinctions, apart from the state of transition, give to both forms a peculiar clinical character, and, as we shall see, also have a decided influence upon the treatment to be employed.

pressure, and the membrane assumes an appearance which might almost be designated as characteristic of catarrh of the middle ear with impermeability of the tube (so called catarrh of the tube).

First of all, the abnormal position of the handle of the malleus on the highly concave membrane will catch the eye (Fig. 94). It appears strongly inclined inwards and backwards, and apparently shortened (v. Tröltsch), while the short process projects outwards like a small white, pointed cone.

In consequence of the excessive projection of the short process of the malleus, several very prominent folds will be formed in the superior portion of the membrane, extending from the short process towards the superior portion (Figs. 94 and 95). The most important of these is the strongly pronounced posterior fold of the membrana tympani, which in the form of a whitish or tendinous grey, sharp ledge, extends backwards, either almost straight or in a semicircle, and forms an acute angle with the handle of the malleus, opening backwards and downwards.*

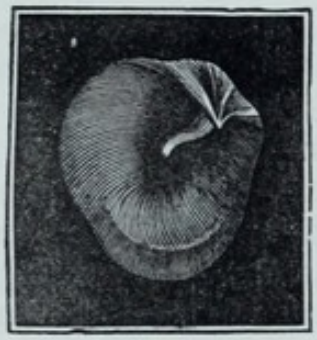

FIG. 94.—APPEARANCE OF THE MEMBRANA TYMPANI IN A CATARRH OF THE EUSTACHIAN TUBE AND OF THE TYMPANIC CAVITY. GREAT INWARD CURVATURE OF THE MEMBRANE. IN A BOY WITH GREAT DEAFNESS, WHICH WAS CURED BY INFLATION AFTER MY METHOD CONTINUED FOR SEVERAL WEEKS.

The inward curvature of the membrane in this instance is rarely uniform. As the periphery of the membrana tympani, on account of the accumulation of circular fibres there, has a greater power of resistance than the central portion, the latter is forced inwards more strongly by the external air-pressure, which produces, especially in the anterior inferior quadrant, a curve, which I first described as the peripheral curve of the membrana tympani, and which can be distinguished by a linear, lustrous stria, visible in that situation (Fig. 94). Besides this lustrous line, which is most strongly defined in the region of the normal cone of light, a small irregular reflection of light will also be found close in front of the inferior extremity of the handle of the malleus. The colour of the membrane is a dark, full-bodied grey (yellowish-grey in the case of exudation), mixed with a violet or reddish tinge, dependent on the intensity of the redness of the inner wall of the tympanic cavity shining through.

After a long duration of the catarrh, partial thinnings of the membrane in one or more places, rarely in the anterior half, oftener in the posterior half, frequently take place. These partial thinnings, caused by the external air-pressure, are very similar to the cicatrices which close the orifices of perforations. They

* If the inclination of the handle of the malleus is very great, it is not unfrequently hidden by the posterior half of the membrane, in which case the posterior fold may be mistaken for the handle.

look like more or less sharply defined depressions, with one or more irregular reflections of light at their lowest part. The outlines of these depressions are generally sharply defined towards one side only, while on the other side they merge imperceptibly into the surrounding surface. If there are several depressions of this kind in the membrane, they will present the appearance of facets. The frequent occurrence of thinning of the posterior superior quadrant is explained by the slight resistance and the yielding character of this portion of the membrane. If it is thinned and forced inwards to such an extent that it comes into contact with portions of the inner wall of the tympanic cavity, the long crus of the incus and the posterior crus of the stapes will be seen behind the handle of the malleus as a bony yellow, angular curved protuberance, bounding a small triangular space of the membrane (Fig. 97). And if the membrane is also in contact with the promontory, the latter will be distinguished as a projection with a yellowish lustre behind the umbo.

The membrana tympani, forced inwards in consequence of the impermeability of the Eustachian tube, presents an important diagnostic appearance before and after inflation when examined by means of Siegle's speculum (*vide* p. 103). For if in a case of impermeability of the tube the air in the external meatus is alternately condensed and rarefied by means of a pneumatic speculum, only a very slight motion of the membrane will be perceptible; as soon, however, as the tube is made permeable by the application of my method or by catheterism, a mobility of the membrane much greater than in the normal state will be observed during the examination with Siegle's speculum. The reason for the slighter mobility of the membrane before inflation, is that the external surface of the membrane is overweighted by the atmospheric pressure; the fact that its mobility after inflation exceeds that of the normal state, however, is a consequence of the slackening of the membrane, caused by the long-continued pressure, which makes it more easily movable.

If the membrane is curved inwards, a remarkable change takes place in its appearance immediately after inflation. The handle of the malleus (Fig. 95), drawn obliquely inwards and backwards, returns nearly to its normal position (Fig. 96); its vessels generally become greatly injected,* the short process of the malleus is much less projecting, and the marked posterior fold of the membrane is almost completely obliterated. In consequence of the great bulging out of the expanded membrane, the

* The injection of the vessels of the handle of the malleus, which takes place immediately after the application of my method or after catheterism, must not be attributed to an irritation of the membrana tympani caused by the jerking action of the current of air. It is rather produced by the rapid change of the position of the membrane and of the handle, by which the direction and relation of the vessels to those in the external meatus are suddenly changed (bend of the membrane), and a temporary stagnation in the veins of the handle takes place.

handle of the malleus, almost invisible, lies in a depressed groove of the pale membrane, which has become non-transparent (Fig. 96). Partial thinnings in the membrana tympani curve outwards in a bubble-like form (v. Tröltsch), and not unfrequently the exudation, forced into them from the tympanic cavity, can be observed, of a yellowish colour, shining through. If the portion of the membrane, situated behind the handle of the malleus, is curved inwards, and if the thinned place has sunk inwards until it has come into contact with the articulation of the stapes and incus and with the promontory (Fig. 97), immediately after inflation, the portions of the inner wall of the tympanic cavity, which have been visible, will disappear, and instead of the previously depressed portion of the membrana tympani,

FIG. 95.—APPEARANCE OF THE MEMBRANA TYMPANI OF A MAN 30 YEARS OF AGE, WHO SUFFERED FOR 2 MONTHS FROM A CATARRH OF THE MIDDLE EAR, WITH GREAT SWELLING OF THE MUCOUS MEMBRANE OF THE EUSTACHIAN TUBE IN CONSEQUENCE OF A COLD IN THE HEAD. THE MEMBRANE WAS CONCAVE, AND ITS COLOUR GREYISH-VIOLET. CURE OF THE GREAT DEAFNESS BY INFLATION AFTER MY METHOD FOR 3 WEEKS.

FIG. 96.—CONDITION OF THE MEMBRANA TYMPANI IN THE SAME PATIENT IMMEDIATELY AFTER INFLATION.

a grey or greyish-yellow, roundish or oval bulla (Fig. 98), extending over the posterior portion of the field of view, will be observed, arching over the handle of the malleus either completely or partially. The duration of such forward curvatures is, however, only very short, as in consequence of the speedy rarefaction of air, the yielding portions of the membrane are forced inwards so far that even after a short time the membrane resumes its previous appearance.

The *subjective phenomena*, which accompany catarrhs of the middle ear, are very various. As a rule the exudation runs its course without pain, but in a few rare cases slight and sudden stitches are felt at the beginning of the disease. The exudation is rarely accompanied by violent phenomena (inflammatory œdema, Schwartze, Zaufal). More frequently, however, especially in recent catarrhs, there is produced a sensation of fulness, numb-

ness, and pressure in the ear, similar to that felt when a little water remains in the ear after a bath. This sensation, which is frequently very unpleasant, depends, as I have already mentioned (*l. c.*), on the quantity of exudation, and on the degree of swelling and impermeability of the Eustachian tube, so that the more trifling the swelling and deafness, the greater is the sensation of fulness, which is generally completely wanting when the tube is quite impermeable.*

An important though not a constant symptom, to which I was the first to draw attention, and which is most frequently observed in recent catarrhs, is the sensation as if a body were moving to

FIG. 97.—APPEARANCE OF THE MEMBRANA TYMPANI IN A YOUNG MAN, 17 YEARS OF AGE, WHO SUFFERED FOR 8 YEARS FROM CHRONIC CATARRH OF THE MIDDLE EAR; NASO-PHARYNGEAL CATARRH WITH GREAT SWELLING OF THE MUCOUS MEMBRANE OF THE EUSTACHIAN TUBE. HEARING-DISTANCE ALMOST NORMAL AFTER 1 INFLATION BY MY METHOD.

FIG. 98.—CONDITION OF THE MEMBRANE IN THE SAME PATIENT IMMEDIATELY AFTER INFLATION.

and fro in the ear, when the position of the head is changed, a feeling which frequently corresponds with the motion of the exudation, visible through the membrana tympani. If the membrane is opaque, the presence of free exudation in the middle ear may with probability be inferred from this symptom.

Subjective hearing-sensations in the secretive forms of catarrh are not constant, but usually intermittent. They frequently occur suddenly in cases where the disease becomes aggravated, accompanied by a sudden decrease in the hearing, and disappear just as rapidly, when an improvement in the hearing takes place either spontaneously or in consequence of treatment. That in this form

* Patients try various methods of removing this troublesome sensation. Most frequently the sensation of pressure is alleviated by inserting the little finger hermetically into the external meatus and by shaking it (alternate condensation and rarefaction of air in the external meatus). As this improvement is, however, only of short duration, the shaking of the finger in the meatus is again and again repeated. But the more frequently this manipulation is performed, the more rapidly the sensation of pressure will return, and, as I have repeatedly observed, a slackening of the membrana tympani and permanent deafness may be caused by continuous use of this manœuvre.

of catarrh the noises are caused by the temporary increase of pressure in the labyrinth, a result of the accumulation of exudation and of the abnormal tension of the sound-conducting apparatus, will be seen from the fact that generally immediately after inflation of the tympanic cavity, the tinnitus either ceases altogether or is considerably diminished. In cases where the tinnitus uninterruptedly continues for some time, and in spite of treatment for an impermeable tube, the prognosis will be unfavourable, because the noises must be considered as indicating the development of permanent changes at the fenestræ of the labyrinth or some labyrinthine complication. In cases of exudation in the middle ear consecutive to pharyngeal syphilis, I have frequently observed constant subjective noises.

The resonance of the patient's own voice is often one of the most troublesome symptoms. It is more noticeable in one-sided affections and in slight catarrhs, than when both ears are diseased and the tubes are greatly swollen. The echo of the patient's own voice, which he compares to the sensation of speaking with the head inside a cask, often induces him to avoid protracted conversations, and the attempts to remove this troublesome sensation by clearing the throat and blowing the nose, are successful only for a short time. Frequently this symptom disappears during treatment; it rarely remains after a cure has been effected.*

A frequent symptom also in the secretive forms of catarrh is a crackling and smacking in the ear, which is especially noticeable in swallowing and masticating, and is produced by the motion of the mucus in the tube, or by the sudden separation of the viscid walls of the Eustachian tube from each other, or by the entrance of air-bubbles through the tube into the tympanic cavity.

The sensations of heaviness and numbness of the head are subjective phenomena of chronic catarrhs, to which special attention must be given. They are most pronounced when there is at the same time swelling in the naso-pharynx, but frequently they are well marked without any naso-pharyngeal complication. Adults often complain of a feeling of pressure and confusion in the head, through which they are rendered unfit for mental work. In children these symptoms become apparent by ill-humour and waywardness. Children, who were formerly cheerful and bright, become morose, taciturn, and are disinclined for play. All these phenomena generally disappear with surprising rapidity after repeated Politzerization or inflation by the catheter.

Functional Disturbances.—The functional disturbances in the catarrhs of the middle ear, accompanied by swelling and secretion,

* In a case of unilateral accumulation of serous exudation, Hagen observed that the patient heard a clashing noise in the ear when percussion was performed on the cranium, which disappeared after removal of the fluid. Zaufal was able to produce the perception of such clashing tones also by musical notes and certain vowels, conducted through the air.

are in most cases disproportionate to the known amount of effusion; the degree of the functional disturbance depending rather on the abnormal tension of the membrana tympani and of the ossicula, caused by the impermeability of the Eustachian tube. This may be ascertained from those cases having a copious accumulation of exudation, in which a striking improvement in the hearing results from inflation, although no diminution of the fluid is demonstrable by inspection of the membrane. I have also observed in cases in which the whole field of view was of an amber-yellow colour, characteristic of an accumulation of secretion, that a striking improvement in the hearing took place after the membrane had been slackened by paracentesis, even before the exudation was removed from the tympanic cavity. But that accumulation of secretion may of itself impair the conduction of sound to a certain degree, is beyond doubt, and is frequently confirmed by experience.

Considerable fluctuations in the hearing-distance, not only on different days, but also at very short intervals, have an important diagnostic significance in this form of catarrh. This depends partly on the changing condition of the swelling in the Eustachian tube, partly on the variable tension of the sound-conducting apparatus, partly also, as I have proved, on the changeable position of the secretion. Many patients hear better when they incline the head forwards or backwards, others when the head is bent to the side, according as, during the one or the other position of the head, the secretion flows from the fenestræ of the labyrinth towards those portions of the tympanic cavity where the conduction of sound is less hindered by it.

Fluctuations in the hearing-distance frequently arise quite suddenly, and generally with the sensation of a report in the ear. This symptom is specially observed in patients who in consequence of a continuous impermeability of the Eustachian tube were very hard of hearing for a considerable time, often for several months, and in whom the air suddenly enters the tympanic cavity, either in consequence of a spontaneous opening of the tube during an act of swallowing—the swelling of the mucous membrane having subsided to a certain degree—or on account of the removal of a mucous plug.* When the report occurs, which is compared to a pistol-shot fired in the head, such a rapid improvement in the hearing takes place, that patients who previously were very deaf can now all at once understand

* A medical man, who according to his statement had been very hard of hearing for two years (with only slight fluctuations) owing to a naso-pharyngeal catarrh, and did not undergo any surgical treatment, told me that while he was quietly watching from his window the turmoil in the street, he was suddenly so surprised by a pistol-shot-like report in the head that he reeled, as if stunned, towards the middle of the room. From that moment his hearing remained constantly normal. When I examined him I found calcareous spots on the drum-heads; by the hearing-test I ascertained his hearing to be normal.

whispered speech at a great distance.* This abrupt change is in many cases very unpleasant for the first few days, because all sounds are heard too loudly and too acutely, but the hyperæsthesia soon passes off. Just as rapidly as the improvement in the hearing, there frequently takes place an aggravation with the sensation of a sudden closure of the ear, or as if a wall were placed before it. I have already mentioned that such fluctuations in the hearing-distance are produced by various external and internal influences. In autumn and in winter, on rainy and foggy days, the hardness of hearing is, as a rule, more considerable in catarrhs of the middle ear than in summer and in dry weather. Abrupt change of temperature not unfrequently causes a sudden aggravation, as does also the excessive use of alcoholic beverages. The power of hearing is, however, subjected to the most frequent fluctuations by becoming complicated with an acute naso-pharyngeal catarrh or by exacerbation of a catarrh already existing in the naso-pharynx.

Hearing through the cranial bones for the watch and the acoumeter is almost always preserved; not unfrequently the ticking of a watch from the temple of the affected side is even heard more intensely. But in cases of exudations in the middle ear, developed in syphilitic patients, perception for the weak vibrations of the watch, sometimes also for the tone of the acoumeter, is generally quite absent. I wish to attach special importance to this symptom, as on account of it I have repeatedly suspected syphilis, a suspicion which was confirmed by minute examination of the case. The tuning-fork, placed upon the middle line of the head, is generally heard better by the deaf ear, and that for the most part in syphilitic patients, in whom, as already mentioned, the affection of the middle ear is frequently complicated with labyrinthine disease.

The results of auscultation in catarrhs of the middle ear accompanied by swelling and secretion, and their diagnostic importance in the catarrhal affections here under discussion, have already been referred to in detail in the general division (p. 134).

Course and Issues.—It has been pointed out at the beginning of this division, that the catarrhs of the middle ear generally run a protracted course, and that their issue in cure or in the development of permanent functional disturbances depends on whether

* As in the case of a chronic impermeability of the Eustachian tube the air in the middle ear is rarefied, it is probable that the sensation of the report is produced by the abrupt equalization of the air-pressure between the tympanic cavity and the external atmosphere. I have, however, observed cases in which a sudden improvement in the hearing accompanied by the above sensation only occurred during or after treatment, in which therefore the permeability of the tube had previously been repeatedly effected by inflation. It is difficult to say what is the cause of the above symptom in such cases, and it can only be suggested that a sudden motion of the ossicula, in consequence of a decrease of the swelling of the mucous membrane or of a slackening of the contraction of the intra-tympanic muscles, may produce it.

the pathological changes subside, or whether formation of permanent hindrances to the conduction of sound takes place (pp. 88, 89). The conditions which influence their issues are exceedingly various, and I will try to sketch the most important of them, as far as this appears necessary from a practical aspect.

The course and issue are most favourable in recent simple catarrhs, or in those which have originated in the course of an acute cold in the head. In healthy subjects, and under normal conditions, catarrh of the middle ear, as a rule, subsides spontaneously with the disappearance of the naso-pharyngeal affection, or after brief treatment. The catarrhs produced by measles and influenza also generally have a favourable course; for sometimes after a few days—frequently, however, only after a few weeks—the swelling decreases, the exudation is reabsorbed, and all morbid symptoms disappear.

Chronic catarrhs, however, take a quite uncertain course. The great tendency to relapses of catarrhs of the middle ear, favours the transition of a catarrh into the chronic state. After a catarrhal affection has ceased, the mucous membrane of the middle ear remains for a long time so sensitive to hurtful influences, that a slight cold, a cold bath, or a somewhat severe cold in the head suffices to produce a re-exudation in the middle ear. It is a peculiarity of such relapses, that the renewed process exceeds the preceding affection in duration, until at last, after frequent relapses, the catarrh becomes permanent and changes are developed, which exclude the possibility of a complete restitution of function. Relapses are specially frequent in children, who are subject to either temporarily recurring or permanent catarrhs of the naso-pharynx with hypertrophy of the tonsils. In such cases the catarrhs of the middle ear recur simultaneously with the naso-pharyngeal catarrhs, mostly in autumn and in spring, and generally subside altogether or partially when the warm season comes in, to return again next autumn. In this manner in children catarrhs may regularly recur for a number of years, frequently until they are fourteen to sixteen years old, when the relapses will either completely cease or occur more rarely.

Chronic naso-pharyngeal catarrhs, and the changes in the naso-pharynx produced by them, have a no less important bearing on the course and issue of the affections of the ear under discussion. Not only are they frequently the chief cause of the disease of the middle ear, but its catarrhal condition is maintained by the continuance of the naso-pharyngeal affection. In a large majority of children suffering from ear-disease, catarrhs of the middle ear are combined with chronic naso-pharyngeal affections, and the local disease in the ear cannot be permanently cured until the affection of the naso-pharynx has been removed. Considering the importance of this subject, we will therefore, at the close of this division, devote a special chapter to the pathology

and treatment of naso-pharyngeal diseases in their relations to affections of the ear.

It has already been pointed out that the condition of the Eustachian tube has a great influence on the course of catarrh of the middle ear. It has to be added here, that even after the exudation has been completely removed from the middle ear and the hearing-function has returned to the normal state, a lasting cure cannot be expected, as long as the permeability of the Eustachian tube has not been established to such an extent that it can be made to gape by the muscles of the tube and the pharynx. Therefore, when treating catarrhs of the middle ear it must be our first endeavour to make the tube permeable, this being one of the most important conditions for normal hearing.

It is of importance, as regards both prognosis and treatment, to learn the amount and the site of the swelling in the tube. While an impermeability of the canal produced by a swelling on the ostium tubæ, which frequently occurs in cases of adenoid vegetations in the naso-pharynx, offers little resistance to treatment after the removal of the naso-pharyngeal affection, extensive swellings in the tube produced by tumefaction and induration of the mucous membrane of the naso-pharynx require a protracted course of treatment, or are incurable. According to Hartmann it may be inferred that a swelling is confined to the ostium tubæ, if the air, propelled after my method, enters into the middle ear under great pressure only, while when the catheter is applied the air flows in freely and with the slightest pressure. If, however, great pressure is also required during catheterization, a diffuse swelling, extending over the whole tube, may be inferred.

The influence of the exudation upon the course of the pathological process depends less upon its quantity than its quality. The quantity of the exudation is by no means always a gauge of the intensity of the process, as generally in cases of trifling swelling a very copious secretion is discharged, while when a great softening of the mucous membrane is demonstrable, only a small quantity of free secretion is effused into the tympanic cavity. According to experience, affections of the latter kind resist treatment more obstinately than catarrhs accompanied by a copious discharge.

Regarding the quality of the exudation, which, as already mentioned (p. 87), may be purely serous or mucous, or both, it has to be remarked, that the liquid secretions can be reabsorbed with much greater rapidity, and can be removed much more easily from the tympanic cavity, than the tough, syrupy, adhesive mucous masses.

Although, as experience shows, the mucous membrane of the tympanum frequently suffers no further pathological changes by protracted contact with the exudation, it is beyond doubt that injurious consequences may be developed through the production

of permanent pathological changes, caused by the protracted stagnation of the secretion in the middle ear. The purulent processes, such as are observed sometimes in the course of chronic catarrhs, accompanied by a discharge of mucus, especially in children, are probably often produced by the retention of the secretion in the middle ear. An exudation which has not been reabsorbed may also produce a permanent hyperæmic condition by protracted contact with the mucous membrane, which may lead to cell-growth and to condensation of the connective-tissue stratum of the mucous membrane of the tympanum, as also of the coverings of the articulations of the ossicula.

Besides the above enumerated conditions we must point out those general diseases which affect the course and issue of catarrhs in an unfavourable manner. Referring in regard to this to the etiological data discussed in the general division (p. 189), I wish to note here, that in the first rank scrofula has to be mentioned as a disease, during which most frequently, and even after only a short duration of the catarrh, adhesion of the ossicula to the walls of the tympanic cavity, combined with a secondary disease of the labyrinth, takes place. Catarrhs also run an unfavourable course in cases of tuberculosis. Bright's disease, anæmia, marasmus, exhausting diseases and all cachexiæ, by which the nutrition of the general system has become deteriorated.* In the conditions enumerated here, frequently only a temporary improvement can be effected in spite of timely treatment, as the process inevitably leads to those adhesive changes, the description of which we reserve for the second portion of this division.†

But even in quite healthy people, in simple catarrhs as well as in those originated by extension from the naso-pharynx, not unfrequently, and independently of the duration of the affection, those adhesive processes in the middle ear will be developed which we have just mentioned. While, according to experience, many catarrhs, even such as have existed for many years, completely subside, and therefore, if I may make use of the expression, preserve for a long time a benignant character, we may find on the other hand, even shortly after the commencement of a slight catarrh, that changes arise in the middle ear which permanently impair the hearing. In the present state of our knowledge we are not in a position to say what is the nature of the influences which act upon the process, so that in one case the cellular elements deposited in the mucous membrane may be reabsorbed by granular or fatty decay, after a long duration of the disease, while in another case, even after a short duration of the

* In syphilitic patients sero-mucous exudation of the middle ear takes a relatively favourable course, even if combined with disease of the labyrinth.

† Compare the pathological changes in the connective-tissue stratum of the mucous membrane of the middle ear (pp. 83, 84).

process, the transformation of the cells into connective tissue takes place.

From what has been said so far, the general indications which influence one in giving a prognosis may be seen. The prognosis will be most favourable in recent simple catarrh, if the patient is otherwise healthy, if an hereditary tendency can be excluded, and if the patient is living in favourable circumstances which permit him to avoid external sources of injury.* The result of the treatment employed also offers indications in regard to prognosis, inasmuch as a considerable increase of the acuteness of hearing after the Eustachian tube has been rendered permeable once or oftener, or after removal of the secretion from the middle ear, entitles us to expect a favourable issue. In existing naso-pharyngeal affections the prognosis will be more favourable if simple swelling and hypersecretion of the mucous membrane has to be dealt with, and no advanced, deep-seated changes in the mucous membrane have taken place; of hypertrophic diseases of the mucous membrane of the naso-pharynx the prognosis of the adenoid growths is relatively the most favourable (Hartmann).

If on the other hand we look at the conditions which make the prognosis unfavourable from the beginning, in the first rank are those general diseases which we already pointed out when discussing the course of the affection, as also hereditary disposition† and old age.

The prognosis is also unfavourable if the catarrh runs its course with continuous subjective noises; if frequent relapses have already occurred (v. Tröltsch); if after the Eustachian tube has been made permeable and the secretion has been removed, no increase in the hearing-distance, or only a slight one, follows; if it can, therefore, be assumed that a new formation of connective tissue in the mucous membrane has already taken place besides the discharge of free exudation, also if perception through the cranial bones is wanting; if the catarrh is combined with obstinate forms of ozæna or of naso-pharyngeal blennorrhœa (Störk); if the patient, on account of his unfavourable condition in life or on account of his calling, remains exposed to unfavourable external influences, and if he is a drunkard, or cannot leave off smoking.

Treatment.—The most important indications to be taken into consideration in treatment of catarrhs of the middle ear, accompanied by swelling and exudation, are the establishment of the permeability of the Eustachian tube, the removal of the exuda-

* The prognosis is on the whole very favourable in uncomplicated catarrh of the tube, if the disease is not of too long standing, and if no permanent changes in the equilibrium of the membrana tympani and of the ossicula, and no secondary disorganizations at the fenestræ of the labyrinth, have yet taken place (v. Tröltsch, *Lehrb.* p. 346).

† It is well known that in cases of hereditary tendency catarrhs rarely subside. We consider, however, the proportion of hereditary cases of catarrhs (1-3 and 1-4) given by Moos and Triquet to be exaggerated.

tion from the tympanic cavity, and of the swelling and secretion in the mucous membrane of the middle ear. If, however, a naso-pharyngeal affection exists, it must be treated at the same time as the local affection, and the general health, as well as the circumstances in which the individual lives, must be taken into account.

Of the methods for propelling air into the middle ear, in order to make the Eustachian tube permeable, the Valsalvian experiment is the least suitable. The reason for this we have already discussed in detail in the general division, and we will here only point out, that especially in this form of catarrh of the middle ear, on account of the great resistance which is produced by the swelling in the tube, and by the accumulation of secretion in the middle ear (Moos), in by far the greatest majority of cases air cannot be pressed into the tympanic cavity even if the Valsalvian experiment is performed with the utmost force, and that in the few cases in which the entrance of air takes place, the effect of the current is mostly trifling and transient. It has already been mentioned, that, besides this, by the forced Valsalvian experiment the hyperæmia and exudation already existing in the middle ear may even be increased.

A different result is obtained from inflation after my method, with which the most favourable cures have been effected, especially in these forms of catarrh. In children it is frequently sufficient simply to blow in air with the mouth by means of a small india-rubber tube (p. 148), the air entering the middle ear even without an act of swallowing and without phonation. It is also not unfrequently possible to press air into the middle ear by the application of my modified method (substituting for the act of swallowing the pronunciation of a word, for instance, *Vaarix, König*); frequently, however, the permeability of the tube is not effected by it, while in the same cases the air is easily propelled during an act of swallowing. While in a number of cases, especially in children, the effect of propelling air with my modified method is equal to that of propelling air during an act of swallowing, yet the effect of the former is frequently slighter and less permanent than that of the latter, during which, through the more powerful action of the current of air, the membrana tympani and the ossicula are more strongly forced outwards and are brought into their former position. It must, however, be remarked, that on the other hand isolated cases are again observed, in which the method with the act of swallowing does not succeed, while air can be propelled into the middle ear by my modified method, sometimes even by means of the Valsalvian experiment. When therefore propelling air during the act of swallowing is not practicable, the modified method may be tried, before catheterism is employed to make the Eustachian tube permeable.

The pressure of air which is applied in my method depends principally on the state of the tubes. If it is apparent, after the

first application, that the entrance of air through compression of the inflating-bag is successful, the compression with the hand must be correspondingly increased, according to the ease or difficulty with which the air penetrates through the tubes (p. 148). As the original force of the current of air is mostly spent in overcoming the resistance in the Eustachian tube when air is propelled for the first time, and its effect upon the walls of the tympanic cavity is therefore frequently but trifling, it is advisable, in cases in which no striking improvement in the hearing takes place after a first inflation, to repeat the manipulation two or three times. Only in cases of very great swelling in the Eustachian tube, when air cannot be pressed into the middle ear by the inflating-bag, or when the improvement in the hearing is inconsiderable after the air has entered, the method is applied to advantage by means of a force-pump, as with it a pressure can be produced of $\frac{3}{10}$ to $\frac{5}{10}$ atm. Such a pressure may also be produced by compression of the inflating-bag; but the jerking action of the force-pump is of considerable importance.

If the resistance in the middle ear is so considerable that propelling air by my method does not succeed at all, or only imperfectly, inflation by the catheter must be resorted to, with the aid of the ordinary inflating-bag, or, if the resistance is too great, by means of the force-pump. By the latter we can either let the current of air pour in continuously with any pressure we wish (generally 0·2 to 0·4 atm.), or cause an interrupted action of the current (of more than 0·5 atm.) by suddenly opening the valve.* The great resistance which has to be overcome by the air-douche with the catheter may be caused either by excessive swelling of the mucous membrane of the tube, by closure of the canal by tough secretion, by great adhesion of the walls of the tube, or, lastly, by accumulation of exudation in the tympanic cavity. Now, experience shows that in case of great resistance it is frequently sufficient merely to apply the air-douche once, by means of the catheter, to lessen the obstruction, and that afterwards the treatment may be successfully continued by propelling air after my method.

The introduction of the catheter must therefore be confined to those cases in which Politzerization does not succeed on account of the resistance in the ear being too great, or in which vapour and medicated fluids are to be conducted into the middle ear. Where, however, the air penetrates powerfully into the middle ear during the application of my method, the air-douche by means of the catheter is contra-indicated, because, as already mentioned, the frequent immediate contact of the hard instrument with the diseased mucous membrane of the tube may only increase the swelling and secretion in the middle ear. Indeed,

* If the capacity of the nasal cavity is sufficiently large, I employ conical catheters in case of very great resistance (cf. p. 157).

experience shows that the action of the propelled air is frequently very different when applied with my method, and when introduced by the catheter. In the latter case, after several days, a noticeable decrease of the exudation is hardly demonstrable when inspecting the membrana tympani, while the subsequent application of my method is followed, even after two or three days, by a rapid decrease of the exudation and a more considerable and steadier improvement in the hearing.

Regarding the therapeutic effect of propelling air after my method, we have already described the mechanical effect of currents of air conducted into the middle ear (p. 104). We have here still to add, that if the Eustachian tube is swollen, considerable subjective relief in the ear and an increase in the hearing-distance will take place immediately after air has been injected; if the tube has been impermeable for some time, patients generally experience a violent report in the ear when the air enters into the tympanic cavity, which is immediately followed by such surprising improvement in the hearing, that those who previously could only understand loud speech in the immediate neighbourhood, now suddenly plainly hear low whispered speech across an ordinary sized room. In spite of this striking increase in the hearing-distance, patients frequently state that they feel a sensation of pressure and of tension in the ear, in consequence of the strong outward curvature of the membrana tympani, which, however, in a short time is replaced by a feeling of ease.

The duration of the increase in the hearing effected by inflation varies according to the degree of the swelling in the tube, the degree of tension of the sound-conducting apparatus, and the quantity and quality of the accumulated secretion. The greater the swelling, the greater the quantity of the exudation, and the tougher its character, the more rapidly the improvement in the hearing will disappear again. Especially in children this occurs often so rapidly, that even after a few minutes the deafness has reached its former degree. Generally, however, the hearing-distance decreases only gradually in the beginning of the treatment, so that on the first or second day after inflation, the deafness seems to be increased again, but decreases after repeated application of my method to a more considerable degree than was the case after the preceding manipulations. These fluctuations become less and less in the further course of the treatment, as the swelling and secretion decrease. This is of importance in prognosis, as we may conclude a decrease of the pathological process from the constant increase of the hearing-distance, while in cases in which the improvement in the hearing always disappears again to a great extent after one or two days, it may be assumed that the catarrh continues unabated and the effusion in the tympanic cavity unchanged. While we must confine ourselves, therefore, in the former cases to treatment with my method,

it will be necessary in the last-named cases to resort to other therapeutic expedients to cause the mechanical removal of the secretion, and to produce a constant improvement in the hearing by decreasing the swelling of the mucous membrane.*

The effect of inflation after my method is not confined to the ear alone, but in cases of naso-pharyngeal catarrh with impeded respiration through the nasal cavity, the permeability of the latter is effected, because the air-current drives the obstructing masses of mucus towards the lower part of the pharynx, as was first described by Lucae (*A. f. O.* vol. iv). The mucous masses are then either swallowed or discharged through the mouth. The latter is especially the case in the application of the modification of my method, proposed by Lucae, which he calls the dry nasal douche (p. 150).

It was mentioned in the description of the symptoms accompanying catarrhs of the middle ear, that in cases of protracted closure of the tube and accumulation of secretion in the middle ear constant heaviness and numbness in the head are not unfrequently felt. These symptoms are removed with surprising rapidity after applying my method of inflation several times; a sensation of relief in the head takes place, as if it had been eased of a heavy load, as the patient frequently expresses himself. Still more remarkable is the effect in children, in whom not only do the uneasiness and ill-temper quickly pass away, and the former cheerful manner soon return, but the unhealthy appearance and the pale, sickly colour of the face, which in children not unfrequently become prominent in the course of chronic catarrhs of the middle ear, soon disappear.

The changes in the appearance of the membrana tympani caused by inflation have already been described (p. 265). It has still to be mentioned here, that the membrane in cases of great inward curvature does not always resume its normal position in proportion to the improvement in hearing, but that in spite of a considerable increase in the hearing-distance it generally appears curved inwards again after several hours. This shows that the pathognomonic position of the membrane and of the handle of the malleus, apparent when the tube is greatly swollen, does not always cause considerable hearing-disturbances of itself, but only in conjunction with abnormal tension of the articulations of the ossicula. Opacities and small circumscribed thinnings of the membrane which may remain, are of no considerable importance to the function; extensive atrophies of the membrane, however, are of themselves sufficient to impede the conduction of sound,

* In reduced, cachectic individuals, also during convalescence from severe illnesses, the improvement in the hearing is seldom permanent during treatment. The reason for this is to be looked for partly in the continuance of the exudation, partly in the relaxation of the tissue, and in the decreased energy of the muscles of the palate and of the Eustachian tube.

which has to be taken into consideration in the treatment of catarrhs of the middle ear.

The duration of the treatment of catarrh of the middle ear by means of inflation after my method, depends on the results it produces. At first it is advisable to inflate daily, as long as the improvement in the hearing passes away for the most part again from day to day. If, however, after treatment for several days no considerable decrease in the hearing-distance is observable, the method is repeated every second, and then every third day, and if the improvement continues, at still greater intervals, once or twice a week, and finally only once a week, until no fluctuations in the hearing-distance can be noticed.

By methodical inflation in this way, a complete cure is effected in the secretive forms of catarrh of the middle ear, not only in recent, but also frequently enough in chronic cases, without any further local treatment. The advantages of this method of treatment, compared with that by the catheter, are sufficiently apparent from the number of cures since my method has become generally known; for no one can deny that the percentage of cured and improved patients is now considerably greater than it was when nothing but the catheter was used.

We must now describe the treatment of those cases in which the absorption of the secretion in the tympanic cavity cannot be effected by simple inflation, partly on account of its excessive quantity, partly because of its tough character, and in which therefore the improvement in the hearing produced by inflation disappears again after a short time. In such cases the mechanical removal of the exudation is advisable, and this is effected either after a method invented by me, or by means of paracentesis of the membrana tympani.

For cases in which the exudation in the tympanic cavity is almost entirely serous, I several years ago invented a method of removing the secretion from the cavity without paracentesis of the membrane. The head of the patient, after he has taken a little water into his mouth, is placed in a position inclined well forwards and somewhat towards the opposite side, which causes the pharyngeal orifice of the Eustachian tube to point directly downwards, while the ostium tympanicum tubæ is directed exactly upwards. This position of the head is retained by the patient for one or two minutes, so that the secretion contained in the depressions of the tympanic cavity may flow towards the orifice of the tube. Then air is propelled after my method during an act of swallowing, to allow the secretion, now deposited above the ostium tubæ, to flow off into the naso-pharynx by opening the Eustachian tube. That this is really the case, is proved not only by Zaufal's* confirmatory experiments on human ears, but also by the observations made by myself in a number of cases,

* *A. f. O.* vol. v.

in which, after the application of my method during the above-described position of the head, a liquid serous, less frequently thick, syrupy exudation, escaped from the nasal orifice. If shortly after this manipulation the membrana tympani is examined in its normal position, instead of the yellowish lustre produced by the exudation, the membrane will be found to be light grey, and in those cases in which the line of the level of the exudation was visible before inflation, it has either completely disappeared, or is considerably lower than before.

In this manner it is not unfrequently possible to remove the accumulated exudation from the middle ear, and to effect a cure by repeatedly propelling air as above directed. In those cases, however, in which the accumulated exudation forms a tough, gelatinous, consistent mass of mucus, its escape through the tube cannot be effected in the above manner, and in such cases its removal from the middle ear will be most safely managed by paracentesis of the membrana tympani.

Weber-Liel has recommended the elastic tympanic catheter for the removal of accumulated secretion from the middle ear. After introducing it through the Eustachian tube into the tympanic cavity, the secretion is to be removed from the middle ear by suction. If, however, the position and relations of the orifice of the tube in the tympanic cavity are remembered, it will immediately be seen that the secretion can be removed by the tympanic catheter only from the upper portion of the tympanic cavity, and not from its lower portions. While it cannot be denied that sometimes a noticeable improvement in the hearing may take place by drawing off only a few drops of secretion (Poorten), the increase in the hearing-distance is due to the opening of the Eustachian tube, rather than to the removal of such a very trifling quantity of fluid. If the secretion is of a tough viscid character, it cannot be removed by the tympanic catheter, because its orifice gets choked by but a little bit of the mass to be sucked out, thus preventing the remainder of the exudation from entering it. But even if a partial removal of the secretion gives in some cases a successful result, the success is only a temporary one, as a lasting improvement in the hearing can be effected only by the complete removal of the secretion. This is done most safely by paracentesis of the membrana tympani, an operation which is not only simple and easy of execution, but which, according to the statements of patients, is hardly more unpleasant than the manipulation with the tympanic catheter.

Paracentesis of the membrana tympani, to effect the removal of mucous masses from the tympanic cavity, was performed by Itard, Busson, Frank, Bonnafont, and Philippeaux, but without precise indications, because the diagnosis of the accumulation of secretion in the tympanum was an uncertain one. It is only since v. Tröltsch introduced his mode of illumination that the

knowledge of those changes on the membrana tympani already described has been acquired, which, as Schwartze's* and my own examinations† have proved, permit us to diagnose with probability or even certainty an accumulation of secretion in the tympanic cavity. To Schwartze belongs the merit of having introduced into practice paracentesis of the membrana tympani, so that it is now in general use, and I consider this operation, after an abundant experience, to be one of the most practically important and successful therapeutic expedients in diseases of the ear.

I perform paracentesis of the membrana tympani in those cases in which, after the application for several days of the methods of treatment already described, no decrease of the exudation is observed, and in which, even when no exudation is demonstrable, the improvement in hearing, the immediate result of inflation, disappears again almost entirely in one or two days. I also frequently perform the operation in those cases in which at the first examination the accumulated exudation is seen to be copious. For although in these cases a cure may be effected by inflation alone, the treatment will frequently extend over several weeks, while by means of paracentesis a complete cure may be accomplished in a few days. The great advantage of this operation lies therefore in shortening the duration of treatment.

Paracentesis of the membrana tympani is an operation so simple and easy of execution, that anyone who is at all familiar with examination of the membrane can perform it without difficulty. During my lectures, the operation is performed by my students, if they have sufficient experience in inspecting the membrane, and I consider preparatory operations on the phantom or on the dead body quite unnecessary.

The instrument used for the operation is a double-edged lancet, 6 ctm. long, and with a knee-like bend near its handle, to which it is either firmly united (Fig. 99) or can be fastened by means of a small screw (Fig. 100). The latter instrument has the advantage that the lancet can be adjusted in different directions, and therefore the incision into the membrana tympani can be made with it as easily in a vertical as in a horizontal direction. Previous to the operation, the point of the lancet must be examined to ascertain that it is intact, because the pain during the operation is increased by the slightest bluntness of the instrument.

The most suitable site for the incision into the membrana tympani is its posterior inferior quadrant, because this place is easily accessible, and is removed further from the inner wall of

* *Paracentese des Trommelfells* (Halle, 1868).

† *Diagnose und Therapie der Ansammlung seröser Flüssigkeit in der Trommelhöhle, Wien. med. Wochenschrift*, 1837, and *Ueber bewegliche Exsudate in der Trommelhöhle, Med. Presse*, 1869.

the tympanic cavity than the portion of the membrane situated immediately behind the umbo, where during incision the promontory might easily be injured. If the posterior wall of the external meatus is only slightly curved, the anterior inferior quadrant (Figs. 101 and 102), which is also removed from the inner wall of the tympanic cavity, may be chosen. If the membrane is strongly curved forward, the most prominent point of the bulging is incised; if it is abnormally curved inwards, the tightly stretched posterior fold of the membrane is operated on.

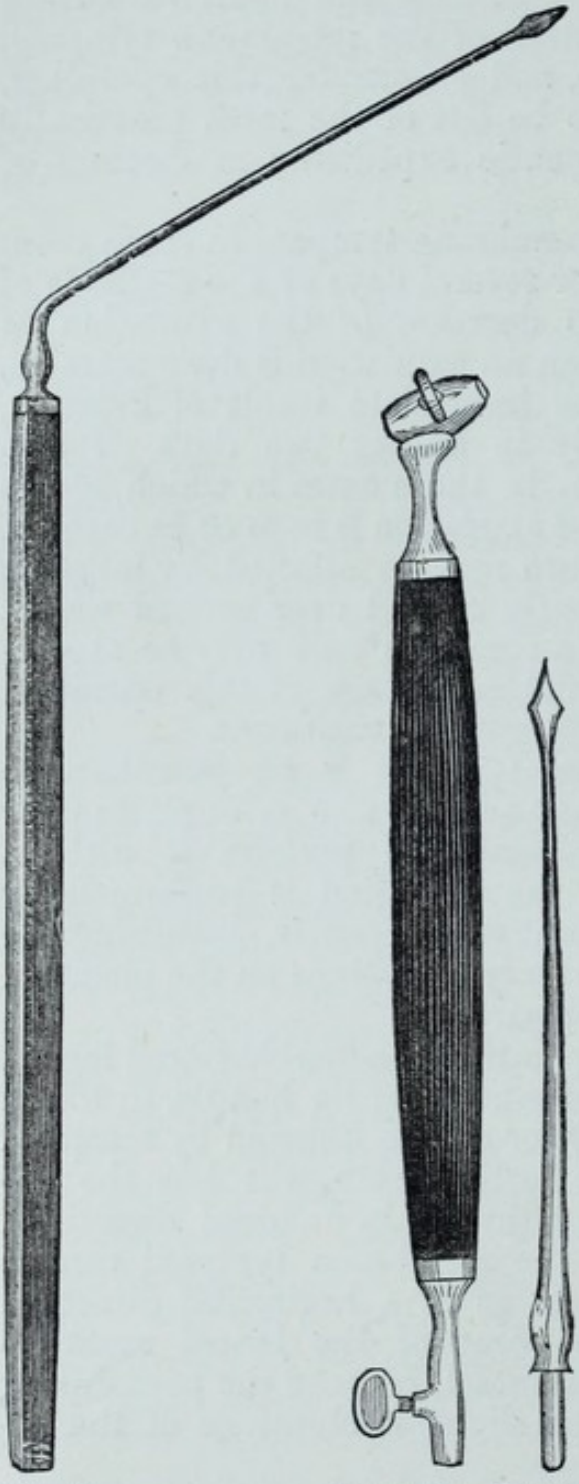

FIG. 99.—LANCET.

FIG. 100.—LANCET WITH ADAPTABLE HANDLE.

As regards the direction of the incision into the membrana tympani, it was formerly laid down as a rule, that it had always to be made parallel with the direction of the radiating fibres, because it was thought that their transverse section would render the re-union of the margins of the wound difficult. According to my experience, however, the direction of the incision has no influence on the duration of cicatrization. For less experienced operators, Bing proposes the use of a horizontal incision, because the walls of the external meatus are not so easily injured in making such an incision as in making a vertical one.

The operation itself is performed in the following manner: The head of the patient, who is seated, is fixed either by an assistant, or by placing it against a head-rest. A speculum as wide and short as possible is inserted into the meatus, and the membrana tympani is illuminated by favourable day-light, or in the absence of this, by the light of gas or a petroleum lamp. To have both

hands free during the operation, the light is thrown into the meatus by means of a forehead mirror.

While the speculum is fixed in the meatus with the fingers of the left hand, and the place on the membrana tympani where the incision is intended to be made is closely kept in view, the instrument, taken hold of by the handle with the thumb, forefinger and middle finger of the right hand, is introduced into the meatus as far as the membrana tympani, the layers of which are rapidly cut by lowering the point of the lancet, and while removing the instrument the incision is widened to 2-3 mm. The operation must be executed rather quickly, especially with children and nervous patients, but always without precipitation, because from a hasty introduction of the instrument, when the eye cannot follow its point, the external meatus is frequently incised instead of

FIG. 101.—VERTICAL INCISION IN FRONT OF AND BELOW THE HANDLE OF THE MALLEUS.

FIG. 102.—HORIZONTAL INCISION IN THE ANTERIOR INFERIOR QUADRANT.

the membrana tympani. Though the mucous membrane of the promontory be injured, no bad effect follows. But on the other hand, the success of the operation may be frustrated by the too great anxiety of the surgeon, as either all the layers are not incised, or the incision is too small for the escape of tenacious mucous masses.

The pain caused by the incision is slight and of short duration when a sharp-pointed lancet is used. Immediately after paracentesis in the somewhat gaping incision (the margins of which either do not bleed at all or only very slightly), a weak pulsation of the fluid or a distinct motion of it will be observed during speech or the act of swallowing. It is only rarely that a small drop of fluid exudes through the orifice to the external surface of the membrane; frequently, however, immediately after the operation, especially if the secretion is serous, several bubbles will be seen rising up behind the membrane during an act of swallowing, due to the entrance of air through the orifice. Sometimes a loud cracking noise will be heard in the ear during deglutition, when the margins of the perforation gape.

To remove exudation from the tympanic cavity after para-

centesis, it is necessary to inject air forcibly, and then the full effect of the operation is obtained. In some cases indeed, the secretion is pressed through the perforation into the external meatus by the Valsalvian experiment, but generally only a very small quantity is got out by that means. A powerful current of air must, therefore, be injected, and in almost all cases it will be possible to drive out the masses of secretion through the incision into the external meatus by means of my method, and that more completely than can be done by the catheter. Only in isolated cases, in which the resistance in the middle ear is very great (v. Tröltsch, Moos), or in which, in consequence of paresis of the muscles of the palate and of the Eustachian tube after diphtheria, their action becomes insufficient in the act of swallowing, will it be necessary to force the air through the catheter into the tympanic cavity. But it may happen that the secretion can be removed neither by the catheter nor by my method, while it is ejected by means of the Valsalvian experiment or more frequently still by blowing the nose violently. When executing the Valsalvian experiment, I have seen a partial escape of the secretion even when no air had penetrated into the tympanic cavity; the reason for this being that the hyperæmia and swelling of the lining membrane of the tympanum, produced by the Valsalvian experiment, are able without further aid to eject a portion of the secretion through the perforation, in consequence of the diminished capacity of the tympanic cavity.

The success of the operation depends chiefly on the complete removal of the secretion from the tympanic cavity. It is, therefore, advisable to apply my method three or four times in succession. Air and secretion pass into the external meatus, if the secretion is liquid, with a hissing and rattling noise; if the mucous masses are tenacious, however, either without any noise or with a grating sound. If the membrana tympani be then inspected, either it will be found covered with a frothy fluid, or a yellow or brownish mucous mass will be seen deposited at the end of the meatus. If there is only a slight quantity of tenacious exudation, the air frequently penetrates the perforation without ejecting it. On the other hand, if there are great masses of exudation, and if the incision in the membrana tympani has been made too small, the mucus is jammed into the orifice of the perforation, while a portion of it hangs out like a yellowish-green mass with a pearly lustre.

If in such cases it is impossible to withdraw the secretion from the tympanic cavity into the external meatus by repeated inflations, I employ rarefaction of air in the external meatus; and I also make use of this method for the removal of exudation from the tympanic cavity in those cases in which the catheter cannot be introduced into the Eustachian tube in consequence of malformations in the naso-pharynx. The method is as follows:

After paracentesis has been performed, the olive-shaped nozzle of the auscultation-tube is hermetically inserted into the external meatus by the patient himself. At the other end of the tube, from which the nozzle is removed, a small ear-syringe is inserted, and the air in the external meatus is rarefied by the gradual retraction of the piston. Sometimes it is sufficient to effect the rarefaction of air by withdrawing the air from the meatus with the mouth, or with a small suction-bag, such as has been proposed by Lucae for other purposes. By this manipulation the pressure in the external meatus becomes less than that in the tympanic cavity, and the secretion enters the external meatus either completely or in great part. The effect of this method may be increased by having the Valsalvian experiment executed during the rarefaction of air.*

The secretion that escapes into the external meatus flows off partially when the head is inclined towards the same side; frequently, however, it is necessary to remove it by means of small pellets of cotton wool, inserted with the bent forceps. Since serous secretion, as I have several times observed, flows partially back into the tympanic cavity after it has been propelled into the external meatus, I push a small pellet of wadding in front of the perforation, before propelling air for the second or third time, by which means the ejected secretion is absorbed, and cannot return into the tympanum. Tenacious mucus may be taken hold of with the bent forceps and pulled out. Injections of tepid water into the external meatus, which are recommended for the removal of mucus, but which may readily produce inflammatory irritation, should only be used in those cases in which the masses cannot be removed in any other way.

I am still more opposed to copious injections of solutions of common salt and soda through the catheter (v. Tröltsch), recommended for the liquefaction of tough mucous masses, because they frequently produce violent reactive inflammation by irritation of the mucous membrane of the middle ear and of the margins of the wound, from which protracted suppuration may follow. The same applies to forcible syringing of the tympanic cavity from the external meatus by means of a syringe, the olive-shaped nozzle of which is inserted hermetically into the external orifice of the ear. The mildest method of introducing a fluid to dissolve the mucus, by which reactive inflammation in the middle ear is not easily provoked, consists in carefully injecting a few drops of tepid water or a weak solution of soda by means of the tympanic catheter, the point of which is pushed through the

* In some cases, in which on account of cicatricial adhesion of the soft palate to the posterior and lateral wall of the pharynx and stricture of the Eustachian tube, the introduction of the catheter was impossible, I removed the secretion from the tympanic cavity by inserting the point of the tympanic catheter from the meatus through the perforation into the tympanic cavity, and then blowing air into it with the mouth, when the secretion was forced from the tympanic cavity into the external meatus.

perforation into the tympanic cavity. If the patient is too restless for this, a few drops of the solution may be instilled into the meatus, and forced into the tympanic cavity by pressing the tragus against the orifice of the ear.*

Immediately after paracentesis, and frequently even before the removal of the secretion, relief is felt in the ear in consequence of the slackening of the membrana tympani, and a remarkable improvement in the hearing may at once be discovered, which increases after the removal of the secretion from the tympanic cavity.

The union and closure of the margins of the incision frequently take place after a few hours, but generally only after twenty-four hours (Schwartze), rarely only after three or four days. Consecutive inflammation of the membrana tympani and of the mucous membrane of the middle ear, which others have reported so frequently, I have observed very rarely in the great number of cases operated on by me (in above 1500 cases only four times, in which there was once thickening of the membrana tympani, once pulmonary tuberculosis), although the operation was frequently performed in winter in patients going about as usual.

To avoid all sources of danger, which might produce inflammation of the membrana tympani, the meatus must be kept closed with cotton-wool on the day of the operation, the patient must abstain from all heavy, heating work, and from exciting spirituous liquors; he must also avoid rapid changes of temperature and close and smoky rooms.

If the membrana tympani be inspected on the day after the operation, its colour will be seen to have changed from a dark yellowish to a light tendinous grey; the membrane will be less drawn in, and the perforation will be indicated by a blackish streak of blood; after some time every trace of the operation disappears, it being very unusual for even a small cicatricial depression to remain at the spot where the incision was made.

As regards the curative effect of paracentesis, I have observed in more than one-third of the cases operated on, especially in those of recent origin, a complete cure after once performing the operation. Sometimes the cure did not occur until several days had elapsed, during which Politzerization was regularly applied. These are cases in which the exudative process had already ceased, the hardness of hearing being caused by the mechanical action of the exudation alone.

In cases in which the effusion from the mucous membrane of the tympanic cavity still continues, especially when there is great

* I cannot recommend injections by means of Pravaz's syringe with a stiff nozzle, on account of the mechanical irritation of the membrana tympani. Drawing the mucus from the tympanic cavity with a small syringe, as recommended by Toynbee, Hinton, and others, is practically worthless, because even by repeated attempts only a small portion of the secretion is withdrawn.

permanent swelling of the tube, in a short time another accumulation of exudation in the tympanic cavity will take place, so that paracentesis has to be repeated several times. I look upon it as a favourable sign when after the first operation tenacious mucus, and at subsequent repetitions serum, is discharged.

The preservation of the permeability of the Eustachian tube by means of Politzerization, and the local treatment of naso-pharyngeal catarrhs, if such exist, are of importance in preventing relapses. What influence repeated inflation of air after the operation has upon the course of the disease, may be seen from the fact that in cases in which two or three days after the operation a slight quantity of exudation, distinguishable by the line of its level, had again been formed, it was made to disappear after applying my method several times.

It is therefore absolutely necessary, in order to maintain the improvement that has been effected, to continue the injection of air by my method after the operation for several months, at first two or three times a week, later on once every eight or fourteen days; and in cases in which circumstances do not permit of the surgeon doing this himself, to let the patient perform the manipulation after due instruction.

If no constant improvement in the hearing is effected in spite of the thorough removal of the secretion and regularly continued Politzerization, this may be traced, provided a repeated accumulation of secretion can be excluded, either to a continuance of the tumefaction of the mucous membrane of the Eustachian tube and of the tympanic cavity, or to an anomaly of tension of the membrana tympani, which has developed in the course of the catarrh. It is not difficult to distinguish the above-named conditions. For while in the first case we find indications of the continuous excessive tumefaction of the mucous membrane of the tube partly in the great resistance which is opposed to the air injected into the tympanic cavity, partly in the previously (p. 135) described rough, crackling and interrupted auscultation noises, we infer an anomaly of tension of the membrana tympani in cases in which no swelling and secretion exist if the air enters the middle ear with slight pressure, if the inwardly curved, thinned membrana tympani is strongly bulged forward, and the remarkable improvement in the hearing disappears again, when the membrane sinks back to its previous position.

Lastly, want of success after the removal of the secretion from the middle ear may be caused by permanent changes in the tissue already present in the mucous membrane of the middle ear. For even if, as experience shows, the adhesive processes emanating from catarrhs frequently develop only after the secretion has ceased, it occurs on the other hand often enough that even during the discharge of secretion, thickening of the mucous membrane, rigidity of the articulations of the ossicula and

adhesions take place. The existence of such changes may with probability be inferred if after the removal of the secretion, as well as after repeatedly injecting air, no material improvement in the hearing results after several days. If besides that there are subjective noises, which are not altered by paracentesis, it is hardly doubtful that in such a case we have to deal with a process of condensation at the fenestræ of the labyrinth.

Concerning the treatment of those catarrhs in which the tumefaction of the mucous membrane of the tube continues in spite of repeated injection of air after paracentesis, and the improvement effected in the hearing disappears again in a short time, we must first note whether this swelling is connected with a simultaneous tumefaction of the mucous membrane of the naso-pharynx. If so, both conditions must be treated; for treatment applied solely to the ear will give only temporary relief. Referring the reader as regards the treatment of naso-pharyngeal affections to the detailed description in the next section, I will here briefly survey the results of my experience respecting the local medication of the mucous membrane of the Eustachian tube and of the tympanic cavity during swelling and secretion.

Substances employed for the removal of catarrhal swelling are introduced into the middle ear either in the form of vapours or gases (p. 142) or as medicated solutions (p. 138), or the diseased mucous membrane may be treated by the introduction of medicated bougies into the Eustachian tube.

With regard to steam, which has been much recommended, I have proved experimentally (p. 144) that a portion of it is precipitated in the conducting-tube and in the catheter, and another portion at the narrowest part of the Eustachian tube, and that less of the steam reaches the tympanic cavity, the greater the tumefaction of the mucous membrane of the tube and the narrower the stricture of the canal caused by it. We have to deal therefore in this kind of medication with the introduction of small quantities of warm water into the middle ear, the action of which is chiefly directed to the mucous membrane of the tube.*

Steam very frequently causes a sensation of pressure and fulness in the ear, an increase of the subjective noises and a temporary aggravation of the hardness of hearing in consequence of an increase of the hyperæmia and swelling of the mucous membrane of the tube. In cases of great secretion its action, even if only temporary, is rather detrimental. But in a few cases, in which with demonstrably great swelling of the tube, only a slight secretion in the middle ear was ascertained by paracentesis, I saw a favourable result from steam, when it was applied alternately with simple injection of air after my method.

* The temperature of the steam can be increased to 40°—50° R., and it is introduced for several minutes by intermittent currents of air. The precautions recommended by v. Tröltsch to prevent a burning sensation in the nose are superfluous, if instead of a metal catheter one made of vulcanite is employed.

Of the drugs applied in vapour-form, sal-ammoniac vapours are much recommended as a remedy for catarrhal affections of the middle ear. In cases of great swelling in the tube they also are for the most part precipitated in the Eustachian tube, and act therefore only upon its mucous membrane, and only reach the tympanic cavity in a fluid state, if strong currents of air are applied. V. Tröltsch recommends sal-ammoniac vapours in the nascent state, which, according to his statement, act much more favourably than vapour which has been developed by heating sal-ammoniac (p. 142).

Besides a sensation of fulness, warmth and burning in the ear, sal-ammoniac vapour produces an itching in the throat and an irritative cough, which frequently makes the application of this remedy troublesome. The irritation of the mucous membrane causes immediately an increased discharge in the Eustachian tube and in the adjoining portions of the pharynx, but I cannot confirm the statement that the vapour liquefies tenacious secretions in the middle ear, and its application preparatory to paracentesis is therefore superfluous. The curative action of sal-ammoniac vapour is lauded by v. Tröltsch, especially in those catarrhs in which an increased discharge from the mucous membrane of the middle ear may be diagnosed by continuous rattling noises during catheterism. My experience is not so favourable. On the contrary, I have found that in cases of increased secretion and accumulation of exudation in the middle ear, an aggravation took place after frequent application of this vapour. In cases, however, in which only a slight quantity of mucus was found after paracentesis, and the swelling in the tube did not subside although air was regularly injected, I have observed favourable results from sal-ammoniac vapour if its introduction was alternated with Politzerization. The effect must be ascribed to the slight reaction produced by the sal-ammoniac particles, which in cases of chronic swellings favourably influences the further course of the affection in so far as the curative action of the propelled air takes effect more rapidly after the application of the vapour. This irritation can be effected in a much simpler and more convenient manner by the injection into the tube of a few (5-6) drops of a concentrated solution of sal-ammoniac (1-10) or of a solution of soda (3-10), and the injection of these solutions often proves to be still more effective than the introduction of vapour.

In preference to steam and sal-ammoniac vapour, I employ in cases of swelling in the middle ear the vapour of turpentine or of ol. pini æther. but only when, after the removal of the exudation from the middle ear, the swelling in the Eustachian tube cannot be lessened by injecting air alone. The application of these vapours is very simple, as it is sufficient either to draw them from a small bottle by means of the inflating-bag (p. 143), or to

instil a few drops of the fluid into the bag, and to press the rapidly forming vapour into the middle ear through the catheter. These also produce slight irritation and a feeling of warmth in the ear, and after treatment for several weeks, not unfrequently effect a rapid subsidence of the swelling of the mucous membrane of the tube, if they are applied alternately with simple inflation of air by my method (2-3 times a week). As already remarked by v. Tröltsch, the effect of carbonic acid gas, formerly much used, is but slight. Yet I have observed in some cases, in which only a slight improvement was produced by the above local treatment (vapours and injections), that the course of the disease took a favourable turn after the application of carbonic acid. In obstinate cases, therefore, this gas may be experimentally introduced, the more so because its preparation and application is very simple, and can be effected without any special trouble in the manner indicated in the general division (p. 144).*

Injections of medicated solutions have a very variable result in the secretive forms of catarrh of the middle ear. On the whole it may be said that as long as a copious discharge takes place, and the secretion is accumulated in the tympanic cavity, injections into the middle ear are of little service; indeed, they frequently aggravate the affection. They are more rarely applied in this form of catarrh than in the adhesive processes, to be described later on, in which an irritation of the mucous membrane and a tumefaction of the connective tissue are provoked by them. I use them in the secretive forms of catarrh only when no constant improvement in the hearing is effected after applying my method for eight to fourteen days, when accumulation of secretion can be excluded owing to the absence of the symptoms already described, or when, after the removal of the secretion from the middle ear, the swelling and impermeability of the Eustachian tube continue. In this case the injections act most favourably when the remedy is allowed to act, only upon the mucous membrane of the tube, as in cases in which the fluid penetrates into the tympanic cavity an aggravation is not unfrequently observed. To confine the remedy to the tube only, it is sufficient, after previously injecting air, to throw eight to ten drops of the solution into the catheter by means of Pravaz's syringe, then to incline the head to the side and a little backwards, when the fluid escapes from the catheter into the Eustachian tube; or, with the head in its normal position, the fluid is blown with the most gentle pressure possible (in the simplest manner with the mouth) into the tube. In this way concentrated solutions of sulphate of zinc (0·2-10) or of

* When judging the effect of vapours and gases we must bear in mind that their introduction always takes place with a certain pressure of air. The improvement effected in the hearing must therefore not be ascribed exclusively to the action of the drug, but to a great extent to the currents of air acting upon the middle ear.

argill. acet. Burowii * may be introduced into the Eustachian tube, to cause subsidence of the swelling of the mucous membrane by their astringent action. According to my experience in obstinate cases, the astringents will have a favourable effect as regards the permeability of the tube only when their application is preceded by several irritating injections of a solution of sal-ammoniac or bicarbonate of soda (p. 293).

In the treatment of catarrhs of the middle ear, we must not, however, confine ourselves exclusively to the application of injections, because very frequently the affection is aggravated by them. They only prove effective when they are applied alternately with Politzerization or catheterization. In these cases it will be observed that, as a rule, not only immediately after the injection, but also during days following it, the hearing-distance does not increase, but may rather decrease, and that the improvement in the hearing will always take place in a noticeable manner only when inflating air is alternated with the injections. In this treatment it is advisable to make a pause of one day between injection and inflation, and also between inflation and injection. If an aggravation of the affection is noticeable after the injections combined with inflations, the latter must again be exclusively employed.

I have previously mentioned that medicated substances may also be applied to the swollen mucous membrane of the tube by means of bougies. This kind of treatment has recently been much practised in America (Albert H. Buck). In my practice I confine myself to the application of bougies (thin violin-strings), which are impregnated with a concentrated solution of nitrate of silver, then dried and pushed through the catheter as far as the isthmus tubæ, and left there for five to ten minutes. I have applied them with a very favourable result in those cases of excessive swelling of the mucous membrane of the tube, in which, in consequence of the great resistance in the tube, Politzerization was impossible, and during catheterism the air could only with great difficulty be pressed into the tympanic cavity, and in which also no subsidence of the swelling of the mucous membrane was produced by injections and vapours. I found in such cases that after the bougie had been introduced three or four times (every second or third day) the permeability of the tube for inflation by my method had been effected.

As I was the first to mention (*Beleuchtungsbilder des Trommelfells*, 1865, p. 92), it is important not to prolong the duration of the treatment of catarrhs of the middle ear beyond a certain time. Experience shows that when, after treatment for several weeks (four or five) by propelling air after my method, or through the catheter, or by injections combined with propelling air, a certain degree of improvement in the hearing has been effected,

* Alum. crudi 70·0 ; Solv. in aqua dest. 280·0 ; Plumb. acet. cryst. solve in aqua dest. 280·0 ; Liqu. mixt. filtra et dilue pond. 800·0. Serv. in vitr. bene clauso.

which does not increase after a continuance of the treatment, an aggravation will take place if the treatment is uninterruptedly persevered in, and the improvement in the hearing which was effected in the beginning will gradually disappear again. Generally a regular treatment of from three to five weeks is sufficient, in which space of time either a cure takes place, or the utmost possible improvement in the hearing is reached. When treatment has ceased, an interval of rest of several weeks (one to six), according to the more or less rapid decrease in the hearing-distance, must always follow, after which, by a rational after-treatment, either a complete cure or a considerable improvement may be effected.

The most important point to be borne in mind during the after-treatment is to keep the tube permeable, because very frequently, even after complete restoration of the hearing-power, slight swellings in the tube remain, and the canal again becomes impermeable from some trifling irritation of the mucous membrane of the naso-pharynx, especially in chronic cases.

Aural surgeons recommend even at present the Valsalvian experiment in the after-treatment of catarrh of the middle ear. But from my experience I must pronounce against it. As the experiment can be conveniently performed, the patient presses air into the tympanic cavity frequently for months several times daily, and is induced thereto by the temporary increase in the hearing-distance which follows each operation. But the more frequently this experiment is performed, the slighter becomes the improvement in hearing, and the slighter also is the duration of this improvement; the hardness of hearing increases more and more, assuming at last a high degree if the application is uninterruptedly continued, as I have frequently observed in patients to whom the frequent performance of the Valsalvian experiment had almost become a habit.

My method for making the Eustachian tube permeable, however, is specially suitable for the after-treatment. By now and then opening the canal and ventilating the tympanic cavity, not only are relapses prevented, but even a considerable improvement in the hearing is effected. Propelling air with the inflating-bag may be performed by the patient himself, after due instruction, but at certain intervals only. For I have repeatedly pointed out in my previous works, that just as by the uninterrupted application of the Valsalvian experiment or of catheterism, by a daily, unremitting use of my method the affection may also be aggravated, and v. Tröltsch reproves with justice the thoughtlessness of those specialists who hand the inflating-bag to the patient without drawing his attention to the consequences of a too frequent use of it. At the most it must be performed two or three times a week, and after an application of from three to four weeks, intervals of one, two, or three months must follow,

when, if a decrease in the power of hearing is noticeable, inflating air in the same manner must be repeated.*

Lastly, the circumstances in which the patient lives, and the state of his general health, have to be taken into consideration in the treatment of catarrhs of the middle ear. In the first place the patient must as much as possible avoid injurious influences due to occupation and to living in damp and close localities. The frequent ventilation of his rooms, the avoidance of close and smoky localities, and plenty of exercise in the open air, if the weather is favourable, must be strongly recommended to him. The diet must be regulated according to the individual circumstances, but the use of wine and beer must be limited to small quantities, and smoking must be greatly restricted. Tepid-baths once or twice a week have often a favourable influence on the course of catarrh; but in cold weather these baths must always be taken at home. Cold-baths and sea-bathing, however, not unfrequently give rise to an aggravation of the affection, and the attention of the patient must specially be drawn to the injurious action of cold douches upon the head, and of diving in the bath. To prevent the entrance of water into the ear when taking river-baths, it is advisable to close the meatus with a plug of cotton wool steeped in oil, and also to limit the action of the cold water upon the head by an oil-skin cap covering the auricles.

Change of air and residence in a mountainous country have a very favourable influence upon the course of the secretive forms of catarrh. In patients in whom the local treatment, continued for months, remained without result, I have observed pretty often a complete cure when they left the town and lived for several months in a mountainous district. In obstinate cases, especially in weakly, anæmic, and scrofulous people, if circumstances permit, it is therefore always advisable to send the patient into a woody or mountainous district when the warm season comes round. If a constitutional affection exists, the result will be still more favourable if hydropathic treatment is combined with residence in the country; for scrofulous persons the brine-and-iodine-baths of Ischl, Kreuznach, Hall (iodine-baths in Upper Austria), Lippik (iodine-baths in Croatia), Iwonicz (Galicia); for anæmic cases the chalybeate wells of Franzensbad, Marienbad, Spaa, Pyrmont, Szliacs (Hungary); for syphilitic people, also, the above-named iodine-baths, and the sulphur wells of Baden near Vienna, Aix-la-Chapelle, Pystjan (Hungary). It is a matter of course that in these constitutional affections the local treatment of the ear-disease must be assisted by suitable internal medication, but we

* In children who, on account of impeded respiration through the nose, always breathe with the mouth open, it is advisable to give instruction to close the mouth several times a day for ten to fifteen minutes, and to breathe through the nose. In this way not only does the nose become more permeable, but the Eustachian tube also is ventilated by the current of air in the upper space of the pharynx (Lucae).

cannot discuss this more in detail, because it belongs to the province of the physician.

The catarrhs of the middle ear, which are combined with prolonged impermeability of the Eustachian tube, cause, as already mentioned, in consequence of the preponderance of the external pressure of air and of the continuous weighting of the membrana tympani, a strong inward curvature and stretching and thinning of the membrane. The abnormal tension and change of position of the membrane and of the ossicula, caused by this, may disappear after the pathological process in the mucous membrane of the middle ear has ceased, and the tension of the sound-conducting apparatus may return to its normal state. Frequently, however, there remains after the Eustachian tube has been made permeable, and after the pathological process has ceased, an anomaly in the tension of the membrana tympani, caused by excessive stretching, which produces hearing-disturbances of different degrees.

I have already remarked, that changes in the tension of the membrana tympani are frequently observed without deafness. Experience shows, however, that beyond a certain degree the anomalies in the tension of the membrana tympani may by themselves act as hindrances to the conduction of sound. Now in cases in which exudation no longer exists in the middle ear, in which the air enters into the tympanic cavity with even a slight pressure and without abnormal auscultation-sounds (without rattling or interruption), in which the depressed membrana tympani is more curved outwards on inflation than in the normal state, and a considerable improvement in the hearing takes place, which disappears again when the membrane gradually sinks back towards the inner wall of the tympanic cavity, it may be concluded, after observation for several days, that the constantly returning deafness is produced by the abnormally decreased tension of the membrana tympani.

Besides the facts here noted, the result of an inspection with Siegle's speculum is of importance in the diagnosis of these anomalies of tension of the membrana tympani. I have already (p. 269) pointed out the great difference in the mobility of the membrane before and after the Eustachian tube has been made permeable, if examined by means of Siegle's speculum. In the anomalies of tension, now under discussion, during the ordinary ocular inspection we may certainly infer abnormally decreased tension of the membrane from the great excursions during the Valsalvian experiment and during the act of swallowing (with closed nostrils); the great mobility of the membrane will, however, appear most remarkable when the pneumatic speculum is used, an instrument which is indispensable for the diagnosis of anomalies of tension, as has already been stated in the general division (p. 103).

In some cases a pathological condition is added to the changes

in tension, produced by the stretching of the membrane, which, as I was the first to point out, develops after protracted impermeability of the Eustachian tube, and may of itself even cause considerable deafness. This is secondary retraction of the tendon of the tensor tympani.

For I have proved* that, in consequence of the inward curvature of the membrane, the point of attachment of the tendon is brought nearer to the inner wall of the tympanic cavity, and the whole tendon is thus slackened. The result of this slackening is a retraction and shortening of the tendon, by which the malleus, and with it the whole ossicular chain, are drawn inwards and kept tightly stretched. We are, however, justified in diagnosing retraction of the tendon of the tensor tympani only when the great improvement in the hearing, which takes place immediately after air has been propelled, disappears again in a few seconds. The assumption that this rapid decrease of hearing is caused by the absorption of the air is not admissible, because the relatively great quantity of air injected cannot possibly be absorbed in a few seconds. It is rather probable that by the outward curvature of the membrane after air has been propelled, the retracted tendon of the tensor tympani is stretched, and that a considerable improvement in hearing is thereby effected, but that next moment the improvement completely disappears by the rapid retraction of the tendon.

In the treatment of these anomalies of tension, simple repeated Politzerization will frequently suffice, especially in cases in which the preceding catarrh was not of long duration, to re-establish the membrana tympani in its normal position. If, however, notwithstanding that the tube is again permeable and Politzerization is frequently repeated, the improvement which takes place after every such manipulation always disappears again, it is first of all advisable to assist the effect of the inflation by rarefaction of the air in the external meatus.

Rarefaction of air in the external meatus for therapeutic purposes was practised by the older aural surgeons, but fell out of use. Cleland (1741) recommended drawing the air out of the meatus.† Another intimation I find in Hannemann *Misc. Nat. Cur.*, Dec. 2.‡ 'A surgeon,' he says, 'who introduced the thin end of a tobacco-pipe far into the ear-passage, then applied the thicker portion of the pipe to his mouth, and sucked it with great vigour, so that the patient felt a pain in the ear through this sucking process, cured several deaf persons by this method, and gave them back the power of hearing.'

Lately, rarefaction of air in the external meatus has again been employed as a means of treatment, and several methods have

* *Beleuchtungsbilder des Trommelfells*, 1865.
† Linke's *Sammlung*, vol. v., 1844, p. 44. Quoted from v. Tröltsch's *Lehrbuch*, 1877.
‡ Quoted from F. Niceus, *Ueber das schwere Gehör*, 1794.

been recommended for its performance. The apparatus proposed by Moos (*l. c.*) is a simple syringe, the thick conical nozzle of which is covered with a short india-rubber tube, to fit hermetically into the external meatus. This apparatus is, however, not well suited for practical use, because ecchymosis and bleeding in the external meatus and on the membrana tympani, indeed even rupture of the membrane, may be caused by a somewhat rapid rarefaction of air.

Recently, Lucae* has recommended for 'deep hearing' continuous negative pressure of air, acting upon the external surface of the membrana tympani; for 'high hearing' positive pressure of air.† For this he uses a mushroom-shaped india-rubber bag provided with an india-rubber tube; before the insertion of the nozzle of the tube into the external meatus weights of 100 to 200 grammes are placed on the bag, and by gradually taking these away the air in the external meatus is rarefied, while it is condensed by replacing them. This tedious manipulation is, however, unnecessary, as simple compression with the fingers is quite sufficient. I use for the rarefaction of air a small round balloon about 6 to 7 ctm. in diameter, with which is connected an india-rubber tube 30 ctm. long, the free extremity of which is provided with an olive-shaped nozzle, fitting exactly into the meatus. The rarefaction of air is effected by first compressing the balloon with two fingers, then fitting its nozzle hermetically into the external meatus, and then gradually relaxing the compression, a procedure which may be repeated four or five times at one sitting.

By the rarefaction of air in this way there is not unfrequently a noticeable, but rarely a permanent, improvement in the hearing effected by it alone. But I can warmly recommend the application of this method of rarefaction of air combined with Politzerization. For the improvement in the hearing effected by injecting air is not only frequently increased by rarefaction of air in the external meatus, but also becomes more constant; the subjective noises often cease completely for some time, or are greatly lessened and less troublesome (Hedinger); but the most remarkable change is the very considerable subjective relief in the ear and in the head, which gives a special value to this method in the treatment of the catarrhs of the middle ear.

A gradual rarefaction of the air in the external meatus is effected by the hermetical occlusion of the external meatus, recommended by me. For I have proved‡ by manometrical experiments, that when the external meatus is hermetically closed, the action of the external air-pressure upon the membrana

* *Berliner Kl. Wochenschrift*, 1874.

† In chronic affections of the middle ear a relatively greater power of perception for high tones, with a decreased perception for low tones, is often observed; the reverse is much rarer.

‡ *Wiener med. Wochenschrift*, 1867.

tympani is suspended and the inward collapse of the latter is prevented.

The external meatus is closed in the most simple manner with cotton-wool moistened with oil and shaped into a plug of the size of a hazel-nut. This is forced into the external orifice of the ear with a moderate pressure, only so far that the external portion of the cartilaginous canal is filled by it. The meatus may be considered as hermetically closed when a loudly-ticking watch, which was formerly heard at a distance, is only perceived in contact with the auricle. It is most convenient for the patient to perform the occlusion in the evening and to remove the plug again in the morning. This manipulation is continued two or three times a week for two or three weeks, in which space of time the positive or negative result of the treatment may be ascertained.

Regarding the effect of hermetical occlusion the same may be said as of rarefaction of air with the suction-bag, only the favourable symptoms are less rapidly developed, while frequently more lasting. The greater constancy of the hearing-distance when applying this treatment, and the more frequent decrease of the subjective noises, are facts sufficiently favourable to justify the application of this simple and easily performed manipulation, by which in many cases the local treatment of catarrhs of the middle ear is greatly assisted.

The rarefaction of air in the external meatus will have a lasting result chiefly in those cases in which it is possible for the stretched membrane to recover its former power of resistance. When, however, the membrane is already in an atrophied condition, the deafness caused by this slackening will not be removed in this way. For such cases I recommended an operation in 1871,* which in my subsequent experience had a favourable result in a number of cases. This is the repeated incision of the tissue of the membrana tympani by means of the doubled-edged lancet used for paracentesis of the membrane. The operative manipulation is similar to that of paracentesis. The place where the incision has to be made is midway between the handle of the malleus and the periphery of the membrane, and I perform the operation four or five times at intervals of two or three days. The size of the incision is 1-2½ mm. As a rule, after twenty-four hours, cicatrization of the margins of the wound takes place, and after the operation I have never observed any great reaction or suppurative inflammation on the membrane.

The therapeutic effect of repeated incision is very variable. In a number of cases the inward curvature of the membrane is lessened, the hearing-distance demonstrably increases, and the improvement in the hearing is more constant. I believe this effect may be traced to a slight adhesive inflammation in the neighbourhood of the incision, by which the tissue of the mem-

* *Wiener med. Wochenschrift*, 1871, and *Wiener med. Ztg.*, 1872.

brane improves in consistency and firmness, and the membrane becomes more suitable for the reception and propagation of the waves of sound. In other cases, however, in spite of several incisions into the tissue of the membrane, no noticeable increase in the hearing-distance is effected; or if an improvement in the hearing takes place, it only lasts for a short time. But yet this operation may be performed in all cases in which it may be inferred that a hearing-disturbance is caused by the abnormally decreased tension of the membrane, for no injurious effect has been seen to follow this method of treatment. With regard to the results of section of the posterior fold of the membrana tympani, first proposed by me, I will give a detailed report in the second portion of this division.*

c. The Diseases of the Naso-pharynx and of the Nasal Cavity with Reference to the Diseases of the Middle Ear.

As is well known, the diseases of the naso-pharynx and of the nasal cavity are not only frequently the forerunners of affections of the middle ear, but also exert an important influence upon the course and results of these affections, as v. Tröltsch has specially

* J. M. G. Itard, *Traité des Maladies de l'Oreille et de l'Audition*, Paris, 1821; Deleau, *Traité du Cathétérisme de la Trompe d'Eustache et de l'Emploie de l'Air atmosphérique dans les Maladies de l'Oreille moyenne*, Paris, 1838; W. Kramer, *Die Erkenntniss und Heilung der Ohrenkrankheiten*, Berlin, 1849; Rau, *Lehrbuch der Ohrenheilkunde*, 1856; Bonnafont, *Traité Théorique et Pratique des Maladies de l'Oreille*, Paris, 1860; Toynbee, *Diseases of the Ear*, London, 1860; v. Tröltsch, *Lehrbuch der Ohrenheilkunde*, 1877; Moos, *Klinik der Ohrenkrankheiten*, 1866; A. Politzer, *Diagnose und Therapie der Ansammlung seröser Flüssigkeit in der Trommelhöhle, Wien. med. Wochenschrift*, 1867; H. Schwartze, *Studien und Beobachtungen über die künstliche Perforation des Trommelfells, Archiv für Ohrenheilkunde*, vols. ii. iii. vi.; A. Politzer, *Ueber bewegliche Exsudate in der Trommelhöhle, Wiener med. Presse*, 1869; Gottstein, *Klinische und kritische Beiträge zur Ohrenheilkunde, Arch. f. Ohrenheilk.*, vol. iv.; A. Politzer, *Therapie der beweglichen Exsudate in der Trommelhöhle, Wiener med. Wochenschrift*, 1870; E. de Rossi, *Le Malattie dell' Orecchio*, Genova, 1871; Lawrence Turnbull, *A Clinical Manual of the Diseases of the Ear*, Philadelphia, 1872; S. Duplay, *Traité de Pathologie externe*, par Follin et Duplay, 1873; A. Politzer, *Seltener Fall eines einfachen chron. Mittelohrcatarrhs, Arch. f. Ohrenheilk.* vol. vii.; St. J. Roosa, *A Practical Treatise of the Diseases of the Ear*, New York, 1873; Zaufal, *Vorkommen seröser Flüssigkeit in der Paukenhöhle, Arch. f. Ohrenheilkunde*, vol. v.; Schurig, *Die Paracentese des Trommelfells, Jahresb. d. Dresd. Ges. f. Natur- und Heilkunde*, 1869-70; Moos, *Ueber seröse Ansammlungen in der Paukenhöhle, Arch. f. Augen- und Ohrenheilkunde*, vol. i.; Fr. E. Weber, *Ueber Secretionen und Ansammlungen von Flüssigkeiten in der Paukenhöhle, deren Wesen, Diagnose und Therapie M. f. O.*, 1869; A. H. Buck, *Mucus in the Cavity of the Tympanum; Transactions of the American Otological Society, C. A. M.* 385; A. Politzer, *Ueber luftdichte Obturation des äusseren Gehörganges als Heilmittel bei chronischen Mittelohrcatarrhen, Wiener med. Wochenschr.*, 1867; Lucae, *Neuer Zusammenhang zwischen Nasen- und Ohrenkrankheiten, Archiv f. Ohrenheilkunde*, vol. iv.; A. H. Buck, *A Method of Using Medicated Eustachian Bougies, Transactions of the Amer. Otolog. Society*, 1875; Pagenstecher, *Bemerkungen zur Balneotherapie der Ohrenkrankheiten, Arch. f. Ohrenheilk.* vol. i.; A. Bing, *Zur Paracentese des Trommelfells, Allg. Wiener med. Zeitung*, 1877; C. Miot, *De la Myringodectomia ou Perforation artificielle du Tympan*, Paris, 1877; E. de Rossi, *VI. Anno di Insegnamento della Otojatria; Cenni Statistico-clinici per l'Anno scolastico* 1876-77, Roma, 1877.

pointed out. We have seen that by the extension of an acute naso-pharyngeal catarrh up the Eustachian tube not only may swelling of the tube, with increased secretion, be developed, but that the inflammation frequently also spreads as far as the tympanic cavity and the mastoid process.

Experience teaches that when the naso-pharyngeal affection ceases the consecutive inflammation in the middle ear often also subsides, but that in a number of cases the inflammatory swelling and secretion in the middle ear continue, with the development of all the consequences which I have already enumerated. On the other hand, in secondary or even in primary affections of the middle ear, the inflammatory process, especially the swelling in the Eustachian tube, is maintained and recovery hindered by complication with or continuance of a naso-pharyngeal affection. From this may be seen the importance of a minute examination of the naso-pharynx, and the employment of rational treatment for the removal of an existing naso-pharyngeal affection, as one of the principal conditions for effecting a favourable result in the numerous obstinate diseases of the middle ear thus complicated.

Before proceeding with the description of the methods of examination of the naso-pharynx and of the nasal cavity, it is necessary first to discuss briefly the pathological changes which occur in the naso-pharynx.

The inflammatory processes in the mucous membrane of the naso-pharynx are generally analogous to those changes which are observed during catarrh of other mucous membranes.

Acute naso-pharyngeal catarrh is characterized by great hyperæmia and swelling of the mucous membrane, which at the commencement is accompanied by the discharge of a serous, watery, and later on of a glairy tenacious mucus. Under normal conditions the course of the acute swelling is short, as after several days (sometimes, however, only after several weeks) the mucous membrane returns to its normal state. In other cases, however, in consequence of external or constitutional influences, the swelling and secretion permanently remain, and the so-called naso-pharyngeal catarrh is developed, which may continue for months or years either with almost uniform intensity or with frequent fluctuations. Indeed, there are persons who are affected with a chronic naso-pharyngeal catarrh during their whole lifetime, and for whom all treatment proves fruitless.

The anatomical changes in chronic inflammation of the mucous membrane of the naso-pharynx consist of parenchymatous swelling and increase in bulk of the membrane, in which its several elements participate to a various degree. Besides hyperæmia and serous infiltration of the tissue, a deposit of cells in the connective-tissue basis and in the submucous tissue of the mucous membrane will, as a rule, be found. These cellular deposits may be transformed into connective tissue,

thereby producing induration of the mucous membrane, or what happens much less frequently, they may give rise to purulent infiltration (phlegmonous inflammation) and the formation of abscesses. The adenoid (His) or cytogenous (Kölliker) tissue, which is contained in the stroma, partly diffusely, partly in accumulations at different places (follicles), as a rule participates to a great extent in the swelling. By the projection of the swollen follicles above the surface of the mucous membrane, the appearance of the granular inflammation of the follicles is produced.

By the excessive growth of the adenoid substance, the so-called adenoid vegetations arise, the relations of which to the affections of the middle ear were first discussed in detail by W. Meyer (of Copenhagen).

From numerous observations he has proved, that on the superior posterior pharyngeal wall, where the mucous membrane structure is situated, which Luschka describes under the name of pharyngeal-tonsil, as well as at other parts of the superior pharynx, growths develop in consequence of chronic inflammation, which on microscopical examination show the peculiarities of the adenoid tissue described by His. For in these growths, besides the enlarged mucous glands, enlarged closed cysts will also be found, and the network of the connective tissue basis is interspersed with a large number of so-called lymphoid corpuscles. The vegetations are either comb-like or tongue-shaped, or they have a strobiliform or globular shape, and are mostly found on the superior pharyngeal wall, from which they not unfrequently extend as far as the posterior nares, and thereby impair the permeability of the nasal cavity.

Besides these changes in the posterior pharynx in chronic catarrhs, not unfrequently an enlargement of the grooves and depressions in Rosenmüller's cavity will be observed, also cysts from the size of a hemp-seed to that of a pea, filled with colloid fluid, the walls of which coalesce, and after discharging their contents into the pharynx, form bridge-like striæ, which give to Rosenmüller's cavity a trabecular appearance.

The affections of the nasal cavity are in immediate connection with the diseases of the naso-pharynx, as they appear generally simultaneously in both parts, and if the pathological process remains in the one, the cure of the other will be retarded. Therefore the pathological relations of both parts must be discussed.

In acute as well as in chronic catarrh, the lower spongy bones show generally the greatest swelling. These are of a cavernous structure, as described by Kohlrausch, which character favours the production of great swelling. Sometimes their convex surfaces are strongly bulged out, the swelling readily yielding to pressure with the probe, while in other cases the swelling is

chiefly found on the inferior margins, which are ragged, and movable to and fro with the probe (Hartmann). These swellings often change very rapidly, as sometimes the spongy bones on the one side, sometimes those of the other, are more swollen, and the corresponding halves of the nose are thereby sometimes more, sometimes less permeable to air. The posterior extremity of the inferior spongy bones may be so much swollen that the mucous membrane hangs down into the nasal orifice, and may be mistaken for polypi. More frequently, however, the posterior extremity swells so considerably that it protrudes above the posterior nares, partially fills the superior pharynx, and covers the orifice of the Eustachian tube so that the ventilation of the tympanic cavity may be obstructed.

The secretion of the pituitary membrane presents very many varieties in quantity as well as in quality. While in some cases of chronic nasal catarrh the pituitary membrane is found to be abnormally dry, in other cases frequently such a copious secretion is observed that a running from the nose of serous, mucous, or purulent (blennorrhœal) secretion (Störk) is almost continuously present.

The secretion of ozæna possesses most unpleasant qualities, both on account of its offensive smell, which banishes individuals so affected from society, and on account of the obstinate formation of crusts, the removal of which is very difficult. It was formerly believed that the ozæna was accompanied by extensive ulcerations with destruction of the pituitary membrane and of the bone below it, but it has been proved by Zaufal's and Hartmann's anatomical examinations that ulcerations are either absent or only exceptionally present. The opinion of Zaufal, who declares, from numerous observations, that the great capacity of the nasal cavity with an abnormal smallness of the spongy bones is not the consequence, but the cause of ozæna, and that, therefore, the formation of crusts and the decomposition arise from stagnation of the secretion in consequence of the air as it penetrates meeting with too little resistance in the wide nose, may be correct in some cases, but does not by any means always hold good. Destruction of the pituitary membrane and of the bone, causing the phenomena of ozæna, arises mostly from syphilis, more rarely from scrofula; once I saw an extensive destruction with exfoliation of pieces of the bone after variola. The syphilitic process in the nose lays bare the spongy bones, or the other osseous walls, and leads to necrosis and exfoliation, while in the pharynx the ulceration produces atrophy of the mucous membrane, the formation of whitish-grey radiating cicatrices, disappearance of the cartilage of the Eustachian tube, and in rare cases ulceration with subsequent closure of the tube.

That croupous and diphtheritic inflammations of the naso-pharynx may spread to the middle ear, the observations of

Wendt (*l. c.*), and Wreden (*M. f. O.*, 1868) have shown. Wendt found in two-fifths of his cases of croup and diphtheria of the naso-pharynx, that the middle ear was also affected by the same process. Wreden observed in eighteen cases that a scarlatinous diphtheria of the naso-pharynx spread to the middle ear.

The formation of polypi in the naso-pharynx is, comparatively speaking, rare, while in the nasal cavity it occurs much more frequently, and the so-called mucous or cellular polypi develop mostly on the central spongy bones. The polypous growths, which only rarely occur in the naso-pharynx, are oftenest found on the superior wall. More frequently, however, polypi, seated in the nasal cavity, protrude into the naso-pharynx, and may there grow to such a considerable size, that they either fill the whole naso-pharynx, or even extend downwards into the inferior pharynx.*

In conclusion we must mention here the malignant new-formations which occur in the naso-pharynx; viz., epithelioma and (of most frequent occurrence) osteo-sarcoma, which generally develops in the body of the sphenoid bone, and grows so far into the pharynx that not only is the superior space of this cavity completely filled by it, and the orifices of the posterior nares and of the Eustachian tubes closed, but the soft palate is also forced downwards and bulged out towards the cavity of the mouth.

1. *Methods of Examination.*

(i.) *Examination of the Nose.*

In the examination of the pathological changes of the pituitary membrane, many obstacles are met with on account of the complicated formation of the nasal cavity, due to the structure of the spongy bones. The examination of the central and posterior portions of the nose is particularly difficult, especially when by congenital abnormal curvatures of the septum narium, or by deformities of the spongy bones, or by pathological changes in the nasal cavity, the space is so narrowed that the introduction of an instrument for diagnostic purposes becomes impossible.

In the examination of the anterior portion of the nasal cavity (*Rhinoscopia anterior* of Cohen), simple inspection with the point of the nose pressed upwards is mostly insufficient, and we are obliged to use instruments to obtain a more complete view of the cavity. The methods of examination differ from each other in that either only the entrance of the nose is widened, or the instrument is pushed deeper into it, so as to procure a more extensive view of the nasal cavity and of the naso-pharynx.

* Störk (*l. c.* p. 210) describes a very interesting case belonging to this category, in which a pyriform growth of the size of an egg, arising from the superior wall of the pharynx, hung down into the inferior pharynx, and was completely removed by the snare.

For simple dilatation of the orifice of the nose, bivalved specula are used, such as the dilators designed by v. Tröltsch, Fränkel, Charrière, Roth, and Simrock. But in case of need, an ordinary ear-speculum, or Itard's forceps, or Bonnafont's bivalved speculum may be employed.

While in most cases the widening of the nasal orifice is sufficient to give information as to the condition of the anterior portion of the nose, it is necessary in cases of great swelling of the pituitary membrane to push it aside with a thick probe, or with Zaufal's nose-spatula, to bring into view the central and posterior regions of the nose.

Of the greatest importance in the examination of the naso-pharynx is perfect illumination either by reflected sunlight or by an artificial light, the effect of which may be increased by concentration of the rays by means of a glass globe filled with water, as designed by Störk. With a mirror fastened to the frontal band, or by means of the various apparatuses constructed for illumination, it is possible to throw a sufficient quantity of light into the nose to light up not only the anterior parts, but also the posterior portions of the nasal cavity and even the naso-pharynx.

In the examination, the anterior extremity of the inferior spongy bone comes first into view, and under favourable circumstances the convex surface as also the inferior margin of this spongy bone can be traced to its posterior extremity. By inclining the head forwards, the base of the nasal cavity and the inferior meatus of the nose are seen, while by an inclination of the head backwards, the posterior and central spongy bones, in many cases portions of the roof of the nose and its interior surface, may be inspected. While generally a small fissure remains between the septum narium and the spongy bones, through which only a small portion of the posterior wall of the pharynx can be seen, a large portion of the naso-pharynx is visible if the spongy bones are undeveloped and widely spreading, as is principally seen in ozæna. In such cases we are able to inspect, besides the posterior wall and the roof of the naso-pharynx, the region of the orifices of the Eustachian tubes, and to discover pathological changes in their neighbourhood when such exist. Michel and also Zaufal, by careful observations through the nose, investigated the motions which take place at the ostium pharyngeum tubæ in relation to the functions of the soft palate. With proper illumination we can recognize the cartilaginous tube as a yellowish swelling, from the anterior end of which a triangular fold extends downwards, and from its posterior and lower end a similar crested fold (Zaufal) stretches to the soft palate. Between those two folds the ostium tubæ appears as a narrow fissure, or as an orifice a few mm. wide. During phonation, and during the act of swallowing, the lip-fold

projects like a wing into the pharynx, and the base of the orifice expands as the levator veli forces the base of the Eustachian tube upwards towards its roof, and seemingly closes the ostium tubæ.

Apart, however, from cases of ozæna and ulceration in the nose and on the palate, direct inspection of the naso-pharynx is on the whole rarely of service. To view the naso-pharynx through the nasal cavity under normal conditions, Zaufal has proposed the use of cylindrical tubes (nose-specula) 3-7 mm. in diameter and 10-12 ctm. long. The introduction of these specula is not so difficult as many affirm. With some practice one will always succeed in those cases in which the introduction of a moderately thick catheter is possible; while their introduction is of course impossible in cases of congenital or acquired deformities in the nose (p. 115). By inserting these specula (made of metal or of vulcanite) beyond the posterior nares, it is possible in many cases to see the orifices of the tubes, and to detect pathological changes in the different portions of the naso-pharynx, which cannot be inspected by any other method of examination.*

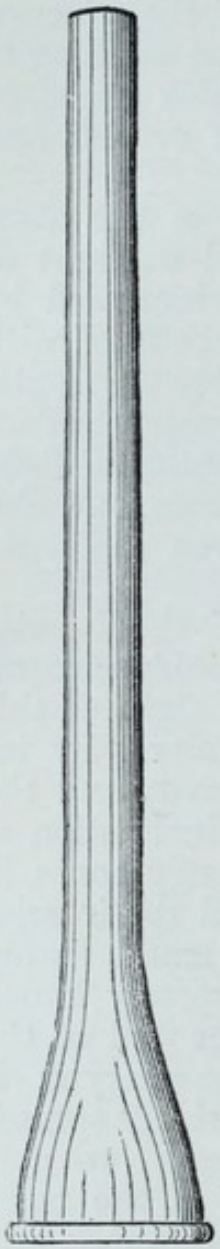

FIG. 103. — ZAUFAL'S NOSE-SPECULUM.

The condition of the nasal cavity, ascertained by anterior rhinoscopy, is very various. In cases of catarrhal swelling the dark or blueish-red pituitary membrane is congested, here and there covered by opaque or greenish mucus; the spongy bones and the septum are in immediate contact, and the lumen of the cavity is more or less narrowed, and sometimes completely impermeable to currents of air. The formation of granulations on the pituitary membrane is rare, and occurs only in circumscribed patches, which in consequence present an uneven glandular appearance.

In the case of polypi, which, as already mentioned, generally spring from the spongy bones, either in the central or in the posterior portion of the nose, one or more roundish, lustrous, blue or yellowish-red tumours will be observed on inspection, by which the corresponding half of the nose is generally completely obstructed. When determining the presence of a nasal

* To examine the lateral walls of the nasal cavity and the spongy bones, Wertheim (*W. m. Presse*, 1869) has designed an instrument, called by him the 'conchoscope,' which consists of a thin tube, in which is fixed in a slit a small mirror, placed at an angle of 45°. On account of the smallness of the mirror very small parts only of the pituitary membrane can be illuminated and inspected, and a great deal of practice is required to form an opinion of the condition of the whole membrane from the partia views obtained with this mirror.

polypus, examination with the probe is indispensable, in order to ascertain the size, mobility and seat of the swelling, and because sometimes the deformed and hypertrophied spongy bones may be mistaken for polypi on simple inspection with the mirror.

In cases of ozæna the walls of the posterior portion of the nose especially are covered with dried secretion and yellowish-green or brownish crusts. These accumulate in great quantities chiefly behind the spongy bones, at the roof of the nose as well as at the roof of the pharynx. After the removal of the crusts the pituitary membrane below is either slightly hyperæmic, swollen or atrophied. Excoriations and ulcerations are on the whole rare, and are chiefly observed in syphilis.

In ulcerative processes due to syphilis, the healing tendency is slight; not uncommonly the destructive process spreads even to the periosteum and to the osseous walls of the nasal cavity, with destruction of a portion of the septum narium, the spongy bones or the hard palate.

(ii.) *Examination of the Pharynx.*

The examination of the pharynx is divided into two parts, viz. examination of the inferior portion (cavum pharyngo-orale) and examination of the superior portion (cavum pharyngo-nasale*).

The examination of the inferior portion of the pharynx is effected in the simplest manner by pressing down the tongue as far as possible by means of a well-constructed spatula, and by requesting the patient to pronounce the vowel *a*, or better still, the consonant *h* (pronounced in German like *ha* in harbour), by which the soft palate is lifted up. The manner in which pathological changes in the arches of the palate, the tonsils and the posterior pharyngeal wall are inspected by means of direct or reflected daylight, or by artificial illumination, is generally known, and requires therefore no further explanation.

The examination of the naso-pharynx is more difficult. To Czermak, and next to him to Semeleder, is due the credit of having introduced into practice this important method of investigation. The examination is performed by means of a round or oval pharyngeal mirror (pharyngoscope) analogous to the laryngeal mirror, by which the walls of the superior pharynx and the region of the posterior nares are illuminated, and become visible by reflection in the mirror. The size of the mirror as well as its inclination towards the handle depend on the capacity of the pharyngeal cavity. If it is roomy, especially if the soft palate is somewhat removed from the posterior pharyngeal wall, a large-sized mirror may be used, because more light is reflected by it

* In the examination of the naso-pharynx the inspection of the posterior portion of the nasal cavity is made at the same time (*Posterior Rhinoscopy*).

into the superior pharynx and into the posterior portion of the nose, those parts being thus more fully illuminated. If the pharynx is narrow, however, especially in children, if the tonsils are greatly swollen and the posterior pharyngeal wall and the soft palate are tumefied, only small mirrors $1\frac{1}{2}$ ctm. in diameter can be used, as by the employment of larger mirrors choking and vomiting are set up, owing to irritation of the pharyngeal mucous membrane, and prevent inspection of the superior pharynx. Besides, experience shows that the irritability of the mucous membrane of the naso-pharynx is often so great, that reflex contractions of the pharyngeal muscles are produced by the slightest contact with the mirror, and that there are, therefore, individuals in whom pharyngoscopy is actually impossible.

If, however, on account of this irritability of the pharyngeal mucous membrane the first attempts prove a failure, the examination must not be wholly abandoned, because the irritability is blunted by continued practice, and the examination is after all successful.

The relaxed condition of the soft palate requisite for the success of the examination is obtained, according to Czermak's direction, by pronouncing vowels with a strong nasal accent, or according to Loewenberg's, by breathing through the nose. The various instruments constructed to elevate and draw the soft palate forwards can rarely be used, and only in certain operations. To make room for the mirror, it is advisable to make the patient turn his head to the side as far as possible, by which means the opposite side of the pharynx is widened.

Inspection of the posterior pharyngeal wall, lying behind the cavity of the mouth, frequently gives information as to the condition of the mucous membrane of the superior pharynx from the changes which can be there observed, such as swelling, congestion, tumefaction, escape of mucus from above, adherent crusts and granulations. Often, however, without the slightest visible change in the posterior pharyngeal wall, far-advanced affections of the mucous membrane of the superior naso-pharynx may be found. The absence of changes on the posterior pharyngeal wall does not, therefore, render the examination of the superior pharynx by the pharyngoscope unnecessary.

The changes which may be seen by the pharyngeal mirror are :

1. Various degrees of redness with a greyish or whitish coating, in chronic swelling and mucous secretion. The redness enables us to estimate the supply of blood in the mucous membrane. Acute catarrh is marked by great redness, combined with tumefaction and swelling of the mucous membrane. In chronic catarrh the mucous membrane is in many cases dark and of a dull blueish-red, an appearance which is sometimes produced by the varicose abnormally enlarged bloodvessels, and by pigmentation (v. Tröltsch).

2. Swelling of the mucous membrane. The latter is either uniformly congested in its whole extent, or in cases of pharyngitis it shows an uneven papillated surface, and in cases of strobiliform or globular adenoid vegetations in the pharynx a glandular appearance.

3. Greenish, yellowish-grey, discoloured membranes and crusts, often distinctly circumscribed and difficult to remove, will be found in cases of ozæna or syphilitic ulceration of the mucous membrane.

If the circumstances are favourable it is possible, as already mentioned, to inspect by means of the pharyngoscope not only the walls of the naso-pharynx, but also the posterior portion of the nasal cavity, and the changes described may be observed at the posterior nares as well as at the posterior portion of the spongy bones.

The pathological changes at the orifices of the Eustachian tubes and in their neighbourhood are of special interest.

In the normal condition the ostium pharyngeum tubæ will be seen in the form of a rounded triangle, with its apex directed upwards, which is bounded behind by the cartilage of the tube strongly projecting in the form of a pale yellow or yellowish-red swelling.

During forced breathing and when sounding a note, the soft palate with the strongly projecting protuberance of the levator curves from below towards this triangle, and the folds, extending from the lip of the tube, move nearer to the middle line. In pathological conditions, the lips of the tube bounding the orifice often appear very much congested and tumefied; the mucous membrane of the ostium tubæ also is itself swollen in various degrees; in many cases circumscribed follicular swellings can be distinguished. In the ostium itself masses of mucus are frequently seen, sometimes also crusts, which project from the naso-pharynx far into the cartilaginous portion of the Eustachian tube. In addition, ulcerations in the neighbourhood of the tube and at its mouth, with stricture of the same and flattening of its lip by ulceration, shrivelling and atrophy of the cartilage, have been observed.

The inspection of the superior pharynx by means of the pharyngoscope requires in some cases to be completed by examination with the probe and with the finger. A rectangularly curved probe, the same as that used for the examination of the larynx, is employed. While the point of the probe is carefully directed by means of the pharyngoscope, it is possible to feel the separate portions of the naso-pharynx, and thus to obtain information as to the character and extent of existing swellings.

Digital examination is effected by feeling the wall of the naso-pharynx with the forefinger, introduced from the mouth behind the soft palate, by which means the amount of swelling, the

capacity of the pharynx and the seat, size, formation and mobility of possible swellings, may be ascertained. This mode of examination is advisable not only in those cases in which, on account of the already mentioned difficulties, the employment of the pharyngoscope is impossible, but also in many cases in which examination with the mirror is practicable, because with the mirror alone the presence of irregularities, especially if the walls are much covered with mucus, cannot be made out with the same certainty as by feeling them with the finger; the irritation so produced is scarcely greater than that caused by the pharyngoscope.

Before commencing the description of the treatment of the diseases of the naso-pharynx, I must draw attention to some of the leading symptoms which accompany these affections.

These symptoms are impeded respiration from obstruction in the nose, and frontal headache. The feeling of obstruction in the nose may exist even when the swelling of the pituitary membrane is only slight; when the swelling is great, the respiration is so impeded that the patient is obliged to breathe through the mouth instead of through the nose. As I have already pointed out (p. 297), this change in the mode of respiration is of importance to the function of hearing in so far as the ventilation of the Eustachian tube is completely suspended, and thus, if swelling exists in the tube, recovery is prevented. In children the expression of the face becomes vacant and stupid, owing to the mouth being kept always open, and the affection can thus often be diagnosed at first sight.

Of importance also are those symptoms which are produced by the cavities adjoining the nose being affected, especially the cavities of the sphenoid bone and of the upper jaw. The violent frontal headaches which occur so frequently with acute, more rarely with chronic, nasal catarrh are well known, as also the sensation of pressure and heaviness in the head, which are, as a rule, accompanied by general exhaustion and mental irritation. If these symptoms are alleviated by injecting air by my method, by which fluids may be forced out of the adjoining cavities, according to A. Hartmann's communications (*Deutsch Arch. f. kl. Med.* vol. xx), who was the first to prove it, it may be assumed with great probability that they are caused by the nasal affection.

Treatment.—In accordance with the above, the treatment of naso-pharyngeal catarrh will chiefly depend on the character of the morbid changes in the pituitary membrane. The treatment adopted in those cases in which there is simply swelling, tumefaction and hypersecretion from the membrane will differ materially from that employed in cases in which secondary changes and growth of connective tissue in and upon the diseased mucous membrane have already developed.

Acute catarrhal swelling of the lining membrane of the naso-pharynx as a rule does not require any treatment, for under

normal conditions it generally soon subsides. It is nevertheless advisable, even in acute catarrhs, to avoid all sources of injury by which the cure might be delayed. Such sources of harm are: rapid change of temperature, especially in winter; living in a close locality or in air impregnated with tobacco-smoke; the use of alcoholic drinks, etc. Abrupt changes of temperature must be specially avoided by those in whom, at every recurrence of the acute swelling in the naso-pharynx, the disease spreads to the mucous membrane of the Eustachian tube, and produces a feeling of pressure and numbness in the ear, because by the action of cold and damp air the swelling and secretion may easily extend to the mucous membrane of the tympanic cavity, and there give rise to permanent changes.

Of the remedies recommended for acute catarrhal swelling of the pituitary membrane we must mention: the inhalation of steam in cases of great tumefaction and obstruction in the nasal cavity; the inhalation of the strongly irritating vapours of acetic acid, ammonia and carbolic acid; and the painting of the anterior portions of the pituitary membrane with cacao-butter or zinc ointment, etc.

Of all the remedies enumerated it may on the whole be said, that they frequently relieve the troublesome subjective symptoms, but that they have no influence on the course of the catarrh. Profuse diaphoresis by the use of hot drinks and vapour-baths, by which in many cases the cold in the head is soon cured, has, however, a better effect.

If the inferior portion of the pharynx be also at the same time congested, tumefied and discharging exudation, the catarrhal phenomena are alleviated by slightly astringent gargles. The chronic naso-pharyngeal catarrhs with great tumefaction, swelling and increased discharge, prove frequently to be very obstinate, especially after the affection has lasted for several years, and in scrofulous and anæmic patients and persons reduced by want of food. In chronic catarrh, treatment will be successful only when it is continued perseveringly for a considerable time. Regarding the application of medicated substances to the diseased pituitary membrane, we must point out that the effect of different remedies depends on individual conditions, so that a remedy will prove exceedingly effective in a number of cases, while in other similar cases it is applied without result. We are, therefore, frequently obliged to apply a whole series of drugs until we discover the remedy which is effective in the special case.

The medicated substances intended to remove the swelling and discharge from the diseased pituitary membrane are applied either in solution or pulverized.

The medicated solutions are applied to the membrane either by instillation and syringing them into the nose, or by the nasal douche, or as a spray.

By means of the nasal douche (named after its inventor, 'Weber's douche'), the fluid is conducted into one of the nasal orifices from an irrigator or other vessel by means of an india-rubber tube, furnished with an olive-shaped nozzle, and which acts as a syphon. By pouring fluid upon the upper surface of the soft palate, closure of the inferior pharynx will take place by reflex action, and thus the fluid, the escape of which downwards is prevented, will flow off through the other nasal orifice.

By Weber's nasal douche the lining membrane of the naso-pharynx is cleansed on all sides, and the mucous masses and crusts deposited in its depressions are washed out. In consequence of the hydrostatic pressure, however, not unfrequently the fluid enters into the frontal cells and produces frontal headache, frequently lasting the whole day, or when the pressure is greater the fluid flows through the Eustachian tubes into the tympanic cavity, and the symptoms of a violent acute otitis media with suppuration and perforation of the membrana tympani come on, (as has been observed in numerous cases by American aural surgeons, especially by Roosa, Knapp, and others).

Therefore, when applying the nasal douche, certain precautions must be observed. They are: (1) Tepid fluids only must be used (v. Tröltsch). (2) The vessel must not be placed too high, so that the fluid passes into the nose with only a slight pressure (v. Tröltsch). (3) The head must not be inclined too much backwards, but more horizontally, to prevent the entrance of the fluid into the frontal cells. (4) If the two nasal cavities are of different width, the fluid must be led through the narrower side of the nose. (5) No concentrated irritating solutions must be applied.*

But in spite of all these precautions it sometimes happens, chiefly in consequence of an involuntary act of swallowing, that during the application of the douche some fluid enters into the middle ear, and the above ill effects ensue. Therefore in cases in which it is necessary to cleanse the whole of the diseased lining membrane of the naso-pharynx with the medicated solution, I prefer to pour the fluid into the nose, and in those cases in which mucous masses and crusts must be removed from the naso-pharynx, to wash them out by repeated tepid injections with an ordinary syringe. To avoid those ill effects when applying the injections, the nozzle of the syringe must not be fitted hermetically into the nose, and the jet of fluid, to prevent the production of frontal headache, must be directed exactly backwards, the head being in a normal position. Schrötter recommends a syringe for squirting into the nose, the nozzles of which can be introduced

* To prevent the entrance of the fluid into the tympanic cavity Zaufal proposes to press the soft palate against the orifices of the tube with the fingers; Störk suggests that the patient should keep a little water in his mouth during the application of the nasal douche.

into the nasal passage. On the whole, injections do not agree well with children.

The nasal douche, which I have applied very often with success, consists in pouring into the nose about 30 grammes (two table-spoonfuls) of the solution by means of a boat-shaped glass vessel (Fig. 104), while the head is inclined backwards ; one half must be poured into each of the nasal orifices, and the patient must be told that at the moment when he becomes conscious that the fluid is in the pharynx, he must quickly bend the head forwards, so that the fluid, which in consequence of the closure of the inferior pharynx has also entered into the other half of the nose, may escape freely through both nasal orifices.

Not to impair the action of the remedy, the patient is not allowed to blow his nose until a quarter of an hour after its application. In all these methods the injected fluid will also enter into the ostium pharyngeum tube and by attraction into the Eustachian tube itself, and will therefore act indirectly upon the middle ear.

Of the various spray apparatuses recommended for the treatment of nasal affections, the one designed by v. Tröltsch has quickly come into general use (*Lehrbuch*, p. 365). It consists of a tube of the thickness of a crow-quill having a fine orifice at its conically pointed extremity, and hermetically fitted into a glass bottle by means of a cork. The condensation of air in the glass bottle is effected by an india-rubber bellows (double balloon), just as in Richardson's spray. It is of special value, because its tube can be pushed through the nose as far as the pharynx, the action of the drug being thus capable of localization to the mucous membrane of the superior pharynx and the region of the tubes, and because much more concentrated solutions may be applied, than with Weber's nasal douche.

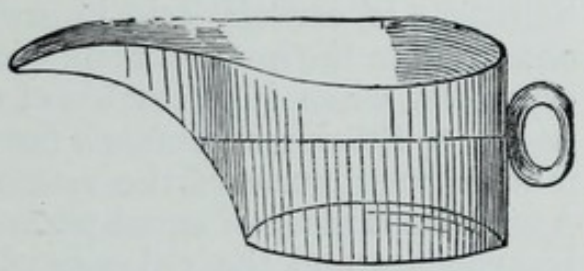

Fig. 104.—Glass Vessel to pour Fluids into the Nose (One-sixth of the actual Size).

The solutions which are employed in these methods for Weber's douche are most frequently 1% solutions of common salt or of bicarbonate of soda, or of the two mixed in equal portions, and weak solutions of permanganate of potash or of salicylic acid (in cases of ozæna). Astringents may be applied only greatly diluted (tannin, zinc. sulph. 1-2 : 1000) with the nasal douche. For the treatment of ozæna very dilute solutions of carbolic acid, permanganate or chlorate of potash are employed. Of the medicated solutions which are used for naso-pharyngeal affections, combined with catarrhal swelling and hypersecretion, and which are poured into the nose, the following have proved to be the most effective.

(1) Concentrated solutions of common salt or diluted Ischl or Kreuznach brine water, especially when the disease is caused by scrofula. (2) Concentrated solutions of tannin, of which as much as will lie on the point of a knife is dissolved in 30·0 grammes of tepid water. The effect of this remedy is in many cases increased by the addition of sulphate of quinine (tannin 3·0, quin. sulph. 0·1) or of salicylic acid (tannin 3·0, acid. salicyl. 0·3), especially if the discharge from the pituitary membrane is excessively purulent. (3) Solutions of zinc sulphate (0·05, aqua dest. 30·0), however, only when the above-mentioned remedies have been applied without success. But it is only advisable to apply them in adults, in whom the solution, poured into the nose, can flow off again in great part through the nose. In children, however, in whom the fluid frequently gets into the stomach, the application of solutions of zinc has to be avoided, because they may produce vomiting. (4) Solutions of crude alum (sulphuric alum earth) and of argilla acetica (acetic argillaceous earth). Both are effective in some cases in which a whole series of remedies has been previously applied without success.* (5) Solutions of carbolic acid in cases of chronic muco-purulent discharge from the mucous membrane of the pharynx (blennorrhœa), especially when it is combined with an offensive smell from the nose. (6) Störk recommends for blennorrhœal discharge from the mucous membrane of the naso-pharynx the following solution: A mixture is made of equal parts (5 grammes) of the salicylate, the bicarbonate and the chlorate of soda, and as much of it as will lie on the point of a knife is dissolved in 30 to 40 grammes of water; two or three drops of unrectified oil of turpentine are mixed with 30 or 40 grammes of warm water; these solutions are then mixed.†

The medicated solutions here enumerated, may, according to the proposal of Störk, O. D. Pomeroy, and Roosa, also be applied by means of a tube curved like the catheter, the point of which is passed through the mouth behind the soft palate, and directed upwards. The solution is injected into the superior pharynx with the head inclined forwards, and will flow off again to a great extent through the nasal orifices. By this method also, however, the injection must be made with a slight pressure only, because if the fluid is injected forcibly, it may easily penetrate to the middle ear and produce violent inflammatory phenomena.

If after treatment for several weeks by the above solutions the condition of the lining membrane of the naso-pharynx does not materially improve, the desired result will frequently be effected by touching it thoroughly with a concentrated solution of nitrate

* Wendt (*Krankheiten der Nasenrachenhöhle*, etc., Ziemssen's *Handbuch*, p. 278) cautions against the use of alum in a fluid form, as he has observed in three cases permanent loss of the sense of smell after its application.

† Gatty has lately recommended for chronic naso-pharyngeal catarrh the introduction of medicated gelatinous bougies (tannin, zinc, alum, carbolic acid) into the nose.

of silver (1·0 to 10·0). The cauterization may be performed in various ways, either by applying the solution immediately to the diseased parts by means of a brush or a small sponge, or by injection through a small syringe (Pravaz's syringe with a long blunt nozzle is most suitable), in which case the patient must incline his head backwards, to allow the lining membrane of the naso-pharynx to come into contact with the fluid. To avoid cauterization of the inferior portion of the pharynx, the patient may take into his mouth, according to the proposal of Störk, a dilute solution of common salt, and swallow it, after the injection has been made. In the so-called chronic catarrh with difficult respiration through the nose, I applied cauterization in the following manner with a very good effect. Two balls of cotton-wool of the size of a hazel-nut, saturated with a concentrated solution of nitrate of silver, were pushed by means of the forceps through the dilated nasal orifices towards the centre of the nasal cavity and the nose was afterwards closed with dry wadding. Then, the head being inclined-backwards, the fluid was squeezed out of the balls of cotton-wool by compressing the nose with the fore-finger and thumb, and in this manner a great portion of the lining membrane of the naso-pharynx was cauterized. After the removal of the cotton-wool by means of the forceps it is advisable to wash the neighbourhood of the nasal orifices with a weak solution of iodide of potassium, to prevent black spots.

Cauterization of the lining membrane of the naso-pharynx, performed in this manner, as a rule immediately causes a violent burning sensation (which is at once relieved by pouring in a tepid solution of common salt) with increased discharge. A material improvement is frequently noticeable after even a few days, as the patient feels relieved and the breathing through the nose is less impeded.*

The number of cauterizations, which have to be performed two or three times per week, must be adapted to the individual case. While it is sometimes possible to remove the swelling by three applications, in other cases it is necessary to perform the cauterization fifteen and even twenty times.

Extensive cauterization of the naso-pharynx is effected by using either a brush provided with a suitably curved handle, or small sponges fastened to a whale-bone staff, which are dipped into a concentrated solution of nitrate of silver. These are pushed forward behind the soft palate, are turned towards the superior pharynx, and by slightly shifting them from right to left its walls are painted.

Insufflation of pulverized substances is much in use, and is either performed through the nasal orifices or from the pharynx.

* In chronic catarrhs, accompanied by little secretion, in which the complaint consists of a sensation of dryness or tension, inhaling hot steam has sometimes a favourable effect.

In the former case the anterior portions of the nasal cavity are also acted upon by the powder; in the latter case the naso-pharynx and the posterior half of the nose are alone brought into contact with the substances which have been blown in. Insufflation through the anterior orifices of the nose has proved to be particularly suitable, and agrees, as a rule, very well with patients, while the same substances applied from the pharynx frequently produce great irritation.

The drugs which are most frequently employed are: alum, which is applied finely pulverized or mixed with gum arabic or sugar of milk; also tannin, oxide of zinc and calomel. Nitrate of silver and narcotics (morphia) require the addition of simple menstrua in greater or less quantity, according to the effect intended.

Powdered substances are most commonly sniffed up into the nasal passages, and thus the medicine comes into contact chiefly with the anterior portions of the nose. To introduce powders farther into the nose, special insufflators, constructed like Störk's laryngeal insufflator, are used; but simple glass tubes or goose-quills may be employed for the same purpose when filled with a small quantity of the powder. It is best blown in with the mouth by means of an india-rubber tube connected with the glass tube, or by the inflating-bag. If the powder is to be blown in from the pharynx, the insufflator intended for the larynx must have a somewhat greater curvature. The curved portion must be inserted behind the soft palate, and the point of the instrument must be directed towards the place to which the remedy is intended to be applied.

Of solid caustics, nitrate of silver is most frequently used, and is best applied by the probe, the point of which may be coated by dipping it in caustic melted by heating. With the probe curved at an angle and prepared in this way, cauterization may be effected at any part of the nose, and by the aid of Zaufal's speculum, also at any point of the naso-pharynx. For cauterization in the naso-pharynx, the curved sound, which is constructed for examination of the same cavity, may be used, or for more extensive cauterizations an instrument for conveying nitrate of silver, which we shall describe when discussing the treatment of adenoid vegetations.*

The introduction of the galvano-cautery has been a valuable addition to the means at our disposal for the treatment of

* In cases of great tumefaction of the lining membrane of the naso-pharynx, in order to cause subsidence of the coincident swelling of the mucous membrane of the Eustachian tubes, I frequently perform circumscribed cauterizations near the orifices of the tubes. I use for this purpose a wide, slightly curved vulcanite catheter, in which a long movable wire is inserted, the point of which has received a coating of nitrate of silver in the form of a ball. The small ball, which during introduction into the nose is hidden in the catheter, is pushed out, when the point of the catheter has arrived at the region of the ostium tubæ, the neighbourhood of which is cauterized by slightly shifting the catheter backwards, forwards, upwards, and downwards. Before the instrument is taken out the point of the wire must again be withdrawn into the catheter.

diseases of the nasal cavity and of the naso-pharynx. Since Voltolini first drew attention to the galvano-caustic treatment of the swellings of the lining membrane of the nose and of the naso-pharynx, this method has been further investigated by Michel and Hartmann. The cauterization is best effected with a finely pointed platinum galvano-cautery, by simply touching the swollen membrane, especially that of the spongy bones, with the red-hot platinum point. My experience agrees with that of the above-mentioned authors; this method of treatment causes very little pain, in many cases the swollen membrane is quickly made to shrivel, and even after one cauterization considerable relief in the nose and in the head is experienced. To swellings in the naso-pharynx, especially granulations, the galvano-cautery can be applied either from the anterior orifices of the nose by means of Zaufal's speculum, or from the pharynx by the aid of the pharyngoscope.

To remove polypi from the nose, forceps were formerly generally in use, and were, as a rule, introduced into the nose without an exact investigation, the polypi when seized being torn out. The operation thus performed was accompanied by very great pain and violent bleeding, for in most cases it was impossible to prevent healthy portions of the lining membrane, and sometimes also portions of the spongy bones, from being torn out. This violent and rough method of operation has been superseded by the application of snares. After v. Tröltsch and Bruns had removed polypi in this manner, Störk* and then Hartmann† and Zaufal‡ constructed special snares armed with pianoforte wire, by which the operation can be performed in a less painful manner and with less loss of blood. After the nasal orifice has been dilated by the same speculum, the separate polypi are searched for, the snare is passed round their roots, and the tumours, of which there are generally several, are strangled or removed one after the other.

Treatment of Adenoid Vegetations.—Whoever has observed and treated a number of cases of adenoid vegetations in the naso-pharynx, will have found that the application of those astringent remedies which are frequently employed for simple catarrhal swellings with increased secretion from the lining membrane of that cavity, prove without effect in such cases. This is explained by the consideration that we have not here to deal with simple serous saturation and tumefaction of the lining membrane, but with hypertrophy, caused by the actual new formation of adenoid tissue in that membrane, which cannot be made to shrivel by the application of astringent remedies. The treatment of adenoid vegetations must, therefore, consist of operations, and the works of W. Meyer have in this respect marked a substantial progress in the treat-

* *Klinik der Kehlkopfkrankheiten*, Enke, Stuttgart, 1876.
† *Deutsche m. Wochenschrift*, No. 28, 1877.
‡ *Prag. med. Wochenschrift*, Nos. 48-50, 1877.

ment of the affections of the ear, combined with disease of the naso-pharynx. The operation proposed by Meyer consists in removing the growths with a sharp instrument, or in destroying the vegetations with solid nitrate of silver. The instrument, designed by Meyer (Fig. 105), is an annular knife, 1 ctm. in diameter, the sharp edge of which is formed by the inner margin of the circle. The length of the instrument is 21 ctm., and on its handle is a mark, by which its position in the naso-pharynx can be seen.

Fig. 105. — Annular Knife of W. Meyer (Half the actual Size).

The destruction of growths is effected in the following manner: The instrument, held in the right hand, is inserted between the septum and the spongy bones as far as the posterior pharynx, with the knife perpendicular, and is then turned so that the position of the knife becomes horizontal. The left forefinger is now introduced through the mouth and behind the soft palate towards the superior wall of the pharynx, until the instrument is felt with the point of the finger. Then the knife is pressed with the tip of the finger against the excrescences, which can be felt on the roof of the pharynx; they are thus forced inside its ring. The instrument is now drawn outwards, and the vegetations surrounded by the circular knife are cut off, and are discharged from the mouth and nose by a strong act of expiration.

This operation may be repeated several times at one sitting, according to the number and size of the vegetations, the growths on one side only being destroyed, or a portion of those on the other side being removed at the same sitting. The bleeding which takes place after the operation is generally inconsiderable, and is quickly stopped by once or twice syringing cold water into the nose with a little force.

The repetition of the operation depends on the number and extent of the growths, and the procedure must be continued until by digital examination no vegetation can be traced which can be operated upon with this knife. As a matter of course this method of operation can only be employed in cases of very prominent strobiliform or globular growths on the superior wall of the pharynx; if the vegetations are flat, however, and also when they are seated on the lateral and posterior pharyngeal walls, scraping off the vegetations by means of a sharp spoon, as proposed by Justi, must be resorted to. The most suitable for this purpose is the spoon, fastened to a ring, designed by Justi, which, put on the middle finger and introduced behind the soft palate, can be applied so as to scrape off the vegetations from all the walls. Justi generally completes the operation at one sitting.

Inflammation of the middle ear following on the application of the sharp spoon, which was observed by W. Meyer, Schwartze, and Wendt, did not once occur in nineteen cases operated on by Justi, and he, as well as Bardenheuer, prefers this method of operation to the tedious destruction by the galvano-cautery proposed by Voltolini.

The second method recommended by Meyer is the destruction of these growths by extensive cauterization with solid nitrate of silver. For this purpose Meyer designed a number of instruments for conveying caustics to the different portions of the walls of the naso-pharynx, and these I have united into one instrument.

The instrument (Fig. 106), consists of a quadrilateral piece of silver, 1½ ctm. long, and 4 mm. in diameter, which is furnished with a handle 20 ctm. long. The four sides as well as the free end of the prism are roughed like a file, in order to give the nitrate of silver, which is melted upon it, a firmer hold. Now, if the posterior, the lateral, or the superior wall of the pharynx is to be cauterized, the nitrate of silver is melted only upon the corresponding surface of the instrument, the anterior extremity of which can be curved as required. It is introduced behind the soft palate into the superior pharynx after depressing the tongue well, and the growths are thoroughly cauterized by passing the instrument backwards and forwards over them several times. The slough caused by the cauterization peels off as a rule on the next day, sometimes only on the second day. The cauterization should not be repeated till after an interval of one day, for an aggravation of the affection, excoriations with bleeding and an increase of the growths have been observed, if they have been touched when the slough was still adhering to them. The severe burning sensation in the naso-pharynx, which is felt immediately after the cauterization, is most quickly removed by pouring a table-spoonful of warm water or of a weak solution of common salt once or twice through the nose into the posterior pharynx.

Fig. 106. — Instrument for conveying Caustics to the Naso-pharynx (One-third the actual Size).

The number of cauterizations depends on the extent and size of the growths; for while in some cases they are completely removed by a few applications (4-8), in others a greater number (10-15) of cauterizations is required. The cauterizations must be repeated until no trace of the growths can be detected on the walls of the naso-pharynx by digital examination.

Snipping off the growths by means of a bent forceps introduced behind the soft palate, as recommended by Meyer and

Störk, is only of service in those cases in which there are isolated excrescences with narrow bases upon the mucous membrane of the naso-pharynx.

In place of Meyer's annular knife, snares are now much employed, and Hartmann's polypus snare,* with a rectangularly curved tube, is specially useful. The end of the tube is 6 mm. wide, and contains a noose of thin steel wire, which must be bent according to the site of the growths, whether on the superior or on the posterior pharyngeal wall. The operation is performed from the pharynx, so that by the aid of the pharyngoscope the separate growths are seen, and removed. In those cases in which Rhinoscopy is not successful, the operation must be performed with the aid of the finger, by which the growths are felt.

Störk employs for this operation a steel guillotine-snare, consisting of a handle, to which various stems with eyelets can be attached, thus adapting it for operations on either of the walls of the naso-pharynx.† I had recently an opportunity of seeing two cases operated on by Störk, in which growths with a broad base were completely removed from the superior pharyngeal wall by this instrument. H. Bensch‡ lately advocated the use of the galvano-cautery, and recommended for the radical removal of naso-pharyngeal polypi a galvano-caustic gouge besides the galvano-caustic ecraseur (Voltolini).

To remove polypi and adenoid growths in the naso-pharynx through the nose by means of his specula, Zaufal has recently invented a snare, which opens in the naso-pharynx. Operations in the posterior pharynx may also be performed by the variously constructed snares of Wilde (v. Tröltsch), Blake, Zaufal and Hartmann, by inserting them through the nose if the nasal cavity has been expanded by Zaufal's dilator, an instrument which consists of two tubes, separable from each other in a parallel direction.

The treatment of the affections of the cavities adjoining the nose has hitherto been limited to the application of cold or warm fomentations, the inhalation of vapours or bleeding from the forehead or from the septum narium; but the morbid process has rarely been affected by these remedies, and the violent frontal headache has seldom been alleviated. Hartmann, however, has now proved by experiment on the dead body, that by compression of the air in the nose, fluids accumulated in the adjoining cavities can be removed; and that not only in acute but also in chronic catarrh the symptoms (frontal headache, heaviness and numbness in the head and sensation of weight in the upper jaw) will be alleviated or completely removed after repeated Politzerization.

* *Ueber Polypenschnürer und ihre Anwendung im Ohre, in der Nase und im Nasenrachenraume, Deutsche med. Wochenschrift*, No. 26, 1877.

† *Sitzungsprotokoll der Naturforscherversammlung in Gratz*, 1875, *Archiv f. Ohrenh.* vol. x. p. 266.

‡ *Beiträge zur Beurtheilung der chirurgischen Behandlung der Nasenrachenpolypen, Inaug. Dissert.* Berlin, 1878.

For the treatment of swellings and increased discharge in the lower portions of the pharynx the application of astringent gargles is sufficient.* If great tumefaction has taken place, subsidence of the swelling of the diseased portions will be effected either by painting with a concentrated solution of nitrate of silver, tincture of iodine or tinctura opii crocata, or by dusting the parts with powdered alum applied with a brush, or with a ball of wadding held with the forceps. Hypertrophied tonsils have to be removed only when they impede the breathing or cause frequent relapses of the pharyngeal catarrh and consecutive swellings on the mucous membrane of the Eustachian tubes and of the tympanic cavity. If granulations have formed on the posterior pharyngeal wall in consequence of chronic inflammation, they must be destroyed by solid nitrate of silver, melted upon an angularly curved probe, by swabbing them with liq. ferr. muriat., or by the galvano-cautery (Michel).

Lastly, attention must be drawn to the importance of the general treatment, which in many cases is a necessary addition to the local. The presence of disorders of nutrition and constitutional peculiarities must be taken into consideration. If the patient's general condition is unsatisfactory, it must be the care of the surgeon to improve it by suitable diet, fitting occupation, frequent exercise in the open air, change of air, residence in the country, especially in mountainous districts well wooded with pines, by baths, etc. Sometimes the most obstinate naso-pharyngeal catarrhs, which have resisted all treatment, will disappear on change of air. If syphilis exists, anti-syphilitic remedies must be employed in conjunction with the local treatment. In scrofulous cases, the use of brine or iodine baths (Ischl, Kreuznach, Reichenhall, Hall in Upper Austria, etc.) has a very favourable effect, and in such cases, especially in children, good results may be obtained by the internal administration of cod-liver oil, iron and iodine. For plethoric patients with a tendency to hæmorrhoids, treatment by mineral waters (Marienbad, Friedrichshall, Ofen, etc.) is indicated. If a tendency to catarrh exists, this disposition can be improved by the systematic use of cold baths and living much in the open air.†

* Gargling of the throat is best carried out according to the following instructions of v. Tröltsch : The head is to be inclined backwards, and a mouthful of the fluid is to be agitated by repeatedly performing the act of swallowing, without, however, allowing any portion of it to pass into the stomach. In this way strong contractions of the muscles of the palate and of the pharynx are induced, and a large surface of the mucous membrane is brought into contact with the gargle.

† H. Wendt, *Krankheiten der Nasenrachenhöhle und des Rachens*, v. Ziemssen's *Handbuch der spec. Path. und Therapie*, 1874 ; B. Fränkel, *Allgemeine Diagnostik der Krankheiten der Nase*, etc. ; *ibid.*, *Krankheiten der Nase*, v. Ziemssen's *Handbuch*, etc., 1876 ; W. Meyer, *Ueber adenoide Vegetationen in der Nasenrachenhöhle*, *Archiv f. Ohrenh.*, vols. vii., viii. ; v. Tröltsch, *Anweisung zum Gebrauch der Nasendouche*, *A. f. O.* vol. ix. ; C. Michel, *Die Krankheiten der Nasenhöhle und des Nasenrachenraumes*, Berlin, 1876 ; v. Tröltsch, *Ein neuer Zerstäubungsapparat*

Catarrh of the Middle Ear.

The Adhesive Processes in the Middle Ear.

Syn.: Otitis media catarrhalis chronica; Otitis media catarrhalis sicca; Otitis media sclerotica; Proliferous inflammation of the middle ear (Roosa); Otitis media iperplastica (de Rossi); Otitis media adhæsiva lentescens.

Catarrh of the middle ear, accompanied by sero-mucous exudation, having been described in the previous division, we will in the present one discuss those adhesive processes which arise in the course of chronic catarrh, and form the basis of permanent defects in hearing.

Attention has already been specially drawn to the fact that a sharply defined separation of the exudative catarrhs of the middle ear from the adhesive processes which are developed out of them, is not practicable. For while those anatomical changes, yet to be described as permanent obstacles to the conduction of sound, are generally developed only after the catarrhal exudation has passed away, it has been sufficiently proved by pathological observations that the adhesive new-formation of connective tissue very often takes place even during the exudative stage of the disease, and that in the course of many adhesive processes the catarrhal secretion does not cease, but is continuous throughout.

It has also been specially mentioned (p. 241), that adhesive processes in the middle ear do not always originate in exudative catarrh, but that often, without a preceding catarrh, an insidious interstitial inflammation is established in the lining membrane of the cavity, in the course of which, owing to condensation and contraction of the lining membrane and of the ligamentous apparatus

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für den Nasenrachenraum, etc., *Arch. f. Ohrenh.* vol. xi.; *idem*, *Lehrbuch der Ohrenheilkunde*, 6th edition, 1877; Lucae, *Die trockene Nasendouche, ein Verfahren*, etc., *Berl. Klin. Wochenschr.* No. 11, 1876; Voltolini, *Die Anwendung der Galvanocaustik*, etc. Wien, 1871; Semeleder, *Die Rhinoscopie und ihr Werth für die ärztliche Praxis*, Leipzig, 1862; Loewenberg, *Die Verwerthung der Rhinoscopie*, *Archiv f. Ohrenh.* vol. ii.; A. Politzer, *Zur Therapie der mit adenoiden Vegetationen im Rachenraume complicirten Erkrankungen des Mittelohrs*, *Allg. Wien. med. Zeitung*, 1875; A. Hartmann, *Die galvanocaustiche Behandlung des Stockschnupfens*, *Deutsche Zeitschr. f. Chir.* vol. ix.; *idem*, *Zur Behandlung des Rachencatarrhs*, *Deutsche med. Wochenschr.* No. 16, 1877; *idem*, *Ueber das Empyem der Stirnhöhlen*, *Deutsch. Arch. f. klin. Med.*, vol. xx. p. 531; *idem*, *Beitrag zur Lehre von der Ozaena*, *Deutsch. med. Wochenschr.* 1878; E. Zaufal, *Die normalen Bewegungen der Rachenmünd. der Eust. Röhre*, *Archiv f. Ohrenh.* vol. ix. 7 and 19; *idem*, *Ueber die Anomalien in der Bild. d. Nasenmuscheln*, No. 23 of the *Aerztl. Correspondenzblatts aus Böhmen*; *idem*, *Ueber die allgemeine Verwendbarkeit der kalten Drahtschlinge*, *Prag. med. Wochenschr.* No. 48-50, 1877; Czermak, *Der Kehlkopfspiegel und seine Verwerthung fur Physiol. und Medicin*, Leipzig, 1863; E. de Rossi, *Le Malattie dell' Orecchio*, Genova, 1871; Frank, *Zur Weber'schen Nasendouche*, *A. f. O.* vol. v.; Schulze, *Beitrag zur Technik der Nasendouche*, *A. f. O.* vol. vi.; Störk, *Klinik der Krankheiten des Kehlkopfes, der Nase und des Rachens*, Stuttgart, F. Enke, 1877; Gustav Justi, *Ueber adenoide Neubildungen im Nasenrachenraume*, *Sammlung klinischer Vorträge von R. Volkmann*, No. 125, 1878.

in the tympanic cavity, rigidity of the ossicular chain, but most commonly anchylosis of the stapes, results. These are the diseases of unfavourable prognosis, commencing usually with trifling symptoms, showing, as a rule, an insidious course, and ending in the highest degree of defective hearing. Although, then, the last-named form of adhesive process developed out of the true middle ear catarrh seems in this way somewhat more sharply defined, yet from a clinical aspect the fact must not be overlooked that cases are frequently observed, showing at the outset swelling and secretion in the middle ear, but where, after the disappearance of the catarrhal phenomena, the disease, in regard to course, symptoms and simultaneous affection of the labyrinth, takes on the character of the above-mentioned interstitial inflammation. We see, therefore, that a sharply defined demarcation between this form of inflammation and the catarrhs does not exist.

The adhesive processes here outlined are out of all proportion more frequent than other forms of inflammation, accompanied by symptoms which point to a simultaneous affection of the labyrinth. The insidious forms especially, which often end in synostosis of the stapes, are more frequently combined with disease of the labyrinth than the adhesive processes arising from true catarrh. However, affections of the labyrinth often occur in conjunction with the last-named forms, especially if of long duration, partly in consequence of the increasing pressure in the labyrinth, partly through the complication of structural changes in the auditory nerve and in the membranous labyrinth.

The diseases of the labyrinth associated with the chronic adhesive processes are generally regarded as of secondary origin. I cannot give my unqualified adhesion to this opinion. For while, as anatomical examinations show, retrograde alterations in the labyrinth (atrophy, fatty, and colloid degeneration) during the adhesive processes are often present, yet, after a short duration of the disease, or even at its commencement, a combination of symptoms is frequently present which leaves no doubt as to the presence of disease of the labyrinth. With such decided labyrinthine symptoms appearing even at the outset of the affection, we are from clinical observation often driven to the assumption, that both divisions of the ear, the tympanum and the labyrinth, have been affected at the same time and by the same disorders of nutrition; in the beginning of the disease, however, the labyrinthine disturbances sometimes prevail to such an extent that we must doubt whether in such cases the primary disease did not originate in the labyrinth, and whether the development of the obstacles to the conduction of sound did not occur later. This conclusion would seem to be supported by the fact that cases have been observed in which the footplate of the stapes has been found anchylosed by a bony ring developed on its labyrinthine aspect (p. 328), without any diseased altera-

tion on the lining membrane of the tympanic cavity being traceable.

It results from the foregoing, that many various forms of disease of the middle ear have been comprehended in the group of adhesive processes, showing many anatomical as well as clinical differences. The association of those interstitial inflammations of the middle ear, so singular in their course, and chiefly confined to the neighbourhood of the labyrinthine fenestræ, with the adhesive processes originating in catarrhs, according to the present state of our knowledge is based only on the fact that obstacles to the conduction of sound exist in both forms. As v. Tröltsch correctly remarks, there is no doubt that, through extension of our anatomical knowledge, this interstitial form of inflammation may attain to a separate position in the series of diseases of the ear. For in those cases where from its commencement it progresses without catarrhal symptoms, it appears as a distinct disease, showing in the majority of cases quite a different character from that of the adhesive processes originating in true catarrh.

Pathologico-anatomical Alterations.—The pathological alterations in the adhesive processes either extend over the whole mucous membrane of the middle ear, or occur in circumscribed areas. The former may be called diffused, the latter circumscribed inflammatory processes. The diffused changes most frequently arise from the secretive forms of catarrh of the middle ear, while the circumscribed obstacles to the conduction of sound, especially those which are developed in the neighbourhood of the fenestræ of the labyrinth, are mostly products of the interstitial form of inflammation of the mucous membrane.

Since the chief characters of the histological changes in the middle ear have already (p. 84) been described, only the results important in a clinical study will now be briefly enumerated.

The structural changes in the mucous membrane consist generally in partial or total transformation of the new-formed round cells into fibrous connective tissue, increase of the quantity of mucous membrane with retrograde metamorphosis of the new-formed tissue, shrinking, sclerosis, atrophy (Schwartze), and calcification.

Thus the appearance of the lining membrane is altered in the most various ways. In cases where the exudative stage has not yet passed away, the hyperæmic mucous membrane, usually unevenly tumefied, appears yellowish or blueish-red, infiltrated with serum or salts, spongy, easily movable, uneven in surface, glandular, and shaggy. The same alterations are to be found on the covering of the ossicula. In consequence of this excessive proliferation of the mucous membrane, the depressions in the tympanic cavity, especially the niches of the fenestræ ovalis and rotunda, as well as the space in the neighbourhood of the head of the malleus

and the body of the incus, are filled up and obliterated, and the capacity of the tympanic cavity is diminished. The Eustachian tube is rendered narrower by the great swelling of its lining membrane, and the mastoid cells are filled with masses of œdematous connective tissue, or with serous saline secretion. The mobility of the ossicula is impaired, but seldom quite lost by anchylosis at this stage (Zaufal). The increase in thickness of the lining membrane is caused partly by proliferation of the round cells, partly by new-formed connective tissue. Therefore, by the round cells undergoing fatty degeneration, a partial repair of the mucous membrane may take place.

In other cases, where the secretion has totally ceased, and where a complete transformation of the new-formed tissue into connective tissue has already taken place, we find the mucous membrane generally smooth, several times as thick as usual, pale, of a dull, tendinous-grey colour, rigid, firmly united with its base, and only slightly movable. The condensation and rigidity affect not only the lining membrane of the tympanic cavity, but often also the folds of the mucous membrane and the ligaments which extend to the ossicula, as well as the covering of the articular capsules. This thickening is generally most strongly marked where the ossicula touch the walls of the tympanic cavity.

In yet another series of cases (according to Toynbee, in about twenty per cent.), we find the tympanic cavity traversed by numerous membranous striæ and bands, which often cross each other, and by which the membrana tympani, the ossicula and the tensor tendon, are abnormally connected with each other and with the walls of the tympanum. In some rare cases such striæ are transformed by a deposit of calcareous salts into bone-like processes (Toynbee, v. Tröltsch) (p. 84).* We further find circumscribed or extensive adhesions between the membrana tympani and the inner wall of the tympanic cavity, and sometimes a partial or complete obliteration of this cavity, by transformation of its excessively proliferated mucous membrane into connective tissue, and its complete and general union with the inner surface of the membrana tympani and the covering of the ossicula.

Through these alterations in the tympanic cavity, the power of vibration of the conducting apparatus is more or less impaired. The greatest obstacles to conduction arise from the intimate attachment of the ossicula to the walls of the tympanic cavity, and from anchylosis of the ossicular joints. This anchylosis is

* Compare Schwartze in Kleb's *Handbuch der patholog. Anatomie*, p. 81, and v. Tröltsch, *Lehrbuch der Ohrenheilkunde*, p. 285.

De Rossi found in the tympanic cavity of a man who became deaf in consequence of a chronic catarrh of the middle ear, microscopic, star-shaped corpuscles encrusted with lime salts in the new-formed connective tissue striæ.

due to the formation either of a tense fibrous tissue (anchylosis membranacea s. spuria), or of osseous substance (anchylosis ossea s. vera).* The anchylosis affects either all the ossicula, or each of them is separately united with the adjoining walls of the tympanic cavity. We find, therefore, sometimes an anchylosis between the head of the malleus and the superior wall of the tympanic cavity, with simultaneous mobility of the incus and stapes. Or the anchylosis may be confined to the incus alone, so that either its short crus, or its long crus, as can be seen from a preparation in my collection, is anchylosed to the posterior wall, while both malleus and stapes are movable.

Among the most important results of chronic inflammation of the mucous membrane of the middle ear, is anchylosis of the stapes with the fenestra ovalis. This lesion has been known since the time of Morgagni, who was the first to describe and show preparations of it. To Joseph Toynbee, however, belongs the great merit of having shown, by numerous post-mortem examinations, that those disturbances of hearing, which formerly were classed under the name of 'nervous deafness,' are caused in the majority of cases by it.

This anchylosis of the stapes is generally the result of a diffused inflammation of the mucous membrane of the tympanic cavity, and is often complicated with anchylosis of the malleus and the incus, with adhesions between the membrana tympani, the ossicula, and the inner wall of the tympanic cavity, and with the formation of striæ and bridges in that cavity, sometimes also with calcification of the membrane of the fenestra rotunda.† Often, however, it follows from circumscribed interstitial inflammation of the mucous membrane, when the pathological changes are principally confined to the neighbourhood of the fenestra ovalis, no signs of disease being visible in the other portions of the middle ear.

Anchylosis of the stapes arises either through a union of the margin of its footplate with the circumference of the fenestra ovalis (anchylosis of the footplate of the stapes), or through union of its crura with the inferior wall of the niche of the fenestra ovalis (anchylosis of the crura of the stapes), the latter being, without doubt, favoured by several anatomical relations. For in normal ears we find the niche of the fenestra ovalis either free, or filled with those thread-like filaments which are the remains of the gelatinous substance found in the fœtal tympanum. In the latter case the filaments extend from the walls of the niche to the crura of the stapes, and are sometimes so abundant as to enclose that bone as if in a tense network. If, then, inflammation is localized in this neighbourhood, anchylosis of the crura of the stapes with

* The distinction between the two forms is sometimes possible even in the dead body after maceration only, which dissolves the membranous union while it has no effect on the osseous.

† Compare Schwartze, *Synostose des Steigbügels*, *A. f. O.* vol. vi.

the niche of the fenestra ovalis will take place with greater facility when there is such a network, than when no filaments exist.

A second predisposing fact, to which I have already drawn attention, is the congenital narrowness of the niche of the fenestra ovalis, by which the crura of the stapes come into immediate contact with the inferior wall of the niche. In such cases, inflammation of a less degree would suffice to cause anchylosis. Microscopic examination of the ears of several people hard of hearing supports this opinion; for along the whole mucous membrane of the tympanic cavity, and, indeed, in the narrow niche of the fenestra ovalis, a morbid change could be traced, and, by closer inspection, a firm union of the crus of the stapes with the inferior wall of the niche was found. In two such cases I could not ascertain, in microscopic sections through the niche of the fenestra ovalis and the crura of the stapes, any increase in bulk of the connective tissue of the adherent mucous membranes, and it seemed not improbable that the anchylosis had been caused by a desquamative inflammation.

The anchylosis of the stapes, as Moos* was the first to prove, is sometimes combined with congenital or acquired hyperostosis of the temporal bone, being part of a general hyperostosis of the skull. This form, from a practical point of view, is of importance in so far as anchylosis due to congenital hyperostosis has deaf-mutism as its consequence, while that due to acquired hyperostosis presents clinical phenomena exactly similar to those of chronic adhesive inflammation of the middle ear, and ends in deafness of a high degree with continuous subjective noises. Moos found near the anchylosis of the stapes in such ears a considerable narrowing of the space in the external and internal meatuses, the fenestra rotunda, and the canal of the cochlea, anchylosis of the malleus and the incus, and osseous closure of one or other of the semi-circular canals.

Anchylosis of the footplate of the stapes with the circumference of the fenestra ovalis, is caused either by calcification and ossification of the ligamentous ring of the stapes (Toynbee, v. Tröltsch), by a growth of cartilage from the circumference of the fenestra ovalis (Wendt), or by deposit of new-formed osseous substance upon the inner surface of the footplate, and in the neighbourhood of the fenestra ovalis. Corresponding with the tendinous ring we find in the latter case, on the labyrinthine side of the fenestra ovalis, a concave osseous deposit, which slopes down towards the middle of the footplate of the stapes. This state of the vestibular surface of the stapes is sometimes associated with other alterations in the tympanic cavity, as Toynbee's sections show; but it occurs also without demonstrable disease of the mucous membrane of the tympanic cavity. In the latter case, the anchylosis of the stapes cannot be regarded as the result of an affection of the middle ear. The microscopic examination of decalcified sections of anchylosis

* *A. f. O.* vol. ii.; *A. f. A. u. O.* vols. ii. iii. vii.

of the stapes, shows ossification of the cells of the cartilaginous coverings concerned; the ligamentum annulare, however, which consists of highly cellular connective tissue (Buck), does not ossify, but its fibres assume a more compact, tendinous condition as the cells disappear; they become impregnated with calcareous salts, which are for the most part extracted by the decalcifying process. Enlargement of the footplate of the stapes (Toynbee) is caused by a deposit of calcareous salts, and an ossification of the ligamentous ring; it is therefore only apparent, not real.

During chronic adhesive processes, pathological alterations in the articulations of the ossicula are by no means rare. The alterations, previously described, are found in most cases in the stapedio-vestibular articulation, less often in the articulation of the malleus and incus, and most rarely in that of the stapes and incus (only twice among 1149 of Toynbee's sections). Of special interest are the alterations in anchylosis of the articulation of the malleus and incus. This occurs mostly in cases of diffused chronic inflammation of the middle ear, associated with extensive adhesions, more rarely with an otherwise normal state of the mucous membrane of the tympanic cavity. Although the occurrence of this anchylosis was long ago proved by the sections of Toynbee, v. Tröltsch, Schwartze and Zaufal, there is still very little known about the histological changes which are developed in this joint. For this reason I will here give a brief account of a case examined by me. A woman, thirty-two years of age, who died of a cerebellar abscess due to caries of the left petrous bone, had been completely deaf on the right side for many years. Examination during life showed the membrana tympani sodden, of a whitish-yellow colour, non-transparent, and much thickened and contracted. At the post-mortem examination, the membrane was found to be united in its whole extent with the inner wall of the tympanic cavity, and the adhesive tissue was permeated with numerous lymphatic vessels and small lymphoid cysts. In section, the membrana tympani was four times its normal thickness, formed of a compact connective tissue permeated with vessels of various size, and its original structural elements could not be recognized. The articulations of the malleus and incus, as well as of the incus and stapes, were completely anchylosed. In microscopic sections of the decalcified articulation of the malleus and incus (Fig. 107), the fibrous capsular ligament (*b*, *e*) was considerably thickened, the articular surfaces of the bones were united everywhere with the wedge-shaped meniscus (*a*), while at the places which were not separated by it, the fissure-like space of the articular cavity (*d*) was visible. The articular cartilages of both bones (*c*) and of the meniscus had lost their sharp outline, and the cartilage cells, by a deposit of calcareous salts, had taken a jagged, irregularly star-shaped form, similar to that of bone-corpuscles. In addition, smaller foci of commencing osseous transformation of cartilaginous cells could be

traced in different places in the interior of the meniscus (*a*). The anchylosis of the articular surfaces with the meniscus is caused by the union of the articular cartilages thus transformed (Fig. 107). This anchylosis originates, therefore, in a direct transformation of cartilaginous into osseous tissue, after the type of the osseous transformation of the cartilaginous islands in the Eustachian tube, as described by Moos.

The pathological alterations in the Eustachian tube are generally dependent on the extent of the inflammatory process in the

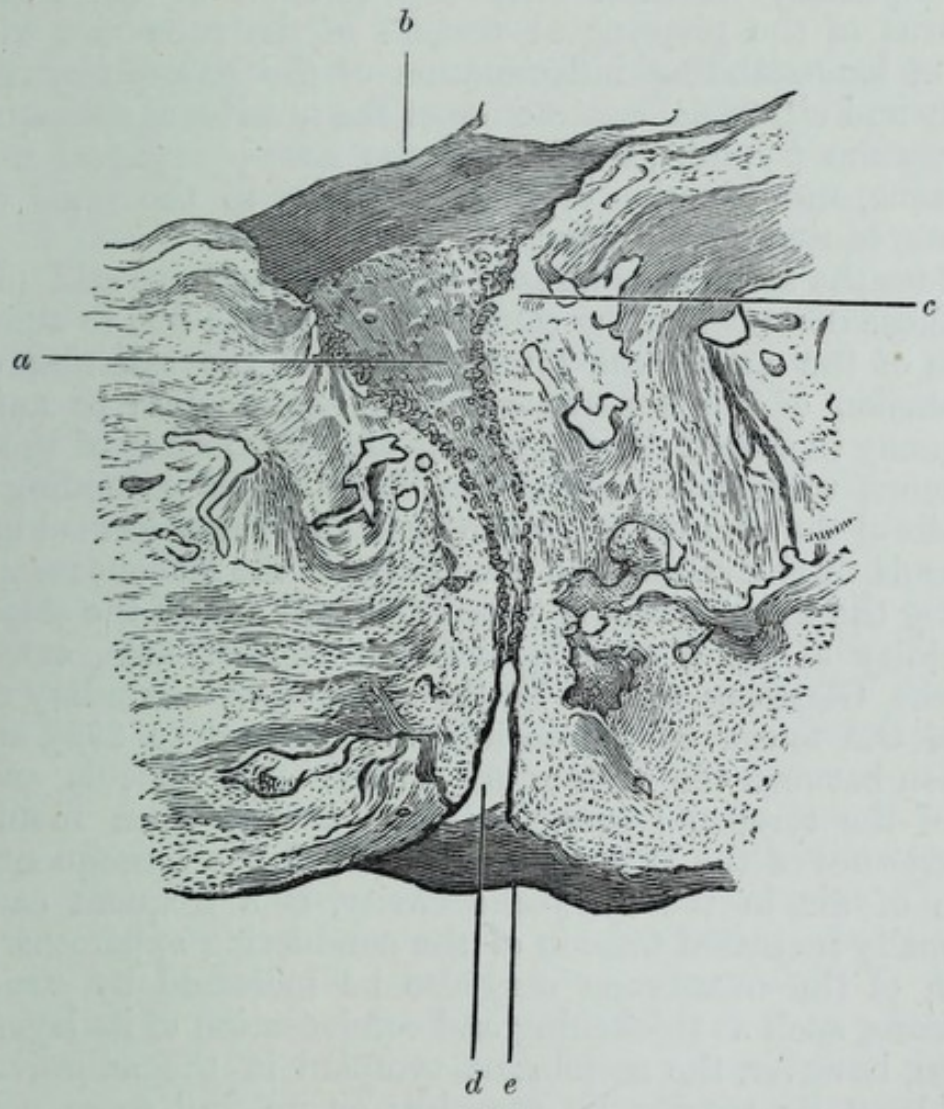

FIG. 107.

middle ear. In the diffused forms, especially in those connected with chronic naso-pharyngeal affections, sometimes a moderate, sometimes a great narrowing of the tube takes place. This occurs oftener than has been generally believed, through hypertrophy of the Eustachian mucous membrane, with consecutive thickening and contraction of its submucous connective tissue (Moos, compare p. 86). In circumscribed interstitial inflammations, however, the Eustachian mucous membrane is, as a rule, normal, and the tube is therefore completely permeable. This holds good, however, only in the majority of cases; for, just as

in cases where there have been adhesive processes, after catarrh has passed away, there may remain a freely permeable and even very wide Eustachian canal (v. Tröltsch), so we often enough find a pronounced stricture of the Eustachian tube in the circumscribed forms of inflammation in the tympanic cavity.

The alterations in the muscles of the Eustachian tube are of consequence in so far as by their decreased power of action the necessary ventilation of the middle ear is interrupted. Besides the paralytic conditions to which we will revert later on, we must especially mention fatty degeneration of the muscular apparatus of the pharyngeal portion of the tube met with in cases of long-standing inflammation of the naso-pharynx, also atrophy and cicatricial contraction of the muscles as consequences of ulceration (syphilis, scrofula) of the naso-pharyngeal mucous membrane, and adhesion of the vela palati to the walls of the pharynx, caused by the same.

Besides the alterations already described, we have still to consider those obstacles to the conduction of sound due to abnormal tension of the membrana tympani and of the ossicular chain. The tension of the apparatus for the conduction of sound is abnormally increased by shrivelling and shortening of the folds of mucous membrane and of the check-bands extending from the walls of the tympanum to the ossicula, by new-formed bridges and bands, by shrivelling and shortening of the mucous membrane covering the tendons of the tensor tympani and of the stapedius, by rigidity of the fibrous band (ligam. mallei. ant), extending from the Glaserian fissure to the malleus, by secondary retraction of the tensor of the membrana tympani (p. 299), and by adhesion between the membrana tympani, the ossicula, and the walls of the tympanic cavity. It has already been mentioned that stricture of the Eustachian canal, and the consequent rarefaction of air in the tympanic cavity, is a frequent cause of abnormally increased tension of the conducting apparatus. The tension of the membrane may also be increased by structural alterations, such as thickening and condensation of its layers.

Often, however, the membrana tympani in the adhesive processes loses its tension by atrophy; or we find some portions of it tightly stretched by thickening or adhesion, while other atrophied parts are at the same time abnormally flaccid. As clinically important, the fact must also be noted that the abnormal tension of the membrana tympani does not always correspond with that of the ossicula, for the membrane may be highly flaccid, while at the same time the ossicular chain is tensely stretched inwards, in consequence of the above-described alterations.

The changes in the intra-tympanic muscles occurring in chronic adhesive affections are to be considered as secondary processes. They consist of fatty degeneration and atrophy, developed partly by inflammation of the neighbouring mucous membrane of the

middle ear, partly by the arrested action of the muscles, in consequence of anchylosis of the ossicula. Pathological alterations in the muscles are, however, by no means so very frequent in inflammations of the middle ear, not accompanied by suppuration, as Wreden and Weber-Liel, not on anatomical but on clinical grounds, have asserted. Even in the inveterate forms, the muscles may be normal in appearance. In several cases where for many years there had existed very marked deafness, the cause of which, as proved by post-mortem examination, was anchylosis of the stapes, I could trace pathological alterations neither in the tensor tympani nor in the stapedius.

Ætiology and Occurrence.—Since the causes of adhesive alterations in the middle ear in the course of chronic catarrh have already had their main features described when treating of the prognosis of the middle ear catarrhs, it is only required here to mention the most important of them. It must, however, be noted, that although in a number of cases these causes can be ascertained, yet often neither the history nor the examination of the patient offers any explanation of the development of the persisting obstacles to the conduction of sound. The most frequent causes of the adhesive processes are the following:

(1) Frequent recurrence of catarrh; (2) chronic naso-pharyngeal catarrh and ozæna, by which recovery from the existing middle ear affection is retarded; (3) paresis and paralysis of the muscles of the palate and tube, which, with facial paralysis, sometimes occur as the sequelæ of diphtheria; also fatty degeneration and atrophy of the same, by which the necessary ventilation of the middle ear is prevented; (4) hereditary tendency. This is one of the most frequent causes of the unfavourable forms of interstitial inflammation of the middle ear (*vide* p. 189); (5) general diseases, especially scrofula, tuberculosis, syphilis, Bright's disease, chronic rheumatism, gout (Toynbee, Harvey), anæmia and marasmus; (6) pregnancy and the puerperal state; (7) external sources of injury, especially such as in consequence of the occupation of the patient continually operate upon the organism (p. 190), living in a damp house, excessive applications of hydropathy to cases of long-standing middle ear catarrh (v. Tröltsch), and protracted sea-bathing; (8) the immoderate use of alcoholic liquors and excessive smoking (Triquet, Ladreit de Lacharrière), by which in chronic catarrh the development of permanent new-formation of tissue in the mucous membrane of the middle ear is favoured.

The adhesive processes in the middle ear occur oftenest in middle-aged and old people, less frequently in children and young persons, who are most subject to the exudative forms of catarrh. The development of adhesive processes in the middle ear, which have arisen during childhood in consequence of catarrhs, can easily be traced to disturbance of nutrition, especially scrofula, or

to hereditary tendency. In a not inconsiderable number of cases, the adhesive processes in the middle-aged are caused by catarrhs which date from childhood.

Adhesive inflammation of the middle ear usually affects both ears, being seldom confined to one only. The disease generally presents the same character in both ears; often, however, the phenomena of the antecedent catarrh appear in the one ear as swelling and secretion, while in the other there exists an interstitial adhesive inflammation of the mucous membrane. But the combination of the last-named form of disease in the one ear, with purulent perforating inflammation in the other, is not uncommon.

Condition of the Membrana Tympani.—The alterations in the membrana tympani observable in adhesive inflammation of the middle ear, especially in its diffused forms, often differ but slightly from those described as occurring in chronic catarrh (p. 262). However, we meet with so various and often so characteristic alterations, that, considering their diagnostic importance, a comprehensive description of the principal conditions is necessary here.

The colour and transparency of the membrane are most frequently affected. In consequence of the thickening of the mucous layer, as also by deposit of a granular substance and fat-gobules in the substantia propria, sometimes also by thickening of the dermic layer, the membrane is partially or wholly rendered dull and non-transparent.

In the former case, the parts affected appear as definite or ill-defined opacities, of a tendinous-grey colour, striated or spotted, and between these the normal or less obscured portions of the membrana tympani appear as dark spots, apparently depressed. They vary greatly in size and shape. Among the more frequent shapes is the semilunar, with the convexity turned towards the periphery, and of the colour of milk-white glass or tendinous-grey, a form which, unlike the chalky deposits, is not sharply defined, but merges into the transparent parts of the membrane (Fig. 108), its margins gradually becoming less distinct. In inveterate catarrh, peripheral, whitish-grey and circular opacities are frequently found, comparable to the arcus senilis of the cornea, and due to the thickening of the mucous membrane of the periphery of the membrana tympani. A small, circumscribed opacity, extending parallel with the handle in the posterior superior quadrant of the membrane, often arises from adhesion of the latter to the long process of the incus; small opacities, star-shaped and somewhat concave, are caused by membranous bands extending between the membrana tympani and the ossicula, or the inner wall of the tympanic cavity.

The partial tendinous-grey chalky deposits on the membrana tympani must next be described. In the affections in question

they are much less frequently observed than in the course of purulent inflammation of the middle ear. In the non-perforating forms they are developed principally in those cases in which the chronic catarrh has been consecutive to acute inflammation of the middle ear, or where in the course of a catarrh a reactive inflammation of the middle ear has been intercurrent. More rarely cases are seen where chalky deposits are developed gradually and without any appearance of inflammation (Moos).

FIG. 108. — SEMILUNAR OPACITY BEHIND THE HANDLE OF THE MALLEUS IN A WOMAN 38 YEARS OLD. DURATION OF THE EAR DISEASE 6 YEARS; GREATLY AGGRAVATED DURING THE LAST 3. ACOUMETER = 1 CM. SPEECH = 10 CM. PERCEPTION THROUGH THE BONES OF THE SKULL UNALTERED. TUNING-FORK ON VERTEX HEARD BEST IN THE AFFECTED RIGHT EAR.

Chalky deposits are among the most easily recognised affections of the membrane in life.* They usually appear on the membrana tympani as chalky-white, sharply defined spots, situated between the handle of the malleus and the periphery. They are found most frequently in front of the handle of the malleus, more rarely behind it, in the shape of a crescent, directed with its convexity towards the periphery (Figs. 109 and 110). Sometimes a chalky spot is visible both in front of and behind the handle, or the inferior extremity of the handle is surrounded by a horseshoe-shaped deposit (Fig. 111). The diameter of these opacities is never so great as to reach to the malleus or to the periphery. Their thickness also is never so great as in the purulent inflammations of the middle ear. (Respecting the histological relations of the chalky deposits on the membrana tympani, compare p. 215.)

Not less frequently is the membrana tympani rendered non-transparent in its whole extent. In this case it appears sometimes irregularly spotted grey, sometimes of a homogeneous blueish-white colour, like a glass surface that has been breathed upon, sometimes as a sodden whitish-grey membrane, almost perfectly opaque, the aspect of which might be compared to a lustrous milk-white glass plate. The most complete opacities are found in connection with a great thickening of the mucous membrane of the membrana tympani, and with its extensive union with the inner wall of the tympanum, in which latter case the membrane presents the appearance of a yellowish disc of parchment. In rare cases, when the tympanic cavity is filled with vascular, œdematous connective tissue, or when greyish-red bands of connective tissue traverse it, or great hyperæmia of the mucous membrane exists, the colour of the membrane will be reddish or blueish-grey.

The appearance of the handle of the malleus is often also per-

* Compare the detailed descriptions of Moos, referring hereto, in his *Klinik der Ohrenkrankheiten*, 1866, p. 99.

ceptibly altered in cases of total or partial opacity of the membrana tympani. Its margins often seem ill-defined, the handle itself much widened, and the umbilical opacity increased, with its outline formed of whitish or yellowish indentations. This apparent enlargement of the handle is, however, by no means caused by increase in size of the bone, as is assumed by many, but by granular degeneration of the small cartilaginous cells, near the handle (v. Tröltsch). In rare cases only, the position of the handle is marked by a dark red band, caused by injection of its vessels.

The lustre of the membrana tympani is often unchanged. The cone of light either shows the normal, triangular shape, or is irregular, indistinct, much narrowed or shortened by contraction of the membrana tympani, displaced backwards and upwards with

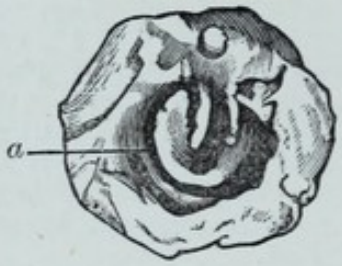

FIG. 109.—INNER SURFACE OF THE RIGHT MEMBRANA TYMPANI OF A WOMAN, 35 YEARS OLD, WHO DIED OF GENERAL PARALYSIS IN CONSEQUENCE OF A PSAMMOMA IN THE BRAIN.

a, An irregular semilunar chalky deposit in front of the handle.

FIG. 110. — SEMILUNAR CHALKY DEPOSIT IN FRONT OF THE HANDLE OF THE MALLEUS IN A MAN 38 YEARS OLD.

FIG. 111. — HORSESHOE CHALKY DEPOSIT IN THE MEMBRANA TYMPANI OF A WOMAN 30 YEARS OLD. DURATION OF THE EAR DISEASE 10 YEARS. TINNITUS SELDOM. ACOUMETER = 30 CM. SPEECH = 3 M.

the umbo, or absent altogether. An indistinct reflection of light (v. Tröltsch), visible behind and above the short process, is the sign of excessive bulging forward of the posterior superior quadrant. Often, however, we find the membrana tympani dull and without lustre.

The curvature of the membrana tympani in the chronic adhesive processes suffers striking alterations, of importance in diagnosis. The causes of these anomalies of curvature have already been discussed in the pathological part of this division, when referring to the fundamental causes of the abnormalities of tension in the sound-conducting apparatus.

To a greater or less extent the membrane appears drawn inwards, thickened, or atrophied and wrinkled (Fig. 112); the handle of the malleus appears foreshortened, displaced inwards, backwards,

and upwards, and its inferior portion partly or altogether covered by the posterior, diminished segment of the membrane; the short process and the fold of the membrane extending backwards from it seem very prominent. This fold, rounded or sharply defined on its superior margin, either extends in a straight direction backwards and upwards, or describes a semicircular curve, disappearing in the posterior inferior quadrant of the membrane.* Two short folds frequently extend simultaneously from the proc. brevis towards the Rivinian segment, and enclose Shrapnell's membrane, which is either depressed or united with the neck of the malleus, and the visible superior surface of the short process (compare the drawing, Fig. 95, p. 270).

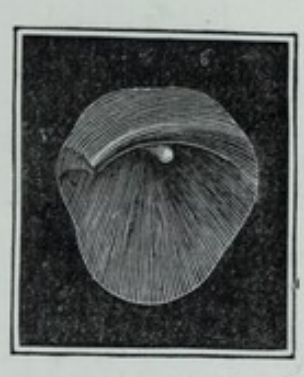

FIG. 112.—WELL-MARKED INWARD CURVATURE OF THE LEFT MEMBRANA TYMPANI OF A YOUNG MAN, HARD OF HEARING FOR 6 YEARS. ACOUMETER ONLY ON CONTACT. SPEECH, 5 CM.; AFTER POLITZERIZING, 1 M.

In addition, not unfrequently circumscribed retractions, similar to scars on the membrana tympani, are observed. These are caused either by partial atrophy (Fig. 113), by ligamentous adhesions, or by immediate union of the membrana tympani with the inner wall of the tympanic cavity (Fig. 114). Their number and extent are very variable. They appear as round or oval dimples on the membrane, occurring now and again with opaque or thickened portions of the membrane round them, or they are met with as extensive depressions, mostly situated behind the handle of the malleus, which come into contact with the deeper parts of the tympanum, and not unfrequently bring into view the outline of the articulation between the incus and stapes (Fig. 113). The thinned parts of the membrane are rarely found flat, on a level with the remaining portions of the membrane; in exceptional cases even constantly bulged out towards the external meatus (compare the analogous conditions of the membrana tympani in catarrhs of the middle ear, as well as the alterations on the membrane, which occur after the injection of air, pp. 268-270).

Adhesive inflammation of the middle ear is not, however, always accompanied by alterations of the membrana tympani. For very often, especially in the interstitial inflammations, localized upon the inner wall of the tympanic cavity, and also more rarely in the adhesive processes after catarrhs, we find the membrane in a

* As Bing was the first to observe, in rare cases a second fold is to be seen underneath the posterior fold of the membrana tympani, extending from the middle of the handle of the malleus towards the posterior margin of the membrane.

In the first edition of his manual, 1862, p. 106, v. Tröltsch says: 'The membrana tympani appears also concave as a whole, and apart from many partial irregularities in its curvature, a curvilinear ledge, extending from the proc. brevis mallei backwards and downwards, is often specially conspicuous, which is to be connected with the abnormal traction inwards of the membrana tympani.'

perfectly normal condition. This negative result is of diagnostic value only in so far as one can assume, with great probability, that an obstacle to the conduction of sound, where the existence of such has been proved by examination with the tuning-fork, has

Fig. 113.—Circumscribed Depressions in the Anterior Inferior Quadrant of the Left Membrana Tympani of a Scrofulous Girl, 12 Years of Age, where the Alterations on the Membrane had been developing themselves for several Years under Observation. Handle of the Malleus strongly inclined Inwards and Backwards, the Posterior Superior Segment of the Membrane united with the Articulation of the Incus and Stapes. Acoumeter = 1 cm., Speech = $\frac{1}{3}$ m.; after Politzerizing, Acoumeter = 15 cm., Speech = 2 m.

Fig. 114.—Circumscribed Adhesion of the Membrana Tympani to the Promontory underneath the Handle of the Malleus.

a, Place of adhesion on the promontory. After a preparation of mine, now in the museum of the College of Physicians in Philadelphia.

its seat, not in the neighbourhood of the membrana tympani, but in the deeper parts.

An important, but not constant, symptom of such processes confined to the vicinity of the fenestra ovalis, is the appearance of hyperæmia of the promontory, shining through the membrane. For, as Schwartze was the first to observe, there is sometimes seen on the perfectly normal membrana tympani a distinct reddish glimmer behind the umbo, which arises from great hyperæmia of the mucous membrane of the promontory. This condition is frequently met with in those severe forms, in which the ear-affection runs its course with continued subjective noises, with rapidly-increasing deafness, and early disappearance of perception through the bones of the head.

Even in the circumscribed inflammations, limited to the neighbourhood of the stapes, the membrana tympani does not always retain its normal appearance throughout the whole course of the case, for after long continuance of such processes diffuse opacities frequently arise, caused by deposition of drops of fat and granular masses, whereby the membrane assumes a dim, lustreless, and dry appearance.

Changes in the External Auditory Meatus.—These are limited in a series of cases to an alteration in the ceruminal secretion, which is often dark-brown, crumbling, and dry. A hypersecretion of the ceruminal glands is seldom observed, but one often finds the external passage dry, especially in the inveterate forms, without any sign of ceruminal secretion. The cessation of the secretion can probably be accounted for by simultaneous disturbances of nutrition in the sympathetic nerves of the middle and external ears. The circumscribed congestion of the skin in the neighbourhood of the ear, which has been observed by Burnett* in several cases, is also a result of disturbances within the range of the sympathetic.

Subjective Symptoms.—Subjective noises are among the most annoying symptoms of adhesive middle-ear inflammation. They are observed here more commonly than in any other form of inflammation of the middle ear. Referring the reader to the introduction to the special part (p. 192) for information regarding the kind of tinnitus, I will here only mention those facts of which a knowledge appears important for clinical purposes.

While the subjective ear-sensations in cases of middle-ear catarrh, complicated by secretion, are either absent altogether or only transient, in the majority of cases of adhesive middle-ear inflammation the noises are continuous. They are brought about by increased pressure in the labyrinth, emanating from the tympanic cavity, or by simultaneous disease of the expansion of the auditory nerve. Often intermittent and weak in the beginning of the disease, the noises become continuous as it proceeds, and frequently increase in intensity in proportion as the acuteness of hearing decreases. They are not always of the same intensity, but are usually loudest in bad and windy weather, after partaking of alcoholic beverages, as also during and after the use of quinine and salicylic preparations, when the patient is affected with a severe cold in the head, after severe mental exertion, nervous excitement, or great fatigue, during bodily indisposition and pregnancy. Sometimes true attacks of excessive loud noises are experienced after a longer or shorter cessation, or when slight tinnitus becomes suddenly so increased that the abnormal sensations spread from the ear through the whole head, giving rise to great anguish and excitement.

The intensity of the sensation does not always, however, depend on the loudness of the noises, but sometimes on different individual conditions. While, during the first part of the disease, many are very unpleasantly affected by the noises, but, as they affirm, gradually get used to them; in other cases, even after many years' duration, the tinnitus continues to cause the most unbearable torture, which embitters the patient's life. In con-

* The Ear, Philadelphia, 1877, p. 390.

sequence of such intense noises in their ears and head, many patients are continually in a stupid, often mentally depressed condition, from which they cannot be relieved by any kind of diversion. In general, the noises are felt much more distressingly by nervous, hysterical, anæmic, and ill-fed individuals, than by strong, healthy persons. It is worth mentioning that children who are affected with continuous noises seldom say anything about the unpleasantness of the sensation, while elderly people are constantly complaining of the annoyance. Sleep is, as a rule, not disturbed even by loud noises; and rarely is it delayed or interrupted.

The subjective ear-sensations and the disturbance of the function of hearing appear often simultaneously. In many cases, however, the noises are present long before deafness is developed, as the only symptom of chronic middle-ear inflammation. In other cases hardness of hearing is the first symptom, to which the subjective noises are added later on. With increase of deafness the noises, as a rule, also increase in intensity. Not unfrequently, however, they become weaker as the deafness increases, until with completely established deafness every subjective ear-sensation ceases. This is tantamount to complete paralysis of the auditory nerves. On the other hand, one observes cases where the noises continue in the most frightful manner after complete extinction of the power of hearing, and indeed they often increase more and more after deafness has been established, a condition which corresponds to the annoying light and colour appearances observed by amaurotic people.

The intensity of the subjective noises is often increased or decreased by a number of mechanical proceedings. As this is of importance for the prognosis of the singing in the ear, the surgeon should never omit to find out those things which bring about an alteration of the subjective sensations during the examination.

A noticeable decrease or a total cessation of the subjective noises often follows on condensation of air in the tympanic cavity, or on rarefaction of air in the external meatus (p. 300). In such cases it may be assumed with great probability that the tinnitus is caused by an increase of pressure in the labyrinth, originating in the middle ear, and the prognosis of the singing in the ear will then be a more favourable one than in those cases where, after the manipulations referred to, the intensity of the tinnitus remains unaltered.

The noises are also not unfrequently made to disappear by pressure on the common carotid. Even if this does not warrant the conclusion that the sole cause of the tinnitus is a disturbance of the circulation in the labyrinth, it at least indicates that by a decrease of the blood-supply to the labyrinth the intensity of the noises may in many cases be lessened. The alterations of the

subjective noises which are caused by pressure on the mastoid process, or on the cervical vertebræ (p. 196), are useless either for diagnosis or prognosis.

Sensations of pain in the ear in the adhesive processes are on the whole observed but seldom; only with a bad cold in the head, or after exposure to cold or draught, stitches in the ear or in the mastoid process (v. Tröltsch) are occasionally experienced. More severe pains occur with intercurrent attacks of acute middle-ear inflammation, and are then always accompanied by hyperæmia of the vessels of the membrana tympani, and by considerable inflammatory swelling of the membrane. But if no congestion is apparent on the membrane after the pain in the ear has lasted for some time, and if after careful examination of the teeth it is found that there is no pain arising from the dental nerves (p. 199), it may with probability be concluded that there is neuralgia of the plexus tympanicus. It is also possible that temporary sensations of pain, similar to those experienced in contracting cicatrices, may be caused by pressure on the nerves of the tympanic cavity by contraction of the newly-formed tissue.

A frequent symptom of the adhesive processes in the middle ear is *excessive sensitiveness to noises* (Hyperæsthesia acoustica) (p. 197). This is often so strongly pronounced, that not only sharp tones but all sorts of music and loud speaking give rise to an unpleasant and often worrying sensation. This symptom may frequently be noticed at the very commencement of insidious inflammations of the middle ear, when the hearing is but slightly disturbed, or it may become apparent only at a later stage of the disease, when the disturbance of hearing has already reached a high degree, so that often people who are very hard of hearing cannot bear loud speaking.

A sensation of heaviness and pressure, and of crackling in the ear, often occurs in the adhesive processes, but much more rarely than in the secretive forms of middle-ear catarrh. One observes much more frequently, especially in inflammation accompanied by continuous noises, a great fulness in the head, a sensation of weight and pressure on the brain, temporary or permanent dizziness, and more or less giddiness. The latter symptom—according to Schwartze most frequent with anchylosis of the stapes—occurs often in an attack associated with sickness, vomiting, unsteadiness of gait, marked increase of the singing in the ear, and a sudden change for the worse in the hearing, which often remains (Menière's group of symptoms); or the attack is less intense, of shorter duration, and disappears without any bad consequences. The supposition of v. Tröltsch, that such attacks are caused by obstruction of the Eustachian tube suddenly occurring in the course of the disease, may be correct in some cases; but in the majority of my observations I found the Eusta-

chian tube free, and as no fresh exudation in the middle ear could be discovered, an extravasation or exudation in the labyrinth must be assumed as their cause.

The patient's spirits very often undergo a palpable change. Persons formerly of gay temperament become mentally depressed, morose, and avoid all company. Moreover, one observes in many patients an impairment of the mental functions, sluggishness of thought (v. Tröltsch), and weakness of memory. All these symptoms are much more prominent in the nervous and hysterical than in the otherwise strong and healthy. But the head symptoms must not without further evidence be connected with the ear disease, as similar symptoms may depend upon simultaneous intracranial alterations, especially disturbances of the circulation in the brain and its membranes. It is only when in the course of treatment the unpleasant sensations in the head have vanished, that one is justified in seeking their cause in the ear disease.

Disturbances of Hearing.—The degree of disturbance of the functions in the adhesive processes is seldom proportional to the extent of the pathological alterations in the tympanic cavity. For while in the dead body one not seldom meets with extensive adhesions caused by bridges of connective tissue between the membrana tympani, the ossicula, and the walls of the tympanic cavity, where during life there was merely a slight disturbance of hearing; on the other hand one often finds a circumscribed adhesion of the malleus, the incus, or the stapes, as the cause of high degrees of functional disturbance. This explains itself, if it be taken into consideration that a circumscribed but close union of the ossicula will cause a greater impediment to the conduction of sound than numerous bridges of connective tissue, by which the ossicula will certainly be stretched tighter, but which still allow of movement of the whole chain to a certain degree. Disturbances of hearing of the highest degree are caused by anchylosis of the stapes, especially if at the same time alterations in the membrane of the fenestra rotunda are present. If the impediments to the conduction of sound in the middle ear are complicated with disease of the labyrinth, the disturbance of hearing is consequently increased in a considerable degree.

The function of hearing suffers the most various disturbances, not only as regards decrease in the acuteness of hearing, but also in respect of the qualitative perception of sound. While in a number of cases the acuteness of hearing for the watch or the acoumeter, and also for speech, is lessened in a corresponding degree, still very often in the power of perception of these tests a great disproportion is observed. Especially in cases where the condition of the membrana tympani is normal, and where the result of examination with the tuning-fork (*vide* Diagnosis) makes the existence of a circumscribed affection in the neighbourhood

of the stapes probable, experiment will often show a great hearing-distance for the watch or the acoumeter, while speech can be understood at a relatively short distance (Lucae). Such disproportion occurs much more seldom in diffuse inflammation of the middle ear, connected with visible alterations in the membrana tympani.* Furthermore, patients often come under observation who hear very slight noises, as for instance the falling of a pin, while they are still excessively deaf for speech. In the same manner a disproportion shows itself between the power of perception of speech and of music.† Persons with whom one can converse only in the closest vicinity can often hear the most subtle modulations in music and singing perfectly well at not too great a distance. Only at greater distances does the perception of soft and subdued notes disappear. Temporary or lasting derangement of the organ of hearing for musical notes is on the whole but seldom observed. It is professional musicians especially, who, when a sudden change for the worse occurs, hearing the notes wrong or confused, complain about this most often.

In the adhesive processes of the middle ear, great variations in the acuteness of hearing occur more seldom than in the secretive forms of catarrh. A remarkably variable hearing-distance is found mostly in those cases in which there are swelling and moderate secretion in the Eustachian tube and on the lining membrane of the tympanic cavity, while in the dry, adhesive processes, or those which come on without preceding secretion, only inconsiderable variations in the hearing can, as a rule, be noted. But in the latter cases also, there is often an evanescent increase or decrease of the acuteness of hearing observable. This is brought about partly by spontaneous alteration of the tension in the middle ear, and partly, in case of simultaneous affection of the labyrinth, by deviations in the power of perception of the auditory nerve.

The most frequent causes of temporary relapses of deafness, are intercurrent naso-pharyngeal catarrhs, bodily indisposition, fatigue, increased tinnitus, excessive mental labour, sexual excesses and pollutions, affections of the mind, fright, close atten-

* As high tones in general are better perceived than deep ones, this disproportion is, according to Lucae, to be explained by the fact that the noise of the watch consists of a number of high tones. This explanation is, however, not sufficient, as the disproportion in the hearing-distance as regards watch and speech should then occur much oftener. The cause of it is, in my opinion, that in anchylosis of the stapes the membrane of the fenestra rotunda very often remains normal. If it is not thickened, or abnormally pressed upon, simple tones and noises can without difficulty be transferred from the membrana tympani through the air column of the tympanic cavity to the membrane of the fenestra rotunda. Speech, however, composed of a number of partial tones, can only be perfectly transmitted to the labyrinth through the ossicular chain. The greater the impediment to the conduction of sound through the ossicula, the greater is the disturbance of hearing for speech.

† Compare *Ohr und Sprache*, by Oskar Wolf, Brunswick, 1871.

tion and long-continued conversation, and in many cases mastication (Lucae). The time of day, too, influences the acuteness of hearing, as most of these patients are harder of hearing in the evening than in the morning; probably in consequence of bodily fatigue. The reverse is more seldom the case. A temporary or lasting change for the worse in the hearing, is further caused by severe illnesses, especially constitutional syphilis, large doses of quinine, and frequently by pregnancy or the puerperal state.

Amongst external influences which act unfavourably upon the power of hearing are to be mentioned: sudden change of temperature, dull and rainy weather, severe storms, great heat, and a prolonged residence in ill-ventilated rooms. On the other hand, clear and dry weather, and residence in elevated places, effect an improvement in the acuteness of hearing. Sometimes the disturbance of the functions alternates between the ears in such a manner that within a given time the power of perception in one ear is reduced from a certain maximum to nil, while a proportional increase in the other ear takes place (Urbantschitsch). That many patients belonging to this group hear much better during a noise, while driving, or during the playing of loud music, I have already pointed out in the section on Paracousis Willisii (p. 202), and that this symptom in my experience occurs in the unfavourable forms of adhesive inflammation of the middle ear.

The perception of the watch and the acoumeter through the bones of the skull (so-called bone-conduction) is often lessened or quite absent, and but rarely is the ticking heard very distinctly. The reason of this decrease in the perception is principally to be looked for in the frequent complication of the adhesive processes with disease of the labyrinth. The bone-conduction may, however, even without affection of the labyrinth, be lessened in some degree by the fact that the rigid chain of the ossicula transfers sound less perfectly to the labyrinth than the normal movable chain (E. H. Weber, Lucae, *vide* p. 173). Perception through the bones of the skull usually disappears in the inveterate forms which are accompanied by continuous noises, especially when they date from childhood. Often, however, it disappears at an early stage in the insidious inflammations, in the hereditary forms, in constitutional syphilis, and in reduced cachectic individuals. It has already been mentioned in the general section (p. 177), that in chronic catarrh perception through the bones of the skull disappears and reappears spontaneously, or in the course of treatment (intermittent perception). I cannot, however, confirm the assertion of Brückner, that the increase and decrease of the acuteness of hearing bear a certain proportion to this phenomenon. As regards the perception of the tuning-fork—the great importance of which for the diagnosis of the adhesive processes we shall become ac-

quainted with later on—when brought into contact with the middle line of the skull, what has already been said in reference to middle-ear catarrhs holds good (p. 274). Low-pitched tuning-forks are, as a rule, perceived more distinctly with the deaf ear; only exceptionally with the normal or less-affected ear.

Phenomena of Auscultation.—These are dependent on the state of the Eustachian tube, and on the degree of tension of the membrana tympani. In the diffuse processes, where the Eustachian tube becomes narrowed through a continual loosening of its lining membrane, or by hypertrophy and shrinking of its submucous connective tissue, the auscultation-sounds, as heard by aid of catheterization, are, according to the degree of the narrowing, indistinct or hardly noticeable, or the passsge of the air through the constricted place gives rise to clapping, rubbing, hissing, and whistling noises, the intensity and shrillness of which are increased by the friction of the air on the abnormally stretched or atrophied membrana tympani, and on the bands of connective tissue in the tympanic cavity. In cases of moderate constriction, the auscultation-sounds will be more plainly perceptible during the act of swallowing; in cases of extreme narrowing, however, they will be unaltered during deglutition. The continuance of the sounds which sometimes occurs after inflation of the middle ear (Schwartze) is probably caused by the circumstance that through retraction of the membrana tympani, now forced outwards, the air is driven from the tympanic cavity through the Eustachian tube into the pharynx. An abnormally wide tube is, however, frequently discovered by means of the catheter, in exhausted diffuse processes (v. Tröltsch). In inflammation confined to the neighbourhood of the labyrinthine fenestræ, and ending with synostosis of the stapes, however, a normal, rushing sound may be noticed, but in this form, too, pronounced cases of narrowing of the tube are observed (compare the Results of Auscultation, pp. 132-137).

Course and Result.—The varied forms of adhesive middle-ear inflammation display such great variety in their progress that we must confine ourselves to a general description of them. As the development of the disturbances of hearing is the main point at issue, it will form the principal subject of the following exposition.

The development of the disturbances of hearing progresses differently in adhesive processes resulting from catarrhs, and in interstitial inflammations. Both forms have this in common, that the disturbances of hearing in the majority of cases exhibit a progressive character. This can be explained, if we consider that the products of disease in the middle ear, and often those in the labyrinth, do not continue in one stage of development, but in course of time undergo further alterations, by which the

functions of the organ of hearing are still further impaired. The new-formation of connective tissue, which like cicatricial tissue has a tendency to contract, becomes in time more tense and less flexible, and may, as we have seen, by chalky deposit or ossification, result in anchylosis of the ossicula with the walls of the tympanic cavity. The alterations developed in the labyrinth, too, cause, in course of time, a progressive disorganization of the auditory nerve, and its expansion.

The progress of the deafness depends, therefore, principally upon retrogressive alterations (contraction, calcification) which are taking place slowly or quickly in the middle ear, and on the participation of the labyrinth sooner or later in the diseased process. While in a number of cases, therefore, only a gradual diminution in the power of hearing is perceptible in the course of many years, yet frequently we meet with those very bad forms where in a surprisingly short time, even in a few weeks or months, great and incurable deafness is developed.

The decrease in the power of hearing in the adhesive processes which result from catarrhs is seldom a steady one. So long as a certain degree of swelling of the lining membrane is present, its reduction may enable spontaneous and considerable improvement in the hearing to take place. But even when the swelling and secretion have completely disappeared, the increase in deafness will seldom be regularly progressive, for often during the course of the disease intervals of different duration occur, in which the deafness either remains stationary, or its increase is hardly perceptible. Such shorter or longer cessation may be followed by a gradual or fitful decrease of the hearing-distance, until the deafness has either reached a degree which will hardly ever be altered, or has become absolute.

A curious course is taken by those insidious interstitial inflammations of the lining membrane of the middle ear, which so often result in anchylosis of the stapes. The affection commences often with slight but gradually increasing subjective noises, which exist for a long time without noticeable deafness, and are often taken for so-called nervous tinnitus, until, after many years, the first commencement of the decrease in hearing is apparent. The deafness which is developed from that point progresses irresistibly with but occasional pauses until it reaches a very high degree or becomes complete. The subjective noises, however, are not a constant symptom of this form; they may be very trifling, or may appear only temporarily, or be altogether absent, so that the only sign of the middle-ear affection consists in a steadily progressing deafness. The absence of other symptoms is the reason, too, why the first commencement of the disease is so often overlooked. The patients only become aware of their ear disease when the deafness makes itself felt in ordinary intercourse; indeed, it not seldom occurs that the

patient, before he himself has an inkling of the defect, has his attention drawn to his deafness by his friends.

Total deafness as the result of adhesive middle-ear inflammation is, on the whole, rare, considering the great number of cases of the disease. It comes on either gradually and without perceptible symptoms, or suddenly, with violent throbbing, giddiness, and fulness in the head; often, however, without phenomena of any kind. I have seen patients who suffered for years from stationary deafness, become completely deaf overnight. A cause for the sudden extinction of hearing cannot always be ascertained. I have noted as most frequent causes—colds, excessive noise, concussion of the skull, affections of the mind, excesses, cerebral and spinal diseases, syphilis, and old age. Either the loss of hearing is permanent, or a certain degree of hearing returns in a few days or weeks. There is no doubt but that in all cases of chronic middle-ear disease, in the course of which there is a sudden disappearance of the hearing, the latter must be caused by the addition of a labyrinthine affection. Anchylosis of the ossicula has only hardness of hearing as its result, not complete deafness, as post-mortem examinations have shown.

In contrast to the insidious adhesive middle-ear inflammations are those rarer forms in which the deafness increases very quickly after but a short duration of the disease, and without traceable exudation in the middle ear. The deafness is developed so rapidly, with attendant subjective noises, that after a few weeks or months, conversation in close proximity becomes very difficult. When examination of the power of perception through the bones of the skull shows that it is decreasing gradually or quickly until it completely disappears, there can be no doubt that the deafness is caused to a great extent by concomitant disease of the labyrinth.

This unfavourable rapid course is seen sometimes in strong healthy people, without any apparent cause for the aggravated character of the affection. Sometimes, however, the malignity of the disease may be traced to scrofulous, tuberculous, or hereditary tendency. But in most cases the rapid deafness is the consequence of constitutional syphilis. The defect in hearing appears either along with the secondary symptoms in the skin, lining membrane of the pharynx, and bones, or is developed a long time after the disappearance of all other secondary symptoms, as the result of isolated syphilitic disease of the ear.

Syphilis seldom remains localized in the middle ear, even in those cases in which the affection originated in a specific naso-pharyngeal inflammation. The functional examination rather tends to the result, that in the majority of cases the labyrinth is simultaneously affected (Schwartze, A. H. Buck). Then, again, there are cases where the specific disease is localized in the

labyrinth, the middle ear remaining intact (Roosa). We may diagnosticate syphilitic disease of the middle ear and labyrinth, when with undoubted constitutional syphilis the objective examination of the membrana tympani and of the Eustachian tube indicates disease of the middle ear, and examination of the power of perception through the bones of the skull (p. 183) discovers an affection of the labyrinth. But where examination of the middle ear gives a negative result, and the deafness is of high degree although of short duration, the assumption of syphilitic disease localized in the labyrinth is justified. This, indeed, refers to fresh cases only, for apart from the fact that syphilis may complicate an inveterate adhesive process in the middle ear, in older cases of the latter disease the labyrinth is so frequently affected that in constitutional syphilis labyrinthine deafness cannot be put to the credit of the specific disease.

As specially important for the development of high degrees of deafness in the adhesive middle-ear process, I would refer to the fact that when in a case of unilateral middle ear affection the power of hearing of the affected ear is either reduced to a minimum or wholly extinct, the tendency of the normal ear to become diseased is thereby considerably increased. Now, experience shows that when in unilateral deafness the previously normal ear becomes diseased, the deafness in it is not gradual, but mostly very rapid, and that in a short time the second ear often becomes deafer than the one which had been affected for years.

Having so far considered only that overwhelming majority of cases in which in the course of chronic adhesive processes the deafness continually increases, it must be added that cases sometimes come under observation where, even after many years' duration of the affection, a decided improvement in the hearing spontaneously takes place. This either lasts for a long time, or sooner or later another change for the worse takes place. The spontaneous improvement has its cause in such cases either in the partial decay and absorption of new-formed tissue in the vicinity of the ossicula, or in the disappearance of an abnormal tension in the sound-conducting apparatus.

Lastly, it may be mentioned that sometimes in the course of so-called dry catarrhs, even after long duration, a serous or mucous exudation in the middle ear results; that further, sometimes a simple acute middle-ear inflammation, or an acute suppurative middle-ear inflammation with perforation, are intercurrent, and are accompanied by considerable change for the worse in the hearing. Such inflammations may either pass off without harm, or leave increased disturbance of the function. Only exceptionally do we observe after simple inflammation an improvement in the hearing.

Diagnosis.—The diagnosis of the adhesive processes in the middle ear is not difficult in those cases where marked alterations

in the membrana tympani, as thickenings, chalky deposits, and contractions or partial atrophy, exist. These appearances in the membrane, when taken in conjunction with the course of the disease, the subjective symptoms, the result of the functional examination, and auscultation, will in most cases lead us to assume the presence of pathological alterations in the sound-conducting apparatus as the basis of the deafness. With a normal membrana tympani, however, or when it exhibits a slightly striated or diffused opacity, such as is often seen in a great number of persons of normal hearing, the diagnosis is more difficult, especially when the Eustachian tube is normally permeable. Here one must often decide whether the deafness is occasioned by a disease of the middle ear or of the labyrinth, and in coming to a diagnosis the results of the functional examination, and that of the permeability of the Eustachian tube, must be taken into consideration.

Especially important for the differential diagnosis of middle-ear and labyrinthine disease is the positive result of examination with the tuning-fork. If in a given case, where the objective indications of a middle-ear affection are wanting, the vibrating tuning-fork, brought into contact with the middle line of the skull, is heard louder by the deaf ear, it may be assumed with certainty that the seat of the disease is in the middle ear, and not in the labyrinth. This also holds good in all those cases where the tuning-fork is heard by the diseased ear only from certain parts of the middle line, but is heard better by the normal or less affected ear from other parts of the middle line (Lucae, Urbantschitsch); for in the pronounced primary labyrinthine affections—in the pure forms of Menière's disease, for instance—the tuning-fork cannot be heard from any part of the middle line by the diseased ear. It must, however, be specially mentioned that a conclusion as to the seat of the disease in the middle-ear may be drawn only from the positive result of the examination with the tuning-fork, but that with a negative result the surgeon is not justified in diagnosticating labyrinthine disease. Because, as has already been pointed out (p. 180), in for other reasons undoubted middle-ear affections the tuning-fork may exceptionally be perceived louder by the normal, or less-affected ear. Of less importance for the diagnosis of the adhesive process is the power of perception of the ticking of the watch or of the acoumeter through the cranial bones (p. 173). Only in those cases where in deafness of high degree (conduction of air) the perception through the cranial bones, even for a low-ticking watch, is perfectly preserved, it may, in default of other diagnostic points, be assumed with great probability that the pathological changes have their seat in the middle ear, and not in the labyrinth. A trifling decrease of the perception, however, may not be accounted for by labyrinthine disease, because, as already mentioned (p. 171), the

transfer of the sound to the labyrinth can be diminished by mere rigidity of the ossicular chain. If, however, with undoubted middle-ear affection the examination with a loud-ticking watch or the acoumeter discloses a complete want of perception through the bones of the skull, it may be taken for granted that the labyrinth is also involved.

The diagnosis of the adhesive processes in the middle ear is often completed by the result of the opening of the Eustachian tube. This is specially of importance when the examination of the membrana tympani and of the Eustachian tube, and the functional examination above described, give a negative result. If in such cases after inflation of the middle ear with the catheter, or by my own method, marked improvement in the hearing takes place, a middle-ear affection can with probability be inferred. A trifling alteration in the hearing-distance, however, does not warrant the assumption of middle-ear disease, for in pronounced labyrinthine disease a slight increase or decrease in hearing is sometimes observed after inflation.

In deafness of high degree, or in total deafness, the surgeon should never omit to examine the patient's power of hearing speech by aid of the ear-trumpet (p. 184). If it be found that loud speech in the immediate neighbourhood of the ear is heard, but cannot be perceived through the ear-trumpet, the surgeon is justified in assuming that the sound reaches the labyrinth through the cranial bones, and not through the ossicula, and that therefore there is anchylosis in some part of the ossicular chain. In such cases it is advisable to complete the examination by means of Bing's entotic ear-trumpet (p. 185). If it be found then that speech is not heard through an ear-trumpet placed in the external meatus, but is clearly understood through the entotic ear-trumpet, it may with great probability be assumed that there is anchylosis of the malleus, or of the incus, but that the stapes is still movable. In a patient who could not understand a word through the ear-trumpet, but who heard plainly through the entotic ear-trumpet, I determined to perforate the membrana tympani as an experiment. Immediately after piercing the membrane a remarkable improvement in the hearing for speech (about $1\frac{1}{2}$ meter) took place. As the patient left Vienna soon after the operation, I know nothing of the ultimate result. It is, however, probable, that the opening closed again, and that the former deafness reappeared.

If the means hitherto enumerated afford no positive result for the determination of the diagnosis of middle-ear disease, then the diagnosis between middle-ear and labyrinthine disease also remains undecided. To obtain direct proof in such cases as to whether an anchylosis of the stapes exists or not, Schwartze has proposed to make an opening in the membrane and through it to examine the mobility of the stapes with a probe. 'If the

stapes is movable, then the slightest touch is most acutely painful, and causes also a loud subjective ringing noise. When anchylosis exists, probing is very much less painful, and causes no tinnitus' (*A. f. O.* vol. v. 1271). These assertions, however, only hold good in those cases in which there is complete bony anchylosis of the stapes, for in membranous anchylosis the pressure of the probe may produce motion, which would give rise to tinnitus. On the other hand, it is possible that when the labyrinth is diseased, and disorganization of the auditory nerve very far advanced, even by probing a perfectly movable stapes no tinnitus could be produced.

We shall now discuss the diagnosis of adhesions between the membrana tympani and the deeper parts of the tympanic cavity, as also the determination of anomalies of tension of the sound-conducting apparatus. The diagnosis of adhesions of the membrana tympani is possible by inspection of the membrane either during inflation or during examination with Siegle's speculum. Thinned parts of the membrane, which lie closely applied to the internal wall of the tympanic cavity, or to the incu-stapedeal articulation, bulge forward like bubbles after an inflation, which renders invisible the previously visible incu-stapedeal articulation or promontory respectively. The bulged-out parts either remain some time in this position, or quickly collapse. Very concave membranes may often be seen to sink back quickly after inflation. Where synechiæ exist, however, the sunken adherent places remain unaltered. If an examination with Siegle's speculum be made (*vide* p. 102) the non-adherent parts of the membrane show a distinct movement as condensation and rarefaction of the air alternate in the external meatus, while the adherent places remain quite unmoved. Bridge-like fibres between the membrane and the internal wall of the tympanic cavity cannot be diagnosticated by this method, because the parts of the membrana tympani concerned possess some mobility, as I have been able to convince myself by post-mortem examinations.

The determination of the anomalies of tension of the sound-conducting apparatus is beset with greater difficulties than is generally thought. Because in addition to the fact that the alteration of tension in the membrana tympani does not always correspond to that in the ossicular chain (p. 332), the methods of examination at present in use for testing the anomalies of tension have proved thoroughly inadequate.

The anomalies of tension of the membrane cannot be determined by inspection alone, it being often found that an opaque, much retracted, and apparently tense membrane turns out on examination with Siegle's speculum to be highly flaccid, while sometimes a normal-looking membrane when similarly examined proves to be tightly stretched.

In the examination with Siegle's speculum, it is the degree of mobility of the membrane from which we infer the increased or decreased tension. As a gauge for this, the mobility of the normal membrane must be taken. Inasmuch, however, as this varies in each individual, it is plain that great tension may be diagnosed only from very slight mobility, and relaxed tension from excessive mobility, but that tension alterations of a lesser degree cannot be recognised by this method.

Yet while it cannot be denied that tension alteration in the membrane and in the ossicular chain are of importance to the functions of the sound-conducting apparatus, the important clinical fact must be prominently stated that but trifling deafness is frequently observed in the case of a tightly stretched membrana tympani, but oftener in the case of a remarkably slackened membrane. This also often holds good in cases where the handle of the malleus is abnormally drawn backwards and inwards, and is only slightly movable. It must, therefore, be assumed that alterations in the tension of the sound-conducting apparatus may exist within certain limits without causing any noticeable disturbance in the functions, and also that the disturbances of hearing produced by anomalies of tension are brought about by the co-operation of a number of alterations in the sound-conducting apparatus, alterations having complicated relations as yet not fully understood.

A motion of the handle of the malleus may be distinctly seen on the normal membrana tympani during examination with Siegle's speculum. During condensation, either the inferior extremity of the handle moves inwards and backwards, or the whole handle executes a motion backwards, with an apparent revolution round its long axis, by which the short process is brought into greater prominence. In cases of disease the handle of the malleus will either partly or wholly lose its mobility by condensation and stiffening of the membrana tympani, by rigidity and anchylosis of the articulation of the malleus and incus, and also by immediate union with the walls of the tympanic cavity. If, therefore, the malleus is ascertained to be movable, it may be assumed, in the case of an obstacle to the conduction of sound, that it has its seat in the deeper-lying parts of the tympanic cavity, and not in the malleus.

The result of the functional examination after inflation of the tympanic cavity allows in many cases an estimate to be formed of the alterations of tension in the sound-conducting apparatus. If this manipulation is followed by a marked improvement in the hearing, it may be assumed that the disturbance of hearing was partly the result of an anomaly of tension in the sound-conducting apparatus, which was removed to a certain extent by moving the membrana tympani outwards. In cases, however, where disease of the middle ear has been ascertained, and where

there is no improvement, or only a slight one after the injection of air into the tympanic cavity, the conclusion must be drawn that the ossicula are fixed in a firm and unyielding manner.*

Prognosis.—The prognosis of the adhesive processes depends upon the pathological alterations in the middle ear already described. As we have to deal here with products of disease which have become organized, a complete return to the normal state is of course out of the question, if a hindrance to the conduction of sound has been caused by them. The prognosis is therefore confined to probable conclusions from the course of the disease and its accompanying symptoms, whether in its further course the disturbance of hearing will increase slowly or quickly, and whether a substantial or only a trifling improvement in the hearing may be expected from the treatment to be applied.

The affections which originate in secretive catarrhs have, as a rule, a more favourable prognosis than the insidious circumscribed inflammations, which are often complicated by an affection of the labyrinth.

The prognosis is relatively more favourable if the disturbance of hearing is not yet of a high degree, although the disease has been of long duration; if it has run its course without subjective noises, or if their occurrence has been only temporary; if the power of perception of the auditory nerve through the cranial bones still suffices for a moderately loud-ticking watch, and if the deafness increases but slightly within a considerable space of time. The prognosis will also be more favourable if a marked improvement in the hearing, and a lessening of the singing in the ear, are observable after the injection of air into the tympanic cavity, from which it may be concluded that a swelling or an anomaly of tension exists in the middle ear, which has still to be removed.

On the contrary, the prognosis is an unfavourable one in cases where after a short duration of the disease a considerable disturbance of hearing has already become developed without any free exudation in the middle ear being traceable, or where the hardness of hearing, irrespective of the duration of the disease, has already reached a very high degree, and where increase in the hearing-distance is either imperceptible or very trifling, after the injection of air into the middle ear. More unfavourable also is the prognosis in cases where with a normal state of the membrana tympani, and a normally permeable Eustachian tube, the process has a steadily progressive, insidious character, where the subjective noises continue uninterruptedly, and where the faculty of perception through the cranial bones is either lessened or has

* In the *A. f. O.* vol. i. 1864, p. 327, I have proved in a lengthened paper on the conduction of sound by the cranial bones, that the intensity with which the tone of a vibrating tuning-fork, brought into contact with the skull, is perceived is increased during the Valsalvian experiment.

quite disappeared. A rapid decrease in the function of hearing may especially be expected in those cases where perception through the cranial bones is wanting after only a short duration of the disease, while in patients in whom this perception is perfectly well preserved, in spite of a disease of the ear of many years' duration, it may be assumed that the hardness of hearing will make no very rapid progress (compare p. 176).

In conclusion we must add, that the prognosis of chronic adhesive processes in the middle ear is an unfavourable one in old people, also in the various general diseases, as scrofula, anæmia, tuberculosis, marasmus, cachexia; that where there is undoubted hereditary tendency it must be considered as specially unfavourable as regards the further course of the disease, and that the external conditions of life, such as occupation, have also in many cases a decided influence upon the prognosis.

Treatment.—As the persistent hindrances to the conduction of sound which have been developed in the course of adhesive inflammation of the ear do not admit of a complete restitution of the function of hearing, it must be the task of the surgeon not only to improve the power of hearing as much as possible, but also to stay the rapid progress of the disease, and to mitigate the tormenting subjective noises as well as the troublesome head symptoms which accompany the disease in the ear.

Injection of Air into the Middle Ear.—On account of its therapeutic importance, injection of air into the middle ear must be here put prominently forward, as it was in the treatment of the diseases of the middle ear already described. As has already been stated (p. 105), by the condensation of air in the middle ear the membrana tympani and the ossicula are forced outwards, and the thickened coverings of the two fenestræ of the labyrinth are stretched. By this means the strong bulging inwards of the membrana tympani is counteracted, and the articulations of the ossicula, if they are not completely anchylosed, are made more movable, and their power of vibration is therefore increased.*

What has been said during the description of the secretive forms of catarrh of the middle ear (pp. 155, 279), as to the slight therapeutic value of the Valsalvian experiment, holds good still more in the case of the adhesive processes in the middle ear now under discussion, as we know from experience that by the employment from time to time of this experiment, only a slight improvement of hearing, or none at all, is the result, while a too frequent performance of the same often results in a rapid change for the worse, and an increase of the subjective noises.

The systematic employment of Politzerization, however, is also to be recommended here in most cases, and may be made use of

* The hypothesis that adhesions are loosened, and ligamentous ones torn, by strong injections of air has not yet been proved.

in all instances in which, during its execution, the air penetrates with sufficient force into the tympanic cavity, and in which, therefore, no great obstacle exists in the Eustachian canal to prevent the entrance of air into that cavity.

The amount of pressure to be applied is here dependent on the greatness of the obstacle in the middle ear. In cases where the diminution in the calibre of the Eustachian canal is not very great, a pressure up to 0·3 atmosphere, by a moderate compression of the inflating-bag in the hollow of the hand, will, as a rule, elicit all the good effects that can be got from condensation of air in the middle ear. But in cases of greater obstacles in the Eustachian tube, of course a greater pressure (up to 0·4 atmosphere and more) must be employed (Hartmann, p. 181), and this must be obtained either by stronger compression of the inflating-bag, or, if this is not sufficient, by the force-pump.

The degree of tension of the membrana tympani must also be considered in determining the amount of pressure to be applied. The tighter the membrane is stretched, as seen by examination with Siegle's speculum, the greater must be the pressure with which the air is propelled into the tympanic cavity. Great force will, however, prove injurious if the Eustachian tube is perfectly permeable and the state of the membrana tympani is normal, or if the membrane is seen to be thinned and slackened to a great extent.

The air-douche with the catheter is to be recommended specially in those cases in which Politzerization fails to effect the entrance of air into the tympanic cavity, on account of marked swelling and narrowing of the Eustachian canal. The pressure made by a strong compression of the inflating-bag with the hollow of the hand will generally also suffice for catheterization (p. 130).* But when the obstacle in the middle ear is very great, the inflating-bag will often be insufficient, and the force-pump (p. 131) will then be required to raise the pressure up to 0·5—0·6 atmosphere, and more.

The curative effect of my method is certainly in many cases quite the same as that of the air-douche with the catheter, but it is often decidedly superior, as regards both the improvement in the hearing power and the diminution of the subjective noises. It must not, however, be left unmentioned, that on the other hand cases occur, where even without marked narrowness of the Eustachian tube, not only does a greater improvement in the hearing, but also a greater subjective relief take place after the air-douche with the catheter, than after the application of my method.

From this it follows, that in every case where catheterization is

* In the case of a roomy nasal cavity, conical catheters are to be preferred to cylindrical instruments (p. 157).

practicable, the application of both methods should be tried, so as to determine from the result, or from the increase of the hearing, which method is the more suited for that special case.

In the adhesive processes the propulsion of air into the middle ear seldom causes such a striking improvement in the hearing as in the sero-mucous catarrhs; indeed, not unfrequently a noticeable decrease in the hearing-distance is observed immediately after the manipulation. This is due to the membrana tympani being too tightly stretched outwards, and to the sudden increase of pressure in the labyrinth caused by the excessive condensation of the air in the tympanic cavity. This momentary change for the worse can quickly be removed in most cases by an act of swallowing, as this allows the air to escape through the widened Eustachian canal. Too powerful inflation is to be avoided in such cases.

The improvement in the hearing which occurs after the propulsion of air is rarely permanent. In most cases, especially at the commencement of the treatment, a decrease in the hearing-distance can be ascertained after twenty-four hours, indeed, it sometimes happens that the improvement in the hearing has completely disappeared after a few minutes, or even a few seconds. As I have already stated, the latter fact is of practical importance, because it leads to the inference that there is a speedy return of the membrana tympani and ossicula to their former position after the injection of air, and that that method is indicated by which the abnormal tension of the sound-conducting apparatus is counteracted.*

We will now discuss the local, medicinal treatment of the adhesive processes in the middle ear. As is known, the remedies are introduced into the middle ear either as vapours or in solution. It has been thought that drugs brought into contact with the lining membrane of the middle ear, would dissolve the exudation deposited in the mucous membrane, and thus lead to its absorption. Now as we have seldom to deal with exudations capable of absorption in this group of the affections of the middle ear, but generally with new formations of connective tissue, it is clear that they cannot be made to disappear through the action of drugs.

* The estimates of the results of treatment of chronic catarrhs of the middle ear by compressed air in the so-called pneumatic cabinets are very different. Magnus, to whom we owe the most reliable information as to the conduct of the organ of hearing in compressed air (*A. f. O.* vol. i.), and also v. Tröltsch deny that there is any value in this method of treatment. In the majority of the cases observed by me, the effect of sitting in the pneumatic cabinet could not be estimated, because, according to the statement of the patients, inflation after my method had been practised simultaneously. In cases where the patient was only exposed to the effect of the compressed air in the cabinet, the result was generally slighter than after the application of my method or of catheterization. In only a few patients could I observe a considerable improvement in the hearing after pneumatic treatment where formerly local treatment had been without results.

The action of drugs in the adhesive processes can therefore be traced to the following facts:

1. As the introduction of vapour as well as the injection of small quantities of fluid into the middle ear is always effected by a certain pressure of air, the resulting improvement in the hearing must be attributed to a great extent to the simultaneous action of the currents of air.

2. The drugs introduced into the middle ear cause more or less irritation, by which the articulations of the ossicula, which have become tight, are loosened. Thus the lining membrane of the middle ear is prepared for the action of the injected air as the loosened parts become more elastic.

3. In cases in which there is still swelling of the mucous membrane of the middle ear, owing to infiltration of cells, the unorganized cellular elements may still partly decay and be absorbed, from the irritation of the drugs.

*Vapours.**—Medicated vapours, first recommended by Saissy, were formerly more frequently used in the treatment of chronic affections of the middle ear than at present. We cannot enter here into a detailed discussion of the numerous remedies, which have been applied in the form of vapour for the chronic catarrhs of the middle ear and their consequences. We will mention only those which have been praised by specialists as particularly effective. They are: steam, sal ammoniac vapour, and the vapours of carbonate of ammonium (v. Tröltsch), iodine, iodic ether (Rau), acetic acid, acetone, pyroligneous acid and tar (Bonnafont); the vapours of turpentine, of different balsams and resins (Hubert-Valleroux), camphor and gases, *e.g.* carbonic acid, recommended by Ruete, and hydrogen gas, proposed by Loewenberg. As regards the effect of steam, and the vapours of sal ammoniac, turpentine, and carbonic acid, I have already given my opinion (p. 292). We have seen, that the operation of these vapours is by no means striking, even in the secretive forms of catarrh of the middle ear, which are much more favourable, and that their application is confined to those cases only, in which, in spite of inflation of air, and paracentesis of the membrana tympani, the swelling of the mucous membrane and the secretion obstinately continue. In the adhesive processes, the prognosis of which is much more unfavourable, we must therefore expect still more insignificant remedial results from the application of vapours.

Injections.†—Injections of medicated solutions into the middle ear are now used much more frequently than vapours, in cases of chronic affection. Of the numerous solutions recommended for injection into the middle ear, must be mentioned: caustic potash, in the proportion of 1 : 400 (Pappenheim, Marc d'Espine,

* On the method of introduction of vapours into the middle ear see p. 142.

† On the method of injection into the middle ear, see p. 137.

Schwartze); caustic soda, 0·5 : 30; lithium carb. 0·1 : 30 (v. Tröltsch); sal ammoniac, 0·5 : 40; chloride of sodium, 0·5 : 15; bicarbonate of soda, 0·5 : 10·0; borax, 0·5 : 20·0; iodide of potassium, 0·5 : 15·0; nitrate of silver, 0·2 : 30·0; corrosive sublimate, 1·0 : 100·0 (Wilde, Toynbee); chloral hydrate, 1·0 : 30·0 (Bonnafont, Lucae, Wreden); acetic acid or lactic acid, 1-5 drops to 40·0 water; muriatic acid, 1-3 drops to 40·0 water.

These solutions produce a more or less pronounced irritation of the mucous membrane of the Eustachian tube and of the tympanic cavity, depending on the degree of concentration of the solution, and on the irritability of the individual mucous membrane. It must once more be emphasized here, that to avoid too great a reaction, only trifling quantities of the fluid (8-10 drops) must be injected, and that the fluid must always be warmed previous to injection. The immediate effect of the injections is seldom subjective relief in the ear; there often arises rather a feeling of fulness and stuffiness in the ear, which lasts several hours, sometimes even several days, and disappears only after inflation of air with the catheter, or by my method. The greatest reaction is caused by solutions of potash and soda, acetic acid, nitrate of silver, corrosive sublimate, sal ammoniac, chloride of sodium, and sulphate of copper (de Rossi). (On the reactive phenomena appearing after irritating injections, see p. 138.)

Of the above solutions I have used in my practice for a number of years bicarbonate of soda chiefly (℞ sodæ bicarb. 0·5, aq. dest. 10·0, glycerine pur. 2·0). This solution acts very mildly, and very rarely causes much irritation of the mucous membrane of the middle ear, and the escape of a portion of the solution into the pharynx does not, as with most of the other solutions, give rise to unpleasant sensations of burning and itching in the throat, often lasting for hours. In the case of undoubted syphilitic affections of the ear, especially if the disease of the middle ear is accompanied with an affection of the labyrinth, I inject solutions of iodide of potassium, but their action must always be supported by general antisyphilitic treatment.

It has been stated above, that the effect of drugs upon the mucous membrane of the middle ear is due to their softening the rigid tissue by irritation. Now, the fact that a more striking improvement in the hearing is observed in some cases after a great than after a slight irritation from injection, is most probably the reason why many specialists advocate the application of strongly irritating fluids. But if the results of the treatment are closely followed, it will be found that, exactly in those cases in which a strong reaction in the middle ear occurred during the treatment, often even after a few months such a rapid change for the worse takes place, that the deafness is greater than before treatment. In my opinion the reason of this is, that through the reactive inflammation a temporary softening of the tissue is cer-

tainly produced, but that at the same time new products of inflammation are induced, through which, after the disappearance of the inflammatory irritation, the newly developed tissue becomes tighter and more rigid than previously.

The same holds good as regards all those methods which have been proposed in order, by an artificially produced inflammation of the middle ear, to bring about a softening of the new-formed tissue in the mucous membrane, and thereby to produce an improvement in the hearing.* But setting aside the fact, that in chronic affections of the middle ear a decrease much oftener than an increase in the hearing results from intercurrent inflammation, these modes of treatment, quite incalculable as to their consequences, must be discarded, because the suppuration provoked in the middle ear may lead to fatal complications, by propagation to the cranial cavity and the venous sinus. Cases of this kind have been several times observed, and I have myself seen violent suppuration in the middle ear arise in patients who had a fluid pressed into their middle ear by means of a syringe inserted into the orifice of the nose, a suppuration which resulted in caries of the mastoid process.

As regards the effects of injections and of vapours, as compared with simple inflation with air, I must from my experience declare that in the great majority of adhesive processes originating in catarrhs, the degree of improvement in the hearing which in any case can be obtained, can be procured by propelling air alone into the middle ear. In a number of cases, however, the effect of the inflation of air is undoubtedly much increased by the combined application of medicated solutions or vapours. This follows from the observation of cases in which by the inflation of air alone an improvement in the hearing to a certain degree had been produced, but in which by a subsequent temporary application of vapours or solutions a still greater increase in the acuteness of hearing had been brought about. I cannot therefore agree with the statement of Burnett, Cassells, and Lennox Browne, that even injections of small quantities of fluid are quite valueless in the treatment of chronic affections of the middle ear.

The question whether better cures are effected in the so-called dry catarrhs of the middle ear by the application of vapours or of medicated solutions, is still a subject of controversy amongst specialists. The fact is that, in the limited number of cases where any improvement is caused by a local medicated treatment, sometimes vapours and sometimes solutions give the more favourable result. On the whole, however, there is very little difference

* To this belong injections of concentrated alkaline solutions, and the inoculation of the secretion of gonorrhœa through the incised membrana tympani proposed by Erhard. Most severe inflammation may also be produced by injections of considerable quantities of fluid, by means of Sæmann's water-douche and Gruber's modification of this method.

between the two methods, as in either case marked and permanent benefit is out of the question. Injections are so far more effective, because the result to be attained can generally be achieved in a shorter time than by treatment with vapours. It is well known that by the application of vapours, fulness in the head, increased tinnitus, decrease in the hearing power, increase of the naso-pharyngeal catarrh, and irritation of the whole respiratory tract, are not unfrequently induced. For this reason the more convenient method of injection, which takes less time (de Rossi) and is less troublesome to the patient, is generally to be preferred to the introduction of vapours. V. Tröltsch says that he has obtained good results from a combination of the two methods, by injecting an irritating fluid after applying steam for a short time.

During the treatment of adhesive processes, where the method of inflation of air is exclusively used, it must not be applied daily, but only every second or third day. When applying drugs, especially in solution, it is advisable to use injections and inflation of air alternately every other day (p. 295), because treatment with injections only often causes a change for the worse. But even with these precautions, medicated treatment not unfrequently proves injurious, for during its course a rapid change for the worse may take place, even after a short time, to disappear only when, after a pause of several days, treatment by inflation of air is again exclusively resorted to. Especially in cases where disease either of the membrana tympani or of the Eustachian tube cannot be proved to exist, and where the disturbance in the hearing is only a trifling one, I must caution against medicated treatment in these insidious inflammations of the middle ear. Indeed, cases sometimes occur, although not often, where a decided change for the worse is brought about by the methodical application of inflation of air only, where therefore every local treatment acts injuriously.

The local treatment of the adhesive processes, especially those combined with anomalies of tension, is in many cases assisted by rarefaction of air in the external meatus (p. 299). The method (p. 300) of momentary rarefaction of air with the inflating-bag, proposed by Lucae, gives most frequently a favourable result, if it is applied after catheterism or Politzerization. The effect of the rarefaction of air is not only observed in a further increase in the hearing-distance, but the subjective noises are also considerably decreased or cease altogether, and a remarkable subjective relief in the ears and in the head takes place. Hermetic occlusion of the external meatus is very effective in many cases of strong bulging inwards of the membrana tympani. The only contra-indication for the rarefaction of air with the inflating-bag in the external meatus is well-marked flaccidity of the membrana tympani.

The results of local treatment depend in the first instance on the nature of the pathological alterations in the sound-conducting apparatus, on the condition of the expansion of the auditory nerve in the labyrinth, and also on the facts which have been enumerated in speaking of prognosis, and which have a favourable or an unfavourable influence upon the course of the disease. The most remarkable is the increase in the hearing-distance in those adhesive processes originating in catarrhs, where a moderate swelling still exists, or where such anomalies of tension had been produced in the sound-conducting apparatus by the diseased process as are capable of partial removal by local treatment. But in cases of tight or but slightly flexible adhesions, or of complete anchylosis of the ossicula, of tight stricture of the Eustachian tube, and also in all cases where the condition in the middle ear is complicated with an affection of the labyrinth, the curative effect will of course either be trifling or nil.

The degree of the improvement of hearing to be obtained cannot be predicted. Where the deafness is not great, and where a noticeable increase in the hearing takes place after inflating the ear once or twice, as a rule a better result may be expected than in cases where the function of hearing has already considerably deteriorated, and where no alteration in the power of hearing, or only a slight one, is noticeable after the Eustachian tube has been made permeable.* Exceptions are, however, not uncommon, for it often occurs that in cases where both ears are affected the power of hearing of the more affected ear is so improved by the treatment that it surpasses that of the previously less affected ear. Complete deafness for speech does not preclude the possibility of improvement in the hearing, as I have observed often enough, in cases where both ears were affected, and where the power of hearing for speech of the one ear had quite ceased, an improvement in hearing of the deafer ear to the extent of $\frac{1}{3}$-1 meter during treatment.

As previously remarked, the duration of the treatment (p. 295) is of great importance in regard to the result. In most cases a change for the worse takes place by too protracted treatment. It must therefore be continued only so long as a steady increase in the hearing-distance can be traced. If, therefore, after treatment for several weeks a cessation of improvement is observed, which continues in spite of continued inflation of air and injection of solutions, the treatment must be stopped, because, if persisted in, the improvement in the hearing already attained will quickly disappear again. The length of time it takes to arrive at the best possible result varies much; in most cases it ranges between

* 'If the local treatment has been applied regularly and carefully for a little time (eight to fourteen days), without any improvement in the functions and the subjective complaints of the patient, it is probable that any further treatment will be useless.'—(Schwartze, *Pract. Beitrag. z. Ohrenh.* 1864.)

three and six weeks, but there are cases, though few, where it is only after treatment for three or four months or more that the greatest improvement in the hearing is reached.

During treatment the increase in the power of hearing is rarely regularly continuous. It is most striking during the first six or eight days, and only slight during the further course. In other cases, however, there is no essential improvement in the hearing noticeable in the beginning, but only after treatment for several weeks.

The improvement in the hearing which results from treatment in the adhesive processes is rarely a lasting one, because the newly-formed connective tissue which fixes the ossicula has a tendency to retraction and shrinking. In most cases there is a decrease in the hearing-distance observable a few months after treatment, and if one has an opportunity of examining these cases after a longer lapse of time—say after a year—one will observe not only a total disappearance of the result gained by treatment, but even greater disturbance in the hearing than there was previous to treatment.

From this the necessity of an occasional after-treatment will become apparent, partly to save what has been gained, and partly to counteract the rapid progress of the disease. This consists either in occasional repetition of the method of treatment previously described, where injections and inflation of air are applied alternately, or in the exclusive application of inflation of air from time to time. Indeed, experience shows that in many cases where, previous to the employment of treatment, a steadily progressive decrease in the hearing was observable, a repetition of the treatment once or twice a year had as its result either a stationary condition of the power of hearing, or a less rapid progress of the disease.

The most simple method for an after-treatment is my method of propelling air into the middle ear. Where circumstances do not permit its execution by the doctor, the patient can apply it himself, after having been carefully instructed. A methodical application of this method is of great importance for the success of the after-treatment, because a rapid decrease in the power of hearing and an increase of the subjective noises are often brought about by its too frequent application. The after-treatment must not be commenced immediately after the local treatment, but when an interval of perhaps six to eight weeks has elapsed. It is then expedient to continue the propulsion of air two or three times a week for five or six weeks, after which another interval must take place, the length of which must depend on the duration of the improvement in the hearing. The longer the hearing-distance remains constant the more expedient is it to have long intervals (two to three months) between the periods of inflation during the after-treatment. In this way for many patients a regular

repetition of inflation of air for several weeks three or four times a year is necessary, while in other cases, where the improvement in the hearing is of longer duration, an after-treatment of several weeks twice a year is quite sufficient.

I have already (p. 296) stated my opinion as to the worthlessness of the Valsalvian experiment, still recommended by many specialists as an after-treatment, but I do not consider it superfluous to state here once more the injurious effect which the too-frequent execution of this experiment has upon the function of hearing.

But while, through the above-described methods of treatment and a rationally instituted after-treatment, a stationary state for a number of years is in many cases produced, local treatment often remains without any result whatever in affections of the middle ear belonging to this group, as the affection progresses irresistibly till, in spite of treatment, deafness of the highest degree has been reached. The insidious inflammations of the middle ear, combined with constant subjective noises, are the most common cases in which all treatment proves useless. Indeed, it may from experience be affirmed with certainty that in a number of cases the unfavourable course is even accelerated by the local treatment, a fact which deserves full consideration in the treatment of chronic affections of the middle ear.

Treatment of the Subjective Noises which accompany the Adhesive Processes.—The treatment of these subjective noises is essentially the same as that of deafness. The removal of the noises, however, is much less frequent in the adhesive processes than in the secretive forms of catarrh. But the subjective hearing-sensations in the adhesive inflammations of the middle ear are often considerably alleviated by treatment. This holds good especially of those noises which proceed from anomalies of tension in the middle ear, and from the abnormal state of pressure in the labyrinth caused thereby. Subjective noises are generally weakened by propelling air into the middle ear and by rarefaction of air in the external meatus. The effect is most striking immediately after the application of these methods, as very loud noises often suddenly cease, or are greatly lessened. This favourable effect is, however, seldom lasting, as after a short time the noises generally return with the same intensity. In many cases the efficacy of my method is most marked, in others again that of catheterism or the rarefaction of air in the external meatus. Sometimes a weakening of the subjective noises is brought about by injection of a medicated solution, or by the introduction of vapours of sulphuric ether, acetic ether (Kramer), or chloroform (Rau), or of a mixture of sulphuric ether with ethylene chloride (liq. anæsth. Hollandi) (6 : 4), where inflation of air had previously been without result.

The influence of treatment upon the subjective noises cannot

be determined beforehand. In a few rare cases the noises cease altogether, in others they become weaker, but in the majority they remain unaltered, even though in the latter a considerable improvement in the hearing has been gained. One will often have to be content with lessening exceedingly turbulent and unpleasant noises to such a degree that they are more bearable to the patient. The lessening of the noises after treatment is often permanent; often, however, an increase is observed after a few weeks or months. The hearing sensations, which had been decreased in their intensity, are often again perceived more strongly if the treatment is continued too long; indeed, by a treatment too much prolonged troublesome noises may be produced when they had not previously existed.

Of external remedies for the subjective noises, counter-irritants behind the ear, especially vesicants, were formerly and are still in great favour with English doctors. Their employment has lately become more rare. Counter-irritants on the mastoid process I found most effective for noises of recent date and also in patients who were troubled with continuous singing in the ear, when this became almost unbearable. If the increase of the noises is not too great, spirituous embrocations on the mastoid process* will give relief. In cases of fitful, violent increase in the singing, however, it is better quickly to lay bare the cutis vera by the application of a fly-blister on the mastoid process, and to increase the irritation by rubbing it with veratrium, mezereon, or antimonial ointment. The result of trials which I made, of dusting the bared places of the skin with sulphate of quinine, was that noises which had not been long in existence sometimes ceased altogether over-night, while in other cases the singing became temporarily weaker with a simultaneous decrease in the hearing; but, for the most part, the remedy had no effect whatever.

With regard to the external application of narcotics, experience shows that in the majority of cases they have no effect upon the subjective noises. As, however, after their application relief from the singing in the ears has been observed in some patients, the tentative application of narcotics is justifiable in those cases in which the inflation of air, injections, or the introduction of chloroform or ethereal vapours has not led to a decrease in the noises.†

Subcutaneous injections of morphia sometimes give relief from the subjective noises (Moos); a relief, however, which gene-

* ℞. Spirit. aromat., spirit. sinap. āā. 30·0. Sig. 20 drops to be rubbed in behind the ear. ℞. Spirit. formic., bals. Hoffmanni. āā. 30·0. Sig. as above.

† ℞. Glycerin. pur. 10·0; extr. laud. aquos, 0·4. M. tere exactissime. Sig. 8-10 drops to be rubbed in behind the ear. ℞. Glycerin. pur. 10·0; acetat. morph. 0·2. M. Sig. as above. ℞. Olei olivarum, chloroform, āā. 8·0. M. Sig. as above. ℞. glypur. 10·0; tinct. belladonnæ, 5·0. M. Sig. as above.

rally ceases soon, though occasionally lasting several weeks. But these injections are suitable only where the noises occur in severe paroxysms.

Equally little to be depended on are narcotic instillations into the external meatus. It no doubt sometimes happens that after the instillation of a few drops of warm water or of some narcotic solution violent noises are alleviated; but more frequently not only is the tinnitus increased, but a considerable decrease in the hearing is caused by the instilled oil or the dissolved cerumen drying up and forming a layer on the membrana tympani. By painting the cartilaginous meatus with medicated glycerine solutions, however, alleviation of the noises and subjective relief are often brought about, especially in cases of dryness of the meatus without secretion. In my practice I apply the following solutions: ℞. Tinct. valerian., 2·0; æth. sulph. 1·0; glycerin. pur. 12·0. ℞. Tinct. valerianæ, 2·0; æth. sulph. 0·5; glycerin. pur. 10·0. Sig. For painting.

It is but rarely that I have observed a favourable effect on the subjective noises from internal medication. According to my experience during recent years, bromide of potassium (in 1-2 gramme doses) has proved most useful in cases where the subjective noises have been increased by nervous excitement. The effect of the remedy is to diminish the tinnitus, and to induce sleep, if the latter has been disturbed by the intensity of the noises.

After the internal administration of hydrobromic acid (10-15 gtt. three times daily, in sugar and water), recommended by Woakes, and of arnica, recommended by Wilde, I did not observe any noticeable decrease in the subjective hearing-sensations. Fluctuations in the intensity of noises are so frequent, that a temporary decrease must not be ascribed to the treatment.

Quinine, which, as is well known, produces tinnitus if taken in large doses, sometimes relieves the subjective noises, especially if they occur periodically, and with symptoms of Menière's vertigo (Charcot). I have pointed out in a former work on subjective aural sensations (*Wien. med. Wochenschr.* 1865), that the noises are often lessened by the exhibition of quinine, the power of hearing being at the same time diminished; but that, as the effect of the quinine passes off, the attacks of tinnitus recur, the former power of hearing returning. This observation has lately been confirmed by Guye.

A favourable influence on the subjective noises is sometimes exerted by the internal administration of iodide of potassium (0·5-1·0 grm. daily) in affections of the ear, due to constitutional syphilis, where the disease of the middle ear is complicated with an affection of the labyrinth. The effect of the internal medication can in such cases be assisted by the inunction of the mastoid process with ointments of iodine (potass. iod. 2·0; ungu. emoll.

20·0; iodine pure, 0·1), or of iodoform (iodoform pur. 0·8; ungu. emoll. 20·0; ol. menth. pip. gtt. 10).

The nitrite of amyl, which has recently been recommended for tinnitus by Michael and Urbantschitsch, has proved of little use in practice. After inhalation of one or two drops of this fluid, a momentary decrease of the tinnitus, and a noticeable increase in the hearing-distance, certainly often take place, but the effect is very rarely lasting. The congestion of the vessels of the head, which, even with the inhalation of one drop, sometimes reaches such a high degree that the patient is seized with the most violent headache and a most painful nervous excitement, renders the application of this remedy specially difficult.

The treatment of subjective noises by electricity will be discussed in detail later on. We will here only remark that not unfrequently the noises are decreased not only temporarily but permanently by the constant current, and that the above-mentioned troublesome head symptoms and attacks of giddiness are also lessened. An improvement of the function of hearing by treatment with galvanism is rarely observed.

Treatment of Stricture of the Eustachian Tube.—In the beginning of this division it was stated that narrowing of the tube is mostly developed in the diffuse inflammations of the middle ear, which are combined with naso-pharyngeal catarrh. The abnormalities of tension in the middle ear, and the great functional disturbances which spring from stricture of the tube, render its artificial dilatation an urgent necessity in all cases in which it has been positively ascertained by objective examination to be present (p. 345).

The means employed for dilating the tube vary with the amount of resistance to be overcome, that is, with the tightness of the stricture. In cases of moderate narrowing, repeated injection of air into the tympanic cavity will often suffice to dilate the tube. In many instances this can be proved by the noise made by the entrance of the air, which during the early examinations is high-pitched and grating, but in the course of treatment may be changed into a soft breezy sound. In those cases, however, in which the symptoms of stricture do not disappear, or in which a tight stricture is diagnosed at the first examination, the introduction of bougies into the Eustachian tube is necessary.

The introduction of bougies into the Eustachian tube (Kramer), formerly often used without definite indications, has of late been confined to cases of undoubted stricture only. In my practice I use either the soft, flexible, French bougies, or small rods of whalebone, and in some cases catgut.

French bougies (made by Galanthe, of Paris), which are covered with a fine lac, and get gradually thinner towards the point, are specially suitable for slight strictures of the tube. Three different thicknesses, from that of a strong thread to a

diameter of ¾ mm., suffice to gradually dilate the contracted portion.

These bougies, however, rarely succeed in penetrating tight strictures, for the flexible point bends before the stricture, and recoils into the throat in the attempt to push it farther forward. In such cases the application of conical whalebone bougies (Leiter, of Vienna) of different thicknesses is advisable, which, by means of their greater resistance, pass the obstruction with more certainty. But their application requires the utmost caution, as the mucous membrane of the tube may easily be injured by force, and a submucous emphysema may result from the subsequent injection of air (p. 129).

Catgut bougies cannot be used for tight strictures, on account of their flexibility. In moderate constrictions they are to be preferred to the French bougies, on account of their rapid swelling, in cases where it is intended to dilate the stricture not gradually, but rapidly. They also serve as medicated bougies in cases of great swelling of the mucous membrane of the Eustachian tube, for, the end of the bougie having been impregnated by maceration for several hours in solutions of zinc, acetate of alumina, or nitrate of silver (Rau), it can be pushed into the tube after it has been dried.* In introducing bougies into the Eustachian tube, the following precautions have to be observed: A short catheter, with a somewhat longer nozzle and more curved than usual, is to be employed, so that the point of the instrument may penetrate as deeply as possible into the tube. The recoil of the bougie into the throat can thus be prevented with greater certainty. To pass the stricture safely, the point of the bougie must be pushed forward to the ostium tympanicum tubæ, therefore 1½-2 c.m. beyond the end of the catheter. Certain marks at the outer end of the bougie serve to control its advance, and to indicate the length of the piece which projects beyond the end of the catheter (Bonnafont).

Penetration into the tympanic cavity, especially during the application of inflexible bougies of whalebone, must be avoided. For although in most cases, as examinations on the dead body show, the instrument, when pushed through the Eustachian tube, will pass between the handle of the malleus and the long crus of the incus, still it may readily injure the structures in the tympanic cavity when the position of the membrana tympani or of the ossicula is abnormal, either congenitally or from disease. Cases are known where a highly concave membrana tympani or a membrane adherent to the inner wall of the tympanic cavity has

* Certain bougies must be avoided in cases of stricture of the tube; these are wax bougies, the surface of which becomes brittle and cracks; parchment bougies, by which the mucous membrane is easily injured (Guye); laminaria bougies, which swell too much behind the stricture, and may therefore tear when pulled out (Wendt); and for a similar reason decalcified ivory bougies (Wilde).

been perforated by the bougie, its point becoming visible in the external meatus (Voltolini). Cases have also been observed where sudden deafness followed immediately on the introduction of the bougie, probably in consequence of dislocation of the articulation of the malleus with the incus, or of the incus with the stapes.

The resistance met with by the bougie in the Eustachian tube is easily overcome in cases of slight stricture. If the constricted portion be short, the bougie will often pass the narrowest point with a jerk. But if the stricture involves a greater portion of the tube, considerable resistance will make itself felt during the advance of the bougie, which only can be overcome without danger if the bougie be pushed forwards gradually with great caution and with occasional rotations round its axis (v. Tröltsch). In such cases it is often possible, after four or five sittings only, to pass the narrowest place by a careful and slow advance. The patient's sensations, even though not reliable in all cases, are important; he complains of a marked stinging sensation in the ear, sometimes in the teeth and in the occiput (v. Tröltsch), when the point of the bougie penetrates into the tympanic cavity, while in cases where it returns to the throat by bending, stinging is felt in the lateral region of the neck.

To effect dilatation, the bougie must remain in position for five, ten, or fifteen minutes, in which case the catheter has to be fixed with Delstanche's nose-pinchers; catgut bougies impregnated with nitrate of silver must never, however, be left longer than three or four minutes in the Eustachian tube, because, by a longer application, inflammation, spreading to the tympanic cavity, may be easily induced.

Flexible bougies, after having been removed from the Eustachian tube, often present at their end a curvature corresponding with the form and direction of the stricture. If catheterization is resorted to immediately after extraction of the bougie, the air is heard to enter the tympanic cavity in a much fuller current than before. Marked subjective relief often ensues, as also a decrease in the tinnitus and a considerable improvement in the hearing. With such favourable results it is always advisable to repeat the manipulation twice or thrice weekly, introducing progressively thicker bougies, and to continue the dilatation till the air enters the tympanic cavity during catheterization or Politzerization without noticeable resistance.

The results of mechanical dilatation of the strictured Eustachian tube are not, on the whole, very good. Cases of striking and lasting improvement in the hearing where, after years, no recurrence of the stricture takes place are very rare, and it is probable that many of the cases of cure of stricture of the tube which have been recorded were strictures not due to the formation of connective tissue, but simply to swelling of the Eustachian

tube, which was capable of resolution. In the majority of cases the stricture recurs, with a corresponding decrease in the hearing-distance gained, and an increase of the subjective noises. If the treatment by dilatation be renewed, an improvement in the hearing mostly occurs, but very rarely to the same extent as before. The result will be still less favourable with later attempts at dilatation, in consequence of the tissue changes, which meanwhile steadily progress, fixing the ossicula to the walls of the tympanic cavity. Nevertheless, in cases of undoubted narrowing of the tube, I look upon the introduction of bougies as very important, because some improvement takes place in the hearing, the often unbearable subjective noises are toned down, and the rapid progress of the disease is also prevented. It must, however, be mentioned, that in many cases no dilatation is effected, in spite of long-continued attempts, and that often neither an increase in the hearing nor a decrease in the tinnitus takes place, in spite of a successful dilatation.

To the above remarks on the local treatment of the adhesive processes we must add, that even in those cases where no increase in the hearing nor lessening of the noises has been brought about by such rational treatment, complete disappearance of the troublesome head symptoms and of the mental depression is observed, a result the importance of which must not be underrated.

I have further emphasized the fact (p. 348), that in unilateral deafness of a high degree, the tendency of the normal ear to be affected by the disease is considerably increased. This shows the importance of early treatment of such cases. If the attempt to improve the hearing power of the diseased ear a little, and to prevent the occurrence of complete deafness, succeeds, the normal ear will not be so easily affected as if the process is left to itself so long that the function of the diseased ear is quite lost.

Treatment of the Naso-pharyngeal Affections accompanying the Adhesive Processes.—Just as in catarrhs accompanied with secretion, the condition of the naso-pharynx has always to be considered in the adhesive processes. As the pathology and treatment of the naso-pharyngeal affections have already been discussed, I must refer the reader to a former division of this book (p. 302-323) for details. It is only necessary to mention here as of importance, that in many adhesive processes, complicated with chronic swelling of the mucous membrane of the naso-pharynx, treatment of the naso-pharyngeal affection alone, especially by repeated cauterization of the vicinity of the Eustachian tube with nitrate of silver or with the galvano-cautery, effects more considerable improvement in the hearing than had resulted from previous local treatment of the middle ear. In cases where a tendency exists to frequent recurrence of the naso-pharyngeal

catarrh, it is advisable to apply to the mucous membrane of the naso-pharynx atomized solutions of tannin or acetate of alumina in the form of powder.

Internal and External Medication.—The internal treatment of the adhesive processes, to which some aural surgeons attach much importance, is of little value, if those cases are excepted in which a constitutional disease is present. Toynbee recommends the internal administration of calomel (0·1-0·2 gram. per dose); Hinton, the bichloride (0·002 gram. thrice daily); Burnett, a solution of strychnine in iron wine (0·07-140·0); Weber-Liel, oleum terebinth.; the French aural surgeons, iodine preparations, especially iodide of iron. The favourable results for which these remedies have been lauded have not been confirmed by experience. In constitutional diseases, however, the good effect of internal treatment on the course of the aural affection cannot in many cases be denied. In general syphilis, the local treatment of the aural affection must be combined with mercurials or iodine, as required; in scrofulous cases, the internal administration of the iodide of potassium or of iron is necessary; and in anæmic, debilitated patients, the more soluble preparations of iron must be prescribed.

Externally, medicated applications in the vicinity of the ear, or in the external meatus, are almost altogether without effect. By painting the external meatus with a concentrated solution of nitrate of silver (Toynbee), or the lining membrane of the osseous meatus with tincture of iodine (Schwartze), by the introduction of carbonic acid gas into the external meatus (often employed in many watering-places), and by the application of counter-irritation to the mastoid process, I have observed no marked difference on the deafness which could with certainty be ascribed to the action of the external application. The inunction of iodine ointments over the mastoid process, much recommended even now, and which I chiefly confine to cases of pronounced syphilis of the ear, I found of just as little value.

The combination of internal and external medication is of some use in cases of rapid deterioration of the hearing and of sudden deafness. I have already mentioned (p. 347), that this sudden aggravation is doubtlessly caused by some labyrinthine complication. To remove this paralysis of the auditory nerve, the patient must avoid for several days all bodily or mental labour, the use of alcoholic drinks and tobacco, and also loud sounds. Internally, iodide of potassium (up to 1 gram. daily), must be given, and when there is marked congestion of the head, determination to the intestinal canal must be effected by the use of Ofner aperient water. In addition, the dermic layer over the mastoid process is to be laid bare by a vesicatory, and painted with veratria ointment. The painting of the external meatus with sulphuric ether and glycerine (1 : 10), or the insertion into the

meatus of a plug of cotton-wool, partly saturated with this mixture, often acts favourably. The application of the constant electric current is only advisable in those cases in which the former hearing-distance does not return after treatment for eight days.

Diet.—This must always be regulated according to individual circumstances. In general strongly spiced and stimulating food, the abundant use of alcoholic drinks and much tobacco-smoking are to be avoided, especially in those cases where the hardness of hearing and tinnitus are undoubtedly aggravated thereby. The patient's own experience therefore guides him in the selection of a proper diet, and an exceedingly severe restriction of the above-named luxuries, as demanded in all cases by many specialists, is by no means always advisable.

Change of Air and Climate.—Although change of air and residence in healthy mountainous regions have not such a favourable influence upon the disease in the case of the adhesive processes as in the secretive catarrhs of the middle ear, which are capable of resolution, there are many cases of the former in which the favourable effect of change of air and climate can also be traced. For cases are frequently met with in which the disease makes rapid progress during the patient's residence in the more severe climate of the north, while it is stationary or more slowly progressive in milder southerly climates. This is specially the case with patients who, in the inclement north, are subject to very frequent naso-pharyngeal catarrhs, but are quite free from them in a southerly climate.

Baths and Hydropathic Cures.—The effect of river and sea-bathing, as well as of the cold-water cure, is generally considered by specialists as detrimental to the course of the adhesive processes. But the injurious influence is in my experience by no means so frequent as is generally supposed; for cases are often observed where, after sea-bathing and cold-water treatment, an improvement in the hearing and a lessening of the subjective noises take place. In anæmic, debilitated people, in the hereditary forms of the adhesive processes, and in the insidious affections of the middle ear, which are associated with continuous noises, the effect of cold water upon the ear is most unfavourable. It is beyond doubt that many of the evil consequences of the cold-water cure are due to its irrational application. In all cases of chronic disease of the ear, especially where cold-water treatment is advisable on account of some other organic or general disease, or for the purpose of fortifying the patient against the recurrence of attacks of catarrh, care must chiefly be taken that the patient does not remain too long in the bath, and that the head is not affected too much by the cold water. Diving and head-douches are to be prohibited, and it is to be recommended, especially while bathing in the sea, that the head should be pro-

tected against the force of a heavy sea by a tightly-fitting oil-cloth cap. It is also absolutely necessary to induce a speedy reaction by plenty of exercise, because otherwise an unpleasant shivering occurs, which is soon followed by stuffiness in the ears, increased tinnitus, and an aggravation of the hardness of hearing.

Regarding the effect of warm baths on chronic affections of the middle ear, specialists have furnished but scanty information. According to my experience, warm baths have often a very favourable influence upon the course of the disease in the adhesive processes originating in catarrhs. In such cases a striking improvement in the hearing often takes place while in the bath, with a sensation as if something were going to open inside the ear. I specially recommend the use of warm plunge baths (every other day) during the local treatment of the aural affection, its favourable effect then resulting much more quickly, probably owing to the relaxation of the tissue of the mucous membrane of the middle ear by the action of the warmth.

Concerning hydropathic treatment I must refer the reader to the discussion of the subject in connection with catarrhs of the middle ear (p. 297). Ladreit de Lacharrière (*Annales des Maladies de l'Oreille*, 1879) praises the effect of sulphur and arsenic baths (Bourbole, Mont Doré) in the case of chronic affections of the middle ear, the latter especially in cases of scrofulous diathesis.

The Operative Treatment of the Adhesive Processes.

a. The Artificial Perforation of the Membrana Tympani.

Historical.—Attempts at the cure of deafness by excision of a piece of the membrana tympani date from the seventeenth century; but the operation, which was performed without any certain indications, was hardly thought worthy of notice by the surgeons of the seventeenth and eighteenth centuries.* The first scientific communications on the artificial perforation of the membrana tympani date from the beginning of this century. It was Himly (1795) and Astley-Cooper who, independently of each other, performed the operation, and also recommended it strongly, being encouraged by the favourable results met with in the beginning. But however favourable these first results were, Cooper and Himly were convinced in a short time that the startling effects were only temporary, as the artificial opening in the membrane was almost always closed up by new-formed cicatricial tissue, and the former degree of deafness always returned.

* For persons hard of hearing, the operation was proposed for the first time by Riolan (1649), and was performed first by Eli (1760) in Paris. Experiments with dogs had been made much earlier by Willis and Valsalva, and those of the latter were cited in the Anatomical Epistles (Epist. XIII.) of Morgagni.—Cf. Schwartze, *Die Paracentese des Trommelfells*, Halle, 1868.

Meanwhile the news of the brilliant results obtained by Cooper spread on the Continent, and while that surgeon, convinced of the uselessness of the operation, had quite abandoned it, it was long afterwards performed in France and Germany with unexampled zeal in hundreds of aural cases. Himly deserves credit for at last putting a stop to this operation, performed to the injury of so many aural patients. By compiling the observations made by the trustworthy surgeons of that time he proved that it was only in exceedingly rare cases that a slight improvement was obtained, while in most, where the operation was performed regardless of the pathological changes in the middle ear, of which little was known at that time, no improvement resulted.

The ill-success of the operation, and the impossibility of keeping the aperture in the membrana tympani open, were the reasons why this method was afterwards only rarely employed. The brilliant results of myringodectomy, which were published by Jos. Gruber in the beginning of the decade 1860-70, differed from former publications of this kind, only in so far that the fact of the subsequent closure of the artificial opening was not communicated.

Indications.—The chief object of making an opening in the membrana tympani is to form a passage for the waves of sound to the labyrinth, in all cases where their propagation from the membrana tympani to the stapes is impeded. The difference in air-pressure between the tympanic cavity and the external atmosphere is also removed by the formation of such an opening, and the anomalies of tension in the sound-conducting apparatus which chiefly occur with great stricture of the Eustachian tube are diminished.

The artificial perforation of the membrana tympani, if means could be found to keep it permanently open, would therefore be advisable: (1) in abnormal thickening, or extensive, firm calcification of the membrana tympani; (2) in fixture of the malleus and incus by immediate ligamentous union with the walls of the tympanic cavity; (3) in great irremovable strictures and adhesion of the Eustachian tube (Cooper); (4) in excessively loud subjective noises, if they cannot be alleviated by the methods of treatment already detailed.

Through the artificial aperture in the membrane, the waves of sound, avoiding the membrana tympani, the malleus and the incus, can strike the foot-plate of the stapes immediately, and can in this way be communicated to the labyrinth. The operation can therefore be immediately successful only when the stapes is still movable, when the membrane of the fenestra rotunda is not thickened or calcified, and when no labyrinthine complication exists. A minute examination of the function before the operation is therefore an important preliminary condition for its performance. Astley-Cooper long ago emphatically stated that the operation may be performed only when the tick-

ing of a watch can be plainly perceived through the cranial bones. Indeed, experience shows that the improvement in the function is but trifling in cases where perception through the cranial bones is weak or quite wanting.

Methods of Operation.

1. *Excision of a piece of the Membrana Tympani.*—This complicated method, formerly almost exclusively employed, has lately fallen into disuse, since an artificial opening in the membrana tympani can be made in a much simpler manner. Not to enumerate the many more or less complicated instruments used for excision, I would refer the reader for details to the exhaustive treatise of Paul Fabrizi, *Ueber die im Ohre vorkommenden Operationen*, Leipzig, 1842.

2. *Sphirotomy.* — This operation, recommended by Wreden, consists in the excision of a piece of the handle of the malleus, so as to remove a portion of the vessels which supply the blood and to prevent the re-formation of the piece of the membrana tympani when the excision has been made. But this method has not proved efficient, because a collateral circulation is very quickly developed by means of the numerous anastomoses of the vessels of the membrana tympani with those of the external meatus and of the tympanic cavity, from which cicatrization of the perforation results. (Prussak, Moos.)

3. *Incision with subsequent Cauterization of the Edges of the Wound.*—This method, which I used before the employment of the galvano-cautery, consisted in the making of a crucial incision, the pointed flaps of which were immediately after the incision touched with nitrate of silver by means of the paracentesis needle. The next day the presence of a round opening at the seat of operation could be made out. The attempt to form a gaping orifice in the membrana tympani by the insertion of a moistened laminaria tent had also to be abandoned, as it appeared that the membrana tympani was unavoidably torn during the extraction of the swollen tent.

4. *Cauterization of the Membrana Tympani with concentrated Sulphuric Acid.*—This method, recommended by Francis Simrock, consists in applying to the membrana tympani a small drop of sulphuric acid on the point of a probe. In a short time a black aperture will be visible in the membrane, the size of which depends on the quantity of the acid. Although this method often causes no sign of irritation on the membrane, cases have been known (Simrock—three times out of seventeen cases) where the cauterization produced inflammation of the membrana tympani.

5. *Galvano-cautery.*—An artificial aperture in the membrana tympani is best made by the galvano-cautery, as proposed by Voltolini. All other operative methods have now become super-

fluous. A simple, angularly curved, pointed cautery suffices to make in a second an aperture in the membrane of the size of a hemp-seed. It is important for the success of the operation that the cautery should become red-hot at the moment the circuit is closed, because the operation will be very painful if it is gradually heated.

The rapid insertion of the red-hot cautery through the meatus to the membrana tympani must be rejected as rude and unsafe. The circuit must rather be closed only when the cautery is in immediate contact with the membrane. The cauterization must last but a moment, because otherwise too much of the membrane would be destroyed. All pressure upon the membrane is to be avoided, as the point of the cautery might easily penetrate to the inner wall of the tympanic cavity, and cause an inflammation of its mucous membrane. To avoid, with more certainty, the cauterization of the mucous membrane of the tympanic cavity, it is best to choose the anterior or the posterior inferior quadrant of the membrane as the seat of operation, because those parts are farthest from the inner wall of the tympanic cavity, while cauterization behind the umbo must be avoided on account of the vicinity of the promontory.

The results of the production of an artificial aperture in the membrana tympani are, briefly, that in a number of cases, immediately after the operation, a striking improvement in the hearing and a decrease of the subjective noises occur, from which it may be inferred with probability, that the stapes is movable, and that the membrane of the fenestra rotunda is in a normal state. In other cases, where pathological alterations exist either at the two fenestræ or in the labyrinth, the functional disturbance will be only slightly, or not at all, altered after the operation.

But the favourable result is of only short duration, for almost without exception the opening is soon closed up again by cicatricial tissue, the hardness of hearing and the noises in the ear again attain their former degree, or are still greater than before the operation, and only in isolated cases does a decided improvement remain after the closure of the aperture.

Attempts to keep the Artificial Aperture in the Membrana Tympani open.—As these artificial apertures are almost without exception soon closed up by cicatricial tissue, many attempts have been made to keep them open by the insertion of catgut strings, whalebone rods, lead wires, and silver cannulæ (Bonnafont), as it was supposed that by the continued presence of these foreign bodies in the aperture the edges of the wound would receive a membranous covering.

In 1868, for the purpose of keeping the aperture in the membrane open, I recommended the insertion of a vulcanite eyelet (Fig. 115; made by Leiter of Vienna). This consists of small tubes, 2-3 mm. long, and 1 mm. wide, which have one or two

grooves on their external surface, into which the margins of the perforation enter.

The insertion of the eyelet is best accomplished by placing it on the point of the paracentesis needle, and pushing it in this way into the aperture. The margins of the perforation fall into the grooves, and hold it so firmly that the needle can be easily pulled out. If the aperture in the membrane is larger than the diameter of the eyelet, its insertion must be delayed until the aperture has sufficiently diminished.

FIG. 115.—VULCANITE EYELET (REAL SIZE).

To give in detail a description of cases of this operation would occupy too much space, and therefore only a brief sketch of the results of this method will be attempted.

The introduction of the eyelet was first tried in those cases where suppuration of the middle ear had formerly existed, and where hardness of hearing of the highest degree had developed after the perforation had closed. Subsequently the operation was also performed in the adhesive processes unaccompanied by perforation of the membrana tympani.

The application of the eyelet succeeds best in those cases in which a small cicatrix or atrophied spot, 1½-2 mm. in size, exists on the membrana tympani, requiring simply to be split by the paracentesis needle, without the use of the galvano-cautery. In these cases suppuration rarely occurs; but the eyelet, in consequence of the centripetal growth of the membrana tympani, is after several weeks removed from the place where it was inserted towards the periphery, and either drops out there, or becomes so completely choked by thickened secretion that it has to be removed. In cases, however, where the membrane is clouded or thickened, or where it has a normal appearance, the eyelet causes, with few exceptions, a purulent inflammation of the membrane. In consequence of the suppuration the eyelet is soon expelled, upon which the suppuration ceases, and the aperture closes up again. In a case where the introduction of the eyelet was accompanied by a striking improvement in the hearing, the purulent inflammation only appeared after the instrument had been in position for six weeks.

After removal of the eyelet the aperture often remains open for months, but will, without exception, be closed at some subsequent date. In several cases considerable improvement in the hearing remained even after cicatrization of the aperture; in the majority of cases, however, the former degree of deafness returned.

Voltolini's proposal to insert into the aperture small tubes of aluminium instead of vulcanite was not more successful. According to him the expulsion of the small tube was to be prevented by clasping the handle of the malleus with a horseshoe-

shaped gold cannula, provided with a canal at its greatest convexity. But this attempt also failed, for some time after the tube was choked by secretion, and the handle became necrosed.

From this it follows that hitherto all attempts to keep an artificial aperture in the membrana tympani permanently open have been without success. According to Simrock, even after complete removal of the membrana tympani with the malleus, a membranous cicatrix, extending over the whole gap, will be developed, which generally unites with the inner wall of the tympanic cavity. As long, then, as no method is invented for keeping a permanent aperture in the membrane, this operation will be of value only in diagnosis and not in treatment.

The solution of this problem would certainly lead to great progress in the treatment of the diseases of the ear. For in many cases in which at present no improvement in the hearing, or only one of short duration, can be obtained, by the production of a permanent aperture not only could very considerable increase in the hearing, but also a lessening or removal of the subjective noises, be accomplished.

In spite of the numerous unsuccessful attempts, continued endeavours in this direction may in the end succeed. This supposition is founded upon the fact that apertures in the membrane which have been caused by pathological processes, especially by suppuration in the middle ear, very often persist during lifetime by their edges being covered with epidermis, and even in spite of rawing of their margins cannot be made to close. The prevention of cicatrization of the artificial aperture might therefore be effected if the same conditions could be induced which lead to the perforation remaining open in pathological cases.

b. Section of the Posterior Fold of the Membrana Tympani.

Indications.—Section of the posterior fold was first recommended by me* (1871), and a year later by Lucae,† and is advisable in all cases where the objective signs of an abnormal inward curvature of the membrana tympani are present, where the inferior extremity of the handle of the malleus is therefore moved abnormally inwards, while the short process of the malleus and the posterior fold of the membrane extending from it project strongly towards the external meatus (p. 337). If these changes are combined with a disturbance of hearing of a high degree and loud subjective noises, which cannot be materially improved by the local methods of treatment already described, an experimental section of the posterior fold of the membrane is in such cases justifiable. By this operation the tightly-stretched

* *Ueber Trommelfellnarben, Wiener med. Wochenschrift*, 1870.

† Langenbeck's *Archiv für Chirurgie*, vol. xiii. 1871.

posterior superior quadrant of the membrane, specially important for the conduction of sound, is relaxed, and by this means the handle of the malleus acquires greater mobility.

Operation.—For section of the posterior fold of the membrana tympani I use a small knife, rounded at its point, sharp-edged, with the blade fixed at an angle to its handle, or the lancet (Fig. 100) represented on p. 286. The section is made perpendicularly to the longitudinal direction of the fold from above downwards, and the most favourable place for the incision is midway between the short process and the peripheral extremity of the fold (Fig. 116). The division of the fold is generally accompanied by a grating noise, the margins of the wound recede from each other, and the handle of the malleus, which was moved inwards, assumes a more perpendicular position. The bleeding after the operation is generally trifling; sometimes it is considerable on severing the vascular bundle which extends from the membrana tympani to the upper wall of the meatus, but it can soon be arrested by applying a small plug of Bruns' cotton-wool to the incision. This application is also advisable when there is only slight bleeding, to prevent the membrana tympani from being clogged with a crust of blood. Sometimes the blood flows from the wound inwards towards the tympanic cavity; in which case the improvement is observable only after its absorption.

FIG. 116.

Results of the Operation.—The success of the operation mainly depends on the simultaneous changes that take place in the middle ear. The increase in the hearing-power will be the greater the less the ossicular chain is weighted or fixed by pathological products; but where firm anchylosis exists between the ossicula and the walls of the tympanic cavity, the operation will produce either no improvement in the hearing, or only a very slight one.

Division of the posterior fold of the membrana tympani has in many cases a striking effect upon the subjective noises, even if no particular improvement in the hearing is produced; they either cease altogether immediately after the operation or become much weaker.

As regards the duration of the improvement, we can only judge from such cases as we have had the opportunity of observing for years. In cases where I performed the operation I have noticed that not unfrequently, even after a striking improvement in the hearing and a lessening of the subjective noises had been obtained, a gradual return to the former hearing-distance and a fresh increase of the subjective noises took place in the course of a few months. In other cases the hearing-distance again

decreases, while the subjective noises are not so intense as they were before. Only in a very small number of cases have I observed an improvement in the hearing lasting for several years, and a permanent removal or diminution of the subjective noises. Von Tröltsch has frequently cut the band which draws the short process forwards, when subjective relief, generally temporary, and a sensation of relaxed tension in the ear have resulted.

An operation must here be mentioned, which I have recently performed, but as yet only in a very small number of cases, viz. section of the anterior ligament of the malleus. From experimental examinations, undertaken in order to ascertain the relative proportions of tension in the sound-conducting apparatus, I found that after section of the tendon of the tensor tympani, the membrana tympani, drawn outwards by aspiration in the external meatus, returns almost to its former position after the aspiration has ceased. I also found that, after severing the articulation of the incus with the stapes, and especially after detaching the incus from the malleus, the handle of the malleus performs a noticeable outward movement, but that the handle, when forced outwards, still springs strongly inwards even after complete isolation of the head and after severing its superior and exterior ligaments. But when the anterior ligament of the malleus (anterior portion of the ligament of the axis) is cut, the recoil of the handle inwards almost completely ceases.

Fig. 117.

As this showed that the influence of the anterior ligament of the malleus upon the position of the handle and upon the tension of the membrana tympani is considerable, I divided this ligament experimentally in several cases, where the membrane was drawn inwards, the handle of the malleus much inclined inwards, and where, after applying the air-douche several times, a striking improvement took place, but only of short duration. The instrument here represented (Fig. 117) is a small, narrow, slightly curved knife, cutting at its point and at its concave edge, which is inserted, after dividing the anterior fold of the membrana tympani, to the depth of 2 mm. towards the tympanic cavity, close in front of the short process, when the ligament is divided by an incision made upwards to the Rivinian segment. The effect of the operation, which will be discussed in detail later on, proved in two cases to be an immediate decrease of the subjective noises, and a considerable improvement in the hearing for acoumeter and for speech, which still continues, several weeks having elapsed.

Multiple incisions of the membrana tympani, in order to relax its extreme tension, have lately been proposed as a new expedient; but apart from the fact, known long ago, that the

tension of the membrana tympani is frequently relaxed and the hearing-distance increased after incision of the membrane in any of its portions, this method cannot be regarded as a new one, because I recommended it as early as 1871 (*Wiener med. Wochenschrift*). Regarding its alleged striking success in cases of abnormal tension, experience has shown that in most cases a few weeks or months after the incisions the increase in the hearing-distance completely disappears, and only very seldom a slight improvement remains. In a number of cases, where immediately after the incisions a considerable improvement in the hearing was noticed, a decided aggravation occurred in a short time, which could not be removed by repeated incisions. The assumption that the abnormal tension of the membrana tympani can permanently be relaxed by the cicatrization of the incisions, is based upon the erroneous supposition that the tension of the membrane is relaxed by cicatrization of the incisions just as by cicatrices of the surface, which fill the apertures due to loss of substance in the membrane. Indeed, the cicatrices of the incisions exhibit a greater power of resistance than before the operation, in consequence of the slight adhesive inflammation in the neighbourhood of the incisions.

Incising the membrana tympani several times is therefore especially advisable in those cases where the membrane is atrophied and slackened, to increase the power of resistance of the membrane by the formation of several cicatrices. As this method has already been alluded to in the description of the treatment of the catarrhs of the middle ear, we refer the reader for details to a former division (p. 301). In cases of atrophy and relaxation, perforation of the membrane by the galvano-cautery has a decidedly injurious effect upon the function of hearing. The improvement in the hearing which occurs immediately after the operation must be ascribed to the perforation of the membrane; but, as I have seen in several cases, after cicatrization a considerable aggravation takes place, because the newly-formed cicatrix is even less tense than the atrophied portion of the membrane which has been destroyed.

McKeown has lately recommended the application of collodion to a large portion of the membrana tympani for relaxation of the membrane, and the disturbances in the hearing connected with it. By this means the concavity of the membrane is supposed to be lessened, and its power of resistance increased. He reports that he has got very favourable results with collodion. He alleges that in several cases a considerable increase in the hearing has been produced, which remained even after the subsequent removal of the collodion, and that loud subjective noises have also been lessened by it. He is of opinion that collodion is suitable for keeping open artificial perforations, for the separation of adhesions between the membrana tympani and the

promontory, and for the prevention of adhesion of the membrane as well as of retraction of the tendon of the tensor tympani; but this must be proved by experience.

c. Tenotomy of the Musculus Tensor Tympani.

Division of the tendon of the tensor tympani, proposed by Hyrtl in his *Topographische Anatomie*, 1847, was first performed in the living ear by Weber-Liel in 1868. The operation has for its object the removal of the excessive tension of the membrana tympani and of the ossicula, and of the abnormal increase of pressure in the labyrinth connected therewith, caused by shortening of the tendon (pp. 299, 332). In ascertaining the indications for the operation, in the first place all those diagnostic facts have to be kept in view, from which retraction of the tendon can with safety be inferred.

The most important objective signs of shortening of this tendon are held to be—great inward curvature of the membrana tympani, foreshortening of the handle of the malleus, great projection of the short process and of the posterior fold, and also such a state of the membrane as is often found when the Eustachian tube is impermeable. But quite similar changes in the membrane may be caused by adhesions in the tympanic cavity, especially by shrinking of the folds of mucous membrane and ligaments which extend from the superior external wall of the tympanic cavity to the head of the malleus and the body of the incus. As the head of the malleus is drawn outwards by the shortening of these check-bands, the handle is forced to take the above-described pathognomonic position, even without retraction of the tendon of the tensor tympani.

In a former work* I pointed out a fact which would to some extent support the inference that the tendon was retracted. This is, as already mentioned (p. 356), that the striking improvement in the hearing which takes place in cases of hardness of hearing of a high degree after injecting air, disappears again after a few minutes, or even a few seconds. As absorption of the injected air cannot take place in so short a time, it has been considered probable that the rapid disappearance of the increase in the hearing is caused by the retraction of the tendon reasserting itself immediately after the injection. But this sign also cannot be considered characteristic of shortening of the tendon, as a rapid decrease in the hearing after injecting air may also be produced by the stretching and subsequent rapid retraction of the above ligamentous adhesions, which cause the abnormal inward inclination of the handle of the malleus, without there being any retraction of the tendon of the tensor tympani.

Another sign, which has been employed to ascertain the pre-

* *Wiener med. Wochenschrift*, 1867.

sence of retraction of the tendon and as an indication for tenotomy, is the toning down of subjective noises by rarefaction of air in the external meatus. As we have seen, by this manipulation the membrana tympani and the ossicula are moved outwards, the tendon of the tensor tympani is stretched, and the intra-labyrinthine pressure is lessened. If, however, the pathological changes in the middle ear, which occur in the adhesive processes, are taken into consideration, it is clear from what has been said before, that the abnormal tension of the membrana tympani and of the ossicula, combined with an increase of pressure in the labyrinth, may also be produced by ligamentous adhesions (which are quite as elastic as the tendon of the tensor tympani), when the air is rarefied in the external meatus.

It will therefore be seen that we have as yet no sign from which we can infer with certainty retraction of the tendon of the tensor tympani. But even in cases where it could be distinctly diagnosed, the operation would be really advisable only when this retraction is the sole, or at least the most important, cause of the disturbance of hearing and of the subjective noises. To this, however, our knowledge of the pathological alterations in the adhesive processes of the middle ear is opposed. We have seen that, besides such shortening of the tendon of the tensor tympani, adhesions of the ossicula, a lessened mobility of the stapes, and changes of the fenestra rotunda are to be found, the importance of which in regard to the deafness is not at all or very little altered by division of the tendon. Magnus and Schwartze therefore asserted with truth, that in the zeal with which some specialists advocated this operation, those changes in the tympanic cavity, already described in detail by Toynbee, were entirely overlooked.

Operation.—The instrument for dividing the tendon of the tensor tympani is introduced into the tympanic cavity in front of the handle of the malleus by some specialists (Weber-Liel), behind it by others (Voltolini, Schwartze, Hartmann, Orne Green). The latter situation is by far the safer, and gives the operation a better chance of success. The sickle designed by Weber-Liel, which rotates on the principle of Wreden's sphirotome, has proved impracticable, because too much of the anterior portion of the membrana tympani is injured by it without any guarantee of safely dividing the tendon owing to its individually different direction.

Jos. Gruber's curved paracentesis needle has proved quite useless; it is introduced in front of the handle of the malleus, and then the tendon is to be divided by an upward incision. If, however, this experiment is tried on the dead body, it will be found, that in whatever way the operation is performed, the tendon is seldom divided (Hartmann), because the edge of the instrument reaches the osseous margin of the annulus tym-

panicus before the tendon of the tensor tympani has been touched.

The instrument designed by Schwartze consists of a small curved knife, rounded at its point, which is introduced into the tympanic cavity behind the handle of the malleus; the tendon is then divided by a downward incision, a method which is much more difficult than section from below upwards.

The tenotome of Hartmann (Fig. 118) consists of a small knife curved on the flat and on the edge, the point of which reaches about 1 mm. farther outwards than its upper edge. This has proved the most serviceable instrument of all, as with it the operation is performed most safely and without any injury to other parts.

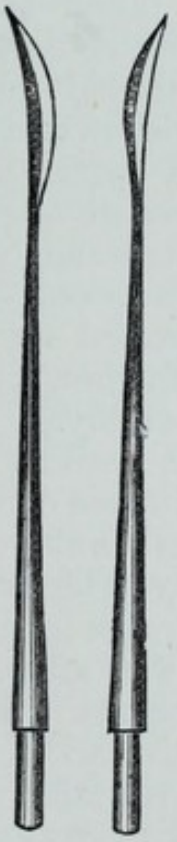

FIG. 118.—HARTMANN'S TENOTOME FOR THE RIGHT AND THE LEFT EARS (HANDLE FOR IT, V. P. 286).

To form an accurate estimate of the success of the operation, it is advisable, as was insisted on by Hartmann, first to make an incision into the posterior segment of the membrana tympani about 1 mm. behind the handle of the malleus, and then to ascertain what change occurs in the hearing-distance and in the subjective noises. Then Hartmann's tenotome is introduced through the incision into the tympanic cavity for a distance of about 3 mm., whereby the instrument is placed below the tendon of the tensor tympani between the handle of the malleus and the long crus of the incus. By slightly sinking its handle the sharp point of the tenotome is forced so far towards the upper part of the tympanic cavity, that the tendon is obliquely divided when the instrument is withdrawn.

The division of the tendon is often accompanied by a peculiar grating noise, and sometimes a considerable effusion of blood into the tympanic cavity is observed after the instrument has been removed, which is absorbed after a few weeks (Schwartze). Division of the chorda tympani cannot always be prevented; I have observed this accident once by a gustatory change on the same side immediately after the operation. The return of the normal sensation of taste after several weeks, led to the inference that the divided nervous extremities had been re-united.

Results of the Operation.—Immediately after division of the tendon of the tensor tympani, in some cases the handle of the malleus is observed to assume a more vertical position; often, however, it retains the same oblique position which it had previous to the tenotomy, although the performance of the operation left no doubt about the successful section of the tendon. This confirms the assertion that the already described adhesive

changes cause abnormal inclination of the handle of the malleus, independently of traction of the tensor tympani.

According to Pomeroy, Bertolet and Orne Green, a decrease of the subjective noises after the operation is to be considered as the most striking subjective change. But, as we have seen, a toning down of the subjective noises often also takes place after a simple incision into the membrana tympani, or after division of its posterior fold. The cases described by them cannot therefore be taken as conclusive of the effect of tenotomy upon the tinnitus, because these specialists omitted to observe the effect of a simple incision into the membrane upon the noises before division of the tendon. In a case where Hartmann performed the operation, he observed that the tinnitus was considerably lessened after a preliminary section of the posterior fold of the membrane, but that no further decrease could be produced by subsequent tenotomy. I met with the same result in the patients operated on by me, with the exception of one case, in which a further, but not permanent, improvement took place after tenotomy.

According to the concurring statements of specialists, the influence of tenotomy upon the disturbance of hearing is even considerably less. A striking improvement in the hearing has very seldom been observed after tenotomy; in most cases the increase in the hearing-distance is but very trifling, or remains as it was after section of the posterior fold of the membrana tympani. This stands to reason, if the many simultaneous pathological changes in the middle ear which impair the power of vibration of the ossicula are taken into consideration.

To determine the value of tenotomy, the changes which occur several weeks or months after the operation are important. The experience which has been gained in competent quarters is, on the whole, unfavourable to the operation; for with only few exceptions, the improvement in the hearing after tenotomy disappears again completely or to a great extent, and the subjective noises reach their former degree; indeed, not unfrequently a rapid aggravation takes place after the operation, which, judging by the former course of the disease, can be attributed to it alone. Several patients, who consulted me some months after tenotomy had been performed, had become completely deaf on the side operated on, while before the operation the deafness was not great, and had for years made but slow progress. Division of the tensor tympani is, therefore, one of those operations which not only are of but trifling use, but which sometimes also have a deleterious influence upon the function of hearing.

In conclusion, a few remarks may be made about the proposal of Kessel to render the stapes movable, or to extract it in cases of anchylosis. The latter operation Kessel founds upon an experiment on a cropper-pigeon, in which, after extraction of the

columella and the partial discharge of the perilymph from the labyrinth, all response to the action of loud sounds ceased. The sensation of sound returned eight days after the operation with the cessation of the discharge, and dissection showed that the fenestra, which had been opened, was again closed by a newly-formed membrane. He is, therefore, of opinion that the extraction of the stapes in man is not only not dangerous, but that it might be of great advantage.

Rendering the stapes movable, like its extraction, is of no real value in the case of the adhesive processes which have arisen without suppuration in the middle ear, as long as an artificial perforation of the membrana tympani cannot be kept open. But even after this problem has been solved, the success of this operation, from my experiments on the dead body, seems to me very doubtful. In a considerable number of normal ears, from which membrana tympani, malleus and incus had been removed, and in which the tendon of the stapedius had been divided, although I made most careful attempts at extraction, I scarcely succeeded in removing the stapes from one-third of the preparations; in the other two-thirds the crura broke, without the foot-plate of the stapes being lifted out of the fenestra ovalis.

The attempts were completely unsuccessful in five preparations, in which the stapes was anchylosed. In three preparations anchylosis of the crura had occurred, and in two of the foot-plate (p. 329). On a careful attempt to detach the adherent portions of the crura from the wall of the niche, fracture of the crura occurred, and in the preparations with anchylosis of the foot-plate, both crura also broke, in spite of the little force which was applied in the attempt at extraction. Indeed, I think that complete detachment of the anchylosed foot-plate from the margin of the fenestra ovalis is impracticable, because the plane of the fenestra ovalis is placed obliquely and is partially hidden, and, therefore, a view of the field of operation is impossible. And by rough manipulation, splinters of the broken foot-plate of the stapes would get into the vestibule, and very easily excite a purulent inflammation in the labyrinth, which not only would destroy the auditory nerve, but might spread through the meatus auditorius internus to the meninges.*

* Besides the treatises and manuals of Lincke, Wilde, Rau, Toynbee, Bonnafont, v. Tröltsch, Moos, de Rossi, Roosa, and Burnett, the following must be mentioned: A. Pagenstecher, *Otiatrische Mittheilungen, Deutsche Klinik*, 1863, Nos. 41, 42, 43, in which Pagenstecher first drew attention to the sclerosed form of inflammation of the middle ear; Schwartze, *Pract. Beiträge zur Ohrenheilkunde*, Halle, 1864; Voltolini, *Zur Function des Steigbügels und dessen Ankylose in der Fenestra ovalis, Deutsche Klinik*, Nos. 34 and 36, 1859; Weber-Liel, *Ueber das Wesen und die Heilbarkeit der häufigsten Form progressiver Schwerhörigkeit*, Berlin, 1873; Hedinger, *Statistischer Bericht, Med. Correspondenzblatt Württembergs*, No. 21, 1872; Louis Blau, *Ueber Cerebralerscheinungen beim chron. Mittelohrcatarrh, Deutsche Zeitschrift für pract. med.* 1877; A. Politzer, *Zur Pathologie und Therapie der Spannungsanomalien des Trommelfells und der Gehörknöchelchen, Allg. Wien. med. Ztg.* 1872.

Purulent Inflammations of the Middle Ear.

a. Acute Purulent Inflammation of the Middle Ear.

Syn.: Otitis media acuta suppurativa seu perforativa; Antro-tympanitis of early authors; Periostitis auris med. (Rau); Acuter eitriger Ohrcatarrh (v. Tröltsch); Acute suppuration of the middle ear (Roosa); Otite media piogenica a forma acuta (De Rossi).

Acute purulent inflammation of the middle ear is characterized by hyperæmia of the mucous membrane, generally setting in with violent febrile symptoms, and leading to a rapid exudation of pus and to perforation of the membrana tympani, which is at the same time inflamed. The anatomical changes are the same as those with which we became acquainted in the description of acute inflammation of the middle ear, with this difference, that the hyperæmia, swelling, and loosening of the mucous membrane are much more intense, the exudation is more copious and contains greater numbers of pus cells, and perforation of the membrana tympani takes place.

There are, however, frequent exceptions to the above changes in the lining membrane of the tympanic cavity. In consumptive people especially, who suffer during the last days of their life from an acute purulent inflammation of the middle ear, it is common to find the hyperæmia almost completely absent, and the mucous membrane of the tympanum covered with a creamy purulent layer, without noticeable swelling, and pale, while the bloodless membrana tympani is softened and perforated in one of its portions.

A deviation in the character of the secretion from the purulent or muco-purulent form may also be observed, especially immediately after the perforation. For an exudation which contains only a slight admixture of pus cells, appears like blood-serum or a yellow, clear, viscid fluid, which assumes a purulent character only after some days.

Cases of acute otitis media, accompanied by hæmorrhagic (otitis media hæmorrhagica, Roosa, Mathewson) or fibrinous exudation, are very rare. I have described a case of the latter kind in my *Beleuchtungsbilder des Trommelfells*, 1865, p. 86.

The pathological changes in this form of inflammation almost always extend over the whole mucous membrane of the middle ear. They spread from the tympanic cavity to the lining membrane of the Eustachian tube, which becomes more or less narrowed by swelling, and to the lining membrane of the mastoid cells, in which purulent exudation will always be found. The free anastomosis between the vessels of the middle and inner

ears leads to great hyperæmia in the labyrinth, and serous effusion, but seldom to purulent inflammation.

Ætiology and Occurrence.—Acute purulent inflammation of the middle ear either takes place primarily in consequence of external influences, after colds, or is caused by propagation of acute or chronic naso-pharyngeal catarrhs to the middle ear. It may also be developed in the course of scarlatina, measles, small-pox, typhus, tuberculosis, diphtheritis,* pneumonia, influenza, whooping-cough, and in the puerperal state. Traumatic acute suppuration in the middle ear is sometimes caused by paracentesis, or by other operations on the membrana tympani, also by contusions of the cranium or of the ear by a blow or a fall, by forcible attempts at extraction of foreign bodies from the ear, and by scalding and cauterization of the ear. That acute suppuration of the middle ear may be caused by Weber's nasal douche, by injections of cold water into the external meatus, and by cold river or sea baths (Knapp, Morpurgo), has already been mentioned.

Acute purulent inflammation of the middle ear occurs more frequently in children than in adults, and is observed oftener in spring and in autumn than in summer and during a severe winter. In spring it sometimes bears an epidemic character. Climate does not seem to have any considerable influence upon the frequency of this inflammatory form ; Knapp (*Z. f. O.* vol. viii.) has calculated, from careful examinations of statistics, that in American as well as in European medical institutions the percentage of aural patients (6-7 per cent.) is pretty equal. In the idiopathic and in the traumatic forms the inflammation affects most commonly one ear ; in scarlatinal and typhoid forms more frequently both.

The excessively frequent occurrence of purulent inflammations of the middle ear in childhood, especially in the course of the acute exanthemata, in severe naso-pharyngeal affections, bronchial catarrhs and pneumonia, is an indisputable fact. It has also been proved by numerous observations of v. Tröltsch, Wreden, Kutschariarz, Zaufal and Brunner, that in the middle ear of the majority of new-born infants mucus or pus is found. I cannot, however, agree with the assumption of those authors that these contents are to be considered as pathological inflammatory products, because it seems to me impossible that almost two-thirds of all new-born infants should suffer from a mucous or purulent inflammation. I am rather inclined to consider those substances as a product of the transformation of the fœtal gelatinous tissue in the middle ear. The argument of v. Tröltsch, that, if purely physiological, these contents ought to be found in all cases, is

* In cases of simple, non-scarlatinal pharyngeal diphtheritis a consecutive otitis media very seldom takes place, but very often in scarlatinal naso-pharyngeal diphtheritis, as I have been informed by Viennese surgeons in most extensive practice among children.

not conclusive, because as a matter of course, in cases where the transformation has already taken place, no fluid will be met with in the middle ear.

Condition of the Membrana Tympani.—The changes in the membrana tympani in acute purulent inflammation of the middle ear are very different before and after the perforation of the membrane. Previous to perforation the appearance of the membrane is often the same as that described in discussing acute inflammation of the middle ear, with this difference, that the phenomena are generally much more strongly marked. The cartilaginous portion of the meatus is not affected, as a rule; in very violent inflammations of the middle ear, however, especially in children, a painful swelling of the cartilaginous meatus, of the whole external region of the ear, and of the lymphatic glands behind it, takes places. The osseous meatus is almost always greatly injected and swollen, and the demarcation between it and the membrana tympani is effaced. The membrane is either uniformly scarlet-red, or yellowish-red, livid and ecchymosed, but seldom injected with radiating vessels. The handle of the malleus is hidden by the swollen cutis, while the short process is set off from the reddened surface like a whitish-yellow pustule. The lustre of the membrane is soon lost by serous saturation and loosening of the epidermic layer, its surface appears stippled, and the small, scattered reflections of light show, often even before perforation of the membrane, a distinct pulsation, as was first observed by me.

The curvature of the membrana tympani becomes changed, partly by exudation thrown out between the layers of the membrane, partly by accumulation of secretion in the tympanum. In rare cases, for a very short time at the commencement of the disease, small, circumscribed protuberances in the form of blisters or of roundish, yellowish-green, interlamellar abscesses are found (Fig. 119). Most frequently the posterior portion of the membrane is bulged forward as a livid, red swelling, covered by a shrivelling epidermic layer, and, after the epidermis has been thrown off, it may be mistaken for a globular polypus on account of its moist surface. At the apex of this protuberance a yellowish-green flat or pointed place is sometimes observed, where, later on, the pus breaks through towards the outside; often, however, it is not possible to ascertain the spot where the perforation of the membrane will take place, although the examination is made immediately before the perforation.

The rupture of the membrane generally occurs in the portions situated midway between the handle and the tendinous ring—seldom at the periphery or close to the handle. According to Wilde and Bing, perforations in front of the handle of the malleus are more frequent, because this portion of the membrane is more exposed to the current of air entering through

the Eustachian tube. The thin membrane of Shrapnell, situated above the short process, is very rarely perforated in acute cases.

The condition of the parts is materially changed after perforation. The osseous meatus is swollen, and covered with shreds of exfoliated epidermis. The membrana tympani, coated with pus, appears, after syringing out the secretion, partially covered with macerated epidermis, in places excoriated, greatly congested and livid, and its curvature effaced or irregular and uneven. The handle of the malleus is almost never visible, and the short process only sometimes. The perforation appears in

FIG. 119.—ABSCESS OF THE SIZE OF A MILLET-SEED IN THE CENTRE OF THE MEMBRANA TYMPANI, 6 HOURS AFTER THE COMMENCEMENT OF THE INFLAMMATION. PERFORATION OF THE MEMBRANE THE NEXT DAY AT THE SAME PLACE. HEARING-DISTANCE BEFORE THE PERFORATION: ACOUMETER = $\frac{1}{3}$ M., WHISPERED SPEECH = 2 M. FROM A DIABETIC PATIENT 30 YEARS OF AGE.

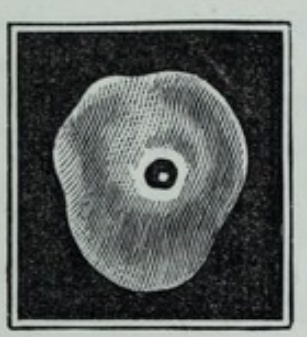

FIG. 120. — PERFORATION OF THE SIZE OF A POPPY-SEED BEHIND THE UMBO IN THE FOURTH WEEK OF THE DISEASE. THE PERFORATION OCCURRED THE THIRD DAY AFTER THE COMMENCEMENT OF THE INFLAMMATION. HEARING-DISTANCE: ACOUMETER = 2 CM. SPEECH = $\frac{1}{3}$ M. FROM A MAN 65 YEARS OF AGE.

FIG. 121.—CONDITION OF THE MEMBRANE IN THE SAME PATIENT AT THE END OF THE SIXTH WEEK. THE OTORRHŒA HAD CEASED FOR A FORTNIGHT. THE PERFORATION IS CLOSED BY A YELLOWISH-GREY, SOMEWHAT DEPRESSED CICATRIX, TO WHICH SEVERAL SMALL VASCULAR TWIGS EXTEND FROM THE PERIPHERY OF THE MEMBRANE. HEARING-DISTANCE: ACOUMETER = 10 CM., SPEECH = 3 M.

cases of moderate discharge as a sharply-defined, black orifice (Fig. 120), of the size of a poppy-seed or a puncture with a needle, in which from time to time a small pulsating air-bubble is visible. The point of perforation is, however, generally not discovered at all, or is only indicated by a small depression filled with secretion, and with a pulsating reflection of light.

As at the beginning of acute cases there is only a disturbance of continuity without loss of substance, and the margins of the wound are therefore closely applied to each other, the point of perforation will in the majority of cases be visible only when the margins are forced asunder by condensation of air in the tympanic cavity, when the secretion in the middle ear is propelled into the meatus with a mucous rattling.

There is a rare, but practically important, condition of the

membrana tympani in acute purulent inflammations of the middle ear observed in which the perforation is situated at the point of a nipple-like projection. It has its seat generally in the posterior portion of the membrane. A small drop of pus at the point of the projecting cone indicates the point of perforation. During the Valsalvian experiment this drop increases in size, but air is seldom forced through the orifice. In this form of perforation of the membrane, which according to my observations is often combined with a painful inflammation of the mastoid process, the suppuration in the middle ear always runs an exceedingly obstinate course.

Character of the Secretion.—The secretion from the inflamed mucous membrane of the middle ear is either purulent or muco-purulent. It contains in addition to mucus and pus cells red blood corpuscles and exfoliated epithelial cells in varying quantity. While a purulent secretion is diffused uniformly in warm water used for syringing the ear, and causes a moderate muddiness of the same, a muco-purulent discharge forms larger or smaller oblong flakes and threads, and extensive lumps with irregular outlines, which, to judge from their form, come from the upper portion of the Eustachian tube and the anterior portion of the tympanum. Sometimes it is so trifling that no discharge from the ear takes place, while in other cases the discharge is so rapid and abundant that the whole field of view is flooded again with secretion soon after syringing. The character of the discharge often changes during the course of the disease; thus a blennorrhœal secretion is followed by a discharge of liquid pus, free from mucus, and *vice versâ*. This fact deserves notice, because, according to my observations, the inflammations of the middle ear which are accompanied by profuse blennorrhœal secretion are always more obstinate than those forms in which there is only a slight admixture of mucus in the purulent secretion.

Subjective Symptoms.—Purulent inflammation of the middle ear generally commences with stinging, aching, piercing and beating pains in the ear, which commonly reach a higher degree than in acute inflammation. Children especially suffer intense pain, quite out of proportion to the pain felt by adults. It is rare for a sensation of fulness and numbness in the ear or violent headache to precede the pain by a few days. The pain is continuous, but not uniformly severe and seldom completely remittent. It is generally increased towards the evening and in the night, while towards morning it commonly so decreases that the patient sleeps uninterruptedly for several hours. Coughing, sneezing, clearing the throat, swallowing, bodily exertion or mental excitement, as a rule increase the pain in a high degree.

The pain is seldom concentrated in the ear, but radiates towards the parietal bone and the region of the neck, less fre-

quently towards the teeth, the forehead (Moos), and the occiput. Symptoms of irritation of the conjunctiva of the same side, œdema of the eyelids, and photophobia (Wilde, Rau) rarely occur, and only in very severe inflammations before the perforation of the membrane. In isolated cases the inflammation is complicated by a pronounced trigeminal neuralgia, which disappears only after the suppuration of the middle ear has ceased (Moos), and is probably caused by hyperæmia and swelling, which have spread from the petrous bone to Gasser's ganglion.

Pain, however, is not a constant symptom of acute suppuration in the middle ear (Schwartze). In tuberculous or cachectic individuals, but sometimes also in quite healthy people, perforation may occur without the least pain, and the patient be made aware of the ear disease only by the discharge.

Subjective noises are a frequent but not constant symptom of acute purulent inflammation of the middle ear. They arise partly from the clogging of the fenestræ of the labyrinth by the discharged exudation (increase of the labyrinthine pressure), partly from simultaneous hyperæmia and serous exudation in the labyrinth; in many forms, especially in typhus, probably from an infiltration of small cells into the membranous labyrinth. The noises are described as rustling, roaring, hissing, knocking, and hammering. They often have a pulsating character, and this sensation frequently corresponds with the pulsating motion visible on the membrana tympani; the latter may, however, take place without the patient perceiving pulsating noises. In the beginning of the inflammation great sensitiveness to external sounds seldom exists.

Acute purulent inflammation of the middle ear is often associated with violent fever and fulness of the head, more rarely with giddiness. The head symptoms may reach such a high degree, especially in young children, that the disease, which not unfrequently is accompanied by fever, vomiting, unconsciousness, and convulsions (v. Tröltsch), bears for the first few days, before the perforation of the membrana tympani, the characters of a meningeal affection or of an acute exanthem, commencing with brain symptoms. If in such cases the membrana tympani is not inspected, it will only be by the occurrence of a purulent discharge from the ear, and the disappearance of the violent phenomena, that the cerebral symptoms will be discovered to have been caused by ear disease.

The practitioner must always keep this fact in view, and v. Tröltsch rightly insists that in the treatment of children in the case of acute, feverish illness, accompanied by brain symptoms, one must never omit to make a minute examination of the ear, to ascertain by the condition of the membrana tympani whether the phenomena originate in the ear or not, so as to prevent by timely treatment the development of dangerous complications.

The symptoms in adults are generally less violent. Often the most violent inflammations of the middle ear pass away without the smallest disturbance of the general health. Sometimes, however, the increase in the temperature and acceleration of the pulse reach a very high degree, as also the fulness in the head, and the stupor; but unconsciousness and delirium rarely occur, and that only in very nervous people.

Hearing Disturbances.—The degree of deafness in acute suppuration of the middle ear depends partly on the intensity of the swelling of the mucous membrane of the middle ear and of the membrana tympani, partly on the quantity of exudation discharged, and on the affection in the labyrinth which sometimes accompanies the inflammation. At the beginning of the inflammation the deafness is often trifling, just as in otitis media acuta; as, however, exudation rapidly takes place in the perforating form, hardness of hearing will also occur much more rapidly. This reaches a very high degree, especially before the perforation of the membrane, when the tympanic cavity is filled with thick or firm exudation, by which on the one hand the power of vibration of the membrana tympani and of the ossicula is reduced to a minimum, and on the other pressure is exercised upon the labyrinthine fenestræ. After perforation and escape of the secretion have taken place, the hearing-distance generally increases, but will continually vary during the further course according to the variable quantity of secretion and the increase and decrease of the swelling.

The power of perception for watch or acoumeter through the cranial bones is as a rule completely preserved, only exceptionally (compare my *Beleuchtungsbilder des Trommelfells*, 1865, p. 86) disappearing in consequence of the above-mentioned simultaneous affection of the labyrinth. This phenomenon lasts, however, generally but a short time, as the perception through the cranial bones returns either after the perforation has taken place, or even before it. But in those serious scarlatinal or diphtheritic forms which occur most frequently in childhood, where the expansion of the auditory nerve is disorganized by a simultaneous exudation or extravasation, or where the labyrinthine capsule is opened by acute caries, the power of perception will completely disappear. The vibrations of the tuning-fork are almost always predominantly perceived by the affected ear from the middle line of the skull, only in exceptional cases by the normal or less affected ear.

Course and Issue.—The course of acute purulent inflammation of the middle ear depends principally on its cause, on the intensity of the process, on the constitution of the individual, and on the external circumstances of the patient. The time which elapses from the beginning of the inflammation to the perforation of the membrana tympani is very variable. While

sometimes even a few hours after the commencement of the process the membrane is found perforated, the perforation as a rule takes place only on the third or fourth day, and in protracted inflammations sometimes only after two to three weeks.

The cause of this early or late perforation is probably the difference in the power of resistance of the membrane. If at the commencement of the inflammation an inflammatory softening or ulceration of the membrane or an abscess in its tissue takes place early, the softened or ulcerated spot will soon give way to the pressure of the accumulated pus, and the purulent discharge will occur in a short time. If, however, the membrane is less affected by the inflammatory process, or if it is thickened by previous pathological changes (Toynbee), it will offer a greater resistance to the pressure of the secretion, and the perforation of the membrane will take place later. Rarely in the case of an intact membrana tympani the pus is discharged through the Eustachian tube into the naso-pharynx.

After the perforation has taken place, which is felt sometimes as if a bladder were bursting, and after the rapid and abundant discharge, the pain ceases either very soon or gradually. Sometimes, however, it continues after the perforation of the membrane with uninterrupted violence, and it is probable that in such cases not only are the superficial layers of the mucous membrane affected by the inflammation, but also the deeper layer of periosteum.

In regard to prognosis, the sensation of pain is of importance in so far as that when it diminishes, a decrease of the inflammation may be inferred, while continuous and recurrent pain points to a continuation or exacerbation of the inflammatory process.

After the purulent effusion takes place, another series of symptoms also disappears. The feverishness ceases almost altogether, and the feelings of fulness in the head, of giddiness and of general nervous irritation, are considerably lessened. The subjective noises either cease altogether, or are weakened; but in very nervous, cachectic and tubercular individuals, and in those severe forms of the disease in which the labyrinth is simultaneously affected by the inflammatory process, the noises in the ear frequently continue with the same intensity.

The changes in the disease, subsequent to perforation, are most remarkable in young children. The violent pain suddenly ceases, the pyrexia declines, and a lengthened sleep takes place. If the inflammation was associated with symptoms of cerebral irritation, with convulsions and unconsciousness, these symptoms also often abruptly disappear.

During the first few days succeeding perforation, the secretion is generally very abundant, especially as long as the acute phenomena last. The abatement of the inflammatory process is

indicated in the normal course of the disease by a gradual lessening of the effusion, and by the decrease or discontinuance of the visible pulsation on the membrana tympani. In proportion as the secretion lessens, an increase in the hearing-distance will be observable, a result of the subsidence of the swelling of the mucous membrane of the middle ear. Finally the secretion ceases altogether, and the orifice of the perforation is closed by newly-formed tissue. The cicatrization takes place either gradually, or so quickly that the orifice is closed during one night, while on the previous day there was still a copious discharge, and the air rushed out with a great rattling noise.

The duration of the suppuration until the perforation is closed varies considerably. In the simple forms, in which perforation of the membrane generally takes place during the early days of the disease, and in which the pain ceases when the effusion occurs, the suppuration lasts, as a rule, ten to twenty days or more. There are, however, cases in which the secretion ceases after two or three days, while in others the suppuration continues for several weeks or months.

After the closure of the perforation, the membrana tympani is found to be greyish-red and lustreless, the handle is barely visible, but the short process is sharply defined. The site of the former perforation is indicated by a yellowish-grey, somewhat depressed cicatrix, to which there sometimes extend from the periphery of the membrane several small vascular twigs (Fig. 121, p. 389); frequently, however, the cicatrix cannot be distinguished at all. In the subsequent course of the disease, the pathological changes in the membrana tympani gradually disappear; the epidermic layer peels off, the diffuse congestion and the great vascular network disappear, the malleus is distinctly visible, and the lustre and transparency of the membrane return so completely, that frequently no trace of a past inflammatory process is observable on the membrane. Often, however, the inflammation leaves permanent traces on the membrane in the form of opacities, calcareous deposits, cicatrices and partial atrophies, but these changes are not always accompanied by a hearing-disturbance.

The restoration of the hearing-power does not always take place immediately after the closure of the perforation, for frequently deafness of varying severity, which gradually decreases, continues for some time, until the swelling of the mucous membrane has entirely subsided. Complete recovery from the pathological condition takes place much more rapidly in the warm season than in winter. Not unfrequently a swelling of the mucous membrane of the middle ear, accompanied by a discharge of serous or colloid secretion, remains after the suppuration has terminated, with the symptoms and results of the already described (pp. 263, 267) catarrhs of the middle ear.

But acute suppuration of the middle ear by no means always runs the regular course just described. This is specially the case with those affections of the middle ear which are developed in the course of scarlatina, typhus, and severe puerperal affections, also in cachectic people, and during convalescence from severe illnesses. A protracted, irregular course is also observed in those inflammations during the course of which periostitis of the mastoid process, or a consecutive otitis externa with swelling and stricture of the meatus, is developed, and lastly in those cases in which granulations have been already formed on the membrana tympani and on the mucous membrane of the tympanic cavity during the early weeks of the attack.

The signs which indicate such an irregular course are frequently recurring attacks of pain, repeated increase of the already diminishing effusion, and its long duration. The symptoms of exacerbation are most marked in those cases in which inflammation of the mastoid process has developed during the suppuration, or in which closure of the margins of the perforation takes place, while the suppuration still continues. The consequences of such temporary closures recurring in the course of the disease, are a number of very violent reactive symptoms, produced by the retention of pus in the middle ear, which only subside when by the pressure of the accumulated secretion the adherent margins of the wound are forced asunder, and the obstacle to the discharge is thus removed. In the severe forms of acute suppuration of the middle ear, also especially in the scarlatinal and diphtheritic inflammations, a rapid absorption of the tissue of the membrana tympani, with the formation of a great gap in the membrane, takes place; so that within a short time the livid, red and turgid mucous membrane of the inner wall of the tympanic cavity, the partially isolated handle of the malleus, and sometimes also the articulations of the incus with the stapes, become visible.

The results of acute purulent inflammation of the middle ear are:

1. Cure with complete restoration of the hearing-power. This takes place, as a rule, within three or four weeks, not unfrequently, however, only after several months.

2. Permanent hearing-disturbances after the suppuration has ceased and the perforation has closed, if during its course adhesions by means of connective tissue have been formed by the proliferation of the mucous membrane, by which the membrana tympani and the ossicula are united to each other, or to the walls of the tympanic cavity. This issue is most frequently observed in scrofulous, sickly people.

3. Permanent hearing-disturbances in consequence of extensive losses of substance in the membrana tympani, with or without simultaneous destructive changes in the ossicula, or in con-

sequence of consecutive copious exudations in the labyrinth, which often completely destroy the function of the auditory nerve. These consequences are most frequently characteristic of the scarlatinal suppuration of the middle ear, and, as Moos correctly remarks, often cannot be prevented by timely surgical aid.

4. Inflammation and caries of the mastoid process, with rupture of the abscess externally, and exfoliation of the necrosed bone. The issue of this affection of the bone, which is observed most frequently in childhood, and to which we will refer in detail in the description of the diseases of the mastoid process, is either cure with the formation of an osseous cicatrix, or a permanent fistula behind the ear.

5. Acute purulent inflammation of the middle ear causes, in some rare cases, death, after the perforation of the membrane; sometimes, however, without perforation. This is due either to pyæmia, or to meningitis, encephalitis, thrombosis of the cranial sinuses, or erosion of the carotid (Toynbee), in consequence of acute caries of the walls of the tympanic cavity (Toynbee), or of the mastoid process, in which the suppuration has spread to the cranial cavity, the venous sinus, or the carotid. Cases of this kind have been described by Toynbee, Schwartze, Wendt, Chimani, and Prout.

6. Transition of the acute purulent inflammation of the middle ear into chronic suppuration of the middle ear, which will be discussed in the next division.

Diagnosis.—The diagnosis of acute purulent inflammation of the middle ear before perforation of the membrana tympani, and the distinction of this inflammatory form from acute myringitis, depends on the different diagnostic indications which we have learned in the description of acute inflammation of the membrana tympani (p. 223). But we have by no means definite indications from which to conclude whether in any given case perforation of the membrana tympani will take place, or whether the process, just as in the acute inflammations of the middle ear, will end without perforation of the membrane. The occurrence of perforation may be expected with probability, only if very violent inflammatory phenomena exist, in case of great swelling of the membrana tympani, through which the green pus can be seen, or if there be a pustule at the summit of the protuberance. But not unfrequently the process subsides, even in cases with very intense inflammatory symptoms, without perforation; while, on the other hand, in cases with very slight objective and subjective phenomena, perforation takes place.

After the perforation has taken place, the diagnosis of acute suppuration of the middle ear is determined: (1) By ocular inspection, as the perforation becomes visible either at once after removal of the secretion, or only after performing the Valsalvian

experiment, or after the application of my method; (2) By auscultation, by which the hissing and rattling of the air pressed into the middle ear can be heard escaping through the perforation. This method is of value especially in those cases in which the orifice, situated in the anterior portion of the membrana tympani, is hidden by the great curvature of the anterior inferior wall of the meatus, or in which the perforation cannot be seen at all, on account of the discharge being too profuse. But the absence of this hissing noise during the Valsalvian experiment by no means precludes the existence of perforation, because the resistance in the Eustachian tube is frequently so considerable that the air does not penetrate into the tympanic cavity, or penetrates with such slight pressure that the margins of the perforation are not forced asunder. It is worthy of notice that sometimes the air easily penetrates with little pressure, while the hissing through the orifice ceases when the pressure is increased. This happens in those rare cases of perforation in which a canal exists, extending obliquely through the layers of the membrane, the external and internal orifices of which are not on the same level, and the walls of which are firmly pressed together by the greater pressure of air.

The diagnosis is difficult in children, if the first inspection takes place after the perforation has already occurred. In this instance the perforation is only rarely visible after syringing, on account of the great swelling, spreading from the membrana tympani to the external meatus, and the rapid discharge of the secretion; and auscultation can just as little be made use of during the Valsalvian experiment, because it can hardly ever be performed with children.

To determine the diagnosis in such cases, whether it is acute purulent inflammation of the middle ear, or whether it is otitis externa, the character of the secretion has first to be taken into consideration. If it contains large, tough, mucous flakes, we are justified in diagnosing an acute purulent inflammation of the middle ear, because the secretion in primary otitis externa contains small lumps of pus and epidermic flakes, but no real mucus. But the secretion from the middle ear may, as we have seen, be also chiefly of a purulent character; therefore the absence of mucus from the discharge does not by any means exclude the existence of an acute suppuration in the middle ear. As it is important in such doubtful cases to learn with certainty the seat of the suppuration, it is advisable to propel air after my method, to ascertain from the audible hissing of the air through the orifice whether a perforation exists. This manipulation is the most easy of execution, because in children it is possible to propel air into the middle ear without an act of swallowing (Schwartze).

Prognosis.—The prognosis of acute purulent inflammations of

the middle ear greatly depends on the cause of the disease, and on the state of the system. It will be favourable if the disease is simple, or has been produced by a naso-pharyngeal catarrh spreading to the middle ear, if the affection occurs in a healthy individual, and the patient lives in favourable external circumstances. Symptoms of favourable import during the course of the disease are: Perforation during the early days of the affection, speedy decrease in the pain, early lessening of the secretion and of the pulsation in the membrana tympani, and lastly, steady increase of the hearing-distance during the discharge. The prognosis is, however, unfavourable in scrofulous, tubercular, and syphilitic individuals, in diabetic persons, and in cachectic people reduced by bodily suffering; also in cases of suppuration of the middle ear which have developed in the course of scarlatina and typhus, but less unfavourable in inflammations after measles.

Symptoms of unfavourable import during the course of the disease are: The continuance and frequent recurrence of pain, permanent profuse discharge after the disease has lasted several weeks, or bleeding from the ear; uninterrupted subjective noises, the rapid absorption of the tissue of the membrana tympani with speedy enlargement of the perforation, the occurrence of granulations on the membrana tympani, the expulsion of one or more of the ossicula, the appearance of swelling in the osseous meatus, painful varying swelling on the mastoid process, great infiltration of the glands on the side of the head, with suppuration of the glandular tissue, and functional disturbances within the range of the facial nerve.

Treatment.—The treatment of acute suppuration of the middle ear at the beginning of the disease and before the perforation of the membrana tympani is very little different from that of acute otitis media. Therefore, to avoid repetition, we must refer the reader in regard to the local treatment, the diet, and the treatment of the simultaneously existing naso-pharyngeal affection, to the division on that disease (pp. 253—260).

It is of special importance to take into consideration those changes in the membrana tympani from which an accumulation of pus in the tympanic cavity may be inferred, especially in children, if the affection is accompanied by great feverishness and cerebral symptoms, or by severe pain which does not diminish.

If the already described objective and subjective symptoms of an accumulation of secretion in the middle ear are present, paracentesis of the membrana tympani must be performed without hesitation at the seat of the greatest forward curvature. By this means not only will the violent pain be quickly alleviated, but the danger of the inflammation spreading to the cranial cavity will also be removed. But the operation is also advisable

in cases in which the most severe sleep-disturbing pain continually exists, which cannot be alleviated by local or internal medication, even if the membrana tympani is not noticeably bulged forwards. (On the details of Paracentesis, *vide* p. 287.)

When performing the operation, special care must be taken that the membrana tympani is completely divided, and that the orifice of the incision is widened a little before the instrument is removed. The bleeding from the wound is generally very trifling, and of short duration. The secretion in the tympanic cavity escapes either immediately after the incision, or, if the inflammation has produced a viscid exudation, only after one or two days. To accelerate the liquefaction of the masses in the tympanic cavity, it is advisable to fill the meatus several times daily with warm water (v. Tröltsch's ear-baths), or with a warm mixture of one part of aqua opii to three parts of distilled water.

During the first days after the perforation, the treatment is confined to the removal of the secretion by washing the meatus with warm water (26°-28° C.), in which a small quantity of boracic acid has been dissolved. A weak stream of water suffices to remove the secretion deposited in the meatus. For this purpose, small vulcanite syringes, holding about 40 grms. of fluid, with a short rounded nozzle (Leiter, of Vienna), are most suitable; of less service are the soft pyriform india-rubber balloons, which in a short time become useless. The employment of the large English ear-syringes, which are very suitable for the removal of foreign bodies, of ceruminal plugs, or inspissated cheesy masses, must be avoided in acute cases, because the inflammatory irritation in the middle ear is increased by the too powerful stream of water. The number of injections during twenty-four hours depends on the amount of the discharge: when it is profuse, the ear must be cleaned out every hour; while in the case of a moderate secretion, two or three injections per day are sufficient.

But by syringing the external meatus, the tympanic cavity is not also freed from secretion, because the stream of water cannot penetrate into the tympanic cavity through the small orifice of the perforation. Therefore, to remove the secretion from the middle ear, it must be driven into the external meatus by a current of air penetrating through the Eustachian tube into the tympanum.

The Valsalvian experiment is as little suited for this purpose as it is for making the Eustachian tube permeable in the catarrhs of the middle ear, although the air enters the tympanic cavity more easily when the membrane is perforated than when it is intact. But even in those cases in which the entrance of air during the Valsalvian experiment is easily accomplished, the secretion is less thoroughly removed from the tympanic cavity, on account of the little pressure, than by propelling air after my

method or with the catheter. That in the case of considerable resistance in the middle ear, a hyperæmia in the head, injurious to the local affection, is produced by the forced expiration during the Valsalvian experiment, is beyond doubt, as already proved.

For repeatedly stated reasons, therefore, the application of my method in acute purulent inflammations of the middle ear is most suited for making the Eustachian tube permeable, and thoroughly removing the secretion from the tympanic cavity, because in most cases the entrance of air into the middle ear is affected by it. This method is to be preferred to catheterism, especially in acute cases, because by the immediate contact of the catheter with the inflamed mucous membrane of the Eustachian tube, the swelling and secretion in the middle ear are increased. Besides, that the curative effect of my method in acute suppuration of the middle ear is greater than that of catheterism, has lately been confirmed by the observations of Knapp (*l. c.*).

Catheterism of the Eustachian tube is, therefore, advisable only in those rare cases in which the resistance in the Eustachian tube is so great, that propelling air after my method is not successful. In the majority of these cases, however, the resistance in the tube is so much lessened, after catheterism has once been employed, that in the further course of treatment the air can be easily propelled after my method.

Besides my own modification of my method (the replacement of the act of swallowing by the pronunciation of separate words, such as *König, Maatrix*), in many cases a modification of my method, which has lately been recommended by Lewi, Holt and Tansley, is suitable; the patient is requested to inflate his cheeks strongly, by which means the soft palate is pressed to the posterior wall of the pharynx, and the superior pharynx is closed below. The same effect can be produced, as I discovered, by attempting to make a deep inspiration through the mouth with the lips slightly opened, or through a short tube held between the lips, while the air is condensed in the naso-pharynx.

The application of the modifications of the closure of the superior pharynx with my method certainly gives the same result in a number of cases as propelling air during an act of swallowing; yet propelling air frequently does not succeed at all, or very slightly, with these modifications. But it must not be left unmentioned, that in some cases, at the moment of a deep expiration or inspiration through the mouth, propelling air succeeds very well; while previously, during the act of swallowing, no air could be pressed into the middle ear.

Regarding the amount of pressure to be applied while propelling air, on the whole the same holds good here as was given in detail in the description of the treatment of acute inflamma-

tion of the middle ear (p. 258). In children and in old people, in nervous, weakly and debilitated individuals, weak currents of air should first be tried by blowing the air in with the mouth (p. 148), and greater pressure (with the balloon) should be employed only if, with slight pressure, the air does not enter into the middle ear at all, or with but little force. In strong adults, however, for the thorough cleansing of the tympanic cavity, it is advisable to use strong currents of air by means of the balloon, without fearing any increase of inflammation, such as is the case in acute inflammations of the middle ear without perforation, as the air entering can escape through the orifice into the external meatus; but when after the occurrence of perforation the pain is still of considerable intensity, the air must be propelled with but slight pressure.

Through this simple method of treatment it is often possible to arrest the suppuration and to bring about a complete cure without any other applications. In cases, however, in which after propelling air for several days no decrease of the secretion is observed, it is well to apply local treatment for its more rapid arrest.

As is well known, for the removal of purulent discharges, astringent instillations, especially solutions of lead and zinc, have hitherto been employed. This treatment has recently, however, been considerably altered by the antiseptic treatment with crystalline boracic acid recommended by Bezold. This acid has been of such excellent service in the great majority of cases of acute purulent inflammation of the middle ear treated by me, that I now use it almost exclusively, and only employ astringents if the suppuration does not decrease with sufficient rapidity with the boracic acid.

The application of this remedy is very simple. After having washed and dried the meatus, a small quantity (about $\frac{1}{12}$ gram.) of the powder is blown into the meatus by means of Störk's laryngeal insufflator, or a goose quill, so far that the membrana tympani is covered with a thick layer of it. Then the meatus is closed with Bruns' cotton wool, and the powder is left in the ear until the following day. If it is then saturated, the ear is washed out, and boracic acid is again blown in. This treatment is continued until the powder remains perfectly dry after having been twenty-four hours in the ear, when it is left two or three days longer in the meatus, which is then washed out. If the powder in the ear remains dry for several days, it may with probability be inferred that the suppuration has ceased.

The great advantage of boracic acid over astringents is the considerable shortening of the duration of treatment. As regards this, my observations agree with those of Bezold, and with the abundant experience of E. Morpurgo. Besides, boracic acid seldom gives rise to a recurrence of the acute symptoms which

are sometimes observed during the application of solutions of zinc and lead.

In spite of this excellent effect of the boracic acid, cases occur in which by its application the secretion is not decreased, while it is quickly removed by the subsequent application of astringent instillations. In acute purulent inflammation of the middle ear I have found sulphate of zinc and sugar of lead to be the most effective astringents. They must, however, only be instilled when the pain has completely ceased, because experience has taught us that, by the application of medicated solutions before the inflammatory phenomena have disappeared, the pain is frequently increased.

To bring the solution immediately into contact with the diseased parts, it is necessary to remove the secretion from the middle ear and from the external meatus by injecting air through the Eustachian tube, and by subsequent syringing of the meatus. The water which has remained in the meatus after syringing is removed by inclining the head to the side and by wiping it out with a small roll of cotton-wool or lint. The solution, which must always be warmed, must remain 10-15 minutes in the ear, and the instillation must be repeated morning and evening.

By the application of sulphate of zinc (zinc sulph. 0·2 ; aqu. dest. 20·0. Sig. 10-15 drops to be instilled tepid) the secretion is often lessened, but seldom quickly arrested. If, therefore, after the zinc has been used several days, no decrease of the secretion is observed, it is advisable to resort to instillation of solutions of lead (plumb. acet. 0·2 ; aqu. dest. 20·0. Sig. as above), by which even after a short time the suppuration is frequently arrested. According to my experience they act much more rapidly if a few days previously a solution of zinc has been instilled. As in applying the astringent solutions in this manner only very slight quantities of the remedy reach the tympanic cavity, it may with probability be assumed that the solution in the first instance acts upon the external surface of the membrana tympani, and that the effect of the remedy spreads by contiguity through the orifice of the perforation to the diseased mucous membrane of the middle ear.

The concentrated solutions of nitrate of silver, recommended by Schwartze for chronic suppuration of the middle ear (caustic treatment) (0·8-1·0 : 10·0 aq. dest.), have also been proposed by Roosa and Pomeroy for the treatment of acute purulent inflammation of the middle ear. As, however, in acute cases, caustic treatment is more frequently followed by a considerable reaction than in chronic forms, nitrate of silver must only be employed when the suppuration proves obstinate to the above treatment.

A method of treatment, hitherto little thought of, but excellent in its results, in the obstinate acute suppurations of the middle

ear, consists of injections of warm water through the catheter into the middle ear (pp. 138, 141). This method, first employed in my clinic by Dr. Edwin Millingen, I now employ in those cases in which the pain continues uninterruptedly after the perforation of the membrana tympani in spite of palliative treatment; in which the suppuration cannot be arrested by the local treatment described; in those obstinate forms, in which the perforation is situated on a nipple-like elevation of the membrana tympani; and lastly in painful inflammations of the mastoid process. It often has a surprisingly rapid effect, as immediately after the injection of the fluid the pain generally ceases, the great suppuration decreases after a few days, the nipple-like elevation of the membrane subsides, and not unfrequently also the violent inflammatory phenomena in the mastoid process completely disappear.

I have previously mentioned that sometimes, in acute purulent inflammations of the middle ear, one or more granulations spring up at the margins of the perforation which prevent the cessation of the suppuration. To remove such growths rapidly it is advisable to touch them with a small drop of liquor ferri muriatis on the point of the probe. After they have been touched several times, the granulations shrivel up as a rule completely, and the suppuration in the middle ear ceases. After the application of boracic acid I have several times seen a rapid subsidence of the granulations and a complete cure.

The painful inflammations of the mastoid process, which appear in the course of acute purulent inflammation of the middle ear, deserve special attention. At the commencement an attempt must be made to subdue the inflammation by an energetic use of antiphlogistics, by the application of several leeches or Heurteloup's suction-syringe to the most painful place, and by continued cold bandages upon the mastoid process. When swelling sets in, it is advisable to paint the mastoid process with tincture of iodine, or to rub in mercurial ointment; and it is often possible to remove by these means the frequently fluctuating inflammatory phenomena in the mastoid process.

If in spite of treatment for several days no decrease in the inflammatory symptoms is observable, it is advisable, if no threatening symptoms are present, to try for several days injections of warm water into the middle ear by means of the catheter. It is only after this has been applied without result that the performance of Wilde's incision must be resorted to, by which the covering of the mastoid process is cut through to the bone at a distance of $1\frac{1}{2}$ cm. from the auricle. This simple operation is specially advisable when the swelling increases with more or less severe pyrexia, and the symptoms of periostitis of the mastoid, or of purulent accumulation below, become more marked. Experience shows that even in those cases in which no pus

escapes from the incision, yet by the incision alone the violent inflammatory phenomena are made to subside. The operation for opening the mastoid process will be discussed in a special division in the description of chronic suppurations of the middle ear.

If the perforation closes after the discharge has ceased, all further local treatment through the external meatus must be avoided, and Politzerization alone must be continued subsequently in treating the still existing deafness. At the beginning this is applied daily, later only once every other day, and if the deafness steadily decreases, only once or twice weekly, until the hearing-test indicates a complete return to the normal state. Many functional disturbances, which cannot be removed by treatment, I have seen sometimes disappear after residence for several weeks in a mountainous district.

After acute suppuration of the middle ear a copious epidermic formation in the meatus and on the membrana tympani frequently takes place for a lengthened period, which causes dry crusts to be formed on the external surface of the membrane. As such layers do not always peel off spontaneously from the membrane, but adhere to it, and impair the hearing-function, it is necessary to loosen them from time to time by softening instillations (sodæ carb. 0·5, aq. destill. 8·0, glycerine 4·0), and to remove them by syringing.

With regard to prophylaxis, it must still be remarked, that after acute suppurations of the middle ear have ceased, on account of the tendency to relapse, the meatus must be protected by cotton-wool in cold and windy weather, and vapour-baths or head-douches, as well as diving while in the bath, must be forbidden.*

b. Chronic Purulent Inflammation of the Middle Ear.

Syn.: Otitis media suppurativa s. perforativa chron.; Otitis interna of the older authors; Chronischer eitriger Ohrcatarrh (v. Tröltsch); Chronic suppuration of the middle ear (Roosa); Chronic purulent inflammation of the middle ear (Burnett); Otite profonde de l'oreille moyenne (Bonnafont); Otite media piogenica a forma chronica (De Rossi).

Chronic purulent inflammation of the middle ear is one of the

* Besides the already quoted manuals and treatises there are still to be mentioned: Alb. H. Buck, *The Importance of Treatment of Aural Diseases in their Early Stages, Especially when Arising from the Exanthemata—Transactions of the Internat. Med. Congress*, Philad. 1876; A. Bing, *Zur Perforation des Trommelfells, Allg. W. med. Ztg.* 1873; H. Knapp, *Ueber primäre acute eitrige Mittelohrentzündung, Z. f. O.* vol. i.; Rob. Wreden, *Die Otitis media neonatorum vom path. anat. Standpunkte, M. f. O.*, 1868; F. Bezold, *Zur antisept. Behandlung der Mittelohreiterungen, A. f. O.*, vol. xv.; Von Tröltsch, *Die Krankheiten des Gehörorgans im Kindesalter*, in Gerhard's *Handbuch der Kinderkrankheiten*, 1880; E. Morpurgo, *Dei Metodi curativi dell' otorrea—Giornale lo Sperimentale*, 1879.

most important diseases of the ear, not only on account of the frequency of its occurrence, and the deterioration of hearing caused by it, but also on account of the general disturbances of nutrition which not unfrequently are developed in the course of such protracted suppurations, and principally on account of those dangerous complications which are sometimes produced by the suppuration spreading to the cranial cavity and to the venous sinuses.

In no form of inflammation of the middle ear is the hearing-apparatus subjected to such extensive changes as in chronic suppuration. The suppurative process involves not only the whole middle ear, but almost always the membrana tympani, and often enough also the external meatus, the labyrinth, and the osseous walls of the middle ear.

The most important change in the mucous membrane in chronic suppuration of the middle ear consists of increase in bulk, caused by excessive infiltration with round cells and enlargement and new formation of vessels. While in this process the periosteal layer of the mucous membrane is either wholly or partially preserved, the sub-epithelial layer, stripped of its epithelium, is so replaced by round cells, that a suppurating granulation-surface, traversed by many vessels, takes its place. The mucous membrane appears red or yellowish-red, of several times its original thickness, smooth or glandular, and frequently so proliferated that the air spaces of the middle ear, the depressions in the walls of the tympanic cavity, or a great part of the space of the tympanic cavity, are filled by the hypertrophied mucous membrane.

The results of suppuration of the middle ear depend to a great extent on the ultimate fate of the infiltrated round cells: (1) the hypertrophy of the mucous membrane may subside by fatty metamorphosis and degeneration of the round cells, but the tissue of the mucous membrane, even in the slighter forms, will scarcely again assume its normal character, as it does after acute inflammation of short duration; (2) by partial hyperplasia of the infiltrated mucous membrane circumscribed elevations are developed in the form of granulations or of pedunculated new-formations, which are called polypi of the tympanic cavity; (3) the purulent process leads to destruction of the tissue, to ulceration, and wasting of the mucous membrane, which is eaten away to the bone, in which case the ulceration may spread to the bone; (4) by transformation of the round into spindle-shaped cells there occurs a formation of a firm connective tissue, similar to cicatricial tissue, in the form of diffuse tendinous calcareous thickenings of the mucous membrane, or of bridges and thick scars, which leads to abnormal adhesion between the membrana tympani, the ossicula, and the walls of the tympanic cavity. These new-formations of connective tissue

may be permanent, or in the subsequent course of the disease shrivelling and sclerosis, calcification, or ossification of the new-formation, more rarely atrophy of the mucous membrane, may result.

The changes in the middle ear enumerated here may be developed one after the other at different periods of the suppurative process, or they may exist simultaneously. In this way, in the same ear, besides granulations on the mucous membrane, a firm organized new-formation of connective tissue, and in other places again an ulcerative defect, extending to the bone, may be found. The epithelium of the mucous membrane, which is wanting in the excessively suppurating places, in other portions so prolife-

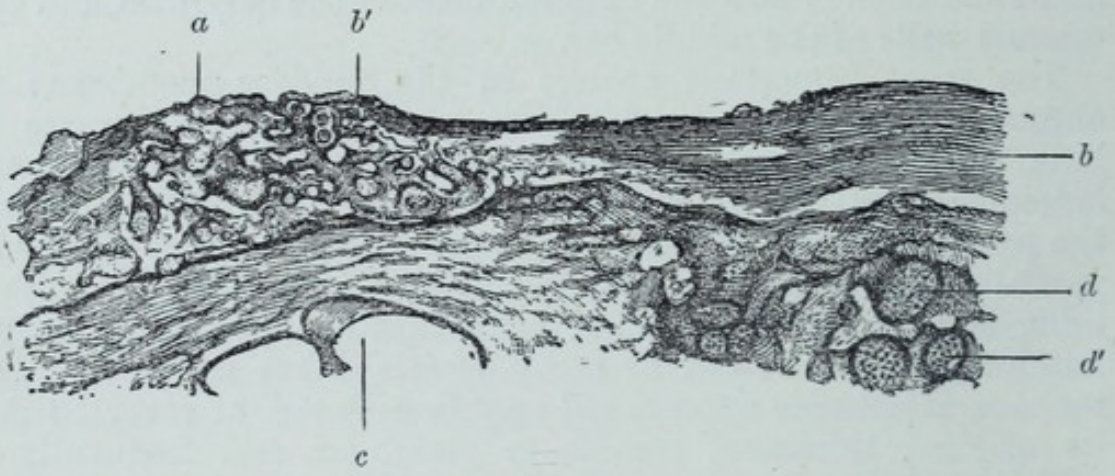

FIG. 122.—MICROSCOPIC SECTION OF THE INNER WALL OF THE TYMPANIC CAVITY OF A WOMAN, 36 YEARS OF AGE, WHO DIED OF PULMONARY PHTHISIS, AND WHO HAD SUFFERED FOR FOUR MONTHS FROM PROFUSE SUPPURATION OF THE MIDDLE EAR ON THE RIGHT SIDE. THE ANTERIOR PORTION OF THE INNER WALL OF THE TYMPANUM IS COMPLETELY DEPRIVED OF ITS MUCOUS MEMBRANE, AND THE EXPOSED BONE IS PALE, SOMEWHAT ROUGH AND UNEVEN. IN THE SECTION THE BOUNDARY OF THE MUCOUS MEMBRANE (*b b'*), WHICH BECOMES THINNER TOWARDS THE PLACE WHERE THE LOSS OF SUBSTANCE HAS OCCURRED (*a*), CAN BE DISTINGUISHED. THE BARE BONE (*a*), THE STRUCTURE OF WHICH IS SHARPLY SET OFF FROM THE CAPSULE OF THE COCHLEA (*c*), LYING BELOW IT, PRESENTS EVERYWHERE THE CHARACTERS OF INFLAMMATION. THE REMAINS OF THE CORRODED OSSEOUS LAMELLA (*a*) PROJECT ON THE SURFACE LIKE SMALL RIDGES. THE VASCULAR SPACES, AS ALSO THE LARGER OSSEOUS SPACES (*d d'*), IN THE POSTERIOR PORTION OF THE PETROUS BONE, ARE FILLED WITH GRANULATION CELLS.

rates, that the cavity of the middle ear is partially or wholly filled by large epidermic layers, which are frequently interwoven (otitis desquamativa). (On the histological changes of the mucous membrane in chronic suppuration of the middle ear, v. pp. 79-87).

The membrana tympani almost always suffers a loss of its continuity in chronic suppuration of the middle ear. Cases in which the suppurative process runs its course without perforation of the membrane are so exceedingly rare, that the assumption that perforation of the membrana tympani is not characteristic of chronic suppuration of the middle ear appears entirely unfounded. While in acute purulent inflammation of the middle

ear, as a rule, only a disturbance in the continuity of the membrana tympani takes place, we have here to deal with loss of substance, produced by absorption of the tissue of the membrane at the margins of the perforation. In this instance all the layers of the membrane are not always uniformly attacked by the destruction, as would appear from the inspection of the living. For when examining the dead body, the dermic layer or the layer of mucous membrane will frequently be wanting to a greater extent than the substantia propria. The margins of the perforation, which in the living almost always appear sharply defined, are often found to be jagged, fringed and irregular at the pathological examination.

The destruction attacks, as a rule, the portions of the membrane situated midway between the periphery and the handle of the malleus. Even in the case of very extensive losses of substance, in the majority of instances, the peripheral portion of the membrane is still found preserved in the form of a detached sickle-shaped ledge. This is not always formed by the tendinous ring, as is generally believed, but, as I have convinced myself by several post-mortem examinations, by the dense peripheral circular fibrous bundles of the membrana tympani. The portions of the membrana tympani situated in front of and behind the short process also resist for a long time the destructive influence of the suppuration.

The remnant of the membrana tympani is subject to many pathological changes in the suppurative process. Sometimes the membrane is uniformly thickened and tumefied, sometimes the layer of mucous membrane alone shows an excess of growth towards the tympanic cavity, or that layer and the substantia propria only change slightly, but numerous papillary villous growths and granulations develop on the dermic layer (Fig. 123), as in myringitis granulosa (p. 226). Lastly, a polypoid degeneration of the membrana tympani (v. Tröltsch) may take place, in which the original elements of the membrane can be traced in the new formation. Sometimes, near the perforation, one or more small swellings exist in the dermic layer, which spread as far as the substantia propria and form the basis of partial atrophied thinnings of the membrane.

After suppuration has ceased, either the margins of the perforation are covered with epithelium, and a permanent aperture in the membrana tympani remains, or the orifice is closed by a deposit of a yellowish-grey plasma on its margins, out of which there very rapidly develops a delicate and thin cicatricial tissue, in which the elastic fibres of the substantia propria are wanting. The cicatrix consists either of fibrous connective tissue, or of an almost structureless membrane, which is covered on both sides with epithelium in large plates. The remains of the membrana tympani are either thickened by a growth of connective tissue,

calcified, ossified, or atrophied, and its inner surface sometimes adheres more or less to the inner wall of the tympanic cavity, and sometimes does not.

In conclusion, we will indicate those pathological changes which in chronic suppuration of the middle ear are developed in the osseous tissue underlying the mucous membrane. It has already (p. 49) been mentioned that numerous bloodvessels, accompanied by prolongations of connective tissue, penetrate from the mucous membrane of the middle ear into the osseous wall, by means of which pathological changes occurring in the mucous membrane spread to the bone. Indeed, on microscopic examination it will very frequently be found, even in those cases in which the bone is apparently normal, after the mucous membrane has been detached, that those prolongations of connective tissue and osseous spaces are infiltrated with round cells, and

FIG. 123.—VILLOUS GROWTHS ON A PERFORATED MEMBRANA TYMPANI. FROM A TUBERCULAR SUBJECT, WHO DIED IN THE GENERAL INFIRMARY OF SECONDARY MENINGITIS BASILARIS, AND WHO SUFFERED FOR MANY YEARS FROM A PROFUSE SUPPURATION OF THE MIDDLE EAR.

a, Proliferating dermic layer, with villous projections; *b*, Substantia propria; *c*, Layer of mucous membrane.

that the vascular spaces are dilated; in a word, that the phenomena of inflammation of the bone are more or less strongly pronounced. This leads either to condensation of the osseous tissue, to hyperostosis and the formation of osteophytes, or to caries and necrosis of the temporal bone and of the ossicula, with all the consequences with which we shall become acquainted in the course of this division.

To get a better view of the changes which take place in the course of chronic suppuration of the middle ear, it seems to me advisable to describe first the purulent processes which are not aggravated by deep complications, and to discuss separately the polypoid formations as well as the carious diseases and their results.

Ætiology and Occurrence.—The transition from acute suppuration of the middle ear to the chronic form is caused partly by general and constitutional diseases, partly by local changes in the ear and in the neighbouring naso-pharynx. Although in many cases the cause of the chronicity of the suppuration cannot be proved, it may frequently be traced to scrofula, tuberculosis,

anæmia, marasmus, and other affections which disturb the nutrition of the general organism. The cases of suppuration of the middle ear, however, which most frequently become chronic, are those which arise in the course of typhus or the acute exanthemata, and the scarlatinal and diphtheritic forms are specially characterized by their obstinate course, which frequently defies all treatment. That chronic suppuration of the middle ear does not always originate from an inflammation, which at its commencement presents the characters of acute otitis purulenta, but that it may also be developed without acute phenomena, has already been pointed out.

Of the local causes which lead to the chronicity of the suppuration the most important are: (1) The granulations and polypous growths on the mucous membrane of the tympanic cavity and on the membrana tympani, which are developed in the acute stage; (2) retention and caseation of the purulent exudation in the different recesses of the tympanic cavity, of the petrous bone, and of the mastoid process; (3) periostitis and caries, which are developed during the acute stage in the mastoid process, or in some other portion of the temporal bone; (4) chronic inflammation of the external meatus and of the membrana tympani, if the process has spread from thence to the middle ear; (5) chronic blenorrhœa of the mucous membrane of the naso-pharynx, and ozæna.

Chronic purulent inflammation of the middle ear occurs at every age, most frequently, however, in childhood. That a large proportion of the purulent processes which are observed in adults date from childhood has been placed beyond doubt. The disease is as frequent in the male as in the female sex. Calling and occupation exert an influence upon the continuance of the suppuration only when the patients, in consequence of their position in life, are frequently exposed to the action of external sources of injury. For this is the reason why chronic suppuration of the middle ear occurs most frequently in the poorer classes, whose bad dwellings and poor nourishment exercise an injurious influence on the system.

Appearance of the Membrana Tympani.—The appearance of the membrana tympani in chronic suppuration of the middle ear varies so much that we must confine ourselves to a description of its principal types. The formation of a correct opinion as to the appearance is of great importance in this form of inflammation, because successful treatment is prevented by overlooking apparently trifling deep changes. In a number of cases the changes can be perceived so plainly and clearly, that we at once gain an insight into the actual condition of the middle ear, while in others, conclusions as to what is seen are drawn with great difficulty if the outlines of the different structures are indistinguishable through growths or adhesions.

As the appearances during the suppurative process are in many ways different from those after the suppuration has ceased, we will first describe the different conditions of the membrana tympani as they occur during the discharge. It is a matter of course that in all cases in which the view of the lower parts is obstructed by accumulated secretion, the ear must be washed out with tepid water (p. 399). If this does not suffice, the remaining fluid is removed by a ball of wadding of the size of a pea, held with the bent forceps. Before we describe the appearance of the membrane we will make a few remarks about the character of the secretion.

In chronic suppuration of the middle ear, just as in acute purulent inflammation, the secretion is either mostly purulent or mostly blenorrhœal (p. 390); it is rarely the case that a transparent colloid mucus is discharged which contains only a small quantity of pus-cells, and completely corresponds with the mucous secretion described when discussing the catarrhs.

The quantity of the secretion is very variable. Sometimes the discharge is so copious that a few minutes after syringing the meatus the pus again escapes from the ear, sometimes so trifling that the secretion is never seen at the external orifice, but dries up in the ear, and forms a darkish green or dirty brown crust, covering the meatus and the membrana tympani. The quantity of the secretion certainly depends mostly on the intensity of the inflammation, but frequently enough in cases of great congestion and tumefaction of the mucous membrane of the middle ear only a slight discharge will be found, while, *vice versa*, there is sometimes a very abundant effusion when the mucous membrane is pale and only slightly swollen. The discharge is greatest in cases of extensive granulations in the middle ear, and of carious affections in the temporal bone.

The yellowish or yellowish-green colour of the secretion is changed in many ways by admixture with dissolved cerumen, epidermic masses, detritus, blood (in the case of polypi and granulations), vegetable organisms, and medicaments. Then the discharge has a reddish, yellow, brownish, dirty grey, or blackish appearance. In cases of caries the discharge is frequently liquid, similar to flesh-rinsings, and very irritating. The occurrence of 'blue otorrhœa,' first observed by Zaufal, is on the whole rare. I have hitherto seen but two cases. Whether the bluish-green colour is produced by the numerous bacteria (bacter. termo) with which the purulent fluid is mixed, or by other substances, has not been proved as yet. It has, however, been ascertained by Zaufal's observations, that the blue pus may be transferred to other individuals suffering from a discharge from the ear, and that this peculiarity of the secretion has no influence upon the course of the purulent process.

The secretion from the tympanic cavity not unfrequently

diffuses an offensive penetrating smell, not only when the discharge from the ear has been neglected, but also in cases in which the greatest care has been taken to keep the ear clean. The offensive character of the secretion is not, however, a sign of caries, as was formerly believed; it is rather caused partly by

FIG. 124.—SEMI-LUNAR, JAGGED ORIFICE IN THE ANTERIOR INFERIOR QUADRANT OF THE RIGHT MEMBRANA TYMPANI. FROM A PREPARATION IN MY COLLECTION.

FIG. 125.—HEART-SHAPED ORIFICE IN THE RIGHT MEMBRANA TYMPANI. FROM A PREPARATION IN MY COLLECTION.

FIG. 126.—KIDNEY-SHAPED PERFORATION IN THE RIGHT EAR OF A BOY, 10 YEARS OF AGE, WHO SUFFERED FOR 6 YEARS FROM SCARLATINAL SUPPURATION OF THE MIDDLE EAR. THE VISIBLE MUCOUS MEMBRANE OF THE TYMPANIC CAVITY IS LIGHT-RED, THE MEMBRANA TYMPANI GREY, THE SHORT PROCESS AND POSTERIOR FOLD PROJECT GREATLY. HEARING-DISTANCE 5 M. FOR SPEECH.

FIG. 127.—KIDNEY-SHAPED PERFORATION IN THE LEFT EAR OF A WOMAN WHO HAD SUFFERED FOR 3 YEARS FROM A CHRONIC SUPPURATION OF THE MIDDLE EAR. THE MUCOUS MEMBRANE OF THE MIDDLE EAR IS DARK-RED, THE CONGESTED MEMBRANA TYMPANI IS COVERED HERE AND THERE WITH GREY EPIDERMIS. HEARING-DISTANCE: ACOUMETER 25 CM., SPEECH 65 CM.

stagnation and decomposition of the pus, partly by admixture of volatile fatty acids from the cerumen.

During examination with the ear-speculum we must concentrate our attention upon the locality and the size of the perforation, upon the condition of the remains of the membrana tympani and of the inner wall of the tympanic cavity, and lastly upon the coincident changes in the external meatus.

The site of the loss of substance is most frequently the anterior inferior portion of the membrana tympani, and next to that its posterior superior quadrant; Shrapnell's membrane, situated above the short process, is more rarely destroyed (Blake, Bezold).

The size of the perforation varies from that of the prick of a needle to the complete destruction of the membrane. But the extent of the loss of substance depends neither on the duration nor on the intensity of the purulent process; for in the tedious profuse suppurations of the middle ear a simple rent will often enough be found, the margins of which touch, and are only forced asunder when the air penetrates through it, while in other cases, after the disease has lasted several months, and frequently when there has been only a very slight discharge, the extent of the perforation amounts to almost two-thirds of the membrane.

The form of the orifice is most frequently roundish, oval, or elliptical, more rarely semi-lunar (Fig. 124) or angular. Those situated below the handle of the malleus receive a marked heart or kidney-shape (Figs. 125, 126, 127) from the extremity of the handle projecting into the perforation, and of these forms the latter is most frequently observed. The form and size of the aperture, are, however, very variable in consequence of the varying swelling of its margins. In cases of profuse discharge, particularly, the smaller perforations can hardly be discovered, especially in children, in whom the meatus is often narrowed by consecutive swelling of its lining membrane. In such cases, even immediately after washing out the secretion, the membrana tympani, covered with dirty greenish exudation, will alone be seen, its peripheral boundary obliterated, the malleus and the short process hidden, one or more pulsating reflections of light on the moist surface, and the locality of the perforation only recognisable from the discharge of pus.

As to the number of perforations, as a rule there is only one aperture in the membrane; but it has been ascertained by numerous observations that the membrane may be perforated in several places. In such cases most frequently two perforations will be found, situated in front of and behind the handle of the malleus, and separated by a bridge, extending from the lower extremity of the handle to the lower periphery of the membrana tympani (Figs. 128, 129). Still rarer are the cases in which the membrane is perforated in three (Fig. 130) or more places (v. Tröltsch, Wreden), or in which the membrana tympani is perforated like a sieve by numerous small orifices, as has been observed by Bonnafont and Schwartze in diphtheritic, tubercular, and pyæmic suppurations of the middle ear.

Appearance of the Membrana Tympani during the Suppuration of the Middle Ear.—We have already pointed out that in the case of a profuse discharge, the appearance is the more indistinct and indefinite the smaller the orifice of the perforation, especially if it is hidden by the anterior inferior wall of the external meatus. The condition of the membrana tympani can be much more clearly seen in the case of great destruction of the

membrane, through which the inner wall of the tympanic cavity becomes visible. The remnant of the membrane, bounding the gap, receives an unequally greenish-yellow or reddish-grey colour from the exudation deposited on its surface or in its interstices, which contrasts greatly with the dark red mucous membrane of the tympanic cavity. Frequently, however, it is congested like the lining membrane of the tympanum, and that either in circumscribed spots, which may easily be mistaken for ulcerations of the membrane, or uniformly, in which case the turgid dermic layer presents a smooth or velvety villous granular appearance. The margin of the perforation is either covered by

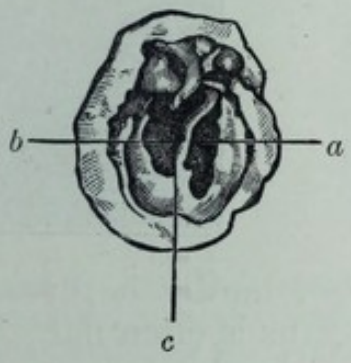

FIG. 128.—DOUBLE PERFORATION OF THE LEFT MEMBRANA TYMPANI, SEEN FROM THE INSIDE.

a, Anterior Perforation; *b*, Posterior Perforation; *c*, Bridge, extending from the Inferior Extremity of the Handle of the Malleus to the lower remaining Part of the Membrana Tympani. (From a Young Man who died of Phthisis Pulmonalis.)

FIG. 129.—DOUBLE PERFORATION OF THE LEFT MEMBRANA TYMPANI OF A GIRL, 19 YEARS OF AGE, WHO SUFFERED FROM CHILDHOOD FROM CHRONIC SUPPURATION OF THE MIDDLE EAR.

secretion, or bounded by a red line; sometimes it is covered with small papillæ. It either does not touch the inner wall of the tympanum or is in immediate contact with it. Most frequently the posterior portion of the margin of the perforation is applied to the promontory, while the anterior margin is not in contact, and throws a shadow upon the deeper-lying inner wall of the tympanic cavity. In the case of small perforations the handle of the malleus can but rarely be distinguished, in consequence of the turgidity of the dermic layer; but when the apertures are larger, and the tissue of the membrane round the handle of the malleus is destroyed, it either protrudes freely into the aperture in its original form and position (Fig. 131), or it appears thickened to several times its normal diameter, drawn inwards, and with its inferior extremity in contact with the inner wall of the tympanum, or it is shortened by carious softening of its inferior extremity (Fig. 132), or wanting altogether.

It is of great importance to form a correct opinion as to the

changes in the mucous membrane visible on the inner wall of the tympanic cavity. In the case of small perforations, 2-3 mm. in size, no sufficient view of the deeper portions will be obtained even with intense illumination, as such apertures always appear as dark orifices. In the case of more extensive defects, however, which allow of the entrance of a greater quantity of light into the tympanic cavity, the existing changes on the inner wall of the tympanum can be minutely examined in proportion to the extent of the orifice. In this way the mucous membrane, which

FIG. 130. — LEFT MEMBRANA TYMPANI PERFORATED IN 3 PLACES; A GREAT GAP BEHIND THE HANDLE OF THE MALLEUS, TWO SMALLER ONES IN FRONT OF IT. FROM A PREPARATION IN MY COLLECTION.

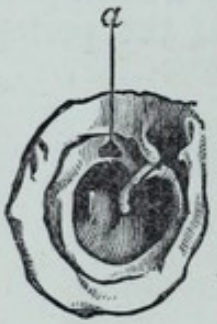

FIG. 131.—GREAT LOSS OF SUBSTANCE IN THE RIGHT MEMBRANA TYMPANI. THE INFERIOR PORTION OF THE HANDLE OF THE MALLEUS IS LAID BARE AND DETACHED; IN THE UPPER PORTION OF THE REMNANT OF THE MEMBRANE IS A SMALL GAP (*a*); THE UPPER SPACE OF THE TYMPANIC CAVITY IS FILLED WITH MASSES OF CONNECTIVE TISSUE. FROM A PREPARATION IN MY COLLECTION.

FIG. 132.—DESTRUCTION OF THE INFERIOR HALF OF THE MEMBRANA TYMPANI, LAYING BARE THE PROMONTORY AND THE NICHE OF THE FENESTRA ROTUNDA. THE INFERIOR EXTREMITY OF THE HANDLE OF THE MALLEUS IS DESTROYED BY NECROSIS; ITS SUPERIOR, THICKENED PORTION WITH THE GREYISH-YELLOW REMNANTS OF THE MEMBRANA TYMPANI IS PRESERVED. FROM A MAN, 24 YEARS OF AGE, WHO HAD AT TIMES SUFFERED FROM OTORRHŒA FROM CHILDHOOD. HEARING-DISTANCE: ACOUMETER = $\frac{2}{3}$ M.; SPEECH = 2 M.

has been laid bare, will be found to be yellowish-red, scarlet or blueish-red of different shades, here and there lustrous, and not unfrequently covered by adherent layers of exudation and epidermis. The tumefaction is either very trifling or so considerable that all the depressions in the tympanic cavity are erased, and the mucous membrane grows through the orifice above the surface of the membrana tympani. Sometimes numerous large and small granulations (Figs. 133 and 134) are formed, which are spread over the whole field of view, or are collected together in groups; or polypi, and in some very rare cases fibrous growths as hard as cartilage, occur, which remain on the inner wall of the

tympanic cavity as yellow protuberances after the suppuration has ceased (Fig. 135).

Appearance of the Membrana Tympani after cessation of the Suppuration.—Variable as the appearance of the membrana tympani is while the secretion lasts, it changes but little when the suppuration is reduced to a slight amount or is arrested altogether. When the swelling of the diseased part subsides, the outlines and forms of the remaining portion of the membrana tympani and the details of the inner wall of the tympanic cavity come

FIG. 133.—THE INFERIOR HALF OF THE LEFT MEMBRANA TYMPANI IS DESTROYED; ON THE DARK-RED INNER WALL OF THE TYMPANIC CAVITY ARE SEVERAL GLOBULAR GRANULATIONS. FROM A MAN, 24 YEARS OF AGE, WHO HAD SUFFERED FROM A DISCHARGE FROM THE LEFT EAR SINCE HE WAS 5 YEARS OLD. HEARING-DISTANCE: ACOUMETER = 0; SPEECH = ⅓ M. PERCEPTION THROUGH THE CRANIAL BONES PRESERVED. IN THE REMAINING UPPER PORTION OF THE MEMBRANE THE THICKENED STUMP OF THE HANDLE OF THE MALLEUS IS RECOGNISABLE.

FIG. 134.—GREAT DESTRUCTION OF THE RIGHT MEMBRANA TYMPANI, OF WHICH ONLY A THICKENED REMNANT IS PRESERVED AT THE SUPERIOR PERIPHERY. GROUPS OF SMALL GRANULATIONS ON THE PROMONTORY. FROM A GIRL, 19 YEARS OLD, WHO HAD SUFFERED SINCE CHILDHOOD FROM A DISCHARGE FROM THE EAR. DESTRUCTION OF THE GROWTH BY TOUCHING IT WITH LIQ. FERRI MURIAT. THE OTORRHŒA HAS CEASED. HEARING-DISTANCE: SPEECH = 2 M.

FIG. 135.—GREAT DESTRUCTION OF THE INFERIOR HALF OF THE LEFT MEMBRANA TYMPANI; ON THE PROMONTORY IS AN OBLONG GROWTH, WHICH APPEARS HARD AS CARTILAGE WHEN FELT WITH THE SOUND; BEHIND IT THE NICHE OF THE FENESTRA ROTUNDA. FROM A MAN, 33 YEARS OF AGE, IN WHOM THE SUPPURATION OF THE MIDDLE EAR COMMENCED 24 YEARS BEFORE. HEARING-DISTANCE: ACOUMETER = 20 CM.; SPEECH = 1 M.

much more distinctly into view. The remains of the membrane are rarely normal in colour, but generally greyish opaque, thickened and like parchment, and not unfrequently more or less calcified. The calcareous deposits appear as sharply defined chalky-white or yellowish spots between the handle of the malleus and the periphery (Figs. 136, 137, 138), and are sometimes of such size, that almost all the remaining portion of the membrane except the peripheral portion of the annulus tendinosus is transformed into a rigid calcareous mass, which has penetrated all the layers (Fig. 139). Rarely a part of the calcified portion projects freely

into the orifice of the perforation (Fig. 140). (On the histological condition of the calcareous deposits in the membrana tympani, v. p. 216)

FIG. 136.—SMALL PERFORATION BEHIND THE UMBO. SEMI-LUNAR CALCAREOUS DEPOSIT IN THE ANTERIOR INFERIOR HALF OF THE MEMBRANA TYMPANI. IN A GIRL, 15 YEARS OF AGE, IN WHOM OTORRHŒA IS ALLEGED TO HAVE APPEARED ABOUT 4 MONTHS BEFORE, AND TO HAVE CEASED IN A FORTNIGHT. HEARING-DISTANCE: WATCH = 40 C.; SPEECH = 4 M. (LEFT EAR.)

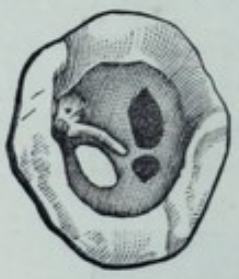

FIG. 137.—DOUBLE PERFORATION OF THE LEFT MEMBRANA TYMPANI; THE GAPS ARE SEPARATED BY A NARROW BRIDGE; IN FRONT OF THE HANDLE OF THE MALLEUS IS AN OBLONG CALCAREOUS DEPOSIT. FROM A PREPARATION IN MY COLLECTION.

The appearance of the handle of the malleus will also vary with the changes of the remnant of the membrana tympani here enumerated. Sometimes it is so embedded in the thickened

FIG. 138.—CENTRAL PERFORATION; IN FRONT OF AND BEHIND THE HANDLE OF THE MALLEUS ARE CIRCUMSCRIBED CALCAREOUS DEPOSITS IN THE MEMBRANA TYMPANI. IN A GIRL, 17 YEARS OF AGE, IN WHOM THE SUPPURATION OF THE MIDDLE EAR COMMENCED 8 YEARS AND CEASED 2 YEARS BEFORE. HEARING-DISTANCE: SPEECH = 1½ M. (RIGHT EAR.)

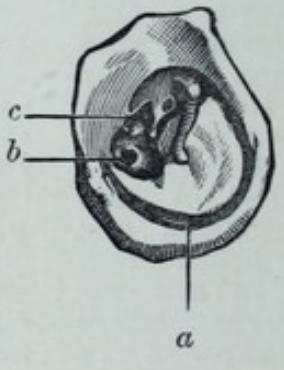

FIG. 139.—EXTENSIVE CALCIFICATION OF THE RIGHT MEMBRANA TYMPANI, INVOLVING ALL THE LAYERS.

a, Peripheral portion, not calcified; *b*, Perforation behind the handle of the malleus; *c*, A thin band, which connects the partly eroded long crus of the incus with the capitulum of the stapes. (From a preparation in my collection.)

layers of the membrane that it is either completely invisible, or is only indicated by a diffuse injection of its vascular bundles. In the case of large gaps, when the handle of the malleus is partly stripped of the tissue of the membrane, it but rarely retains its normal position (Fig. 141), inclining more or less

towards the inner wall of the tympanic cavity, and it is often foreshortened to such an extent that its inferior extremity seems to lie immediately below the short process (Fig. 142). The retraction of the malleus, caused by the traction of the tensor tympani, is sometimes so great that its inferior extremity comes into contact with the inner wall of the tympanic cavity, and anchyloses with it. The place of union is situated mostly above the highest point of the promontory, and is indicated either by a circumscribed thickening of the adjoining mucous membrane, or

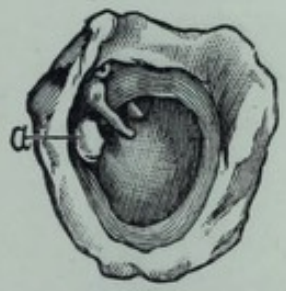

FIG. 140. — GREAT DESTRUCTION OF THE MEMBRANA TYMPANI; THE INFERIOR EXTREMITY OF THE HANDLE OF THE MALLEUS IS LAID BARE.

a, In front of the handle of the malleus is a calcareous deposit, which partially projects freely into the gap. (Left ear.) From a preparation in my collection.

FIG. 141.—LARGE PERFORATION IN THE RIGHT MEMBRANA TYMPANI; THE INFERIOR HALF OF THE HANDLE OF THE MALLEUS IS FREE; IN THE SUPERIOR QUADRANT OF THE FIELD OF VIEW THE INFERIOR EXTREMITY OF THE LONG CRUS OF THE INCUS, AND IN THE POSTERIOR INFERIOR QUADRANT THE NICHE OF THE FENESTRA ROTUNDA, ARE VISIBLE. FROM A MAN, 28 YEARS OF AGE, IN WHOM THE SUPPURATION OF THE MIDDLE EAR TOOK PLACE IN CHILDHOOD AFTER SCARLATINA. HEARING-DISTANCE: WATCH = IN CONTACT; SPEECH = $\frac{1}{3}$ M.

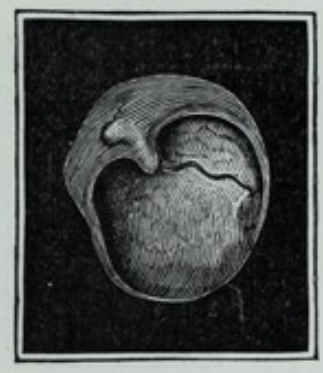

FIG. 142.—LARGE PERFORATION OF THE MEMBRANA TYMPANI; THE HANDLE OF THE MALLEUS IS FORESHORTENED; ITS INFERIOR EXTREMITY IS IN CONTACT WITH THE INNER WALL OF THE TYMPANIC CAVITY; FROM THE POINT OF CONTACT A TORTUOUS VESSEL EXTENDS TOWARDS THE NICHE OF THE FENESTRA ROTUNDA. FROM A YOUNG MAN, 19 YEARS OF AGE, WHO WAS AFFECTED WITH PURULENT INFLAMMATION OF THE MIDDLE EAR DURING SCARLET FEVER 10 YEARS AGO. HEARING-DISTANCE: ACOUMETER = 1 M.; SPEECH = $1\frac{1}{2}$ M.

by one or more vascular twigs extending downwards from the point of contact. Rarely is the handle moved so much inwards and upwards, that it is entirely hidden from view.

Besides this apparent shortening of the handle of the malleus, sometimes a real one is met with, caused by erosion. The handle then appears uneven, pointed, not unlike a rusty tack; very seldom is it destroyed up to the short process.

The changes on the inner wall of the tympanic cavity, after the suppuration has ceased, vary in many ways. The mucous membrane is either rose-red, or yellowish-red, or pale-yellow, and

of normal appearance. In the case of cicatricial condensation of the tissue, it appears of a tendinous-grey colour, uneven and lustrous. Not unfrequently vascular ramifications can be plainly distinguished on the promontory, most frequently one or two large veins, which extend along Jacobson's nerve in an almost perpendicular direction from above downwards (Fig. 143). If during the period of suppuration the protuberances and depressions on the inner wall of the tympanic cavity were indistinct and erased, in consequence of the tumefaction of the mucous membrane, they will be so much the more easily distinguishable after the

FIG. 143.—KIDNEY-SHAPED PERFORATION BELOW AND BEHIND THE HANDLE OF THE MALLEUS; ON THE PALE-YELLOW PROMONTORY IS A DARK-RED TORTUOUS VEIN; BEHIND IT IS THE NICHE OF THE FENESTRA ROTUNDA. THE MEMBRANA TYMPANI IS GREYISH, OPAQUE AND DRY. FROM A GIRL, 20 YEARS OF AGE, IN WHOM THE SUPPURATION APPEARED IN CHILDHOOD, AND CEASED 2 YEARS AGO. HEARING-DISTANCE: ACOUMETER = 1 M.; WHISPERED SPEECH = 6 M. (RIGHT EAR.)

FIG. 144.—LARGE PERFORATION IN THE MEMBRANA TYMPANI IN FRONT OF THE HANDLE OF THE MALLEUS. FROM A GIRL, 18 YEARS OF AGE, WHO HAD SUFFERED FROM A DISCHARGE FROM THE EAR SINCE CHILDHOOD. HEARING-DISTANCE: WATCH = 4 CM.; SPEECH = $\frac{1}{3}$ M. (RIGHT EAR.)

suppuration has ceased. If destruction of the anterior portion of the membrana tympani (Fig. 144) has taken place, the anterior part of the tympanic cavity, extending to the ostium tympanicum tubæ, will become visible as a dark funnel-shaped depression. If the orifice extends nearly to the lower periphery of the membrane, a portion of the obliquely placed inferior wall of the tympanic cavity, with its ridgy protuberances and dark depressions, will frequently also come into view (Fig. 145). The knowledge of this appearance is important, because these osseous projections might be mistaken for trabecular outgrowths of the mucous membrane in the tympanic cavity. In the case of large perforations on the posterior half of the membrane (Fig. 146, 147), which are bounded in front by the handle of the malleus and below by the concave, sharply defined margin of the perforation, the promontory will be seen, not unfrequently projecting through the gap like a hillock above the level of the remnant of

the membrana tympani. Above and in front of it, the detached articulation of the stapes and the incus (Fig. 147), or in cases in which the inferior portion of the long crus of the incus is eroded, the two crura of the stapes and its round capitulum (Figs. 145, 146) with the tendon of the stapedius extending backwards (Figs. 146, 148), come clearly into view, as also at the posterior boundary of the promontory the dark niche of the fenestra rotunda, about 2 cm. in diameter.

The appearances here described, as seen through the aural

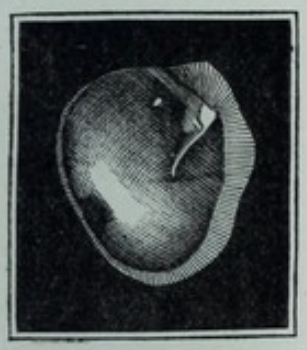

FIG. 145.—EXTENSIVE PERFORATION OF THE RIGHT MEMBRANA TYMPANI, OF WHICH ONLY A SMALL BORDER IS PRESERVED AT THE PERIPHERY. THE INFERIOR EXTREMITY OF THE HANDLE OF THE MALLEUS IS ANCHYLOSED WITH THE INNER WALL OF THE TYMPANIC CAVITY ABOVE THE PROMONTORY. IN THE POSTERIOR SUPERIOR QUADRANT OF THE FIELD OF VIEW THE ROUND CAPITULUM OF THE STAPES, BEHIND THE PROMONTORY THE NICHE OF THE FENESTRA ROTUNDA, AND IN THE INFERIOR PORTION OF THE FIELD OF VIEW THE DEPRESSIONS AND RIDGY PROTUBERANCES OF THE LOWER WALL OF THE TYMPANIC CAVITY ARE VISIBLE. FROM A YOUNG MAN, 17 YEARS OF AGE, IN WHOM THE SUPPURATION COMMENCED IN CHILDHOOD DURING SCARLATINA, AND LASTED UNTIL 3 YEARS AGO. HEARING-DISTANCE: WATCH = 2 CM.; SPEECH = $\frac{1}{2}$ M.

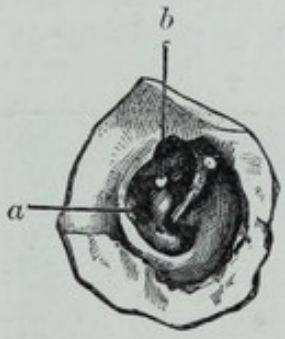

FIG. 146.—PERFORATION OF THE POSTERIOR HALF OF THE RIGHT MEMBRANA TYMPANI.

a, Fenestra rotunda; *b*, The capitulum of the stapes, with the tendon of the stapedius, laid bare by the destruction of the long crus of the incus. From a preparation in my collection.

speculum, offer in the majority of cases sufficient indications for the diagnosis of perforations caused by chronic suppuration of the middle ear. Besides that, the noise of the air rushing through the perforation during the Valsalvian experiment, or when applying my method, is an important objective sign in ascertaining that the membrane is perforated. In the secreting stage it will be heard as rattling, after the suppuration has ceased as hissing, the pitch of which depends less on the size of the orifice in the membrane than on the condition of the Eustachian tube. This is generally somewhat constricted by the preceding purulent in-

flammation, rarely abnormally dilated by atrophy of its osseous portion (v. Tröltsch). In the former case a high-pitched hissing noise will be produced by the current of air through the middle ear; in the latter case a broad blowing sound. A well-known experiment, by which the presence of a perforation can be ascertained, consists in filling the external meatus with warm water, and injecting air into the middle ear, when air-bubbles will appear on the surface of the fluid.

Frequently enough, however, the air, entering into the middle ear, does not escape through the orifice into the external meatus, although a perforation exists. The diagnosis of perforation of

FIG. 147.—PERFORATION OF THE POSTERIOR HALF OF THE RIGHT MEMBRANA TYMPANI. BEHIND THE UMBO IS THE STRONGLY PROJECTING YELLOWISH-GREY PROMONTORY, ABOVE IT THE LONG CRUS OF THE INCUS LYING FREE AND THE POSTERIOR CRUS OF THE STAPES. FROM A YOUNG MAN, 16 YEARS OF AGE, IN WHOM THE PURULENT INFLAMMATION COMMENCED 2 YEARS AGO AFTER A COLD BATH. AFTER THE REMOVAL OF A SMALL POLYPUS SEATED ON THE PROMONTORY, THE SUPPURATION CEASED. LATER ON THE ORIFICE WAS CLOSED BY A LARGE THIN CICATRIX. HEARING-DISTANCE: ACOUMETER = 1 M.; SPEECH = NEARLY NORMAL.

FIG. 148.—EXTENSIVE PERFORATION IN THE POSTERIOR AND INFERIOR PORTION OF THE RIGHT MEMBRANA TYMPANI. IN THE POSTERIOR SUPERIOR QUADRANT OF THE FIELD OF VIEW THE CAPITULUM OF THE STAPES WITH THE TENDON OF THE STAPEDIUS, BELOW IT THE PALE YELLOW PROMONTORY, AND BEHIND IT THE NICHE OF THE FENESTRA ROTUNDA ARE VISIBLE. FROM A MAN, 50 YEARS OF AGE.

the membrane is made much more difficult when the loss of substance is closed by exudation, or is overgrown by granulations, or when the margins of the perforation are applied to the inner wall of the tympanic cavity, and the sharply-defined boundary between the membrana tympani and the mucous membrane of the tympanum is wanting. In such cases it often remains undecided whether it is a chronic suppuration of the middle ear or a chronic myringitis, until by continued observation in the subsequent course of the disease the diagnosis is decided by the temporary penetration of pus or air, or by the appearance of the perforation in the membrane.

That others besides these conditions render the recognition of the appearance of the membrane and of the tympanum diffi-

cult, will be easily comprehended if the great variety of the changes in them, caused by the pathological process, are taken into consideration. It is, for instance, frequently impossible to ascertain whether an uneven and granular surface, which extends over the whole field of view, belongs to the membrana tympani or to the inner wall of the tympanic cavity; for it may not be possible when air is condensed in the middle ear to recognise from the penetration of secretion at a circumscribed point of the field of view, or from a great forward curvature of the granular surface, that the latter belongs to the membrana tympani. In this instance, also, we are frequently able to judge correctly of the result of the inspection through the speculum, only by the changes which occur in the diseased portions in the subsequent course of the affection. In this way a granular surface, extending over the whole field of view, may be taken for a growth of the mucous membrane of the inner wall of the tympanic cavity, until, after the swollen portions have subsided, we are informed by the handle of the malleus becoming visible, that the granular surface was formed by the dermic layer of the membrana tympani. On the other hand, in extensive perforations of the membrana tympani the congested mucous membrane of the inner wall of the tympanic cavity, or, after the suppuration has ceased, the tendinous-grey, lustrous cicatricial tissue covering it, may be thought to be the membrana tympani, if the ledge-shaped remnants of the membrane which still exist at some parts of the periphery, or the stump of the handle of the malleus, did not show by their position in relation to the deeper-lying field of view that the latter belongs to the inner wall of the tympanic cavity. In the same manner portions of the inner wall of the tympanic cavity may be mistaken for remains of the membrana tympani. Sometimes a sharply-defined, circumscribed, round, or oval point on the promontory looks at first sight exactly like the orifice of a perforation, because the surrounding portions of the wall of the tympanum are covered with a thick, grey, epithelial layer, and thereby appear like remains of the membrana tympani.

Perforation of Shrapnell's Membrane.— Although perforation of this part (p. 22) takes place very rarely (Blake), in comparison with those observed in other portions of the membrana tympani, it occurs, nevertheless, more frequently than has been hitherto assumed.

The perforation may be confined to Shrapnell's membrane alone, or another orifice in the membrana tympani may exist. The orifice above the short process leads immediately into the system of cavities (drawn on p. 42, and first described by me), situated between Shrapnell's membrane and the neck of the malleus, which are partly closed, and partly communicate with each other and with the remaining space of the tympanic cavity. Clinical experience teaches that in isolated cases a purulent inflammation

takes place in this system of cavities with perforation of Shrapnell's membrane, without the inflammation spreading to the rest of the tympanic cavity. In the majority of cases, however, the perforation of Shrapnell's membrane is caused by a purulent inflammation spread over the whole middle ear; but in the course of the process the suppuration in the middle ear may cease, while it obstinately continues for a long time in the system of cavities bordering on Shrapnell's membrane. In this space also small polypi sometimes appear, which press through the perforated membrane into the external meatus (Cl. Blake), and frequently caseous or cholesteatomatous masses (Bezold) will be found here, while they are absent from the remaining portions of the tympanic cavity.

FIG. 149.—DESTRUCTION OF SHRAPNELL'S MEMBRANE ON THE LEFT SIDE. ABOVE THE SHORT PROCESS IS A LARGE JAGGED GAP IN THE BONE, THROUGH WHICH THE MUCOUS MEMBRANE OF THE TYMPANIC CAVITY IS GROWING. FROM A GIRL, 16 YEARS OLD, IN WHOM SUPPURATION OF THE MIDDLE EAR HAD EXISTED FOR 4 YEARS IN BOTH EARS. LATELY SHE HAD HAD CONTINUOUS HEADACHES AND TWITCHINGS OF THE FACIAL MUSCLES. IN SPITE OF REPEATED REMOVAL OF THE PROTRUDING NEW-FORMATION, IT AGAIN AND AGAIN GREW OUT INTO THE EXTERNAL MEATUS. BUT AFTER SEVERAL INJECTIONS OF WARM WATER INTO THE TYMPANIC CAVITY BY MEANS OF THE CATHETER, THE SUPPURATION RAPIDLY DECREASED, AND SUCH CONTRACTION OF THE PROLIFERATING MUCOUS MEMBRANE TOOK PLACE THAT THE INNER WALL OF THE TYMPANIC CAVITY BECAME VISIBLE THROUGH THE GAP. SUBSEQUENTLY THERE PROVED TO BE AN ADHESION OF THE MEMBRANA TYMPANI TO THE PROMONTORY.

When inspecting the membrana tympani, close above the short process there will be found an orifice filled with secretion, through which a sound can be introduced into a cavity, the base of which is formed by the neck of the malleus. During the Valsalvian experiment pus or air very rarely penetrates through this orifice. The membrana tympani itself is sometimes moist, tumefied, and secreting; sometimes again dry and lustreless, especially in those cases in which the pus is confined to the already-mentioned system of cavities.

The suppurations of the middle ear, accompanied by perforation of Shrapnell's membrane, are characterized by their tediousness and obstinate course (Blake, Burnett, Orne Green). If suppuration continues long in this situation it leads not unfrequently to caries of the malleus, and incus, and to absorption of the osseous tissue above the Rivinian fissure, producing gaps above the short process in the upper wall of the external meatus, which in some cases become so extensive that a large portion of the upper part of the tympanic cavity comes clearly into view.

The appearance of the osseous meatus in cases where such

gaps have been formed varies according to the stage of the process, whether the suppuration in the middle ear still continues or has ceased. The formation of a diagnosis is often very difficult for one who has not had much practice, and a correct estimation of the state of the meatus is only possible when the anatomical relations of this region are steadily kept in view. In those cases especially in which the malleus is hidden by infiltra-

FIG. 150.—DESTRUCTION OF THE RIGHT MEMBRANE OF SHRAPNELL; GAP OF THE SIZE OF A SMALL PEA ABOVE THE SHORT PROCESS, THE BASE OF WHICH IS LINED BY A SMOOTH, DRY, AND GREY CICATRIX. FROM A GIRL, 20 YEARS OLD, WHO HAD SUFFERED FROM EAR-AFFECTION FROM CHILDHOOD. THE SUPPURATION IS LOCALIZED TO THE SPACE ABOVE THE SHORT PROCESS. AFTER SEVERAL FRUITLESS ATTEMPTS AT TREATMENT, THE SUPPURATING CAVITY WAS CLEANSED BY MEANS OF A SMALL TYMPANIC TUBE, INSERTED FROM THE MEATUS, AND THEN A FEW DROPS OF A 10 PER CENT. SOLUTION OF NITRATE OF SILVER WERE INJECTED THROUGH THE SAME TUBE, BY WHICH THE SECRETION WAS ARRESTED ON THE FOLLOWING DAY. SEVERAL SUBSEQUENT SLIGHT RELAPSES WERE QUICKLY DISPOSED OF BY THE SAME TREATMENT. HEARING-DISTANCE: ACOUMETER = 11 CM.; SPEECH = 1½ M.

FIG. 151.—LARGE DEFECT IN THE BONE AT THE INNER BOUNDARY OF THE SUPERIOR WALL OF THE MEATUS IN A GIRL, 26 YEARS OF AGE, WHO HAD SUPPURATION OF THE MIDDLE EAR IN CHILDHOOD, WHICH ONLY CEASED A FEW YEARS AGO. MEMBRANA TYMPANI DRY, GREY, AND OPAQUE; CONTRACTED BY CICATRICES IN FRONT OF AND BELOW THE UMBO, AND ATROPHIED BEHIND THE HANDLE OF THE MALLEUS. THROUGH THE GAP IN THE OSSEOUS WALL THE HEAD OF THE MALLEUS, THE LIGAM. MALLEI ANT., AND THE BODY OF THE INCUS WITH THE LONG PROCESS COULD BE SEEN. A VERY THIN MEMBRANE, WHICH CLOSES THE GAP AND IS CLOSELY APPLIED TO THE OSSICULA, CURVES OUTWARDS AFTER AIR HAS BEEN PROPELLED. HEARING-DISTANCE: ACOUMETER = 50 CM.; WHISPERED SPEECH = 5 M.

tion of the layers of the membrana tympani, in consequence of continued suppuration of the middle ear, or in which the mucous membrane of the middle ear proliferates through the gap into the meatus, so that the membrana tympani is partially or wholly covered by granulation tissue, a diagnosis is generally quite impossible at the first examination. Such growths are frequently mistaken for polypi of the external meatus, until after repeatedly removing them their true nature is ascertained by their exceedingly rapid reappearance from below, and by careful probing.

A much clearer insight into the state of the deeper parts can be got when the secretion has ceased. Then the diagnosis is facilitated by the fact that the defect in the bone is situated

above the short process, and may therefore be considered to have its seat in the upper wall of the osseous meatus. The appearance varies according to the size of the gap in this wall, and according to the anatomical condition of the structures in the tympanic cavity. If the gap is of the size of a hemp-seed or of a small pea, the background is seen to be formed by a tendinous grey, smooth and lustrous cicatrix (Fig. 150), or the bared neck of the malleus, covered by a delicate cicatrix, and a portion of the head of the malleus are exposed to view. But if the defect in the bone is of greater size the articulation of the malleus and incus is sometimes so completely exposed that it can be minutely examined in all its anatomical details (Fig. 151).* In several cases in which the incus was destroyed, I have seen the exposed head of the malleus; if this was also decayed there could be obtained, in proportion to the size of the gap in the meatus, a clear view of portions of the inner wall of the tympanic cavity, which under ordinary circumstances, even if the membrana tympani were completely destroyed, could not be seen. These are the niche of the fenestra ovalis, the yellowish Fallopian canal situated above it, and in the case of gaps of still larger size and extending more backwards, even the upper part of the horizontal semicircular canal. When such gaps occur in the external meatus the membrana tympani is generally grey and opaque, sometimes thickened, and either completely or partially adherent to the inner wall of the tympanic cavity, in consequence of which one or more irregular yellowish indentations will be observed on its external surface. The superior, detached margin of the membrane next the gap in the bone is frequently thickened and everted.

To the appearances of the membrane here described there have still to be added the most important of the pathological changes in the external meatus, which are developed in the course of chronic suppuration of the middle ear. Through the prolonged action of the pus upon the meatus its integument becomes macerated, but in consequence of the irritation of the cutis great proliferation of epidermic cells is induced, which protects the corium from the action of the corrosive secretion. This is the only explanation of the fact that frequently, in spite of otorrhœa of many years' standing, no inflammatory changes take place in the meatus.

Oftener, however, it leads to a temporary follicular or diffuse inflammation in the meatus; to complete exfoliation of the epidermic layer, laying bare the papillary stratum; to a partial or extensive increase in bulk of the cutis, and consequent narrowing of the meatus; to the formation of granulations and polypi; to periosteal proliferations and exostoses in the osseous portion; and more rarely to caries and necrosis of the osseous walls.

* Compare my *Beleuchtungsbilder des Trommelfells*, p. 122.

Ulceration of the dermic layer of the meatus is, on the whole, rare in the suppurative processes of the middle ear, which do not produce caries (v. Tröltsch), but in a small number of patients, mostly scrofulous or cachectic, I have seen on the inferior wall of the cartilaginous meatus a deep-seated ulcer, bounded by sharply-defined, raised margins, and extending to the external orifice of the ear, at first sight looking very like a syphilitic ulcer, and cicatrizing only after prolonged local treatment. On the auricle and round the ear, especially in children and in persons with a tender, irritable skin, the action of the secretion produces a watery eczema, sometimes deep-seated ecthymatous pustules, and sometimes a chronic diffuse dermatitis with enlargement of the thickened and hardened auricle. A frequent phenomenon, especially in children, is the swelling of the cervical and submaxillary glands, and more rarely the lymphatic glands behind the ear. The glandular infiltration is in most cases due to the vicinity of the seat of suppuration, and the assumption of a scrofulous basis is only justifiable if other characteristic signs of scrofula are also present. When describing the carious processes we will discuss the more serious affections which spread from the tympanic cavity or from the mastoid process along the walls of the meatus.

Subjective Symptoms.—Chronic suppuration of the middle ear runs its course frequently without any striking subjective phenomena, even in cases in which the greater portion of the membrana tympani has been destroyed, and deafness of a high degree exists. Pain is a frequently-recurring symptom during its course. It is almost constantly experienced in the intercurrent acute inflammations of the middle ear, and in the secondary inflammations of the external meatus; it is also felt in cases of stagnation of pus in the tympanic cavity, due to a temporary closure of the margins of the perforation, to stricture of the meatus, or to polypi and masses of granulations, and when pus or decomposed cheesy masses become inspissated in the tympanic cavity and in the mastoid cells, when the mucous membrane is ulcerated and when there is a carious affection of the osseous walls of the middle ear. Unlike what occurs in the acute form, the pain is seldom produced by neuralgia of the plexus tympanicus or by hyperæmia and inflammation spreading from the pars petrosa to the Gasserian ganglion (v. Tröltsch, Moos).

More frequently suppuration of the middle ear is accompanied by a number of unpleasant head symptoms, such as oppression and heaviness in the head or obstinate headache, which sometimes produce great mental depression. If one ear alone is diseased, as a rule only the corresponding side of the head or the occiput is affected. These symptoms are most frequently observed when Shrapnell's membrane is perforated, when the escape of the pus is mechanically obstructed, or when inspissated masses have

accumulated in the middle ear; not unfrequently, however, they exist without any demonstrable obstruction to the discharge of the secretion, especially in nervous, anæmic and debilitated individuals. In some cases the cause of these symptoms may be ascribed to an abnormal increase of the labyrinthine pressure; more frequently, however, to hyperæmia spreading from the osseous walls of the middle ear to the dura mater and veins of the brain (v. Tröltsch), as it is an established fact that the vessels of the diploë of the temporal bone freely communicate with the sinuses in the cranial cavity.*

The unpleasant head symptoms disappear as a rule after the suppuration has ceased. A surprisingly rapid relief takes place, especially after the removal of inspissated secretion and polypi from the middle ear. Cases are, however, observed in which, on the contrary, when the secretion has completely ceased, a continuous headache or sense of oppression is developed on the corresponding side of the head or in the whole head, which only disappears when the purulent secretion returns.

This form of inflammation of the middle ear is frequently accompanied by slight giddiness; but serious attacks of giddiness with vomiting, unsteadiness of gait and increased tinnitus are on the whole rare in suppuration of the middle ear without caries. This symptom is mostly caused by pathological products, which increase the labyrinthine pressure by clogging the footplate of the stapes and the membrane of the fenestra rotunda. Temporary hyperæmia in the labyrinth, however, passing thence from the middle ear, may cause giddiness.

Subjective hearing-sensations are disproportionately more rare in chronic suppuration of the middle ear than in the chronic catarrhs of the middle ear. The reason for this is, that in the catarrhs which run their course without perforation of the membrana tympani hearing-sensations are very frequently caused by the great difference between the air-pressure of the external atmosphere and in the middle ear, while in purulent inflammation of the middle ear, as long as the membrane is perforated, an equalization of the air-pressure takes place through the orifice. The noises are mostly intermittent and generally caused by great accumulation of secretion or by acute subsequent suppuration; rarely they are continuous when the labyrinthine fenestræ are constantly clogged or when there are secondary pathological changes in the labyrinth, in syphilitic affections or in very old adhesive processes. Painful sensitiveness to noises (*vide* Hyperæsthesia Acoust. p. 197) rarely occurs in cases of chronic suppuration of the middle ear.

In conclusion, we must mention the alterations in taste and smell observed in these latter cases. Claude Bernard has

* Prof. Zuckerkandl, who experimented in my presence, injected a substance into the diploë of the mastoid process and of the pyramidal portion of the petrous bone, which at once entered into the sinuses of the brain.

observed a diminution of the sense of taste in cases of facial paralysis. In a case described by Moos, after the introduction of an artificial membrane an acute sensation of taste was perceived. The same author observed, after the extirpation of a polypus arising in the region of the stapes, a temporary paralysis of taste, caused by a lesion of the chorda tympani (*Z. f. O.* vol. viii.). We are indebted to August Carl for an interesting and highly important observation on himself: he suffered from childhood from suppuration of the left middle ear, and his membrana tympani was almost completely destroyed. When testing his sense of taste, Carl found that it was completely lost in the anterior portions of the left half of the tongue, while it remained intact on the right half. He is of opinion that the deterioration of the sense was caused by an affection of the plexus tympanicus due to the suppuration, this plexus, as we know, containing fibres of the glosso-pharyngeal nerve, and that in this way the sensation of taste in the anterior half of the tongue was brought about. Urbantschitsch also arrived at the same result from observations on a considerable number of his patients. He found that the sensation of taste in the tongue, the soft and hard palates was almost constantly altered in cases of chronic suppuration of the middle ear, and that even in many patients the sense was quite lost. It is, nevertheless, striking that, remarkable as the alteration in this sense may appear when tested, patients never complain of such a change when eating or drinking, even though both ears are suppurating. In the same manner, though not in the same proportions, an alteration in the sense of touch in the tongue is observed, according to descriptions by Wilde, Toynbee, v. Tröltsch, Moos, and Urbantschitsch. (Compare Vintschgau, *Geschmackssinn* in Herrmann's *Handbuch der Physiologie*, vol. iii.)

An alteration in the sense of smell in cases of chronic suppuration of the middle ear is by no means rare. Diminished sensibility to certain smells is most frequently observed, rarely complete insensibility, which often may be traced to a simultaneous naso-pharyngeal affection, though sometimes occurring without demonstrable disease of the pituitary membrane.

Much more rarely a disagreeable smell, temporarily accompanied by a nauseous taste on the palate, is perceived. The reason for this may in some cases be traced to an intermittent escape of pus through the Eustachian tube into the naso-pharynx; sometimes, however, the unpleasant smell occurs without demonstrable cause.

Hearing Disturbances.—In the course of chronic suppuration of the middle ear the hearing-power presents great fluctuations, which depend partly on the varying degree of swelling of the mucous membrane and on the patency of the Eustachian tube, partly on the quantity of secretion in the tympanic cavity. As

in catarrhs generally, changes in the weather and in the temperature exert also in these cases a marked influence upon the hearing-power. A temporary or even lasting impairment of hearing takes place in cases of recurrent inflammation of the middle ear, in intercurrent naso-pharyngeal catarrh, in serious illnesses, in tubercular disease, and in general syphilis. Slight fluctuations in the hearing-distance are observed in cases of excessive proliferation of the mucous membrane of the middle ear, by which the ossicula are enclosed on all sides, also in cases of rigid adhesion or anchylosis of the ossicula and in advanced labyrinthine affections.

Of main importance in relation to the degree of deafness after the suppuration has ceased are the pathological changes which have been produced by the inflammatory process in the middle ear. If during the secretion only great swelling and loosening of the mucous membrane exist, which, after the suppuration has ceased, subside to such a degree that the ossicula regain their vibrating power in great part, an improvement in the hearing always takes place. If, however, the ossicula are fixed by those soft or cicatricial new-formations previously mentioned, if especially the niches of the two labyrinthine fenestræ are filled by the proliferating mucous membrane, and the stapes is thereby firmly fixed, the cessation of the discharge will not produce any improvement in the hearing, or only a slight one. It even happens, that immediately after the suppuration has ceased a remarkable change for the worse in the hearing is noticeable, which only disappears with recurrence of the discharge. This fact can only be explained by retraction of the new-formed connective tissue of the previously swollen and hypertrophied mucous membrane after the secretion has ceased, by which the ossicula become more rigidly fixed, while the connective tissue is relaxed by a return of the purulent inflammation and the ossicula become more movable.

What influence the formation of cicatrices and extensive calcifications of the membrana tympani, adhesions of the membrane to the deeper structures in the tympanic cavity, permanent apertures in the membrane and the destruction and exfoliation of the ossicula, have upon the degree of deafness, will be seen in the description of the results of chronic suppuration of the middle ear. (Compare Oskar Wolf, *Sprache and Ohr*, 1871.)

The power of perception of the auditory nerve through the cranial bones in cases of chronic suppuration of the middle ear is in the majority of patients normal, even for low sounds. But in advanced age, or when the affection dates from earliest childhood, also in the case of long-existing adhesive changes in the tympanic cavity accompanied by great hardness of hearing, in the case of a simultaneous syphilitic labyrinthine affection, and not unfrequently also in consequence of constant intense subjective

noises, the perception of sound through the cranial bones is diminished or completely absent. The same may be said of the perception of the tuning-fork brought in contact with the cranial bones, the vibrations of which are generally heard louder by the affected ear, and only rarely so by the unaffected or better-hearing ear.

Course and Results.—The course of chronic purulent inflammation of the middle ear depends frequently upon the original cause of the affection, but principally upon the local changes present in the ear and in the naso-pharyngeal mucous membrane, and on the state of the general health. Considering the great variety which pathological observation of this form of disease determines in regard to its issues and consequences, it is impossible to enter into a detailed discussion of its course, and we must therefore confine ourselves to a general description.

Regarding the suppuration itself, it continues generally without interruption in the scrofulous, tubercular, or scarlatinal forms, and in cases of diffuse granulations, of polypi and of caries. Very frequently, however, the secretion ceases spontaneously and completely, to return again after a short pause or after an interval of years, with or without the symptoms of an acute inflammation. Relapses are caused most commonly by catching cold, by the entrance of water into the meatus while washing or bathing, by intercurrent naso-pharyngeal catarrhs and bronchitis, or by local, or general febrile diseases. Relapses are specially frequent when the perforation of the membrane has not been closed by a cicatrix (Schwartze), when, therefore, the bare mucous membrane of the tympanic cavity is exposed to the immediate action of external sources of injury. The seasons also exert an influence upon the purulent process, especially in children, in whom an arrest of the suppuration is frequently observed in spring, to return again in autumn.

The suppurative process as a rule ceases uniformly over the whole mucous membrane of the middle ear and on the membrana tympani. But cases are frequently seen in which the remnant of the membrana tympani is dry and lustrous, while the inner wall of the tympanic cavity is still covered by pus, and *vice versâ*. In like manner, in cases of extensive deficiency of the membrana tympani, circumscribed parts of the mucous membrane of the tympanic cavity are found to be covered by a dry, lustrous, cicatricial tissue, while other portions are still covered by pus, after the removal of which a tumefied or granulating patch of mucous membrane will be observed.

The result obtained by examination with the speculum varies greatly during the continuance of the suppuration. Frequently the field illuminated remains unchanged for years; often, however, even after a short time, especially after intercurrent acute relapses, it presents an appearance materially different

from that at former examinations. Sometimes even after the space of a few weeks a great enlargement, rarely a decrease, of the perforation will be seen, or adhesive cicatrization between the membrana tympani and the deeper portions of the tympanic cavity. The field of view may also appear to be totally changed by a rapid growth of granulations and polypi in the middle ear. The development of such proliferations does not depend on the duration of the suppurative process. I have seen cases in which the discharge continued for more than twenty-five years, and no great proliferation of the mucous membrane could be observed in the secreting portions of the tympanic cavity. In other cases, however, after a few months' duration the suppuration has caused the membrana tympani and the mucous membrane of the tympanic cavity to be covered with granulations, not unfrequently even masses of polypi are found in the middle ear. Although the occurrence of this hyperplasia is undoubtedly favoured by a scrofulous, tubercular, or anæmic constitution, or by general syphilis, it is, on the other hand, frequently met with in perfectly healthy people without any demonstrable cause for its early appearance. On the whole the same may also be said of the development of ulcers on the mucous membrane of the middle ear, and of carious affections of the temporal bone originating in the middle ear, a detailed description of which will be given later.

We now pass to the discussion of the results of chronic suppurative inflammation of the middle ear after the purulent discharge has ceased. These are: cure with closure of the perforation by cicatricial tissue, adhesions in the middle ear, the covering of the margins of the perforation with epidermis, when the gap in the membrane becomes permanent, and desquamative processes on the mucous membrane of the middle ear.

These changes form the basis of hearing-disturbances of different degrees, but their removal with complete restoration of the hearing is by no means rare. This, however, takes place only in those cases in which the pathological changes in the neighbourhood of the ossicula completely subside, in which the patency of the Eustachian tube again becomes normal, and in which the perforation in the membrana tympani is cicatrized without impairment of its vibrating power. But it rarely regains its former normal appearance, as opacities, calcareous patches, or partial thinnings of the membrane generally remain.

The closure of the perforation by cicatricial tissue is by no means so rare as was formerly thought. This termination depends neither on the duration of the discharge nor on the amount of the loss of substance. For frequently very extensive perforations of many years' standing cicatrize, while small ones which have been produced by suppuration of short duration

often remain permanently open after their margins have been covered over by epidermis.

The cicatrization takes place either uniformly from the margins of the perforation until the gradually diminishing orifice is closed, or, as will be seen in Fig. 152, from one margin only until the opposite margin is reached; or, first of all, a ligamentous bridge is formed across the gap, the margins of which unite with those of the perforation, forming a cicatrix which completely fills up the orifice. (On the Histological Characters of Cicatrices of the Membrana Tympani, *vide* p. 407.)

FIG. 152.—PERFORATION IN THE ANTERIOR INFERIOR QUADRANT OF THE LEFT MEMBRANA TYMPANI. FROM THE POSTERIOR MARGIN OF THE DEFECT THERE EXTENDS CICATRICIAL TISSUE, WHICH DOES NOT YET QUITE CLOSE THE GAP. BEHIND THE HANDLE OF THE MALLEUS IS AN IRREGULAR CALCAREOUS DEPOSIT. FROM A MAN, 64 YEARS OF AGE, IN WHOM PURULENT INFLAMMATION OF THE MIDDLE EAR MADE ITS APPEARANCE A YEAR BEFORE. AFTER TREATING IT FOR A FORTNIGHT WITH A CONCENTRATED SOLUTION OF NITRATE OF SILVER (1 IN 10), THE SUPPURATION CEASED. HEARING-DISTANCE: SPEECH = $\frac{1}{3}$ M.; AFTER THE SECRETION HAD CEASED = 5 M.

FIG. 153.—KIDNEY-SHAPED CICATRIX BELOW THE HANDLE OF THE MALLEUS. FROM A WOMAN, 48 YEARS OF AGE, IN WHOM PURULENT INFLAMMATION OF THE MIDDLE EAR COMMENCED 2 YEARS BEFORE, BUT CEASED AFTER A FEW WEEKS. GREAT DETERIORATION IN THE HEARING-POWER AFTER CLOSURE OF PERFORATION. HEARING-DISTANCE: WATCH = IN CONTACT WITH AURICLE; SPEECH = 1 M.

When the membrana tympani is inspected the cicatrices appear as sharply-defined dark spots, mostly depressed, at the base of which an irregular reflection of light is visible. Their size varies as that of the perforations. Their form is roundish or elliptical (Fig. 154), frequently kidney-shaped (Fig. 153), and rarely angular. As a rule only one cicatricial depression exists on the membrana tympani, but not unfrequently two (Fig. 154) or more cicatrices or cicatrix-like depressions are visible on the membrane. But such thinned places may not always be considered as cicatrices closing the same number of previously-existing perforations; for it is ascertained by observation on patients that even during the cicatrization of a perforation of the membrana tympani, or after its closure, atrophic thinnings may occur in one or more spots, which on inspection cannot be dis-

tinguished by anything from the real cicatrices (Fig. 155). The tissue of the membrane in the neighbourhood of the cicatrix is rarely normally transparent, but more or less opaque, and here

FIG. 154.—LARGE CICATRIX BEHIND THE HANDLE OF THE MALLEUS IN A MAN, WHO SUFFERED IN CHILDHOOD FROM OTORRHŒA ON THE RIGHT SIDE. WHILE UNDER OBSERVATION A CICATRIX-LIKE ATROPHY AROSE IN FRONT OF THE HANDLE OF THE MALLEUS. HEARING-DISTANCE: WATCH = 0; SPEECH = $\frac{1}{3}$ M.

FIG. 155.—CICATRIX OF THE SIZE OF A PIN-HEAD, SURROUNDED BY A CALCIFIED PORTION OF THE MEMBRANE IN FRONT OF THE HANDLE OF THE MALLEUS; BEHIND IT, A SHARPLY DEFINED SEMI-LUNAR CALCIFICATION. FROM A MAN, 50 YEARS OLD, WHO HAD A DISCHARGE FROM THE EAR IN CHILDHOOD, BUT WHO EXPERIENCED A HEARING-DISTURBANCE ONLY HALF A YEAR AGO. HEARING-DISTANCE: ACOUMETER = $\frac{1}{3}$ M.; SPEECH = $4\frac{1}{2}$ M.

and there thickened. Not unfrequently there are found next the cicatrix, in front of and behind the handle of the malleus,

FIG. 156.—LARGE HEART-SHAPED CICATRIX BELOW THE HANDLE OF THE MALLEUS; BEFORE AND BEHIND IT TWO SHARPLY DEFINED CALCAREOUS SPOTS. FROM A GIRL, 19 YEARS OLD, WHO SUFFERED FROM A DISCHARGE FROM THE EAR FROM CHILDHOOD UNTIL 6 YEARS BEFORE. HEARING-DISTANCE: WATCH = 25 CM.; SPEECH = 2 M.

FIG. 157.—LARGE SHARPLY DEFINED CICATRIX BEHIND AND BELOW THE HANDLE OF THE MALLEUS. FROM A MAN, 34 YEARS OLD, WHO IN CHILDHOOD HAD A PURULENT DISCHARGE FROM THE EAR FOR SEVERAL YEARS. AFTER PROPELLING AIR INTO THE MIDDLE EAR, THE CICATRIX, LYING AGAINST THE WALL OF THE TYMPANIC CAVITY, BULGES FORWARD IN THE FORM OF A BUBBLE TOWARDS THE EXTERNAL MEATUS. HEARING-DISTANCE: ACOUMETER = 2 CM.; SPEECH = $\frac{1}{2}$ M.

sharply-defined, calcareous spots (Figs. 156, 157), or an almost complete calcification of the tissue surrounding the cicatrix. The cicatrix itself is calcified very rarely (Moos).

A difference is made between free, applied, and adherent cicatrices. As a rule only small cicatrices are free, as they rarely move inwards so far as to come into contact with the inner wall of the tympanic cavity. Cicatrices of a larger size, however, are almost always applied so closely to that wall that the outlines of the latter can be seen almost as clearly as in cases of extensive loss of substance. This is especially the case with those cicatrices which extend over the posterior half of the membrana tympani, and are lying upon the promontory. Then the latter is generally seen in the form of a reddish or yellowish lustrous protuberance (Fig. 157), upon which one or more strongly-marked vessels may frequently be observed through the transparent cicatrix. In the posterior inferior quadrant the dark niche of the fenestra rotunda shines through, while in the posterior superior quadrant the articulation of the stapes with the incus projects on the surface of the closely-applied cicatrix in the form of a yellowish triangle (Fig. 157). In cases in which the long crus of the incus has been destroyed by the suppuration, the outlines of the head of the stapes with its pit-like depression, and of the tendon of the stapedius muscle, directed backwards, come distinctly into view.

The appearance of cicatrices after the closure of the defect in the membrana tympani remains frequently unchanged; sometimes, however, after some time has elapsed, an enlargement of the cicatrices to several times their original size is observed. I have also several times seen at a subsequent examination a perforation in the place of a former cicatrix, without any suppuration having meanwhile taken place from the mucous membrane of the middle ear. It is probable that in such cases no real cicatrization had occurred; in a preparation in which two depressed cicatrices of the size of a pea were visible, they proved on closer examination to be simply epidermic plates, and a double perforation was discovered after their removal.

The diagnosis of cicatrices of the membrana tympani is generally easy. Small, sharply-defined, and dark cicatrices certainly may at first sight look to the inexperienced eye like perforations, especially in those rare cases in which the reflection of light on the cicatrix exhibits a pulsating movement (Schwartze). But the absence of the noise produced in perforation during condensation of air in the middle ear, and the subsequent globular curvature of the depression outwards above the level of the other portions of the membrane, will at once lead to the recognition of the cicatrix. Moreover, free cicatrices present during an act of deglutition or during quiet respiration (Blake's manometrical cicatrix) a remarkable mobility. Larger and very delicate cicatrices, which are applied to the inner wall of the tympanic cavity, and which in appearance can hardly be distinguished from the moist and lustrous mucous membrane of the exposed inner wall, may also be mistaken for a large perforation. This mistake may

frequently be avoided by observing that the cicatrix extends from one or more points of the former margin of the perforation to the inner wall of the tympanic cavity as a wrinkled, striped, and lustrous membrane. (Compare my *Plast. Darstellungen der wichtigsten Krankheiten des Trommelfells*, No. 11.) But in those cases in which the lateral portions of the cul-de-sac-like cicatrix are hidden by the remnant of the membrana tympani (Fig. 158), it will be possible to ascertain with certainty the presence of a cicatrix, applied to the wall of the tympanic cavity, only by observing the change in the appearance of the membrana tympani after condensation of air in the middle ear. If it is not adherent to the wall of the tympanum it will project above the level of the remnant of the membrane in the form of a grey knob-like bubble, when the previously visible structure on the inner wall of the tympanic cavity will quite disappear. Cicatrices which extend over the posterior half of the membrane are frequently bulged forward by the air-douche, to such an extent that the handle of the malleus is mostly hidden by this bubble-shaped protuberance. This appearance is, however, only of short duration, as the cicatrix, becoming wrinkled, soon sinks inward again, and the membrane resumes its former appearance.

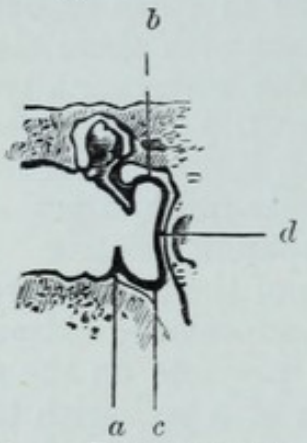

FIG. 158. — DIAGRAMMATIC SECTION THROUGH THE EXTERNAL MEATUS AND THE MIDDLE EAR, IN WHICH THE POSITION OF AN EXTENSIVE CICATRIX OF THE MEMBRANA TYMPANI, IN CONTACT WITH THE INNER WALL OF THE TYMPANIC CAVITY, IS ILLUSTRATED.

a, Ledge-shaped remnant of the membrane; *b*, *c*, The lateral portions of the cicatrix, extending from the remnant of the membrane to the inner wall of the tympanic cavity; *d*, portion of the cicatrix applied to the inner wall of the tympanic cavity.

It is different in those cases in which the cicatrix on the membrane is adherent to the inner wall of the tympanic cavity. Such adhesions are produced either by immediate contact of the inflamed surfaces, or by proliferation of the mucous membrane of the middle ear, which brings about contact between the walls of the tympanic cavity, the ossicula, and the membrana tympani.

Small cicatrices rarely adhere to the inner wall of the tympanic cavity. In cases where this takes place the cicatrix forms a cone, narrowing inwards, with a black or reddish background, which remains immovable during condensation of air in the middle ear, as well as during the examination with Siegle's speculum. Such circumscribed conical adhesions I have rarely found in front of the malleus, oftener below and behind it, but most frequently in the posterior superior quadrant of the membrane, in which case

the articulation of the incus with the malleus or the head of the stapes was united with the cicatrix.

Adhesion of the cicatrix takes place much more frequently when the cicatrix is extensive, such cicatrices being applied in great part to the inner wall of the tympanic cavity. In this instance the cicatrix, and frequently also the remnant of the membrana tympani, are adherent either only at a circumscribed spot, or over a greater extent of surface to the promontory and the articulation of the stapes with the incus.

But the adhesive changes are rarely confined to the region of the membrana tympani, for adhesions are met with simultaneously in

FIG. 159. — ADHERENT CICATRICES IN THE MEMBRANA TYMPANI BELOW THE HANDLE OF THE MALLEUS, WITH A REDDISH GREY BACKGROUND. FROM A GIRL, 10 YEARS OLD, WHO SUFFERED, WHEN FROM 1 TO 2 YEARS OLD, FROM OTORRHŒA, AS A SEQUEL TO MEASLES. HEARING-DISTANCE FOR THE WATCH = 2 CM.; FOR LOUD SPEECH = 1 M.

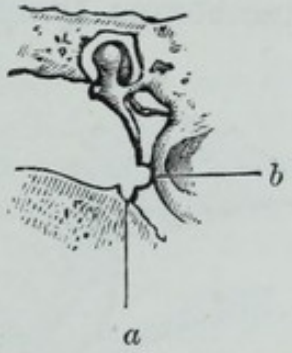

FIG. 160. — DIAGRAMMATIC SECTION THROUGH THE EXTERNAL MEATUS AND THE TYMPANIC CAVITY, SHOWING THE ADHESION OF A CICATRIX, SITUATED BELOW THE HANDLE OF THE MALLEUS, TO THE INNER WALL OF THE TYMPANIC CAVITY.

a, Membrana tympani; *b*, Cicatrix adhering to the promontory.

other portions of the middle ear, the most important of which are those in the upper part of the tympanic cavity, because the articulations of the malleus, incus, and stapes become fixed by them.

The adhesion of the portions in contact takes place generally during the stage of secretion, more rarely after the suppuration has ceased. Frequently obstinate cases of suppuration of the middle ear cease after adhesion of the cicatrix of the membrana tympani to the inner wall of the tympanic cavity; more frequently, however, the suppuration continues uninterruptedly, or ceases in some portions, which are closed by the adhesions, while it continues the more obstinately in other portions.

It would lead us too far to enter into a detailed description of the adhesive processes produced by suppuration of the middle ear, because, as the sections of Toynbee, v. Tröltsch, Schwartze, Moos, and myself have shown, their anatomical differences are so great, that hardly one appearance of the parts completely coincides with the other. Considering, however, the practical importance of the subject, we will here briefly describe the appearances

which are more frequently met with in the adhesive processes. The annexed illustrations will materially facilitate their comprehension.

Most frequently a cicatrix, extending over the posterior half of the membrana tympani, is found to be adherent to the posterior and inner wall of the tympanic cavity. This condition is illustrated by the annexed drawing (Fig. 161), a horizontal section through the external meatus and the tympanic cavity. We see behind the transverse section of the handle of the malleus (*a*), the position of the adhesion of the depressed cicatrix (*b*) to the posterior wall of the tympanic cavity, and further inwards the head of the stapes (*c*) united with the cicatrix, while the anterior half of the membrana tympani (*d*) is free from the inner wall of the

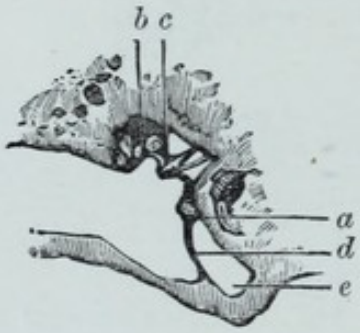

FIG. 161.

FIG. 162.

tympanic cavity. Such appearances, when examined by the speculum, are only distinguished from non-adherent cicatrices by the fact that the adherent portions do not change their position, either after air has been propelled into the middle ear, or during examination with Siegle's speculum, while the free portions of the membrana tympani exhibit great mobility. The boundary between the free and adherent portions is frequently marked by a white or grey line, where the motion of the non-adherent portion abruptly ceases.

In the vertical section through the meatus and the tympanic cavity (Fig. 162) there is represented the adhesion of a large cicatrix, extending over the inferior and lateral portions of the membrana tympani, to the inner wall of the tympanic cavity; (*a*) represents the crescent-shaped remnant of the membrana tympani, from which the cicatrix extends inwards at a sharp angle, its margin folding in upon the inner wall of the tympanic cavity (*c*) and uniting with it. Such a cicatrix connected with the margins of the perforation forms a cul-de-sac, by which the inferior and middle space of the tympanic cavity, which is in connection with the external meatus, is closed towards the Eustachian tube as well as towards the antrum mastoideum and the superior space of the tympanic cavity.

When inspecting the membrana tympani in such cases, the short process of the malleus and the posterior fold of the mem-

brane appear to be projecting, while the generally thickened handle of the malleus is inclined inwards so much that its inferior extremity is in contact with the inner wall of the tympanic cavity; on the whole, however it strongly projects above the level of the depressed cicatrix. The outlines of the inner wall of the tympanic cavity, the promontory, the niche of the fenestra rotunda and the articulation of the incus with the stapes are sometimes more and sometimes less clearly defined. The remnant of the membrane either merges into the cicatrix without any visible boundary line, or they form at their place of union a sharp bend from which in some places the cicatrix, extending to the inner wall of the tympanic cavity, can be plainly distinguished. The surface of the adherent cicatrix is either lustrous or moist and secreting.

The diagnosis of such adherent culs-de-sac may therefore frequently be made by simple inspection, but one must not omit to inspect the membrana tympani when air is being propelled into the middle ear, and to make an examination with Siegle's speculum in order to ascertain the boundaries of the movable and immovable portions and the extent of the adhesions. This is specially important in those cases of hearing-disturbance of a high degree, in which it is intended to separate the adhesions in order to bring about an improvement in the hearing.

The recognition of adhesions of the membrana tympani or of the tympanic cavity is in many cases facilitated, as I was the first to point out, by carefully probing the portions which are depressed. If those places which do not bulge out when air is propelled into the middle ear have a firm osseous base when felt with the probe, an immediate union of the cicatrix with the bone may be assumed as probable, if ocular inspection and testing with the pneumatic speculum lead to the same conclusion. The inflexibility of a hard place, when examined with the probe, must however not be taken by itself as a sign of adhesion, because greatly thickened and calcified portions of the membrana tympani will also be found to be as hard as bone.

Just as little may it be inferred from the flexibility of some portions of the membrane, that no adhesions exist between them and the inner wall of the tympanic cavity because the bridge of connective tissue which unites the membrane and the promontory is sometimes very broad and therefore yields on contact.

The diagnosis of adherent cicatrices forming culs-de-sac is rendered very difficult when the continuity of the remnant of the membrana tympani with the cicatrix is not apparent, and when in addition the cicatricial tissue extending in front of the ost. tymp. tubæ is ruptured so that the air can freely pass from the Eustachian tube into the external meatus. This causes the non-adherent portions to remain immovable when air enters the

tympanic cavity. As I have repeatedly observed, such openings are also to be found in the superior portions of the cul-de-sac, in front of or behind the handle of the malleus, so that an immediate communication is established between the external meatus and the superior space of the tympanic cavity.

Different from these cul-de-sac-like cicatrices are those adhesions in which adhesive cicatrization takes place only over a circumscribed portion of the remnant of the membrana tympani. Most frequently such partial cicatrices (Fig. 163), extend from the posterior margin of the perforation to the promontory and unite with its cicatricially changed mucous membrane, while the superior inferior margin of the perforation is free from the inner wall of the tympanic cavity. Again, in other cases the anterior margin of the perforation unites by means of cicatricial tissue with the inner wall of the tympanic cavity, without the posterior superior remnant of the membrana tympani coming in contact with the deeper parts.

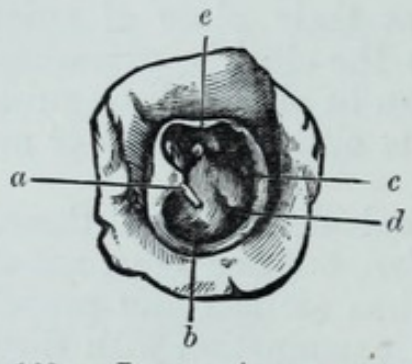

FIG. 163. — LARGE APERTURE IN THE LEFT MEMBRANA TYMPANI.

a, Bare handle of the malleus; *b*, Free sickle-shaped remnant of the membrana tympani; *c*, Adherent cicatrix, extending from the posterior remnant of the membrana tympani to the inner wall of the tympanic cavity; *d*, Free semicircular margin of the cicatrix; *e*, Capitulum of the adherent stapes; above it the wall of the meatus, partially decayed. (From a preparation in my collection.)

Of special interest are those partial cicatrices which extend from the anterior margin of the perforation to the inner wall of the tympanum, and form a partition between the ost. tymp. tubæ and the tympanic cavity. The diagnosis of such membranous septa can only be made with certainty if, as in Fig. 164, the deep-seated, darkish-grey cicatrix, sharply defined from the inner wall of the tympanic cavity, can be seen through the perforation bulging forward a little during the Valsalvian experiment, and showing a distinct movement during examination with Siegle's speculum. During catheterization the friction of the air over the cicatrix is so great, that on auscultation a distinct perforation-noise seems to be heard. But we may convince ourselves, by inserting a manometer hermetically into the meatus, that the air does not pass into the meatus, as the fluid is only slightly forced outwards on the injection of air, and not cast out, as in the case of ordinary perforations of the membrana tympani.

Frequently, however, such cicatrices, probably in consequence of the repeated impact of the air upon them while blowing the nose, are ruptured in one or more places, the air then escaping freely into the meatus. In a preparation in my collection (Fig. 165) the membrana tympani is seen to be totally destroyed,

with the exception of a narrow ledge-shaped remnant. In front of the ost. tymp. tubæ is stretched a membrane, concave towards the tympanic cavity, and perforated in three places, which is connected externally with the remnant of the membrana tympani, and internally somewhat indistinctly with the inner wall of the tympanic cavity. The handle of the malleus projects freely into the perforation, and behind it protrudes the capitulum of the stapes with the tendon of the stapedius; the long crus of the incus is destroyed.

When circumstances are favourable such perforated cicatrices can easily be diagnosticated if (Fig. 166), behind the anterior ledge-shaped remnant of the membrane in the anterior portion of the field of view, a black gap is visible, through which air or mucus-bubbles pass during the Valsalvian experiment.

We have so far only spoken of those extensive adhesions which

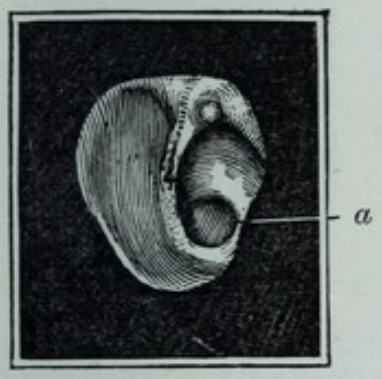

FIG. 164. — MEMBRANOUS SEPTUM BETWEEN TYMPANIC CAVITY AND EUSTACHIAN TUBE. FROM A WOMAN, 29 YEARS OF AGE, WHO SUFFERED SEVERAL YEARS AGO FROM SUPPURATION OF THE MIDDLE EAR. HEARING-DISTANCE: ACOUMETER = 5 CM.; SPEECH = 2½ M.

FIG. 165.

arise from the cicatrization of large perforations in the membrana tympani. But in the case of small perforations also extensive adhesions between the membrane and the inner wall of the tympanic cavity may take place, when, during the suppurative process, the proliferating mucous membrane of the internal surface of the membrana tympani comes into immediate contact with that of the inner wall of the tympanum. Then the membrane appears sodden, whitish-yellow, opaque, and drawn inwards, the posterior fold strongly projecting; or the membrane is flattened, rigid, and immovable, only slightly flexible when felt with the probe, and sometimes even the line of its separation from the meatus is obliterated. In other cases sharply defined, pit-like depressions (Fig. 167) are found, which have originated partly in retraction of the cicatricial tissue in some places, partly in partial atrophy of the substantia propria, or in cord-like thickenings on the surface of the cicatrized membrana tympani. By such cords the

handle of the malleus is drawn strongly backwards and inwards and sometimes so tightly united to the incus and stapes, that the vibrating power of the ossicula is thereby reduced to a minimum. The recognition of the formation of such cords is of great importance, for, as we will see later on, their division by operation is frequently followed by a striking improvement in the hearing.

It has already been mentioned, that after chronic suppurations of the middle ear have subsided, the promontory is covered by an irregular, tendinous-grey, partially lustrous cicatricial tissue in consequence of the shrivelling up of the proliferating mucous membrane, by which means the niches of the two labyrinthine fenestræ are filled up. In the case of extensive deficiency of the membrana tympani such a condition may easily be mistaken for a thickened or opaque membrane, if some projecting ledge-shaped

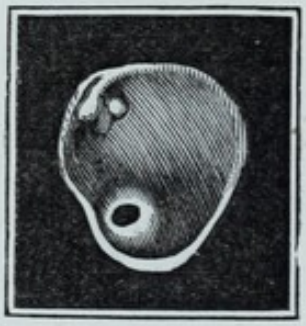

FIG. 166.—LARGE PERFORATION IN THE MEMBRANA TYMPANI; IN FRONT AND ABOVE THE SHORT PROCESS WITH THE STUMP OF THE MALLEUS; BEHIND IT THE CAPITULUM OF THE STAPES IS VISIBLE. THE CICATRIX, EXTENDING FROM THE ANTERIOR REMNANT OF THE MEMBRANA TYMPANI TO THE INNER WALL OF THE TYMPANIC CAVITY, IS PERFORATED. FROM A WOMAN, 48 YEARS OF AGE, WHO SUFFERED FOR 28 YEARS FROM DISCHARGE FROM THE EAR. SPEECH UNDERSTOOD ONLY WHEN SPOKEN DIRECTLY INTO THE EAR.

FIG. 167. — CICATRICIAL DEPRESSIONS AND CORD-SHAPED THICKENINGS ON THE MEMBRANA TYMPANI. FROM A YOUNG MAN, 19 YEARS OF AGE, WHO SUFFERED IN CHILDHOOD FROM OTORRHŒA. HEARING-DISTANCE FOR SPEECH = $\frac{2}{3}$ M.

remnants of the membrane, or the stump of the handle of the malleus projecting freely into the gap, do not indicate a cicatrix on the inner wall of the tympanic cavity.

By the adhesive processes above described, the middle ear is divided into several irregular spaces, which either communicate with each other, or are completely separate. Just as we have seen that the Eustachian tube may be closed against the tympanic cavity by a cicatrix, so the entrance into the antrum mastoideum may become obstructed by a membranous septum, and the communication between the tympanic cavity and the mastoid cells abolished (v. Tröltsch). The tympanic cavity itself also may be divided by pseudo-membranes, by adherent cicatrices of the membrana tympani, or by the direct formation from the remnant

of the membrane into several irregular spaces. In this way I found in a preparation (Fig. 169), that the tympanic cavity was divided into an anterior (*a*) and a posterior (*c*) half by a bridge of connective tissue, extending from the membrana tympani to the inner wall of the tympanic cavity, and which were connected with each other by the superior space of the tympanic cavity. In other cases, especially when this space was filled up with masses of connective tissue, these portions of the tympanum were completely separate.

If, however, any of these cavities are so completely closed that no air can enter them, they gradually collapse or they are filled up with thick, whitish epithelial masses mixed with cholestearin

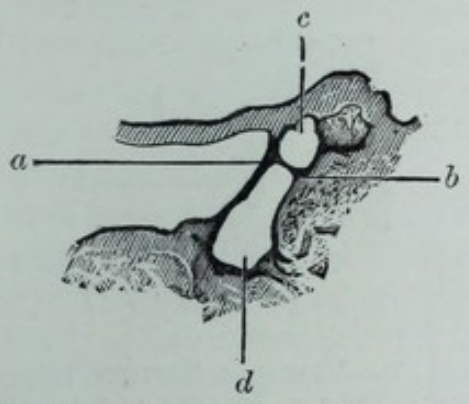

FIG. 168.—MEMBRANOUS BRIDGE FROM THE MEMBRANA TYMPANI (*a*) TO THE INNER WALL OF THE TYMPANIC CAVITY (*b*). HORIZONTAL SECTION THROUGH THE LEFT EAR OF A GIRL, WHO DIED OF GENERAL PARALYSIS, CAUSED BY A TUMOUR OF THE BRAIN, AND WHO PREVIOUSLY SUFFERED FROM SUPPURATION OF THE MIDDLE EAR.

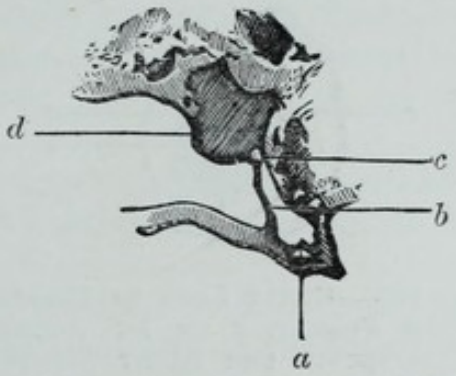

FIG. 169. — DIAGRAMMATIC SECTION THROUGH THE EXTERNAL MEATUS AND TYMPANIC CAVITY, TO SHOW THE DIVERTICULUM, CONTAINING A DEPOSIT OF EXUDATION IN THE POSTERIOR SPACE OF THE TYMPANIC CAVITY.

a, Anterior portion of the tympanic cavity; *b*, Membrana tympani; *c*, Adherent handle of the malleus; *d*, Posterior portion of the membrana tympani, bulged forward by exudation.

crystals, which, if they are deposited within the field of view, (most frequently in the region of Shrapnell's membrane) may be observed as whitish tumours, from which after incision those inspissated masses can be removed by means of the probe and the tympanic tube.

Equally interesting and important are those diverticula in the posterior superior portion of the tympanic cavity, which communicate only with a portion of the superior space of the tympanic cavity or with the cells of the mastoid process. In these, which are completely separated from the anterior portion of the tympanic cavity, either a discharge of a viscid brown fluid or a purulent inflammation takes place. In the first case, the portion of the membrana tympani situated behind the handle of the malleus is bulged forward without inflammatory symptoms in the form of a darkish-brown tumour; in the second case may be seen a red or greenish globular bulging, the formation of which was accompanied

by violent pains and from which pus will flow after incision. Such limited suppurations are exceedingly tedious, because the seat of the suppuration cannot be reached by the current of air entering into the anterior portion of the tympanic cavity.

Suppurations confined to the posterior superior portion of the tympanic cavity are equally obstinate. Here the secretion, generally crumbling, escapes into the external meatus through a small perforation in the posterior superior quadrant, but at the same time, through adhesion of the anterior remnant of the membrana tympani to the promontory, the anterior portion of the tympanic cavity is separated from the posterior secreting portion, in such a way that air propelled through the Eustachian tube

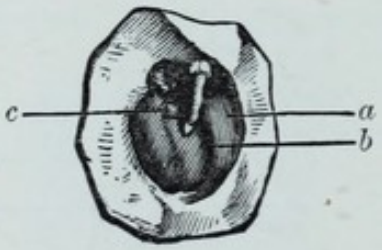

FIG. 170.—GREAT LOSS OF SUBSTANCE WITH FORMATION OF AN ADHERENT CICATRIX IN THE RIGHT MEMBRANA TYMPANI.

a, Anterior thickened remnant of the membrane; *b*, cicatrix, extending from the margin of the remnant of the membrane to the promontory; *c*, Capitulum of the stapes, covered by cicatricial tissue; above it a bridge, extending into the upper space of the tympanic cavity. (From a preparation in my collection.)

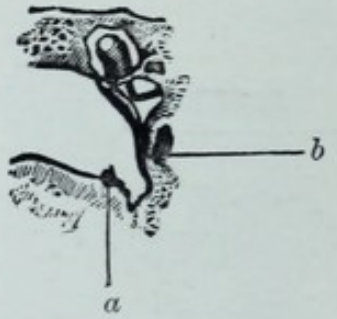

FIG. 171.—VERTICAL SECTION THROUGH THE EXTERNAL MEATUS AND THE TYMPANIC CAVITY.

a, Free ledge-shaped remnant of the membrana tympani; *b*, Place of adhesion of the margin of the perforation.

only enters into the anterior portions of the tympanum (Fig. 170). The same holds good of those cases in which, as in a preparation in my collection (Fig. 171), the inferior half of the membrana tympani is destroyed, and the inferior margin of the superior half of the membrane (*b*) is so adherent to the inner wall of the tympanic cavity that the superior space of the cavity is only in communication with the inferior portion by a small aperture above the stapes. The lower portion of the tympanum, communicating with the Eustachian tube, is dry, while in the upper space of the cavity, which is closed from the tube, a purulent inflammation exists.

As a matter of course, the capacity of the middle ear becomes narrowed and diminished by these adhesive changes. This occurs, however, not only in the region of the membrana tympani, but also frequently enough in the superior and lateral depressions of the tympanic cavity, which are more or less completely filled with masses of connective tissue produced by proliferation of the

mucous membrane, so that some portions of the tympanum are completely obliterated. Such masses, sometimes soft and moist, sometimes tough, are most commonly met with in the upper space of the tympanic cavity and in the mastoid process, the air spaces of which are closed by a reddish mass of connective tissue.

Much more rarely is the whole tympanic cavity filled everywhere with masses of connective tissue, which completely adhere to the cicatrized membrana tympani. Such complete obliteration of the tympanum as has been described by v. Tröltsch (*Virch. Arch.* vol. xvii.), and by me (*A. f. O.* vol. v.), is always accompanied by deafness of a high degree. It is only in exceptional cases that the obstructing growth of connective tissue extends so far into the Eustachian tube, that the latter is completely closed by it. Sometimes bands of connective tissue are found stretched out in front of the ost. tymp. tubæ, as has been described by v. Tröltsch and Magnus.

These new-formations of connective tissue, after they have existed for some time, may become ossified or calcified by a deposit of calcareous salts. (Compare Schwartze, *Path. Anatomie des Gehörorgans.*) In a case observed by me in which, after the subsidence of a chronic suppuration of the right ear deafness of high degree was developed, the post-mortem examination showed that the head of the malleus and the body of the incus were to a great extent enveloped in an osseous mass, firmly united with the upper and outer wall of the tympanic cavity, which no doubt had its origin in a proliferation of the mucous membrane. Still more frequently does the proliferation of connective tissue ossify in the cells of the mastoid process, which thus becomes transformed into a solid body in which either only very few air spaces or none at all are to be found (sclerosis of the mastoid process).

The presence of masses of connective tissue in the neighbourhood of the ossicula can only be inferred from the great deafness which they produce. A reliable diagnosis, however, can only be made after inspection of the lateral depressions in the tympanic cavity. But even in the case of large perforations this is generally impossible on account of the obstruction which the remnant of the membrana tympani and the handle of the malleus oppose to the introduction of instruments for illuminating the tympanic cavity. Only in those cases in which the remnant of the membrane is so far removed from the inner wall of the tympanic cavity that Blake's small tympanum-mirror can be introduced into that cavity, is it possible, by the aid of intense illumination, to see some parts of the superior and posterior regions of the tympanum. It requires, however, much practice to form a correct opinion as to what is seen. The great progress which has lately been made in the recognition of diseases in the cavities of the body, in consequence of Jos. Leiter's introduction of the

electric light, leads us to expect with certainty that this method may also be applied with advantage in otology, especially in regard to illuminating the lateral depressions in the tympanic cavity. The same arrangement of Leiter's apparatus which makes it possible to see distinctly the changes in the lateral regions of the bladder by the insertion of an optical instrument, would without doubt enable us in some cases to inspect minutely the upper space of the tympanum as far as the entrance into the mastoid cells, if it were modified in a suitable manner for the ear. Its importance in practice is apparent, for if we succeed in obtaining a distinct view of the illuminated portions, it would not be difficult to enter the upper space of the tympanic cavity with delicately constructed instruments, and to remove from thence many obstacles to the conduction of sound.

Although it will be seen, from the above, that in many cases the diagnosis of the adhesive processes is rendered possible by a number of characteristic indications seen on examination with the speculum, it must on the other hand be pointed out, that the anatomical changes within the field of view are frequently so complicated, that to understand what is seen is very difficult, or even quite impossible. This refers especially to those cases in which the secretion still continues and the outlines of the different structures have become obscured and indistinct in consequence of tumefaction of the inflamed parts. In this way it happens, that in case of adhesive processes even the most experienced specialist is frequently able to make a precise diagnosis only after observing the changes which occur in the course of the disease. The deviations from the normal state which present themselves to the eye are of such variety, that only by an exact knowledge of the anatomical relations and by many years' practice are we enabled to understand the details correctly, and to form, in difficult cases, an opinion from what we have observed. The formation of a correct diagnosis in the adhesive processes is, however, not only of theoretical, but also, as we shall see, of practical value, inasmuch as by means of an operation based upon the diagnosis, a striking improvement in the hearing may be effected, where previously all other methods of treatment remained without result.

To the above changes, produced by chronic suppuration of the middle ear, we will here add some rarer ones of interest as regards diagnosis.

Among these, in the first instance, are those forms of extensive defect in the membrana tympani in which, as will be observed in Fig. 172, a tongue-shaped remnant of the membrane extends to the promontory, and is adherent to it. During life I have seen such extended remnants in the shape of whitish or reddish bands bridging over the space between the periphery of the membrane and the inner wall of the tympanum. They are frequently the

cause of the obstinate continuance of the suppuration, which ceases only when such bands are divided.

The detachment of the handle of the malleus from the membrana tympani (Toynbee) is another less rare anomaly after subsidence of suppuration. This is produced by the inferior free extremity of the handle, which is inclined inwards, not uniting with the cicatrix during the process of cicatrization of the perforation in the membrane. More rarely a true detachment of the handle of the malleus from the membrane, softened by inflammation, is effected by traction of the tensor tympani muscle. In the preparation the inferior portion of the handle will either be found to protrude freely into the tympanic cavity, or, as in Fig. 173, a broad bridge of connective tissue or several thread-like bands connect the handle and the membrana tympani. The previous aperture is either cicatrized, or one or two perforations

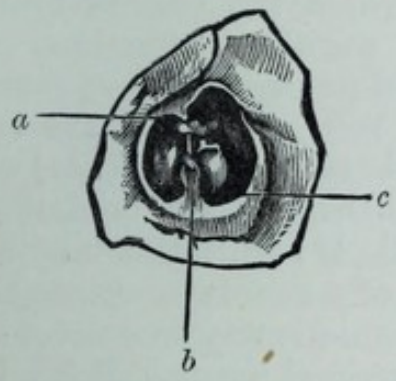

FIG. 172.—LARGE GAP IN THE MEMBRANA TYMPANI.

a, Short process of the malleus with the stump of the handle; *b*, Tongue-shaped remnant of the membrane; *c*, Fenestra rotunda. (From a preparation in my collection).

FIG. 173.—DETACHMENT OF THE HANDLE OF THE MALLEUS FROM THE MEMBRANA TYMPANI.

a, Membrana tympani; *b*, Inferior extremity of the handle of the malleus, detached from the membrana tympani.

(Schwartze) exist besides the detachment of the handle. I found in a preparation, analogous to a case described by Moos, the superior portion of the handle of the malleus with the short process detached from the membrane, while the inferior extremity was firmly united to the umbo. In a case observed by me, the detached handle did not project inwards, but into the lumen of the external meatus, while the cicatrized non-adherent membrana tympani lay to the inside of it.

The detachment of the inferior extremity of the handle of the malleus can in many cases be diagnosticated in life. For the bony yellow line can be observed which indicates the direction of the handle of the malleus, more or less sharply defined in the centre or immediately below the short process, and the umbo of the membrana tympani is seen to be greatly flattened. As, however, in consequence of thickening and opacity of the dermic layer, portions of the handle of the malleus may also be so thickened that on examination with the speculum it may be mistaken for a

detachment of the handle, this anomaly can only be diagnosticated with certainty when the flattened parts, corresponding with the site of the handle, prove flexible when felt with the probe. As the handle of the malleus transmits the waves of sound striking the membrana tympani to the ossicular chain, it is clear that the propagation of sound must be decreased by its partial detachment.

After the cessation of chronic suppuration of the middle ear complete detachment of the chorda tympani in the posterior portions of extensive gaps in the membrana tympani seldom occurs. Cases in which the chorda tympani is embedded in a thickened remnant of the membrane (Moos) or in a band which, corresponding with the site of the posterior pocket of v. Tröltsch, extends from the handle of the malleus backwards and divides the perforation into two gaps, are not unfrequent. But in literature I find no example of a case in which the chorda tympani had been detached by a preceding purulent affection, as in anatomical preparations by the chemical process. I have observed this in a boy, nine years of age, who suffered four years before from a purulent inflammation of the right middle ear, which subsided after it had lasted for six months, and left behind great deafness. On examination (Fig. 174), I found the membrana tympani destroyed, with the exception of a narrow remnant at the periphery; the inner wall of the tympanic cavity was covered by a tendinous-grey lustrous and dry cicatricial tissue. Behind the handle of the malleus, which was inclined inwards and united to the promontory by its inferior extremity, the detached chorda tympani extended backwards as a white, here and there lustrous thread. The site of this band left no doubt that it was formed by the chorda tympani. This assumption became a certainty when the patient stated that he perceived a stinging pain and a sour taste on the tip of his tongue when the band was touched.

FIG. 174.

We will now discuss the functional disturbances produced by cicatrices of the membrana tympani and by the adhesive processes.

In the case of non-adherent cicatrices sometimes almost normal hearing, sometimes deafness of a high degree, will be met with. This depends less on the size of the cicatrix than on the co-existing obstacles to the conduction of sound produced in the ossicular chain during the preceding inflammatory process.

Clinical observation, however, shows that in many cases the deafness must be ascribed to the alteration in tension of the sound-conducting apparatus, caused by the cicatrix. If the cicatrix is rather tense, the power of vibration of the membrana tympani is only slightly decreased by it. Not only do thin flaccid

cicatrices, however, produce irregular vibrations in the membrane but, what is still more important in consequence of the flaccidity of the cicatrix, the membrane and the whole ossicular chain are stretched inwards more tightly from the preponderance of the external air pressure, and the conduction of sound is thereby impaired. This will be observed in those cases in which, without any accumulation of secretion or swelling of the mucous membrane of the middle ear having taken place, a considerable improvement in the hearing results when, after propelling air into the middle ear, the cicatrix is stretched outwards, but in which the previous degree of hardness of hearing returns when the cicatrix sinks inwards again. I must, however, observe that I have met with almost normal hearing in cases in which large and loose cicatrices existed, which even during calm respiration were seen to move in and out.

Cicatrices which come in contact with the promontory and the articulation of the incus with the stapes, impede of course more or less the power of vibration of the ossicula. In such cases also a striking improvement in the hearing frequently takes place when the cicatrix is curved outwards by condensation of air in the middle ear. Sometimes, however, a decrease in the acuteness of hearing results after the cicatrix has been bulged out, which only disappears when it assumes its previous position. This applies chiefly to those cases in which the continuity of the ossicular chain has been interrupted by destruction of the long crus of the incus, in which, therefore, the transmission of sound to the labyrinth is effected by the immediate contact of the cicatrix with the stapes. It is clear that in such cases a decrease in the hearing-distance must take place when the cicatrix is lifted off the stapes.

The deafness produced by adhesive processes in the middle ear varies according to the extent of the obstacles to the conduction of sound which have been set up in the ossicular chain. If the adhesion is confined to the portion of the membrana tympani situated below the handle of the malleus, the acuteness of hearing, as I have repeatedly observed, may still be considerable. Adhesions in the upper half of the membrane, however, produce more frequently a considerable hearing-disturbance, especially when the handle of the malleus is drawn inwards by the adherent cicatrix so that it anchyloses with the promontory.

In the same way the adhesion of the cicatrized membrana tympani to the incus and stapes, as well as adhesions which unite the ossicula to each other, will produce deafness of different degrees according to the firmness and tightness of the new-formed ligaments. But when the articulation of the incus with the stapes has been destroyed by the purulent process, the adhesion of the membrana tympani or of the cicatrix to the stapes may be of advantage to the hearing, because in that

case the sound is immediately transferred from the cicatrix to the stapes. It has already been pointed out, that masses of connective tissue developed in the upper space of the tympanic cavity, and in the niches of the labyrinthine fenestræ by which the ossicula are immovably fixed, generally produce very great deafness.

Permanent Perforations in the Membrana Tympani.—A permanent perforation in the membrana tympani is not unfrequently the result of a chronic suppuration of the middle ear after the suppuration has ceased, the margins of the perforation becoming covered with epidermis. This chiefly takes place in the case of extensive losses of substance extending to the tendinous ring; but, frequently enough, small gaps are observed to remain permanently. According to Schwartze, calcification of the margin of the perforation is frequently the cause of its remaining permanently open. But apart from the fact that the margins of permanent perforations, as I have observed in several post-mortem examinations, do not always receive their intensely white colour from calcification, but also by accumulation of horny epithelial cells, it is proved, by the examination of patients, that perforations in the midst of completely calcified portions of the membrana tympani frequently cicatrize. Therefore the anatomical causes of the permanence of perforations are yet unknown to us. But a searching investigation in this direction would certainly be of great practical importance, as by such knowledge the problem of keeping an artificial perforation in the membrana tympani perfectly open might possibly be solved.

But it is not every perforation which remains open for some time after the suppuration has ceased that may be considered as permanent, because occasionally, although not frequently, cases are observed in which the perforation cicatrizes several years after the suppuration has ceased. In a case, described by me, in which the membrana tympani was destroyed, with the exception of a narrow fragment at the periphery, after a discharge from the right ear of seventeen years' duration (*W. m. W.* 1871), I found a year later the membrane reproduced, and only a small aperture of 3 mm. left below the handle of the malleus. I lately saw the same case again (1880), and found this small defect also quite closed, the membrane not being adherent to any of the parts below it. This is the most extensive reproduction of the membrana tympani which I have hitherto observed, after suppuration of the middle ear lasting for many years.

In the case of a permanent defect in the membrana tympani (so-called dry perforation), the membrane does not always retain a constant appearance. Large apertures are often after some time diminished to the size of a pin-hole; more frequently, however,

an enlargement of the perforation is observed, especially after repeated relapses of the suppuration, but sometimes also without any recurrence of the secretion. Not unfrequently the defect alters its position so completely, that after some time it shows itself in quite a different portion of the membrane. In a case in which a polypus of the tympanum proliferated through a perforation of the size of a pea, I found six months after the removal of the polypus the membrana tympani dry, a large calcareous deposit in the former site of the perforation, and in the posterior superior quadrant of the membrane a round, black aperture the size of a pin's head. At subsequent examinations with the speculum not unfrequently calcareous spots, atrophied depressions and adhesions are found, of which no traces were observed in previous examinations.

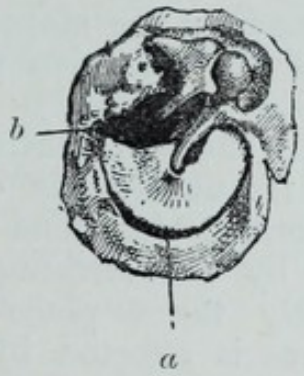

FIG. 175.—EXTENSIVE CALCIFICATION OF THE LEFT MEMBRANA TYMPANI, AFFECTING ALL ITS LAYERS.

a, The peripheral portion as well as a narrow strip in front of the handle of the malleus not calcified; *b*, Irregular defect in the posterior superior quadrant of the membrane. Membrana tympani and malleus rigid and immovable; continuity between incus and stapes destroyed; the latter, however, completely movable. (From a girl, 16 years of age, who died of pulmonary phthisis.) Similar changes also existed in the right ear. The patient could understand whispered speech in both ears from any part of a hospital ward 18 m. long.

Concerning the hearing-disturbances in cases of permanent perforation, numerous observations, made on patients by early authors, have already proved that a fairly good hearing-power may still exist, even in cases of extensive destruction of the membrane. Indeed, even when the malleus and the incus were destroyed and exfoliated, or when the malleus was completely fixed by an almost total calcification of the remnant of the membrane (Fig. 175), whispered speech could be still understood at a great distance, provided the foot-plate of the stapes was movable, and the membrane of the fenestra rotunda was not thickened. In these cases hearing is effected by the waves of sound falling immediately upon the movable foot-plate of the stapes. In the case of permanent perforations it may, therefore, always be inferred from the existence of a great hearing-distance, that the mobility of the stapes has not been impaired by the purulent process. But in the case of more considerable deafness, a material obstacle to the conduction of sound in the stapes or in the membrane of the fenestra rotunda must be assumed. The obstacles to the transmission of sound by the stapes are of various kinds. Most frequently it is tight, sclerotized, new-formed connective tissue at the niche of the fenestra ovalis which fixes the stapes. The latter may, however, also lose its

power of vibration without any adhesion to the surrounding parts, in consequence of the malleus and the incus being drawn inwards by adhesions, by which the stapes is forced inwards and fixed, owing to the pressure exerted upon it by the long crus of the incus. This is certainly a frequent cause of great deafness in cases of permanent perforation, and its detection is therefore important; because, by removal of the pressure which rests upon the stapes, a striking improvement in the hearing may be effected. This is brought about either by the employment of an artificial membrane (Knapp) which presses upon the short process of the malleus, so that the handle of the malleus and the long crus of the incus are moved outwards, or by separating the long crus from the stapes by operation (*vide* the operative treatment of the adhesive processes after the suppuration of the middle ear has ceased).

Besides the tight fixture of the ossicula, their want of tension is also frequently the cause of great deafness in the case of permanent perforations of the membrana tympani. This is proved by the striking improvement in the hearing which frequently takes place when contact between the relaxed structures is effected by the injection of a few drops of fluid into the tympanic cavity, or by the pressure of an artificial membrane upon the lower part of the handle of the malleus. And there is no doubt that in many cases also change of the pressure in the labyrinth exerts an influence upon the hearing, which remains after suppuration of the middle ear has ceased.

In the so-called dry perforations the hearing-power is not subject to those great fluctuations observed in the secretory stage. Sometimes, however, a striking increase in the hearing takes place quite suddenly, which generally disappears again after a short time. Hearing better in a noise (Paracousis Willisii) occurs more rarely after exhausted suppuration of the middle ear than in the adhesive processes, which run their course without perforation of the membrane.*

As a rule the deafness, after suppuration has ceased, does not exhibit that progressive character which is characteristic of the chronic adhesive processes, in which no suppuration takes place. Cases are not unfrequent in which, after suppuration has ceased, the deafness remains stationary for years, indeed even during a lifetime. Frequently enough, however, after suppuration has ceased, a progressive or fitful decrease in the hearing-power, ending even in total deafness, is observed, which is due partly to continually increasing rigidity of the new-formed connective

* I have lately proved by experiment the correctness of my statement on p. 202, regarding Paracousis Willisii. For I found in almost two-thirds of the cases in which hardness of hearing existed in consequence of chronic suppuration of the middle ear, that a more or less striking increase of the hearing-distance took place when a low-tuned (A below the bass clef) vibrating tuning-fork was placed upon the vertex.

tissue, and to anchylosis of the ossicula, and partly to secondary changes in the labyrinth, to which we will refer when discussing the diseases of the nervous apparatus.

Experience shows, that if one ear is affected by great deafness, the tendency of the normal ear also to become diseased is thereby increased. But in such cases purulent inflammation rarely takes place, the disease making its appearance usually in that chronic insidious form which, if the previously diseased ear has already become quite deaf, in a short time also destroys the function of the one secondarily affected.

Retained Secretion and Desquamative Products in the Middle Ear.—We have frequently spoken of inspissated secretion, which accumulates in the middle ear during purulent processes and after they have ceased. The recognition of such masses is of the greatest importance, because if they remain for a length of time in the middle ear, fatal caries and necrosis, or destruction of the temporal bone caused by ulceration from pressure, frequently occur, consequences which may be prevented by a timely removal of the masses. They appear sometimes as a cheesy exudation, sometimes as soft, greasy, dirty-grey masses, sometimes again as epithelial cholesteatomatous accumulations.

Obstruction to the escape of the secretion and its stagnation in the air spaces of the tympanic cavity and of the mastoid process must be considered as the most frequent cause of such accumulations. The retained pus either decomposes into a greasy substance or becomes inspissated and forms, together with the epithelial and other ingredients of the secretion, a friable mass similar to tubercular matter, which sometimes may remain long without damaging the surrounding tissues, but which frequently corrodes the mucous membrane and the osseous walls of the middle ear.

These offensively smelling cheesy or greasy masses, which consist of detritus, epithelial *débris*, a few pus-cells, fat-globules and micrococci, are most frequently met with in the mastoid cells, in the antrum mastoideum, and in the upper space of the tympanic cavity, at the post-mortem examination of cases in which, in consequence of caries and necrosis of the temporal bone, a fatal result has taken place owing to a cerebral affection or to a venous thrombosis. Although, doubtless, in many of these cases caries is produced by these corroding masses, still the possibility must not be lost sight of, that those dirty-grey, greasy products may partly be caused by the necrosis of the osseous tissue itself.

A frequent cause of compact accumulations in the middle ear is the excessive growth of epithelial cells on the diseased mucous membrane. Spontaneous discharge being prevented, and the epithelial layers adhering closely to their base, a stratification of the cells, and a formation of strong plates and tumours takes place, which fill up some portions of the middle ear or all its spaces.

Sometimes the epithelial cells surround a central nucleus of cheesy pus (v. Tröltsch).

The occurrence of such masses in the ear has been long known to pathological anatomists, as will be seen from the descriptions of Rokitansky (*Lehrbuch der path. Anat.*), and Virchow (*Arch.*, vol. viii.). For more exact knowledge of these pathological products, their behaviour in the temporal bone and their injurious action upon the vital organs, we are, however, indebted to the more recent works of Toynbee, v. Tröltsch, Schwartze, Moos, Lucae, Bezold, and Wendt. The name 'desquamative inflammation of the mucous membrane of the middle ear,' introduced by the latter, must not be considered to indicate a peculiar process, for in most cases we have only to deal with the consequences of a suppuration of the middle ear, *i.e.* with changes in the mucous membrane of the middle ear produced by the purulent process, which is accompanied by an excessive desquamation of epithelial cells.

According to Wendt, these changes of the mucous membrane consist in the epithelial layer assuming the character of the epidermis, the deepest layers of which exhibit the characteristics of the rete Malpighii. The changes in the rete mucosa are very various. In several cases examined by me, I found the mucous membrane sometimes cicatricially thickened, sometimes again so thinned that it almost seemed to have disappeared, and sometimes it was quite wanting. Several times I saw small, white, and smooth epithelial globules, of the size of a pin-head or pepper-corn, enclosed in the red, succulent mucous membrane of the upper space of the tympanic cavity. These may arise from the glandular depressions in the proliferating mucous membrane, which are lined with epithelium, becoming closed at the surface by pressure, and by their epithelial layer then continuing to proliferate in the enclosed space. It is probable that many large, sharply defined epithelial tumours in the temporal bone, called cholesteatomata, arise from such embedded masses.

The accumulation of desquamative products in the middle ear frequently takes place during the purulent process, but often only after suppuration has ceased. Regarding the formation of such masses in the suppurative stage, I have already pointed out (p. 406) that in many cases of suppuration of the middle ear some portions of the mucous membrane are denuded of their epithelial layer, while in other, sometimes small, sometimes extensive places, a proliferation and desquamation of epithelium takes place. During suppuration, therefore, either only very occasional epithelial flakes are found in the secretion, or even with the naked eye little lumps are seen, in size like grit or hemp-seed, which consist of pus and numerous large flattened epithelial plates.

This peculiarity of the secretion I have found rarely in profuse

suppuration, but more frequently in cases of chronic suppuration with little discharge, especially in individuals affected with scrofula or tubercle; in suppurations of the middle ear complicated with ozæna; in perforation of Shrapnell's membrane; and in those cases of adhesion between the cicatrized membrana tympani and the inner wall of the tympanic cavity, in which the secretion could escape only through a small opening in the posterior superior, or, more rarely, in the anterior superior quadrant of the membrane; and lastly, in cases of fistula in the osseous meatus.

If the desquamation is not excessive, and there is no great obstacle to the spontaneous discharge of the loosened epithelium, the process may go on for years without leading to an accumulation in the middle ear. But if the escape of the secretion becomes obstructed by proliferation of the mucous membrane in the middle ear, by adhesion of the membrana tympani to the inner wall of the tympanum, by the formation of loculi in the middle ear, by constrictions in the meatus, or by large polypi, then the epithelial masses become consolidated into larger lumps, or into whitish-yellow flakes, which gradually become embedded in the spaces of the mastoid process and of the tympanum, and, in isolated cases, even penetrate into the external meatus (Moos). There sometimes occurs a spontaneous expulsion of such masses through the external meatus, or much more rarely, through the Eustachian tube (Wendt), if fluid secretion gathered behind the accumulation pushes it out, or the mass expands from saturation.

The products of desquamation in the middle ear often appear as sharply defined tumours, consisting of a homogeneous mass, or of concentrically arranged lamellæ, sometimes covered with a shining, mother-of-pearl-like membrane (Toynbee's Molluscous tumours), and which, from their form and appearance, possess a great resemblance to cholesteatomata, yet can only in the rarest cases be considered as such, in the sense of morbid anatomists.

The size of these tumours varies from that of a hemp-seed to that of a walnut and upwards. Their shape is either round or quite irregular, corresponding to the concavities of the middle ear, and to the cavities in the temporal bone caused by the destruction and atrophy of the bone tissue. The surface is seldom regular, generally like that of a gland with tubercular and conical projections. On section these tumours sometimes present an iridescent appearance, and sometimes again the appearance of newly-curdled cream-cheese. Examined by the microscope, the masses are seen to consist of large round, or polygonal epithelial plates, often non-nucleated, between which, besides numerous granules and fat-globules, very often cholestearine crystals and bacteria, and more rarely nucleated giant cells (Lucae), are deposited. Beside and between the epithelial masses there are

sometimes found caseous exudations, or semi-fluid masses of detritus.

After suppuration is exhausted, in those cases in which the perforation is closed by cicatricial tissue, it rarely goes on to desquamation in the lining membrane of the middle ear. But even with persistent perforations, the mucous membrane often retains a moist lustre, or it is dry without any greater desquamation of epithelium ever taking place. In a number of cases, however, immediately on the cessation of suppuration desquamation begins, and sometimes goes on slowly, but sometimes so rapidly that often in a few weeks after the complete removal of the masses, the tympanic cavity is again filled with consolidated masses of epithelium. Sometimes a cessation of the desquamation of new strata takes place, so that the already formed stratified epithelial layers dry up into a hard, solid mass (Schwartze), which extends from the external meatus through the tympanic cavity into the mastoid cells, protects the mucous membrane from external sources of injury, and may be present during a whole lifetime without causing inconvenience.

Frequently, however, after long cessation, either a rapid accession of new strata may take place (Bezold), or behind the masses a suppurative inflammation may begin, which, as the escape of the pus is obstructed, produces the most violent inflammatory symptoms and consecutive caries, should the obstruction to the escape of the pus not have been removed, either spontaneously or by artificial means.

The destruction of the bone-tissue, when there are products of desquamation in the temporal bone, is sometimes no doubt caused by the retention of pus, but frequently by the accumulated masses themselves. In consequence of the continuous desquamation and of the formation of new lamellæ on the outer surface of the masses of epidermis, the size of these may gradually or suddenly so increase that the adjoining bone-tissue must yield to the destructive pressure (v. Tröltsch).

We therefore find at post-mortem examinations of cases in which cholesteatomatous products have accumulated in the ear, smaller or larger defects and excavations in the temporal bone, which are quite filled with these masses. The osseous atrophy sometimes reaches such a degree, as I have observed in several preparations, that by destruction of a great part of the petrous bone, the pars mastoidea, and the walls of the meatus, an enormous irregular cavity is formed in the temporal bone, which is surrounded by smooth, or in places rough, ridgy walls. Sometimes, as I saw in one case, there is a marked caries beside the portions which are worn away.

The products of desquamation may, without coincidence with caries, break through the surface of the temporal bone at various places. This happens most frequently with extensive accumula-

tions, but also with smaller masses we may find a perforation of the osseous walls towards the cranial cavity. The eruption of cholesteatomatous products occurs most favourably in those cases in which the posterior superior wall of the meatus towards the mastoid cells is worn away, and the masses discharge themselves into the external meatus (Bezold, Schwartze, Politzer), or in which the external shell of the mastoid process is destroyed from within, and the masses here find an outlet (Steinbrügge). On the other hand, the eruption of the masses at the posterior wall of the pyramid of the petrous bone (Bezold), at the tegmen tympani, at the roof of the antrum mastoideum, or towards the lateral sinus (Toynbee, v. Tröltsch, Schwartze), leads to a fatal issue from meningitis, cerebral abscess, and thrombosis of the sinus. I saw a highly interesting preparation of this kind in the collection of Professor Burkhardt-Merian, at Basle. Not only were the roof of the tympanum, the antrum mastoideum, and the sigmoid groove worn away by the masses accumulated in the antrum mastoideum, but the incisura mastoidea also was opened below, whereby an abscess nearly the size of the closed hand was produced in the lateral cervical region.

The bone cavities which are found in conjunction with an accumulation of cholesteatomatous masses in the temporal bone, do not wholly arise from destructive pressure. On the contrary, it is certain that such defects very often owe their origin to previous caries or necrosis, or to the gradual absorption of the bone-tissue by the suppurative process, and that on the termination of this process the cavity becomes clothed with cicatricial tissue, which, by the abundant desquamation of epithelium at its surface, causes the formation of masses of cholesteatomatous particles in the existing excavations. In the case of one of my patients, whom during many years I have repeatedly examined and treated, in consequence of caries and necrosis of the tympanum and mastoid process, a portion of the latter was exfoliated after the destruction of the posterior superior wall of the meatus. Hence arose, in the posterior portion of the temporal bone, a large irregular cavity filled with grey cicatricial tissue, capable of being examined through the large gap in the wall of the meatus. In this cavity there is now a continuous desquamation, so that on the removal of the accumulated masses the cavity is always, in the course of a few months, refilled with dirty yellow cohering epidermic masses. A great sense of oppression and pain in the side of the head affected disappear immediately upon the complete removal of the masses from the ear.

Clinical information regarding the products of the diseases here described is therapeutically of the greatest importance; for without taking into account the destructive nature of these products, the suppuration in the middle ear cannot be arrested by any kind of treatment whatever until those masses are removed from the

ear. Important evidence of the presence of caseous or cholesteatomatous masses in the middle ear is afforded by the frequent appearance in the water used for syringing of little gritty lumps, or of whitish-yellow shreds of considerable size, which when rubbed between the fingers emit an offensive smell, and, under the microscope, present the characters of caseous pus, or globular masses of epithelium. The diagnosis gains in probability if, the middle ear having been carefully cleansed for several days, these almost characteristic grains and lumps continue to reappear in the secretion. The occurrence of these in the early days of observation, however, by no means warrants the assumption of accumulations in the interior, for similar crumb-like masses are also found in the meatus and in the portions of the tympanum near the opening of the perforation, when the ear has not been cleansed for a considerable time. In such cases the harder particles in the secretion entirely disappear after the meatus has been washed out two or three times.

Objective information regarding the products of desquamation cannot be attained by ocular inspection, except when white or whitish-yellow shreds are lodged in the orifice of the perforation, the connection of which with the masses lying to the side of the tympanic cavity may be recognised by probing. In the case of small perforations or partial sacculations in the tympanum, the diagnosis of accumulation is supported by the presence of extensive or circumscribed bulgings forward of the membrana tympani. In cases of larger defects of the membrana tympani, a small piece of yellowish-white epidermis appearing from behind the edge of the perforation is often sufficient to direct attention to the accumulation of large masses in the superior or posterior spaces of the tympanum.

Such conditions very easily escape notice on superficial observation. Therefore, in chronic and obstinate cases, especially when associated therewith there is persistent sense of oppression and pains in the affected side of the head, one must always carefully observe whether masses of epidermis do not sometimes appear in the region of the field of vision, having forced a way for themselves from the interior. If the subjective head-symptoms become more prominent, or if frequent inflammations occur without known cause, then one must, if objective information as to the accumulation of masses in the interior fails, consider the possibility of such deposits, and have recourse to the operations necessary for their removal (*vide* Treatment). Sometimes infiltration and bulging of the lining membrane of the posterior superior wall of the meatus is caused by the retention of these products. But this—generally an unfavourable sign in regard to prognosis—is by no means characteristic of caseous exudations and masses of epidermis, since such bulgings take place also in cases of consecutive otitis externa, of caries of the walls of the meatus,

and suppurative undermining of the walls of the meatus. That masses of epidermis of considerable size may often exist in the middle ear for a very long time, without striking objective or subjective symptoms, has already been prominently brought forward.

The formation of crusts in the outer and middle ears should also be mentioned here. These arise from the drying up of the secretion not removed in cases of scanty exudation. The brownish-green crusts generally lodge in the inner section of the osseous meatus, and frequently extend over the remnant of the membrana tympani, through the opening of the perforation and into the tympanum. They often adhere so firmly to the subjacent tissue, that they can with difficulty be removed by a blunt probe. Sometimes the cure of the suppuration in the middle ear is quite prevented by the formation of a crust which adheres firmly for a long time. But often enough in cases in which the suppuration has long been believed to be arrested, it is found to be still going on beneath the crust. On the removal of the latter the underlying surface is seen covered with a layer of thick pus, and sometimes even studded with granulations of considerable size. This is in contradiction to the theory that suppuration is always arrested by the formation of crusts ; it is, on the contrary, probable that suppuration is frequently maintained by the mechanical irritation of the crust, and the formation of granulations favoured. Sometimes small perforations are blocked by a crust, as by a plug, and the closure of the gap is thereby hindered.

We sometimes observe small, dry, firmly-adherent crusts in the bases of depressed, adherent cicatrices of the membrana tympani. They are most frequent in the base of cicatrized perforations of Shrapnell's membrane, and next most common on cicatrices in the posterior superior quadrant of the membrana tympani, which have adhered to the articulation of the incus with the stapes, or to the head of the stapes separated from the incus. The diagnosis of a crust in this situation is therefore important, because, as I have several times observed, by the careful removal of quite small crusts from this region, a surprising improvement in the hearing is produced.

Prognosis.—The prognosis of chronic suppuration of the middle ear is generally uncertain, for as long as the suppurative process continues, we can never foretell with certainty what course it will take (Wilde). But the cause of the onset of the suppuration, the local changes present in the middle ear, and especially the state of the general health at the time, frequently offer important grounds for the determination of the prognosis. This applies not only to the possibility of the removal of the purulent secretion, but also to the improvement in the function of hearing to be obtained.

The prognosis of the suppurative processes is more favourable when the disease is idiopathic, and the individuals strong and healthy, than in the case of anæmic, debilitated persons, or when the disease has arisen in the course of scarlatina, typhus, scrofula, tubercle, syphilis, and other cachexiæ, or of suppurations of the middle ear accompanied by chronic blennorrhœa of the naso-pharynx and ozæna. A more favourable course may generally be expected in those cases in which the secretion is slight, or where there exists a possibility of the resolution of the morbid changes in the middle ear; also when the defects in the membrana tympani are not extensive, when the mucous membrane of the middle ear is smooth, not granular, and when the Eustachian tube is patent.

But a less favourable prognosis must be formed when there is a profuse blennorrhagic secretion, large perforations in the membrana tympani, perforation of Shrapnell's membrane (Bezold), excessive proliferation of the mucous membrane of the tympanum, or extensive formation of granulations on the same; also when there is polypoid degeneration of the membrana tympani, ulceration of the lining membrane and of the osseous walls of the middle ear, tight stricture of the Eustachian tube, desquamation, paresis and paralysis of the facial nerve, or those secondary changes in the external meatus, accompanied with bulging in the upper wall of the meatus, with which we shall become acquainted in the description of the carious processes.

The prognosis for the hearing is hardly determinable in the suppurative stage, for this is not always conditioned by permanent obstacles to the conduction of sound, but by simple swelling of the mucous membrane enveloping the ossicula, which may be almost entirely resolved on the cessation of suppuration. One is generally justified, however, in forming a more favourable prognosis in those cases in which the hearing-disturbance is not of a high degree, or in which, after the injection of air into the middle ear, and after the removal of the secretion, a striking improvement in the hearing takes place, than in those in which the greatly-impaired function only undergoes a slight improvement from the dilatation of the Eustachian tube, and in the course of treatment. Exfoliation of the ossicula, as well as tight stricture of the meatus tending to complete obliteration, render the prognosis still less favourable.

On the cessation of the otorrhœa the prognosis regarding the function of hearing is most favourable in those cases in which the orifice of the perforation cicatrizes, and only a slight disturbance of the hearing remains. But it is unfavourable if after the closure of the perforation a striking decrease in the hearing takes place, for this signifies a more serious obstacle to the conduction of sound at the malleus or incus.

In cases of persistent perforation of the membrana tympani

the prognosis is more favourable when, in spite of the long continuance of the affection, the hearing-distance remains stationary; unfavourable if after the cessation of suppuration great deafness remains, and no change is experienced either from the dilatation of the Eustachian tube or the application of an artificial membrana tympani. And the prognosis is bad when the hearing-disturbance continues progressive, and when it is associated with continual subjective noises, and a diminution of the perception of sound through the cranial bones for the acoumeter and the tuning-fork. Moos especially considers the disappearance of perception for the high tones of the tuning-fork through the cranial bones an unfavourable symptom.

Treatment.—The treatment of chronic suppurative inflammation of the middle ear is in the first place determined by the local changes in the mucous membrane of the middle ear, in the remnant of the membrana tympani, and in the external meatus. It is essentially different in those forms in which the suppuration is associated with a simple infiltration and tumefaction of the mucous membrane, from that employed in forms in which granulations and polypoid proliferations in the tympanum and on the remnant of the membrana tympani have already been developed, or in which a copious desquamation is going on in the mucous membrane of the middle ear, and inspissated masses are lodged in the middle ear. The method of treatment frequently undergoes various modifications according to the quality and quantity of the secretion, the place and size of the perforation in the membrana tympani, the secondary changes in the external meatus, and, which must be particularly insisted on, the state of the general health at the time, as will be seen from the following account of the treatment of chronic suppuration of the middle ear in its different stages and conditions.

Local Treatment of Chronic Suppuration of the Middle Ear.

a. Removal of the Secretion from the Middle Ear.

The first duty in the local treatment of chronic suppuration of the middle ear consists in the removal of the inflammatory infiltration of the mucous membrane, and in the arrest of the muco-purulent secretion. One of the most important conditions for the cure of chronic otorrhœa is the thorough cleansing of the middle ear from the masses of secretion, because, on account of its irregular pitted structure, these masses easily become stationary, and by their putrefaction keep up the suppuration, and may easily produce ulceration of the mucous membrane and of the bone. The removal of the secretion is urgently required for this reason also, that it forms precipitates with the medicinal applications employed, thus preventing their curative action on the diseased membrane.

1. *Injection of Air into the Middle Ear.*—The treatment by which cleansing the middle ear from the secretion is most surely effected has already been described in detail in the treatment of acute suppurative inflammation of the middle ear (p. 400), and to avoid repetition we must refer the reader to that section. It is here only necessary, regarding chronic forms, to insist upon the fact that even in cases of large orifices in the membrana tympani, syringing the meatus alone is not enough to remove the pus from the tympanic cavity, but that the pus must first be forced into the external meatus, by means of a stream of air injected through the Eustachian tube. Likewise it must be emphasized that here also, for the reasons already given, Valsalva's experiment is not of much use for the injection of air into the middle ear, but that in the great majority of cases my method is to be recommended, and that catheterism is only employed in those exceptional cases in which from great resistance in the middle ear the introduction of air by my method does not succeed (*vide* p. 400).

The efficacy of the stream of air through the catheter is materially enhanced, as I first showed, and as one can convince one's self by auscultation, if during the injection air is also slowly inhaled through the constricted mouth or through an india-rubber tube held between the lips, by which the velum palati is raised, and the Eustachian tube dilated.

By the injection of air the secretion is, however, by no means completely removed from the middle ear. It is most thoroughly cleared out of the Eustachian tube and the anterior portion of the tympanic cavity, whilst the pus lodging in the posterior portions of the cavity and in the mastoid cells is less affected by the stream of air. Its effect upon the contents of the middle ear varies greatly, not only according to the pressure, but also to the size and position of the perforation. When there are large orifices in the membrana tympani, through which the air can readily escape, the secretion is not so easily forced out of the posterior parts as when the openings are of moderate size (1-2 mm.), and the air, streaming into the external meatus, finds a moderate resistance, whereby the effective pressure on the contents of the tympanum is increased. But very small openings offer a great resistance to the entrance of air and secretion into the meatus.

In reference to the position of the perforation, it must be stated that the secretion is more thoroughly blown out of the tympanum in the case of perforations in the posterior superior parts of the membrana tympani than in the case of those in the anterior inferior quadrant. The proposal to form in the latter cases a second artificial opening behind the handle of the malleus has not proved practicable, for besides the fact that the effect of the stream of air upon the posterior portion of the

middle ear is not increased thereby, the opening, moreover, closes up again in a few days.

It is more to the purpose, when the effect of the air introduced through the tube proves insufficient, to cause a stream of air to operate for a time on the middle ear through the opening of the perforation. I use for this purpose, especially when the perforations are large, a smooth india-rubber tube (Fig. 177), rounded at its anterior end, joined to an air-balloon, and pushed forward close to the opening of the perforation. By the stream of air penetrating into the tympanic cavity, large quantities of secretion are often driven into the external meatus, and the cavity is cleared. In order to act more powerfully on the posterior superior portion of the middle ear, I introduce a short (5-6 cm.) flexible tube into the opening of the perforation, and, with the point directed upwards and backwards, blow air into the tympanum, whereby the fluid secretion is driven out of the antrum mastoideum even. In the case of fluid secretion, I have lately been applying this treatment more frequently than the syringings with the same instrument formerly recommended, but which I now use chiefly for the removal of tough, inspissated secretions.

Lucae lately invented a method for clearing the Eustachian tube, which consists in forcing air out of the meatus into the tympanic cavity by means of the small balloon used for rarefying the air in the external meatus, described at p. 300, whereby the secretion is driven out through the Eustachian tube into the pharynx. The air coming from the pharyngeal orifice of the tube escapes then with a distinctly audible whistling or rattling sound. The practical use of this method is, however, very slight. For besides the fact that only the secretion lodging in the anterior portions of the tympanum is removed by condensation of air from the external meatus, this method is found to be much less efficient for the improvement of hearing in most cases than the introduction of air through the Eustachian tube. The evil effects of this treatment are severe vertigo, tinnitus aurium, and a sense of stupefaction, which sometimes last a considerable time and are most speedily removed by the introduction of air by my method. These symptoms are specially intense when the Eustachian tube is constricted by great tumefaction of its mucous membrane, because then the air compressed in the middle ear exercises undue pressure on the fenestræ of the labyrinth. Nevertheless, I have succeeded, in several cases in which air could not be forced into the tympanum by my method, in restoring the free passage of the Eustachian tube by condensation of air in the external meatus, with a consequent remarkable increase in the hearing-power. After several applications of this treatment the introduction of air by my method can almost always be carried out without impediment.

2. *Syringing the Meatus.*—This manipulation has already

been described in the part treating of acute suppuration of the middle ear. It remains still to add a few cautions which must be observed in cases of chronic otorrhœa. First, it must be remembered that the jet of water penetrates to the tympanic cavity the more powerfully the larger the opening of the perforation, although the amount of pressure be the same. When the resistance in the Eustachian tube is slight the fluid injected easily penetrates into the pharyngeal space, and flows away either through the nostrils or into the pharynx. To prevent the latter the head should be well inclined forward during syringing (Burkhardt-Merian). When the Eustachian tube is not patent, however, the suddenly increased pressure on the fenestræ of the labyrinth may cause such severe vertigo that the patient loses consciousness. The first injections should therefore be made with caution, and only with slight pressure, in order to become acquainted with their effect in the individual case. Sometimes with very weak injections such severe vertigo is caused that they have to be given up, and the treatment confined to dry cleansing. In cases in which this must be left to the patient the 'cotton-holder,' (Fig. 176) invented by Burkhardt-Merian, is of most service, the anterior flat spatulate extremity of which has longitudinal ridges on both sides. By laying a flattened piece of lint or boracic wadding on the ridged surface, and turning the instrument round several times, a projecting oblong roll shaped like a pencil in front is formed, which, by means of the 'cotton-holder,' is pushed into the meatus, and close up to the membrana tympani. When the instrument is repeatedly rotated the secretion becomes absorbed by the wadding, which, when removed from the ear, can easily be taken off.

FIG. 176.

The number of times the ear is to be syringed in the twenty-four hours is determined by the amount of secretion. The meatus should be syringed three or four times in profuse otorrhœa, but when the secretion is moderate, once or twice is sufficient.

With regard to the fluid used for syringing, it is to be noted that here, as in acute suppuration of the middle ear, injections of warm water, without medication, often act injuriously (*vide* p. 399). The addition of carbonate of soda, according to my experience, oftener increases than diminishes the suppuration. Burkhardt-Merian recommends as the best a 5 per cent. solution of Glauber's salt, which does not irritate the mucous membrane, and holds the albumen of the sero-pus in solution. I generally use a solution of pulverized boracic acid, recommended by Bezold, of which as much as will cover the point of a knife is dissolved

in about 0·2 litre of warm water. If the exudation has a bad smell, which in spite of the boracic injections does not disappear in a few days, then a tea-spoonful of a 10 per cent. alcoholic solution of salicylic acid (Burkhardt-Merian), or a tea-spoonful of a solution of permanganate of potash (10·0 in 200·0), may be added to the cleansing-water. When the bad smell obstinately continues, especially in desquamative forms, and carious processes with a markedly offensive exudation, these agents are usually inefficient, and disinfectant injections of solutions of carbolic acid (2-3 per cent.) must then be energetically resorted to, for which purpose the 50 per cent. carbolic spirit is suitable, according to Burkhardt-Merian, a tea-spoonful of the spirit being put in 100-150 grammes of water. In profuse blennorrhœa, which makes applications from the external meatus impossible, I use a solution of 4-5 drops of oil of turpentine (not spirit of turpentine), in 0·2 litre of warm water, with which I syringe twice or thrice in the day. By the exclusive use of this injection I have observed, in very obstinate forms of blennorrhœa, a speedy diminution and cessation of the exudation. Syringing with tea, still recommended by some physicians, has been proved useless, and in many cases even injurious.

The fluid remaining in the inner parts after syringing must—for the exact examination of the parts, or when medicinal substances are to be applied, or cauterization resorted to—be removed by a pencil of Bruns' wadding, introduced into the meatus, with the head inclined to the side. If this is not sufficient, then the fluid or secretion must be removed by a small ball of wadding held in the bent forceps (p. 96), or by Burkhardt-Merian's cotton-holder, the ear being illuminated by the speculum.

.3 *Removal of Inspissated Masses from the Middle Ear.*—By simple syringing of the meatus, purulent or muco-purulent secretion is cleared out with a gentle pressure of the syringe. But tough mucous-plugs, and especially inspissated crumbly secretions, such as are often found accumulated in the interior in cases of neglected otorrhœa with slight exudation, often cling so firmly to the underlying tissue that they are but rarely washed out even by powerful injections. It is therefore necessary to soften the masses beforehand by pouring in warm water (v. Tröltsch) or a solution of soda, or, according to Burkhardt-Merian, by means of a carbolic spray (2 per cent. mixed with a little glycerine), and besides this to loosen it with the blunt probe. But even by this manipulation crumbly secretions, or those dried up to crusts, are not always entirely removed from the deep portions of the meatus. For this purpose straight or curved syringe nozzles were made of ivory and vulcanite, which, during syringing, are pushed forward into the deep parts of the meatus. This operation, however, especially if it is not carried

out by an experienced hand, may easily cause an injury to the meatus. The addition of an india-rubber tube to the syringe is better, yet the diseased parts may easily be irritated by its sharp edges.

For the removal of inspissated masses from the meatus, I have for some time used an india-rubber tube (Fig. 177), 5-8 cm. long, and 4 mm. wide, smooth, thin, and somewhat rounded at its anterior orifice, the other extremity, which is funnel-shaped, being fixed on the syringe. When the syringe is filled it is pushed with the tube 2 cm. deep into the external meatus. By this method of syringing, secretions lodging near the opening for the discharge are loosened, and washed out by the whirling motion of the fluid. The effect of such injections, however, is not confined to the external meatus, but often extends to the tympanum, from which also inspissated masses are washed away, especially when the perforations are large. The manipulation is so simple, that in cases in which there is a disposition to the formation of such masses, the performance of this kind of injection may be entrusted to the patient, particularly as, on account of the softness of the tube, there is no possibility of injury.

The use of this soft instrument is, however, only possible when the lumen of the meatus is wide enough to admit of the point of the india-rubber tube being inserted without resistance. But in those cases in which the meatus is constricted by infiltration and tumefaction of its lining membrane, or by polypoid proliferations, granulations, and exostoses, it is better to push an elastic tympanic-tube, 5-6 cm. long, such as I use instead of the former longer ones (p. 140), carefully through the constricted parts, till its point meets with a slight resistance, and thereupon to commence the injection. By this means the masses lodging behind the stricture, or hemmed in between the proliferations, are most surely driven out. It is understood that at the same time the necessary operations for dilating the meatus must be performed (*vide* 'Treatment of the Constrictions of the External Meatus'). It is much more difficult to remove retained secretion and masses of epidermis accumulated in the upper portion of the tympanum and in the antrum mastoideum, especially as the latter, as already mentioned, very often form conglobated flakes or lumps. In this case it is hardly ever possible, even with the strongest injections into the external meatus, to loosen the small particles of the mass, and therefore the spray of water must be directed immediately against the mass by the insertion of a specially constructed tube into the tympanum. Syringing is the more certain to succeed if the secretions have first been loosened by softening instillations (carbonate of soda 0·5, aq. dest. 6·0, glycerine 4·0, 10-15 drops), or by a weak carbolic and glycerine spray. The latter is especially suitable if a too rapid distension of the masses of epidermis is caused by solutions poured in, whereby

very violent inflammatory symptoms are occasioned, combined with severe swelling and constriction of the meatus.

Washing out the tympanic cavity is effected from the external meatus or from the Eustachian tube. We choose the former method when the meatus is not constricted, and the introduction of the tube through the opening of the perforation can be closely watched with the eye. One often succeeds by pushing the short, elastic tympanic tube, which is slightly bent at its anterior extremity, through the gap in the membrane, so far into the tympanum that the injected fluid penetrates to the caseous masses, crumbling and washing them out, or else the masses of epidermis are rapidly distended, and so forced into the external meatus. If the tympanic tube proves insufficient, then the use of Toynbee's conical metal tube, slightly bent at the point, which was designed for washing out the antrum mastoideum, is to be recommended, or the silver cannula invented by Hartmann (Fig. 178), which is fitted with an india-rubber tube 20-25 cm. long, for the purpose of being united to the nozzle of a syringe. The manipulation is as follows: sufficient light being thrown on the field of view, the point of the instrument is pushed carefully into the opening of the perforation, and the end is turned down towards the inferior wall of the meatus. By this means the cannula, its point being bent accordingly, is so fixed in its position that it does not easily slip out of the opening of perforation during syringing. By gently turning the india-rubber tube round its long axis during the syringing the orifice of the cannula is directed in turn against the superior portion of the tympanic cavity and the antrum mastoideum.

Fig. 177.

As metallic cannulæ, even when carefully inserted, often cause pain, I have lately been using vulcanite cannulæ of the same form and size, which are much more easily borne, and yet are sufficiently stiff not to be forced out of the opening of the perforation during the injection. The lumen of these cannulæ admits of the insertion of a thin, elastic tympanic tube, the use of which is recommended in cases in which the secretion cannot be removed by Hartmann's cannula alone. Because the orifice of the cannula when introduced into the tympanic cavity can be directed with precision backwards and upwards towards the entrance to the mastoid process, it is possible to make the point of the tympanic tube penetrate to the immediate neighbourhood of the antrum mastoideum, and by injections to force masses of

secretion out of the middle ear, where all former attempts to accomplish this had proved fruitless.

The use of the tympanic tube and Hartmann's cannula is to be recommended also, especially in cases of perforation of Shrapnell's membrane, for clearing out the suppurating cavity between the malleus and the outer wall of the tympanum and for the removal of inspissated masses of epidermis from this space. The use of this tube is likewise advisable in those cases of obstinate suppuration in which the membrana tympani has become adherent to the inner wall of the tympanum, and there is an opening in the posterior superior quadrant of the membrane, from which a crumbly secretion escapes. In the last-named cases this is often the only kind of treatment by which a cure can be effected.

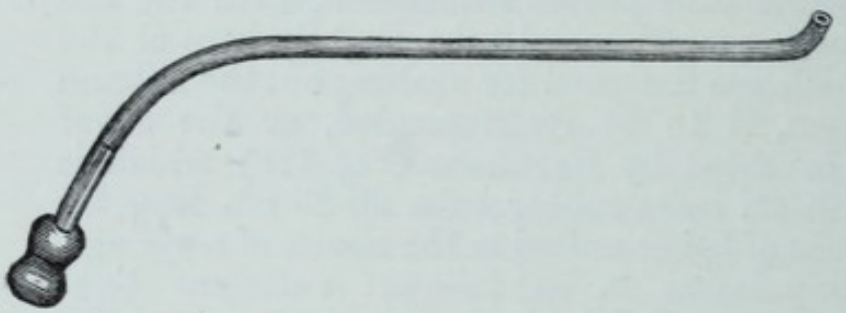

FIG. 178.—HARTMANN'S CANNULA.

The result is, however, seldom speedy, for the period of treatment extends in most cases over weeks or months.

When there are layers of epithelial scales adherent to each other it is necessary to make use of the blunt probe in order to loosen them speedily. If we succeed in bringing a piece of the mass so far within the range of vision that it can be grasped by the forceps, then coherent laminæ of surprising size are sometimes extracted from the interior along with it. But if there is a break in the compact mass the remainder is the more surely and quickly washed out by subsequent injections. In the case of small perforations, which render the insertion of the cannula and the exit of the mass difficult, it is well to enlarge the opening with a small knife or with the paracentesis needle.

The second method—washing out the tympanic cavity through the Eustachian tube—is resorted to in those cases in which, on account of stricture of the meatus, the above manipulations are impracticable. In the description of the details of this treatment it was (p. 139) stated that for injections through the Eustachian tube a catheter with a highly curved beak is used, and that in cases of considerable resistance in the middle ear and in the external meatus the injection must be performed by means of a tympanic tube pushed through the catheter into the tympanum.

In injections through the Eustachian tube the fluid often

flows freely, but frequently only by drops, into the meatus. It sometimes even happens that, in spite of the fluid being proved by auscultation to have penetrated into the middle ear, not a single drop reaches the meatus. The greater part runs off through the nostrils. To prevent its flowing into the inferior pharyngeal space the patient is made to breathe exclusively through the mouth during the injection.

Although in many cases inspissated masses are completely softened and forced into the meatus by injections per tubam, yet it is sometimes found that in syringing through the catheter the fluid runs almost entirely away without taking with it a particle from the interior, whilst in the same case, by the introduction of a tube from the meatus into the opening of the perforation, large quantities of hard masses are washed away. This happens particularly when the secretions are lodged in the posterior spaces of the tympanum, its anterior portion being empty, or when particular parts are so sacculated by adhesive formations that they do not communicate at all with the Eustachian tube (*vide* p. 442).

Direct injections into the tympanic cavity from the external meatus, as well as through the Eustachian tube, often cause severe giddiness and a sense of stupefaction, in consequence of the suddenly increased pressure on the fenestræ of the labyrinth. Sometimes violent pain in the ear occurs, especially when the injected fluid does not flow off through the external meatus, but penetrates to the mass, and by quickly forcing it asunder produces a sudden pressure on the walls of the tympanum. When, therefore, during syringing vertigo or pain commences, the injection must either be entirely suspended, or continued with less force.

The effect of syringing inspissated masses out of the middle ear is often astounding, for directly after their removal not only do the very violent pain in the ear and the severe oppression and headache in the affected side begin to abate, but, as I have repeatedly observed, ominous symptoms, such as vomiting, giddiness, and stupefaction, rigors and facial paresis, are speedily removed.*

b. The Local Use of Medicated Substances for the Removal of Suppuration of the Middle Ear.

A recent important advance in the therapeutics of chronic suppuration of the middle ear has to be recorded. Whilst the unsatisfactory treatment by simple syringing and subsequent instillation of astringent solutions into the meatus formerly in use was generally extremely tedious, and very often entirely without result, by the methods now in use not only is the term of treat-

* Compare my essay *Ueber die Andwendung des Paukenröhrchens*, *W. m. W.*, 1875, Nos. 15, 16.

ment substantially shortened, but the suppurative process also is arrested in a far greater number of cases than before.

Although suppuration of the middle ear is not unfrequently cured by the injection of air into the tympanum, and by careful syringing of the ear, without further medication, yet experience shows that in many cases it is only by the use of medicinal agents that the infiltration of the mucous membrane can be resolved, and the arrest of the suppuration accomplished.

The medicinal agents used are applied to the mucous membrane of the middle ear in the form of solutions or as powders. Solutions must always be dropped in slightly warmed, for when cold or not warmed they often produce pain and fits of giddiness. When the perforation of the membrana tympani is large the fluid will penetrate by its own weight into the tympanum, and wash the mucous membrane very thoroughly; but when the perforation is small, so that little or none of the solution reaches the middle ear, it is necessary to force the fluid into the tympanum, which is most simply done by pressing the tragus backwards and inwards over the external orifice of the ear, and a part of the fluid frequently runs off through the Eustachian tube into the pharynx.

If the anterior half of the membrane is perforated, then by this process only the anterior portion of the tympanum and the Eustachian tube are washed. Therefore in order to make the remedy act also upon the posterior portions of the middle ear, the head must, during the compression, be bent not only to the side, but also somewhat backwards. But the inclination of the head backwards must be avoided when caustic solutions are being used, for from the penetration of the corrosive fluid into the mastoid cells violent inflammation in the mastoid process may result. Besides, we shall see that for the removal of the suppuration it is by no means necessary that the whole of the mucous membrane of the middle ear should be acted on by the remedy.

The compression of the fluid in the external meatus sometimes occasions severe vertigo. In such cases it is more advisable to inject air by my method, the head being bent to the side and the external meatus filled, by which means the air-bubbles escape through the meatus, whilst the fluid penetrates in their place into the tympanum.

By the use of this last method the tympanic cavity is often thoroughly cleansed by the solution without the latter flowing away through the Eustachian tube so frequently as it would if the fluid were compressed in the external meatus. The injection of the remedy by means of the catheter, formerly much used, is now only resorted to in exceptional cases.

In the use of medicinal agents in a pulverized form we must be particularly careful that they are brought into direct contact

with the diseased parts. This is done most surely by blowing the powder in towards the deeper parts of the meatus. For this purpose Störk's laryngeal insufflator is used, or the insufflator (Fig. 179) made from my design by Leiter of Vienna, or a glass cannula, rounded in front, furnished with a short india-rubber tube or a quill, with which the patient may himself perform the insufflation.

No decided opinion can at present be given concerning the mode of operation of medicinal agents. We know only this much, that by many drugs, especially by alcohol and pulverized substances, water is withdrawn from the diseased tissues; that other remedies, by their caustic operation, produce a strong re-

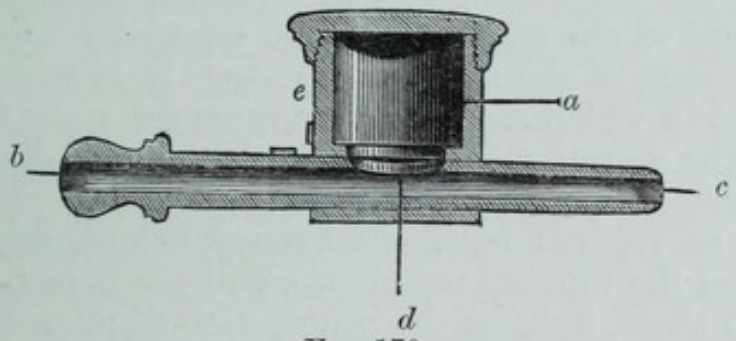

FIG. 179.

a, Powder chamber; *b*, *c*, Tube; *d*. Corresponding openings in the tube and powder chamber; *e*, Boundaries by which chamber and tube communicate. By a half turn of the tube the openings are closed, and the powder which has penetrated is blown into the meatus by an air-balloon fixed on the outer end.

action and a rapid change in the circulation and nutrition of the mucous membrane; and that further, by the chemical and mechanical irritation which many medicinal agents produce, the degeneration and absorption of the round cells infiltrated in the tissue take place. The old popular idea that astringents act by contracting the vessels has been refuted by the researches of Prosoroff (comp. Bezold, *l.c.*). On the other hand, there is no doubt that antiseptics, having properties which prevent putrefaction and decomposition, exercise a favourable influence on the course of suppurative processes in the middle ear.

The curative effect of medicinal agents is not always dependent on their immediate and general contact with the diseased parts. On the contrary, it is shown by experience that often enough, even when the application of a remedy is circumscribed, its operation extends by contiguity to the parts not touched by it. And I have already shown that in the case of small perforations, through which hardly a trace of the medicinal agent can penetrate to the tympanic cavity, the suppuration in the middle ear is nevertheless arrested, if the attempt to remove the secretion to the outer surface of the membrana tympani is successful. In the same way we very frequently observe in the case of large defects of the membrana tympani, when the greatly swollen or granular mucous membrane on the inner wall of the tympanic cavity lies exposed,

a complete resolution of the suppurative processes over the whole mucous membrane of the middle ear, when the remedy is applied only to circumscribed parts of the promontory, or when limited cauterization is used.

We have now to describe the different medications recommended in cases of chronic suppuration of the middle ear.

1. *The Antiseptic Treatment*, an acquisition of recent date, takes the first rank in the methods of treatment hitherto practised in cases of suppuration of the middle ear. According to the general results gained by experience of antiseptic treatment in surgery, there are very important indications, even on anatomical grounds, for its use in suppurations of the middle ear. We have already stated that the stagnation of the secretion is favoured by the irregular form of the tympanum, and especially by the complex cellular structure of the mastoid process. It is now known that in all cavities in which secretions stagnate for some time, decomposition of the secretion is begun by a general development of micro-organisms, especially when air is admitted. The secretion is changed as regards both consistency, colour, and smell, acts corrosively on the mucous membrane and the bones, and by long contact with these, induces the penetration of micrococci into the living tissue. From previous experience, there is no doubt that from this may arise deep-reaching changes in the temporal bone, tending to necrobiosis, with the fatal consequences to be described later, and that by the direct reception of bacteria (cocco-bacteria septica) into the blood a fatal result may be brought about by septicæmia.

We thus have sufficient indications for the use of the antiseptic treatment in suppurations of the middle ear. Of course the carrying out of a regular, strict antisepsis in the ear is met with many difficulties (Bezold), because the admission of air through the Eustachian tube on the one side, and the meatus on the other, cannot be prevented. Nevertheless, by the careful cleansing of the ear—an important condition in antiseptic treatment—and by the anti-bacterial action of special medicinal agents, the development of causes of putrefaction is not only limited, but altogether prevented. One may be convinced of this by occasional microscopic examination of the secretion, and I consider it generally very important to repeatedly examine the secretion for micrococci during the course of treatment, especially in cases of offensive exudation, and in obstinate forms.

Among antiseptic remedies, finely powdered boracic acid, recommended by Bezold, takes the first place. The method of its application was described in the therapeutics of acute suppuration of the middle ear (p. 401). We have still to add, that in cases of profuse secretion, at least as much powder must be insufflated as will fill the osseous meatus ; and after the insufflation, the orifice of the meatus must be stopped with boracic or carbolic wadding.

As long as the suppuration continues, the boracic acid is used once or twice daily—the secretion having always been previously removed. If the suppuration abates, then it is sufficient to blow the powder in every two days, and at last every three days. If the powder remains dry in the meatus for several days, we may conclude that the suppuration has diminished or ceased.

It is not advisable to syringe out the dry powder for some days immediately after the stoppage of the secretion, because, by the entrance of fluid into the tympanic cavity, suppuration may again be set up. But syringing does no harm after a week or a fortnight, especially if the fluid remaining in the ear is immediately removed by means of Bruns' wadding.

Although the boracic treatment, in regard to the number of cases cured, does not show such astonishing effects in cases of chronic suppuration of the middle ear as in the acute forms, yet I must express my opinion, drawn from the numerous surprising results which I have produced by this means, that the introduction of this method of treatment into aural practice (Bezold), must be looked upon as an important advance in the therapeutics of chronic suppurations of the middle ear. For besides its efficacy in diminishing the secretion, the boracic acid also possesses the invaluable property of never producing an inflammatory reaction, nor forming those injurious adherent precipitates such as mineral salts give rise to (Morpurgo). The boracic acid may therefore be used for a long time without any bad effects, and thus its application can be entrusted to the patient without fear of the injurious consequences which result from the use for a time of astringents without medical supervision. In complicated forms it is always advisable to begin the treatment of suppuration of the middle ear with boracic acid.

Diminution of the secretion rarely results rapidly from boracic treatment. To be sure, one notices cases in which the exudation ceases after the second or third insufflation of the powder; but on the whole a noticeable diminution of the secretion is only to be reckoned upon after some weeks of treatment; indeed, the cure often only begins when the boracic acid has been used for several months.

It must, however, be stated that in spite of the favourable operation of this remedy, it not unfrequently proves useless, particularly in cases of blennorrhœa, but also in apparently slighter forms, and that in cases of great proliferation of the mucous membrane, formation of granulations in the outer and middle ears, excessive desquamation in the middle ear, and persistent offensive exudation, boracic acid is almost always without effect. To increase the antiseptic efficacy of boracic powder, I have it mixed with one drop of carbolic acid (to 1 gramme of boracic powder), when there is an offensive exudation, and with

some drops of common oil of turpentine when the secretion is of a blennorrhagic nature.

For antiseptic treatment, solutions of carbolic acid (1·0 in 10·0 glycerine or ol. oliv.) have lately been recommended by Hagen, Paulsen, and Menière. When the ear has been cleansed, a ball of cotton-wool, soaked in carbolic solution, is pushed in as far as the opening of the perforation, by means of the bent forceps (p. 96), and left in the ear for twenty-four hours. Now although the antiseptic action of carbolic acid is far more energetic than that of boracic, yet the latter has proved itself far more efficacious in cases of suppuration of the middle ear. Besides, the carbolic treatment possesses many disadvantages by which its application is restricted. Fritsch has shown that a 3 per cent. carbolic solution at the least is necessary for the destruction of bacteria, and that by 5 per cent. solutions the epithelium is destroyed and the tissue corroded. Indeed, an inflammatory action in the middle ear is not unfrequently produced by concentrated solutions (Cassells), and ulcers even are formed in the external meatus (de Rossi). The carbolic treatment is extremely disagreeable, especially for children, on account of the repulsive taste and smell caused by the partial escape of the remedy through the Eustachian tube into the pharynx. But nevertheless, I have often noted very good effects from carbolic treatment in cases where the boracic and alcoholic treatments were of no use, especially when the secretion had a bad smell, or contained great quantities of micrococci. The following solution has proved the most efficacious in my experience : ℞. Acid. carbol. 1·0, spirit. vini rectif., aq. destill. a.a. 15·0 : M. Sig. 15-20 drops to be instilled. Stronger solutions of carbolic acid in alcohol must only be used with gradually increased concentration (from 3-8 per cent.), as they often occasion a violent burning in the ear, but they prove very efficacious in many obstinate forms.

Moreover, I use in practice a 2-3 per cent. carbolic solution at the beginning of the treatment for cleansing the ear when there is an offensive exudation. In many such cases I have found the boracic acid only efficacious when the middle ear had first been washed for several days with the carbolic solution. Further, I use carbolic solutions for cleansing carious cavities in the mastoid process, and for syringing in cases of carious affections generally. When using carbolic injections in the latter processes, it is important to keep in mind the fact that after the frequent washing out of considerable cavities with carbolic solutions, the carbolic acid being absorbed into the blood, symptoms of carbolic poisoning set in, such as : diminished frequency of pulse, exhaustion, faintness—in a word, symptoms of collapse. One must, therefore, always pay attention to the first sign of the reception of carbolic acid into the blood—*i.e.*, the greenish colour of the urine—and then stop the use of the acid at once.

Salicylic acid has not been much approved of in cases of suppuration of the middle ear, in spite of its well-known antiseptic qualities. The aqueous solutions (1 in 200) (Bezold), and still more the alcoholic solutions of this remedy, often cause severe reaction. In obstinate cases, nevertheless, trial of salicylic spirit, the strength of which is gradually increased (2-10 per cent.), may be properly made. According to Burkhardt-Merian, in several cases in which the 10 per cent. salicylic spirit, prescribed as an addition to syringing, was instilled by mistake, a cure occurred after the second and third application. For offensive exudations, Burkhardt-Merian recommends insufflations of a mixture of two parts of powdered boracic acid to one part of salicylic acid.

Thymol (0·5 in 100) and iodoform insufflated as powder (Rankin, Czarda), solutions of borax or a mixture of the borax solution (4 per cent.) with a solution of salicylic acid (5 per cent.) (Ogston), the permanganate of potash (0·1 to 0·5 in 25·0), strongly recommended by Howe; weak solutions of tincture of iodine (1 in 15 spirit. vin.) (Valeris), and powdered benzoic acid, used by me in several cases with good effect, but which is very irritating, come next to boracic acid generally in regard to efficacy. Each of the remedies mentioned here, however, may, under certain circumstances, have good results in cases in which boracic or alcoholic treatment, or the caustic method, would be applied without effect.

2. *The Alcoholic Treatment.*—Rectified spirit, first proposed by Hassenstein for otitis mycosa, was recommended for suppuration of the middle ear by Lœwenberg (*El Pabellon Medico*, Madrid, 1870), and later by Weber-Liel and Cassells. In the use of alcohol it is, above all, necessary to remove the secretion from the deeper parts by cleansing, and then to dry the meatus with a little pad of Bruns' wadding. The head being bent to the side, the moderately-warmed alcohol is then poured into the meatus by means of a teaspoon, and left in the ear 10-15 minutes at least. In most cases the pouring of it in produces a slightly warm sensation, and but seldom, and that mostly at the beginning of the treatment, severe burning or violent pain. When this is too intense, it is well to dilute the alcohol at first with an equal quantity of distilled water. If the diluted alcohol is easily borne, it may gradually be increased in strength. When there is copious exudation, the instillation must be repeated twice or thrice daily; when the secretion is moderate in amount, one application is enough.

Directly after the action of the alcohol, the mucous membrane of the wall of the promontory, formerly sodden and red, presents a pale greyish-red colour, in consequence of the coagulation of the mucus and albumen on its surface.

The effect of rectified spirit is excellent in isolated cases, but it falls short of that of boracic acid in regard to the number of good

results from it, and of the caustic treatment as regards rapidity of effect. According to my observations, alcohol is generally less effective in cases of suppuration of the middle ear with simple tumefaction of the mucous membrane, than in granular forms, and in excessive proliferation of the lining membrane of the middle ear. In a considerable number of cases of this kind where every method of treatment had failed, when alcohol had been used for some time I have observed complete disappearance of the proliferations and cessation of the suppuration.

Although the action of alcohol is inconstant, and often commences only after the application has been continued for some time, it yet ranks among the most valuable remedies, next to boracic acid, for this disease. In uncomplicated forms, when the boracic treatment has been tried for several weeks without effect, I apply the alcoholic treatment directly after it; in the granulating form I use alcohol first. Besides its power of shrivelling up the proliferating mucous membrane, it also possesses the principal property of spirit of wine; for the albuminates precipitated by it, partly soluble in warm water, are much more easily and perfectly removed from the ear by syringing than those formed by astringents or by nitrate of silver. Alcohol, therefore, like boracic acid, is specially suited for self-treatment in those lingering forms in which, as so often happens, external circumstances render constant medical supervision of the patient impossible.

3. *The Caustic Treatment.*—To Schwartze belongs the credit of having brought into general use concentrated solutions of nitrate of silver, for effectually cauterizing the diseased mucous membrane. The concentration of the solutions used by me varies from 0·6-1·0 in 10·0 aq. dest. Before applying this solution, the tympanic cavity must be washed out in the manner already indicated, because when the cleansing is insufficient the silver solution unites with the secretion and forms an albuminate of silver, instead of acting on the mucous membrane.

For cauterizing, from 15-20 drops are sufficient, and this, slightly warmed, is poured into the external meatus by means of a horn or glass spoon, the head being inclined to one side. It is not good to heat the fluid much, because it thus becomes decomposed, and the oxide of silver is precipitated in black grains. When the perforation is large, simple instillation is enough; but when small, the solution is forced into the tympanum by pressing in the tragus towards the external orifice of the ear, as before mentioned.

Solutions of lunar caustic seldom cause painful burning in the ear, but the penetration of a few drops of the solution into the pharyngeal space is almost constantly accompanied by a burning feeling, and itching in the lateral part of the pharynx. To remove this quickly, two or three table-spoonfuls of warm salt

water are poured into the naso-pharynx, through the nostril on the side affected.

To form a proper eschar, the solution must remain in the ear at least one or two minutes. But when there is violent reaction, the ear must be syringed at once.

After each application, the excess of lunar caustic must be removed by syringing with simple lukewarm water. Neutralization, even with weak solutions of common salt, is not only superfluous but even injurious, in so far that the precipitates of chloride of silver formed in the tympanum remain firmly adherent to it. In private practice it is advisable to moisten the parts round the orifice of the ear with a solution of iodide of potassium after each cauterization, to prevent blackish-brown spots from appearing on the skin.

The eschar arising from the application is generally cast off within twenty-four hours, but sometimes not for two or three days. As a rule a second cauterization should not be performed until the eschar has been quite cast off from the mucous membrane.

The efficacy of the caustic treatment does not depend so much upon the duration of the ailment as upon the local changes. This treatment acts more favourably in cases of large gaps in the membrana tympani, and of simple, uncomplicated tumefaction of the mucous membrane of the middle ear; but less favourably in cases of profuse suppuration and small perforations, of diffuse proliferations of the mucous membrane, and extensive granulations in the middle ear. Yet in several cases in which the membrana tympani and the inner wall of the tympanum were thickly covered with granulations, I have observed complete disappearance of these after repeated cauterization. The caustic treatment is contra-indicated in cases of painful inflammation of the middle ear, of infiltration and bulging of the postero-superior wall of the meatus, of accumulation of caseous exudation or masses of epidermis in the middle ear, and where there are symptoms of caries of the temporal bone; also in cases in which cauterizing produces too much reaction, or when, after repeated application, the suppuration still increases. When the perforations are very small, from the size of the point of a needle to that of a millet-seed, it is not advisable to force the fluid into the tympanic cavity, because the expulsion of the eschar from the tympanum is thus prevented. Cauterizing the mucous membrane of the tube, generally much swollen in cases of suppuration of the middle ear, is of use only in the stage of healing; I have never observed the unfavourable results from it so much feared by many specialists, viz., strictures of the Eustachian tube.

The efficacy of concentrated solutions of lunar caustic is often shown after the second or third application in the reduction or

complete stoppage of the suppuration. If no diminution of the secretion is noticeable after the eighth or tenth application of the caustic, then this treatment must be discontinued, and succeeded by another application of boracic acid or alcohol; and if this is of no use, by insufflations of pulv. alum. crud., or alumina acet. Solutions of lapis (nitras argenti), combined with and following the application of the last two remedies, are among the most effective methods of cure in a great number of obstinate cases which resist the antiseptic or astringent treatment. It must not be overlooked, however, that nitrate of silver also forms with the secretion firmly adhering deposits, and therefore I now use the caustic method much less frequently than formerly, and only after the antiseptic or alcoholic treatment has been tried. The caustic treatment cannot of course be entrusted to the patient.

4. *Astringents.*—These are now applied in many ways by specialists. Those most in use are solutions of sulphate of zinc (0·2-0·4 in 20·0) and acetate of lead (0·2-0·4 in 20·0), and, next to these, solutions of sulphate of copper (0·1 in 20·0); more rarely solutions of liquor ferri (0·1 in 30·0), of crude alum (0·3 in 20·0), and of acetate of zinc (0·2 in 20·0). In applying these remedies the fact must always be kept in mind that the mineral salts form with the albumen of the muco-purulent secretions, combinations soluble only with difficulty. Hence arise more or less firmly adhering deposits in the middle ear, which accumulate in the depressions of the tympanum and cannot be removed even by the most forcible injections. The ill-effect of such deposits is sufficiently shown by experience. For by the deposition of such masses in the neighbourhood of the ossicula, not only is the vibrating power of the latter diminished, but when the suppuration has ceased it may be set up again by the constant irritation of the mucous membrane caused by the remaining precipitates. In spite of the astonishing efficacy of many astringents (particularly acetate of lead) in reducing the secretion, I now instil astringents into the ear less and less in cases of chronic otorrhœa, and confine their application to those cases in which there is a small perforation in the membrana tympani, and the previous antiseptic or caustic treatment has been without result. In the case of large perforations, when the suppuration has not been reduced by the last-named treatment, I avoid the use of astringent solutions, and sometimes apply instead tampons of Bruns' wadding impregnated with astringent salts, which, by means of the bent forceps, are pushed in to the inner wall of the tympanum and removed in twenty-four hours. By partially acting upon the mucous membrane of the middle ear in this way, we sometimes succeed in combating obstinate suppurations of the middle ear, without any fear of the formation of firm deposits in the depressions of the tympanum.

One of the most efficient of the mineral salts is alum in the

form of powder. Its effect, especially if the caustic method has been applied previously, is often astonishing, for the most obstinate forms of suppuration in the ear, which for years have been treated without result, are sometimes arrested by a single application of crude alum. When the secretion is moderate it is enough to dust the mucous membrane with a small quantity of the powder; but when the secretion is more profuse as much powder as can be heaped up on the point of a knife must be insufflated. In blennorrhagic forms alum is generally ineffectual.

The duration of treatment depends on the efficacy of the remedy. As long as the powder becomes moistened within twenty-four hours, the insufflations must be continued, the meatus having been previously cleansed. If the powder remains dry after being in the ear several days we may conclude that the secretion has been stopped. The removal of the remaining powder by syringing should not, just as with boracic acid, be attempted for eight or fourteen days. If the sixth or eighth application of alum powder does not reduce the otorrhœa, then this remedy may be laid aside as useless.

The use of alum powder, however, has a drawback, by which its application is materially restricted. For it forms, with the secretion, firmly-adhering masses, which obstruct the escape of the discharge and irritate the mucous membrane, unless they are loosened by the probe and carefully removed by syringing. The application of this remedy must therefore never be entrusted to the patient, but always be under the control of the surgeon; for only by close inspection of the ear can the presence of such deposits of alum be discovered. As long as these are not perfectly removed the insufflation of the powder must not be renewed.

A very efficacious preparation at this stage is alumina acet., which is best prepared according to the modified magistral formula prescribed by Burow in the Imperial garrison-hospital here, No. I. (Dr. Chimani. Comp. p. 295).*

I frequently use this after the caustic treatment, instead of alum powder. But as this remedy also, like the other salts, forms crumbly deposits in the interior, its application must be watched, and if no diminution of the suppuration is noticeable after it has been used six or eight times it must be discontinued.

In medicinal solutions a flaky sediment is often deposited in a short time, which, as Lœwenberg and Binz have pointed out, consists of fungus growths. To prevent these having an injurious effect Lœwenberg proposes boiling the solution occasionally. When solutions of zinc have been applied for some time without result I have repeatedly observed great tumefaction of the mucous membrane of the middle ear, and the formation of polypous proliferations on it. Lead and iron preparations form the

* In the magistral formula given on p. 295, the combining weight of plumb. acet. is to be considered as 28·0.

strongest and most firmly-adhering precipitates, which can be syringed out of the external meatus even only after they have been mechanically loosened with the probe. Solutions of crude alum (Bonnafont) are not very efficacious, and they not unfrequently cause an eruption of painful pimples in the external meatus when they have been applied for a considerable time (v. Tröltsch). According to de Rossi and Morpurgo, this might be connected with a rapid and extensive formation of fungi in alum solutions. Solutions of tannin, as well as decoctions containing tannic acid, have proved ineffectual in chronic suppurations of the middle ear, and weak solutions of lunar caustic are likewise of little use. The medicated gelatine-bougies, first proposed by Catti for the treatment of chronic catarrh of the nasopharynx, were recommended later by Gruber for the treatment of chronic otorrhœa also. But they have the disadvantage of forming with the secretion a dirty, greasy mass, by which the ear is polluted, and no better result is produced by this complicated and expensive method than by simply dropping astringents into the ear. I have several times observed that by the use of such bougies growths of fungi in the ear and an offensive exudation were produced. Pulverized magnesia, recommended by Hinton, and calomel, proposed by Wendt, have not been adopted in practice on account of their uncertain action. I have no experience of the operation of metallic combinations with carbolic acid.

5. *Washing out the Tympanic Cavity* through the Eustachian tube by means of warm water (for the details of this method see pp. 139, 456) is often accompanied by very favourable results in most obstinate cases of suppuration of the middle ear. I employ the injections simple, or with a slight addition of boracic acid, in those cases in which no diminution of the secretion could be produced by the already mentioned methods. Syringing the cavity of the tympanum acts particularly favourably when there is a profuse blennorrhagic secretion, and when, on account of the rapid renewal of the secretion, the medicated agents applied from the meatus can be but imperfectly brought into contact with the mucous membrane of the middle ear. I have seen surprising results from this treatment (Millingen, cf. p. 403, Hinton) in those complicated forms in which the excessively proliferating mucous membrane of the middle ear penetrates through the opening of the perforation into the external meatus, and also in those secondary infiltrations and constrictions of the external meatus which prevent medical treatment from this side. In a not insignificant number of such cases, in which every previous treatment was without result, I have observed a rapid reduction and cessation of the suppuration when the tympanum had been repeatedly syringed. The following is a startling example of this:

A female operative, nineteen years old, deaf for nine years, had

suffered for three months from suppuration of the left middle ear, with troublesome subjective noises and severe pain in the half of the head affected. When examined the meatus was found to be constricted like a funnel towards the membrana tympani, and filled with granulations, which grew out from the tympanic cavity. The treatment while the patient was moving about had consisted for fully a year in occasionally removing the growths, and in cauterizing them with nitrate of silver, muriate of iron, and the galvano-cautery, and in incisions of the infiltrated walls of the meatus, besides the injection of air into the middle ear, and repeated cleansing of the deeper parts by the tympanic tube. Yet the suppuration continued unabated, the granulations always grew out again from the tympanum, and the constriction of the meatus remained unaltered. The increase of the headache, frequent fits of giddiness, and occasional twitchings of the face, caused it to be taken up at the clinic, when syringing the tympanic cavity through the catheter with warm water was at once begun. After three days' application of the injections the suppuration was scanty, the meatus appeared considerably dilated, and the granulations for the most part were shrivelled up. By the sixth day the suppuration had completely ceased, and examination on the ninth day showed: the lumen of the meatus of normal size, no trace of the former granulations, the handle of the malleus distinctly visible, the membrana tympani dry and somewhat thickened, the posterior half infiltrated and adhering to the promontory. The hearing-distance, which before treatment was $\frac{1}{2}$ metre for speech, had increased to $2\frac{1}{2}$ metres. The subjective symptoms, the violent headache, the noises in the ear, and the giddiness were quite gone. There was no relapse in three years.

Syringing with Saemann's water-douche, or Gruber's modification of it (*vide* p. 160), could only be suitable in those cases in which there is suppuration of the middle ear, with perforation of the membrana tympani in both ears. When only one side is affected this method must be strictly avoided, because the fluid injected into the naso-pharyngeal space easily penetrates to the sound ear, and there sets up violent inflammation, which may lead to suppuration and perforation of the membrana tympani, with all the already mentioned dangerous complications.

6. *The Dry Treatment of Chronic Suppuration of the Middle Ear*, brought forward by Yearsley, has lately been recommended instead of syringing by Burkhardt-Merian, Becker, Schalle, Cassells, and F. M. Pierce. In this method the removal of the pus is effected by absorption by means of medicated cotton-wool freed from grease (salicylic, carbolic, or boracic wadding), or by tampons of lint, which are pushed up to the membrana tympani with the bent forceps or Burkhardt-Merian's wadding-bearer. The latter instrument (p. 462) is specially useful for absorbing larger

quantities of secretion in the interior, whilst small rolled-up pads, held by the bent forceps, are more suitable for soaking up smaller quantities of mucus and pus, in the perforation or in the pitted depressions of the tympanum.

Schalle recommends, for dry cleansing, a pad of lint, 5-6 cm. long, pointed and turned up at the end, which remains in the ear after the secretion has been removed. In the latter case it is advisable to sprinkle the turned-up part of the pad with boracic powder, according to Hassenstein's recommendation.

Although it must be admitted that in many cases of chronic suppuration of the middle ear the purulent secretion is certainly increased by syringing the ear, whilst it rapidly decreases when the injections are discontinued, yet, in my opinion, syringing the meatus is to be preferred to dry-cleansing in the majority of cases, because the secretion can never be so thoroughly removed by the latter as by the stream of water. That continuously employed injections exercise an important influence on the course of suppuration of the middle ear is evident from the observation that in those cases of chronic otorrhœa in which the meatus is daily washed out, the exudation is generally very moderate and has no bad smell, the mucous membrane of the tympanum remains smooth, and there seldom occur symptoms of reaction. And it is an undoubted fact that in cases in which the syringe has not been used for a long time we very frequently find at our first examination offensive inspissated masses of secretion, full of micrococci and vibriones, lying in the interior; and on their removal polypous growths and granulations on the membrana tympani and on the mucous membrane of the tympanum make their appearance, their origin being probably due to the stagnation of the secretion. The continued presence of the secretion in the meatus and in the tympanum also forms an obstacle to the escape of the pus from the cellular air-spaces of the petrous bone and of the mastoid process. Hence arises the accumulation of those inspissated, putrid masses which may so frequently be indicated as the cause of caries and necrosis of the petrous bone, and of consecutive fatal affections of the brain and the cranial sinuses.

The results of the dry treatment are much more favourable in the acute than in the chronic form of suppuration of the middle ear. This is explained by the consideration that the tendency to complete resolution of the inflammatory process is much greater in acute inflammation than in chronic suppuration. Yet we see in many chronic cases even a more favourable result from the dry treatment than from syringing.

The method of the dry treatment is as follows: first, the secretion which has been forced into the meatus by the injection of air is removed as completely as possible by repeated soaking up. Then either a small tampon of antiseptic cotton-wool, or

a pad of lint sprinkled with boracic powder, is pushed in as far as the membrana tympani, and changed every twelve or twenty-four hours, according to the profuseness of the secretion; or, after the dry cleansing, the tampon is removed, and then a considerable quantity of boracic powder is blown into the meatus, and if this is moistened by the following day it is again removed by being brushed out with a roll of lint or by moist boracic wadding. I generally prefer the latter method, yet I have repeatedly seen good results from the antiseptic tampon, when dry-cleansing and the subsequent insufflation of boracic powder were of no use.

As the efficacy of the dry treatment depends upon purely individual conditions, its use must be at first merely tentative in each case; no definite indications for its employment can be given. We can only state generally that dry-cleansing is specially indicated when violent giddiness is set up even by weak injections, and that it may be applied tentatively in those suppurations of the middle ear with watery or profuse blennorrhagic secretion, in which the suppuration has not been diminished, but rather increased by the continued use of injections. Dry-cleansing is contra-indicated when the exudation has a bad smell, when the secretion is in a crumbly condition, or when the lining membrane of the meatus or the mucous membrane of the tympanum is in a very irritable state. One of the important advantages of syringing over dry-cleansing is that in tedious suppurations, where the removal of the secretion must be attended to by the patient himself, this can never be done so thoroughly by dry-cleansing as by syringing. The surgeon alone, who is able to recognise the condition of the membrana tympani with his speculum, is in a position to manage the dry treatment properly; therefore if it is to be continued for some time this method may be entrusted to the patient himself only after the surgeon is satisfied that the former possesses the skill necessary for the removal of the secretion.

Treatment of Granular Suppuration of the Middle Ear.

The change in the mucous membrane of the middle ear consists in the development of numerous roundish or villous excrescences on its surface, which lend a glandular, papillary, granular appearance to the exposed covering of the promontory. The generally red sodden surface presents a mass of small reflections of light, which arise from the points of the proliferations. The granular condition either extends over the whole mucous membrane of the middle ear, or affects only isolated parts of it. Frequently, as is shown by post-mortem examinations, the promontory alone is verrucose, while the rest of the mucous membrane is smooth. Isolated or clustered granulations are often

found at the same time on the membrana tympani, especially near the margins of the perforation.

The granular form of suppuration of the middle ear is specially distinguished by its obstinacy, and its diagnosis is therefore important, because the suppuration does not cease until the granulations have been removed. Most of the remedies already mentioned are ineffectual in this affection; therefore from the first the treatment must be different from that of simple suppuration of the middle ear. There are two methods by which the removal of the granulations may be accomplished: their destruction by caustics, and the alcoholic treatment, under which they gradually shrivel.

Removal of the granulations by cauterization is applicable when they are on the promontory or on parts of the inferior or posterior wall of the tympanum within view, where therefore the cautery can be exactly applied to the proliferations. Cauterization is less suitable for extensive granulations on the mucous membrane of the middle ear, although, according to my observations, a circumscribed application of the cautery sometimes also suffices to shrivel up diffuse proliferations, untouched by the caustic.

One of the most usual applications for cauterizing granulations is nitrate of silver, which I formerly often used, melting it on to the point of an angularly curved steel or brass wire.* The chloride of iron, as a liquid or in crystals, possesses many advantages for cauterization. For whilst lunar caustic almost without exception occasions violent pain, often lasting several hours, indeed even a whole day, and sometimes severe inflammation and a great after-growth of granulations, after the application of chloride of iron the pain is generally trifling, and often entirely absent. Still more important is it that lunar caustic forms but a superficial eschar, and that—particularly when the granulations are extensive—often as much new tissue has regrown as was destroyed by the lunar caustic; whereas the chloride of iron penetrates deeper into the tissue, and more surely produces mortification and removal of the granulations. I have seen granulations on the membrana tympani and on the cicatrices of the membrana tympani disappear after one or two applications of the chloride of iron.

The application of the chloride of iron to the proliferation is most simply made by means of a probe dipped in the fluid. If from insufficient practice the drop is rubbed off against the speculum or the wall of the meatus, it is better to apply the remedy by means of a small brush or a small ball of wadding saturated with the fluid. I frequently use crystalline chloride of

* According to Bezold, the simplest way is to dip the moistened point of the probe into the nitrate of silver, and melt what adheres to it over the flame of a candle.

iron, small particles of which, adhering to the wet point of the probe, are applied to the part to be cauterized. Cauterizing with nitrate of silver, as well as with chloride of iron, may be repeated only after the eschar has been removed by syringing. The one disadvantage of the use of chloride of iron is the formation of black adherent deposits, which often can be loosened only by the probe, so as then to be removed by repeated injections. The cleansing is most certain to succeed in those cases if the meatus-tube designed by me (Fig. 177, p. 465) be fixed on the syringe, and the point pushed in towards the deeper parts of the meatus.

I have several times seen single granulations, or groups of them, shrivel up after being touched with pure carbolic acid, concentrated salicylic spirit, or with a little drop of a concentrated solution of chromic acid.

Galvano-caustic destruction of the granulations with pointed or rounded flexible cauteries (for the details of this treatment see the operations for polypi) has this advantage, that the violent pain lasts for the moment of the operation, ceasing completely after the cauterization. The proliferations are more thoroughly destroyed than by lunar caustic or chloride of iron, and severe reaction almost never results, and, as I have several times observed, the proliferations are shrivelled up even at the parts not touched by the cautery. By skilful manipulation the possibility of an affection of the bone being caused by cauterizing is excluded. But although this method is preferable, yet its complicated apparatus and the imperfect knowledge of its management are against its use being widely extended among practitioners.

The more important to the practitioner, therefore, is the alcoholic treatment of granular suppuration of the middle ear. I have proved this method in so many cases that in my opinion it is sufficient in the majority, and I now use caustics only when the alcoholic treatment is not successful, or when the granulations are not extensive, but confined to the promontory and the membrana tympani, when they are more rapidly removed by caustics than by alcoholic treatment.

The advantages of the alcoholic treatment are that the pain is slight, that the alcohol does not form adhering deposits with the secretion, and that the application is very simple, the careful cleansing of the ear and the subsequent pouring of the warmed solution into the meatus being all that is required. A further advantage of this method is that the remedy penetrates into the depressions of the tympanum, and therefore is much more effective than caustics, especially in diffuse and extensive granulations. But, on the other hand, the duration of the alcoholic treatment is generally rather long, for the granulations often disappear only after the instillation has gone on for weeks, and even months. A successful result from this treatment is to be anticipated with certainty only when it has been continued for some time and

without interruption. The alcohol must be poured in three or four times a day, and left in the ear at least half an hour. With the disappearance of the proliferations the otorrhœa also generally ceases.

Lastly, there remains to be mentioned the operative treatment of granulations, introduced by Oscar Wolf. This consists in scraping off the proliferations from the promontory or from the accessible inferior or posterior wall of the tympanum, by means of small, sharp spoons of various shapes (Fig. 180). This method, however, is only suitable in cases of sharply-defined granulations, whether single or in groups. The scraping often only partially succeeds, and the remainder of the granulations must be cauterized or removed by the instillation of alcohol. In such cases, however, the duration of treatment is very much shortened by this operation.

FIG. 180. OSCAR WOLF'S SHARP SPOON.

There are as yet such unreliable records as to the galvanic treatment of suppuration of the middle ear, related by Beard (*v.* Roosa, *l. c.* p. 377), and consisting in the immediate operation of the electric current on the ear, or in galvanization of the sympathetic, that nothing can be said as to its value. To arrive at a conclusion regarding its efficacy, it must be used alone, to the exclusion of every other kind of local treatment.

Concluding Remarks on the Treatment of Chronic Suppuration of the Middle Ear.—From the above it can be gathered that there is generally a choice of remedies, and an order in which they are most usefully applied. The following remarks may be allowed here by way of supplement. First, it must be pointed out that the action of many remedies varies in different individuals, so that a usually efficacious remedy is often applied without result, whilst in the same case, the suppuration is quickly removed by a commonly less effectual preparation. In many cases, therefore, trial alone can fix the choice of the remedy; *i.e.*, one only learns from the successive application of different remedies, which of these is efficacious in the given case.

Clinical experience shows further that many remedies do not act on their first application, but that, with the same remedy, a surprisingly favourable result is produced if it is again applied later, after some other remedy has been used. Thus, one often observes that in cases in which boracic acid, rectified spirit or an alcoholic solution of carbolic acid have been applied for some time without the slightest result, a rapid diminution of the suppuration is produced when they are used again after an interval,

during which caustics have been employed with an equal want of success.

Of special importance to the result is the length of time the remedies are applied. Since, according to my experience (*vide Ueber die Wahl der Adstringentien bei eitrigen Mittelohrcatarrhen, W. M. Pr.* 1866), most preparations lose their effect after lengthened uninterrupted application, it is useful—even if the suppuration is decreasing—after some weeks to allow a pause of several days, during which one must confine one's self to occasional syringing or dry-cleansing of the ear. After such pauses, the same, or a fresh remedy often acts much more rapidly. I have frequently seen the suppuration cease only when the medicated treatment was interrupted.

I must, for the reasons already given (p. 476), pronounce most decidedly against the continued use of astringent metallic salts, and too frequent cauterization with concentrated solutions of nitrate of silver. In the rare cases in which I have recourse to these remedies, I never use them for more than two or three weeks. But boracic acid and alcohol, which I often apply alternately, may be used for a long time without injury, and are therefore particularly suited for self-treatment of chronic suppuration of the middle ear. Both remedies often begin to act only after several months' application. I have not unfrequently seen cases in which boracic acid or rectified spirit remained without result for some weeks, while after several months of self-treatment they brought about the entire cessation of the suppuration. Regarding self-treatment, it is to be remarked that this may be entrusted to the patient himself or his attendants for a considerable space of time, only when the affection is uncomplicated, and the application of boracic acid or alcohol is suitable, and after one is satisfied that the people concerned possess the skill necessary to the performance of the manipulations. But an occasional examination of the ear is required here also, in order to watch the changes in the middle ear—often serious in their consequences—which arise in the course of treatment.

From what has been said, it is clear that the question of the duration of treatment in chronic suppuration of the middle ear—in so far as a limited space of time is understood—cannot be discussed. As long as the process of suppuration continues, the treatment must not be discontinued for any length of time, if the injurious results of neglected otorrhœa are to be avoided.

Attention must always be paid to the condition of the nasopharyngeal space in the treatment of chronic purulent otitis media, as in catarrhal affections of the middle ear generally. The simultaneous treatment of diseases present in the nasopharynx is the more important because these often give rise to the obstinate continuance of the suppuration of the middle ear,

and from want of attention to this circumstance all local treatment remains without result. Particular attention must be paid to the changes in the part round the mouth of the tube, and to the condition of the Eustachian tube. I have often seen cases in which obstinate suppuration of the middle ear has only ceased when the scabs have been removed from the mouth of the Eustachian tube, when the cautery has been applied to ulcers in that neighbourhood, or even more frequently when the Eustachian tube has been syringed. For particulars, reference must be made to a previous section on Treatment of Naso-pharyngeal Affections (pp. 312-323).

In the internal treatment of chronic suppuration of the middle ear, particular regard must be paid to co-existing constitutional ailments. The influence of a rational internal medication on the local disorder is especially striking here. But suppuration of the middle ear stands so frequently in undoubted relationship to the state of the general health, that the necessity of general treatment in many cases is very evident. The obstinate continuance of the suppuration—if not caused by complicated local changes—is frequently the consequence of dyscrasia, most often of scrofula, tubercle, or anæmia. And, *vice versâ*, the local disorder may form the basis of general disease. For although patients, for years affected with otorrhœa, often look strong and robust, yet in other cases the injurious effects of the suppuration upon the system is very strikingly apparent. Children especially become anæmic, sallow and thin, but regain their healthy appearance when the suppuration ceases. Chronic suppuration of the middle ear may even lead to extensive injurious changes in the body, besides the dangerous complications from the process spreading to neighbouring vital organs. Thus miliary tubercle may be developed from the softening and absorption of caseous pus from the temporal bone (v. Tröltsch), just as in other cases of caseous otitis (Bühl). It is well known that signs of scrofula or tubercle sometimes arise during chronic otorrhœa. But it would be going too far always to regard suppuration as the primary cause of the dyscrasia in these cases. Still, it is certain that where there is already a tendency to these general diseases, their outbreak is favoured by chronic suppuration.

Among general diseases, it is particularly in cases of anæmia and scrofula that the local treatment must always be combined with suitable internal treatment. For anæmic, poorly nourished patients the lengthened use of easily digested preparations of iron is advisable; for scrofulous persons, iodide of potassium and syrupus ferri iodidi; and when the digestion is good, cod-liver oil should be used. The latter, as also the preparations of iron and iodine, are frequently exhibited, too, with good results in persons who appear healthy, if the suppuration continues obstinate in spite of continued local treatment. Where there is constitu-

tional syphilis, the suppuration is often arrested only by a suitable anti-syphilitic, iodine or mercurial treatment.

External medication in the great majority of cases has no effect. I have seldom seen good results from rubbing or painting the mastoid process with iodine ointment or tincture of iodine, so much used up to this time; in several cases I have observed an increase in the secretion after painting with iodine. But I have obtained favourable results from the outward application of preparations of iodine in cases of obstinate scrofulous otorrhœa, of suppuration of the ear complicated with syphilis, and of painful inflammation of the mastoid process arising in the course of suppuration of the middle ear. In the last-named cases iodoform (℞. iodoformi, olei fœniculi a.a. 2·0, vaselini 20·0), on account of its rapid action, is particularly serviceable for embrocation over the mastoid process.

The diet in chronic suppuration of the middle ear deserves full consideration. Its influence on the local disorder renders it important, especially in children. For weakly, anæmic and debilitated persons, strong nourishing food, consisting chiefly of meat, milk, and eggs, is highly to be recommended. Alcoholic drinks may only be used in such quantity that no great congestion of the brain is produced by them. The influence of alcohol on the suppuration varies with the individual. For, whilst the secretion is sometimes strikingly increased after the use of a small quantity of wine, yet in many cases, especially in the anæmic and debilitated, the moderate use of a good red wine proves beneficial. Smoking must be limited, particularly if the mucous membrane of the naso-pharynx is irritable; snuffing must be forbidden under all circumstances. In short, let the patient avoid all that produces great congestion of the brain, *e.g.*, gymnastics, dancing, hunting, cold baths, overloading the stomach, etc. For the same reason, where there is chronic constipation, suitable remedies must be used for its removal. Residence in damp, musty dwellings, and in moist, smoky localities must be avoided, and the necessary ventilation of the dwelling-rooms must be attended to. In winter, when the rooms cannot be often aired, turpentine should be evaporated, or Bittner's conifer-spirit (Reichenau, Lower-Austria) sprinkled over the room. In fine weather the patient should have frequent exercise in the open air, but when the weather is damp, cold or stormy, or when there is a thaw, all which so often cause relapses and increase the otorrhœa, the patient must be forbidden to go out or to remain long in the open air. Additional particulars as to diet will be found in the part on the treatment of the adhesive processes (p. 371).

Change of air often has an extremely favourable effect on the course of obstinate suppurations of the middle ear. Cases in which careful and continued local treatment often remains without result are cured, as I have repeatedly noticed, in a sur-

prisingly short time after removal to a wooded or hilly district, without any local medication except simple syringing, which must be entrusted to the patient himself or his attendants if he is removed for some time from the care of the surgeon. In the same way change of climate, *e.g.* residence in the south for the winter, very often has a favourable influence on the suppurative process, especially in those cases in which the suppuration ceases in summer, but returns with the advent of cold weather, or in which the catarrh of the naso-pharynx, and with it the suppuration of the ear, becomes aggravated in autumn.

With regard to the use of baths in suppuration of the middle ear, the same remarks apply as were used in the part concerning the treatment of catarrh of the middle ear (pp. 297, 371). We have still to add that cold baths and cold-water cures have generally a bad effect on the process of suppuration, on account of the severe congestion of the head which they occasion. These are advisable only after the cessation of the suppuration, and especially when the secretion stops for some time but returns with every severe nasal catarrh or sore throat. In such cases, by toning the skin to changes of temperature, the frequent relapses of the naso-pharyngeal catarrh are prevented, and in this way a favourable influence is indirectly exercised on the affection of the ear.

The effect of warm baths on suppuration of the middle ear is more favourable. According to my observations the local treatment of obstinate forms is materially aided by the use of warm baths twice or thrice a week. In intermittent acute inflammations of the middle ear also warm baths often prove of great service. Here, as in the cold-water treatment, the entrance of water into the ear must be avoided.

According to my observations the so-called indifferent thermal-springs (Neuhaus, Tüffer in Steiermark, Gastein, Ragaz) act very favourably. Chronic blennorrhœa, which has withstood all local treatment, is often removed by them in a short time. Burkhardt-Merian recommends Ragaz for this, especially for those forms of intermittent otorrhœa in which the profuse suppuration stops after having gone on for several hours, but only to return in a few hours with the same intensity. In a case observed by him, in which the otorrhœa was associated with very troublesome sleeplessness, and intense pain deep in the mastoid process, which had gone on for half a year, a complete cure was effected after three weeks' use of the thermal-baths of Ragaz.

Of the use of iron baths (Franzensbad, Spa, Pyrmont, Schwalbach) in anæmic and debilitated individuals, of iodine baths (Hall, Ivonitz, Lippik, Sulzbrunn by Kempten and Tölz) in scrofulous and syphilitic cases, of sulphur baths (Aix, Baden by Vienna, Teplitz, Mehadia, Barèges, Cauterets, Pedigorsk) in inveterate syphilis, as well as of the spas recommended for these cachexiæ, besides referring the reader to the data on the subject

given in the treatment of catarrh of the middle ear and of the adhesive processes (pp. 323, 372), it must here be said that even in healthy individuals the use of brine baths (Ischl, Kreuznach) and sulphur baths often acts favourably on the suppuration, when previous local treatment has been of no use. If circumstances do not permit of the journey to a brine bath, then artificial brine baths (containing 1-3 per cent. salt) may be taken at home.

After the cessation of suppuration of the middle ear, one must abstain from the use of any local medication, for experience shows that the suppuration is easily brought back by syringing or instillation of remedies, as well as by every irritative interference with the mucous membrane. Only where there is a tendency to relapse may a small quantity of boracic powder be insufflated once or twice a week after the cessation of the secretion, but without syringing the ear (Burkhardt-Merian).

The patient must not, however, entirely withdraw himself from the care of the surgeon immediately upon the arrest of the secretion, for, as has already been mentioned, adherent crusts frequently form, or inspissated masses accumulate in the deeper parts from the rapid desquamation of the epithelium, and these, on account of their injurious effect on the walls of the middle ear (*vide* p. 454), must be removed from time to time. Periodical examination every month or two is specially necessary when there is a tendency to the recurrence of such accumulations, or when the patient becomes aware of the re-appearance in the meatus of a little secretion with an offensive smell.

The treatment for the removal of accumulated masses of epidermis from the tympanic cavity has already been described (p. 463), and it merely remains to make a few remarks regarding the removal from the deeper parts of firmly adhering crusts. Spontaneous discharge of these crusts occurs only after many months, and although they may long be borne without injury, they not unfrequently cause recurrence of the suppuration with violent reaction. Therefore, when the crusts have adhered for some time, their spontaneous discharge should not be waited for, and their careful removal must be undertaken.

Loosening the crusts with a blunt probe is only permissible when they do not adhere very firmly, and may be loosened from the underlying tissues without difficulty. If this is not the case all forcible manipulation with instruments must be avoided, because the parts covered by the crust become excoriated, and the suppuration is easily brought back. The instillation of solvents is likewise to be avoided as much as possible, for by the spread of the fluid in the middle ear the suppuration often readily returns. As the most gentle treatment for softening the crust, we would recommend that a small pad of cotton-wool, the size of the crust, and dipped in a weak solution of glycerine, be inserted by means

of forceps as far as the crust, and pressed against it moderately firmly. By this means the crust becomes so softened within twenty-four hours, that it can either be loosened by the probe and drawn out, or stripped off by a small roll of wadding. The removal of softened crusts by syringing is not advisable, because the suppuration often recurs after the penetration of water into the tympanum. It is only when extensive crusts can be removed in no other way that we must have recourse to injections (best with a 5 per cent. solution of boracic acid), but the residue of the fluid must be soaked up immediately by a little pad of Bruns' wadding.

When the opening of the perforation does not become closed on the cessation of suppuration of the middle ear, it is necessary for the prevention of relapses that the ear be protected from anything by which it might be injured from without. The tender, highly-irritable mucous membrane of the tympanum is protected from external influences by the membrana tympani itself, when that is intact; but when the membrane is perforated, the exposed mucous membrane is immediately affected by cold, wind, damp, dust, etc. Therefore the patient is strongly recommended to close the external orifice of the ear with a loose plug of cotton-wool or lint in stormy and damp weather, and in washing the ear to guard against the entrance into the tympanum of the fluid, and especially of cold water, for often merely by a few drops of cold water, which reach the tympanum through the opening of the perforation, the return of violent purulent inflammation may be occasioned. The patient must also remain indoors in cold or windy weather when he is suffering from severe nasal catarrh, since from the effect of cold, the catarrh easily spreads to the middle ear, and the suppuration returns.

Treatment of the Deafness.

a. Injection of Air into the Middle Ear, and Rarefaction of Air in the External Meatus.

The injection of air into the middle ear serves not only for the removal of the secretion from the tympanum, but also for the improvement of the function of hearing. In the secreting stage, in most cases a more or less noticeable increase in the hearing-distance takes place after each injection of air. This is chiefly caused by the secretion, which impedes the motion of the ossicula, being removed, and at the same time the position of the remnant of the membrana tympani and of the ossicula being corrected. A decrease in the hearing-distance is but rarely seen immediately after the air is injected, in consequence of the membrane being clogged by the secretion poured into the meatus.

But in these cases a striking improvement in the hearing follows on the secretion being removed by syringing or soaking up.

In the same way a remarkable increase in the hearing is frequently produced on the cessation of the suppuration by the injection of air, even when the perforation still exists, and for this reason, that the remnant of the membrana tympani and the chain of bones are forced from within into a position approaching the normal one (*vide* p. 108), while in cases of new-formation and adhesions the ribbon-like bands are also stretched, and the tight tension of the apparatus for the conduction of sound is diminished.

As in catarrhs generally, so also in purulent otitis media in all stages of the process, a too protracted and uninterrupted injection of air is injurious to the function of hearing. The treatment by inflating air according to my method, or by the catheter, must therefore be occasionally suspended, and it is best to continue it twice or thrice a week for four or five weeks, and then to allow a pause of two or three weeks. But when the secretion is profuse, the intervals must be shorter in order to prevent accumulations of secretion in the middle ear.

The value of rarefaction of air in the external meatus has not been sufficiently appreciated in the treatment of suppuration of the middle ear. E. Politzer saw in the case of a girl with obstinate otorrhœa, when the injection of air through the Eustachian tube was impracticable, great quantities of matter come out through the opening of the perforation, after the air in the meatus had been rarefied, and the secretion rapidly decrease after repeated application of the treatment. Reasoning from this observation, I have frequently applied this method lately in the secreting stage, often with very favourable results as regards the diminution of the secretion and the improvement of the hearing-distance, especially in cases in which air could not be injected, or when the suppurating part was separated from the Eustachian tube by adhesions. In the case of small perforations, I could bring away far more secretion from the tympanic cavity by means of rarefaction of the air in the meatus, combined with injection of air through the tube, than by injecting air per tubam alone. When the suppuration has ceased, this treatment may often be applied with very good results as regards the improvement of hearing, when the injection of air per tubam is employed without effect, especially when the membrana tympani is adherent to the articulation of the stapes with the incus, or to the part of the stapes separate from the incus, or in cases of cicatricial adhesions. In a series of such cases in which, on account of the partial adhesion of the membrana tympani to the inner wall of the tympanum, the air injected through the Eustachian tube could not penetrate to the region of the articulation of the incus with the stapes, it was

only after the rarefaction of the air in the meatus that an increase in the power of hearing and a diminution of the subjective noises took place. Consequently in many cases rarefaction of air is the only treatment by which an improvement in the hearing can be produced.

b. The Artificial Membrana Tympani.

We doubtless owe the invention of the artificial membrana tympani to the well-known observation of aural patients, who were surprised by the startling increase in the sharpness of their hearing when the remnant of the membrana tympani was touched in the attempt to remove the secretion lodged in the interior, by means of a rolled-up piece of paper or an ear-pick. Notes on the use of an artificial membrana tympani are found in the works of Marcus Banzer (*Disputatio de auditione læsa*, 1640), Autenrieth (*Tübinger Bl. f. Nat. u. Arzneik.* vol. i. 1815), Itard, Deleau, and Linke (vol. ii. 1845), but the suggestions of these authors had little attention paid to them by aurists. In 1848 Yearsley, and in 1849 Erhard, proposed, independently of each other, the introduction of a ball of wadding as far as the remnant of the membrana tympani, in order to produce an improvement in the hearing in cases of perforation of the membrane; and soon after this (1852), Toynbee constructed the artificial membrana tympani which bears his name, and a series of good results was recorded, by which the attention of aurists was directed to this subject.

The high value of this invention is at once evident if we consider the number of aural patients at present who are suffering from purulent otitis media, with perforation of the membrana tympani, and who experience no real improvement in their greatly impaired function from any kind of treatment whatever, while, by the use of the artificial membrana tympani their power of hearing is often so materially improved that they are, even after years of deafness, restored to unimpaired intercourse with those around them.

Toynbee's membrana tympani (Fig. 181) consists of a round india-rubber plate 6 or 7 mm. in diameter, which is fixed on the end of a silver wire corresponding in length to the meatus. To unite the plate securely to the wire, it is advisable, as proposed by Lochner, to fix the centre of the plate between two little rings, which are formed by the silver wire terminating in a double spiral. Lucae fixed the plate on a thin india-rubber tube, Burkhardt-Merian on a solid strip of india-rubber, instead of on a metal wire. Fastening the india-rubber plate to a linen thread is so far impracticable in that its introduction into the ear by means of a cannula bearing the thread, or by forceps, is too troublesome, and also because the plate, when without a firm

support, exercises too little pressure, and generally produces less improvement in the hearing than when it is fixed on wire.

As Toynbee's membrana tympani often becomes useless after several applications, I have invented for use among the poor, in order to spare patients the expense of procuring the instrument, an artificial membrana tympani, the manufacture of which is very easy and simple. A piece, ½ cm. long, is cut from the side of an india-rubber tube 2-3 mm. thick, and the lower end being perforated, it is fixed to a moderately strong wire, in the manner indicated in Fig. 182. In several cases in which attempts were made in vain with other artificial membranes, I have seen a striking increase in the hearing on the introduction as far as the

FIG. 181. — TOYNBEE'S MEMBRANA TYMPANI.

FIG. 182.—ARTIFICIAL MEMBRANA TYMPANI FOR USE IN PRACTICE AMONG THE POOR.

FIG. 183.—HASSENSTEIN'S WADDING-BEARER.

remnant of the membrana tympani of an india-rubber tube corresponding to the length of the meatus, and rounded or obliquely cut off at the inner extremity.

Another modification of Toynbee's membrana tympani, designed by me, is its union with a stapes bone, taken from a dead body, for cases in which the crura have been destroyed by erosion, and only the base of the stapes is present in the fenestra ovalis. It is introduced so that the stapes, fastened by thread to the india-rubber plate, is made to lie in the niche of the fenestra ovalis. The waves of sound falling on the affixed stapes are conveyed by it to the foot-plate of the stapes in the fenestra ovalis.

Hassenstein's wadding-bearer (Fig. 183) consists of metal forceps, 3 cm. long, for holding a firmly rolled, longish-shaped pad of wadding. The branches of the small instrument are so firmly held together by a little movable ring that the pad cannot fall from it. The larger the perforation of the membrana tympani, the firmer must be the front of the pad.

Hartmann's artificial membrana tympani is made of a slender piece of fish-bone, 5 cm. long and 2 mm. broad. One end of the

bone is then bent backwards 1 cm., and, in common with its long part, wound round with wadding. Thus the bent part, being covered with wadding, easily fits into the deeper parts.

The choice of the varieties of artificial membrane here described always depends upon their efficacy in the special case; and therefore for every patient for whom an artificial membrane is indicated, several forms must be tried, from which that is selected which acts most favourably. I seldom use Toynbee's membrane now, indeed only when it acts more favourably than the other forms. In my practice I more commonly use Hassenstein's instrument, and sometimes Hartmann's. The disadvantages of Toynbee's are: the unpleasant and often painful sensation when the india-rubber plate is being passed through the narrowest part of the meatus, and the troublesome rattling in the ear which occurs during speaking or chewing from the movements of the jaw-bone being conveyed to the meatus, and thence to the metal wire and the india-rubber plate. These unpleasant effects are quite absent when Hassenstein's forceps are used. This instrument, besides, acts more favourably in most cases, and when the secretion is still going on, it offers this advantage, that the secretion is soaked up by the wadding, and that by applying wadding impregnated with boracic or salicylic acid, or with an astringent, a curative action is at the same time in operation on the diseased mucous membrane of the middle ear. In many cases a simple ball of wadding, moistened with weak glycerine or vaseline, can best be borne, this being introduced and again removed by means of forceps.

Regarding the application of the artificial membrana tympani, it is to be noted that Toynbee's membrane, which I bend slightly to correspond with the inclination of the membrana tympani (p. 19), must be moistened before application. If the india-rubber plate is too large, it may be cut smaller by scissors. When Hassenstein's or Hartmann's instrument is used, after the suppuration has ceased, the wadding is soaked either in a weak solution of glycerine (4-5 drops to 10 gram. aqua), or, better, in vaseline, as proposed by Clarence J. Blake. But if the suppuration is still going on, the wadding is dipped in an alcoholic solution of boracic acid, mixed with a little glycerine, or in solution of acetate of aluminium, for the purpose of checking the suppuration. When medicated wadding is used, it is enough simply to damp it with water or very weak glycerine.

The introduction of the artificial membrana tympani is best effected by the patient himself, he having been previously instructed by the surgeon. As the efficacy of the instrument depends greatly upon the direction and quality of the pressure, the patient will, by practice, hit the right spot far more surely than the surgeon. For, to nullify the action of the artificial membrane, there is often needed only a very slightly too strong

pressure inwards, or, on the other hand, a rather too weak pressure on the remnant of the membrana tympani. Although no improvement in the hearing may take place after the first application of the different forms of artificial membrane, one must by no means abstain from further attempts, for frequently after repeated fruitless trials, one is surprised by the startling effect of the artificial membrane on its being tried once more after a few days.

The mode of action of the artificial membrana tympani has not been perfectly explained as yet. Toynbee's idea that the opening of the perforation is closed by the india-rubber plate and the resonance of the tympanic cavity thereby restored, has been proved erroneous by its having been shown that large perforations are not closed by the artificial membrane in cases in which this instrument has been successfully used. I have shown experimentally (*vide* p. 70) that waves of sound are conveyed by the india-rubber plate to the ossicula. Erhard's explanation is of considerable value, viz., that the artificial membrane acts chiefly by pressure on the remnant of the membrana tympani, and on the handle of the malleus, or on the part of the stapes separated from the incus, whereby the loosely articulated ossicula are pressed against each other, and the conduction of sound is improved. Whether the simultaneous variations in the intralabyrinthine pressure have any influence on the increase in the hearing, as Lucae supposes, has not yet been proved.

Knapp's theory (communicated verbally) concerning the mode of action of the artificial membrane seems to me of importance in its explanation. While previously it was believed that the ossicula are pressed inwards by the artificial membrane, Knapp thinks that by the pressure on the short process of the malleus—which of course lies across the axis of the malleus—the handle of the malleus, and with it the incus and stapes, turn somewhat outwards. The improvement in hearing is therefore produced by the chain of ossicula, which has been tightly pressed inwards, being turned outwards into a position approaching the normal one. By a series of experiments which I have made on patients, I have in several cases convinced myself of the truth of Knapp's theory. If in cases in which the artificial membrane effects an improvement in the hearing moderate pressure with a blunt probe be made on the short process, a decided increase of hearing is thereupon observed. But in other cases the pressure on the short process was without result, whilst touching the inferior part of the handle effected an increase in the hearing.

The indication for the use of the artificial membrana tympani is present in all those cases of existing or exhausted suppuration of the middle ear in which the improvement in hearing necessary for common intercourse cannot be effected by local treatment. The size of the perforation in the membrana tympani is not

determinative as to this indication, for even when the openings are small the effect is not unfrequently astonishing. The use of the instrument is superfluous when only one ear is affected, for the result is not a material improvement on the hearing-power of the one normal ear. Its use is contra-indicated when severe giddiness is set up by its application, or when there is a reactive inflammation in the middle ear or in the meatus. In many cases after the suppuration is exhausted there remains such irritability in the middle ear that the suppuration returns after a quarter of an hour's use of the wadding-pad. In such cases we must abstain from using the artificial membrane. Nor can it be used for children; the experiment in suitable cases should be confined to trying whether the instrument does affect the hearing-distance, in order to find out whether it might be of use to the individual in question at a later date.

The degree of improvement in hearing on the introduction of the artificial membrana tympani varies greatly, and chiefly depends upon the anatomical changes in the middle ear. The increase in hearing is often so great that patients with whom one could formerly converse only when quite close to them, understand what is said at a distance of 6 or 8 metres and more, after the artificial membrana tympani has been applied. In other cases the increase in hearing amounts only to $\frac{1}{3}$ or $\frac{1}{2}$ metre. Still, even this result is a great gain to many patients in so far that conversation is made much easier. Thus I have repeatedly seen persons who on account of their extreme deafness were on the verge of losing their situations, enabled to retain them, their hearing having been so much improved by the artificial membrane that they could now without difficulty communicate with their superiors.

Although the effect of the artificial membrane is generally less in proportion to the degree in which the hearing is disturbed, yet this should not prevent its being tried, even in the case of total deafness. In the case of a man, sixty years old, who had suffered for thirty years from suppuration of both middle ears, the secretion having ceased twenty years before, there resulted several months ago total deafness. I found both tympanic membranes destroyed, and the deafness so great that no vocal sound whatever could be heard. Nevertheless I introduced, by way of experiment, Hassenstein's wadding-bearer, and, to the great astonishment of the patient, there resulted such an improvement in his hearing that he could quite understand what was spoken into his ear, whilst previously he could only be communicated with by writing.

The observation of Lucae and Moos regarding the improvement in the perception of sound through the cranial bones after the introduction of the artificial membrana tympani is worth notice. After its application subjective noises are generally

diminished, more rarely increased, and sometimes first produced by the artificial membrane. Perceptions of taste from contact with the chorda tympani, first observed by Moos, are rare.

The increase in hearing produced by the artificial membrana tympani certainly often disappears on the instrument being removed from the ear, but not unfrequently continues for a time. But cases in which a permanent improvement takes place, after the artificial membrana tympani has been used for some time, are more rare, and it is well gradually to accustom such patients to do without the membrane. According to my experience, after the artificial membrane has been applied for some time, a pause in its use for several days is generally required, for after such a pause the instrument exercises a much more favourable influence than when its use is uninterrupted.

This membrane, like every foreign body, causes irritation of the remnant of the membrana tympani and of the mucous membrane of the tympanum. The diseased parts must therefore be gradually accustomed to contact with the instrument. I allow it to be worn for half an hour only during the first four or five days, adding half an hour in every four or five days; six to eight hours daily should be the maximum for wearing it. As a rule the patient should use it only when he is conversing with others, and should lay it aside when he is alone. Before going to sleep instruments must always be removed from the ear, cleaned and dried, and the pad of cotton-wool must be changed every day by means of Hassenstein's forceps. If the secretion is still going on the ear must be syringed before and after the artificial membrane is applied, and occasionally a little boracic powder should be blown in. If an intercurrent painful inflammation take place the use of the membrane must be discontinued until the symptoms of inflammation have quite disappeared. In conclusion, it must be stated that even when the membrana tympani is not perforated a not inconsiderable improvement in the hearing may frequently be produced by pressure on the membrana tympani, as is evident from the observations of v. Tröltsch, Menière, Pomeroy, myself, and others.

The Operative Treatment of Chronic Suppuration of the Middle Ear.

a. Operations During the Suppuration.

1. *The Enlargement of Small Perforations.*—This is indicated: (i.) In cases of profuse blennorrhagic secretion, when the escape of the mucous masses through the narrow opening is prevented. The enlargement of the opening renders the penetration of air into the tympanum easier, and thereby enables a more thorough removal of the secretion from the middle ear to

be made. In the same way, after this operation, the cleansing of the tympanum per tubam—often so effective—succeeds far more surely and completely. I have often seen obstinate suppurations heal rapidly after enlargement of a small perforation.

(ii.) In cases of small perforation, when violent symptoms of reaction appear in consequence of the retention of pus from the occasional agglutination of the edges of the wound, or from the obstruction of the opening in the membrana tympani by inspissated secretion.

(iii.) When there is an accumulation of caseous masses or conglobated epithelial plates in the middle ear, which stop up the opening of the perforation, bulge out the membrana tympani, and, if left there long, may produce dangerous complications (*vide* p. 454). By the enlargement of the opening of the perforation not only is the obstacle to the escape of the masses into the meatus removed, but the introduction of the little tube through the perforation into the tympanic cavity, necessary to the liquefaction and removal of the secretion (p. 466), is rendered possible.

(iv.) When there are polypi and granulations in the tympanum, if the membrana tympani is bulged forwards by them and the escape of the pus is obstructed. The dilatation is performed here in order to admit of the introduction into the tympanum of instruments necessary to the removal of the new-formation, and to procure a free outlet for the stagnating pus.

(v.) In cases of obstinate suppuration of the middle ear, in which, in order to cleanse the tympanum, Hartmann's cannula or the flexible tympanic tube must be introduced through the opening of the perforation, but where the diameter of the opening is too small to admit of this.

The operative treatment is very simple. The paracentesis-needle (p. 286) is sunk half its length into the opening of the perforation, and the latter is enlarged by an incision 3 to 4 mm. long. The incision must always be in that direction in which the greatest bulging forwards of the membrana tympani is seen; if there is nothing of the kind it may be made in any direction. Immediately after the operation thick pus or polypous masses often penetrate into the meatus. Severe reaction seldom follows the incision; only in a few attempts to enlarge the narrow opening of Shrapnell's membrane downwards have I seen severe infiltration and swelling developed in the membrana tympani and the meatus, accompanied by violent pain. In the majority of cases the edges of the incision unite in a day or two. It is then necessary to separate the coalescing edges by means of a probe or with the paracentesis-needle repeatedly; indeed, until the object of the dilatation has been attained.

2. *The Formation of a Second Perforation in the Membrana Tympani.*—This is indicated: (i.) When loculæ and sacculations

are formed in the tympanic cavity, if in some of these a purulent or mucous exudation is developed, accompanied by the objective and subjective symptoms already described (p. 441).

(ii.) When the membrana tympani is greatly bulged forwards at a distant part of the membrane from the perforation, if frequently-recurring pain renders retention of pus in the deeper portions probable, or when the suppuration continues obstinate, and as the cause of this may be assumed an accumulation of caseous substance or polypous proliferations behind the arched part of the membrana tympani.

A second perforation has for its object not only the formation of a free outlet for the secretion, but also the introduction of an elastic or stiff tube through the incision, for the purpose of syringing out the secretion. In this case also the rapidly-closing edges of the incision must frequently be separated, and the incision kept open until the suppuration behind the incised part has ceased. If the suppuration is not soon arrested by repeatedly syringing such sacculated parts, then injections of weak alcoholic solutions of carbolic acid (p. 472), or a few drops of a concentrated solution of nitrate of silver, through the elastic tube, often prove very efficacious.

The operative treatment of granulating suppuration of the middle ear has already been described (p. 483); the operations for polypi are treated of along with new-formations in the apparatus for the conduction of sound.

b. Operative Treatment after Suppuration of the Middle Ear is exhausted.

The operative treatment for disturbances of hearing caused by the adhesive processes after the suppuration of the middle ear is exhausted, has a greater future than the operative treatment of the non-suppurative adhesive processes. This opinion is supported by the comparative results from a considerable number of patients. For whilst in the case of adhesive processes which have arisen without suppuration (p. 372) the results of the operative treatment are less favourable, and permanent only in isolated cases, we see in the case of adhesions caused by suppuration of the middle ear, after several operations, a striking improvement in the hearing, often continuing for years.

The cause of the difference in the result probably lies in this, that in the non-suppurative forms the tendency to progressive shrinking of the new-formed connective tissue is incomparably greater than in the purulent processes; and besides, in the important circumstance that the expansion of the auditory nerve in the labyrinth is much more rarely affected in the case of purulent otitis media than when the adhesive processes are non-purulent.

Operations to improve the function of hearing after the suppuration has ceased are only indicated if the deafness is serious, and if no increase in the hearing can be produced by the above methods of treatment. It is always necessary first to ascertain the degree of mobility of the individual parts of the thickened or adherent membrana tympani and of the ossicula, by injecting air into the tympanum, and then by Siegle's speculum, and, what is most important, to try the perceptive power of the auditory nerve through the cranial bones. Operation is permissible only if a low-ticking watch is heard through the cranial bones. If the perceptive power for the ticking is lost, little result is to be expected from an operation.

In proceeding to give an account of various operations of this class I must remark that in this province we are only taking the first steps at present, and it is generally a case of merely empirical treatment, because the complex nature of the changes occurring here renders it impossible to foretell with certainty the result of an operation. But yet former results are encouraging enough to justify an operation in a case for which nothing more can be done by other means. Extensive operations, however, are unsuitable here, for from too energetic measures there may easily result a recurrence of the suppuration with severe symptoms of reaction.

1. *The separation of thickened and cicatricially altered parts of the membrana tympani, which have adhered to the inner wall of the tympanum or to the incus and stapes* is the operation after cessation of suppuration of the middle ear which most frequently is accompanied by an important improvement in the hearing.

The performance of the operation requires first of all the determination of the locality and extent of the existing adhesions, by objective examination with the aural speculum in conjunction with the pneumatic speculum and the probe, and also the determination of the degree in which the function is disturbed, and the alteration in the hearing-distance after air has been forced into the middle ear. If the hearing-disturbance is great, and sufficient improvement for ordinary intercourse is not produced by repeated injections of air, then the experimental separation of those parts of the membrana tympani which are shown by examination to be most tightly strained is indicated.

I confine myself here to simple incisions, made with a little narrow knife (Fig. 184), rounded in front, and carried perpendicularly into the most tense parts of the membrana tympani, whether thickened or cicatrized. Severe inflammation almost never follows the incision. But I consider the so-called synechotomy decidedly injurious; *i.e.*, the loosening of adhering parts of the membrana tympani from the inner wall of the tympanum by means of little rounded knives, placed at right angles with

the axis of the instrument, for the loosening hardly ever succeeds, and the parts cannot be prevented from growing together again. Besides, by such operations reactive purulent inflammation is frequently produced, after the cessation of which the disturbance of the hearing goes on increasing, in consequence of the growing extent of the adhesions.

Simple incisions are indicated in the following cases of changes in the membrana tympani and in the inner wall of the tympanum: (i.) In the case of adhesions between the membrana tympani and the inner wall of the tympanum, when pitted depressions and thickened bands are visible on the surface of the membrana tympani (*vide* p. 440). By such fibrous formations the handle of the malleus is not unfrequently drawn strongly backwards and fixed, or it is united by a cord-like bridge with the long process of the incus, or with the crura of the stapes, whereby the vibrating power of the chain of ossicula is reduced to a minimum. In such cases, by one or two incisions made perpendicularly in the direction of the fibres, the tightly-fixed ossicula are often so materially relaxed that the displaced handle of the malleus assumes a more perpendicular position, and the power of hearing is at once improved to a considerable extent. The separation is often accompanied by a grating sound, and the sides of the incision are seen to gape in consequence of the retraction of the cut fibres.

FIG. 184.

(ii.) When there is a strongly-projecting fold behind the membrana tympani, and simultaneous retraction of the handle of the malleus.

The operation is indicated both in cicatrized openings in the membrana tympani and in persistent perforations, if the excessive deafness cannot be cured by any of the above methods of treatment. The division of this posterior fold is performed perpendicularly to the length of the fold, in the same way as in the non-purulent adhesive processes (*vide* p. 377). The result as regards the improvement of the hearing has in several cases been astonishing and permanent. Where there were subjective sounds these were greatly reduced after the operation; in some cases quite removed. Sometimes there has followed on incisions at this part a reactive purulent inflammation of the membrana tympani, which has passed off without injurious consequences.

(iii.) When there is thickening and inflexibility of the posterior segments of the membrana tympani.

This is of great consequence in connection with the disturbance of the function, because this part of the membrane is the most important for the conduction of sound. If, therefore, the posterior part appear dull and opaque, scarcely movable when tried by Siegle's speculum, and, when probed, stiff and unyield-

ing, I make an incision parallel with the handle of the malleus, midway between it and the posterior periphery of the membrane.

When the ossicula are not anchylosed the hearing-distance is often considerably increased by the relaxation of the membrana tympani.

I saw a most striking improvement in the hearing in the case of a man in his thirtieth year, who, on the cessation of a double otorrhœa, from which he had suffered for several years, was so deaf that he could not understand loud talking on either side at a greater distance than half a metre. Both membranes were much thickened, the handle drawn inwards, the posterior half of the membrane arched outwards, stiff and immovable. Strong injections of air caused no alteration in the hearing-distance. The sound of even a weak-ticking watch was perceived through the cranial bones. Without promising the patient any certain result, I made an incision 2 mm. long on both sides, through the posterior portion of the membrana tympani, parallel with the handle of the malleus. The hearing-distance of the right ear increased to 1½ metre, that of the left to 6 metres for whispered speech, and I was lately able, a year and a half after the operation, to convince myself of the permanence of the improvement in the hearing.

(iv.) When the lower end of the handle of the malleus or the part of the membrana tympani corresponding to the umbo has adhered to the wall of the promontory. The handle of the malleus appears greatly retracted, shortened, and perfectly immovable. It adheres directly to the wall of the promontory, or indirectly by a band of connective tissue, from which grey cicatricial tissue stretches downwards to the wall of the promontory.

Such abnormal adhesions of the handle, by which the incus and stapes are pressed strongly inwards, often occasion great disturbance of the hearing, which, as I have observed in many cases, is materially improved by repeated perpendicular incisions into the cicatricial tissue found in the immediate neighbourhood of the handle. But this operation is contra-indicated in those cases in which the long process of the incus has disappeared by absorption, for then the motion of the malleus exercises no influence on that of the stapes. The adhesion of the malleus is not quite removed by the incision, but the firmness of its union with the inner wall of the tympanum is lessened, and thus the whole ossicular chain is relaxed. The separation of the adherent handle from the promontory possesses no advantages over perpendicular incisions, for it is not possible to prevent the disunited parts from growing together again.

(v.) When there is a firm cicatrix in the posterior superior quadrant of the membrana tympani, so firmly adherent to the

articulation of the incus with the stapes, or to the part of the stapes separated from the incus, and the neighbourhood of the niche, that the motion of the stapes is thereby impeded.

By a horizontal incision immediately beneath the capitulum of the stapes the cicatricial tissue is divided, and the stapes thereby more or less relaxed. I perform the same operation when the inner wall of the tympanum is exposed, and the niche of the fenestra ovalis is filled with shining grey cicatricial tissue, and the stapes is so fixed thereby that its capitulum, as examined by Siegle's speculum or by the probe, remains perfectly immovable. Sometimes the tendon of the stapedius appears enveloped in the cicatricial tissue surrounding the niche of the fenestra ovalis, and is then visible on the surface of the cicatrix as whitish projecting striæ extending backwards from the capitulum of the stapes. By cicatricial shrinking of the sheath of the tendon, the muscle may be so shortened that the stapes becomes abnormally fixed by this means alone. Following Kessel's plan (*A. f. O.* vol. xi.), I have in several cases of this kind divided the muscle by an incision perpendicular to its length, and with good results as regards the improvement of the function of hearing. In my opinion the sole indication for tenotomy of the stapedius is the existence of the above-mentioned changes in the part surrounding the fenestra ovalis, when the muscle is enveloped in the cicatrix. But in the present state of our knowledge of the function of the stapedius, there is no reason for section of the muscle when it is lying free, and the value of the operation appears the more doubtful that it is sometimes followed by severe giddiness and intense hyperæsthesia to sounds, as appears from an observation of J. Pollak's (*A. W. M. Ztg.*, 1880).

(vi.) Operative separation of adhesion of the incus with the stapes. This operation is indicated in those cases in which, in consequence of partial or entire loss of the membrana tympani, the malleus and the incus are so greatly retracted by tension of the tendon of the tensor tympani, or by new-formed adhesions, that the stapes is pressed inwards by the long process of the incus, and immovably fixed. We conclude that there is such an obstacle to the conduction of sound if, in a case of great deafness, the handle of the malleus appears strongly inclined inwards and foreshortened, and the adhesion of the incus with the stapes is seen as a yellow rectangle projecting from the posterior superior quadrant of the field of vision (*vide* Fig. 148, p. 420), if the adherent part exhibits no noticeable motion when examined by Siegle's speculum, and if an improvement in the hearing takes place when the handle of the malleus is moved backwards by mechanical means, *e.g.*, by the pressure of the probe on the short process of the malleus. But even when mechanical manipulation has no influence on the power of hearing, improvement in the hearing may yet be possible, as I have several times

observed, for the incus may be so firmly fixed by tight adhesions to the walls of the tympanum, that mechanical pressure on the malleus produces no motion of the incus and stapes. A more favourable issue to this operation is possible only when, by separating the incus from the stapes, the latter is freed, and becomes again in part movable and capable of vibrating. But the operation is without result if the stapes has grown firmly into the niche of the fenestra ovalis; it is often very difficult to determine this, and therefore in doubtful cases the operation is only an experiment.

The operation may be performed by two methods according to the anatomical relations of the case. The first method consists in separating the articulation of the incus with the stapes by means of a small knife, rounded in front, and with a moderately curved surface. This method is to be recommended in those cases in which the incu-stapedial articulation is so exposed that it can be easily reached by the instrument. But it is impracticable when there are cicatricial adhesions between this articulation and the parts surrounding the niche of the fenestra ovalis, or when the articulation has been ossified by the previous inflammatory process, a change which may be conjectured from the great resistance met with in the attempt to cut through the joint. For such cases, the second method is to be recommended, which consists in snipping through the lower end of the long process of the incus by means of small probe-pointed scissors, after which the upper portion of the process of the incus is pressed forwards by a probe to prevent the separated extremities from reuniting.

2. *Operative Treatment for Producing a Cicatrix to Close up a Perforation of the Membrana Tympani.*—Whilst, as we have seen, perforations of the membrana tympani are frequently closed by cicatricial tissue directly after the suppuration has ceased, especially in the acute processes, yet these openings in the membrane very often remain persistent. For the latter cases, various operations are now proposed to bring about cicatrization. But just as we have hitherto scarcely succeeded in keeping open an artificial opening in the membrana tympani, so all previous attempts at the formation of a cicatrix to close the perforative opening have in the majority of cases been ineffectual.

Cicatrization of perforations of the membrana tympani is unquestionably of use in many cases, because, in the first place, the majority of the waves of sound are conveyed by the new-formed cicatrix to the ossicular chain; and, in the second place, by the closure of the opening the mucous membrane of the tympanum is protected from the injurious effects of cold, dust, and damp. But in other cases cicatrization of the gap in the membrana tympani may even impair the hearing-power of the individual,

namely, when there exist on the malleus or incus obstacles to the conduction of sound, or when the stapes has been isolated by the wearing away of the long process of the incus. In such cases sound-waves which, during the persistence of the perforation, could fall directly on the stapes, meet with great resistance at the malleus and incus when a cicatrix has been formed, and, as is shown by repeated observations, there not only results great deafness, but sometimes also violent tinnitus.

From this it is clear that when an attempt to close the opening in the membrana tympani is about to be made, one must always first ascertain whether greater harm will not result from the cicatrization. Therefore, as preliminary experiment, it is advisable to stop up small perforations with a little drop of thin glycerine on the point of a probe, and larger openings with a little bit of moistened paper or silk, and then to examine the hearing-power. The operation is permissible only if the hearing-distance is thus increased, or at least not diminished.

The simplest method of inducing the formation of cicatricial tissue on the margins of the perforation consists in rawing them by slight cauterization with a globule of lunar caustic, melted on to the point of a probe. The epidermic covering of the margin of the perforation is destroyed by the cauterization, and a reaction is produced which not unfrequently leads to new formation. In this way I have seen perforations of from 3 to 4 mm. in diameter, reduced to 1 mm. and less. In one case an opening the size of a lentil was reduced to that of a pin-point without its being possible to produce by continued cauterization its complete closure.

After the margin of the perforation has been cauterized, there frequently results, however, reactive inflammation of the membrana tympani, which spreads to the mucous membrane of the tympanum, and sets up again a long exhausted suppuration of the middle ear. If, in such cases, the attempt to arrest the secretion be successful, the opening is generally found to be still larger than before, in consequence of the previous suppuration.

Another method by which the formation of a cicatrix may be produced consists in making several incisions in the margin of the perforation. But this operation is not only very painful, but also produces, much oftener than cauterization, a reactive suppuration of the middle ear; and when this is exhausted the gap in the membrana tympani is, as a rule, larger than before the operation. Thus we see that the effect of neither method can be reckoned upon beforehand.

Cl. J. Blake has recommended covering the opening of the perforation with a sheet of moistened paper of corresponding size for the purpose of inducing the formation of cicatricial tissue. Not only is the mucous membrane of the tympanum protected by this means from external injurious influences, but the margins

of the perforation also are easily irritated, and the gap is diminished by the gradual formation of new tissue. Complete closure of old perforations has not been obtained by this method.

Myringo-plasty has lately been proposed by Berthold* as a new operative treatment for closing persistent perforations. In the case of a man, twenty-two years old, who had suffered since his fifth year from suppuration of both middle ears, myringo-plasty was performed on the left ear—the hearing-distance of which, after the suppuration had ceased, was 5 metres for whispered speech—for the purpose of closing a gap about 4 mm. wide beneath the umbo. The margins of the wound were freshened by applying a piece of adhesive plaster across the opening of the perforation. This was removed in three days, and a piece of skin, taken from the arm, was pushed in as far as the membrana tympani, and lightly pressed on the surface of the wound at the edges of the perforation, and the meatus closed with antiseptic wadding. After several days, the meatus having been carefully syringed, by which a part of the transplanted skin was removed, the opening was seen to be reduced to the size of a pin-point, and fourteen days later the perforation was completely closed, but without material increase of the hearing-power. With the exception of a second case described by Berthold, in which myringo-plasty was performed with good result, we have as yet no further observations regarding this operation. Experiments which I have made on living beings as to the practicability of this operation for various sizes of perforations show that only when the openings are small, or under 3 mm. in width, can the application of the transplanted piece to the edges of the perforation on all sides be performed with certainty, and that in larger perforations one rarely succeeds in making the piece fit exactly, because the edges of the perforation are on different levels.

3. *Treatment for keeping Gaps in the Membrana Tympani Open, and for the Restoration of the Opening in Perforations which have been closed by Cicatricial Tissue.* — The indication for this treatment is present in all cases in which, when the perforation has been temporarily closed by secretion or by epidermic masses, a striking decrease in the hearing-power results, which disappears when these have been removed. If in such cases, after cessation of the suppuration, the opening of the perforation is observed to be rapidly lessening, and therefore its complete closure may in a short time be expected, an attempt is made to prevent this by inserting a small thin leaden tent into the opening. But in doing this, one must see that the tent does not come in contact with the inner wall of the tympanum, and that it is worn only for a few hours in the

* *Tagebl. d.* 51, *Naturforschervers. in Cassel*, 1878.

day; for if it is left long in, the purulent inflammation may readily return. But even then, the edges of the perforation but rarely receive a covering of epidermis when there is a tendency to the formation of a cicatrix to close the opening. It is always preferable to the other method of destroying the growing cicatrix by the probe or the cautery, for by these latter means return of the suppuration is very often caused, and when there is a tendency to cicatrization, the closure of the opening cannot be prevented.

The restoration of a perforation closed by cicatricial tissue is indicated in cases in which, as long as the opening existed, the power of hearing was not materially diminished, but immediately after the cicatrization of the gap, intense deafness and severe tinnitus set in, and where, therefore, there is probably an impediment to the conduction of sound at the malleus or incus, the stapes being free and movable.

The methods hitherto proposed for destroying the cicatrix by caustics or the galvano-cautery have not yielded favourable results in so far that purulent inflammations frequently took place, and the closure of the opening could not be prevented. The mildest treatment is to split the cicatrix with a paracentesis-needle, and to insert a vulcanite eyelet into the restored opening. This method, which was described in detail, p. 375, is, however, only suitable for small, free cicatrices, 2 to $2\frac{1}{2}$ mm. in size, and serves to keep the gap in the membrana tympani open only for a time. For observations have hitherto shown that by wearing the eyelet for some time suppuration is set up, or else the eyelet moves away from its place towards the periphery and falls out, or is closed by secretion. In a case observed by me, in which there was no noticeable disturbance of the hearing from a perforation in the left ear, which had existed for several months, there suddenly resulted, immediately upon the cicatrization of the gap, a decrease in the hearing-power (watch = in contact, speech = 1 m.), and intense tinnitus. After an incision had been made in the reniform cicatrix lying under the handle of the malleus (Fig. 185), and the eyelet had been introduced, the hearing-distance increased to about 13 metres for speech, and at the same time the troublesome noises disappeared. In the course of six months the eyelet had moved upwards and backwards, leaving a sinus connected with the cicatrix, and filled with cicatricial tissue (Fig. 186). In consequence of suppuration of the middle ear, which occurred during an attack of typhus, the eyelet was so choked with secretion that it had to be removed by forceps. Soon after the opening healed up completely, and the hearing-distance decreased, but there yet remained, on the whole, a considerable degree of improvement in the hearing, which still continues—twelve years after the operation.

In conclusion, there remains to be mentioned the making of

several incisions into relaxed cicatrices, first proposed by me. This operation is indicated in cases of depressed relaxed cicatrices, when the deafness is diminished by bulging the cicatrix outwards, and when the same degree of disturbance of the hearing reappears when the cicatrix has returned to its former position. In these cases there result from the several incisions circumscribed condensations in the relaxed cicatrix, whereby its resistance is materially increased, and, with it, the vibrating power of the whole membrana tympani (comp. p. 380). No corroboration of the favourable results published by McKeown, which he says he has produced by applying collodion to relaxed

FIG. 185.

FIG. 186.

cicatrices of the membrana tympani, has as yet been received.

Carious Affections of the Temporal Bone developed in the Course of Suppuration of the Middle Ear.

Ætiology and Occurrence.—The occurrence of ulcerative osseous affections in the course of suppuration of the middle ear, the significance of which has already been pointed out, is due sometimes to certain local changes in the ear, sometimes to constitutional taint, especially to tuberculosis, scrofula, syphilis, marasmus, and other cachexiæ. Among the more important local changes are the following: stricture of the external meatus, polypi and granulations leading to retention of pus in the middle ear, stagnation, thickening, caseation, and decomposition of the purulent secretion in the air-spaces of the temporal bone, and finally catarrhal ulceration and wasting of the mucous membrane, extending in some places to the complete laying bare of the walls of the middle ear down to the osseous tissue (*vide* p. 405).

We have already indicated, in the anatomical section (p. 48), that the lining membrane of the tympanic cavity must be looked upon as consisting of two closely applied layers, the deeper of which plays the part of the periosteum. From these layers there penetrate numerous vascular prolongations of connective tissue into the interior of the bone, by which pathological changes become propagated into the spaces of the bone.

We very often find, therefore, even with quite a normal appearance of the osseous wall that has been stripped of its red and hypertrophied mucous membrane, an accumulation of round cells in the osseous spaces, which in their further progress either decay and become absorbed, or by conversion into connective tissue and by subsequent deposition of calcareous material lead to thickening of the bone, or finally, by degeneration and erosion, lead to ulcerative ostitis (osseous caries and necrosis.)*

In one of the cases of painless subsiding caries of the capsule of the cochlea described by Moos and Steinbrügge (*Z. f. O.* vol. x.), at certain points there was apparent a conversion of the groups of cartilage-elements lying in the cavity of the cochlea into granulation cells, while at other points there was a destruction of the capsule by molecular necrosis.

Caries of the temporal bone is developed more frequently in the course of acute purulent inflammation of the middle ear, especially in the scarlatinal forms (Moos, Burkhardt-Merian), than in chronic suppuration of the middle ear. The extent of it varies greatly. Between the slight circumscribed caries, confined to the size of a pin-head, and the extensive inflammation and destruction involving almost the whole of the temporal bone, there are found numerous varieties in the extent of the osseous affection. The most extensive destructions are found in these cases depending on scarlatina, tuberculosis, or scrofula. The mastoid process† and part of the posterior superior wall of the meatus adjoining it are most commonly affected; next, as regards frequency, comes caries of the walls of the tympanum, especially of the tegmen tympani and the promontory; and more rarely the pars petrosa and the anterior wall of the meatus are attacked. The process may confine itself to one of the portions named, but frequently it is found that several portions are carious and necrosed at the same time, often the mastoid process and the external meatus, or the mastoid process and the posterior portion of the pars petrosa, and lastly, the greater part of the temporal bone may be involved in the ulcerative process; indeed, the affection of the bones may spread from the temporal to the neighbouring cranial bones, most frequently to the occipital bone, more rarely to the zygoma, the parietal bone, or the cervical vertebræ.

Caries and necrosis spreading from the middle ear always lead, according to the extent and depth of the ulceration, to important changes in regard to the capacity of the middle ear and the

* The possibility of a primary osseous affection of the temporal bone, an affection therefore not induced by disease of the lining membrane of the middle ear or of the meatus, cannot be admitted, as definite clinical proof of such an affection has not yet been adduced.

† The affections of this process are described in a special section on account of their practical importance.

meatus. From degeneration and absorption of the osseous tissue, or from necrosis and exfoliation of bone in masses, there arises at individual places considerable enlargement of the cavity, and consequently increased communication between the meatus, the mastoid process, and the tympanum; while at other parts, especially in the vicinity of carious portions, the cavity is considerably contracted by diffuse, sclerosed osteophytes, or more frequently by flat, reticularly fenestrated ones (Zuckerkandl). The latter rise to a considerable height on the walls of the air-spaces in the mastoid process in chronic inflammation of the middle ear, or are at first filled with granulation tissue, which afterwards becomes ossified into a solid mass.

Simultaneously with caries of the temporal bone, one generally finds extensive changes in the lining membrane of the middle ear and of the meatus, as well as in the membrana tympani and in the ossicula. The mucous membrane is not unfrequently found to be ulcerated, or changed into a spongy granulation tissue, wholly or partially filling the cavities of the middle ear, and growing out into the meatus, or studded with polypous proliferations. The lining membrane of the meatus, especially in its osseous portions, appears infiltrated, undermined, or loosened, the membrana tympani to a great extent destroyed or degenerated with the formation of polypi (v. Tröltsch), very seldom wholly or partially united to the inner wall of the tympanum, the ossicula loosely articulated, carious, or exfoliated. The spaces not filled with proliferations of mucous membrane contain offensive, caseous, or greasy masses, or blood and exfoliated spiculæ of bone, mixed with grumous fluid, rarely with cholesteatomatous epidermic masses.

Caries of the ossicula occurs either independently or as a complication of caries of other portions of the temporal bone. The destruction is usually confined to one of the bones, more rarely the whole chain is affected.

Caries of the malleus most frequently affects the capitulum. But caries of this part very seldom exists independently, being generally combined with caries and necrosis of the body of the incus. In such cases the ulceration commonly spreads to the interior of the bone from the surface of the articulation of the malleus and incus directed inwards, after the joint has been opened by erosion of the capsular ligament or the union of the two ossicula has been loosened or quite destroyed.

The destruction is sometimes so extensive that one finds either only small eroded remains of the head of the malleus and of the body of the incus, generally embedded in granulation tissue, or else the head of the malleus quite absent, so that it appears to be sharply cut off above the short process.

The handle of the malleus, as long as it is surrounded by the tissue of the membrana tympani, rarely becomes carious, and

even when completely exposed it often withstands for a long time the corrosive action of the secretion, because the osseous tissue of the malleus receives its nourishment not only from the vessels of the membrana tympani, but also from an artery penetrating into the bone directly from the vessels of the tympanum (Kessel).

In cases of caries of the handle of the malleus its lower portion is generally lost, and then the remaining part projects into the opening of the perforation like the point of a rusty tack. The handle of the malleus is rarely so completely destroyed that only the head and a little stump at the short process are left.

The short process of the incus is seldom destroyed, but the

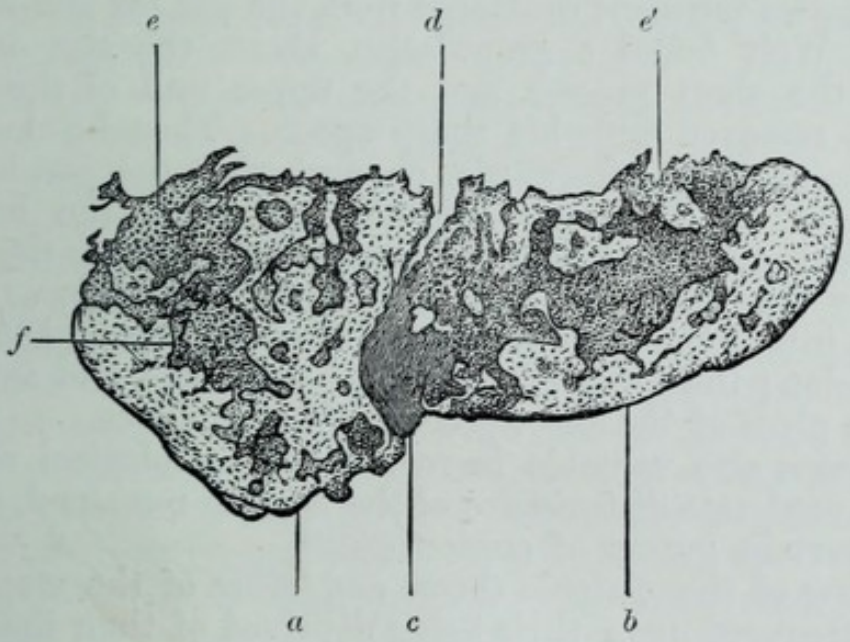

FIG. 187.—MICROSCOPIC SECTION OF THE CARIOUS ARTICULATION OF THE MALLEUS AND INCUS IN A WOMAN, 32 YEARS OLD, WHO DIED FROM AN ABSCESS IN THE CEREBELLUM, AND WHO HAD SUFFERED FROM OTORRHŒA FROM CHILDHOOD.

a, Head of malleus; *b*, Body of the incus; *c*, Capsular ligament; *d*, Cavity of the joint opened by erosion of the capsular ligament; *ee'*, Enlarged osseous spaces filled with round cells.

long process is very frequently, often indeed in the course of simple suppuration of the middle ear with swelling and secretion, uncomplicated with caries of other parts, or with the formation of granulations. There is not always a carious process involved in this, but only softening and atrophy of the bone, caused by the continual action of the secretion on the long process of the incus, which is exposed on all sides. I have sometimes found a thin ligament stretched between the stump of the long process of the incus and the head of the stapes. The importance of the interruption of the conduction of sound between the membrana tympani and the stapes, arising from the loss of the long process of the incus, has already been brought forward among the consequences of chronic inflammation of the middle ear.

Destruction of isolated parts of the stapes is also not infre-

quent. The head and the crura are most commonly destroyed, and of the latter sometimes the anterior, sometimes the posterior alone, but the destruction is rarely so complete that only the foot-plate in the fenestra ovalis remains.

Necrosis and exfoliation of the whole malleus by itself, without caries of the walls of the tympanum, is very rare indeed. A case of this kind lately reported by O. Wolf (*Z. f. O.* vol. x.) deserves special attention, because it did not arise from exudative necrosis after an acute infectious disease, but apparently from an independent ostitis of the malleus.

In the case of a woman thirty years old, healthy until then, but not very strong, who had suffered for some months from a slight painless purulent discharge from the left ear and moderate deafness, Wolf found a granulation about the size of a pea between the short process and the upper wall of the meatus, which he removed with his sharp spoon. Then he came upon carious bones, and afterwards, on syringing the ear, he found the malleus in the water, slightly eroded at the head and handle, but otherwise in good condition. When the wound caused by the operation had healed, the membrana tympani appeared intact, though somewhat drawn inwards and thickened like a tendon; the anterior process of the incus had apparently taken the place of the short process of the malleus.

The case is also valuable in regard to physiological acoustics, for but a moderate disturbance of the hearing remained, and that only for certain groups of consonants.

Softening of the ossicula (head and crura of the stapes), probably consequent upon their being deprived of their lime by the purulent secretion, was first observed by A. Hartmann (*A. f. O.* vol. xiii.) in the case of a phthisical patient.

The suppurative process in the middle ear leads further to slackening and to partial or entire luxation of the articulations, through inflammatory softening or ulceration of the capsular ligaments, even without caries of the ossicula. Mutual displacement and separation of the joints is also frequently caused by the pressure of inspissated masses or granulations upon the ossicula, or by the direct penetration of such substances into the cavities of the joints. Dislocation most frequently occurs at the articulation of the stapes with the incus, more rarely at that of the malleus with the incus, whereby the incus is pushed against the antrum mastoideum, or suppurates away, so that only the malleus and the stapes are found post-mortem.

The separation of the articulation of the malleus and the incus almost always occasions a change in the position of the malleus, especially when the handle is exposed and the check-ligaments are relaxed. The malleus then appears almost rotated on its axis, and hanging either from the tensor tendon or lig. mall. ant. I saw a most striking case of this kind in a man

who had suffered for many years from suppuration of the right middle ear. The membrana tympani was totally destroyed. The malleus, hanging by its anterior ligament, appeared so twisted round upon its axis that its head was turned downwards and outwards towards the lumen of the meatus, but the handle inwards towards the upper space of the tympanum.

The union of the edges of the stapes with the fenestra ovalis is also often so relaxed that the stapes falls out of the fenestra ovalis at the least touch with the probe (Schwartze). Yet at post-mortem examinations in which the membrana tympani, the malleus, and the incus are wanting, the stapes is most frequently found still preserved.

Besides the ligaments of the joints, the ligaments and check-ligaments uniting the ossicula with the walls of the tympanum, as well as the muscular tendons, are sometimes also relaxed and destroyed by the suppurative process, so that some or all of the ossicula suppurate away spontaneously, or are syringed out by the injection.

The character of the suppuration of the middle ear has undoubtedly a great influence upon the production of exfoliation of the ossicula. Whilst idiopathic suppurations of the middle ear rarely lead to exfoliation of these bones, one often sees them discharged by suppuration in forms caused by scarlatina, especially if complicated with diphtheria, and more rarely in tuberculous and scrofulous suppurations, when they are either carious, or, more frequently, perfectly normal. Exfoliation occurs not only from diseases of long duration, but sometimes just a few weeks after the beginning of the suppuration of the middle ear. Numerous examples of this kind are to be found recorded in the literature of diseases of the ear. In one of my cases in which an attack of scarlatina had occurred several weeks before, all the six ossicula were syringed out of the ears at the same time, and when carefully examined they proved to be quite normal. The boy in question was perfectly deaf in both ears.

General Symptoms of Caries of the Temporal Bone.—Of the subjective symptoms of caries of the temporal bone pain is generally the most prominent. This, which is usually very intense and permanent, is not always in proportion to the extent of the carious process, for sometimes very limited ulcerations of the bone are associated with violent pain, whilst in other cases, especially in tuberculous and scrofulous persons, caries, with the formation of extensive sequestra, often runs its course altogether without pain.

The cause of the pain lies sometimes in the inflammation of the periosteum and of the bone accompanying the ulcerative process, sometimes in the retention of the secretion, in which case the most intense pain will often decrease if the pus escapes spontaneously or is removed artificially. Simultaneous pains in

the face, probably from the caries spreading to the Gasserian ganglion, are rare. The pain often ceases also when the formation of sequestra is completed, but sometimes enclosed sequestra, or those partially adhering to the non-necrosed bones, are the cause of obstinate pain, which only ceases on the removal of the dead bone.

The following are frequent symptoms of caries, but by no means constant or characteristic: severe subjective noises, vertigo, stupefaction, great irritability of the nervous system, occasional excitement, and sleeplessness.

The objective signs of caries of the temporal bone are much more important. These are very variable, and by no means always so pronounced that we may infer from them that there is ulceration or necrosis deep in the bone. Still, the nature of the discharge and the changes in the external meatus and in the neighbourhood of the ear which accompany caries, and also not unfrequently functional disturbances in the area of the facial nerve, offer important grounds for supposing, most probably with justice, that caries does exist.

The discharge, especially when the caries is extensive, is very copious, and thick like cream, though it is often thin like meat-washings, and bloody, offensive, and corrosive. The suppuration may occasionally stop or suddenly cease entirely, if the escape of the secretion is prevented by constriction of the meatus, by granulations, or by the presence of sequestra. The recognition of such retention, as has already been emphasized, is of great practical importance, for the removal of the obstacle to the escape of the pus is often vital.

The consecutive changes in the external meatus are of special importance, particularly in reference to diagnosis. Diffuse swelling and infiltration of the cutis of the meatus, especially in the cartilaginous portion, and the outbreak of granulations and polypous proliferations in the osseous portion are not rare; less common is the formation of a deep ulcer on the inferior cartilaginous wall of the meatus, and its extension to the concha of the auricle. The frequent occurrence of bulging of the cutis of the upper and posterior wall of the meatus is of much greater importance. From the extension of the inflammation of the middle ear to the air-cells and diploe-spaces (*vide* p. 10) between the laminæ of the upper wall of the meatus (v. Tröltsch), or from caries of the mastoid process extending from the posterior superior wall of the meatus, there often result periostitis, infiltration, undermining and separation of the periosteum and the cutis by collections of pus, and, in consequence, a bulging of the wall of the meatus to such an extent that the bulged-out cutis reaches the floor of the meatus, and the lumen of the canal is quite obliterated. Such bulging of the lining membrane of the meatus, when frequently recurring or continuing long, must be regarded

as an unfavourable complication in suppuration of the middle ear, in so far that it generally accompanies obstinate periostitis, or caries of the superior and posterior walls of the meatus and of the mastoid process.

On examining such cases we find a tumour, convex below and not sharply defined, of a grey colour or dark red, and sensitive to the touch of the probe, which feels either hard and firm or, if undermined by pus, soft and yielding.

Bulging of the upper wall of the meatus generally takes place with violent pain, and is rarely painless. Resolution occurs either spontaneously or from treatment, especially when the tympanum has been washed out per tubam with warm water; or it goes on often only after some weeks to rupture of the hard resistant cutis, with discharge of fluid or caseous pus, cholesteatomatous masses, or necrosed pieces of bone from the meatus and the mastoid process. It rarely happens that part of the cartilage of the meatus is laid bare and eroded by the suppuration so that its jagged edges project into the cavity of the abscess or freely into the lumen of the canal.

After spontaneous rupture or artificial opening of such bulgings careful probing of the parts is necessary. By carefully probing one can often ascertain with certainty the extent of the loosening of the wall of the meatus, the length and direction of fistulous canals, the locality and size of carious parts, possible communications between the meatus and the mastoid process, and the presence of a sequestrum.

In consequence of caries of the temporal bone, extensive inflammatory collections and abscesses are often formed in the neighbourhood of the ear. Their most frequent site is about the mastoid process and the region below the auricle. They arise either from the extension of the inflammation from the bones or soft parts of the temporal bone to the surrounding parts, or from ulceration, or rupture, or sinking of the pus in the neighbouring tissue, or, lastly, without immediate connection with the morbid collection in the temporal bone, from the extension of the inflammation, by means of the blood and lymphatic vessels, to the soft parts surrounding the temporal bone.

The objective appearance varies greatly. Sometimes the region of the mastoid process is found to be much infiltrated, swollen, hard, or fluctuating, the auricle standing out from the head, and either normal or infiltrated; sometimes again in purulent infiltration of the lower wall of the meatus, and in caries and rupture into the interior of the mastoid process, a hard, painful swelling beneath the auricle, affecting the lateral cervical region, is found caused by infiltration of the subcutaneous connective tissue of the parotid and cervical glands. Occasionally the inflammation spreads on the one side to the occipital and cervical regions (with contraction of the cervical muscles), and on the other to

the crown of the head and the face. Erysipelas even sometimes occurs in the auricular region with great œdema of the face and eyelids, and may spread to the face, and even to the other side of the head, and along the neck to the thorax and the upper arm.

If it advances to the formation of an abscess in the parts surrounding the ear, then the pus either makes its way into the external meatus by bursting through the cartilage, one of the fissures of Santorini, or the membranous lamina completing the cartilaginous channel (p. 5), or it works its way to the surface of the skin on the external auricular region, breaks out in front of or behind the ear, and escapes to the outside; occasionally the pus penetrates inwards to the naso-pharyngeal space, where it may result in a retro-pharyngeal abscess (Chimani). The cavity of the abscess in the part round the ear may close up quickly if it has no direct communication with the carious tissue, but if there is a direct communication between the abscess and the carious tissue, then the spot where the abscess has broken through often becomes a fistulous opening, which generally remains so for years, indeed commonly until the deep osseous disease is cured.

There is great diversity in the site of these fistulæ, whose walls generally consist of infiltrated, callous tissue, often defying every attempt at treatment. They most frequently arise in the region of the mastoid process, sometimes under the auricle, and in front of the tragus. Fistulous canals communicating with the carious substance in the temporal bone not uncommonly open at distant parts, such as at the occiput, the cervical region, or, as in a case observed by me, in the supra-clavicular region. The number of these openings also varies. There is often only one opening, but sometimes there arise at different periods, close together or separated by a considerable distance, fistulous openings which communicate with each other directly or by their canals opening into the carious cavity. Sometimes a fistulous opening cicatrizes, and another breaks out at a different place.

A frequent symptom of caries developing in the temporal bone in the course of suppuration of the middle ear is paresis and paralysis of the facial nerve. (See p. 34 for the anatomical relations of this nerve to the temporal bone and the middle ear.)

Lesions within the area of the facial nerve are caused:

1. By inflammation, without caries of the osseous canal, spreading from the mucous membrane of the middle ear to the osseous walls of the Fallopian canal, and to the sheath of the facial nerve. Here, on account of the unyielding nature of the osseous walls, such pressure is exercised on the nerve-fibres when there is even but a slight exudation into the neurilemma that partial or total facial paralysis results. These are the more favourable forms of facial paresis in suppuration of the middle ear, for after resolution of the inflammation in the Fallopian canal, and after absorption

of the exudation, the paralysis completely disappears. Congenital gaps in the Fallopian canal favour, as already mentioned, the development of facial paralysis in cases of suppuration of the middle ear.

My observations show that slight facial paresis, only perceptible on close examination, is much more frequent than has been supposed in simple cases of chronic suppuration of the middle ear. If we compare the two sides of the face, especially when the suppuration of the middle ear is confined to one side, we often perceive an impaired action of the muscles of the side affected (Wilde). The observations of Wilde, v. Tröltsch, Tillmanus, etc., show that facial paresis sometimes occurs even in cases of simple, non-perforating catarrh. The most striking case which has come under my notice was that of a woman, thirty-three years old, in whom three and a half years before, at the time her hearing began to be impaired on the right side, twitchings of the muscles on that side set in, and continued for four months, when a gradually increasing facial paralysis commenced, which was complete in the course of a year. The deafness increased in proportion, so that examination showed the power of hearing to be reduced to half a metre for loud speech, the membrana tympani being highly concave, opaque, and in parts atrophied. The tuning-fork was heard loudly through the cranial bones by the affected ear. In all probability there existed here a gap in the Fallopian canal, so that in consequence of the shrinking of the mucous membrane of the middle ear, caused by the catarrhal inflammation, the facial nerve covered by this membrane was involved in the shrinking process.

2. By caries and necrosis of the Fallopian canal. These affect either a circumscribed part (generally the horizontal portion) of the osseous canal, or, as is more frequently the case in extensive caries, the inner and upper wall of the tympanum and the pars petrosa.

But caries of the Fallopian canal is not always followed by paralysis of the facial nerve, for records of post-mortem examinations show that a great part of the portion of the facial nerve which enters the tympanum may be laid bare either by congenital fissures or by caries of the osseous canal, and be bathed in pus without any sign of facial paralysis having been perceived during life. Paralysis is developed only when the inflammation or ulceration seizes upon the nerve itself.

Facial paralysis is generally unilateral. Bilateral paralysis of the facial nerve occurs but rarely in suppuration of the middle ear, though frequent in intra-cranial diseases, especially in basal tumours and in syphilis. A peculiarly wooden and immovable expression is characteristic of such bilateral total facial paralysis. In a case observed by v. Tröltsch (*Lehrbuch*, p. 481), the corneæ were partly dried in consequence of ectropion of the under lids,

the under lip hung loosely down, and the chin had to be pushed up in speaking and in eating.

The degree of facial paralysis varies according as transmission is interrupted only in certain bundles, or in the whole nerve trunk. In the former case the different branches of the facial nerve are unequally affected, so that the paralysis is sometimes most pronounced in the upper branches stretching towards the forehead and the orbicularis palpebrarum, and sometimes in the lower branches going off towards the nose and the angle of the mouth. General, though slight, paresis of the facial nerve points to diminished conducting-power in the whole nerve trunk. But complete and persisting paralysis affecting all the ramifications of the nerve affords grounds for concluding that there is a deep-seated lesion and interruption of their conducting-power.

Along with the well-known symptoms of paralysis of the facial muscles, there is also sometimes found paralysis of the muscles of the soft palate on the side affected. In determining paralysis of the muscles of the palate, curvature of the uvula towards the normal or the affected side is not so valuable a sign as the diminished mobility of that side of the palate corresponding with the diseased ear, perceptible on phonation. But there is often no trace of loss of motion in the velum palati. In these latter cases the disease of the nerve must be external to the geniculate ganglion, while in cases of paralysis of the velum palati it is assumed that there is lesion of the facial nerve internal to that ganglion, yet this assumption is by no means always correct. In a case in which I made a post-mortem examination, in which the whole of the pars petrosa was affected by caries, and the part of the facial nerve beyond the genu was thickened by infiltration and of a red colour, there was during life no paralysis of the velum palati, in spite of severe facial paralysis. Moos and Steinbrügge observed a precisely similar case (*Z. f. O.* vol. x.).

The effect of the electric current on the paralysed nerve and muscles varies greatly. In slight cases the reaction is often normal or somewhat increased. In severe cases the muscles of the side affected especially exhibit an abnormal reaction. The faradic contractility of the muscles at the beginning of the disease is frequently increased (Erb, Benedikt), but diminishes rapidly in its further course till it is quite lost, whilst the muscles respond more strongly to the galvanic current than do those on the normal side. In cases of advanced atrophy of the nerve and muscles, galvanic contractility also entirely disappears. When recovery or material improvement commences in such cases electric contractility, according to Benedikt, returns in inverse order to that in which it was lost. But the electric irritability of the nerve and muscles is not always proportionate to the actual improvement, for according to Erb, the electric excitability may be diminished after the return of mobility.

The course of facial paralysis is dependent upon the character of the anatomical changes, and upon the ratio at which the affection of the nerve advances. Sometimes severe pain in the ear and in the corresponding side of the face precedes the paralysis, but at other times there is not the least pain, and the paralysis is introduced by twitchings of the facial muscles (spasmodic tic), which may last for a shorter or longer period; or, lastly, the paralysis may come on quite suddenly, without any premonitory symptoms.

If the paralysis is caused by inflammation of the neurilemma and by effusion of exudation between the nerve-bundles, then the paretic condition varies on different days, according to the variable pressure to which the nerve is subjected by the exudation. A sudden relapse may follow an improvement which has lasted for days or weeks. If improvement or recovery occurs, it does not always affect all the ramifications of the nerve equally, for some branches remain paralysed longer than others. Recovery is sometimes limited to certain branches, while the paretic condition continues permanently in the area of distribution of others.

The results of facial paralysis are: (1) Complete recovery in those cases in which the inflammation, which has extended to the facial nerve, is fully resolved. (2) Persistent paresis of the whole nerve or of certain of its branches, when by thickening and retraction of the neurilemma the conducting-power of the nerve is impaired, or when individual nerve-bundles have their function destroyed by ulceration or fatty degeneration. (3) Complete and persistent paralysis of the facial nerve, when the conducting-power of the nerve trunk has been destroyed by ulceration or formation of indurated masses. The results of such paralysis are secondary atrophy of the facial muscles, rarely also of the corresponding half of the jaw, permanent conjunctival catarrh, and, when the corresponding side of the palate is paralysed, secondary catarrh of the middle ear on the previously healthy side. The latter is due to the abolition of the co-operative action of the whole group of palatine muscles, whereby the ventilation of the normal middle ear is prevented. The result, as I have had several opportunities of observing, is permanent hyperæmic engorgement in the tympanum and serous or mucous exudation, which, in spite of frequently repeated paracentesis of the membrana tympani, lasts for years, and always leads to renewed collections of exudation in the middle ear.

Although, according to the foregoing, secondary facial paralysis is not always of unfavourable prognosis, still its appearance in the course of suppuration of the middle ear must always be regarded as serious, for it is often the forerunner of a fatal cerebral affection, more rarely of a fatal sinus-thrombosis. Long continuance of the normal response of the nerve to electric irritation (constant

current) is generally to be regarded as a favourable symptom, while rapid diminution of the response is unfavourable (Erb). The prognosis is also more serious when there occurs rapid total paralysis with visible caries and necrosis in the interior of the ear.

There remains to be mentioned, in conclusion, as a frequent symptom of caries of the petrous bone, acceleration of the pulse and increase of temperature, especially towards evening—signs which may be of diagnostic importance in latent forms.

Diagnosis of Caries and Necrosis in the Temporal Bone.—The diagnosis of caries and necrosis of the temporal bone, especially when the affection is deep-seated and when striking symptoms are wanting, is very difficult, and often quite impossible. Examination is rendered especially difficult by the narrowing of the meatus, which often accompanies caries of the temporal bone, as well as by the rapid discharge of pus from the interior when there is profuse secretion, so that the field of vision is again flooded by secretion immediately after syringing. A diagnosis can be made with certainty only when objective knowledge of the carious and necrosed parts can be attained by means of the probe. This is possible only when carious parts of the osseous meatus are exposed, or when a sequestrum has penetrated from the mastoid process, or some other portion of the temporal bone, into the tympanic cavity or the external meatus, and can be touched and moved by the point of the probe. Probing is specially important in the recognition of caries and necrosis if the bare bone is overgrown with granulation tissue, or so completely concealed by it that nothing can be seen of the sequestrum on examination with the speculum. It must be borne in mind that the floor of the tympanum has a rough feeling like that of caries when touched with the probe, even when the bone is not diseased.

But although the use of the probe is so important in the diagnosis of caries of the petrous bone, we must most emphatically point out the dangers which may result from careless probing. For from coarse manipulation with the probe not only may destruction of the membrana tympani readily result, but also dislocation of the ossicula, the articulations of which are readily relaxed. Thus, not only is the possibility of a restoration of normal sound-conduction permanently lost, but there is also the danger that, by the dislocation of the stapes, generally very loose in the fenestra ovalis, pus may escape into the cavity of the labyrinth, the expansion of the auditory nerve be destroyed thereby, and the pus then penetrate through the internal meatus into the cranial cavity. So also in caries of the already thinned inner wall of the tympanum, the brittle bony lamella may easily give way when roughly probed, with the same mischievous result of a flow of pus into the cavity of the labyrinth. But besides this, rough probing may also have dangerous consequences, by

opening into certain spaces in the diploe, into which the pus may penetrate, and thence enter the venous passages in the skull and general circulation.

When examination with the probe yields no positive result, it is only from the coincidence of several symptoms that caries of the temporal bone may with probability be assumed to exist. Thus we may consider it as highly probable that there is ulceration of the temporal bone in cases of persistent or frequently recurring pain in the ear, with a copious or offensive discharge like meat-washings, when at the same time the osseous meatus is constricted by infiltration or bulging of its lining membrane, or by polypous proliferations, or in cases of frequently recurring abscesses in the parts round the ear.

The presence, in cases of caries, of elastic fibres in the secretion, first noticed by Moos, is by no means constant, and therefore the finding of such fibres is not a decisive proof, for similar fragments of tissue may occur in the secretion when the tissue of the membrana tympani is destroyed. Their occurrence in cases in which the whole membrane is destroyed is of more value; Moos himself cites one such. So also much dependence cannot be placed upon the abundance of carbonate of lime in the secretion, in cases of caries, as asserted by v. Tröltsch, for this also is not constant, and an exact chemical proof of it is very difficult.

Prognosis of Caries of the Temporal Bone.—The prognosis of caries depends upon the character of the ulcerative process, its locality, and partly on its extent. The chances of limiting the ulceration are greatest in otherwise healthy patients, in superficial caries, and when the local conditions are favourable to the escape of the secretion and the removal of the sequestrum. On the other hand, the prognosis is unfavourable in individuals suffering from constitutional diseases, especially tubercle, scrofula, inveterate syphilis, and marasmus, also in deep-seated caries of the pyramid or of the mastoid process, in abnormal adhesion of the membrana tympani to the inner wall of the tympanum, and in extensive formation of granulations in the middle ear, which leads to the retention of the putrid secretion in the interior, and prevents the removal of inspissated masses.

The extent of the ulceration of the bone has less influence on the prognosis with regard to fatal results, for, as we shall see, a very limited caries confined to the roof of the tympanum sometimes leads to rupture into the cranial cavity, while in extensive caries, reaching to the dura mater and the venous sinuses, a great part of the temporal bone may form a sequestrum, and be ejected without causing a fatal result. Still, the hearing function is generally destroyed to a greater degree when the caries and necrosis are extensive than when the affection is limited.

The Course and Result of Caries of the Temporal Bone.—The

course of caries of the temporal bone is uncertain. It is either developed acutely, with rapid destruction of tissue and formation of sequestra in the bone, or the ulceration runs a chronic, slow course, and only after long duration ends by the formation of a sequestrum. Not unfrequently an occasional pause during its course occurs, which is succeeded by an exacerbation of the destructive ostitis, either gradually or with violent symptoms of reaction. The caries may even be entirely cured at one part of the temporal bone, and then break out again after some months or years at another part or in the neighbourhood of the former inflammation.

The results of caries are:

1. Recovery without material deformity of the framework of the temporal bone. This result is most frequent in caries of the superficial osseous lamella of the external meatus and of the middle ear, more rare in deep-seated affections of the bone.

2. Recovery with permanent loss of osseous tissue. The destruction in this case does not always take place with exfoliation of osseous fragments, but may occur with a gradual absorption of the bone-tissue spreading from the surface to the interior, which leads to great enlargement of the middle ear and of the external meatus, and to confluence of the enlarged spaces by disappearance of the intermediate walls. In other cases the caries heals after arrest of the ulceration, with exfoliation of necrosed fragments of bone in the form of irregular, rough, and sometimes much fenestrated sequestra.

The formation of sequestra in the temporal bone sometimes goes on very rapidly, especially in the course of scarlet fever in children, but generally it is very slow. By the presence of the sequestrum in the carious cavity profuse suppuration and the formation of new granulations are almost always maintained, while on the removal of the fragment of bone the suppuration generally rapidly decreases and the proliferations soon shrivel up. Violent pains, convulsions, and vomiting (Moos) often cease on the removal of sequestra. Sometimes the sequestrum wanders from its original situation, frequently from the mastoid process and the tympanum to the external meatus, more rarely, as in one of my cases, from the mastoid process into the tympanic cavity. Sequestra of the labyrinth either remain in their original situation or enter the tympanum and then the external meatus.

The size and form of exfoliated necrosed fragments of the temporal bone depend upon the site and extent of the caries. The more extensive and the deeper seated the disease of the bone, the larger, as a rule, is the sequestrum. The latter is either in one piece or in several fragments. In children very extensive destruction and exfoliating necrosis occur just as in adults.

Superficial necrosis limited to the osseous meatus is localized,

as I have repeatedly noticed in tuberculous individuals, on the inner portion of the posterior superior wall, which is exfoliated in the form of a curved, bow-shaped, jagged lamella, with a part of the sulcus tympanicus visible on its inner edge. Such sequestra are generally covered over with granulation-tissue, and may be extracted with small polypus-forceps after they have been loosened with the probe. I have several times found the anterior inferior wall of the meatus exposed and rough, but again becoming covered with smooth cicatricial tissue in the course of treatment, without exfoliation of the necrosed bone. In children in whom the development of the osseous meatus from the annulus tympanicus is just going on, and its union with the other parts of the temporal bone is still not very firm, whole pieces of the annulus tympanicus, and rarely, as I saw in one case, both annuli tympanici (Fig. 188) are completely necrosed and discharged as sequestra, on which the sulcus tympanicus is generally quite visible.

Circumscribed, superficial necrosis of the walls of the tympanic cavity, according to my observations, most commonly affects the external osseous layer of the promontory, which is thrown off in the form of thin, serrated laminæ, among which there is sometimes a piece of the sulcus Jacobsonii, which indicates the seat of the necrosis. In other cases there is developed in consequence of ulcerative destruction of the mucous membrane, without any visible caries of the bone, an ulcer in the bone of the promontory, penetrating to the lamella of the labyrinth, and receiving a worm-eaten, ragged appearance from the numerous ridges and depressions of the inner wall of the tympanum. Superficial sequestra on the outer and superior wall of the tympanum are rare.

Of greater extent and importance is the formation of sequestra in cases of deep-seated caries. This is almost never confined to one portion of the temporal bone, but if so most frequently to the mastoid process and the labyrinth. More frequently sequestra are formed at the same time in parts of the meatus and of the mastoid process, or of the mastoid process and the pyramid, or of a great part of the temporal bone with parts of the meatus, the squamous bone, the mastoid process, and the labyrinth.

The literature of diseases of the ear is rich in examples of necrosis and spontaneous exfoliation of great parts of the temporal bone. Voltolini (*M. f. O.* 1874) saw, in the case of a child of twenty-two months, an exfoliation of the annulus tympanicus with part of the pars squamosa and mastoid, which took place in the course of a syphilitic suppuration of the right middle ear. Michael (*Z. f. O.* vol. viii.) extracted from the left ear of a child of three years, several sequestra, and among them the upper portion of the inner wall of the tympanum containing the greater part of the fenestra ovalis and part of the facial canal which runs over it. Not unfrequently single parts of the labyrinth, or the whole

of it, are exfoliated. Most frequently, as is shown by the observations of Toynbee, Menière, Lucae, Dennert (*A. f. O.* vol. x.), Cassells, Shaw, Pomeroy, Richey (Schwartze) (*Chicago Med. Journal*, vol. xxvi.), Gruber, Pareidt, etc., the cochlea forms the sequestrum owing to the caries and necrosis penetrating from the inner wall of the tympanum to the labyrinth. In the case of a girl of seven years, observed by me, after two years' chronic suppuration of the left middle ear, a polypus appeared growing from the tympanum; and on its removal a sequestrum was seen in the interior, which, on being extracted, proved to be the cochlea with the whole modiolus and with the greater part of the osseous lamina spiralis (Fig. 189). On testing the hearing, there

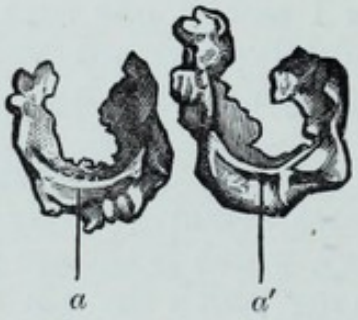

FIG. 188.—ANNULI TYMPANICI NECROSED AND EXFOLIATED DURING SCARLATINOUS SUPPURATION OF THE MIDDLE EAR.

a, *a'*, Sulc. tymp. From preparations in my collection.

FIG. 189.
Twice the actual size.

was found to be total deafness on the left side; the tuning-fork applied to the vertex was only perceived by the right ear. In the case of a girl of eight years, Guye extracted the semicircular canals with a part of the vestibule as sequestra from the opened mastoid process. In this case, the absence of all disturbances of co-ordination was interesting. Cases of sequestra consisting of the whole labyrinth are rarer. Of such deserving of mention is a sequestrum described by Toynbee (*A. f. O.* vol. i.), which included the whole labyrinth, with the internal meatus and the commencement of the facial canal. Wilde describes a sequestrum extracted by Sir Philip Crampton, which consisted of the whole labyrinth and the inner wall of the tympanum. This case is also so far interesting, in that a unilateral paresis of the extremities disappeared on the removal of the sequestrum. In the case of a child, Voltolini likewise extracted the whole labyrinth, and described (*M. f. O.* 1870) a similar preparation which was removed from the ear by Jacobi. Delstanche the younger (*A. f. O.* vol. x.), in the case of a scrofulous child of six years, removed, along with necrosed parts of the osseous meatus, the complete osseous labyrinth, of which only one of the semicircular canals was wanting. At the Milan Congress, 1880 (*A. f. O.* vol. xvi.), Gottstein showed a sequestrum extracted from the region of the

mastoid process (girl of eight), in which were perceptible a part of the squamous bone, of the ann. tymp., of the mastoid process, and of the labyrinth with the fenestra ovalis. In a case observed by Moos of a man with caries of the petrous bone, and who had suffered for a week from violent vertigo and vomiting without fever or cerebral symptoms, there followed on the extraction of an exfoliated osseous semicircular canal from the external meatus complete disappearance of these symptoms. A month before, the hearing-distance for speech was three metres, and the high and low notes of the tuning-fork were heard. After the extraction of the sequestrum, there was total deafness on the side affected. But discharge of the sequestra does not always take place; they may remain in the interior, and be found post-mortem in the temporal bone, as recorded by Toynbee (*l. c.*), v. Tröltsch (*Virch. Arch.* vol. xvii.), and shown by several preparations in my collection.

While, then, as we shall see later on, ulceration of the tegmen tympani hardly as large as a pin-head is sufficient to give rise to secondary fatal meningitis, we see from the cases here quoted that cure is possible in spite of extensive destruction of the petrous bone, reaching almost to the dura mater. This result occurs only when proliferations of the connective tissue are developed on the outer lamella of the dura mater, whilst the osseous ulceration is extending to it, whereby a protecting wall is raised against the approaching suppurative process. This has been shown by the proliferation of the connective tissue of the external meatus, observed by Wendt, which in the case of a sequestrum of the pyramid prevented the suppuration from spreading to the base of the skull.

When the sequestrum has been discharged or removed, the cavity formed by the loss of substance is either rapidly filled up with granulations which ossify after being changed into fibrous connective tissue (callus), or the walls become overgrown even in the presence of the sequestrum with a thin layer of connective tissue covered with epithelium, which on the removal of the sequestrum often forms a basis for the deposit of stratified laminæ or cholesteatomatous masses (comp. p. 454).

As formerly mentioned, after caries and necrosis of the temporal bone are exhausted there frequently remain abnormal cavities and a confluence of the spaces of the meatus, the mastoid process, and the tympanum, and also fistulous openings round the ear. Often however, through exostosis and hyperostosis, they end not only in obliteration of the cavities formed by the necrosis, but also in narrowing and obliteration of parts of the tympanic cavity and of the meatus, or in obliteration of the whole meatus, and in atresia of the external meatus, which is closed at various depths with unyielding osseous masses like a cul-de-sac. These changes result of course in deafness of the highest degree, and sometimes,

even when the labyrinth is uninjured, in total deafness. In necrosis of the labyrinth the power of hearing is generally quite destroyed, but yet when there is erosion of the semicircular canals, the perception of sound may still exist in various degrees if the purulent effusion does not reach the cochlea. (For the value of examination with the tuning-fork in carious processes, see p. 183.)

Suppurations of the Middle Ear Terminating Fatally.

A fatal issue occurs in suppuration of the middle ear:

a. When caries of the temporal bone extends to adjacent vital organs; thus:

1. By purulent meningitis, or by the formation of cerebral abscesses, the surface of the petrous bone, which is directed towards the cranial cavity, being fenestrated in one or more places, and the suppuration spreading to the meninges and the brain.

2. By septic phlebitis, thrombosis, embolism, and septicæmia, consequent upon the extension of the purulent process to the venous sinuses on the petrous bone, or the sinus of the jugular vein.

3. By bleeding from the ear; the internal carotid artery on the anterior section of the temporal bone or the lateral sinus on the inner side of the mastoid process being eroded.

b. Without bursting of the suppuration into the cranial cavity:

1. By phlebitis of the cerebral sinuses; more rarely by meningitis and cerebral abscess.

2. By the reception of septic matter into the blood from the cavities in the temporal bone (pyæmia), or by a general cachexia, proceeding from the local disease, especially tuberculosis.*

1. *Fatal Termination of Suppuration of the Middle Ear resulting from Meningitis and Cerebral Abscess.*

The bursting of pus into the cranial cavity from the temporal bone, with consecutive meningitis and cerebral abscess, may occur in the following various sites at the base of the skull:

(*a*) On the tegmen tympani and on the roof of the antrum mastoideum. The roof of the tympanic cavity either exhibits one small perforation only, or is broken in several places like a sieve (as in a perforation in my collection), or in the process of destruction an aperture with jagged, irregular edges is made, involving most of the tegmen tympani, by means of which the

* The determination of the percentage of cases of suppuration of the middle ear which prove fatal is impossible, because, amongst the great number of cases dismissed as cured or improved, many undoubtedly terminate fatally without the knowledge of the physician formerly in attendance. The number of deaths, therefore, recorded by any observer may form but a fraction of the fatal cases which have been widely dispersed and withdrawn from his notice.

pus or cholesteatomatous masses (Burkhardt-Merian, Bezold) penetrate from the middle ear into the cranial cavity, or into the brain substance. The presence of fissures in the roof of the tympanic cavity favours the advance of the suppuration from the middle ear to the cranial cavity (Fig. 190), as has been already demonstrated in the anatomical part.

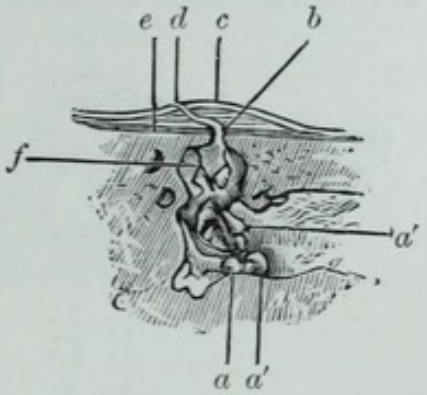

FIG. 190.—DIAGRAM OF A SECTION OF THE TYMPANIC CAVITY FROM A PATIENT WHO DIED OF A CEREBRAL ABSCESS FROM AN OTITIS.

a, *a'*, *a''*, Bulbous, pedunculated polypi growing out of the tympanic cavity into the auditory canal; *b*, Fissure in the tegmen tympani, 1½ mm. in size, without trace of caries in the vicinity; *c*, The dura mater adhering to the brain lifted up like a tumour by the exudation; *d*, Sinus in the dura mater passing obliquely, the inner opening of which communicates directly with an abscess the size of a hen's egg in the temporal lobe. From a girl, 21 years of age, who had suffered since childhood from scarlatinal suppuration of the middle ear, and had for 5 weeks endured violent headaches, but had nevertheless been on her feet up to the day of her death. In the tenth week of her residence in the hospital, sudden rigors, temperature 40·2° C., general convulsions, inertia of the pupils, rigidity of the neck, eyes turned inwards and upwards, pulse thread-like and irregular, stupor, death in 7½ hours.

(*b*) On the posterior surface of the pyramid of the petrous bone. The suppuration in the bone advances from the tympanic cavity or the antrum mastoideum without injury to the capsule of the labyrinth, passing through the pneumatic and diploetic spaces of the petrous bone towards its posterior surface (Fig. 191), whereby the pus not unfrequently makes a way for itself through the petroso-mastoidean canal, which is not always obliterated (Voltolini).

On the other hand, there are cases in which the capsule of the labyrinth is either partially destroyed or wholly stripped from the surrounding bone by an extensive ulceration (Fig. 192).

(*c*) Through the internal auditory meatus, when after erosion of a semicircular canal (Fig. 193), of the vestibule, of the cochlea, or of one of the two fenestræ of the labyrinth (Schwartze), the cribriform lamina separating the internal auditory meatus from the labyrinth becomes fenestrated, and the pus reaches the base of the skull through the above meatus. In the same way, after erosion of the Fallopian canal, the suppuration may advance along the facial nerve to the internal auditory meatus, and thence to the base of the skull. Suppuration rarely spreads from the labyrinth to the base of the skull by means of the aqueducts of the vestibule and of the cochlea (Gull).

Otitic Meningitis.

Anatomical Changes in the Meninges.—Inflammation of the outer layer of the dura mater, resulting from caries of the bone, spreads inwards through its strata, with greater or less rapidity.

Frequently, before cribration of the dura mater, inflammation arises on its inner surface, and from thence may attack the pia mater and the brain. A circumscribed pachymeningitis of this sort sometimes induces a matting together of the dura with the pia mater and the brain.

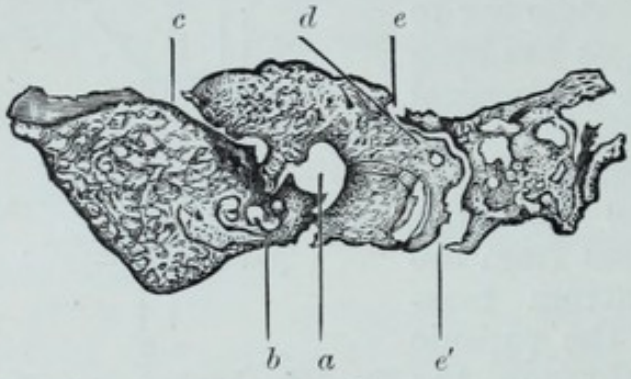

FIG. 191.—DIAGRAM OF A HORIZONTAL SECTION OF THE PYRAMID OF THE PETROUS BONE IN A PATIENT WHO DIED OF ABSCESS OF THE CEREBELLUM.

a, Vestibule; *b*, Cochlea; *c*, Internal auditory meatus; *d*, Semicircular canal; *e*, Tympanic aperture of a carious canal running behind the semicircular canals and discharging itself at *e'* on the posterior surface of the pyramid, close to a second opening. Two apertures, corresponding to these openings, were found in the superior vermiform process of the cerebellum leading into two separate abscess-cavities, the size of a nut, in the left cerebellar hemisphere. From a woman, 32 years of age, who had suffered since childhood from otorrhœa of the left ear; the symptoms of the consecutive cerebral affection being: bilious vomiting, convulsions, with left facial paresis, and violent occipital pain, lasting for 4 weeks before death.

When a perforation of the dura mater follows, its tissue appears infiltrated in the neighbourhood of the aperture, much thickened by layers of exudation, or undermined by pus, and separated from its osseous basis. The ulceration is either so extensive that after removal of the brain a jagged aperture over the tegmen tympani is apparent in the dura mater, or the pus discharges itself from the osseous aperture into the cranial cavity, through a sinus running obliquely in the thickened dura mater, the internal orifice being thus discovered at some distance from the breach in the bone (Fig. 190). In one case I found several perforations in the dura mater corresponding to the sieve-like cribration of the tegmen tympani.

Consecutive purulent meningitis seldom limits itself to the dura mater (*pachymeningitis purulenta*), but in general attacks almost simultaneously the soft meninges (*leptomeningitis purulenta*). The extension of the affection varies greatly. At times the inflammation attacks only a small area in the vicinity of the ulcerated spot; more frequently, however, purulent infiltration is discovered in the lower surface of the cerebellum and the covering of the medulla oblongata. In more severe cases the meningitis extends not only over the whole base of the brain, but also to the convexity of the cerebrum and as far as the canal of the spinal cord. The brain cavities contain an excessive quantity of serous or purulent fluid, and the brain substance beneath the dura mater, which is infiltrated with pus, appears sodden with serum, ecchymosed, and softened.

The destruction of the osseous parts adjoining the dura mater does not always lead to fatal meningitis. By reason of its strong

fibrous structure, the dura mater frequently withstands for a long time the destructive action of the pus. In the case of a consumptive patient, examined by me during life, and in whom no marked symptoms of caries existed beyond profuse otorrhœa and great contraction of the meatus, I discovered after death the membrana tympani destroyed, the malleus

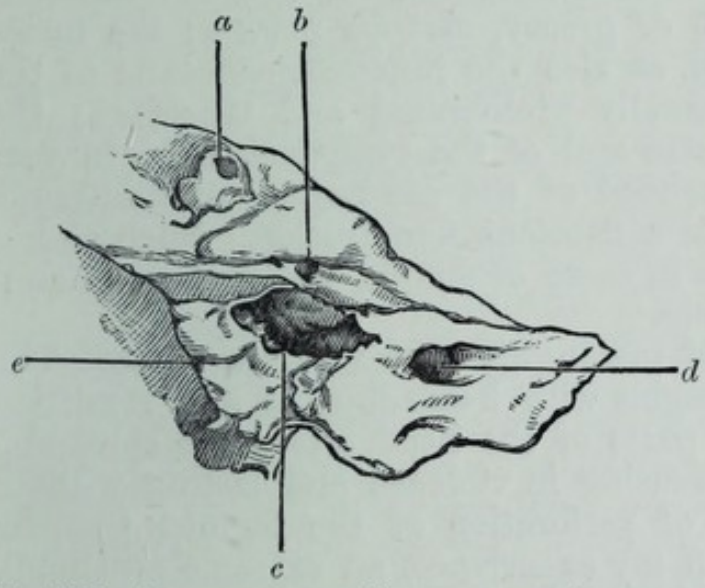

FIG. 192.—DIAGRAM OF THE SUPERIOR AND POSTERIOR SURFACE OF THE PETROUS BONE IN A PATIENT WHO DIED OF CEREBELLAR ABSCESS FROM AN OTITIS.

a, An irregular osseous defect in the tegmen tympani, 5 mm. in size; the bared mucous membrane with a pin-hole perforation, the dura mater at that point swollen and discoloured; *b*, Fenestra in the superficial petrosal sinus containing a thrombus; *c*, Necrosed aperture in the posterior surface of the pyramid in which the rough and uneven capsule of the labyrinth is visible; *d*, Meatus auditorius internus; *e*, Lateral sinus. In the left cerebellar hemisphere two abscesses, the size of a hazel-nut, communicating with the fissure in the petrous bone. The facial nerve swollen and infiltrated with pus. From a woman 36 years of age, scrofulous, affected for 2 years with otorrhœa of the ear, and suffering, when admitted, from violent occipital pain and left facial paralysis. Fourteen days after her admission repeated bilious vomiting and fever set in, this condition lasting for 9 days. On the tenth day the patient lost consciousness, neck became rigid, left pupil contracted, and pulse thready; death on the following day without convulsions.

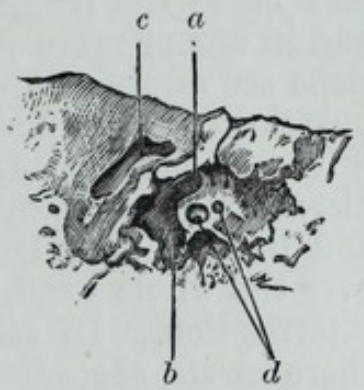

FIG. 193.—DIAGRAM OF THE INNER WALL OF THE TYMPANIC CAVITY FROM A TUBERCULAR PATIENT, 59 YEARS OF AGE, WHOSE DEATH HAD BEEN CAUSED BY PURULENT MENINGITIS.

a, Fenestra ovalis; *b*, Fenestra rotunda; *c*, Eroded horizontal semicircular canal through which, as well as through the two eroded apertures on the promontory *d*, the pus discharged into the cavity of the labyrinth and thence to the base of the skull. Purulent pachy- and lepto-meningitis. Destruction of the facial nerve. During life there was no perception of the tuning-fork from the vertex in the affected ear.

and the incus absent, and in the tympanic cavity an irregular osseous sequestrum the size of a hazel-nut, which had wandered from the mastoid process. The roof of the tympanic cavity showed two large, irregular perforations in the bone, at which the thickened mucous membrane was fenestrated. Corresponding to these, there existed on the outer surface of the dura mater layers of exudation firmly adhering to its tissue, without there

being any sign of inflammatory change on the inner surface turned towards the pia mater.

Symptoms.—As regards the objective result in the ear, in cases of fatal suppuration of the middle ear, the symptoms described in caries are of frequent occurrence, thus: narrowing of the meatus, its channel being filled up by polypous growths and granulations, and in the deeper parts either fetid and discoloured secretions often mixed with blood, or greasy, caseous masses; the membrana tympani perforated, as also the mucous membrane of the middle ear, which is usually proliferated and ulcerated; the osseous walls of the meatus and of the tympanic cavity in part laid bare; the neighbourhood of the ear normal or infiltrated, and in one or more places a fistulous fenestration. Such alterations are rarely met with in cases of simple, uncomplicated suppurations of the middle ear.

The clinical picture of meningitis otitica varies much. The disease almost always begins with headaches, at first remitting and limited to isolated parts of the head, afterwards spreading over the whole head, increasing in violence and lasting without interruption. In cases of perforation of the tegmen tympani there exists, according to my experience, an extreme sensibility to pressure upon the portion of the temple overlying the auricle. I have several times observed upon this spot a livid discolouration of the skin, even before the appearance of a fatal issue.

At the beginning of the disease frequent accompaniments of the headache are persistent, bilious or mucous vomiting, great agitation, sleeplessness, loss of memory, and hyperæsthesia of the cutaneous nerves. With the further extension of the inflammation consciousness becomes more and more dulled, convulsions of the muscles of the extremities and of the face make their appearance, more especially on the affected side, increasing to general convulsions either with or without convulsions of the neck and opisthotonos. The pupils are usually strongly contracted, reacting but little to light; the temperature variable, sometimes moderately high, sometimes again very high, more especially in meningitis affecting the convex surface of the brain. The frequency of the pulse, at the beginning almost always great, is at a later period diminished by the increase of the cerebral pressure, again to increase in the last stage of the disease. At the close paralyses occur—that is, either paralysis of the individual extremities or hemiplegia; the pupils dilate for the most part unequally; paralysis of the muscles of the bladder and of the rectum comes on; the respiration becomes hurried, the pulse small and frequent, and death follows on a comatose condition with symptoms of general paralysis.

The combination of symptoms here described is by no means constant in every case, for frequently during its whole course a series of marked symptoms may be wanting, such as convulsions

and slowness of the pulse. Those most constant are headache, vomiting, the diminution, and later, the loss of consciousness.

Course.—Its course is sometimes slow, sometimes very rapid. In its protracted forms the outbreak of the violent symptoms is often preceded for weeks or months by intermittent attacks of severe headache, and, later, by spasms in the muscles of the face, or facial paralysis. Even after the appearance of the above-named alarming phenomena, its progress may drag slowly up to the time of death, the vomiting, loss of consciousness, and convulsions may disappear again entirely, and the health be apparently normal for a longer or shorter period. Such paroxysmal attacks may often recur at greater intervals, until finally, after weeks or months, the illness terminates fatally with coma and general paralysis. In the case of a girl of twelve years of age under my care, suffering from chronic suppuration of the right middle ear, who had lain, according to her parent's statement, for eight days in a state of unconsciousness and stupor, recovery was brought about, after repeated washing out of the tympanic cavity, by means of a tympanic catheter inserted in the aperture of the perforation (see p. 464). Two years later, without apparent retention of pus in the middle ear, she succumbed to a meningitis within six days.

In other cases its course is short, especially in children, when meningitis supervenes in the course of acute purulent inflammation of the middle ear (Prout), sometimes also in chronic suppuration of the middle ear. I have seen cases in which the whole process up to death occupied only two or three days.

Result.—The result of otitic meningitis is almost without exception fatal, when the inner meninges are attacked after the discharge of the pus into the cranial cavity *ex continuo*. On the other hand, the possibility of recovery is not excluded if the inflammation of the inner meninges has arisen without the interposition of caries and perforation of the dura mater, or, even in the presence of caries, when only the outer surface of the dura mater is affected (see the case, p. 529). In such cases, by the occurrence of favourable local changes, such as the removal of a sequestrum or of decomposed retention-products, the inflammation may be resolved, and recovery may take place. Anatomical changes of this nature may have existed in a series of those rare cases cited in literature, as recovery from meningitis otitica. Kippe (*Z. f. O.*, vol. viii.) describes two cases of recovery from otitic meningitis in spite of decided cerebral symptoms and optic neuritis, and quotes from Albutt two similar cases in which the diagnosis of meningitis is based by him upon the existence of optic neuritis. A case of recovery from an otitic cerebral illness, under my observation, arouses special interest because the entire combination of symptoms and the progress betokened a deep-seated affection of the brain.

M. S., seventeen years of age, a sufferer since childhood from left otorrhœa, presented herself in 1871 with a highly vascular polypus in the tympanic cavity. After its removal a relapse occurred some months later. After repeated removal and cauterization of the granulations, the patient, who dreaded the operation, remained away. Six years later (May, 1877), symptoms of meningitis appeared, preceded by earache and giddiness; viz., vomiting, headache, obfuscation of the consciousness, eclamptic attacks with complete unconsciousness, hyperæsthesia of the skin and optic neuritis, lasting with trifling fluctuations during several weeks, after transference to the general hospital. After removal to the country the convulsions became rarer, but the unconsciousness continued, and decided hemiplegia was developed in the affected side. This condition remained unchanged after her return in the following autumn to Duchek's clinique. Three months later the patient was taken home in the same unconscious state, when, upon two consecutive days, tetanus of four hours' duration made its appearance. Immediately afterwards a marked improvement in the condition of the patient ensued, and in March, 1878, consciousness completely returned, whilst the disappearance of paralysis in the extremities followed nine months later. Since then she has been in perfect health, the polypous growths have been shrivelled up by instillations of rectified spirit, and at present a perforation still exists in Shrapnell's membrane through which only a moderate secretion escapes.

Diagnosis.—The diagnosis of otitic meningitis is often very difficult, more especially at the beginning. We have seen how in the case of children particularly, but also in the case of adults, well-marked symptoms of meningitis may be developed in consequence of the retention of pus in the course of acute as well as of chronic middle-ear suppurations, these symptoms quickly receding whenever the pus has made a way of escape for itself. Vomiting, convulsions, and loss of consciousness, which may entirely disappear again, are therefore by no means to be regarded as certain indications of meningitis. It is only by the occurrence of paralysis of the muscles of the extremities and of the sphincter of the pupil, in conjunction with the above symptoms, especially with evidence at the same time of an optic neuritis (Zaufal) and a hyperæmic engorgement of the retinal veins, that we are justified in diagnosing meningitis with great probability; yet in the later stage particularly, it may be easily confounded with cerebral abscess. Tubercular meningitis also, developed in an individual suffering from suppuration of the middle ear, may, without direct connection with it, be taken for purulent otitic meningitis.

Prognosis.—The prognosis of meningitis otitica is unfavourable. Nevertheless, let the prognosis be cautious, for, especially

at the beginning of the illness, decided meningeal symptoms may be produced by great hyperæmia of the brain, consequently without purulent inflammation. When the symptoms of compression of the brain become more markedly apparent, then only can a fatal issue be anticipated with great probability. Unfavourable prognostic signs during its progress are : the appearance and the rapid increase of facial paralysis, optic neuritis, and disappearance of perception for the tuning-fork through the bones of the skull (p. 183). On the other hand, better perception for the tuning-fork upon the diseased side by no means precludes the existence of a meningeal affection.

Otitic Cerebral Abscess.

This is developed either by continuity, by direct extension of the suppuration to the brain substance, or without direct connection with the pus-centre in the temporal bone. In the former case adhesion of the dura mater to the surface of the brain frequently takes place before the rupture in the neighbourhood of the ulcerated spot in the bone, thereby preventing the extension of the suppuration to the base of the brain, whilst the pus from the ruptured spot spreads directly to the brain substance. Frequently, however, adhesions of this sort are wanting. Indeed, cerebral abscesses have been often observed whose connection with the pus-centre in the temporal bone could not be proved (Thompson). Cases of cerebral abscess are very rare in which the membrana tympani is found intact (Schwartze), or in which every trace of ulceration in the bone is absent (Toynbee, *l. c.;* and Moos, *Virch. Arch.* vol. xxxvi.).

It is probable, as supposed by Binswanger (*Breslauer ärztl. Ztg.* 1879) and Loewenberg (*Z. f. O.* vol. x.), that in the last-named cases the spread of inflammation from the pus-centre to the brain is brought about by the immigration of bacteria through the meshes of the prolongations of the connective tissue which accompany the anastomosing blood and lymphatic vessels of the middle ear and of the cranial cavity. In support of this we have an observation of Moos and Steinbrügge proving in one case the existence of a multitude of bacteria in a cerebral abscess a few hours after death.

The otitic cerebral abscess usually develops as the result of chronic suppuration of the middle ear, very seldom in the course of acute purulent inflammation of the middle ear (Lebert, Farwick, *A. f. O.* vol. vi.), or from an injury when suppuration of the middle ear already exists (Roosa). According to Lebert, the otitic form the fourth part of all cerebral abscesses. The seat of the cerebral abscess is the cerebral hemisphere, more frequently the cerebellum, or both simultaneously (v. Tröltsch, *A. f. O.* vol. iv.). A distinct relation between the localization

of the cerebral abscess and the situation of the disease in different parts of the petrous bone, as believed by Toynbee, is not supported by Gull and Custer's observations (*Inaugural Dissertation*, 1879). On the whole, however, abscesses in the cerebrum are chiefly developed in ulceration of the tegmen tympani and upper surface of the pyramid; abscesses in the cerebellum, on the other hand, mostly in caries on the posterior surface of the pyramid, more rarely in affections of the mastoid process (Pomeroy). As a rule, the abscess is situated in the half of the brain corresponding to the affected ear; in exceptional cases, as in those of v. Tröltsch (*A. f. O.* vol. iv.) and Magnus, in the other half of the brain, without connection with the seat of the disease.

The number and size of these abscesses vary much. Sometimes only one exists; at other times several connected, or quite isolated, pus-centres are found in the brain. Oftentimes a fistulous canal exists between the ulcerated spot in the dura mater and the abscess in the brain, thus affording direct communication between the pus-centre in the temporal bone and the cerebral abscess, whose contents at times, under favourable conditions, may escape by the meatus.*

The cerebral abscess is, however, at times completely isolated and separated from the carious centre by a thin layer of normal brain substance. A cerebral abscess may vary in size from that of a pea to that of a duck's egg and upwards. Many abscesses reach such an extent that they engage almost the whole lobe of the cerebrum or cerebellum, their walls being formed only by a thin layer of the cortex of the brain. Older abscesses are sometimes surrounded by a connective tissue capsule (Steinbrügge). Cerebral abscess is not unfrequently complicated (Gauderou, *Progr. med.* 1876) with basilar meningitis and phlebitis of the venous sinuses (Wreden).

Symptoms, Course, Duration, and Results of Cerebral Abscess.—The symptoms called forth by otitic brain abscess vary much according to the seat and extent of the abscess. Patients almost always complain of violent headache, and, when the seat of the abscess is in the cerebral hemisphere, of pain in the side of the head involved. Abscesses of the cerebellum, on the other hand, give rise to persistent occipital pains. The following symptoms usually accompany cerebral abscess, but are by no means constant in all cases: intermittent febrile movements with slight shiverings; giddiness; sleeplessness; insensibility; convulsions; and pareses of the extremities and of the muscles of the face; hemi-

* Such cases were formerly erroneously explained as primary cerebral abscesses which had made an exit for themselves through the ear outwards—hence the term cerebral otorrhœa. Thanks to the excellent works of Abercrombie and Lebert, proof was, however, furnished from numerous observations, that cerebral abscesses existing along with suppuration from the ear arise almost without exception secondarily as a sequel to the aural affection, a fact with which Morgagni was already acquainted.

plegia (Steinbrügge, Clarke); the head is dragged tightly backwards upon the neck by the contraction of the muscles; trismus; eclamptic attacks; strabismus; derangements of sight and speech; delirium; and incontinence of urine. Distinct localizing symptoms are often wanting.

Huguenin looks for an explanation of this in the fact that abscesses in the brain usually have their seat in the temporal lobe, in which there are no fibrous strands for motion and sensation. This explanation is, however, insufficient, for in the case of abscesses which involve almost the whole cerebral hemisphere, localizing symptoms have not been observed.

The course of cerebral abscess is very irregular, and in many cases latent, without marked brain symptoms. Alarming symptoms are developed sometimes months, sometimes weeks, before the fatal issue, continuing seldom however without interruptions, being rather paroxysmal in character with longer or shorter intervals. In other cases the severe cerebral symptoms are developed only a few hours before death. (See case p. 527).

The duration of abscess in the brain is likewise subject to great fluctuations, and sometimes cannot be determined on account of the slightly marked character of the symptoms. Cases in which the alarming symptoms ran a remarkably short course up to death, presented on dissection an old abscess surrounded by a connective tissue capsule. The pathological changes in the neighbouring brain substance in cases of multiple pus-centres indicate that these date from different periods.

The result of otitic brain disease is fatal. Death results either from meningitis, after bursting of the abscess on the upper surface of the brain, or from encephalitis in the vicinity of the abscess, or from its rupture, and the discharge of its contents into the ventricle of the brain. Finally, the fatal issue may result from cerebral compression, from paralysis of the centres of respiration and circulation, from exhaustion, or from metastasis to other organs, especially the lungs.

Diagnosis.—The diagnosis of cerebral abscess is often very difficult because of its uncertain course and the indefinite combination of symptoms. In the latent stage every diagnostic point is absent, whilst, on the other hand, upon the appearance of its violent symptoms it is often scarcely possible to distinguish it from meningitis. After the outbreak of the more violent cerebral symptoms, a probable diagnosis of abscess of the brain is therefore possible only when, for a considerable time, a constant unilateral or occipital pain has existed. Toynbee discovered a remarkable sensibility to percussion of the skull on the suspected side.

Prognosis.—When the diagnosis of cerebral abscess is once fairly established the prognosis must be absolutely unfavourable.

The descriptions of the cases quoted in the literature of this subject as recoveries render the diagnosis of otitic brain abscess doubtful.

2. *Suppuration of the Middle Ear ending Fatally from Phlebitis of the Cerebral Sinuses.*

Among the venous sinuses traversing the temporal bone the most frequently affected is the transverse sinus to the inner side of the mastoid process; the superior petrosal and the cavernous sinuses, and, in destruction of the lower wall of the tympanic cavity, especially if there is already a fissure in existence there, the bulbus venæ jugularis int., are more rarely involved.

An affection of the venous sinus is induced either by the direct contact of a carious or necrosed part of the temporal bone with the coat of the vein adjoining it, or not unfrequently without perceptible alteration in the state of the bone. In the former case, especially in affections of the lateral sinus, after separation of the wall of the vein, there is discovered in the bone a defect of variable size, which communicates either with the cavity of the mastoid process or with the tympanic cavity by means of a fistulous canal in the posterior part of the pyramid. Communication rarely exists between the sinus and the osseous meatus by means of a fistulous canal opening on its posterior superior wall. The neighbourhood of the necrosed portion of the sinus is often greatly softened and osteoporosed, whilst smooth or irregular osteophytes grow exuberantly on other parts.

When in an existing sinus-phlebitis the bone is met with apparently normal, then a very thin transparent piece of bone with numerous small openings is frequently discovered between the sinus and the mastoid process, by means of which the veins of its mucous membrane pass through the mastoid cells, to discharge themselves into the transverse sinus. It is therefore now beyond doubt that, especially in septic processes in the middle ear, either the inflammation is transmitted to the sinus by means of these veins, or that, by the confinement of purulent secretions in the tympanic cavity or the mastoid process, by an increase of pressure a part of the liquid is filtered through the already-named venous canals, and by contact with the wall of the venous sinus septic phlebitis may be produced (A. Politzer, *A. f. O.* vol. vii.).

The changes in the venous wall vary much. When it comes into contact with the necrosed osseous wall it has the appearance of being thickened, brownish-yellow, or discoloured on its outer surface, or detached to a varied extent by purulent or hæmorrhagic extravasation, or by greasy masses; lastly, ulcerated and perforated. The inner wall of the vein, corresponding to the osseous part adjoining it, is likewise inflamed and tumefied,

villous, or covered with firmly adherent layers of exudation, or destroyed by the action of the ichorous secretion. The lumen of the sinus contains a discoloured thrombus, solid or disintegrated, usually stationary, which sometimes stretches to the confluence of the sinuses on the one side, on the other in the jugular vein, as far as the subclavian. In this way phlebitis and thrombosis may extend from the transverse sinus to the superior and inferior petrosal sinuses, the cavernous sinus, and the emissary veins of Santorini (Orne Green, Chimani). Along with meningitis or cerebral abscess the escape of pus into the cranial cavity is of frequent occurrence near the thrombus in the sinus.

Carious destruction of the sigmoid sinus does not necessarily imply consecutive inflammation of the venous sinus itself, particularly when the escape of pus from the mastoid process is not stopped. In one of my cases of caries of the mastoid process, with formation of sequestra and bursting externally, the osseous wall of the transverse sinus was deficient to the extent of 3 cm. in length and 1½ cm. in breadth. The bare venous wall was covered with granulation tissue, the inner surface of the venous sinus being normal. In a case observed first in my clinique by J. Pollak a great part of the mastoid process with the furrow of the sigmoid sinus was exfoliated, without any affection of the venous sinus.

The formation of a thrombus in the lateral sinus is not absolutely fatal. When the coagulum has no septic character, and when, after the formation of the thrombus, favourable local changes make their appearance in the neighbourhood of the lateral sinus, absorption of the coagulum may take place without resulting in embolism and blood-poisoning. Thrombi without septic character may exist for a long time without occasioning remarkable symptoms. In the case of a girl (*A. f. O.* vii.) who suffered from caries of the mastoid process with rupture externally and into the external meatus, consecutive to suppuration of the right middle ear, and who died from a caseous infiltration of the lungs, Eysell found at the post-mortem examination an old thrombus in the lateral sinus. In one of my cases in which death was occasioned by an abscess in the cerebellum, resulting from caries of the right side, affecting almost the whole of the petrous bone, without there having been any apparent evidence during life of the existence of a sinus affection, I discovered in the transverse sinus a thrombus several centimetres long, so closely adherent to the wall of the sinus that it must have existed there for a long time. Fränkel describes a similar case (*Z. f. O.* vol. viii.).

Symptoms.—The most marked symptoms of sinus-phlebitis are severe shiverings, followed after a duration of varied length by an unusually high temperature (over 40° C., 104° F.). The periods of remission, which in the beginning of the illness are

complete and of long duration, become always shorter and more imperfect, so that after repeated shiverings the apyretic interval does not return, and the temperature rarely sinks below 39° (102·2° F.). There is always observed corresponding acceleration of the pulse; the skin becomes dry, and of a jaundiced colour after the illness has lasted some days; the tongue dry and smoky, the head giddy, often painful, consciousness clear almost up to the last hour of life.

In many cases an œdematous swelling is developed in the mastoid region (Griesinger) from engorgement of the emissary veins of Santorini, and in the case of thrombosis in the internal jugular vein along its course a hard cord is felt, painful, but especially tender on pressure, and occasionally, after a certain period, such an œdema in the lateral region of the neck, that the almost simultaneous extension to the external jugular vein is thereby masked. In cases where from continuation of the thrombus into the bulbus venæ jugularis int., pressure is exercised upon the vagus, the glosso-pharyngeal, and the spinal accessory nerves in their passage through the jugular foramen, paralysis is produced in the area of these nerves (Beck, *Deutsche Klinik*, 1863).

In extension of the thrombosis to the emissary veins, according to the observations of Orne Green (*American Journal of Otology*, vol. iii.), there occur painful infiltration and induration of the subcutaneous and subfascial connective tissue, reaching as far as the region of the neck. In like manner an advance of the thrombus from the jugular vein to the facial gives rise to œdema and erysipelas of the face and eyelids (Wreden).

Sinus-thrombosis presents a complicated combination of symptoms when the thrombus-formation reaches the superior and inferior petrosal sinuses and the cavernous sinus. The presence of a coagulum or the purulent degeneration of a thrombus leads to the formation of coagula in the ophthalmic veins, engorgement of the orbital vessels, disturbances of vision, photophobia, paralysis of the oculomotor and abducent nerves, exophthalmus, ptosis, œdema of the eyelids or to sloughing of the orbital tissues. As symptoms of thrombosis in the superior petrosal sinus, the following have been cited: epistaxis, swelling of the veins extending from the anterior fontanelle to the temples, and epileptiform attacks. In my cases of erosion and thrombosis of the superior petrosal sinus none of those symptoms existed. The literature of diseases of the ear shows only a small number of cases of complicated sinus-thrombosis. Two cases of special interest, and of which I had an opportunity of seeing the preparations, may be given here.

The first case, seen by Dr. R. Chimani in the garrison-hospital No. I., was that of a soldier, thirty years of age, afflicted since

childhood with suppuration of the right middle ear, and admitted suffering from pain in the mastoid process and in the occiput, severe vertigo and high fever. Several days later a tumour was formed over the mastoid process, gradually extending to the centre of the parietal and of the occipital bones. After incision discoloured pus was discharged, and on probing the mastoid process the parietal and occipital bones were found to be roughened. After several days boring pains and sensations of heat came on, with disturbance of vision and exophthalmus on the right side. Towards the end of the third week symptoms of pneumonia, jaundice, vomiting, delirium, loss of consciousness, collapse, and death in three days. Result of post-mortem examination: caries of the right petrous bone, with rupture into the sigmoid sinus; thrombosis of the right transverse sinus, both carotid sinuses, and the circular sinus of Ridley, as well as of the left cavernous sinus and the superior petrosal; purulent degeneration of the thrombi and inflammation of the walls of the above-named sinuses; thrombosis of the right ophthalmic vein, purulent infiltration of the connective tissue of the right orbit, chronic œdema of the pia mater and arachnoid; numerous pneumonic and gangrenous centres in both lungs.

The second preparation was brought under my notice in the interesting collection of Professor Burkhardt-Merian, of Basle. This had belonged to a woman twenty-five years of age, who at the ages of fourteen and sixteen had suffered from inflammation of the left middle ear, but since that time had been in apparent good health. Three weeks before death violent pains in the left side of the head set in, radiating towards the forehead, the cheek, and the neighbourhood of the eye. Three days later pain in the mastoid process; Wilde's incision was made without coming upon pus. Again, seven days later, collapse, swelling of the left eyelid, exophthalmus, sluggish action of the pupil. Opening of the mastoid process with discharge of an immense quantity of ichorous pus. Two days later swelling of the eyelid and exophthalmus on the right side also. Incision of the upper eyelid with discharge of thick pus. Death in three days. Result of post-mortem examination: large cholesteatoma of the tympanic cavity, and of the mastoid process, growing into the transverse sinus and the incisura mastoidea by means of a pea-sized perforation. Thrombo-phlebitis of the left transverse sinus, and of the jugular veins; basilar meningitis. Ichorous coagulum, reaching by means of the inferior petrosal sinus to the cavernous sinus. The region about the sella turcica of a dirty green colour, and the ophthalmic veins on both sides involved in the phlebitis.

Course.—Sinus-thrombosis runs a very irregular course. The process is sometimes rapid, as when within a few days death occurs with symptoms of cyanosis and collapse, or by metastasis to vital organs; and sometimes so slow that long intervals

of apparently normal health follow upon the several attacks of shivering, until at last, after the lapse of several weeks or months, the patient succumbs to pyæmia.

Results.—The result of secondary sinus-phlebitis is with few exceptions fatal. Death most commonly results from metastasis, especially by embolic pleuro-pneumonia, or gangrene of the lungs, less frequently by abscess of the liver and nephritis. But in isolated cases the fatal issue is brought about without metastasis by means of the paralysing influence of the pyæmic blood upon the nervous system, or by the height of the fever. Recovery is very rare. The proof of such a result is indeed difficult, for the existence of sinus-thrombosis can by no means be affirmed with certainty, in spite of shiverings, high fever, and even pain along the corresponding jugular vein, without definite evidence of the formation of a thrombus there. Even cases such as that described by Prescott Hewett (*Lancet*, 1861), in which, besides the symptoms above described, metastasis occurred in the joints and in the lungs, cannot be regarded as conclusively indicating recovery from sinus-thrombosis, for a similar combination of symptoms may also be produced, without affection of the sinus, by the direct reception of septic material into the circulation from the cavities in the temporal bone. The same may be said of the case described by Sédillot. Wreden records a case of recovery from sinus-thrombosis, in which the symptoms of thrombosis of the transverse sinus, of the internal jugular vein and of the cavernous sinus were clearly marked.

Diagnosis.—Thrombosis of the lateral sinus may be diagnosed with probability when a highly febrile temperature follows upon repeated shiverings, particularly when in the course of the affection metastasis to other organs occurs. The diagnosis is absolutely certain only when proof exists of the presence of a solid thrombus in the jugular vein. There is danger of confounding it with meningitis and cerebral abscess only in the case of the simultaneous appearance of the sinus affection with these brain diseases. When such is not the case the differential diagnosis is all the easier, as the groups of symptoms characterizing both forms of disease present many divergencies. Whilst in meningitis and cerebral abscess there are neither such severe rigors nor such high temperatures as in sinus-thrombosis, in the latter we find the brain symptoms only slightly marked, consciousness often remaining unimpaired even up to the end.

Prognosis.—The prognosis of otitic sinus diseases is in general unfavourable. But at the beginning of the disease a prognosis must be given with caution, when beyond intermittent shiverings and high temperatures there are no other phenomena of pyæmia, for in the case of exacerbations of suppurative diseases of the middle ear, violent attacks of fever may pass off without further

result. On the other hand, a fatal issue may with certainty be predicted when the thrombus advances to the jugular vein, and signs of metastasis to the internal organs appear.

At the beginning of this chapter it was stated that a fatal issue may occur without extension of caries to the cerebral sinuses, by the direct reception of septic material from the cavities of the middle ear into the circulation of the blood, and this may be illustrated by the following case, observed by Staff-Surgeon Chimani, who showed me the preparation relating to it, and had the kindness to give me an epitome of its history.

The case was that of a soldier, twenty-three years of age, who fell ill, after a cold bath, of an acute suppuration of the left middle ear, attended with fever. Upon the sixteenth day of the illness, without symptoms of retention of pus, shiverings set in, with a rise of temperature to 40·3° (104·7° F.), soon followed by painful inflammation of the right sterno-clavicular articulation, great respiratory distress, and jaundice. Rapid decrease of the temperature and collapse took place, with death on the twenty-third day of the illness. On dissection no change was apparent in the brain and in the sinuses, the pyramid of the petrous bone was congested, the cavities of the middle ear were filled with thick yellow fœtid pus, the mucous membrane was dusky red and swollen, a small ulcer was found on the promontory, the posterior half of the membrana tympani was destroyed. Numerous caseous infarcts of the size of a pea were found in the lungs, and also purulent inflammation of the right sterno-clavicular articulation, and detachment of the first costal cartilage from its insertion on the manubrium sterni.

3. *Fatal Suppuration of the Middle Ear in consequence of Erosion of the Internal Carotid Artery.*

A fatal issue to suppuration of the middle ear from bleeding from the eroded internal carotid artery may be reckoned amongst the rarest of results. Hessler (*A. f. O.* vol. xviii.) has the merit of having collected the cases scattered through medical literature, and of having by his critical remarks given them value. Thirteen cases, including one observed by Hessler himself, have up to this time been described, in which the diagnosis was ulceration of the internal carotid, and this was afterwards confirmed by post-mortem examination.

Anatomy.—In every case the portion of the carotid canal adjoining the tympanic cavity was carious and defective to a varied extent. The destruction was commonly associated with spreading caries in the temporal bone, and the osseous gap in the carotid canal was either free, or still occluded with sequestra. The aperture in the generally softened arterial wall was always

found at the spot where the course of the vessel passed from the vertical to the horizontal direction. Only in two cases observed by Baizeau (*Gaz. des Hôp.* 1861, 88) and Choyau (*Arch. gén. de Méd.* 1866) was the carotid perforated in two places; in all the other cases there was a fissure in the arterial wall of 3-8 mm. in length and 2-6 mm. in breadth, its edges being either serrated and fringed, or more rarely as if incised (Grossmann, *Casuist. Beitr. z. Ophth. und Otiatr.* Pesth, 1879). A direct communication between the tympanic cavity and the eroded artery could be proved in every case. In the case described by Busch and Santesson (*Schmidt'sche Jahrb.* 1862), the transverse sinus was also simultaneously eroded. In every case, the blood poured forth through the perforated membrana tympani into the external meatus, but in Pilz's case the membrana tympani was intact, and the blood escaped by a fistulous aperture in the lower wall of the meatus, leading to an abscess-cavity involving the anterior portion of the petrous bone, and opening by another fistulous aperture upon the upper wall of the pharynx.

As regards complications, tuberculosis existed in seven cases, scrofula in one, secondary syphilis in one (*Pilz, Dissert. inaug.* Berlin, 1865), and in one case the cause of the suppuration of the middle ear was said to be corrosion with concentrated acids (Sokolowsky, *Centralbl. f. Chir.* 1881).

In several cases the erosion of the carotid was complicated with circumscribed pachymeningitis, with basilar meningitis, meningitis of the upper surface of the brain, and with cerebral abscess.

Regarding the commencement of erosion of the carotid, it must be accepted as beyond doubt that in most cases the inflammatory softening of the arterial wall, by its being bathed in pus and ichor, so diminishes its power of resistance that the repeated shock of the blood-wave against it finally produces an aperture in the arterial wall. In rarer instances, the aperture may be produced by the wearing pressure of a sequestrum against it.

The duration of the ear disease up to the commencement of the bleeding varied between seven and eleven years. In two cases only is the suppuration said to have lasted but several months; and in the case of syphilis observed by Pilz, it is stated to have appeared in the course of an acute caries.

Symptoms.—The discharge of blood from the ear in the majority of cases is profuse, but not always in spouts. In some cases a continuous oozing only was observed, whilst in four instances the stream of blood burst with such force from the ear that it formed a jet as thick as the little finger (Chassaignac, *Traité de la Suppuration;* Hessler), or that the plug was ejected from the meatus (Broca, Hermann). The amount of blood lost in a more violent bleeding varied from 240-1500 grammes. The blood is generally bright red, seldom mixed with pus. Some-

times the blood escapes at the same time through the Eustachian tube into the naso-pharynx. Pain during the bleeding was seen in only one case. On the other hand, especially in the case of profuse hæmorrhage, anæmia, with fainting-fits and collapse, was rapidly induced.

The number of hæmorrhages before the fatal issue varied in the thirteen cases from one (Hessler) to three, four, seven, and even twenty (Toynbee, *Diseases of the Ear*, 1860).

The duration of each attack of hæmorrhage varies from four to ten minutes (Prescott Hewett, *Arch. gén. de Méd.* xiv. 1837); in one case it was seven hours (Broca-Jolly, *Arch. de Méd.* 1866); and in another six days with barely twenty-four hours' intermission (Hermann, *Wien med. Wochenschr.*, 1867). The period from the commencement of the first hæmorrhage till the fatal issue, if the three cases are excluded in which the carotid was ligatured, varied from five minutes to thirteen days. In the cases operated upon, death occurred in one in three days, in another in four weeks, and in Pilz's case (erosion of the right carotid), operated upon by Billroth, seventeen days after ligature of the right and three days after ligature of the left carotid.

In every case the result was fatal; three times from profuse hæmorrhage, and in the remaining cases from exhaustion or pulmonary phthisis (Broca).

The diagnosis depends on the bright red colour of the arterial blood, and the cessation of the hæmorrhage on compression of the carotid. It must be accepted as certain that the bleeding proceeds from the carotid when the blood spurts from the ear in great gushes with each systole of the heart. Should the bleeding not be very violent, it might be inferred that there was erosion of the middle meningeal artery (Ward, *Transact. of the Pathol. Soc.* 1846), or of some other small branch of the carotid. Bleeding from the lateral sinus may be distinguished from carotid hæmorrhage by the fact that in the former the blood-stream is dark red, and continues after compression of the carotid.

The *prognosis*, as far as experience has yet shown, is absolutely unfavourable.

Treatment.—In the case of every aural hæmorrhage which arouses suspicion of erosion of the carotid, an endeavour must in the first place be made to stop the bleeding by means of compression of the common carotid. This, however, can only be of service when it is carried out immediately, and for a considerable time. It is of importance to teach some one in attendance upon the patient how compression is to be applied, so that, in the event of a recurrence of the bleeding before the return of the physician, much loss of blood may be avoided.

Should the compression be insufficient or impossible on account of the extreme pain which it causes (Toynbee), then liga-

ture of the common carotid must be tried. In one of the cases operated upon, in which nine days after ligature hæmorrhage from the ear, mouth, and nose recurred, ligature of the other carotid had to be resorted to; but three days later death occurred during an attack of bleeding. Although among the small number of cases hitherto observed the operation has never proved successful, this by no means precludes the possibility of a successful issue in future operations, should the local changes in the vicinity of the eroded carotid prove to be more favourable, and the obliteration of the carotid, which has been obstructed by a ligature thrombus, be rendered possible. Whether in the case described by Denucé (*Bull. de l'Acad.* 1878) of recovery from an arterial hæmorrhage from the ear by the use of ligature of the carotid, the cause of the bleeding was erosion of the internal carotid, must remain undecided. For the details of the operation, reference must be made to the large manuals of surgery.

Plugging the external meatus, preventing as it does for the moment the rapid gush of the blood, has proved useless, as the blood speedily makes a way for itself through the Eustachian tube into the naso-pharynx. Just as little benefit may be looked for from the use of injections of solutions of chloride of zinc and of iron, from the application of cold, and from the internal administration of ergot of rye and gallic acid.

The Treatment of the Carious Processes in the Temporal Bone.—In the treatment of caries of the temporal bone the most thorough removal of the stagnating secretion from the deeper parts must first be effected. This is one of the chief conditions for the limitation of the caries and for preventing its advance to the cranial cavity. The methods of washing out the tympanic cavity, as well as the choice of antiseptic solution, have been already discussed (p. 464), and only a few observations remain to be added here. Should the meatus be contracted by infiltration of its walls, by granulations, or by undermining of its superior posterior wall with pus, the very first thing to be done is washing out the secretion with boracic or carbolic solution, through small, elastic tubes passed into the deeper parts; then the contracted portions of the meatus must be dilated as speedily as possible by the insertion of wedge-shaped pledgets of lint or antiseptic wadding of progressively increasing size, or of short drainage-tubes, or lastly by incision. This is specially important, not only on account of the freer escape of secretion from the interior, but also because it renders possible the washing out of the tympanic cavity through the Eustachian tube, as contractions of the meatus present a considerable obstacle to the entrance of fluid into the middle ear.

Syringing the tympanic cavity through the Eustachian tube (p. 478) with warm water, or with a weak solution of borax, has

proved so useful in my practice that I must call attention to it as the most efficacious method of treatment yet suggested. The injections not only wash out putrid secretions and caseous masses, but also frequently rapidly remove or alleviate the violent pains in ear and head which accompany caries. I attach all the more importance to this procedure in the treatment of caries, that the subjective symptoms, in my experience, are never so quickly removed by any other local application as by syringing the tympanic cavity per tubam.

As regards local application, I limit myself to the trifling addition of boracic or carbolic acid to the fluid for injection. Astringent solutions of zinc and lead, as well as of sulphate of copper, so strongly recommended in caries, must be avoided, as they often give rise to great reaction and hinder the escape of pus by the formation of deposits.

The operative treatment of caries before the exfoliation of the sequestra is limited to the osseous meatus and the mastoid process. Moreover, all interference, especially erasure of carious spots on the bone, is to be avoided in cases of evident caries of the inner wall of the tympanic cavity, as the thin osseous wall separating the tympanic cavity from the labyrinth may be fenestrated by a trifling pressure, and the labyrinth laid open. While I must refer the reader to the special section regarding the mastoid process, I must here call attention to the fact as regards caries of the auditory canal, that the scraping out of rough bare pieces of bone by means of Oscar Wolf's sharp scoop (p. 484) can only be successful if applied to caries of the superficial lamellæ; but that if the disease of the bone is more deeply seated the scooping out is without success. It would be well, in every case in which there is evidence of a carious spot in the meatus, to try scooping out to a depth of 1-2 mm. A deeper penetration is to be avoided, especially on the upper wall of the meatus, on account of the vicinity of the cranial cavity.

After having scraped the diseased bone it is well to blow iodoform in powder upon the denuded parts, by which means the suppuration is diminished, and the rapid formation of healthy granulation tissue, changing to cicatricial tissue, is most effectually brought about.

The method of removal of an exfoliated sequestrum from the ear is regulated by its size, form, and position, as well as by the relative capacity of the external meatus. The smaller the exfoliated piece of bone, the more readily will it be removed by strong injections or by the forceps. The greater the size and the more irregular the form of the sequestrum, and the narrower the meatus, the more difficult is the extraction. But the removal of small sequestra frequently presents difficulties, more especially when they are deeply seated or so much embedded in granula-

tion tissue that the sequestrum can be seized only after tearing away the granulations.

The extraction from the external meatus of larger sequestra, originating usually in the mastoid process, more rarely in the pyramid of the petrous bone, is only permissible by means of the dressing forceps after the usual method, when this can be accomplished without the exertion of too much force. Extraction, however, should not be attempted when the sequestrum is known to be too large for the lumen of the external meatus, for, by the use of force, angular sequestra with sharp projections might cause injury to the infiltrated cutis and to the cartilage of the meatus, setting up a widespread and sometimes erysipelatous inflammation in the neighbourhood of the ear, and leaving tight stricture of the meatus as a later result.

In the case of large sequestra not removable by simple extraction, cautious crushing of the bone may be recommended as the surest method. For this purpose I use a pair of sharp bone forceps made of good steel, of the form and size of the accompanying drawing (Fig. 194), by means of which, during anæsthesia, the sequestrum can be crushed into several small pieces. In the case of a girl four years old, in whom a flat sequestrum more than 1 cm. broad, firmly adherent with its flat surface external, could not possibly be laid hold of, it was extracted by means of an incision of corresponding size on the posterior cartilaginous wall of the meatus; cicatrization of the tolerably wide incision followed shortly after, in spite of the continuance of the otorrhœa. This treatment has quite recently been recommended by Schwartze (note to Moldenhauer's article *A. f. O.* vol. xviii.).

FIG. 194.

Repeated attempts to soften sequestra by gradual decalcification with a very weak solution of muriatic acid have proved unsuccessful.

Although in the treatment of caries of the petrous bone most importance is to be attached to local applications, yet these must be combined with general treatment suited to the constitution of the individual. In the case of debilitated patients in particular, when, as is so frequent in caries, the pulse is quick, or in the evenings a high temperature comes on, with acceleration of the pulse, moderate doses of quinine are to be recommended. Preparations of iron in cases of anæmia are only suitable when digestion has not been destroyed. Their exhibition, however, is not advisable when there is pain in the ear, as it is frequently increased by such preparations. On the other hand, when the pain is of long duration large doses of iodide of potassium internally are recommended ($\frac{1}{2}$-1 grm. daily), or iodoform (0·1 in 30·0 aq. dest.; 5-10 drops thrice daily),

may be administered when not contra-indicated by tuberculosis or great debility. Mineral water containing iodine, iodine baths, and the use of simple thermal springs, are in many instances most effectual in limiting the local affection, as well as in raising the general tone.

Treatment of Facial Paralysis.—This coincides with the treatment of suppuration of the middle ear and of carious affections of the petrous bone. At the beginning of the affection, more especially when it commences with violent pain in the ear, indicating the probability of recent inflammation of the bone, large doses of iodide of potassium (0·5-1·0 daily) or iodoform (as above) may be of much service. The effect, moreover, may be increased by the embrocation of ointments containing iodine or iodoform, with the addition of morphia or the extr. laud. aquos. on the mastoid process and in the vicinity of the ear.

Galvanic treatment is to be employed only when signs of reaction have disappeared, and no symptoms exist which threaten danger. The result is often favourable, and in my practice I have met repeatedly with cases in which paralysis of the face of long duration, and not improving under treatment with iodine, has been removed, or substantially improved by the use of the galvanic current. When the paralysis lasts for a lengthened period, especially after the cure of caries and cessation of the suppuration, and when ulceration or the formation of callus may be supposed to be its cause, it must of course be understood that then all treatment will be useless, and in such cases the employment of the Faradic current will only have as its object to counteract the atrophy of the muscles on the affected side. In isolated cases, even with long continuance of paralysis after caries, I have myself observed a marked improvement result from the use of iodine baths and of simple thermal springs.

The treatment of otitic meningitis and of cerebral abscess is a treatment of symptoms, and for further details we must refer to the handbooks of special pathology and therapeutics. Cold bandages, bags of ice, or Leiter's cooling apparatus; internally the use of narcotics, subcutaneous injections of morphia, to combat the intense pain in the head; derivations from the intestinal canal (calomel), enemata in obstinate constipation, stimulants (camphor, ether, wine) are the best remedies at the onset of depression. In secondary sinus thrombosis the high temperature may be lessened by large doses of quinine. In all serious complications, however, antiseptic cleansing of the ear must not be omitted.

Diseases of the Mastoid Process, with Particular Reference to the Operative Opening of the Same.

The diseases of the mastoid process are, apart from their pathological interest, of so much importance in practice that they must be very minutely described. Before passing to the description of the pathological changes in the mastoid process, however, some anatomical details relating to the surgical opening of that process, and which supplement the remarks already made (p. 59), must be discussed at greater length.

The mastoid process presents an extraordinary diversity in regard to its size and form, as well as to the number and extent of its pneumatic spaces; even in the same individual there is often a considerable difference between the two processes.

This process, which according to general acceptation is quite absent in the new-born child, is even in the early days of life, as I have observed on numerous temporal bones, very often indicated by a tubercle situated behind the annulus tympanicus, which, partly by independent growth and partly by the traction of a muscle, appears in the first years of life as a considerable blunt protuberance, which does not reach its complete development until the age of puberty.

In the adult great variations are found in the size of the mastoid process; sometimes it is very strongly developed, at other times it is stunted, being only a short, blunt, and solid tubercle. On the whole, however, it is of moderate size.

The condition of its internal structure is just as variable. In the first place the antrum mastoideum varies in regard to size and form. Up to the end of the second year of age it is frequently not only relatively large, but absolutely larger than in the adult (Hartmann). In the latter, the antrum seldom reaches beyond a medium size, is often much contracted, and but rarely altogether absent. The knowledge of these variations is important, because in opening the mastoid process we strive to lay bare the antrum, in order to bring about a communication between the aperture of the operation and the tympanic cavity, so as to allow of a thorough washing out of the middle ear.*

The antrum mastoideum is usually connected with the pneumatic cells of the mastoid process by numerous lacunæ, but often enough by only a narrow canal. The size, disposition, and extent of the latter are so different in different individuals, that one mastoid process scarcely ever corresponds with another (compare Linke's *Handbuch*, vol. i.; also Wildermuth, Schwartze, and Eysell, Alb. H. Buck). In early authors, observations are found that the structure of the mastoid process does not always

* Toynbee (*l. c.* 1860) points out in his anatomical description of the mastoid process that the antrum mastoideum is mostly formed by the pars squamosa of the temporal bone.

consist of pneumatic spaces, but often entirely, or in part, of an adipose spongy osseous substance, or of a compact solid, as if sclerosed, osseous mass (Toynbee, *l. c.*; Luschka, *Anat. des menschl. Kopfes*, p. 34).

To Zuckerkandl (*M. f. O.*, 1879) belongs the credit of having proved by numerous sections that the mastoid process with predominant pneumatic spaces is by no means so frequent as has

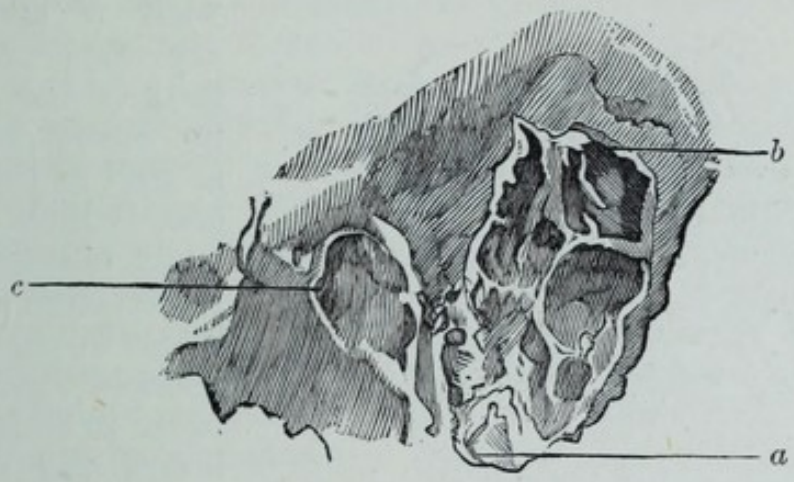

FIG. 195.

been thought, but that it is very often formed, in whole or in part, by a fatty or diploe-like osseous substance. He found among 250 temporal bones that only 36·8 per cent. had the mastoid process entirely pneumatic; in 43·2 per cent. it was

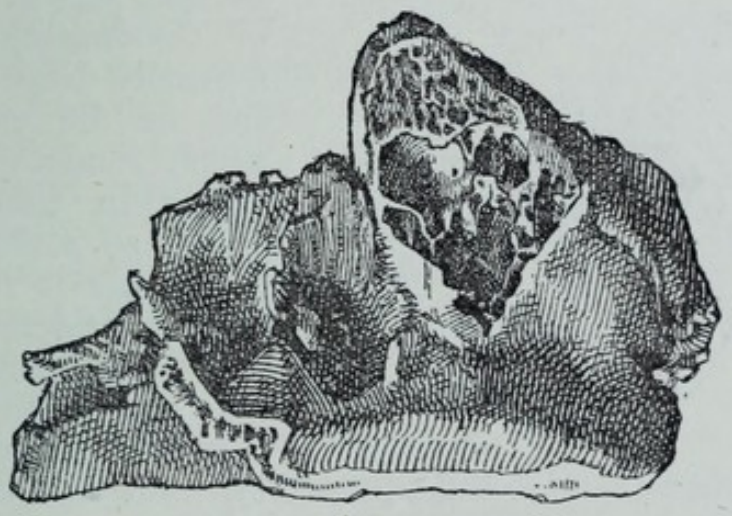

FIG. 196.

partly like diploe, partly pneumatic; and in 20 per cent. it was wholly composed of fatty diploe-like or sclerotized osseous tissue.

The accompanying woodcuts illustrate the above-described variations in the interior of the mastoid process. Fig. 195 represents a mastoid process with a thin osseous shell formed throughout from the apex (*a*) to the upper end (*b*) of large pneumatic spaces. In Fig. 196, the lower end of the process is like diploe, while the upper two-thirds contain pneumatic spaces. In

Fig. 197, a larger portion of the inferior posterior part of the process has a structure like diploe, extending from the apex to *a*, *a'*, and it is only in the anterior superior part that several pneumatic spaces (*b*) are met with. Lastly, in Fig. 198, the interior of the mastoid process from its apex (*a*) to the margin of the narrow antrum (*b*) is filled with a small-celled diploe.

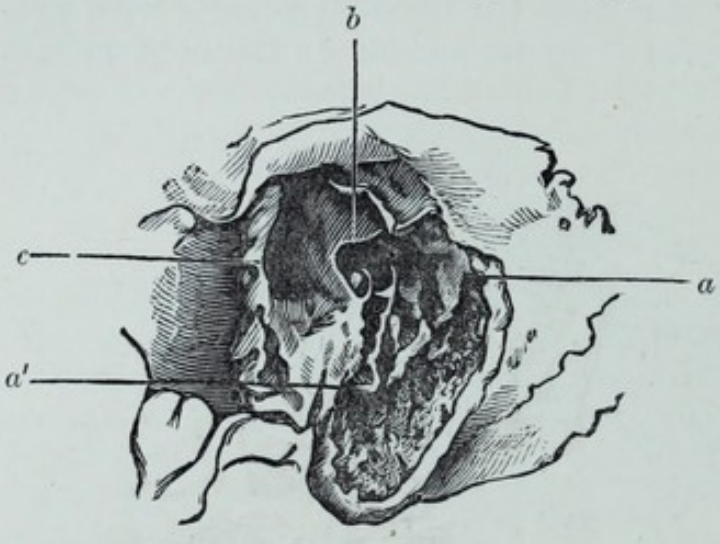

Fig. 197.

It is the latter, by no means rare, form, as well as the compact one, which offers a great obstacle to the penetration of the antrum in opening the mastoid process, because in such temporal bones the antrum is often undeveloped, and frequently at the same time the sigmoid sinus is found to be so pushed forward and outwards, that it may very easily be laid bare in making the opening.

The relation of the mastoid process to the middle cranial fossa and to the sigmoid sinus, described above (p. 60), plays an important part in the opening of the mastoid. An abnormally deep situation of the middle cranial fossa, which renders it liable to injury in this operation, occurs so seldom that on the whole it may be put out of consideration. Hartmann (*Langenb. Archiv.* vol. xxi.) found in more than one third of a hundred temporal bones examined the linea temporalis on a level with, or 1 cm. higher than, the base of the middle cranial fossa. The anatomical variations in the relation of the sigmoid sinus to the mastoid process have a greater range. Bezold and Hartmann have drawn attention in particular to the greatly advanced position of the sinus, and pointed out the possibility of not being able to avoid laying it bare in such cases in the opening of the mastoid process.

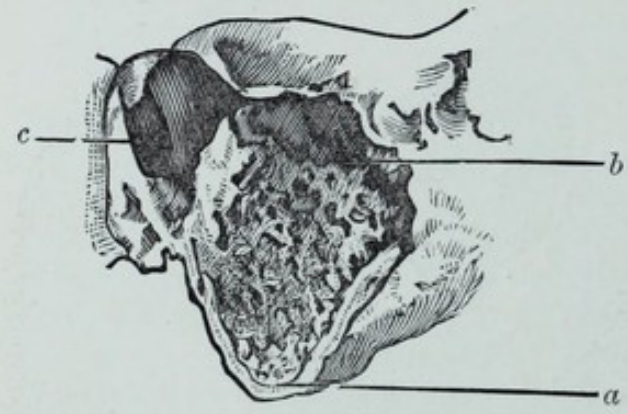

Fig. 198.

In my examination of over 400 temporal bones, this unfavourable position of the sinus was more frequent in the diploetic and sclerotized mastoid processes.

I found the most favourable relation in those well-developed processes which were throughout pneumatic. In them (Fig. 199) there is usually a wide space between the posterior wall of the auditory meatus and the sigmoid sinus, which as the lines in the figure converging towards the antrum show, permit easy penetration towards the latter, without occasioning the slightest danger of injuring the sinus.

The relation is less favourable in the greater portion of diploetic mastoid processes. In them (Fig. 200) the space between the auditory meatus and the sigmoid sinus is much narrowed, so that during the operation the surgeon passes close upon the wall of the sinus (*e'*) or injures it for want of sufficient caution.

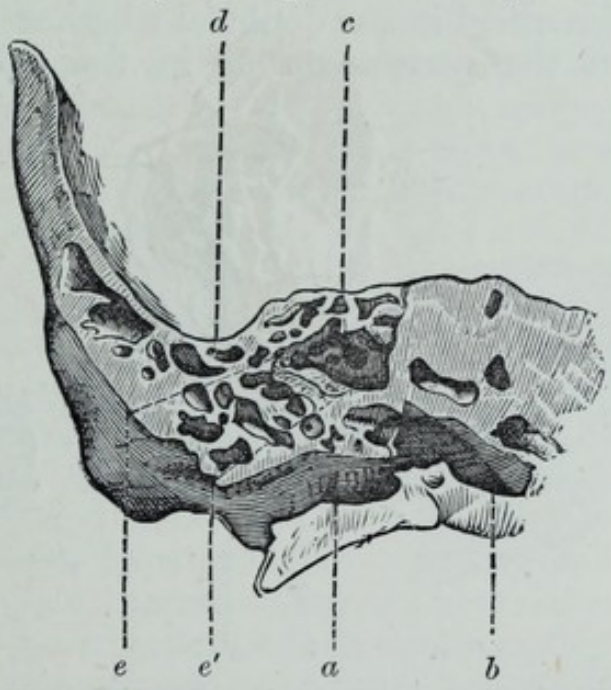

FIG. 199.—HORIZONTAL SECTION THROUGH A PNEUMATIC MASTOID PROCESS.

a, Posterior wall of the auditory meatus; *b*, Tympanic cavity; *c*, Antrum mastoideum; *d*, Sigmoid sinus; *e*, *e'*, Place for operation on the external plate of the mastoid process.

The case is most unfavourable when the sinus is pushed so far forward that only a very small space remains between it and the posterior wall of the auditory meatus. On such temporal bones the sinus turns at the same time very much outwards (Hartmann). These abnormal positions are most frequently found in compact or completely diploetic and undeveloped mastoid processes. This is represented in the accompanying illustration (Fig. 201). The opening of the sinus is unavoidable when the surgeon penetrates to the antrum from the seat of the operation (*d*, *e*) through the funnel-shaped space indicated by the dotted lines.

In a preparation in my collection the sinus arches forwards and outwards so much that it quite divides the inferior portion of the mastoid process from the superior, and, moreover, there exists on what is usually the commencement to the operative incision an opening 1 cm. in extent on the mastoid process, through which the sigmoid sinus is immediately reached.

a. Periostitis Mastoidea (Primary Acute Inflammation of the External Mastoid Region. Burnett).

Primary diseases of the mastoid process without simultaneous affection of some other portion of the organ of hearing are, on the whole, rare. Inflammation begins either on the ex-

ternal periosteal covering (periostit. mast.), or in the internal cell-spaces of the mastoid process (ostit. mast.).

Primary periostit. mast. is extremely rare, and there are only a few cases to be found in literature, described by Voltolini (*M. f. O.* 1875 and 1877), Blake (*Arch. of Ophth. and Ot.* vol. v.), Knapp (*Otolog. Cong.* 1876), Jacobi (*A. f. O.* vol. xv.), Turnbull, Swan Burnett (*Z. f. O.* vol. ix.), and Hotz (ibid.). Till now I have only observed three cases. In several of those described it was doubtful whether the inflammation had its seat in the periosteum or in the subcutaneous connective tissue.

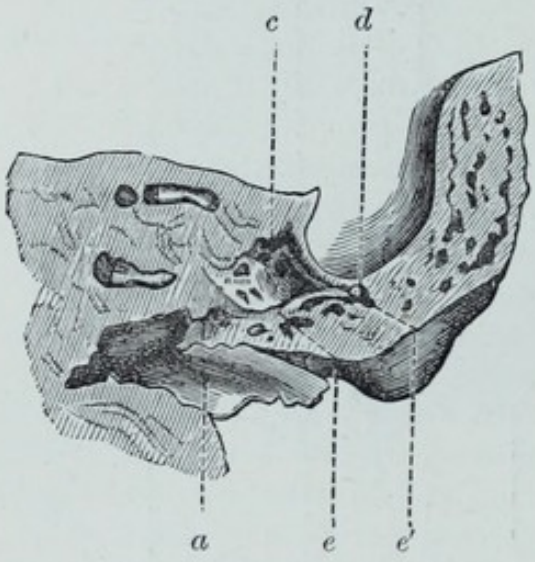

FIG. 200. — HORIZONTAL SECTION THROUGH A PARTLY DIPLOETIC, PARTLY PNEUMATIC, MASTOID PROCESS.

a, Posterior wall of the auditory meatus; *c*, Antrum mastoideum; *d*, Sigmoid sinus; *e*, *e'*, Seat of operation.

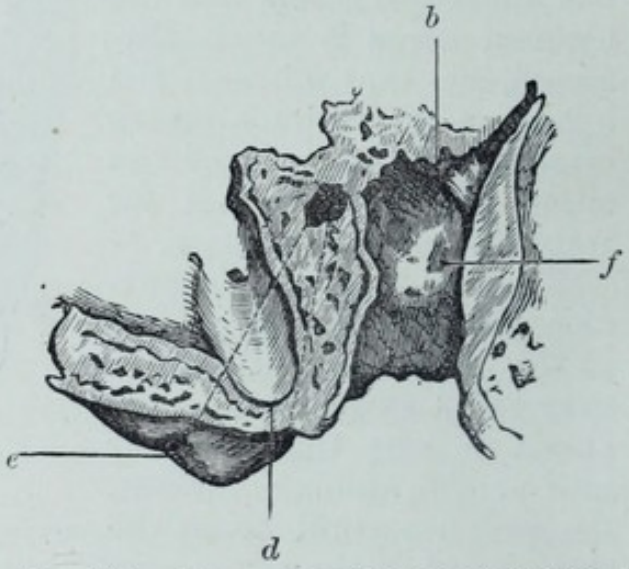

FIG. 201.—HORIZONTAL SECTION THROUGH A COMPACT MASTOID PROCESS WITH SCATTERED DIPLOETIC SPACES.

b, Tympanic cavity; *f*, Inferior wall of the auditory meatus; *d*, Sigmoid sinus; *e*, Posterior limit of the seat of operation.

This form of inflammation is oftener observed in adults than in children.

The inflammation, which occurs after catching cold, but usually without any traceable cause, affects either a limited part of the periosteum or spreads over the whole mastoid region, even to the temple. It is characterized by the formation of a hard, usually red swelling on the mastoid process, which becomes ill-defined towards its margins, and is painful on pressure. Sometimes, though not constantly, the superior portion of the sterno-cleido-mastoid muscle is, as Knapp first observed, involved in the inflammatory process. With the exception of a slight reddening on the posterior wall of the auditory meatus, no inflammatory symptoms are to be found on the membrana tympani and in the meatus.

The function of hearing is normal, rarely weakened by old-standing adhesive processes in the middle ear or by accumulations of serous fluid. The most prominent subjective symptoms are violent spontaneous pains in the inflamed area, which radiate in

various directions over the head. The accompanying pyrexia is usually moderate, but may reach a high degree if abscesses form.

The course and termination of primary periostitis mastoidea are generally as follows: The inflammation reaches its acme after some days, and the infiltration subsides without suppuration, or as in the cases observed by Roosa and Ely (*Z. f. O.* vol. ix.), Webster (*Arch. of Ot.* viii.), and Knapp, an abscess forms and recovery ensues after spontaneous rupture, or after opening of the abscess, or the pus finds its way into the external auditory meatus, one of the incisuræ Santorini or the membranous part of the cartilaginous portion being broken through, as has been observed by Swan Burnett (*Z. f. O.* vol. ix.), Hotz, and myself. Complications of this form of disease with caries and inflammation in the interior of the mastoid process have not yet been observed. In one of my cases, after incision and discharge of the pus, a circumscribed roughness was left on the bone, and in the course of some days it was covered with granulations and quickly healed up. In one of Hotz's cases, several splinters of bone came off the cortical layer.

The diagnosis depends on the objective changes on the mastoid process, taken together with the absence of inflammatory phenomena in other portions of the temporal bone. In long continuance of the infiltration and pain, the possibility of a secondary affection from inflammation of the external periosteum extending to the interior of the mastoid process cannot be excluded. It is possible by a superficial examination to confound this with those painful swellings on the mastoid process, which sometimes exist in cases of deep-seated furuncles on the posterior wall of the auditory meatus or in primary inflammation of the lymphatic gland lying on the mastoid process when it cannot be easily moved.

The prognosis of primary periostitis mastoidea is favourable.

Treatment consists in the use of energetic antiphlogistics (see below); and if, after two or three days, the inflammatory symptoms do not subside, an incision must be made in the swelling down to the periosteum. When there is an abscess, the pus must be evacuated by a sufficiently deep incision.

The secondary periostitis mastoidea which arises from extension of inflammation or caries from the interior of the mastoid process, or from the walls of the external meatus, will be discussed along with the terminations of ostitis mastoidea.

b. Ostitis Mastoidea (Inflammation of the Cell-spaces of the Mastoid Process).

The inflammatory processes which affect the muco-periosteal lining of the pneumatic spaces of the mastoid process seldom arise primarily, but usually by extension of inflammation from the tympanic cavity, more rarely from the external meatus.

Primary inflammation of the lining of the mastoid cells is very rare, and appears either spontaneously without any known cause, or from the effects of cold, injury, or syphilis. Still more rarely does it appear, as in one of my cases, several weeks after the termination of acute suppuration of the middle ear; without any reactive phenomena in the tympanic cavity, there commenced an extremely painful acute inflammation in the interior of the mastoid process, which led to the formation of an abscess and terminated after several weeks by bursting externally, the perforation gradually cicatrizing.

Primary ostitis mastoidea begins with or without pyrexia, with slight pain in the region of the mastoid, which after a time becomes stinging, tearing, and throbbing, usually without redness or swelling of the integuments. After several days in intense inflammation, or when it nears the surface, there is a feeling of pressure on the external surface and at the apex of the mastoid, and in consequence of secondary periostitis mastoidea, there is a painful swelling in the soft parts over that process, and of the lymphatic gland lying upon it. If it goes on to suppuration, it spreads towards the tympanic cavity, with the same symptoms which have been described in acute purulent inflammation of the middle ear (p. 388); the abscess seldom bursts externally. The statement of Kirchner (*A. f. O.* vol. xiv.), that the pus can make a way for itself to the outside from the interior of the mastoid process through the fissura mast. squam.,* has not been verified, as in ostitis mastoidea without direct communication with the accumulations of pus in the mastoid process, an external subperiosteal abscess may form.

The course of primary ostitis mastoidea is very short in the spontaneous cases and in those confined to the mastoid process, as after six or eight days the acme of the inflammation is reached, and even in suppuration and external rupture recovery takes place after two or three weeks. On the other hand, the traumatic and syphilitic inflammations which end in caries have a long and uncertain course, as also those forms in which the inflammation spreads to the tympanic cavity and the membrana tympani becomes perforated. In such cases the perforation is usually found in the posterior superior quadrant of the membrane at the apex of a nipple-shaped elevation.

The diagnosis of primary ostitis mastoidea depends on the persistent pain in the interior of the bone, and on the late appearance of swellings on the mastoid process and in its neighbourhood. The diagnosis is, however, impossible if, at the time of the first examination, great infiltration or an abscess already exists on the mastoid process, as these also occur in primary periostitis mastoidea. If in such a case after Wilde's incision (see below), or

* According to Kirchner, the fissura mast. squam. was described by Du Verney and Cloquet; *vide* foot-note, p. 7.

after discharge of an external abscess, the pains in the mastoid process remain unabated, then only may we suspect a deeply situated abscess in the bone. Also after the inflammation has extended to the tympanic cavity, it is not possible to determine whether the case in question is one of primary or of secondary inflammation of the mastoid process.

Secondary reactive inflammation of the mastoid process occurs much oftener in the course of acute or chronic suppuration of the middle ear. I choose this designation because in suppuration of the middle ear the mastoid process almost without exception is involved in the pathological process, but the inflammatory changes in it are developed without reactive phenomena, and generally quite without symptoms.

In my numerous post-mortem examinations of purulent affections of the middle ear, I did not find a single case in which there had not been simultaneous pathological changes in the mastoid cells. The results varied according as the suppuration had ceased or not.

When suppuration continues till death, the lining of the mastoid cells is found to be reddened, tumefied, smooth, or glandular, sometimes covered with microscopically small polypi (Wendt, Eysell, and the author). The cell-spaces are filled either with a purulent or muco-purulent fluid, or with semi-liquid, crumbling masses similar to tubercular matter, or the mucous membrane proliferates so excessively in them, that they are completely filled up with granulation tissue.

The mastoid process is seldom found to be normal after exhausted suppuration of the middle ear. The lining of the cell-spaces is sometimes thickened and covered with many layers of thick and dry epidermis; sometimes filled with succulent connective-tissue growths or layers of epidermis, or completely obliterated by sclerosis; sometimes, also, circumscribed or extended caries and necrosis of the bone are present.

The pathological changes in the mastoid process recorded here may exist for many years without occasioning any subjective symptoms whatever. The absence of external changes on the mastoid process and of subjective symptoms does not therefore ensure the absence of an affection of the mastoid process.

Etiology.—Secondary reactive inflammation of the mastoid process is developed either in consequence of external injuries, as cold, wet, trauma, injection of great quantities of fluid into the middle ear; or in consequence of general affections, as tuberculosis, scarlatina, typhus, syphilis; most frequently, however, it is occasioned by hindrance to the escape, combined with stagnation and decomposition of, purulent ichorous or caseous secretions in the cellular spaces of the mastoid process.

Symptoms.—The most prominent symptoms are: violent pains in the mastoid region extending to the neck, great sense of

pressure, moderate or high fever, tinnitus, and, more rarely, giddiness. The mastoid region may remain unchanged even during a long-continued inflammation. Swelling of the soft parts over the mastoid process occurs most rapidly when the inflammation is situated in the superficial parts of the bone. It is a red, hot, hard or slightly fluctuating swelling, which may extend backwards and downwards beyond the borders of that process. When the swelling is extensive, there is often a contraction of the sterno-cleido-mastoid muscle. Examination of the ear with the mirror discovers very variable conditions. The deeper parts of the meatus are either contracted or unchanged, and the perforated membrana tympani smooth or granular. In many cases the suppuration is profuse; in others, again, the escape of the pus is prevented by the obstacles already mentioned.

Course and Termination.—The course of secondary inflammations of the mastoid process varies according to their intensity, extent, and cause. Slight inflammation may be resolved without further consequences, the inflammatory phenomena disappearing after a few days, either spontaneously or under the influence of mild antiphlogistics. Such recurring inflammations lead to hypertrophy and proliferation of the lining of the mastoid cells, to sclerosis and eburnation of the mastoid process, and in superficial inflammations, to thickening of the external periosteum.

Severe inflammations, in which the osseous tissue is also to a great extent affected, cause the formation of an osseous abscess, frequently terminating in caries and necrosis of the mastoid process. The osseous abscess is either confined to a narrow, circumscribed part of the mastoid process, and situated beneath its surface, sometimes superficially, sometimes deep in the immediate neighbourhood of the sigmoid sinus, or it spreads over the greater part of the mastoid process. The abscess is either in connection with the tympanic cavity or quite separate from it. The communication is sometimes interrupted by the closure of the entrance of the mastoid cells with caseous secretions or granulation masses.

Purulent inflammation of the mastoid process rarely ends in recovery without caries, the pus becoming either absorbed or thickened, or discharged into the tympanic cavity through the antrum mastoideum. The latter termination is recognised by the sudden and copious discharge of pus from the ear, and the rapid subsidence of the inflammatory signs about the mastoid process after long-continued pain in that region.

The most common termination is in caries and necrosis. These are either confined to the mastoid process or combined with caries of some other portion of the temporal bone (*vide* p. 509). They affect either the superficial layers of the mastoid process or its central part, or they may be seated in the deeper layers in the immediate neighbourhood of the sigmoid sinus.

Caries and necrosis of the mastoid process set in with violent reactive symptoms, or may run their course without symptoms, even in cases of extensive destruction, particularly in phthisical individuals.

In a case observed by Moos (*A. f. A. u. O.* iii.), that of a phthisical patient who suffered from obstinate suppuration of the middle ear, it was found after death that the central part of the mastoid process was completely necrosed, while during life no sign of an affection of that process was observed.

In a woman in my clinique, who died at the age of thirty-six from pulmonary phthisis, and who had suffered for many years from profuse otorrhœa on the right side, the mastoid region was quite normal and not painful on pressure. Symmetrical percussion of the mastoid process with that of the normal side elicited a markedly shorter sound on the affected ear. On post-mortem examination, not only was the membrana tympani found to be destroyed, but the whole of the interior of the mastoid process was necrosed, even to the outer shell, and the osseous *débris* was embedded in thickened pus. After the purulent and osseous masses had been washed away the mastoid process presented a single cavity, formed by thin rough walls; the external wall was so thin that it could be broken by slight pressure.

In a girl eighteen years of age, who had also died from pulmonary phthisis, and who had suffered from childhood from otorrhœa on the left side, the external meatus was greatly contracted from infiltration, and the discharge was profuse, yet there was no appearance of an affection of the mastoid process.

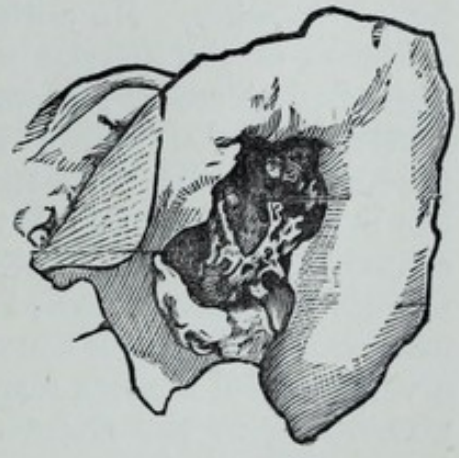

Fig. 202.

After removal of the external soft parts the autopsy showed that the posterior wall of the auditory meatus was almost completely destroyed (Fig. 202), and in the superior portion of the mastoid process there was a cavity about the size of a small nut, lined with smooth granulation tissue, in immediate communication with the lumen of the external meatus.

After destroying the external osseous lamellæ the cavity discharged itself outwards by an opening nearly 2 cm. in extent, and on looking through the opening a rough cellular sequestrum about the size of a hazel-nut was seen.

In contrast with those rare occurrences are the numerous cases in which the osseous abscess in the mastoid process bursts in various directions. Most frequently it bursts outwards, as the cortical layer becomes softened and destroyed, and with violent

reactive symptoms; but sometimes, without any such, an abscess forms in the mastoid region, which, if its contents are not removed in time by an artificial opening, bursts spontaneously after ulceration of the periosteum and cutis, through one or more places.

Sometimes an abscess forms between the periosteum and the bone before the rupture of the cortical portion. The immediate connection of the external abscess with the interior of the mastoid process is often very difficult to find after rupture of the cortex. A communication can be recognised with certainty only when the probe can penetrate into the cavity of the mastoid process through the opening in the bone, or when after injections into the tympanic cavity the fluid escapes through the opening in the integument on the mastoid process. A negative result, however, does not exclude the possibility of a direct communication between the mastoid process and the abscess above it.

Every abscess of the mastoid process appearing in the course of suppuration of the middle ear must not be regarded as caused by caries of the process. Particularly in children have I seen isolated abscesses, which probably originate through the medium of the lymphatic vessels, extending from the interior of the mastoid process to the surface, or by propagation of the inflammation from the external meatus. They develop very quickly, and burst very often into the cartilagino-membranous portion of the external meatus, if the pus has not been evacuated in time by an incision. In both cases recovery rapidly follows by the adhesion of the abscess walls, which is favoured by the application of pressure by a suitable bandage.

Although the rapid development of an abscess of the mastoid process generally betokens the presence of an isolated abscess in the interior of that process, it is not always the case. In a case observed in my clinique, in which bilateral suppuration of the middle ear, accompanied by profuse discharge and great deafness occurred during convalescence from typhus, within two days a very painful abscess formed on the right mastoid process, which was, owing to the short time it had taken to develop, mistaken for an abscess without rupture of the cortical layer. After the abscess had been opened, however, the probe could pass into the interior of the mastoid process through an opening $\frac{1}{2}$ cm. large. After the removal of several sequestra about the size of small peas the otorrhœa stopped on both sides, the perforation healed up, and the hearing became quite normal. Fourteen days later the wound on the mastoid process cicatrized, the cavity having become filled up with granulation tissue.

More rarely the rupture of the abscess in the mastoid process takes place on the posterior superior wall of the osseous meatus. The spontaneous discharge of the contents of the abscess in that situation is often preceded by long-continued inflammation of

the periosteum and of the integument of the auditory meatus, with great infiltration and bulging of the wall of the meatus (*vide* p. 514), till the osseous wall is broken through and the contents of the abscess press into the bulged parts (Fig. 203). The knowledge of such purulent accumulations, which prevent the escape of the pus by contracting the meatus, is of importance in so far as it points to rupture of the abscess in the mastoid process on the posterior superior wall of the meatus being imminent or having already occurred, and in respect of treatment it shows that by timely incision of the bulging part pus gathered in the mastoid process, caseous exudation, masses of epidermis (Bezold), and small osseous *débris* or larger sequestra may escape from the mastoid process into the auditory meatus.

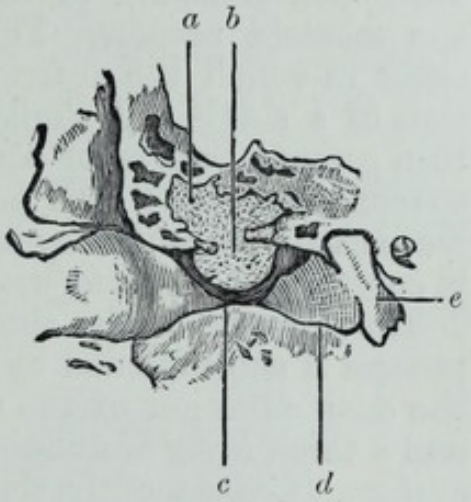

FIG. 203.

a, Cavity of abscess in mastoid process; *b*, Site of rupture on the posterior superior wall of the meatus; *c*, Lining membrane of the meatus swollen out to the anterior inferior wall; *d*, Inner portion of the external auditory meatus; *e*, Tympanic cavity.

Very various are the changes which take place after rupture of the external osseous plate or of the posterior wall of the auditory meatus, and after removal of the pus, caseous masses, or sequestra from the cavity of the abscess. Frequently, and particularly in children and young persons, the cavity is filled up with ossifying connective tissue, and then, as a rule, there remains a funnel-shaped scar on the mastoid process. In other cases a suppurating cavity with one or more persistent fistulæ may exist for years or during a whole lifetime on the mastoid process. In the cells of such cavities caseous masses are formed by stagnation, which hinder the development of benignant granulations. Sometimes the cavity is covered over with a layer of smooth connective tissue, which produces epidermis cells, and leads to the formation of accumulations of cholesteatomatous masses in the mastoid process. Large polypi seldom originate in the lining membrane of the cavity, growing, as Trautmann observed in one case, through the opening on the posterior wall of the auditory meatus into the meatus. In a man thirty-six years of age, in whose case it was said that in childhood a large sequestrum had been discharged behind the ear, I saw a firm, cauliflower, pedunculated growth, the size of a nut, growing out of the mastoid process through a large opening in the outer shell of the bone. Its removal was effected by the snare. When no growths exist in the cavity and the external opening in the mastoid process is very large, portions of the tympanic cavity can be seen through it when the light is sufficiently good. In a young man who had

had a large sequestrum removed from behind his ear in childhood, I could distinctly see the ostium tympanicum tubæ through the large opening.

On the whole, the rupture rarely occurs towards the incisura mastoidea (Bezold), or towards the inner (median) surface of the mastoid process. The tendency to this chiefly occurs in cases in which the inferior portion of the mastoid process consists of a single cell, similar to the bulla ossea of the dog, with a thin osseous wall, or of several large pneumatic cells, which are covered internally with a thin osseous shell. The pus will the more easily make its way in that direction when the external shell is compact and able to withstand the abscess pressing against it.

The bursting of the abscess on the median side of the mastoid process is accompanied by very unpleasant complications, because the deep situation of the rupture, behind the fasciæ of the neck and a thick layer of muscles, prevents the pus from coming to the surface. Consequently, the pus is spread out in the deeper layers, which leads to extensive painful infiltrations on the side of the neck, with the formation of abscesses, and in the end to external rupture, as has been verified by recent observations of Bezold, Burkhardt-Merian, and myself.

The diagnosis of median rupture can only be made with certainty when with continued pain on the mastoid process, increased on pressure, no infiltration of the overlying periosteum and cutis exists, while below the mastoid process a painful, hard infiltration extending downwards is developed.

Lastly, we must mention rupture of the mastoid abscess through the roof of the antrum mastoideum towards the cranial cavity, and towards the sigmoid sinus, with the already mentioned issues (p. 526) in meningitis, abscess of the brain, and sinus thrombosis.

Prognosis.—The prognosis is dependent on the intensity, extent, and situation of the inflammation, on the simultaneous changes in the tympanic cavity and in the external meatus, and on the state of the general system. It is favourable in regard both to the possibility of recovery and the freedom from danger of perforation when the inflammation and pus are not deeply seated, when there is a sufficiently free escape of secretion from the tympanic cavity and from the external auditory meatus, and when the patient is healthy. The prognosis is unfavourable both when it issues in caries and when it extends to the cranial cavity in cases of extensive and deep-seated abscess combined with persistent high fever; when the tympanic cavity is filled with granulations and caseous masses; when there are contractions of the auditory meatus; and when the patient is tubercular and cachectic.

In regard to the prognosis of suppuration of the middle ear in secondary affections of the mastoid process, it is important to

notice that after rupture of the mastoid abscess externally, suppurations of the middle ear, acute as well as chronic, often heal up very quickly. These facts, supported by abundant experience, are an important indication for the operative opening of the mastoid process.

Treatment.—The treatment of the inflammatory diseases of the mastoid process and of their sequelæ depends on the duration of the affection of the middle ear, on the intensity of the symptoms, on the superficial or deep situation of the affection, and on the complications which favour a quick and active extension.

The treatment of inflammations of the mastoid process, preceded by violent pain, which occur in the course of acute and chronic suppuration of the middle ear has already been discussed (p. 403). Instead of the cold compresses I now use Leiter's cooling apparatus, constructed in such a way that three rows of the leaden tube come in front of the ear and from six to eight behind it (Fig. 204). As the immediate contact of the metal is unpleasant to the patient, it is better to cover the mastoid process with a double layer of thin linen. To prevent the cold affecting the anterior portion of the ear, the anterior layer of tubes must be bent up till it stands out from the surface of the body.

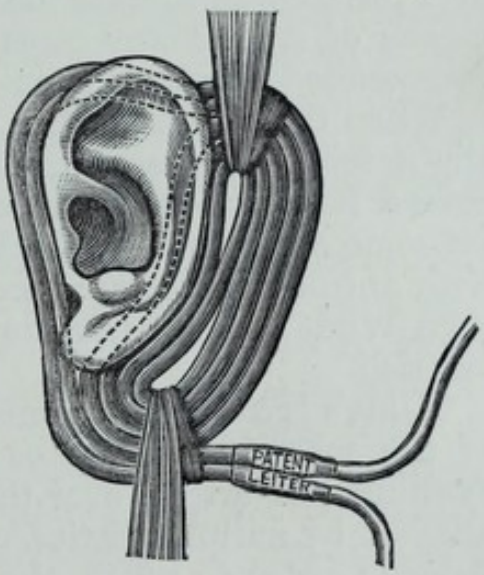

FIG. 204.

The great advantage of this apparatus over the cold compress is that the degree of cold always remains the same.

The results which I have recently obtained by the use of Leiter's apparatus in cases of acute inflammation of the mastoid process have been most favourable, as the inflammation completely subsided without local bleeding. I am convinced that by the timely use of this apparatus the termination of many cases in abscesses and caries can be prevented.

Simultaneously with the use of antiphlogistics the mastoid process can be painted with tincture of iodine or rubbed with unguentum cinereum. Local bleeding should only be had recourse to when, after using cold appliances continuously for one or two days, the pain remains unabated and the redness and swelling over the mastoid process increase. After bleeding, Leiter's apparatus must again be applied. An attempt can then be made to cleanse the middle ear thoroughly from secretion. Should an obstacle exist in the external meatus preventing the escape of the pus, it must be quickly removed (p. 544), and when the size of the auditory meatus and the position of the

perforation in the membrana tympani permit of it, the stagnating secretion can be washed out by the introduction of a bent tympanic catheter or Hartmann's cannula into the tympanic cavity. It must be observed that the point of the catheter or of the cannula should be directed upwards and backwards towards the antrum mastoideum to allow the stream of water to reach far enough.

In many cases, much good is derived from washing out the tympanic cavity with lukewarm water by means of the catheter through the Eustachian tube, not only when it is impossible to do so from the external auditory meatus, but also combined with the latter method. I attach great importance to this treatment, as I have cured intense inflammation of the mastoid process by means of it in many cases in which other specialists have recommended operative opening of the mastoid process.

When the inflammation is ushered in only by great pain and slight febrile movement, without such dangerous symptoms as severe headache and rigors, the middle ear should be syringed for some days through the Eustachian tube, and when that along with antiphlogistics produces no abatement in the inflammation, then Wilde's incision or the opening of the mastoid process must be tried.

Wilde's incision is recommended in those cases of inflammation of the mastoid process or its periosteum in which a painful swelling has arisen over the mastoid process which cannot be allayed by antiphlogistics. The incision should extend to the bone, in order to reach the infiltrated parts, to let out the pus which may have formed underneath the periosteum, and, in the case of abscess in the interior of the mastoid process, to render the rupture of the osseous shell easier. So long as the infiltrated parts feel hard and resistant, and no definite fluctuation is observable, it is difficult to determine whether the pus will be reached by Wilde's incision or not. In very hard swellings over the mastoid process when deep formation of pus was not suspected, after Wilde's incision I have often found either that pus had formed between the periosteum and the bone (purulent periostitis), or a perforation on the external osseous shell through which pus flowed from the interior of the mastoid process. In other cases, again, when indistinct fluctuation indicated the probability of pus having accumulated in the deeper portions, I have found no signs of it after free incision of the soft parts down to the bone.

Even in those cases in which no pus is found, the effect of Wilde's incision is often very favourable, as it not only allays pain and feverishness, but also diminishes local phenomena, the excessive suppuration in the middle ear, the swelling in the external meatus and on the mastoid process. In a number of cases, therefore, the dangerous subjective and objective symptoms

of inflammation of the mastoid process may completely disappear without the escape of pus through the incision.

According to the statements of most specialists, Wilde's incision should be made 1 cm. behind the place of attachment of the auricle and parallel with it. I do not keep exactly to that part, but make the incision where the infiltration is greatest and where examination suggests an accumulation of pus in the deeper parts. On the other hand, when there are no sure signs of an accumulation of pus under the periosteum of the mastoid process, I make the incision close to the place of attachment of the auricle, in order to use it—in case Wilde's incision should be unsuccessful—for the operation of opening the mastoid process.

Although Wilde's incision does not always evacuate the accumulation of pus, it has the advantage that in from one to three days the pus may find its way into the cut; failing that, the already decayed external osseous shell is more easily broken through after the incision and the pus finds its way out from the interior of the mastoid process.

After Wilde's incision has been made, the periosteum has to be examined (Hotz) and the exposed bone to be probed, in order to ascertain if it be smooth or rough, and if the shell be already broken through, in which case the probe will enter the interior of the mastoid process. When there are roughnesses on the external shell, the bone is often so soft and rotten that the slightest pressure of the probe is sufficient to break it and to open the osseous abscess. If we find the periosteum and the cortex unchanged after Wilde's incision, and there is no abatement of the pain experienced after one or two days, then is it almost certain that the abscess is situated in the interior of the mastoid process, and surgical operation becomes necessary.

Opening of the mastoid process is performed for the removal of pus, ichor, or caseous exudation which may have collected in its interior, and to effect a communication between the opening and the tympanic cavity by extending it to the antrum mastoideum. Then it is possible to wash out the whole of the middle ear, and by removing the stagnating and putrid secretion, to prevent the development of serious affections of the brain and sinuses.

We will not enter into a detailed description of the historical development of the operation.* It need only be remarked that, in former times, opening of the mastoid process was practised without definite indications on account of the pathological changes in the ear being unknown, and that in the first half of this century it was very seldom performed, after the Danish physician Berger (1791) fell a victim to the senseless procedure of attempting to

* The operation is said by some to have been first performed by Riolan in the middle of the seventeenth century; according to others, by Petit, 1750; and later, by Jasser, 1776.

cure chronic deafness which had arisen without suppuration of the middle ear by perforating the mastoid process.

It is only within the last twenty years that the real indications have been laid down and the operation perfected from pathological investigations and clinical observations made by v. Tröltsch, Forget, Follin, Mayer, Moos, Jacobi, Hartmann, Bezold, and others, but principally by the abundant clinical observations of Schwartze.

Many experiments, however, and an exact study of the anatomical and pathological relations of the mastoid process, must still be made before the indications for the operation can be placed on a rational basis.

The most recently stated indications for opening the mastoid process are:

1. Purulent inflammation in the mastoid process appearing in the course of acute suppuration of the middle ear, when persistent severe pain in the bones cannot be subdued by the application for several days of cold by means of the ice-bag or Leiter's apparatus, or by Wilde's incision (Schwartze).

2. Painful inflammations in the mastoid process occurring in acute and chronic suppurations of the middle ear, frequently preceded by great infiltration and redness of the external integument, when these are caused by stagnation of the pus in consequence of contractions of the external meatus or of numerous growths filling up the tympanic cavity and covering the perforation. The operation is absolutely necessary when several attempts to remove the obstacle to the escape of the pus have failed, more especially in all cases of suppuration of the middle ear when the discharge suddenly ceases, while the inflammatory symptoms in the mastoid process continue (Grüning). The indication exists in such cases even when the soft parts over the mastoid process are not swollen or infiltrated.

3. Persistent pain in the mastoid process, when at the same time the posterior superior wall of the meatus is bulged out by the inflammation having been transmitted to it from the mastoid cells (Toynbee, Duplay), and when after incision of the suppurating wall of the meatus the mastoid abscess is either not emptied at all, or only insufficiently, and when the symptoms indicating the retention of pus in the mastoid process remain unabated.

4. Obstinate pain in the mastoid process, lasting for days or weeks, without proof of stagnation of pus and swelling on the mastoid process, particularly when the latter is very tender on pressure, as very probably there exists a circumscribed osseous abscess situated deep in the mastoid process and not communicating with the tympanic cavity.

5. As a vital indication in every suppuration of the middle ear combined with inflammation of the mastoid process, in which fever, vertigo, and headache are developed during the course of

the affection, symptoms which may foretell the approach of a dangerous complication. In such cases the indication for the operation is vital.

The next question is whether there are also certain characteristic symptoms corresponding to the already described indications, from which the presence of pus or other noxious inflammatory products in the mastoid process can be determined with certainty. This must be answered in the negative. We have seen that large sequestra may sometimes be present in the mastoid process, and that the interior of it may be filled with pus and osseous *débris*, without the slightest pain being felt either spontaneously or from pressure, and also that during extensive suppuration the external integument of the mastoid process may remain quite unchanged. On the other hand, not unfrequently in cases of severe and persistent pain in the mastoid process, which with great probability indicates the presence of an osseous abscess, we find, after opening the mastoid process, either diploetic or sclerosed tissue (Hartmann, Orne Green), or tough mucous masses (Zaufal), or lastly, granulation tissue, which by incarceration in the pneumatic spaces may cause great pain (Wendt). Even the most severe reactive symptoms, with swelling and infiltration of the soft parts over the mastoid process, are no sure sign of an abscess in that process, as in several operations in which I was certain of an extensive mastoid abscess on account of a large swelling having formed behind the ear, only cellular tissue was found on penetrating towards the antrum mastoideum. Percussion and auscultation of the mastoid process cannot be relied upon for the diagnosis of an osseous abscess. In a unilateral affection, indeed, I found the percussion-sound very often shorter on the affected side; but this sign is also often found in unilateral suppuration of the middle ear without inflammatory phenomena in the mastoid process.

Another important point to be noticed in connection with the performance of the operation is the impossibility of ascertaining in a living person whether the mastoid process be pneumatic, diploetic, or solid, and whether in a given case an anomalous state of the base of the skull or of the sigmoid sinus is present or not. It is during the operation that one learns all that; consequently it is only very rarely that its success can be foretold.

As to the time when the operation should be performed writers do not agree, notwithstanding the numerous observations made. While one proposes that the operation should be done as soon as there are symptoms of inflammation of the mastoid process, another defers it till dangerous symptoms (fever, headache, etc.) set in. The latter proposal must not be adopted, as in many cases it would then be too late to operate. On the other hand, I am not in favour of operating at an early period in all cases, as

very often, especially in acute but also in chronic suppuration of the middle ear, a complete cure is effected by the energetic use of antiphlogistics, and after the tympanic cavity has been washed out by injections into the antrum mastoideum by means of the tympanic catheter or Hartmann's cannula, in cases in which other specialists would certainly open the mastoid process. I am of opinion, therefore, that in the absence of dangerous symptoms the operation should be performed when all other remedies have failed after suitable trial.

The question whether the surgeon, in view of possible injury to his reputation, should operate in cases in which dangerous symptoms appear in the course of the treatment, or are observed at the first examination, must be thus answered: in such cases it is absolutely necessary to undertake the operation. Before doing so, however, the relatives of the patient must be informed that very possibly the affection has already extended to the cranial cavity; that therefore, in spite of the operation, the disease may end fatally; and that it is only undertaken to save, if possible, the threatened life of the patient.

This caution is necessary, because the commencement of dangerous symptoms does not show whether the suppuration has already attacked the vital organs or not. Otitic abscesses of the brain may exist for a long time without marked symptoms. It is also to be observed that even after the operation the carious process may extend to the cranial cavity, and that death may ensue from pyæmia, exhaustion, or in tubercular subjects from the addition of phthisis. The operation must not be undertaken when there are definite symptoms of a cerebral or sinus affection, or in cases in which there exists a severe constitutional ailment.

In the case of a robust but scrofulous girl, twenty-two years of age, who had suffered for two years from chronic suppuration of the left middle ear, and who had come to the clinique with violent pain in the mastoid process and moderate swelling of the integuments over it, the mastoid process was opened, after energetic antiphlogistics and narcotics had been used in vain to allay the pain and give repose. The pain was completely removed and a refreshing sleep enjoyed after the removal of a sequestrum of the size of a hazel-nut and syringing with 2 per cent. solution of carbolic acid. A favourable issue to the operation was expected, as in the course of several days the graver symptoms completely disappeared. On the thirteenth day after the operation violent headache was felt, with increase of the temperature and of the frequency of the pulse and vomiting, which however ceased after a few days. Then followed an abundant fœtid discharge from the ear, and facial paralysis of the left side quickly set in. At the end of the fourth week there again occurred violent occipital pains, with rigors, stupor, frequent small pulse,

inactivity of the pupils, and death. Post-mortem appearances (Fig. 205). — Large gap in the posterior osseous wall of the meatus, through which the cavity of the mastoid process could be reached. The posterior section of this space led to the sigmoid sinus by an opening 3 mm. wide and 10 mm. high (*a*). On the wall of the vein was a fresh, firmly-attached thrombus. From the perforation almost to the anterior point of the pyramid (*b*) the whole pars petrosa was carious and partly necrosed, so that the whole capsule of the labyrinth (*c*, *c'*) was separated from the surrounding osseous substance and could be easily lifted off. The osseous parts surrounding the capsule of the labyrinth were broken up into pieces of various sizes. The

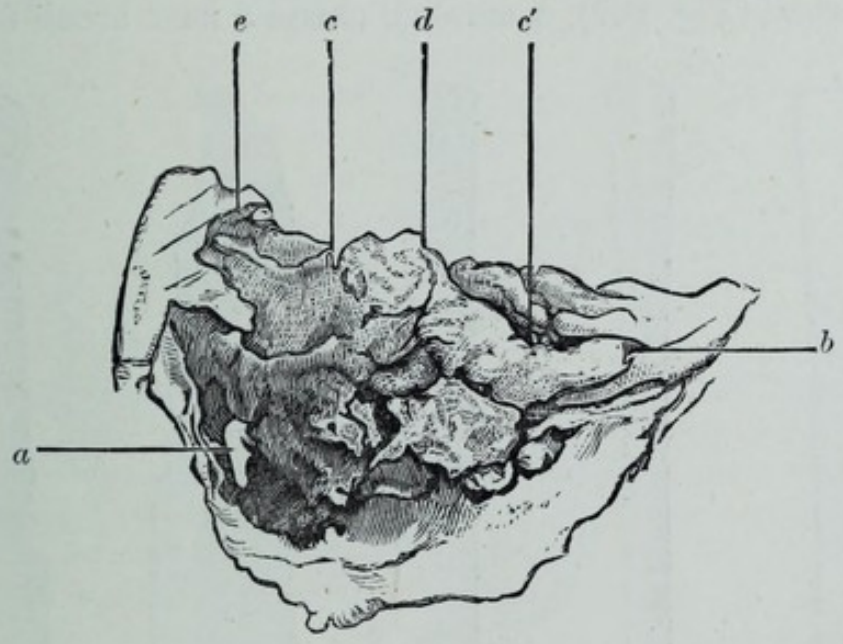

FIG. 205.—VIEW OF THE SUPERIOR AND POSTERIOR SURFACES OF THE PYRAMID.

membrana tympani and ossicula were wanting. The cavity of the labyrinth was unopened, and the cochlea was dyed black-brown by a hæmorrhagic extravasation. The facial nerve (*d*) was reddened, and the nerve-sheath thickened by infiltration. The dura mater in the neighbourhood of the meatus auditorius internus was cribrated; there was a gap, corresponding to that first mentioned, on the adherent cerebellum which led to an abscess cavity about the size of a nut.

A case with a similar course has been observed by Pavley (*A. of Otol.* 1880).

For the performance of the operation, formerly trepans of various size and form were used, replaced of late by drills of various construction (Jacobi, Lucae, A. H. Buck). The first-mentioned have long since been done away with as useless and unnecessary; the drills, however, which have been recommended

till very recently, have been properly set aside on account of their uncertain and dangerous advance in the deep parts, and on account of their soiling the wound with splinters. I agree with Schwartze, that the most rational and safest method is to open the mastoid process with a chisel, as by carefully removing the bone in layers, the dangers arising from the anomalous formation of the mastoid process can be duly met.

No one should operate on the living before having performed the operation at least forty or fifty times on the dead.

The instruments used for opening the mastoid process consist of the following: A broad and a small scalpel, a pointed and a blunt bistoury, dissecting forceps, several catch-forceps, a raspatory, a straight chisel 7 mm. broad (Fig. 206), a hollow chisel 6 mm. broad (Fig. 207), a smaller chisel 5 mm. broad (Fig. 208),

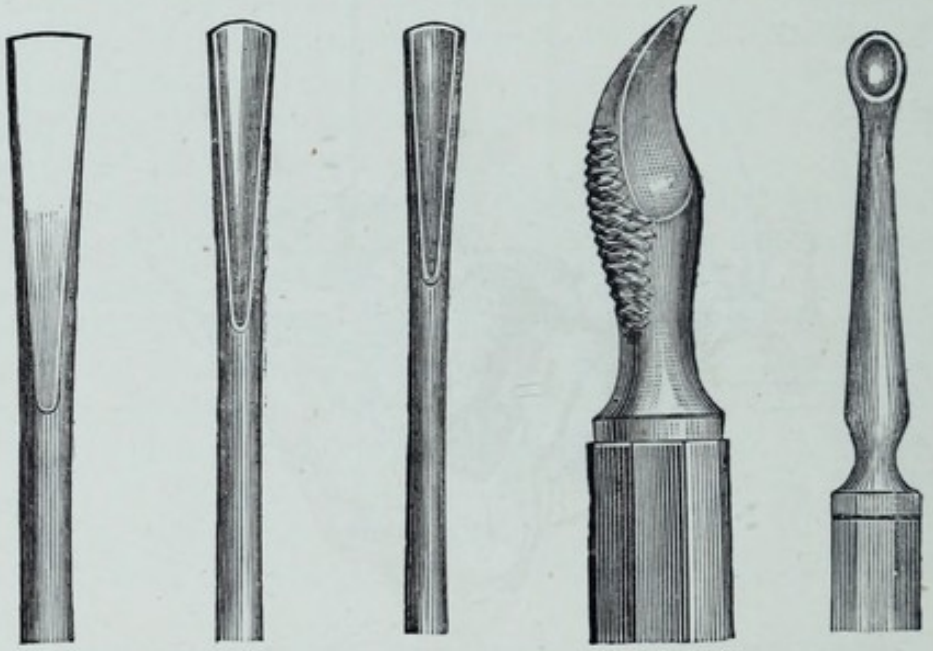

Fig. 206. Fig. 207. Fig. 208. Fig. 209. Fig. 210.

a lead or wooden hammer, a bone knife with a concave edge for widening the opening on the external osseous shell (Fig. 209), a sharp spoon of the size represented in Fig. 210, several sharp and blunt hooks, strong dressing-forceps for catching and withdrawing loose sequestra, hollow and blunt probes, and ligatures. All instruments must be put into carbolic solution for half an hour before the operation.

The method of opening the mastoid process is as follows: After the hair about the mastoid region has been shaved off, and the skin washed with soap and carbolic solution, the patient being anæsthetized, a perpendicular incision is made through the skin down to the bone close to the place of attachment of the auricle, beginning 1 or 2 cm. above the linea temporalis, and from 4 to 5 cm. long. The bleeding is then stopped with sponges, and if profuse, the arteries are twisted with catch-forceps or

ligatured. The field of operation must be washed over every two or three minutes with carbolic solution (3 per cent.).

The incision is made immediately at the place of attachment of the auricle with the view of placing the external opening in the bone as far to the front as possible, so that opening of the lateral sinus may be most surely prevented (Bezold). No attention need be paid to the course of the external arteries, as their direction varies so much at that place, and it is impossible to avoid cutting some vessels in separating the soft parts in the neighbourhood of the auricle.

Formerly I employed a straight incision, but in more recent cases I have preferred a flap; from the superior end of the perpendicular incision, a second one 3 cm. long is directed back-

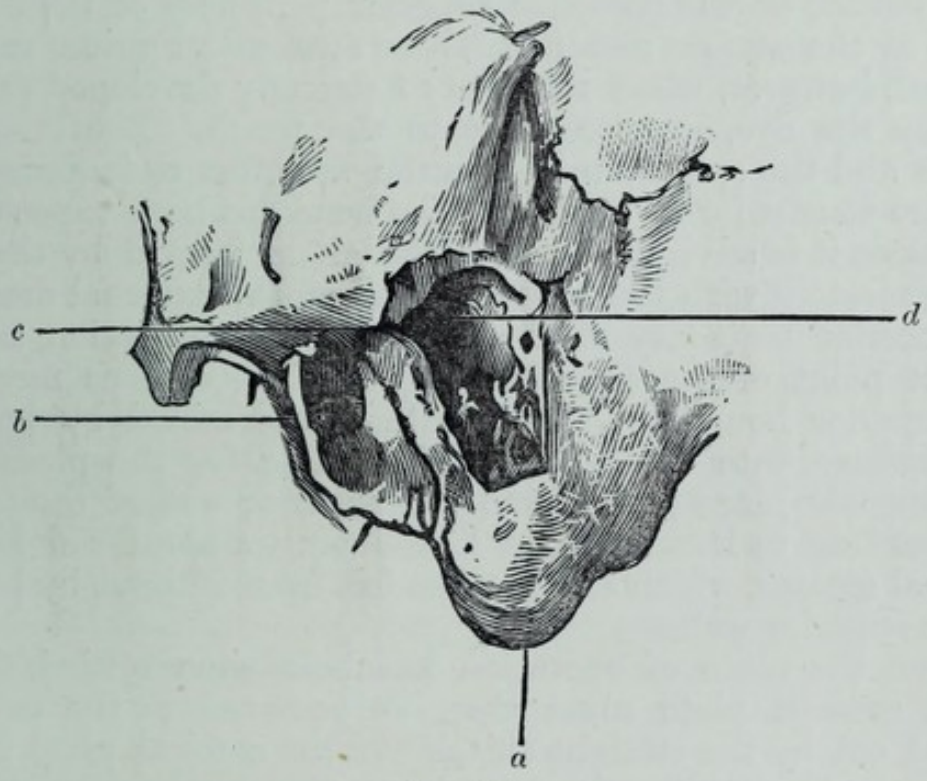

FIG. 211.

a, Apex of mastoid process; *b*, External meatus; *c*, The part of the superior wall of the external meatus passing into the planum temporale; *d*, Orifice made by operation, with the funnel-shaped depression leading to the antrum. (In the illustration the upper border of the orifice is placed about 3 mm. too high.)

wards at right angles, and the soft parts are then so dissected off from the bone as to form a sufficiently large flap. This method has the advantage of laying bare a greater surface of the cortical portion of the mastoid process, and so affording a better view of the locality and extent of any pathological changes that may have taken place in the bone, and thus rendering the operation easier.

When the soft parts are divided down to the periosteum, the latter can be so far separated forwards and backwards by means

of the raspatory, that the site of the external osseous opening is left entirely free from periosteum.*

If any part of the exposed bone appear inflamed, infiltrated with pus, discoloured and rough, or perforated with a small opening, it is most advisable to make the opening at that part, as the seat of the disease will thus be more surely reached. On the other hand, if the exposed bone be normal in appearance, that part must be chosen from which the antrum mastoideum can be soonest reached, without injuring the sinus or the cranial fossa. This is the anterior superior quadrant of the mastoid process (Fig. 211). According to the observations of Hartmann and Bezold, the spot is situated beneath the linea temporalis above the superior wall of the external meatus, and about 7 mm. behind the spina supra meatum. It is a more or less strongly developed pointed protuberance on the posterior superior periphery of the external orifice of the osseous meatus. These anatomical guides can only be used, however, when they are so strongly developed as to be seen by the eye, or perceptible to the touch. The linea temporalis and the spina supra meatum are often so indistinct that they are sought for in vain after the bone has been exposed. In such cases it is advisable to take the angle formed by the plane of the mastoid with the posterior wall of the external meatus as the anterior boundary of the orifice of the operation, and the highest point of the superior margin of the osseous meatus as the superior boundary. This is best ascertained by inserting the forefinger into the incision and feeling for the place where the temporal plane passes into the superior wall of the meatus; or according to Hartmann, by introducing a blunt rod into the external meatus, which can then be felt from without by pressing on the superior wall.

When the place of operation has been thus settled, the external osseous plate must then be removed to the extent of about 1 cm. by the straight chisel. If the cortical plate be thin, as in most mastoids with strongly marked pneumatic spaces, or if it have become rotten and brittle by inflammation, a few slight strokes with the hammer are sufficient to expose the mastoid cells. In children, in whom the cortical plate is thinner, and the antrum lies nearer the surface than in adults, and when the bone on inspection is evidently diseased, I use merely a hand-chisel, as pressure by the hand is sufficient to break through the bone. In this manner I have succeeded in several cases in removing the cortical plate, and in opening the abscess cavity by the use of the hand-chisel two or three times.

After the removal of the thin or it may be already necrosed

* As, according to Bezold, the breadth of the surface of attachment of the auricle above the superior wall of the external meatus amounts to 15 mm., and mostly extends over the mastoid plane, the orifice of the opening in the bone comes to lie in front of the line of attachment of the auricle.

cortical plate, the irregular abscess cavity, filled with pus or ichor, is sometimes immediately reached, containing a large movable or still adherent sequestrum, or some small osseous *débris;* in other cases, one comes at once upon cholesteatomatous epidermic masses, after the removal of which, there appears in the interior an offensive, greasy, discoloured secretion, mixed with small osseous fragments. Lastly, one may meet with a bleeding granulation tissue filling up the cell-spaces in the interior of the mastoid process, often extending to the neighbourhood of the antrum, and sometimes even connected with similar growths in the tympanic cavity.

It is otherwise in those cases in which the mastoid process has a very thick cortical plate, or is in most parts sclerosed, or almost quite diploetic. Sometimes the external plate is so thick that one has to penetrate for the depth of ½ cm. and more, before reaching the pus or diploe. When the cortex to the extent already mentioned has been taken away by the straight chisel, the broad gouge is first used to penetrate more deeply, and then the narrow one, with which a gradually diminishing funnel-shaped canal is made towards the antrum mastoideum. In order to avoid injuring the sinus, the chisel must be kept directed forwards, nearly parallel to the posterior wall of the external meatus. When the operative incision lies near the front, it is not advisable to pierce deeper than from 14 to 15 mm., in case of injuring the labyrinth or the facial canal.*

When the bone is solid it must be penetrated gradually by layers, as by that means serious injury cannot easily be inflicted, even when the situation of the sinus is so abnormal that it is impossible to avoid it by taking every precaution in regard to the position and the direction of the line of operation. When, even by carefully removing the bone in thin layers, the membranous wall of the sinus or the dura mater is exposed over a circumscribed area, no serious injury has been done (Neuling), as the exposed part of the venous wall or the dura mater becomes covered with granulation tissue, and cicatrization sets in without injurious consequences. Serious injuries of the sinus arise only when a splinter of bone makes a slit in the venous wall (Schwartze), an event which can only happen by chiselling out the bone too quickly or in a careless way. It is, of course, understood, that should one come unexpectedly upon the wall of the sinus before reaching the accumulation of pus, the chisel must be laid aside. When the dura mater is exposed an attempt can always be made to penetrate at a deeper place.

But even in those operations in which, while a properly made

* Schwartze begins the opening in the bone with a bore of 10 mm., and according to him the distance from the posterior edge of the opening to the antrum amounts to 18 mm. According to Bezold, who makes the external orifice only 7 mm. in size, the distance from the anterior periphery of the opening measures only 12 mm.

funnel-shaped crater has been directed towards the antrum, sclerosed osseous tissue is still met with at a depth of 1½ cm., I desist from penetrating further, as in such cases the pus is seldom found, and further because an attempt to pierce a sclerosed or diploetic mastoid process through to the antrum, more or less involves the danger of injuring the horizontal semicircular canal or the facial canal.

The difficulties are not less which are met with in the operations on highly diploetic mastoid processes. The cortex is often so thick that diploe is first found at a depth of from 3 to 6 mm. It appears as a dark red, soft, slightly bleeding osseous tissue, which offers only a slight resistance to the chisel when the hammer is applied. It is therefore better, as soon as the diploetic tissue is reached, to use either the hand-chisel or the sharp scoop, in order to proceed more carefully towards the antrum. If before reaching the antrum a compact mass of bone is not met with, no attempt must be made to penetrate further, as it cannot be ascertained whether the solid osseous tissue belongs in such cases to the wall of the sigmoid sinus, or whether it is sclerosed tissue, which, as Hartmann observed, has formed round the accumulation of pus.

From the above it is clear that the success of the operation—*i.e.*, the restoration of a communication between the antrum mastoideum and the tympanic cavity through the artificial opening—depends on various circumstances. In the first place, there are the numerous normal varieties in the anatomical construction of the mastoid process and in the course of the sigmoid sinus, which have an important influence on the result of the operation. Then there are the difficulties which are called forth by pathological changes with otherwise favourable normal construction. As the most important of them must be mentioned, the interrupted inter-communication of the individual cell-spaces with each other and with the antrum mastoideum by connective tissue-growths, or by new formation of osseous masses and pathological sclerosis of the mastoid process. In the first case there are often one or more superficial accumulations of pus in the bone, which are quite separated from the antrum, so that it is only by penetrating further with the chisel or sharp scoop that the antrum is reached. Sometimes, however, penetration to the region of the antrum gives no result, when the latter is filled with granulation tissue or quite obliterated by osseous proliferation, in which case communication between the mastoid process and the tympanic cavity cannot be effected. Sometimes the communication establishes itself several days after the operation.

The method of treatment is different from that above described in those rare cases in which the pus is situated in the lower section of the mastoid process, and the appearances (p. 560) lead to the supposition that the abscess will break on the mesial wall of

the mastoid, or into the incisura mastoidea. In such cases, according to Bezold's proposal (*Deutsche Med. Wochenschrift*, 1881), the entrance to the canal of operation should not be made in the place above mentioned, but on the inferior section of the mastoid process, which should be perforated in its whole thickness to the incisura mastoidea. In a case observed by me, in which the appearances corresponded to those described by Bezold as indicating rupture of the abscess on the mesial wall of the mastoid process, the extensive inflammatory infiltration around that process quite subsided after the use of Leiter's cooling apparatus.

The treatment after opening the mastoid process varies, according as we reach the accumulation of pus and restore communication with the tympanic cavity, or, notwithstanding the deepest possible penetration, reach neither the pus nor the antrum.* In the former case, after sequestra of bone or cholesteatomatous masses have been removed by washing out the middle ear, antiseptic injections through the artificial opening on the mastoid process are then to be employed, when the fluid, as a rule, escapes by the external meatus. This is, however, by no means a sure sign of communication between the mastoid process and the tympanic cavity, as there is often immediate communication between the lumen of the meatus and the mastoid process through one or more fistulous canals. After the operation, a drainage-tube of the same thickness is laid in the opening of the wound.

As long as the secretion is offensive and contains crumbling lumps I use a weak carbolic solution (1-2 per cent.) as a cleansing agent; after the bad smell has disappeared and the character of the secretion improved, a weak solution of boracic acid suffices.† Syringing may be discontinued only when the suppuration in the tympanic cavity has quite ceased. So long as that is not the case, it is not advisable to let the communication between the mastoid process and the tympanic cavity be interrupted. It becomes, therefore, necessary to remove by scraping or crushing the rapidly forming granulations, which in a short time block up the way to the tympanic cavity, from the walls of the cavity and the opening of the operation, and to prevent contraction of the canal by the insertion of a suitable leaden pin (Schwartze) having its external end turned down, or, what is still better, a leaden tube with lateral openings. Circumscribed roughnesses in the cavity of the operation which do not become in a short time covered over with granulation tissue, and fungous granulations having an unhealthy appearance, should be scraped off by the sharp scoop

* L. Turnbull (*Med. and Surg. Reporter*, 1878) cured a case by evacuating a dark red fluid from the mastoid process, and Zaufal another by the removal of a colloid mucous mass.

† Resorcin is also used as an antiseptic. De Rossi (*Z. f. O.* vol. x.) recently recommended it for suppuration of the middle ear, as a 4 per cent. solution dropped into the meatus.

(Fig. 210) (Schede). In the already described changes in the cavity of the mastoid process the most effectual remedy is sprinkling with a thin layer of iodoform powder, by which not only is the secretion improved and lessened, but also the formation of better granulations capable of organization is induced.* Cassells has the merit of introducing this excellent method of treatment (*Brit. Med. Journal*, 1878). It is only when the suppuration in the tympanic cavity and in the auditory meatus has ceased, and but scanty secretion comes from the bottom of the canal of the operation, that the leaden pin can be removed in order to allow the canal to close.

In cases in which on account of the sclerosed or diploetic character of the mastoid process, neither the accumulation of pus nor the antrum can be reached, the wound is sprinkled with iodoform powder, then bandaged, and the bandage is not changed for five or six days.

Results of the Operation.—These are generally favourable when the pus has been evacuated and the communication between the mastoid process and the tympanic cavity established, provided that the caries is confined to the mastoid process and that the suppuration has not extended to the cranial cavity. In such cases alarming symptoms disappear often a few hours after the operation, and after the stagnating secretion has been removed. Not only do the violent pain and giddiness cease, but very often the fever also subsides. The following case will serve as a good example:

In a girl, seven years of age, there appeared, in the course of an acute suppuration of the middle ear of three weeks' duration, an inflammation in the mastoid process with high fever, which quite typically after twenty hours had become so exacerbated as to reach an acme of over 40·5° (105° F.). After twelve days in this condition, when I visited the girl, she was very much reduced, and of a pale yellow complexion. The posterior superior wall of the meatus was so strongly bulged forwards and downwards that the swelling quite blocked the lumen of the meatus. The skin over the mastoid process was normal in appearance, not swollen, and over the bone slightly movable. Pains in the mastoid process were not complained of, but on the other hand, very acute pain was felt on slight pressure on the bone.

After an incision had been made in the swollen integument of the posterior superior wall of the meatus, the pus escaped very sparingly, and the fever continued unabated. On the following day, during anæsthesia, opening of the mastoid process was undertaken. After a perpendicular incision 3 cm. long had been made parallel with the place of attachment of the auricle down to the bone, and after the periosteum had been sufficiently

* The offensive smell of the iodoform is best allayed by placing half a tonka bean in the powder, or by adding 1 or 2 gram. of the tincture of the bean to 4 or 5 gram. of the powder.

scraped off, the uppermost osseous lamella, at the junction of the cortex of the mastoid process with the posterior superior wall of the meatus, was raised by the pressure of the hand on a straight chisel. After the second application of the chisel, and the removal of the osseous lamella, greyish crumbling discoloured pus was exposed to view. Through the artificial opening, access was obtained into a tolerably spacious cavity, in washing out which the fluid escaped by the external meatus. Two hours after the operation, the temperature sank to 36·6° (97·8° F.), and in the following days an increase of the temperature above normal was only observable for a short time. The general health quickly improved, but the wound remained open for several years, as the cavity in the mastoid process did not become obliterated.

The number of published cases is still too small to give statistics of the results. Hitherto, however, the results have been so favourable, that the operation may be reckoned one of the most successful of those on the ear. Schwartze, who has had the largest experience, states that recovery took place in 70 per cent. of his cases, while 10 per cent. remained uncured, and 20 per cent. died. The proportion of the cured becomes smaller when it is taken into consideration that nearly the half of Schwartze's operations were performed in cases in which fistulæ already existed on the mastoid process, and when those cases are deducted which, according to our knowledge of the disease, would probably have ended favourably without operation. On the other hand, from a consideration of the causes of death, it results that the operation is not dangerous when it is performed with due care. Only in one case (among fifty) in which, on account of the anomalous formation of the temporal bone, the cranial fossa was opened and a splinter of bone perforated the dura mater, did death ensue from traumatic cranial meningitis. In the remaining cases, tuberculosis, pyæmia, meningitis, carcinoma, anæmia, were the cause of death. The exposure of the wall of the venous sinus, or of the dura mater, is by no means dangerous when the latter are not injured; therefore the appearance of unfavourable anatomical conditions must not deter one from performing the operation when it is clearly indicated. Schwartze relates cases in which the venous sinus and the dura mater were exposed, once even with injury to the middle meningeal artery, without serious consequences. In one of my cases (a woman, age twenty-seven) in which, during suppuration of the left middle ear, said to have lasted from childhood, acute inflammation in the mastoid process with high fever (40·2°, 104·4° F.) and violent headache appeared, leading to opening of the mastoid process, in spite of closely adhering to the necessary precautions, I cut to a depth of not quite ½ cm., and came upon a grey yielding membrane, which I took to be the dura mater. The surface of the wound was sprinkled with iodoform, and dressed

with antiseptic wadding. On the third day the headache ceased and the temperature fell to 38° (100° F.). In the following days, during which the temperature sank below 37° (97° F.), the patient quickly recovered, and the exposed bone and the dura mater were covered over with fine granulations; fourteen days after the operation the suppuration of the middle ear ceased, the perforation in the membrana tympani closed, and at the end of the fourth week the patient was dismissed with a cicatrized wound and normal hearing.

As to the influence of the operation upon suppuration of the middle ear, a rapid decrease of the secretion and not infrequently a speedy cure of the suppuration of the middle ear are observed not only in acute but also in chronic cases. The hearing-function is restored more frequently in the acute than in the chronic forms. In many cases, however, in spite of a successful operation, the secretion in the middle ear continues unabated without any apparent reason.

That the operation, in many cases, has a favourable influence on the state of the general system, is proved by experience. Debilitated anæmic patients recover very quickly. This is easily accounted for when it is considered that the existence of a collection of pus in the bone affects the quality of the blood and nutrition. The removal of cheesy exudation from the mastoid process is also of importance in so far as that the caseous osteitis may form the starting-point of dangerous forms of tuberculosis of the lungs.

Highly interesting are the results of the operation in those cases in which, on account of the diploetic or sclerosed character of the mastoid process, the collection of pus and the antrum cannot be reached. Schwartze relates several cases in which, after an unsuccessful operation, the alarming symptoms quickly subsided. Orne Green (*I. Otolog. Congress*, 1876) observed rapid cessation of pain after the removal of a piece of bone from the sclerosed mastoid process. I have myself in six cases, in which there existed marked indications for the opening of the mastoid process, and where, on operation, the process was found partly diploetic and partly sclerosed, observed, after a wedge of bone had been chiselled out, an astonishingly favourable result, although no pus was found in the bone. In all the cases there was not only a rapid cessation of the long-continued pain in the ear and giddiness, but also a rapid decrease in the suppuration in the middle ear, till it ceased altogether, and the perforation closed (in four cases). An explanation of these facts cannot yet be given, and we must limit ourselves to the fact that the hyperæmia in the temporal bone, and in the veins of the skull, is partly removed by the operation. This is confirmed by Zaufal's observation that in one case, after the opening of the mastoid process, on the retina of the affected side hyperæmia

and ecchymosis, which formerly existed, disappeared.* An analogous favourable effect of the removal of a part of a bone by the chisel, we see in recent times in those extensive inflammations of bone where, after excision of a circumscribed piece, the osteitis soon subsides.

The fact that after the spontaneous rupture of an abscess in the mastoid process, or after its opening by operation, chronic suppuration of the middle ear is not unfrequently cured, suggests the idea that the operation may be employed for the cure of obstinate suppuration of the middle ear. Schwartze is opposed to this idea. When one considers, however, that frequently even when only a diploetic or sclerosed piece of bone is chiselled out of the mastoid process protracted suppurations cease, I think that when all other means (p. 470) fail in terminating the suppuration, the operation should be performed as a last resource. The experiment seems the more justifiable, as, in my opinion, the size of the wedge must be limited to $\frac{1}{2}$-$\frac{3}{4}$ cm., a harmless performance, by which there is almost no fear of exposing the dura mater or the transverse sinus. On the other hand, I agree with Schwartze in objecting to penetrating deeper down to the antrum.

Along with the opening by operation of the mastoid process, there are still to be mentioned those conditions which are observed on that process in cases of long-standing fistulous openings. Such fistulæ often remain in young people, less frequently in adults, after the abscess in the mastoid process has burst spontaneously, and, as a rule, they defy local treatment. The fistulous openings on the skin rarely correspond with the perforations in the bone. The tissues around them are often infiltrated, and their margins granular or callous.

The surest course for the cure of such fistulæ is to enlarge the opening in the bone sufficiently to allow of the diseased parts in the interior of the mastoid process being scooped out. With this view a vertical incision, 3-4 cm. long, is made through the cutaneous fistulæ to the periosteum, and the latter is separated so far from the bone, both anteriorly and posteriorly, by the raspatory, that a large part of the cortex is exposed. The opening in the bone is then enlarged either with the chisel, or with a short bone-knife, or curved forceps, and the interior of the mastoid process minutely examined.

Here are found the greatest variety of changes. Sometimes we find one or more large cavities with irregular indentations, which contain offensive cheesy masses, and after these have been washed out, the osseous walls feel rough or are covered with granulations. In other cases the entire cavity is filled up with spongy granu-

* I cannot from my own experience confirm the conclusion that optic neuritis and the appearance of engorgement of the retina occurring in suppuration of the middle ear are sure signs of an already commenced secondary cerebral affection, as I have recently found such phenomena in cases in which there was not the slightest indication of a cerebral affection.

lation tissue. Lastly, the osseous tissue may be found sclerosed, with a narrow fistulous canal winding into the interior or towards the posterior wall of the external meatus.

After the removal of the retained masses, the highly proliferating spongy granulations must then be got rid of. This is best accomplished by means of common dressing-forceps or a sharp scoop. The cavity is then to be minutely probed, and wherever a rough part is found, it must be erased by the scoop. On account of the nearness of the sinus and the dura mater, we must proceed very cautiously when parts of the interior or superior wall of the cavity are being scooped out. The cavity is then to be washed out with carbolic solution, sprinkled with iodoform powder and dressed. If, when the dressing is being renewed at the end of some days, roughnesses are found on one or more places in the cavity, the scraping may be carefully repeated. In this way I have often cured by cicatrization fistulæ which had existed for years.

The procedure is more difficult when the bone is sclerosed and traversed by narrow fistulous canals. In order to avoid complications in such cases, it is better not to penetrate deeper than 1 cm. at the most, more especially when the fistulous canal runs straight down. It is only when the latter runs in the direction of the antrum or of the posterior wall of the external meatus, that the chisel can be used without danger, following the direction of the fistulous canal.

According to the usual classification in text-books, there would now come the description of aural polypi and other neoplasms in the middle ear, traumatic affections and neuroses of that part. Considering, however, that aural polypi arise in the middle ear as well as in the external meatus, and neoplasms of the external meatus frequently involve the middle ear and *vice versâ ;* that traumatic lesions frequently affect the auditory meatus and the middle ear at the same time ; and that also neuroses of both portions of the ear may appear together, I have thought it better, for the sake of clearness, to treat the above diseases of the sound-conducting apparatus separately, after the diseases of the external ear.*

* Besides the text- and hand-books on diseases of the ear mentioned at p. 385, the works of the following authors remain to be given : Franc. Wenc. Hegebarth, *De Otorrhœa*, Dissert. Vindob. 1833 ; Leopoldus a Stur, *De Otitide*, Vindob. 1834 ; Wreden, *Die Otit. med. neonat. vom anatomisch-pathologischen Standpunkte*, *M. f. O.* 1868 ; Knapp, *Ueber prim. acute eitrige Mittelohrentzündung*, *Z. f. O.* i. ; Bing, *Zur Perforation des Trommelfells*, *Allg. Wien. med. Ztg.* 1873 ; Cassells, *Treatment of Chronic Exanthemal Catarrh of the Tympanum*, Glasgow, 1873 and 1874 ; O. Wolf, *Zur operativen Behandlung der Ohreiterungen*, *A. f. A. u. O.* iv. ; A. Politzer, *Ueber die Anwendung des Paukenröhrchens*, *Wien. med. Wochenschr.* 1875 ; A. Politzer, *Zur Behandlung der chron. Mittelohreiterung*, *Wien. med. Wochenschr.* 1876 ; A. H. Buck, *The Importance of Treatment of Aural Diseases in their Early Stages, especially when arising from the Exanthemata*, Philadelphia, 1876 ; Lucae, *Zur Behandlung der Otit. purulenta chron.*, *Berl. Klin. Wochenschr.* 1878 ; Erhard, *Ueber Schwerhörigkeit, heilbar durch Druck*, Leipzig, 1856 ; Toynbee,

On the Use of an Artificial Membrana Tympani in Cases of Deafness dependent upon Perforation or Destruction of the Natural Organ, London, 1857 ; Spencer, *The Function and Utility of the Artificial Drum-Membrane*, Philadelphia, 1876 ; Turnbull, *A New Artificial Membrana Tympani, The Med. and Surg. Reporter*, 1876 ; Boeters, *Ueber Necrose des Gehörlabyrinths*, Halle, 1875 ; Tillmanns, *Ueber Facialislähmung bei Ohrenkrankheiten*, Halle, 1869 ; Moos, *Ueber den Zusammenhang zwischen epileptiformen Erscheinungen und Ohrenkrankheiten, A. f. A. u. O.* iv. ; Eysell, *Ueber tödtliche Ohrenkrankheiten*, Halle, 1872 ; Hotz, *Two Cases of Death resulting from Aural Disease*, Illinois, 1876 ; Burkhardt-Merian, *Beitr. zur Pathologie und patholog. Anatomie des Ohres, A. f. O.* xiii. ; Kretschy, *Ueber Sinusthrombose, Meningitis, Kleinhirnabscess nach Otit. med., Wien. med. Wochenschr.* 1879 ; J. A. Andrews, *On the Metastases of Inflammations from the Ear to the Brain, New York Med. Journ.* 1881 ; Schwartze, *Beiträge zur Pathologie und patholog. Anat. des Ohres, A. f. O.* i. ; Lebert, *Ueber Hirnabscesse, Virch. Arch.* vol. lxxviii. ; Thompson, *Case of Otitis, Cerebral Abscess and Malformation of the Heart, Med. Times and Gaz.* 1873 ; Moos, *Sectionsergebnisse von Ohrenkranken, A. f. A. u. O.* iii. ; Dalby, *Diseases of the Ear, and their Relation to Pyæmia and Abscess of the Brain, Brit. Med. Journ.* 1874 ; Fränkel, *Beitr. zur Pathol. und pathol. Anat. d. Gehöror., Z. f. O.* viii. ; Th. Barr, *Case of Aural Disease terminating in Cerebral Abscess, Glasgow Med. Journ.* 1878 ; Politzer, *Zur path. Anat. der consecut. Sinusaffectionen, A. f. O.* vii. ; Pooley, *A Contribution to the Pathology of the Organ of Hearing, A. of Otol.* 1880 ; Moos, *Sinusthrombose und Phlebitis, A. f. A. u. O.* viii. ; Arnemann, *Bemerkungen über die Durchbohrung des Proc. mast., etc.*, Göttingen, 1792 ; Buck, *Diseases of the Mastoid Process, their Diagnosis, etc.*, New York, 1873 ; Schwartze und Eysell, *Ueber die künstl. Eröffnung des Warzenfortsatzes, A. f. O.* vii. ; Schwartze, *Casuistik zur chirur. Eröffnung des Warzenfortsatzes, A. f. O.* xi. xii. xiii. xiv. ; De Rossi, *Contribuzione allo Studio della Medicina Operatoria dell'Orecchio*, etc., Roma, 1878 ; Knapp, *Case of Trephining the Mastoid, Transact. of the Amer. Ot. Soc.* 1879 ; Hotze, *Die fruhzeitige Perforation des Warzenforts*, etc., *Z. f. O.* ix. ; Lucae, *Caries necrot. des Warzenforts., A. f. O.* xiv. ; Turnbull, *Remarks on Perforation of the Mastoid Process, Med. and Surg. Reporter*, Philadelphia, 1878 ; Gerster, *Ein operativ geheilter Fall von käsiger Osteitis des Warzenforts., Z. f. O.* viii. ; Moos, *Vier Fälle von schweren Erkrankungen des Warzenforts., Z. f. O.* viii. ; Hartmann, *Ueber Sclerose des Warzenforts., Z. f. O.* viii. ; *Idem., Ueber Sequesterbildung im Warzentheile des Kindes, A. f. A. u. O.* vii. ; Neuling, *Ueber Trepanation des Warzenforts.*, Kiel, 1877 ; Bircher, *Beitr. zur oper. Behandl. der Ohreiterungen*, Bern, 1878.

DISEASES OF THE SOUND-CONDUCTING APPARATUS.

II. DISEASES OF THE EXTERNAL EAR (AURICLE AND EXTERNAL AUDITORY MEATUS).

A. Anomalies of Secretion in the External Auditory Meatus.

Hypersecretion of the Ceruminal Glands, Formation of Ceruminal Plugs.

The exudation of the ceruminal secretion, a product of the ceruminal and sebaceous glands, takes place, for reasons already mentioned (p. 13), chiefly in the cartilaginous, and only to a small extent at the commencement of the osseous section of the external auditory meatus. In normal circumstances the secretion is removed partly by the movements of the jaw and partly by various manual operations. Frequently, however, the cerumen remains in the meatus, thereby forming a plug by which the canal becomes obliterated and the function of hearing mechanically impaired.

Ætiology.—The causes of ceruminal accumulation in the external auditory meatus are: 1. Habitual or frequently-recurring hyperæmia of the lining membrane of the meatus, combined with hypersecretion of the glandular elements of the latter. 2. Congenital or acquired contraction of the external meatus, preventing the discharge of the cerumen. To this class belong exostoses in the external section of the meatus and the slit-like contraction of the external orifice of the ear caused in old age by atrophy and shrivelling of the cartilage of the meatus. 3. Abnormal nature of the ceruminal secretion, the retention of a tough secretion, which becomes matted with little hairs of the cutis, favouring the accumulation of the masses formed afterwards. 4. Improper cleansing of the external meatus, especially in persons who usually allow, when washing, a quantity of water or soap-suds to flow into the meatus and then insert into the latter a pointed piece of the towel. The liquid ceruminal secretion is thereby pushed from the cartilaginous into the osseous section, and is finally formed into a lump. Indeed, ceruminal accumulation is much oftener

found in those who clean the meatus than in those who abstain from working with it. 5. Eczema, circumscribed and diffuse otitis externa, suppurations of the middle ear, after the termination of which a plug very often forms. 6. Foreign bodies in the ear, on which the cerumen sticks till an occluding plug is formed.

Accumulations of cerumen occur either without any other disturbance or combined with diseases of the middle ear and of the labyrinth. In people with sound ears the plug may attain a considerable size before the hearing becomes notably affected. Such are those interstitial plugs which do not completely fill up the lumen of the meatus, and do not lie upon the membrana tympani. Mechanical disturbance of the hearing only commences when the lumen of the auditory meatus is completely obstructed by secretion, or when the plug rapidly swells during washing, bathing, or perspiration; or lastly, when it is by shaking driven against the membrana tympani (occluding plugs).

Symptoms.—Frequent but not constant symptoms of accumulation of cerumen in the external meatus are: a feeling of confusion and fulness in the ear, subjective sensations of hearing, resonance of one's own voice, sometimes giddiness and vertigo in consequence of the increased intra-auricular pressure, rarely mental depression (Roosa and Ely, *Z. f. O.* x.). More or less severe stinging pains in the ear occur only when the plug is very hard, in consequence of the pressure on the walls of the auditory meatus and on the membrana tympani. In such cases, after removal of the accumulation, there is frequently found a circumscribed inflammation of the osseous meatus, rarely of the membrana tympani.

The disturbance of hearing varies according to the degree of occlusion, and the apposition of the plug to the membrana tympani. I have never observed total deafness even in cases of complete occlusion. When speech cannot be understood, it may be accepted as probable that there is disease of the middle ear or of the labyrinth. In primary accumulations, the hearing-distance often varies suddenly, especially when the plug swells and shortly afterwards contracts, or when it undergoes a sudden change of position from movements of the jaw.

In literature much is said about the injurious influence which hard ceruminal plugs may exert upon the neighbouring tissues. Toynbee (*l. c.*) and v. Tröltsch (*Virch. Arch.* vol. xvii.) record post-mortem examinations showing enlargement of the external meatus, the formation of apertures in the walls of the meatus, and perforation of the membrana tympani. Although the possibility of such changes cannot be denied, still, judging from the reports of such conditions, I believe that in most cases they have been sequelæ of an exhausted suppuration of the middle ear, and that consequently such perforations were not immediately caused by these accumulations.

Diagnosis.—By examination with the speculum, and not unfrequently also with the naked eye, the external meatus is seen to be plugged by either a light yellow or black-brown greasy mass, glistening or dull, which on being touched with the probe feels doughy, half liquid, or hard as a stone. The following may be mistaken for ceruminal plugs: purulent masses remaining after an exhausted otorrhœa, mixed with epidermis and dried up to a brown crust; foreign bodies enveloped in cerumen; and often balls of cotton-wool, which have been pushed too far down, and have through time become brown.

After its removal, the obstructing plug often exhibits impressions of the external surface of the membrana tympani, the umbo, and the short process. The mass consists either chiefly of ceruminal secretion, or in great part of cornified epidermic cells (Wreden, Clarence T. Blake) or epidermic plates closely packed together or spirally arranged (Bezold), and uprooted hairs, with a slight mixture of cerumen and cholestearine.

Prognosis.—In regard to the restoration of the function of hearing, this is favourable only when the deafness took place suddenly after a bath or washing, because then the probable cause of the disturbance of hearing would be a primary ceruminal plug. When this is not the case, one must be very careful in giving a prognosis, in view of the fact that accumulation of cerumen is very often associated with the adhesive processes in the middle ear, or with disease of the labyrinth (according to Toynbee, 160 times out of 200 cases). When the tuning-fork is heard better in the occluded ear it must not be accepted as a sign of the occlusion, as this is also observed, as a rule, in diseases of the middle ear. If, on the other hand, the tuning-fork is perceived through the cranial bones by the better-hearing ear, it is very probable that there is a complication with disease of the labyrinth.

Treatment.—The removal of the ceruminal plug is most surely effected by forcibly syringing with warm water; the syringe employed should be large, capable of holding 100 to 150 grammes, and the accumulation will be the more rapidly got rid of if the rounded india-rubber nozzle, illustrated on p. 465, be fixed on the syringe and pushed up to the accumulation.

Immediate syringing on the first examination is indicated only when the plug has a glistening greasy appearance and feels soft on being probed. On the other hand, when the cerumen appears lustreless, dry, and hard, it is better to soften it by the instillation of warm water, weak glycerine, or oil into the ear, but a solution of soda and glycerine is best (sodæ carbon. 0·5, aqua dest. s. glycerine pur āā. 5·0 S.; ten drops to be warmed and poured into the ear thrice daily). After twenty-four hours the cerumen is so soft and loosened that it comes out after 2-4 injections. When the cerumen cannot be removed by repeated syringing it is

better to continue the instillation, because by frequent and violent injections otitis externa may be excited. When the drops are prescribed the patient's attention should be drawn to the fact that the deafness will increase, in consequence of the swelling of the cerumen.

After the removal of primary ceruminal accumulations the function of hearing, as a rule, becomes immediately normal and the subjective symptoms disappear. It is only in exceptional cases that slight deafness remains for a few days, in consequence of the long-continued pressure on the membrana tympani, but that quickly disappears when the latter has attained its normal tension. After syringing it is necessary, as a protection from cold, and particularly in winter, to close the ear with cotton-wool.

In the majority of cases after the removal of one mass another accumulates. The interval between the recurrences varies from several months to several years. There are cases, however, in which the meatus becomes plugged with secretion in five or six weeks. In such cases the patient should be instructed in the use of the syringe, and advised to use the drops and injections at stated intervals.

A decrease or an entire cessation of ceruminal secretion is often observed in the insidious adhesive processes in the middle ear (v. Tröltsch). The cause appears to lie in an affection of the trophic nerve of the ear accompanying the disease of the tympanum. Also in recent catarrh of the middle ear the secretion sometimes disappears, but returns again when an improvement has been gained by treatment. Upon this is based the assumption that the return of secretion is a favourable sign. This is, however, contradicted by the fact that often during treatment of chronic adhesive processes in the middle ear the secretion returns without any improvement in the hearing. The ceruminal secretion seldom completely ceases for any length of time when the state of the external and middle ears is otherwise normal. This anomaly is mostly found in old people with a dry skin, and in persons who habitually wash out the auditory meatus. Examination finds the cartilaginous section free from cerumen, pale and dull. The want of cerumen is often accompanied by itching of various degrees, a feeling of dryness, and contraction in the ear.

The treatment consists in painting the cartilaginous meatus with a small quantity of vaseline, or with unguent. præcip. alb. (0·2 in 10) at times.

B. Eczema and other Diseases of the Skin of the External Ear.

Eczema of the external ear occurs either as a primary affection or combined with eczema on other parts of the body. It is either acute or chronic. Of all the various forms of eczema the moist and the scaly are the commonest on the external ear.

Acute eczema attacks either the auricle or the external meatus, or extends over the whole of the external portion of the ear. It begins with great redness and swelling of the skin, which is soon followed by the formation of numerous thickly spread vesicles containing serous matter (Eczema vesiculosum). The eruption mostly occurs on the posterior surface of the auricle and on the lobule, the entire auricle seldom being affected. Vesicles are rarely visible in the auditory meatus on account of their early abortion.

After the bursting of the vesicles moist surfaces, denuded of epidermis, are found on the auricle and in the meatus, which become covered in a few days with light yellow crusts (Eczema crustosum), under which the exudation of a serous or viscid fluid continues. After the scabs fall off circumscribed, excoriated spots are sometimes found covered with pus (Eczema impetiginosum).

Etiology.—Acute eczema is developed either without any known cause, or in consequence of external sources of irritation, especially after cold baths, from the influence of heat, warm fomentations, or the application of irritating drugs (chloroform, rancid fat and oils, mercurial ointments, mustard-poultices, etc.). Among those artificial forms is reckoned that circumscribed eczema on the upper surface of the crista helicis which occurs, usually symmetrically on both ears, in persons who sleep on hard pillows of horse-hair. Acute eczema often arises in the course of acute or chronic otorrhœa from the action of the irritating secretion, especially in children and in individuals whose skin is easily irritated.

Symptoms.—Acute eczema begins with a feeling of heat, burning, and itching, followed, after the appearance of the vesicles, by great pain in the part affected. In the case of children, and more rarely in adults, the disease is accompanied by slight pyrexia, restlessness, and sleeplessness.

The function of hearing is normal in cases in which the eczema is limited to the auricle; in disease of the auditory meatus there occurs a mechanical disturbance of hearing combined with subjective noises caused by the swelling of its lining membrane, and by the desquamation and accumulation of epidermis, exudation, and crusts.

Course.—The course of acute eczema is in the majority of cases typical. In slight cases the vesicles dry up quickly after the second or third day, the epidermis then desquamates and recovery takes place. More frequently, after the vesicles have burst, there is an abundant discharge of clear secretion, which abates after several days, and the parts laid bare become covered with light or brownish-yellow crusts. In normal circumstances, when the exudation is at a stand-still, a new epidermis forms beneath the crust, which, after the latter has peeled off, very soon

assumes its natural appearance. Sometimes, however, the exudation of clear or purulent fluid beneath the crust continues for several weeks before the formation of a new epidermic layer.

Results.—Acute eczema generally ends in recovery, which sometimes takes place in a few days, but frequently not for some weeks. The eczema sometimes heals on one part of the auricle or meatus and breaks out on another. Repeated relapses, caused by the continuance of the cause, by general illness, or by extending eczema on other parts of the body, occasion deeper tissue-changes in the cutis and the transition of the acute into the chronic form.

Chronic Eczema is distinguished from the acute form by the deeper tissue-changes in the cutis. While in acute eczema the inflammation is confined to the uppermost layer of the cutis, in chronic eczema there is hypertrophy of the subcutaneous connective tissue which leads to narrowing of the cartilaginous auditory meatus and condensation, enlargement, and rigidity of the auricle. The secretion and scabbing are localized in the depressions of the auricle and on the posterior part of its attachment, while there is abundant desquamation on the remaining parts.

Chronic eczema of the auricle and of the external meatus appears most frequently as crusty or scaly eczema. The two forms may be combined. The crust form is characterized by the formation of thick scabs, under which a serous or purulent fluid is exuded. It presents, therefore, on the whole, the same phenomena as acute eczema in the scabbing stage.

The scaly form of eczema is characterized by hyperæmia and hypertrophy of the cutis combined with continued desquamation of the epidermis. The affection is often combined with eczema of the scalp, and is but rarely confined to the auricle or auditory meatus. Squamous eczema may arise out of the chronic moist form, but it occurs more frequently on the cutis as a scaly eczema without any preceding serous exudation. In slight cases the desquamation is so trifling that it is confined to a few depressions of the auricle or to the parts surrounding the external orifice of the ear. In more severe forms, however, the eczema spreads not only over the auricle and its neighbourhood, but over the entire auditory meatus and the external surface of the membrana tympani. In this case the auricle is enlarged owing to the great infiltration of the cutis, and the meatus is narrowed; and in the depressions on the superior and posterior places of attachment of the auricle as well as on the superior periphery of the external orifice of the ear there are found ragged, slightly secreting fissures of the skin which are difficult to heal.

Of the symptoms of chronic eczema a troublesome itching is the most constant, causing the patient to be continually scratching the meatus with some hard instrument, thereby setting up intercurrent painful inflammation in that canal. Subjective

noises are induced either by plugging of the meatus with desquamated scales or by secondary hyperæmia in the middle ear and in the labyrinth. So, also, disturbances of the hearing may arise without mechanical obstruction in the auditory meatus by simultaneous swelling of the mucous membrane of the tympanic cavity and of the Eustachian tube.

The course and termination of chronic eczema vary according to the severity of the skin-affection. The slighter forms, confined to the ear alone, may recover spontaneously or disappear after short treatment, while the severe forms very rarely recede spontaneously, and prove very stubborn to treatment. Even when recovery is apparent, there is a relapse of the eczema sooner or later. Sometimes there are intercurrent painful follicular inflammations in the external meatus.

Diagnosis.—The diagnosis depends on the above-described objective signs. According to Auspitz it is possible to confound it with seborrhœa of the external ear, but in the latter there is an absence of redness and infiltration of the skin.

The *prognosis* of chronic eczema is favourable only as regards the recurrence of exudation or desquamation in its slighter forms; on the other hand, in severe cases, complicated with eczema of the scalp, or other parts of the body, and combined with hypertrophy of the cutis, it is most unfavourable.

Treatment.—In the treatment of eczema of the ear, the causes and the stages of the skin-affection must be considered. Although acute eczema often heals spontaneously, it is necessary to avoid in the acute stage all injurious irritation which keeps up the exudation and impedes the growth of new epidermis. The patient must, therefore, be forbidden to wash the affected parts with water, or to syringe the ear, while he is to protect the inflamed parts of the skin, or those laid bare by the bursting of the vesicles, from the influence of the air by painting them with ungu. emolliens or vaseline. Moist surfaces on the auricle, especially intertrigo behind the ear, which occurs frequently in children, are best covered with powder. The latter remedy, however, is not suitable for acute eczema of the auditory meatus on account of the rapid obstruction of the canal. Cold compresses on the region of the ear, with the addition of liq. plumb. acet. or Goulard's lotion, are indicated only in extensive and painful eruptions in the stage of vesication.

When a patient presents himself for treatment at the scabbing stage, the crusts must be first removed, in order, if possible, to render remedies effectual on the diseased cutis. Forcible loosening of closely adherent scabs or the rubbing of them off by means of dry linen cloths I consider injurious, because I have observed the formation afterwards of new and thicker scabs notwithstanding the use of the most effective remedies. The crusts are best softened by the application of sweet oil or of

balsam of Peru, and may be removed on the following day by a brush or forceps.

Then, without irritating the exposed parts further, the auricle, with all its depressions, is painted with a medicated ointment. For this purpose the following are the best: Hebra's diachylon ointment (prepared with olive oil); ungu. plumbi carbonatis and ungu. emolliens, āā. part. æqual.; ungu. vaselin. plumb. (empl. diachyl. s., vaselin. pur. āā. part. æqual.); ungu. acid. boraci. (1 in 15 vasel.); ungu. oxid. zinc. (1 in 30); Pagenstecher's ointment (Hedinger). In addition, both auricles are covered with fine linen spread with the ointment. By means of complete contact, the cloth is pressed into the depressions of the auricle, and particularly during the night by the putting on a wadding compress fixed by a light bandage. Small pledgets, corresponding to the width of the auditory meatus and impregnated with the ointment, are pushed into the meatus. Those as well as the dressing on the auricle must be changed every twenty-four hours, and the ointment mixed with exudation should not be washed, but carefully brushed off.

The prevention of scabbing, by means of the immediate action of medicated stuffs on the diseased corium, has not always proved suitable in aural eczema, for after this proceeding I have frequently observed a continuation of the exudation with constantly renewed formation of crusts. In these cases healing commenced by the crust not being removed, but saturated twice with balsam of Peru till it loosened of itself.*

After the crust is removed, the newly-formed epidermis is tender and little resistant, and the cutis remains for a long time hyperæmic. All irritation, therefore, which might destroy the epithelium and increase the hyperæmia of the cutis, must be avoided; frequent washing and rubbing of the skin must be discontinued, as well as syringing of the auditory meatus, and for several weeks these parts of the skin should be anointed with a thin layer of vaseline, cold cream, or a weak precipitate ointment (0·2 in 15).

The treatment of squamous eczema is regulated by the intensity of the desquamation and the amount of the infiltration of the skin. In its slighter forms on the auricle, repeated painting with tinct. rusci, carbolic spirit (1 in 30), an alcoholic solution of boracic acid (1 in 20), or frequent cleansing with tar or soft soap (Auspitz), often suffice to effect a cure. More severe forms with great thickening of the epidermis and infiltration of the cutis, on the other hand, prove very obstinate. If the epidermis is much thickened and indurated, it must be softened by repeated application of sweet or olive oil, cod-liver oil, or balsam

* The painting with solution of lunar caustic (1-3 per cent.), recommended by Wilde, and later by Knapp (*Z. f. O.* vol. x.), ranks next to the above treatment in regard to rapid and sure action in moist and scabbing eczema.

of Peru, and carefully stripped off. It is necessary to wash more obstinate parts with a solution of potash soap in spirit, in order to remove the indurated epithelium. After that, tar may be used. The first proceeding consists in rubbing ol. rusci into the reddened parts by means of a stiff pencil, and this is repeated till the brown tarry scurf has been rubbed off. When the skin has become smoother, more flexible, and paler by this repeated painting with tar, it is time to employ the tar-ointment (ol. fagi 10·0, glycerine 5·0, ungu. emolliens 40·0), painting with ol. cadini and glycerine (1 in 25), carbolic ointment (1·40), white or yellow precipitate ointment, ungu. Wilsoni (benzoic acid 5·0, ungu. commun. 150·0; strain and add oxid. zinci 25·0). Of these remedies, sometimes the one and sometimes the other is effectual, according to the case.

Amongst all the remedies for squamous eczema in the external auditory meatus, painting with concentrated solutions of lunar caustic is the most effectual. After the scales have been removed from the walls of the meatus by means of a dry pellet of cotton-wool, the solution is applied to them with a brush or a ball of cotton-wool. The scurf falls off in one or two days in the form of blackish-brown dry plates, leaving the cutis smooth and paler in colour. In slight cases, the cutis resumes its normal appearance after having been cauterized two or three times. In more severe cases, combined with great narrowing of the cartilaginous meatus, cauterizing requires to be oftener repeated (8 to 10 times), in order to allay the swelling of the cutis. Fissures must be touched with solid caustic when they show no tendency to heal.

After the caustic treatment it is necessary, in order to prevent relapses, to anoint the cutis of the cartilaginous meatus twice a week with a thin layer of white precipitate ointment, or with a weak ointment of ol. cadini (1 in 40 vaseline), and to continue it for some time. By that means the troublesome itching is most surely subdued.

With the healing of the eczema, the disturbance of hearing and subjective noises which accompany it frequently disappear, but not always.

Internal treatment of aural eczema is almost superfluous. I confine myself to the use of iron and iodide in anæmic and scrofulous patients. I have had no experience of arsenic for obstinate eczema, recommended by Hebra and Auspitz.

Among the rarer affections of the skin of the external ear are reckoned the efflorescence of variola in the external auditory meatus as observed by Wendt, pemphigus, herpes zoster, lupus, and psoriasis.

Herpes Zoster.—This affection is characterized by the painful development of transparent vesicles grouped together on a reddened surface. The site is either the posterior surface of the

auricle, particularly the lobe, or the region in front of the tragus, according as the herpes is caused by an affection of the trigeminus or of the great auricular nerve. The formation of these vesicles is preceded, as observed by Burnett, Orne Green, and Anstie, by violent and rarely remitting pains in the head and in the neighbourhood of the ear, which continue for several days. After the eruption appears, accompanied sometimes by fever, the pain generally subsides, but it may also continue till the vesicles dry up. Neuralgia, which usually remains after the termination of zoster along the intercostal nerves, has not been observed, to my knowledge, after herpes zoster of the auricle.

The termination is recovery, as after bursting of the vesicles the diseased parts become covered with a crust, which falls off on the formation of a new epidermis.

Treatment consists in combating the violent pain by the internal exhibition of a narcotic, and when that is ineffectual, by a subcutaneous injection of morphia. After the vesicles break, their drying up is effected by sprinkling them with powder or anointing them with unguent. plumb. acet. or plumb. carbonatis.

Lupus.—Lupous affections of the auricle are extremely rare, and are mostly combined with lupus on the face and on the parts round the ear. According to Neumann (*M. f. O.* 1869), lupus maculosus occurs most frequently, and appears in the form of brown tubercles of the size of a pinhead or lentil, covered with scales, which seldom ulcerate, but by their shrivelling leave cicatrices on the skin. In this, as well as in the smaller extent of the efflorescence and in the more moderate formation of scales, lupus differs from the equally rare psoriasis, which only occurs combined with extensive psoriasis of the rest of the skin. Still more seldom is lupus erythematosus met with, and then never alone, but with coincident affection of the skin of the face. There are spots, at first circumscribed, but later confluent, red, and covered with thin scales. Cases of lupus exulcerans have been very seldom met with. One case in my practice affected an otherwise healthy young man, belonging to the better class, and had existed for some months, seated on the auricle. The lupous ulceration appeared on the upper half of the auricle, and extended round to its posterior surface. On individual parts of the anterior surface, the skin was so completely destroyed that the cartilage of the ear, suffused with blood, was quite exposed. The sharply defined edges of the skin appeared spongy, soft, and bled easily. By the repeated application of the sharp scoop and cauterization with solid lunar caustic, a cure was effected after some weeks' treatment, leaving, however, cicatrization and slight deformity of the auricle.

For lupus maculosus, Neumann recommends painting with iodized glycerine (1 in 2), or pencilling with concentrated carbolic acid or cauterization with a 50 per cent. solution of lunar

caustic. For lupus erythematosus, rubbing with soft soap and with white precipitate ointment (10 per cent.) are recommended. The use of iodide of mercury ointment (1 in 5-15) recommended by Cazenave is more effectual, as also pyrogallic acid (1 in 10 vaseline, Jarisch). According to Veiel, the most effectual local treatment is multiple scarification, followed by cauterization with chloride of zinc.

C. Hyperæmia and Hæmorrhage of the External Ear.

Hyperæmia of the auricle is caused either by mechanical irritation, the action of cold (frost) or heat, or it is the expression of an engorgement of the cutis remaining after exhausted eczema and erysipelatous inflammation. As an accompaniment of an engorgement of blood in the vessels of the head, it is oftenest observed in cyanosis due to valvular insufficiency. In isolated cases it is to be regarded as an angioneurosis referable to the sympathetic nerve. Hyperæmia occurs in these cases generally unilaterally, less frequently bilaterally, and especially in the evening with great redness and warmth of the auricle, and with a burning sensation, to which are often added tinnitus aurium, giddiness, and slight faintings. Those quickly evanescent conditions, returning at irregular intervals, appear sometimes in individuals with sound ears, oftener, however, in the course of adhesive otitis media (Burnett). For chronic hyperæmia, cold compresses with Goulard's lotion, and anointing the auricle in the evening with vaseline, are recommended, and for the angioneurotic form galvanization of the sympathetic in the neck.

Hyperæmia of the external auditory meatus regularly accompanies hyperæmia and inflammation in the tympanic cavity and in the mastoid process. If often appears as a sequel to an exhausted inflammation of the meatus, especially to eczema and furuncles, and is also observed in congestion of the head and in inflammation near the ear, especially of the parotid.

Congestion occurs especially in the osseous, less frequently in the cartilaginous portion, and extends, as a rule, to the upper parts of the membrana tympani, and along the handle of the malleus.

Long-continued hyperæmia leads to hypersecretion of the ceruminal glands, or to abnormal exudation with the formation of a crumbling friable secretion.

Hæmorrhage in the Auricle (Othæmatoma, Hæmatoma auris).

Othæmatoma arises from a sudden effusion of blood between the cartilage of the ear and the perichondrium, by which the latter, with or without destruction of its continuity, is extensively separated from the cartilage. As the cartilage of the ear is

traversed by numerous vascular bands of connective tissue (Pareidt), it is probable that by violent pulling, through the rupture of these vessels an othæmatoma with partial tearing of the cartilage may be occasioned (Haupt, *Dissers. inaug.* Wurzburg, 1867).

Etiology.—Othæmatoma most frequently arises from injury, seldom spontaneously. In a case described by Brunner (*A. f. O.* vol. v.), the cause was ascribed to long contact of the auricle with a cold pane of glass. The fact that often after violent pulling the auricle remains intact, while at other times a slight pull suffices to give rise to an escape of blood, renders it probable that certain tissue-changes in the cartilage are the predisposing cause of the othæmatoma. The following are given by L. Meyer, Pareidt, Haupt, Leubuscher, Simon, Virchow, and J. Pollak, as degenerations of the cartilage of the ear: softening and fissure, the formation of cavities with gelatinous homogeneous contents, proliferation of vessels and new formations. It might be imagined that repeated injuries give rise to such changes in the cartilage, that at last a little violence would cause an effusion of blood.

Among the twenty-seven cases observed by Brigade-surgeon R. Chimani in the course of fourteen years, twenty-one were traumatic and six spontaneous in origin. In nineteen cases of the first category, in which the cause was positively ascertained, the othæmatoma in the left auricle was due nine times to a box on the ear, twice to a blow with the fist, once to pulling, and once to a blow with a bayonet-sheath; in the right ear, twice to a box on the ear, three times to blows, and once (complicated with rupture of the membrana tympani) to falling into water from a considerable height. In the two remaining cases of othæmatoma of the left auricle, it was doubtful whether they had been caused by a box on the ear or otherwise.

Of the six spontaneous othæmatomata, four were on the left and two on the right auricle. Of the individuals between twenty-one and twenty-six years of age, five were perfectly healthy, and only one debilitated by the cachexia of intermittent fever. Twenty-one cases were dismissed cured; in five the auricle was more or less deformed, and in one the cartilage of the ear was for the most part lost by ulceration.

Occurrence. — Othæmatoma occurs in healthy individuals, remarkably often, however, in imbeciles. Frequently the left auricle is affected, seldom both (Hun). While Gudden affirms, from the fact of its being most common on the left side, that it is solely caused by injury (ill-treatment), Simon believes (*Berl. Kl. Wochenschr.* 1865) that in imbeciles it is always caused by tissue-changes in the auricle. Roosa (*l. c.*) connects othæmatoma in imbeciles with disease of the brain, relying upon the experiment of Brown Sequard, who observed the occurrence of

hæmorrhage in the auricle after severing the restiform body in animals.

Symptoms.—Othæmatoma appears at the commencement as a bluish-red swelling on the anterior surface of the auricle, rounded or irregular, doughy or hard to the touch, and seldom distinctly fluctuating. Spontaneous othæmatoma rarely attains the size of the traumatic. While the former occupies only smaller sections of the concave surface of the auricle, especially the concha and the intercrural fossa, the traumatic variety covers the whole anterior surface of the auricle, the swelling sometimes occluding the external auditory meatus, and, as I have seen in one case, it may spread itself on the posterior surface of the auricle, crossing over the superior margin of the helix.

Spontaneous othæmatoma often develops without any subjective troubles, while the traumatic is mostly associated with great pain, feeling of heat, and tension. By the addition of reactive inflammation severe pain is also felt in a later stage of spontaneous othæmatoma. Subjective noises and disturbances of hearing are only observed when the auditory meatus is occluded by the swelling, or when the membrana tympani is injured.

Course and Termination.—The course of othæmatoma depends on the extent of the hæmorrhage and the degree of the lesion of the cartilage. When the latter is not much altered by the hæmorrhage the termination is far more favourable than when the cartilaginous tissue is fissured by the effusion. In some cases recovery takes place by absorption without malformation of the auricle, while in other cases the latter remains greatly deformed by cicatricial thickening, atrophy, and shrivelling of the cartilage and skin. In a few cases, and more commonly in the traumatic than in the spontaneous form, there occurs an extensive inflammation of the cartilage, which becomes covered with a bloody, gelatinous, and afterwards purulent exudation that may lead to partial ulceration and multiple perforation of the cartilage and of the cutis, and even partial loss of the auricle.

In a young man, age twenty-three, who suffered from spontaneous othæmatoma occupying the superior section of the left auricle, which had continued for six days, the fluctuating swelling was punctured (Fig. 212, *a*) at its highest part on account of the extreme pain, and pure blood escaped. During the following days blood and gelatinous masses were discharged from the cavity. On being probed the cartilage was found to be perforated at one part, and the edges of the perforation were jagged. By repeated injection of a concentrated solution of nitrate of silver (2-4 in 10) a gradual decrease of the exudation and diminution of the cavity were observed. In the sixth week there was a relapse with increase of the swelling, which required to be opened. Treatment with lunar caustic was repeated till the

cicatrization was complete, which ensued at the end of the third month. Beyond a small tubercle on the place of the incision, no other deformity was noticed on the cartilage of the ear. That a tissue-change in the cartilage was the cause of the othæmatoma in this case seemed the more probable, as an opaque condensation of the cartilage, 4-5 mm. in extent, was found on the right ear, corresponding to the site of the affection on the other side.

Less favourable was the termination of a case which I had occasion to see in the service of Brigade-surgeon Chimani. An othæmatoma developed in the course of a cachexia, due to intermittent fever, in which the whole of the anterior and the greater part of the posterior surface of the auricle were involved, only the tragus and the lobe remaining intact. The auricle presented a globular, hard, bluish-red swelling, which stood out at right angles from the head, and extended into the external orifice of the ear. Putrid and ichorous ulceration of the greater part of the auricle commenced with severe general symptoms, so that the auricle was destroyed to below the crista helicis, and only the tragus, antitragus, lobe, and a small piece of the cartilage of the helix remained. At the same time the lumen of the auditory meatus was contracted to a slit, in consequence of the cicatricial shrinking of its posterior superior wall. The duration of the affection till cicatrization set in was eleven weeks.

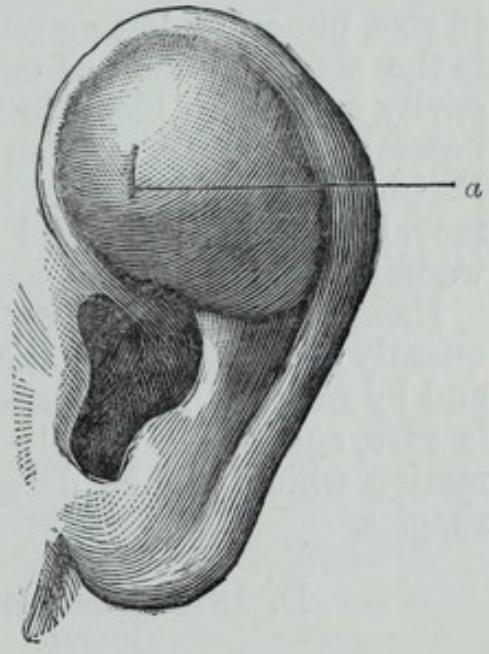

FIG. 212.

Diagnosis.—The diagnosis of othæmatoma can be made with certainty when it can be proved that the affection commenced suddenly after an injury. In the spontaneous form the rapid development of the swelling determines the diagnosis, and having regard, to that it is impossible to confound it with perichondritis auriculæ, angioma, or a neoplasm.

Prognosis.—The prognosis of traumatic othæmatoma is, owing to absorption without malformation of the auricle, more favourable than that of the spontaneous form, those cases being excepted in which, through injury, there is a deep-seated lesion of the cartilage. It is a favourable sign when the swelling decreases during its course without reaction, but unfavourable when violent inflammatory symptoms are superadded, which require the swelling to be opened.

Treatment.—In the case of small, painless tumours, it is best not to interfere, as all treatment, such as pressure, embrocation,

etc., rather tends to renew the bleeding than to quicken the absorption of the extravasation. For this reason, therefore, massage, recommended by Meyer (*A. f. O.* xvi.), must be used only with great caution, and by no means at the beginning, but in the third or fourth week. When the swelling is painful neither pressure nor massage must be used. On the other hand, in traumatic and in inflammatory othæmatoma, cold compresses, by means of ice-bags, or Leiter's apparatus (p. 561), are advisable, and on the cessation of pain, applications of Goulard's lotion. When, notwithstanding antiphlogistics, pain still continues after four or five days, and the swelling has not decreased in size, puncture, letting out the contents, and moderate pressure is the surest method of curing the disease. In many cases the cavity refills with blood, or viscid fluid, so that repeated puncture becomes necessary. When the tumour is of large circumference, R. Chimani recommends the splitting of the swelling, the removal of its contents, and the insertion of carbolic or salicylic wadding into the cavity, and afterwards a compress bandage.

Hæmorrhage in the external auditory meatus is most frequently caused by traumatic injuries of the cutis or of the cartilage, and by fracture of the osseous walls. Spontaneous hæmorrhage is rare, and arises usually in those idiopathic forms of inflammation which will be described later as otitis externa hæmorrhagica.

D. Inflammations of the External Ear.

a. Inflammation of the Auricle.

1. *Dermatitis of the Auricle.*

Acute inflammation of the auricle is among the rare affections of the ear. It affects either the cutis or the perichondrium. Dermatitis of the auricle is oftenest caused by frost or heat, less frequently by the sting of an insect and by cauterants. Sometimes it is observed as an extension of erysipelatous inflammation in cases of erysipelas of the face and head.

The inflammation usually extends over the entire auricle; the latter appears very red, tumid, and enlarged, the skin tense and shining. Sometimes, especially after frost-bite, there are formed either hard, deep, red tubercles on the skin, or extensive vesicles which burst in a short time and discharge serous fluid. The inflammation is often limited to the lobe and lower section of the auricle, after perforation of the lobe and from the mechanical irritation of heavy ear-rings.

The symptoms accompanying inflammation are a severe burning sensation, a feeling of tension and pressure in the auricle, flying stitches and afterwards persistent pain, to which are sometimes added fever, giddiness, and tinnitus.

The course is such that in slight attacks the inflammatory phenomena subside after a few days, and the auricle resumes its normal appearance. Even in cases in which numerous vesicles formed I have seen recovery set in within a few days after the latter had burst, the exposed parts becoming quickly covered with normal epidermis. It is but seldom that firmly adherent crusts form, after the removal of which the parts of the cutis affected remain red for a long time.

The course of inflammation of the auricle, caused by frost-bite, is more obstinate. The slight attacks in which only the superficial layers of the skin are affected heal quickly. In more severe attacks, excoriations form on several parts of the auricle, especially on its prominences, which are difficult to heal, and become covered sooner or later with sanguineous crusts. After these have been thrown off, there often remains for years on the hypertrophied and reddened auricle a continual desquamation of the cutis. The highest degree of frost-bite, as it often happens in the north along with frost-bite of the nose, leads to gangrene of the cutis and of the cartilage, with partial loss of the auricle and shrivelling of the remainder to a shapeless appendage.

The treatment in the reactive stage consists in the local application of cold, which is continued so long as the patient can bear it. In the slighter forms, cold compresses with Goulard's lotion and tincture of opium (200·0 to 10·0) are sufficient; in more serious forms a small ice-bag or Leiter's apparatus is recommended. Parts of the skin laid bare by vesication or excoriation should be anointed with ungu. plumbi carb., and ungu. diachyli, boracic or zinc ointment, the applications to be continued till the exposed parts are covered with resistant epidermis.

2. *Perichondritis of the Auricle* (*Perichondritis Auriculæ*).

Perichondritis is very rarely met with, only isolated cases being recorded by Wilde (German translation, p. 200), R. Chimani (*A. f. O.* ii.), Knapp (*Z. f. O.* x.), and O. D. Pomeroy (*Transact. of the Am. Otol. Soc.* ix.). It becomes developed without any known cause, and affects the anterior surface of the auricle without involving the lobe, this being the characteristic of this form of inflammation.

The auditory meatus either remains intact, or the inflammation begins in it and extends to the auricle. In a case observed by Knapp, the affection was complicated with otitis media perforativa.

At the acme of the inflammation, a red or bluish-red, uneven, fluctuating swelling is found on the anterior surface of the auricle, occupying the greater part of the concha and the fossa helicis,

and appearing sharply demarcated below from the margin of the lobe. At first it seems very similar to othæmatoma, but it differs from the latter in its gradual development with inflammatory phenomena and in its contents, which consist of a synovia-like or purulent fluid, but not blood. After long duration of the tumour, it becomes difficult to distinguish it from othæmatoma, because the latter in its later stages sometimes contains no blood, but only a transparent syrupy fluid. Probing the incised tumour reveals a more or less extensive loosening of the perichondrium and denudation of the uneven, rough cartilage.

The terminations of perichondritis are: recovery after the formation of an abscess and discharge of the synovial fluid mixed with pus, without the shape of the auricle being changed (Chimani), or shrivelling and marked deformity of the cartilage, as is observed in the worst forms of othæmatoma (Knapp). In the cases observed, the course was slow, and in one recorded by Knapp, in which the inflammation originated in a furuncular swelling in the meatus, repeated formations of tumours on various parts of the auricle took place. The duration of the inflammation varied from three to ten weeks.

The treatment of perichondritis consists at first in the energetic application of antiphlogistics, and in the early incision of the fluctuating tumour. The succeeding treatment by antiseptics and the application of a pressure-bandage is analogous to that already referred to in the treatment of othæmatoma.

As extremely rare occurrences, we must mention gangrene and noma of the auricle, observed by Hutchinson (*Med. Times and Gazette*, 1881). After removal of the necrosed parts and cauterization with nitrate of mercury, recovery followed in the latter case. There is further the affection called by Wilde (*l. c.* p. 208) pemphigus gangrænosus, which appears behind and on the ears, and is met with frequently among the lower classes in Ireland; it is phagedænic in character, and generally terminates fatally. Jansh and Chiari have also observed a case of a tubercular hard tumour on the left auricle of a phthisical patient.

b. Inflammation of the External Auditory Meatus.

The seat of the primary forms of inflammation is the cutis of the external meatus, from which the changes extend but seldom to its cartilaginous or osseous walls. It is situated either in the cartilaginous section, where the glandular element of the cutis is affected, or in the osseous portion of the meatus, from which the more superficial, spreading inflammation frequently extends to the cutis of the membrana tympani. The external meatus in its whole extent is seldom uniformly inflamed.

Otitis externa presents a series of characteristic forms, whose character depends partly upon the situation, partly upon the

nature of the exudation and the cause of the inflammation. As the description of the various clinical forms of inflammation is our aim, it must be observed that combined forms occur very often, rendering the classification of special cases in a certain group difficult.

1. *Follicular Inflammation of the External Auditory Meatus (Otitis Externa Follicularis s. Circumscripta).*

Follicular inflammation of the external meatus has its seat chiefly in the cartilaginous section. The process commences either in a hair follicle or in a gland, but very often a whole group of neighbouring follicles and glands is affected. The inflammation is seated either in the deeper parts of the cutis lying near the perichondrium or in the superficial layers of the same.

Etiology.—Follicular inflammation, commonly called furunculosis of the auditory meatus, occurs often without any known cause in healthy, strong persons; sometimes it is a part of general furunculosis of the external integument. Intercurrent furuncular formations are observed in the course of chronic purulent otitis media and chronic eczema of the external meatus. Other causative conditions are: mechanical irritation of the meatus, especially frequent syringing; scratching with hard instruments in pruritus of the external meatus; injuries of the same; irritation caused by foreign bodies; instillation of irritating substances into the ear; the prolonged use of alum solutions (v. Tröltsch, Hagen).

The results of Loewenberg's investigations on this subject are of importance as regards both the development and the treatment of furunculosis. Incited by Pasteur's investigations, he found in furuncular pus not exposed to the air, masses of microorganisms, which he looked upon as the cause of the furunculosis. The origin of furuncles is thereby explained, for micrococci suspended in air and water get into the auditory meatus, and by wandering into the glandular follicles set up inflammation. If the pus is discharged into the meatus, multiple furuncles may arise from the wandering of micrococci into other follicles, as is confirmed by the rapid recurrence of furuncles in the meatus.

Occurrence.—Furunculosis of the auditory meatus occurs especially in spring and autumn, so often that one is inclined to look upon the affection as epidemic in character. It occurs oftener in adults than in children; it is often observed in anæmia, in disorders of menstruation, in diabetes mellitus, and at the change of life (Hagen).

Symptoms.—The symptoms vary according as the inflammation is situated in the neighbourhood of the perichondrium, or in the superficial layers of the cutis. The affection begins,

particularly when it is deeply situated, with gradually increasing, tearing or beating pains, which radiate towards various parts of the head and neck, till the height of the inflammation is reached, when the patient is robbed of his sleep. By touching the ear, but especially by movement of the jaw, the pain is increased. Feverish movements and loss of appetite are not uncommon in the first few days. A feeling of fulness, subjective noises and disturbances of hearing occur, as a rule, only when the lumen of the meatus becomes blocked by a furuncle, very exceptionally when the meatus is free, and then it is in consequence of hyperæmia spreading to the middle and internal ears.

When the inflammation is deep-seated, the tumour due to the exudation appears flat, without sharp outlines, and only slightly red. When the site is superficial, on the other hand, the tumour is very red, livid, and sharply-defined, and generally develops without much pain, sometimes without any. The seat of the inflammation is most frequently the anterior inferior wall of the meatus. Often the furuncles are multiple, arising simultaneously or rapidly succeeding each other, so that by mutual contact they close up the lumen of the meatus. When they form on the anterior wall of the auditory meatus, the region in front of the tragus appears swollen and of a bluish-red colour, and when they are seated on the posterior wall there is sometimes so much swelling over the mastoid process that it might be mistaken for periostitis mastoidea. Coincident glandular swellings on the side of the neck are on the whole rare.

Course.—The exudation thrown out in the neighbourhood of the follicle in most cases after the inflammation has lasted for four or five days, breaks down into pus. It is seldom that the abscess does not form for eight or ten days. Bursting usually takes place at the yellowish acuminate prominence at the highest part of the tumour, rarely at the side. The deeper the seat of the exudation, the more delay is there in the discharge of the abscess into the meatus. The inflammation seldom subsides without the formation of an abscess.

After the spontaneous or artificial opening of the abscess, the violent pain, as a rule, disappears, and gradually also all the other symptoms. Sometimes, however, violent exacerbations occur, in consequence either of recurrences at other parts, or of plugging of the opening of the abscess and obstruction to the escape of the pus from its cavity.

After the abscess has discharged, the tumour subsides in a short time; yet there often remains a slight infiltration and elevation on the affected part for some weeks. Spongy granulation tissue often projects from the orifice of the abscess-cavity, and may be mistaken for a fungiform polypus on the wall of the meatus. The course is always protracted by such growths, and cure is effected only after they have been removed.

Furunculosis of the auditory meatus tends to relapse. They appear sometimes at shorter, sometimes at longer intervals (habitual furunculosis), and often cause emaciation and nervous excitement.

Diagnosis.—Having regard to the subjective and objective symptoms, this presents no difficulties. On a superficial examination exostoses in the external meatus, covered with reddened cutis, and those bulgings of the wall of the meatus which develop in the course of inflammation of the mastoid process, might be confounded with furuncles. The formation, sometimes with great pain, of single or multiple pustules in those parts of the osseous section of the auditory meatus in which the glandular elements are wanting, does not belong to the category of follicular inflammations.

Treatment.—In the stage of exudation the chief end of treatment is to allay the pain and get rid of it as soon as possible. In very painful, deep-seated inflammations it is best to make an incision in the tumour with or without local anæsthesia (Loewenberg), whether suppuration has commenced or not. In the latter case a bloody liquid will be discharged through the incision, and the pain will be alleviated by the relaxation of the cutis. When the pus is not reached by the incision it very soon makes a way for itself into the opening. Incision is also recommended when the pus has reached the surface of the cutis, and the tumour is pointing at one place, but has not burst on account of the resistance of the dermic layer. Even in those cases in which an opening has already formed on the surface, which, on account of its smallness or in consequence of being plugged by a furuncle, is insufficient for the discharge of the pus, it is often necessary to extend the opening. After spontaneous or operative opening of the abscess it is advisable to exert moderate pressure on the external surface of the cartilaginous meatus, in order to bring the pus and the furuncular plug from the deeper parts to the surface.

Besides incision, other remedies may be used to allay pain; narcotic embrocations round the ear (p. 256); little plugs of wadding dipped in a mixture of aq. opii 4·0, aq. dest. 12·0, and put into the auditory meatus; the introduction of a longish piece of lard covered with morphia and boracic ointment (boracic acid 1·0, vaseline 20·0, acet. morph. 0·2) into the auditory meatus; and the application of a warm raisin boiled in milk (popular remedy). These remedies are particularly recommended in the case of those who are afraid of operations. Leeches are rarely used; they are only necessary when incision does not allay the pain and when there is at the same time a large swelling in front of the tragus or on the mastoid region. Warm poultices allay the pain in some cases, while they increase it in others. Schwartze and Loewenberg reject them; the latter because,

according to his idea, they favour the development of furuncular bacteria. On the other hand, I have recently seen rapid relief follow the application of Leiter's cooling apparatus (p. 561). Syringing the ear is to be avoided, as it may give rise to fresh eruptions.

The introduction of antiseptic treatment has made considerable improvement in the therapeutics of furunculosis of the external meatus. While with the earlier methods of treatment multiple furuncles were more frequent and there were no known remedies for the prevention of fresh eruptions, it was observed that with antiseptic treatment new eruptions and relapses were less frequent. The most effectual remedies are carbolic acid as carbolic glycerine (0·5 in 15·0) applied with a brush, boracic acid as a powder (Morpurgo) or as an alcoholic solution in the proportions of 1 in 20 (Loewenberg), to be dropped into the ear. Both remedies may be used before and after the opening of the abscess. I have seen the abscess, after repeated painting of the furuncle, recede without bursting into the meatus. Loewenberg obtained the same result in a case in which no incision could be made, by instillations of an alcoholic solution of boracic acid. This method is in any case preferable to cauterization with lunar caustic, recommended by Wilde, and the painful injections of 2-5 drops of a 5 per cent. carbolic solution into the furuncle, proposed by Weber-Liel.

After the furuncle has been cut the incision should be immediately anointed with carbolic glycerine or solution of boracic acid, to act on the micrococci and to prevent the bacteria from wandering into the neighbouring follicles; and it is advisable to continue the instillation of the boracic solution till the incision is cicatrized.

After-Treatment.—After the follicular inflammation has terminated, the ceruminal secretion either ceases altogether or is of a crumbling, scaly nature. This abnormal secretion is usually accompanied with a troublesome itching, which causes the patient to scratch the meatus with all sorts of hard bodies. Such mechanical irritation is frequently the cause of relapses. The patient must therefore be strictly forbidden to scratch the meatus.

To prevent this troublesome itching it is recommended that the cartilaginous meatus should be anointed every second day for several weeks after the disappearance of the furuncle with a precipitate ointment (hydr. præcip. alb. 0·3, ungu. emoll. or vaseline 12·0), or with boracic ointment (1 to 20 vaseline). The ointment must be very sparingly applied, as by the introduction of large quantities the meatus would become blocked up in a very short time. I have also found painting with alcohol, as recommended by Weber-Liel, useful in several cases. Frequent wetting of the meatus with water, as in washing, is quite as injurious as in the case of eczema.

2. *Diffuse Inflammation of the External Auditory Meatus (Otitis Externa Diffusa).*

Diffuse inflammation of the external auditory meatus is very rare as an idiopathic affection. It is more frequently due to the instillation or injection of irritating substances, or to mechanical and traumatic causes. I cannot confirm the assertion that this affection occurs most frequently in children. I have repeatedly convinced myself that this diagnosis is often made in children in cases of acute purulent otitis media, the mistake arising from the fact that examination with the speculum is impossible.

Although my experience agrees with that of Bezold that idiopathic diffuse inflammation of the auditory meatus is much more rarely met with than would appear from descriptions in books, I cannot accept his opinion that idiopathic inflammation of the auditory meatus with suppuration has no right to a place in the pathology of the ear. For, while the acute form of this affection is almost always of a desquamative character, I have observed in a few cases, in addition to inflammatory desquamation, an exudation of pus in the auditory meatus, when disease of the middle ear could with certainty be excluded. The following description of otitis externa diffusa differs a little from that usually given in text-books.

Symptoms. — The symptoms of otitis externa are specially marked in the osseous section and on the external surface of the membrana tympani. The inflammation begins with great hyperæmia and painful swelling of the cutis, followed in a few days by a serous or viscid exudation. On examination the contracted meatus and the external surface of the membrana tympani are found covered with a layer of white epidermis, which on syringing peels off, retaining the pouch-like form of the canal. After the removal of this pouch the cutis and membrana tympani appear red and swollen, parts of the malleus are not visible, and the boundary between the membrana tympani and the auditory meatus is obliterated. Sometimes the meatus is so contracted by diffuse swelling or simultaneous follicular inflammation in its cartilaginous section that it is impossible to get a view of the deeper parts.

The subjective symptoms of otitis externa are violent radiating pains, increased by pressure near the ear and by the movements of the jaw; sometimes there are also subjective noises and giddiness.

The function of hearing is normal or but slightly impaired. It is only when the cutis of the membrana tympani is greatly swollen or when there is an accumulation of exudation and epidermic plates in front of the membrane, and in cases of secondary swellings in the middle ear, that there is great difficulty of hearing.

In some cases I observed a group of symptoms deviating from those described; the inflammation developed with very slight reactive phenomena, but with rapidly increasing deafness and tinnitus. On examination, the meatus was found filled with an epidermic plug reaching to the membrane; after its removal the noises and deafness disappeared. The lining membrane of the meatus and the membrana tympani were moderately swollen and reddened, and covered with a thin layer of pus. Examination of the plug with the microscope revealed masses of micrococci in and on the cells. Whether in such cases these are the cause of the disease or are developed after exudation, has not yet been ascertained.

Course and Result.—In some cases the acme of the disease is reached on the third day, in others the course is irregular, the symptoms of resolution being followed by repeated exacerbations, with increased exudation and desquamation of epidermic plates. Therefore a cessation of the inflammatory phenomena can be looked upon as a sign of resolution only when the secretion ceases and the meatus becomes dry.

The result of this form of inflammation is generally recovery, with complete restoration of the function of hearing; but subjective noises and deafness may remain long after the cessation of the inflammation of the meatus. The acute form sometimes, though not often, terminates in circumscribed ulceration on the membrana tympani, with perforation from without inwards, or in circumscribed ulceration on the inferior wall of the osseous meatus, with exposure of the bone and the growth of granulations in the area of the exposed parts. I observed once after the removal of a granulation which had arisen after four weeks' duration of the inflammation, the formation of an ulcer on the posterior superior wall of the meatus, which extended to the posterior half of the membrana tympani, and only healed up after being touched several times with powdered alum.

Transition into the chronic form is rare. It subsides generally without pain, often with great itching, and sometimes with subjective noises and deafness. The secretion is seldom so abundant that it runs out of the ear; it is usually of a thick, offensive, greasy nature, and contains, besides epidermis and pus-cells, many micrococci. After cleansing the meatus, the osseous section is found swollen, and often on its posterior superior wall, and sometimes on the dull membrana tympani, one or more granulations of the size of a hemp-seed are seen. Sometimes in chronic inflammation of the osseous section a fibrous polypus, filling up the meatus, is developed, after the removal of which the membrana tympani appears intact. As a rule, one or two days after the extraction of such polypi, the secretion stops completely, and the hearing at the same time becomes quite normal.

Termination of the inflammation in hyperostosis with contrac-

tion of the meatus, in ulceration and extension of the suppuration to the parotid, and in caries with rupture towards the mastoid process, the cranial cavity and the maxillary joint, is seldom met with in idiopathic, but chiefly in the traumatic, the syphilitic, and in those secondary inflammations of the meatus arising in the course of chronic otitis media.

Diagnosis.—The diagnosis of primary otitis externa can only be made with certainty when the view of the walls of the meatus and of the membrana tympani is uninterrupted on every side, and when there is no suppuration in the middle ear. The diagnosis is more difficult when the meatus is much contracted, and when there is simultaneous follicular inflammation, as those conditions are very often combined with diffuse swelling of the walls of the meatus. To complete the diagnosis the epidermic scales which have been cast off must be microscopically examined, to ascertain whether the inflammation is not caused by fungi (Hyphomycetes or Otitis externa parasitica).

Prognosis.—The prognosis of idiopathic otitis externa is favourable, as not only do the acute forms subside without after-effects, but even those chronic cases in which granulations or large polypi have developed recover after their removal. Less favourable is the prognosis of traumatic inflammation and of those caused by corrosion of the walls of the meatus, for by carious ulceration of the osseous walls the inflammation may spread to the cranial cavity or to the lateral sinus (Toynbee).

Treatment.—In acute inflammation, so long as the violent reactive symptoms last, the same palliative treatment is suitable as in acute otitis media (p. 253). In the idiopathic form anti-phlogistics are almost superfluous; in traumatic inflammations, on the other hand, cold applications, especially Leiter's apparatus, are recommended. With the commencement of secretion and shedding of the epidermic scales, local treatment must begin. While formerly instillation of zinc and lead solutions and cauterizations with concentrated solutions of lunar caustic were employed, recently antiseptic treatment in these forms of inflammation has come more into use. In acute cases the repeated insufflation of boracic powder is almost always successful in abating the secretion. This may also be tried at once in chronic cases, when there is no extensive swelling or granulation in the meatus. If it does not act favourably after a few days, instillation of a spirituous solution of boracic acid (1 in 20), or of a glycerine solution of the same (Cresswell Baber), should be tried. In obstinate cases these remedies prove effectual after several cauterizations with a concentrated solution of lunar caustic (0·8 in 10·0).*

* For those inflammations of the auditory meatus complicated with the formation of granulations and polypi, see the section on Aural Polypi.

3. *Otitis Externa Hæmorrhagica.*

This form is characterized by hæmorrhagic effusion in the osseous portion of the external auditory meatus, accompanied with more or less well-marked reactive symptoms (Bing). It occurs usually in young persons without any known cause, commencing with moderate pain, tinnitus, and slight deafness. Examination reveals one or more dark blue elongated swellings in the osseous meatus, situated on its inferior, more rarely on its posterior walls; these often extend to the inferior posterior segment of the membrana tympani on the one side, and on the other to the cartilaginous meatus, and by contracting the lumen of the meatus they interfere with the examination of the membrane. The condition in such cases is one of superficial inflammation of the cutis, the epidermis being raised to a great extent by the hæmorrhagic exudation. On being probed, the swelling feels soft and yielding, and may be perforated by very slight pressure, a blood-coloured fluid escaping. Schwartze has observed the formation of hæmorrhagic vesicles in the osseous meatus at the beginning of violent otitis media.

The acme of this form of inflammation is as a rule reached on the third day. The hæmorrhagic vesicles may remain for several days after the disappearance of the reactive symptoms, their contents being discharged by rupture or absorbed. Very often after the disappearance of the vesicles, others appear on other parts of the meatus.

The result of otitis externa hæmorrhagica is always recovery; the elevated epidermis of the meatus and of the membrane being cast off in large scales after eight to fourteen days, the diseased parts become covered with a fine, dry epidermic layer, and the hearing becomes normal.

Treatment consists in opening the vesicles by means of a probe, and the subsequent removal of their contents by the insertion of Bruns' wadding into the meatus. The latter is then filled with powdered boracic acid, and this application is repeated till the powder remains perfectly dry for twenty-four hours. As a rule the powder only requires to be used three or four times to check the secretion in the meatus and on the external surface of the membrana tympani.

4. *Croupous and Diphtheritic Inflammation of the External Auditory Meatus* (*Otitis Externa Crouposa*).

Croupous otitis externa is one of the rare forms of disease of the external meatus. Wilde (*l. c.* pp. 231, 232) indicates its occurrence, for he sometimes found the meatus and the membrana tympani covered with a layer of lymph, similar to that which lines the trachea in croup. Gottstein observed in one case, along with a croupous exudation on the tonsils, a

croupous membrane adhering to the posterior wall of the osseous portion of the meatus, after the removal of which the excoriated surface bled slightly. Attention was first drawn to this form of disease by Bezold's communications (*Virch. Arch.* vol. lxx.). He saw eleven cases of this affection in the space of three years. According to him, the exudation of fibrin is confined to the osseous section of the meatus and the external surface of the membrana tympani. It seldom occurs alone, but usually after an exhausted otitis media, or along with furunculosis of the meatus. The formation of fibrinous membranes takes place at intervals of from one to two days; they may be loosened from the underlying tissue by moderately strong injections, and appear as solid, firm casts of the osseous meatus and of the membrana tympani.

This inflammation, which usually affects healthy people, is developed with moderate pain, which reaches its acme with the commencement of fibrinous exudation, and ends, as a rule, with the casting off of the membrane. The exudation may be repeated several times, but almost always without any other complication; it ends in recovery with complete restoration of the hearing.

The prognosis of this form of inflammation is very favourable.

Treatment consists in the removal of the croupous membrane by means of injections, or with the forceps, and the subsequent insertion of boracic acid into the meatus.

Otitis externa diphtheritica seldom appears primarily, but is usually a complication of scarlatinous diphtheritis of the throat and of the middle ear. Primary diphtheritis of the meatus is, according to the observations of Moos, Bezold, Wreden, and Kraussold, developed during an epidemic diphtheritis out of an already existing otitis externa on excoriated parts of the meatus.

In the primary as well as in the secondary forms of this affection, the walls of the meatus appear covered with a dirty greyish-white exudation, which cannot be removed either by injections or by the forceps. After the membrane has been forcibly loosened by the probe, the wall of the meatus appears excoriated, ulcerated, and bleeding. The slightest touch on the ulcerated parts is extremely painful. The meatus is sometimes so contracted that it is possible to get a view of the deeper parts only after necrosis and shedding of the membrane (Blau). The parts about the ear are red and swollen, as are also the lateral cervical and the lymphatic glands behind the ear. Inflammation, commencing with moderate secretion, is accompanied in the primary form with great pain, feeling of fulness, tinnitus, and deafness; that, on the other hand, associated with diphtheritis of the middle ear runs its course,

according to Wreden, Wendt, and Blau, almost without pain, and with anæsthesia of the region of the ear.

Diphtheritic inflammation of the meatus has an uncertain course. Sometimes the exudation is rapidly thrown off, but often it remains firm for a very long time, or there are repeated exudations either on the already affected or on other parts of the meatus. In a very interesting case of diphtheritis of the middle ear and of the meatus described by Blau, the affection extended to the auricle, and deep cutaneous ulcers formed on the latter.

Diphtheritic inflammation of the meatus terminates without any permanent changes when the seat of the exudation is superficial; on the other hand, when the affection is deep-seated, the ulcers on the cutis, long persisting and easily made to bleed, heal by cicatrization.

The *diagnosis* of diphtheritis of the meatus can be made with certainty only when the presence of the peculiar adherent diphtheritic membrane has been ascertained by examination, after the removal of which an ulcerated bleeding surface is exposed. The diagnosis is rendered more probable when there exists an epidemic of diphtheritis, and coincident suppuration of the middle ear along with naso-pharyngeal diphtheritis. The white exudations seen in children, occurring in the course of acute scarlatinous suppuration of the middle ear, extending to the external orifice of the ear, and due to maceration of the epidermis, must not be confounded with diphtheritis of the meatus. They differ from the latter in being easily peeled off in large flakes.

The *prognosis* of primary diphtheritis confined to the meatus is, on the whole, favourable. The prognosis of the forms complicated with pharyngeal and middle ear diphtheritis is unfavourable; for, on account of the simultaneous extensive destruction of the membrana tympani, the frequent exfoliation of the ossicles, the consecutive caries, and very often the addition of an affection of the labyrinth, the function of hearing is much impaired.

The occurrence of a diphtheritic inflammation of the middle ear, which was doubted some years ago, has been established by the observations of Wendt, Wreden, Moos, Bezold, Küpper, Burkhardt-Merian, Gottstein, Blau, and others. The occurrence of this form as a primary inflammation of the middle ear has been clinically demonstrated only in the two cases of Burkhardt-Merian (*Samml. klin. Vortr. von Volkmann*, No. 182); on the other hand, it has been confirmed by clinical observations and post-mortem examinations, that otitis media diphtheritica arises usually from the transmission of scarlatinous naso-pharyngeal diphtheritis. Although, as Burkhardt-Merian rightly observes, scarlatinous diphtheritis of the middle ear occurs much oftener than was formerly supposed, yet the assertion that in the most

severe forms of acute scarlatinous suppuration of the middle ear we have to deal with a diphtheritic process, is going too far. This follows from the observation of those frequent scarlatinous suppurations of the middle ear, where in a short time extensive destruction of the tissue of the membrana tympani and loosening and discharge of the ossicula had resulted, without any trace of diphtheritis in the naso-pharyngeal cavity being present during the whole process.

Otitis media diphtheritica often leads to deep-seated changes in the ear. The disorganization is not always confined to the membrana tympani and the ligamentous apparatus of the ossicles, for it may seize upon the osseous walls of the middle ear and lead to caries and necrosis of the temporal bone, and by erosion of the Fallopian canal to paralysis of the facial nerve (Blau). Simultaneous loss of hearing without caries of the labyrinth is by no means rare; and according to examinations made by Moos, it may be the consequence of secondary inflammation, with small-celled infiltration of the membranous labyrinth. That the labyrinth, however, may remain intact, even in very severe forms of middle-ear diphtheritis, has been proved by several cases, in which I ascertained a hearing-distance of over six metres for whispered speech, notwithstanding an extensive and persistent aperture in the membrana tympani. Paralysis of the velum palati, which sometimes remains after pharyngeal diphtheritis, leads, as has been already mentioned, through impaired ventilation of the middle ear, to hyperæmia and catarrh of the latter.

The *treatment* of otitis diphtheritica is antiseptic. In primary diphtheritis of the meatus it is advisable, according to Burkhardt-Merian, to fill the canal at times with lime-water, in order to favour the loosening and separation of the diphtheritic membrane. After the fluid has been left for fifteen or twenty minutes in the ear the meatus should be syringed with a weak solution of boracic acid, and then filled with finely-powdered boracic acid. If the membrane is repeatedly formed again, the affected parts should be touched with carbolic glycerine (1 in 15) or carbolic spirit (1 in 20), and in addition the meatus should be filled several times a day with an alcoholic solution of boracic acid (1 in 20). Mechanical removal of the diphtheritic membrane hastens the recovery just as little as cauterization with lunar caustic. The same treatment is used in diphtheritis of the middle ear. If it arises as usual from the propagation of scarlatinous diphtheritis of the naso-pharynx, it is advisable to cleanse the middle ear from time to time by means of Weber's nasal douche or Saemann's water-douche, but only in bilateral affection of the middle ear and when the strength of the patient permits. On the other hand, in cases of naso-pharyngeal diphtheritis without aural affection, injections into the nose should

be used with great caution, as by too strong pressure the fluid may penetrate into the Eustachian tubes and the diphtheritic process be readily transmitted to the middle ear.

5. *Syphilitic Inflammation of the External Ear (Otitis Externa Syphilitica).*

Syphilitic affections of the auricle in the form of squamous, pustular, and papular eruptions occur only in general cutaneous syphilis, and especially when the skin of the forehead and the scalp are affected at the same time. Tubercular syphilides are seldom met with, but according to an observation made by Burnett, they may spread over the entire auricle, and by the formation of deep-seated ulcers partially destroy it.

Of the syphilitic affections occurring in the external meatus, condylomata and ulcers have been the most accurately studied.* Condylomata in the auditory meatus occur only in general syphilis, and often with condylomata at the same time on other parts of the body. They usually occur simultaneously with general symptoms of syphilis (Stöhr, *A. f. O.* vol. v.); *i.e.*, with signs of syphilitic affections of the skin, pharyngeal ulcers, and glandular swellings.

The initial stage of condylomata as a rule escapes observation on account of the absence of striking symptoms. According to Knapp (*Z. f. O.* vol. viii.) they commence with reddish, gradually increasing efflorescences in the meatus, followed by diffuse swelling of its walls, with moderate secretion. On the secreting parts the condylomata spring up, more or less quickly, in the form of reddish or greyish-red, ragged warty excrescences, which extend from the entrance of the ear to the osseous meatus, and render the lumen of the canal quite impermeable. In one of my cases the condylomata were limited to the parts of the cartilaginous section bounding the orifice of the ear.

While the initial stage runs its course without symptoms, violent, radiating pains, increased by movement of the jaw, appear with the formation of the condylomata, and especially with their ulceration; only in a few cases is there any fever (Stöhr). Subjective noises and deafness are caused either by mechanical obstruction of the auditory meatus or by consecutive affection of the middle ear, which, as in a case observed by Knapp, may be associated with bilateral perforation of the membrana tympani.

* Among 1,200 syphilitic patients, of whom 980 had condylomata, Desprès (*Ann. d. Mal. de l'Or.* etc. 1878) observed condylomata in the external meatus five times. Buck (*Am. Journ. of Otol.* 1879) among 4,000 persons with ear disease met with 30 cases of syphilis of the ear, 5 of which suffered from condylomata and ulcers. Ravogli (*Congressber. Maitland*, 1880) among 144 cases of syphilis found the middle ear affected fifteen times and the external meatus only once.

Condylomata of the auditory meatus either heal by resolution, which quickly follows on energetic general treatment and the suppression of the other syphilitic symptoms, or end in destruction of the efflorescences with profuse, fœtid secretion and the formation of unhealthy, confluent ulcers, seated usually on the inferior posterior wall, and healing very slowly. By rational local and general treatment cure follows after some weeks or months, with or without cicatrization. In the latter case that portion of the meatus appears sunken and devoid of hairs. Stricture of the meatus seldom remains.

The diagnosis of condylomata in the auditory meatus, which can be confounded with granulations only on superficial observation, depends on the simultaneous existence of the characteristic symptoms of syphilis on the genitals, the skin, and the throat, and on the accompanying glandular swellings.

The prognosis of condylomata of the auditory meatus is favourable.

Syphilitic ulcers seldom attack the external ear without a simultaneous affection of the middle ear. Alb. H. Buck (*Am. Journ. of Otol.* 1879) records several cases of syphilitic ulceration on the auricle and in the meatus, with characteristic base and steep, elevated margins. The occurrence of nasal and pharyngeal syphilis, and the infiltration of the cervical glands at the same time were evidence of the specific nature of the affection. In a case communicated by Ravogli (*l. c.*) of a tubercular syphilide on the side of the neck, several syphilitic tubercles were developed in the meatus and on the membrana tympani, which formed angry, isolated ulcers with deep base and elevated margins.

In a case observed by me, a characteristic ulcer formed on the inferior wall of the meatus in the course of chronic suppuration of the middle ear. The fatty base of the ulcer occupied the anterior and lateral walls of the cartilaginous portion, and its steep, elevated margins involved the external orifice of the ear. The simultaneous occurrence of pharyngeal syphilis left no doubt as to the syphilitic nature of the disease. In a second case there was, in addition to an ulcer occupying the whole length of the cartilaginous wall of the auditory meatus, a second round one with elevated edges in the concha.

Syphilitic inflammation of the throat is well known to transmit itself to the middle ear. Either catarrh occurs with impermeability of the Eustachian tube and accumulation of serum or mucus in the middle ear, or the ulceration extends to the cartilage of the tube, whereby a portion of it is destroyed, leading to subsequent contraction or adhesion of the tube. Moreover, simple as well as ulcerative syphilitic inflammation of the pharyngeal cavity may lead to purulent otitis media with perforation of the membrana tympani; but examination with the aural speculum seldom reveals a condition differing from the common forms. Often in affections of

the middle ear caused by syphilis, perception for the acoumeter and the tuning-fork through the cranial bones is lessened or quite wanting (complication with syphilitic affection of the labyrinth), an incident which supports the diagnosis of a specific ear-affection when there are other syphilitic symptoms present.

The treatment of condylomata of the auditory meatus consists, besides general treatment, in several (3-6) cauterizations of the granulations with lunar caustic or concentrated solutions of chromic acid, and, after reduction of the warty growths, in anointing them with corrosive sublimate solution (0·1 in 30·0), or tincture of iodine. Knapp recommends dusting the condylomata with calomel and afterwards painting with a 1 per cent. solution of nitrate of silver. In ulceration of the auditory meatus it is recommended to paint the ulcerated parts several times with tincture of iodine, and when the ulcer has lost its fatty appearance, to apply to it camphorated oil. In one case cicatrization was brought about by keeping a plug of mercurial plaster in the meatus.

The following is an example of rapid recovery from condylomata of the meatus. In a middle-aged woman, two months after the primary infection, a feeling of dulness was felt in the left ear, and soon after that otorrhœa commenced. Six weeks later she experienced great pain, which obliged her to seek medical aid. Present state: Warty, dirty-grey condylomata at the entrance to the ear, abundant discharge, moderate deafness, cutaneous syphilis for two months, palmar psoriasis, pustules and scabs on the bridge of the nose, syphilitic sore-throat. Treatment.—Besides general treatment, three cauterizations with nitrate of silver, then brushing with corrosive sublimate solution (0·1 in 30·0) for four days. On the following day the meatus became dry, the diseased parts smooth but still red, and hearing normal.

c. *Parasitic Inflammation of the External Auditory Meatus* (*Otomycosis* [*Virchow*], *Myringomycosis Aspergillina* [*Wreden*]).

Although single cases of fungus in the ear had already been observed by Mayer,* Pacini,† and Carl Cramer,‡ the attention of otologists was first drawn to the peculiar form of inflammation of the auditory meatus caused by fungus by a short communication of Schwartze's (*A. f. O.* ii.), and particularly by a detailed work of Wreden's (*Monograph*, 1868). More recently the pathology of otomycosis has been greatly enriched by valuable contributions from Burnett, Blake, Cassells, Hassenstein, Hagen, Bezold, Steudener, Loewenberg, and others.

* Müller's *Arch. f. Anat.* etc. 1844. † Firenze, 1851.
‡ *Vierteljahrschr. d. naturf. Ges. in Zürich*, 1859-60.

The most common fungus in the ear belongs, according to Wreden, to the species Aspergillus nigricans and flavescens, and, according to Bezold, to the species A. fumigatus. The following are much rarer: the Trichothecium roseum Lk., described by Steudener; a fungus with grass-green conidia (Otomyces Hageni), described by Hagen; the Otomyces purpureus of Wreden; and the Ascophora elegans of v. Tröltsch.

An examination of a fungous mass removed from the ear gives the following result: there is a felt-like, mycelial structure, intermixed with cast-off epidermis, from which arise upright, cylindrical, rigid filaments, often furnished with septa (Hyphæ, Fig. 213, *b*, *b'*), which support the head of the fungus (sporangium or fruit-capsule, *c*). The latter consists of the central vesicular enlargement (receptaculum, *d*), the long radiating cells

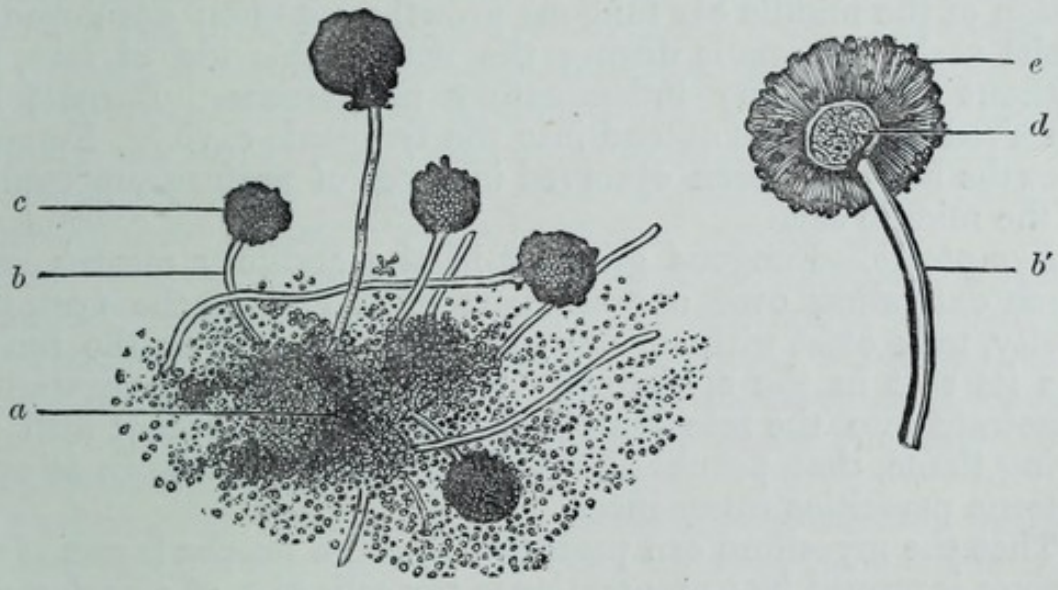

FIG. 213.—ASPERGILLUS NIGRICANS.

a, Mycelium covered with numerous fallen spores; *b*, Hypha; *c*, Sporangium, with ripe spores; *b'*, Hypha; *d*, Receptaculum; *e*, Sterigmata with spores.

seated upon the latter (sterigmata, *e*), and the round conidia or spores growing on its free end.

The colour of the various forms of fungi depends upon that of the conidia. They are black-brown in A. nigricans, yellowish or greenish in A. flavescens and in A. glaucus, and greyish-black in A. fumigatus. According to Burnett (*Am. Journ. of Ot.* 1879), the fructification-heads are smaller and narrower in A. glaucus than in A. nigricans. A. fumigatus possesses the smallest sporangium, and, according to Bezold, more rarely occasions inflammation in the ear than the other species.

Etiology.—The fungous spores which reach the meatus from the atmosphere can, under favourable circumstances, germinate and increase very rapidly. According to Bezold, fungous growths are oftenest observed after the instillation of oily substances, which, like all fats (Loewenberg), form a very nutritive material for the development of fungi. That the application of medicated

substances containing fungi (Loewenberg) can give rise to otomycosis has not yet been proved. On the other hand, I can after some experience confirm the statement made by Bezold that fungi are developed in the ears of persons living in a damp, mouldy locality. One case of mine was observed in a young man employed in the manufacture of yeast. Very often the cause of otomycosis cannot be ascertained.

Otomycosis running its course with reactive phenomena occurs usually in middle-aged people, almost never in children, and but seldom in old people; it is more common among the poor than among the rich. The frequent development of fungi in individuals affected with chronic catarrh of the middle ear, depends certainly upon the instillation of all kinds of fatty, easily decomposing substances into the auditory meatus. In chronic suppuration of the middle ear fungous growths are often developed on moist scabs, especially during the use of chloride of iron, but without causing any inflammatory phenomena. Burnett has observed the fungus extend into the tympanic cavity. Fungous growths have not been observed in cases of profuse suppuration of the middle ear.

Symptoms.—Fungous growths in the auditory meatus, even when extending over a great part of it and of the tympanic cavity, may exist without any symptoms, so long as the fungus has its seat in the epidermis. When, however, the vegetations penetrate into the rete Malpighii and come in contact with the living tissue, that peculiar form of inflammation known as otitis externa parasitica commences.

That the mycelium can penetrate into the deeper layers of the corium is proved by a preparation in my collection of a perforation of the membrana tympani, in which the remnant of the periphery is seen to be permeated by the mycelium. I have also found from observation that the penetration of aspergillous growths into the living tissue can give rise to violent inflammatory phenomena. In a man suffering from chronic catarrh of the middle ear, I found on examination that the osseous meatus was sown with small, sulphur-yellow globules on short stalks, which proved to be aspergillous growths (A. flav.). Inflammatory phenomena were quite absent. On the following day at a demonstration of the patient before the Medical Association, one of those present, through careless management of the speculum, made a little scratch on the auditory meatus, and on the next day an extensive otitis externa developed with violent reactive symptoms and the formation and exfoliation of shreds of epidermis infiltrated with masses of fungus. In another case in which masses of aspergillus, reaching nearly to the external orifice of the ear, existed without symptoms, I made an incision in the cutis, on a thickly sown part of the inferior cartilaginous wall. After some days a rather prominent, slightly painful

infiltration of the cutis formed at the place of incision, which, however, receded at the end of fourteen days. According to Wreden, the inoculation experiments which he made in healthy meatuses remained without results.

The subjective phenomena of parasitic otitis externa are great itching and flying stitches, which increase to violent pains radiating towards the head and throat. In most cases tinnitus and deafness are superadded.

On examination of the meatus in cases of A. nigricans, the osseous section especially and the membrana tympani are found covered with a black-spotted or entirely black membrane having the appearance of being strewn with fine coal-dust. On syringing it is washed out in shreds of considerable thickness, on the surface of which the characteristic black spots (sporangia) are visible either with the naked eye or with a lens. According to Loewenberg, the epidermis permeated with mycelium may take the form of small cysts, on the inner surface of which the fungous growths are seated. In cases of A. flavesc., the surface of the epidermis invaded with mycelium appears covered with a yellowish mass of dust like the powder of lycopodium.

After removal of such membranes from the meatus, the lining membrane of its osseous section and the membrana tympani are found very red, swollen, and in great part devoid of the epidermic layer. Here and there, however, are seen solitary, irregular grey islands, on which after removal with the probe epidermic cells mixed with fungous spores are recognised.

Course and Termination.—The course of parasitic otitis externa depends upon the extent of the fungous growths and the time treatment commenced. When the affection is left to itself or treated by a physician who does not know its nature, the inflammation may continue for several weeks without in the least abating, and, as I have observed in several cases, may lead to perforation of the membrana tympani from without inwards. In many cases the inflammation ceases, notwithstanding the presence of fungous growths in the ear, only to reappear with renewed vigour at intervals of weeks or months. On examining such cases the meatus is very often found filled with fungous membranes closely packed.

Immediately after removal of the membrane in the inflammatory stage there is a decided diminution of the pain and of the subjective noises, speedily followed by cure on proper treatment being employed. When, however, after the removal of the fungous membrane no antiparasitic remedy is used, on the following day, even in cases in which the reactive symptoms continue, the meatus is often found re-covered with a thick fungous membrane similar to what had been already removed. Such rapid recurrence may go on till either the fungus becomes exhausted or treatment effects a cure.

Diagnosis.—The diagnosis of fungous growths in the meatus presents no difficulty when with decided symptoms of otitis externa the characteristic appearance of the meatus is found on examination with the speculum. Sometimes, however, blackish-brown epidermic plates are syringed out of the ear, on which the brown covering appears as dust, coal-dust, or vegetable *débris*, which might be mistaken for those fungous membranes. In doubtful cases, therefore, microscopic examination is indispensable before giving a diagnosis.

Prognosis.—The prognosis of otitis externa parasitica is in all respects favourable, as, by the use of parasiticides, a rapid cure is effected, and, even after perforation of the membrana tympani, cicatrization of the aperture speedily follows (*cf.* Bezold on *Otomycosis*, 1880). The prognosis is not so favourable, however, when there is the possibility of a recurrence of the inflammation, particularly in persons who live in damp, mouldy localities, in which the cause of a renewed attack is always present. I have also seen frequent relapses in persons in the most favourable circumstances without apparent cause.

Treatment.—Of the numerous remedies recommended for the removal of fungous growths, rectified spirit, recommended by Hassenstein and Küchenmeister, has proved the best. It is used as follows: After the fungous membranes have been nearly all removed by syringing, the meatus is then filled by means of a warm spoon with rectified spirit, which is kept in the ear for at least a quarter of an hour. This procedure is, at first, to be repeated twice daily. As a rule, the spirit can be well borne. When it causes a burning feeling, it is advisable at first to dilute the spirit with distilled water, and gradually to employ concentrated spirit of wine.

The result of the treatment is so quick, that even after two days no sign of fungus is visible in the meatus. The lining membrane of the meatus and the membrana tympani appear covered with a fine dry epidermis; pain, tinnitus, and deafness disappear, and after three or four days' treatment the cure is almost complete.

In order to prevent relapses, I consider it well to advise the patient to continue the application of the spirit at increasing intervals, but at least once every four weeks, throughout a whole year.

Besides spirit, there are a number of other remedies for the destruction of fungi. Among the most effective of these are boracic acid in powder or in spirituous solution (1 in 20), or mixed with an equal amount of oxide of zinc (Theobald); permanganate of potassium in 1-2 per cent. solution (v. Tröltsch, Schwartze, Hagen); carbolic acid free from creosote (3·0 in 100·0 oil or glycerine, Lucæ); spirituous solution of tannin (50 per cent., Wreden); spirituous solution of salicylic acid (2 per

cent., Bezold); chlorinated lime (0·07-0·15 in 35·0 aq. dest., Wreden); hyposulphite of soda (0·2 in 30·0, Blake, Burnett); and Fowler's solution of arsenic.

Pityriasis alba, described by Ladreit de Lacharrière (*Annal. des Mal. de l'Oreilles*, etc. 1875), remains to be mentioned as a rare mycosis. It occurs along with pityriasis capitis at the age of from forty to fifty years. After removal of the scales, which microscopically show the characteristic fungous spores, the cutis of the meatus appears thickened and red. This mycosis is not to be confounded with seborrhœa of the meatus, in which there is also a formation of fatty scales. The treatment of p. alba consists in the extraction of the stiffest hairs, and in painting the lining membrane of the meatus with a 1 per cent. solution of corrosive sublimate.

E. Contractions and Adhesions of the External Auditory Meatus.

Contractions in the external auditory meatus are caused by infiltration and bulging out of its lining membrane, by cicatrization, or by hyperostosis and osseous new-formation on the walls of the meatus. The contractions caused by swelling and hypertrophy of the cutis most frequently develop in the secondary inflammations in the course of chronic suppuration of the middle ear, and further in chronic eczema and in the primary forms of otitis externa. Cicatricial strictures occur in chronic secondary inflammations of the meatus in the course of lingering suppurations of the middle ear, after diphtheritic and syphilitic ulcerations, after injuries and cauterizations (with concentrated acids, galvano-cautery, solid lunar caustic) of the lining membrane of the meatus. A fissure-like contraction of the orifice of the ear, caused by shrivelling and collapse of the cartilaginous wall of the meatus (v. Tröltsch), is very frequently met with in old persons.

The contractions are either temporary or permanent. Among the first are reckoned the swelling up of the cutis, caused by inflammatory infiltration, which, not only in the acute, but also in the chronic forms, recedes spontaneously or after suitable treatment. Sometimes, however, in long-continued infiltration of the cutis, particularly in the course of chronic suppuration of the middle ear, there occurs a new-formation of connective tissue with permanent thickening and condensation of the tissue of the cutis, associated with a considerable contraction of the lumen of the meatus.

The strictures caused by ulceration and cauterization are somewhat different. In some few cases there are circumscribed annular strictures, which, as in a case observed by Morpurgo, are like the diaphragm in an optical instrument, enclosing an orifice

from the size of a pin-head to that of a small lentil. This condition may easily be mistaken for perforation of the membrana tympani when the slight distance of the new-formed membrane from the external orifice of the ear is overlooked. In other cases permanent strictures remain from extensive callous condensation and shrivelling of the subcutaneous connective tissue, mostly situated in the middle and cartilaginous sections. The contraction is either circumscribed, then affecting generally the middle of the meatus, or it is long, extending usually from the neighbourhood of the external orifice of the ear to the osseous meatus.

Osseous strictures are caused either by a more or less regular periosteal ossification of the walls of the meatus, or by hyperostosis proceeding from the posterior superior wall of the osseous meatus, which, like an inclined plane, sinks from without inwards towards the inferior wall of the meatus, and obstructs the view of the membrana tympani by forming a fissure-like contraction of the lumen of the canal. Such strictures, usually associated with great deafness, frequently develop after carious processes in the temporal bone, especially after exfoliation of large osseous sequestra from the mastoid process through an opening in the wall of the meatus. The slit-like contraction of the meatus, formed by the abnormal inward curvature of its anterior inferior wall, is traced to an anomaly of formation.

The form of the stricture of the meatus is round or fissure-like, seldom like an hour-glass. After exhausted suppuration the contracted part remains long unchanged; in the secreting stage, however, its size varies by the deposition of secretion and by increase and decrease of the swelling of the cutis.

Contractions of the external meatus, even when very pronounced, occasion of themselves but slightly marked disturbance of hearing. Although in the majority of cases the power of hearing is more or less considerably decreased, that is owing to simultaneous adhesive processes or destructive changes in the middle ear, or to the accumulation of thickened secretion behind the stricture. During the existence of suppuration of the middle ear stricture may occasion a fatal affection of the brain or sinus by retention of the pus (Orne Green, Roosa).

In the examination of strictures of the meatus careful probing of the parts contracted is indispensable. For it not only shows the difference of the membranous stricture from the osseous, but also indicates the length of it. If it be short, the point of the probe will move with much more freedom behind the contracted part than when it is long.

The treatment of strictures of the external meatus depends on the anatomical cause of the contraction and on the condition of the parts of the external and middle ears lying behind the stricture. In contractions caused by swelling or hypertrophy

of the cutis—when they cannot be removed by the treatment spoken of under inflammations of the external meatus—it is advisable to dilate the contracted parts gradually by the insertion of conical, resistant cotton-wool pads, impregnated with acetate of lead. Should the latter prove insufficient, compressed sponge tents should then be introduced, gradually increasing in diameter and allowed to remain till moderate pain is caused by their swelling. This is, as Gottstein rightly observes, preferable to dilatation by means of laminaria tents, which by swelling too quickly often occasion violent reaction and subsequently greater contraction. Energetic attempts at dilatation may even have as their result adhesion of the walls of the auditory meatus, when the epidermic surface is torn off by the pressure of the dilator and the exposed parts touch each other. Rapid dilatation is, however, necessary when it is a question of removing stagnating secretion from the deeper sections of the meatus and of the tympanic cavity in order to check its deleterious effects. As in those cases in which after the compressed sponge has been removed the contraction soon returns, it is necessary, in order to keep up a free discharge of the secretion, to insert an india-rubber tube of corresponding size immediately after the dilatation. The wearing of short vulcanite or silver cannulæ is recommended also in the case of fissure-like contraction of the external orifice of the meatus, caused by collapse.

Long-continued contractions caused by hypertrophy of the lining membrane of the meatus prove very obstinate to the methods of dilatation described, as after repeated use of the compressed sponge the contraction again reaches its former degree; sometimes even it increases in consequence of the mechanical irritation. In such cases repeated longitudinal scarifications of the cartilaginous meatus, with subsequent introduction of compressed sponge tents, prove very effectual. In cicatricial strictures a marked dilatation is seldom achieved by surgical intervention. Long osseous strictures are incurable, and the chiselling-out process proposed by some is not only useless but dangerous. By progressive but not energetic attempts at dilatation by means of the compressed sponge, continued for months in many cases, slight dilatation is attained. Too energetic attempts may have an opposite effect. With doubtful symptoms of retention of pus the opening of the mastoid process is advised (Schwartze).

Contractions of the auditory meatus are frequently caused by those bony formations termed *exostoses*, upon the origin of which the views of observers differ greatly.

Hedinger regards exostoses in general as the result of a hypertrophic inflammation of the lining membrane of the meatus with ossification of the new-formed connective tissue. Cassells (*Transact. of the Internation. Med. Congr.* London, 1881) accepts two

kinds of osseous new-formation: hyperostosis and exostosis, which vary in regard to origin, size, form, and structure. Hyperostoses are hyperplasiæ; they occur only in the inner portion of the osseous meatus, and never before complete ossification of the latter; they are of the consistence of ivory, have no pedicle, and are immovable, of conical form, and stand in no relation to other affections of the ear. The seat of exostoses proper is the boundary between the osseous and the cartilaginous meatus. They are always pedunculate, slightly movable, and of very diverse form. Unlike the hyperostoses, several exostoses are never found at the same time, yet the two forms of osseous tumour may occur together. Exostoses, according to Cassells, are often developed from polypous granulations, which gradually become converted into bone by a process of ossification extending from their base.

According to v. Tröltsch, no sharply defined line separates the exostoses from the hyperostoses, but he applies the latter term to those diffuse osseous growths occupying the whole length of the meatus, and exostoses to the circumscribed, tumour-like osseous new-formations.

According to Schwartze, Virchow, and Nélaton, the nature of the exostoses, whether spongy or compact, depends on the more or less advanced stage of the development of the osseous tissue.

The originating causes of the exostoses are in the majority of cases not ascertained, because there is very little opportunity of observing their development clinically. The following may serve as the origin of a series of cases: 1. Partial hyperplasiæ during the stages of development and ossification of the osseous meatus. To this form, according to my idea, belong those bilateral osteomata arising without symptoms, seated symmetrically in the aural passages, and agreeing on the two sides in regard to form. Their site is the middle and inner sections of the osseous meatus. They are sessile or pedunculate, but never reach such a size as to completely fill the meatus. 2. Circumscribed, chronic periosteal inflammation in the osseous meatus. 3. Diffuse inflammations of the external meatus, whether primary or developed in the course of chronic suppuration of the middle ear. 4. Hereditary tendency (Schwartze). 5. Syphilis (Roosa) and gout (Toynbee) are much seldomer the cause of exostoses than was at one time supposed. That either of these general diseases has given rise to the aural affection can be considered probable only when osseous tumours appear simultaneously on other parts of the body, the origin of which can be traced to the general disease.

Moos describes (*A. f. A. u. O.* ii.) three cases of symmetrical, bilateral exostosis on the superior wall of the meatus, on which were seated to the right and left of Shrapnell's membrane two white tubercles larger than hemp-seed, whose development was

referred by him to an irritative process at the union of the annulus tympanicus with the squama of the temporal bone.

The condition is represented in the accompanying illustration (Fig. 214). It must, however, remain undecided whether one is here dealing with an osteoma or with a solid connective-tissue tumour. I examined, indeed, more than a thousand skulls and temporal bones without having met with any similar formation in the meatus, and there is just as little information as to such conditions on macerated temporal bones to be obtained from other sources. It may be that these tumours are either destroyed by maceration, or, if indeed they possess osseous structure, are not immediately, but by fibrous tissue, connected with the wall of the meatus.

The frequent occurrence of exostoses of the meatus among the aborigines of America has been repeatedly confirmed. Seligmann examined six skulls of Titicacas and found this anomaly five times; Welcker saw exostoses in the meatus among North American tribes; and C. J. Blake also found, while examining numerous skulls of the Mound Builders in Tennessee, exostoses in the auditory meatus in 25 per cent. Turner found in an artificially deformed Peruvian skull both meatuses closed by hard ivory-like exostoses, and similar ones in both ears of a flat-headed Chenook Indian. Whether these anomalies depend on certain racial peculiarities or on the mechanical irritation of the meatus caused by the wearing of heavy ear-pendants, has not yet been ascertained.

Fig. 214.

Exostoses of the external meatus appear as white or yellowish, smooth, seldom rough tumours of various size, seated on the wall of the meatus, either with a broad ill-defined base or sharply demarcated and circumscribed. They may originate in any point of the meatus. Frequent sites of exostoses are the place of union of the osseous with the cartilaginous section and the posterior wall of the meatus (Delstanche, Gardiner-Brown), especially its external section covered by the cartilaginous portion. Exostoses growing on this part are often seen with the naked eye immediately behind the external orifice of the ear, and attain such a size that they convert the lumen of the meatus into a narrow slit. By pressure of the new-formation on the cartilaginous wall, the latter atrophies, till it disappears altogether, or the exostosis adheres to the cartilage so completely that the tumour may be mistaken for an ossifying enchondroma.

Exostoses may occur singly or in numbers in the meatus. Often there are found two exostoses, which contract the meatus to a fissure or to an hour-glass shape. Sometimes a small

exostosis is placed on the top of a larger one (Moos). Bilateral exostoses are very frequent, but not always symmetrical on the same part of the meatus. Once I observed on the left two and on the right three exostoses in the osseous section, proceeding from the anterior, superior and posterior walls; great deafness and tinnitus had lasted since a confinement thirty-one years before. As simultaneous changes in the ear, I have found most frequently chronic catarrh of the middle ear without evident connection with the osteoma, chronic suppuration of the middle ear with or without polypi in the meatus (Cassells), chronic otitis externa with moderate desquamative secretion and chronic eczema. There are very rarely simultaneous exostoses on other parts of the body. In a Greek, aged forty-four years, who had never suffered from syphilis, there existed, besides an exostosis almost completely closing up the left meatus, an osseous tumour as large as the fist on the left temple, which had gradually reached this size in the course of twenty-four years.

The occurrence of exostoses in the tympanic cavity is very rare. Zaufal (*A. f. O.* ii.) found in the macerated skull of a boy, nine years old, on both sides symmetrical exostoses in the tympanic cavity with partial closure of the fenestra rotunda. The exostoses occupied the space between the eminentia pyramidalis, the niche of the fenestra rotunda and the membrana tympani. Moos (*A. f. A. u. O.* ii.) described several instances of congenital and acquired hyperostosis of the temporal bone (p. 329).

The subjective symptoms accompanying exostosis of the meatus are oftener caused by simultaneous affections of the middle ear and of the meatus than by the tumour itself. Small exostoses not occluding the canal almost always run their course without symptoms. Large osseous tumours, on the other hand, may give rise to painful inflammation with suppuration by pressing on the opposite wall of the meatus, the exostosis itself being also similarly affected. In such a case I once observed a bed-sore, as it were, arise on an exostosis.

As to the further history of exostoses, small tumours may last for a lifetime without injuring the ear. Large tumours may, apart from deafness, be injurious by favouring the accumulation of cerumen and epidermic masses in the deeper parts of the meatus, by closing it up and by preventing the exit of pus in cases of co-existing suppuration of the middle ear, and by rendering the surgical removal of polypi difficult.

From its characteristic appearance, in my experience the diagnosis of exostosis presents no difficulty. It is only when the lining membrane of the meatus is inflamed and swollen that the red, secreting swelling can be mistaken for the bulged-out cutis of the meatus or for a polypus. The resistance of the tumour on being probed leaves no doubt as to its nature.

Treatment.—Local painting with tincture of iodine and

solutions of lunar caustic recommended for the absorption of the new-formation are not only useless, but may give rise to inflammation and painful ulceration of the cutis covering the exostosis. The internal exhibition of iodine and mercurial preparations is only to be advised when the disease has a syphilitic basis.

When exostoses have attained such a size that great deafness is caused by the complete closure of the meatus, it is better, before proceeding to surgical means, to make some attempts at dilatation, which in many cases have favourable results. If solid bodies introduced between the exostosis and the wall of the meatus and retained there for a long time succeed in causing atrophy of the exostosis and so establishing a small slit in the lumen of the auditory meatus, that is quite enough for the entrance of the waves of sound. Bonnafont (*Union méd.* 1863) describes three cases of extreme deafness from exostosis of the meatus, in which normal hearing was restored by a very small opening being formed by the long continued introduction of a metal rod between the meatus and the exostosis. Von Tröltsch has observed the circumference of an exostosis decrease after laminaria tents had been introduced for years. In one case, in which a piece of the laminaria which had been left in caused superficial necrosis of the walls of the meatus, after removal of the small sequestrum a considerable dilatation of the meatus was observed and the hearing returned.

In fissure-like contraction of the meatus by exostosis, cerumen and epidermic masses accumulate behind the stricture. Their removal by the ordinary injections is seldom possible, as the stream of water does not enter the opening with sufficient force. In such cases, the desired result is most speedily attained by pushing the point of a tympanic catheter (p. 140) through the opening towards the interior, and then by means of a Pravaz's syringe, the nozzle of which goes into the outer end of the catheter, injecting ten drops of a warm solution of soda in glycerine. The masses so softened can easily be syringed out on the following day with warm water injected by means of a large syringe through the inserted catheter. This procedure is chiefly recommended in fibrous or osseous strictures of the meatus for the removal of purulent, inspissated or cheesy secretion from the deeper parts of the ear.

The indications for the surgical removal of exostoses are the following: 1. Extreme deafness, in consequence of complete closure of the meatus by the exostosis. 2. Suppuration of the middle ear, the escape of the pus from which is prevented by the tumour. In such cases speedy action is the more urgent the more marked the symptoms of retention of pus.

Methods of operation recommended for the removal of exostosis: 1. Removal by means of a gouge (Heinecke, Cassells, one case reported by the author). This has the advantage of quickly

removing the new-formation; it requires, however, great caution, on account of the great bleeding, which obstructs the view of the field of operation, and on account of the possible danger of injuring deeper parts by the slipping of the instrument (Field). Aldinger effected a complete cure by this operation with restoration of hearing. 2. Perforation of the exostosis by means of files (Bonnafont), drills, and dentists' drill-machines (Mathewson, Delstanche *fils*, Bremer). This procedure necessitates less interference than the former, but the result is much less sure, as the perforation very often closes notwithstanding the insertion of ivory or lead pins. Bonnafont (*Union méd.* 1868) describes a case of cure of total deafness by trephining with a round file an exostosis completely closing up the middle section of the meatus. The tumour, 6-7 mm. in thickness, was perforated in the course of ten days, and the canal kept open by the insertion of whalebone tents. 3. Removal by means of a gouge and mallet (Cassells) is only practicable in the case of pedunculate exostoses and those seated near the external orifice of the ear. In a case operated upon by Knorre the removal was rendered easier by sinking one arm of the forceps into a perforation of the exostosis, while the tumour was seized by the other and torn off. 4. Destruction of the exostosis by the galvano-cautery, recommended by Voltolini and Delstanche, is very slow, but it has this advantage, that the operation gives rise to but slight bleeding and moderate pain. Moos has cured one case by the combined use of the galvano-cautery and the insertion of laminaria tents. 5. Removal by means of a fine chain saw or extraction by means of an ecraseur can only be performed in a few cases. For pedunculate tumours with contracted base the elastic ligature recommended by v. Dittel may be used.

Acquired atresia of the external auditory meatus is caused: 1. By the immediate contact of the walls of the auditory meatus deprived of their epidermis in the course of secondary inflammation of the meatus, due to chronic suppuration of the middle ear. 2. By combined caries and necrosis of the mastoid process and of the walls of the meatus, as, after the expulsion of one or more sequestra, the granulation tissue growing into the lumen of the meatus is changed into fibrous connective or into osseous tissue after adhesion to the walls of the meatus. In such cases there are often besides osseous atresia of the meatus, contracted osseous cicatrices on the mastoid process. 3. By the adhesion of considerable granulations proceeding from the walls of the osseous section and filling up its lumen, their epithelium being afterwards lost by long contact of the growths. Here also the connective tissue closing the meatus becomes changed into a fibrous mass or into bone. In a case of pedunculate polypus, reaching to the external orifice of the ear, in which operation was not permitted, I found at a later examination atresia of the meatus,

caused by adhesion of the polypus on every side with its walls. 4. By traumatic lesions (Samuel Sexton), cauterization, burning and ulceration of the walls of the meatus. Adhesion in these cases is caused either by the contact of the exposed walls or by the contact of the granulations rising from the surface of the tumour. 5. By a phlegmonous, periauricular inflammation extending into the meatus, with the formation of a mass of adhesive connective tissue in the cartilaginous portion (Ladreit de Lacharrière).

Fibrous atresia is caused either by a membranous septum stretched out usually at the entrance to the ear or in the osseous section, or by a long mass of connective tissue varying in thickness. Osseous atresia, usually of considerable thickness, is oftenest situated in the external section of the osseous meatus, the whole canal being seldom filled up by the osseous masses (Zuckerkandl).

The objective symptoms of atresia vary according to its seat and extent. In the fibrous as well as in the osseous forms of atresia the walls of the meatus run up to the adhesion without clear demarcation, thereby giving the canal the appearance of a *cul-de-sac*. The further the atresia extends outwards the shorter appears the canal of the ear. This is of importance in the diagnosis of atresia. It is only when it is limited to the innermost section of the osseous meatus that the surface of the adherent parts may be mistaken for the membrana tympani. The adhesion existing between the walls of the meatus on all sides and the background, the absence of the short process and of the handle of the malleus, and the diminished distance from the external orifice of the ear to the inner end of the meatus compared with that of the other side, are sufficient guides, however, for the diagnosis of atresia.

Further, the adherent parts must be probed in order to ascertain whether the adhesion be membranous, fibrous, or osseous. In the last case the background is hard as bone. It is more difficult to distinguish between a membranous septum and an extensive connective-tissue adhesion, particularly when the expanded membrane is somewhat thick and not very yielding.

In such cases the degree of hearing sometimes informs us of the thickness of the atresia. In osseous atresia or in extensive connective-tissue adhesions there is total deafness, or nearly so; in membranous closure (septum), on the other hand, there may be a considerable hearing-distance for speech. As, however, perception for loud speaking is partly through the bones of the head, it is advisable to use an ear-trumpet in testing the distance for speech. In osseous or extensive connective-tissue adhesions what is spoken through the ear-trumpet is either not heard at all or is understood with difficulty. In membranous closure of slight thickness, however, even low speaking can be understood,

provided that the tympanic apparatus and the labyrinth have undergone no great changes. When whispering is understood through the ear-trumpet it is very probable that the septum is very thin; and this is in so far practically of importance that in such a case one can at once have recourse to surgical treatment of the atresia, while in cases in which speech is not understood with the help of the ear-trumpet surgical interference must be avoided.

To illustrate what has been said I may relate briefly an instructive case from my practice. A girl twelve years of age had suffered at the age of two from left otorrhœa, and two years later from right otorrhœa also. At the age of nine years the discharge stopped in both ears. According to her mother she heard quite well while the otorrhœa lasted, but as soon as it ceased she became deaf. The examination gave as result: symmetrical *cul-de-sac* closure of both meatuses almost in the middle of the osseous section (*cf.* diagrammatic sketch of the right meatus, Fig. 215). The background is yellowish-white, and somewhat yielding on being probed. Hearing-distance right and left for the acoumeter 1 cm., for loud speech 15 cm. Through the ear-trumpet whispering is well heard on both sides.

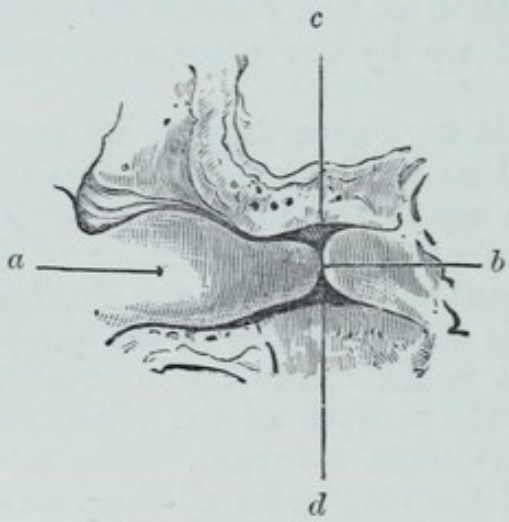

FIG. 215.

a, Cartilaginous meatus; *b*, Septum in the osseous section; *c*, *d*, Peripheral thickened part of the septum.

Supported by the results of this testing, I proceeded to divide the septum with the paracentesis needle. On the right ear the hearing improved 8 cm. for the acoumeter and 5 metres for speech; on the left the septum proved to be thicker and more resistant, and the improvement in hearing was less than on the right. After the operation, to prevent renewed adhesion, leaden pegs* were introduced and allowed to remain with few interruptions for several weeks. The result was: on the right, persistency of the opening by the formation of epidermis on the severed edges of the septum and permanent improvement in the hearing; on the left, moderate reaction at the seat of operation and, later, recurrence of the adhesion of the meatus.

In cicatricial closure of the cartilaginous meatus in the neighbourhood of the external orifice of the ear, especially when of great thickness, simple incision and the insertion of leaden pegs have proved insufficient, and it is in such cases that partial

* The introduction of correspondingly thick leaden tubes is preferable to that of leaden pegs, as the wearing of the former assists the hearing.

excision of the cicatrix is necessary before the introduction of tents (Ladreit de Lacharrière, Samuel Sexton).

Those partial adhesions in the external meatus are still to be mentioned which arise from the immediate contact of granulations, deprived of epithelium, lying opposite to each other. In a case of furunculosis of the meatus, observed by Engelmann (*A. f. O.* iv.), from the adhesion of two opposite granulations in the middle of the cartilaginous meatus, a cord-like bridge was formed across its lumen, which shrivelled up and broke in a few days. Bing (*Wiener med. Blätter*, 1879) observed a similar cord-like formation between the cartilaginous and osseous meatus, in the course of a secondary otitis externa, which was resolved after being incised and having the cut edges touched with liq. ferr. mur.

F. Foreign Bodies in the Ear.

Foreign bodies in the external meatus most frequently come under observation in the case of children, who insert into their ears such various things as peas, beans, pieces of paper, cherry-stones, coffee-beans, carob-stones, pebbles, glass beads, wooden balls, fruit-stones, sealing-wax, slate-pencil, metallic buttons, grains of shot, and so on. In adults, foreign bodies get into the meatus mostly by accident. According to my experience, the most common are pieces of camphor and of garlic, which have been put into the meatus to allay the pain of toothache or ear-ache, and objects used for picking the ear, especially the bone or porcelain heads of small lead pencils, less frequently rolls of paper, tooth-picks, matches, and ear-picks. Besides these, pellets of cotton-wool, leaves, and pieces of branches, grains of wheat and millet, oats and barley, etc., sometimes get into the meatus.

The symptoms which foreign bodies give rise to are by no means so serious as was at one time thought. Experience has taught that the consequences attributed to foreign bodies are, with few exceptions, due to the awkward attempts made at extraction by non-professional hands.

In a considerable number of cases which were examined for other disorders of hearing, I found the greatest variety of objects in the meatus, of which the patient had not the slightest idea, and which must have lain in the ear for a very long time. Once I found a slate-pencil 3 cm. long which, according to the patient, aged seventy years, had lain there for fifty years. As the patient found no inconvenience from it he allowed it to remain, till deafness, caused by a ceruminal plug, forced him to seek medical aid. Lucae removed with a ceruminal plug a cherry-stone which had been in the ear for forty years. A similar case in which the cherry-stone had remained in the ear for forty-two years is related by Zaufal (*Prag. med. Wochenschr.* 1881). One of my audience at a discourse on foreign bodies informed me that twenty-two years

before a slate-pencil had been put into his ear, but had fallen out again of its own accord; nevertheless, I found the pencil 1 cm. long fixed by cerumen in the middle of the inferior wall of his meatus. Reim has described a case in which a carious back-tooth lay in the meatus for forty years without causing any disturbance. Barr (*Glasg. Med. Journ.* vol. xv.) observed a case in which a pea lay for two years in the ear without causing pain or inflammation. Marchal (*Rev. med. franc. et étrang.* 1844) extracted a coral bead from the ear of an officer, fifty years of age, which had got into the ear when he was five years old. Numerous similar observations are to be found both in the earlier and in recent literature.

Sometimes, however, foreign bodies not only cause violent reflex phenomena in the course of the trigeminus and vagus nerves supplying the external meatus, but also occasion long-persistent general nervous attacks which only disappear after the extraction of the foreign body.

The literature of otology is rich in suitable examples, but only a few of the most interesting need be given. Arnold (cited by Moos) found in a girl that the cause of a persistent cough with frequent vomiting was the presence of two beans in the auditory meatuses. After these were removed she quite recovered. In a case of Toynbee's (*l. c.*), an obstinate cough ceased after the extraction of a sequestrum of bone. I have observed a similar case in my practice. Fabricius von Hilden (cited by v. Tröltsch) cured a girl suffering from epilepsy, a dry cough, anæsthesia of one half of the body, and atrophy of the left arm, by removing a glass bead which had lain in the meatus for eight years. Heydenreich (*A. f. A. u. O.* vi.) observed in one case in which a sunflower-seed had lain for nine years in the meatus, monthly attacks of hemicrania of the opposite side, with a feeling of stinging and heat in the affected ear, owing to irritation of a branch of the trigeminus. Maclagan (cited by Wilde) is said to have cured a case of epilepsy and deafness by removal of a foreign body from the ear.

On the whole, however, the worst consequences of foreign bodies in the ear are due to violent attempts at extraction. In this way not only is the meatus, and sometimes also the membrana tympani, injured, but the body lying in the cartilaginous section is driven into the osseous section, and either impacted at the narrowest part of it or after rupture of the membrane forced into the tympanic cavity.

Such attempts, usually attended with severe bleeding, give rise to traumatic otitis externa and sometimes also to purulent otitis media preceded by great dizziness, in consequence of which the auditory meatus becomes so contracted by swelling and granulations that the foreign body is lost to view and its removal is rendered very difficult or altogether impossible.

In the course of such inflammations the swelling in the meatus may recede spontaneously under suitable treatment, and the removal of the foreign body may be rendered easier. Very often, however, the imprisoned body maintains the inflammation and suppuration so long that it is either spontaneously discharged or extracted. When the lesion and inflammation are limited to the external meatus, cure is almost always effected, even after long continuance of the affection. But when the membrana tympani has been injured and suppuration of the middle ear has occurred, extensive destruction of the membrane with great deafness often remains. In one of my cases there existed, in addition, violent constant tinnitus, hyperæsthesia acoustica, and persistent headache.

That coarse attempts at extraction may also cause complications dangerous to life is proved by recorded cases of fatal termination in consequence of meningitis and abscess of the brain (Weinlechner, Fränkl, Wendt, Lucae, Zaufal).

At the examination of the meatus the first thing is to make sure of the presence of a foreign body, as it often happens in the case of children who say they have put something in the ear, that nothing can be discovered. In several such cases I have found the meatus injured by former coarse attempts at extraction. Pilcher (cited by Th. Barr) and Szokalski have even observed such blind attempts result fatally from meningitis, and especially from erosion of the carotid; Lucae once observed injury and caries of the inner wall of the tympanic cavity and complete deafness.

After having ascertained the presence of a foreign body, its size, form, consistency, and position have next to be made out. Frequently a glance is sufficient to recognize the body, but very often when it is lodged deeply or covered with effused blood or secretion it is more difficult to judge, as children are often unable to say what kind of body they put into the ear.

The method of removal of a foreign body depends upon its seat, consistency, size, and form, and upon the state in which the ear is found at the first examination; that is, whether no attempt has yet been made at extraction, or whether the meatus has not already been injured, inflamed, and swollen by violent attempts at removal.

The removal of foreign bodies from the ear is, with few exceptions very easy and simple, provided that no difficulties have been created by previous attempts. The latter occurrence is unfortunately so frequent that, according to my notes, scarcely 10 per cent. of the cases come untouched to the specialist. In the majority of cases the body has been forced inwards and impacted, with injury to the meatus and the membrana tympani, by the anxious relatives or by a medical man not acquainted with the subject.

The surest and best way of removing foreign bodies from the

ear is by the use of strong injections of tepid water by means of a large English syringe, to the end of which is attached a short india-rubber tube (Lucae) or the tube which is figured on p. 465. By pushing it up to the foreign body the strength of the injection is increased, and the body is so much the more quickly and surely expelled. Voltolini recommends for heavy bodies—for example, grains of shot—that the injections should be made with the patient lying on his back and the head inclined backwards, so that the body can the more easily be washed out of the sinus of the inferior wall of the meatus.

When foreign bodies have not been disturbed by any attempts at extraction, any other method than syringing is rarely required. Injections are contra-indicated when the foreign body is the head of a pencil and its cavity is directed outwards, for then by strong syringing the water would enter the cavity and force the body inwards, and cause it to be impacted; also, when the membrane is perforated, as then injections would cause dizziness, or the water would escape by the Eustachian tube (Zaufal).

Zaufal recommends injections, of oil instead of water when the body is one that would swell. But, leaving out of account the slight expulsive force of oil injections, we consider this precaution unnecessary, because, in cases in which the body cannot be got out after several strong water injections, its enlargement may be prevented by immediately pouring alcohol into the ear.

If the body is so firmly fixed in the meatus that it cannot be got out by strong injections, it is advisable to try the agglutinative method recommended by Loewenberg, before proceeding to operative measures. This consists in dipping the point of a medium-sized camel-hair brush into a concentrated solution of glue and inserting it into the meatus so as to bring it into contact with the foreign body, which has been previously dried. By the drying of the thick fluid the brush sticks so hard to the body that it can be drawn out when there is not too much resistance. This proceeding is very suitable for bodies liable to swell, wooden balls and cherry-stones, but only when there is no inflammatory secretion in the meatus, as that prevents the drying of the glue. For pebbles freshly-prepared cement is preferable to glue. For glass or steel beads with the opening turned outwards Lucae recommends a fine moist laminaria tent, to be pushed into the orifice of the bead, which may be removed at the end of half an hour, when the tent has expanded.

As to the surgical methods employed for removing foreign bodies from the ear when injections and the agglutinative method have been tried without effect, no rule can be given, as they must be regulated by a number of circumstances, which vary in each case. While the formation of the meatus, its width, and curvature, present many individual varieties, the situation is still further modified by the size, form, consistency, and position

of the foreign body, and by the presence of already-commencing inflammation, swelling, or contraction of the meatus. The proper proceeding to be adopted in each case is determined by a correct judgment of the circumstances, and, here more than elsewhere, the success of the operation depends on the acuteness of the surgeon.

In every case, also, in which previous attempts at extraction have failed, the surgeon must consider well whether it would be better to operate at once or to postpone operating till more favourable circumstances present themselves. If the chances are favourable, then it is better to operate at once, especially when the meatus has been injured by previous attempts at extraction, as in that case the inflammation so set up may take an unfavourable course, owing to the presence of the foreign body. Immediate operation is also advisable in cases in which a persistent cough or other troublesome symptoms are caused by the foreign body. It is better to wait patiently when there is no danger to be feared, or when, the body being situated deeply and there being coincident inflammatory contraction of the meatus, operative treatment is impossible. The application of cold by means of Leiter's apparatus and the insufflation of boracic powder or the instillation of spirituous solution of boracic acid are here recommended in order to allay the swelling in the meatus; and only when the body can be seen should further steps be taken to remove it.

If the body—for example, a pea, bean, a swollen carob-stone, or a wooden ball—be wedged in the narrowest part of the meatus, or seated in front or behind its isthmus, and by the great swelling pressed on all sides immovably against the walls of the meatus, extraction is best accomplished with a strong curved hook (Fig. 216) or with a firm needle with its point at right angles to its long axis (Fig. 217).

The instrument fixed on the handle (Fig. 100) is, in the case of bodies impacted not more deeply than the commencement of the osseous meatus, introduced so that it is pushed with its hook horizontal between the body and the upper wall of the meatus till it gets behind the foreign body. It is then turned so that its point is directed towards the body. The handle is next pressed upwards as far as possible, so that the point of the hook may penetrate deeply into the body in order to ensure its removal as safely as may be. When, however, the body is situated in the inner section of the osseous meatus it is better to insert the hook between the anterior inferior wall and the body, for by pushing it along the superior wall the posterior superior part of the membrana tympani might very easily be injured.

Instruments like corkscrews, recommended for the extraction of objects that may swell, are of little use, as they generally

straighten when the body is firmly wedged. For many cases, however, Elsberg's screw hook is recommended.

On the other hand, especially in the presence of traumatic inflammation, we must condemn the use of the galvano-cautery, recommended by Voltolini, for burning foreign bodies, as the inflammation is increased by the combined action of the radiating heat. According to my idea the galvano-cautery is only suited for such an object as an impacted cherry-stone, in which a hole might be burned for the introduction of an extraction-hook.

For deeply impacted bodies liable to swell, when the membrana tympani is perforated, injections through the Eustachian tube should be tried before proceeding to surgical means. In this way foreign bodies have been several times washed out from the ear (Deleau, Lucae).

Fig. 216.

Fig. 217.

The procedure is very different in the case of hard foreign bodies, such as pebbles, glass beads, slate-pencil, cherry-stones, etc. If the body is impacted in the cartilaginous section its removal is in most cases very easily effected, as by the insertion of a slightly-curved or hook-shaped probe (Burkhardt-Merian) behind, it is got out without any difficulty.

It would take too much time to enumerate all the instruments used for the removal of foreign bodies. I have found the fenestrated curette (Fig. 218) most useful, but under certain circumstances one can use with advantage Lister's blunt hook, Guye's fenestrated forceps, Tiemann's bullet-forceps, Sapolini's needle-shaped pointed pincers, Trautmann's lock forceps. The use of common forceps must be avoided, as they only wedge the foreign body more firmly (Burkhardt-Merian).

The removal of hard bodies situated in the narrowest part of the meatus or pushed behind the isthmus into the tympanic cavity is exceptionally difficult. This refers more particularly to irregular bodies such as pebbles, slate-pencil, glass beads, etc., which in certain positions easily pass the narrowest part of the meatus, while on the slightest touch the position so changes that the largest diameter lies across the axis of the meatus,

The removal of such bodies from the deeper sections of the meatus depends upon their size and position and on the relative capacities of the meatus. In some cases the extraction is very easily accomplished, as the body can be loosened by careful manipulation and its position changed. In the case of a boy who

had six pebbles in his ear, and in whom no previous attempts at extraction had been made, I got all of them out very easily by means of a slightly bent probe. In other cases again, all attempts at extraction completely fail; the extraction must then be postponed till the conditions become more favourable, or, when dangerous symptoms appear, the auricle and the posterior wall of the cartilaginous meatus must be detached, in order that the body may be extracted by that way. But this proceeding, which must only be undertaken when the body is impacted in the inner section of the meatus or in the tympanic cavity, may also fail, as has been proved by experiments made on the dead subject.

Fig. 218.

The separation of the auricle for the removal of deeply imprisoned bodies was recommended by Paul von Ægina (see Lincke, p. 586). In recent times the operation has been performed by Langenbeck and Moldenhauer. In Langenbeck's case, communicated by Israel (*Berl. med. W.* 1876), a button was removed from the tympanic cavity after partial separation of the posterior attachment of the auricle. Moldenhauer (*A. f. O.* xviii.), in the case of a boy three and a half years of age, removed a stone after complete separation of the auricle from its insertion posteriorly. After the separation of the posterior wall of the meatus as deeply as possible, he recommends the use of small obtuse-angled, smoothed and grooved levers, bent in various directions, for picking out the body. Schwartze contributes (in the same place) several cases in which the operation was successfully performed with union by first intention from the use of Lister's dressing.

In some few cases foreign bodies also reach the tympanic cavity from the naso-pharynx. Urbantschitsch (*Berl. klin. Wochenschr.* 1878), saw an oat-husk, which had stuck in the throat in chewing an ear of grain, wander through the tube into the tympanic cavity and into the external meatus. Schalle (ibid. 1878) communicated a case in which, during the application of the nasal douche by means of a vulcanite syringe, a piece broken off from the latter reached the tympanic cavity and there caused acute suppuration, and was removed by incision of the membrane.

Among foreign bodies in the ear are still to be mentioned insects which penetrate into the auditory meatus (the house-fly, fleas, bugs, beetles, especially the earwig, cockroaches, etc.). They often stick in the cerumen and die in the ear, without causing any sensation. In one case I found in the softened mass of a ceruminal plug a fly, a bug, and a beetle.

When, on the other hand, living insects reach the osseous meatus and the membrana tympani, they often cause violent noises and very painful sensations. A miller, whose membrana tympani was for a few minutes struck by the fore-feet of a cock-roach which had become fixed in the isthmus, affirmed that he was driven nearly mad. The insect, which was killed by pouring in oil, was driven still deeper in by attempts at extraction, and had to be removed in pieces by syringing.

Insects are most rapidly killed by pouring oil into the meatus; the ear should then be syringed with warm water.

Although the feeling as if there were an insect moving about in the ear sometimes depends only on irritation of the nerve in the meatus, I would still recommend, even in all those cases in which examination with the speculum gives a negative result, that the ear should be syringed. In a case in which the patient attributed an extremely troublesome and painful sensation in the ear to the presence of an insect, no sign of a foreign body could be discovered on the most minute examination, but, after syringing, a grey spot was noticed on the surface of the water, which proved to be an exceedingly small bug. In a man who complained for a short time of troublesome noises in the ear and gave as the cause of it that an insect had entered the meatus, Drs. J. Pollak and Hrubesch found in the water with which they had syringed the ear, a very small spider, which had remained undiscovered during the examination with the speculum.

The larvæ of the blue-bottle, which sometimes develop during summer in the ears of children with neglected, offensive discharges, must be mentioned. They adhere so firmly by their suckers, usually in depressions of the tympanic cavity, that they can be but seldom got out by syringing, and forceps scarcely ever succeed better. Such larvæ are most surely removed by dropping oil or glycerine mixed with some drops of petroleum, turpentine, or an ethereal oil into the ear. Some minutes after the instillation the larvæ leave their hiding-place and creep out of the meatus.

New-Formations in the Sound-Conducting Apparatus.

1. *Connective-tissue New-Formations.*

a. On the Auricle.

Of connective-tissue growths occurring on the auricle, the fibroma and the myxofibroma are most frequently observed (Knapp, *A. f. A. u. O.* v.; Agnew, Turnbull, *London Med. Congr.* 1881; Finley, *Philadelphia Med. Times*, ix.; Bürkner, *A. f. O.* xvii.). These tumours are developed principally on the lobe, usually in

consequence of its having been pierced, and occur with special frequency in negro women (Turnbull). Their growth is slow and painless. They often attain enormous size, which, as in cases of Agnew and Turnbull, sometimes surpasses in circumference that of the auricle.

In almost all the known cases the fibroma attacked both sides, but was of unequal size in the two ears. They appear as globular, semi-globular, or lobulated, partly movable tumours of more or less solid consistency. They consist in the most part of fibrous connective tissue, which in a few cases is also mixed with mucous tissue. Fibroma of the auricle is benignant, as after total extirpation it does not recur. In a case described by Agnew (*Transact. of the Am. Otolog. Soc.* 1878) a myxofibroma of the auricle, which originated in a traumatic cicatrix, always recurred after having been repeatedly removed.

Treatment consists in so extirpating the tumour that the cicatrix may not disfigure the auricle.

Angiomata are more rarely observed on the auricle. They appear as bluish-red, more or less pulsating tumours, from the size of a lentil to that of a walnut, situated at the entrance to the ear, on the lobe (Kipp), or on the posterior, or the anterior surface of the auricle. Sometimes several angiomata coexist on the auricle and its neighbourhood, as in a case of Turnbull's (*Lond. Med. Congr.* 1881), in which one tumour was seated near the orifice of the ear, and another behind and above the ear, connected with it by a vascular cord. To this class belongs a case described by Mussey (*Am. Journ. of the Med. Sciences,* 1853, cited by Virchow), in which one angioma arose in the concha, a second on the tragus, and a third on the lobe, and involved the lateral cervical region between the angle of the lower jaw and the mastoid process.

Angiomata either date from birth or arise, as in Kipp's case, after freezing of the auricle. Their growth is sometimes slow, sometimes very rapid. The dilated condition of the vessels extends sometimes to the meatus, the region of the ear, and the scalp. With a gradual growth angiomata cause scarcely any disturbance; with a rapid growth, on the other hand, throbbing pains are often experienced in the affected parts. By thinning of the skin on some parts of the tumour dangerous hæmorrhages may arise by rupture of the dilated vessels. In a case described by Jüngken (*Berl. klin. Wochenschr.* 1869) a fatal termination resulted from hæmorrhage, notwithstanding that the carotid had been tied some years before.

The treatment of angiomata depends on their size and extent. In small, flat angiomata it is recommended to insert several aseptic silk threads dipped in chloride of iron through the tumour, in order to coagulate its contents and cause it to shrivel up. This method is in every way preferable to brushing with

nitric acid and vaccination of the tumour. Growths with thin pedicles are best removed after the vessels have been partially atrophied by acupressure (Martin, *Gaz. d. Hôp.* 102). Chimani, in the case of a boy fifteen years of age, cured a considerable tumour after four weeks' treatment by repeated injections of liq. ferr. mur., and partial excision of the atrophied parts. Yet I must object to this method because, from the experience of eminent surgeons, it may lead to suppuration and ichorous ulceration of the tumour with subsequent blood-poisoning. By the rational use of the thermopuncture by means of Pacquelin's thermocautère, that termination will not only be avoided, but cure will be much more quickly and surely effected than by the other treatment. In small tumours the operation can be completed at one sitting by the repeated insertion of the thermocautère. In large vascular tumours, on the other hand, it is better to extend the operation and perform it at intervals of five or six days, because, if extensive scabs are formed, reactive inflammation with great secondary hæmorrhage may readily occur. If there are near the auricle large arteries leading to the angioma, they must be subcutaneously ligatured before the operation. Jüngken cured one case by electro-puncture. Ligature of the carotid is necessary only when relapses occur, in spite of the repeated application of the thermocautère. Dupuytren, Mussey, and Weinlechner have had cures from this operation.

The case of angioma of the auricle observed by me affected a youth nineteen years of age, in whom the growth had increased progressively since his birth, painlessly and without disturbing the hearing. On examination the left auricle (Fig. 219) is found considerably enlarged, of a bluish-red colour, and strongly pulsating. The hollows on its anterior surface are partly obliterated, and only the helix (*a*) and the antihelix (*b*) appear as enormous swellings. The posterior surface of the auricle is uneven and rough, and from this the growth extends 5 or 6 cm. behind and over the insertion of the auricle. On compression of that part there occurs a marked diminution in the auricle. Some hours before his admission, severe hæmorrhage commenced after the spontaneous rupture of a superficial vessel on the posterior surface of the auricle, which the patient stopped by compression and application of tinder.

Four weeks later, with a view to radical treatment of the angioma, he was admitted to Billroth's clinique. After subcutaneous ligature of the largely dilated posterior auricular artery, only the part of the tumour lying behind the ear which contained the largest blood-vessels leading to the angioma was cauterized by the rectangularly bent point of Pacquelin's cautery. On the fourth and eighth days after the operation there was severe hæmorrhage at the place of operation, which was stopped by ligature of the spouting vessels.

In its further course, after the scab had been thrown off, a granulating surface, the size of a half-crown, formed behind the ear, which gradually decreased. At the same time the circumference of the auricle had decreased by half, and the pulsation in it had quite ceased. By continued treatment with caustic ointment (argent. nitr. 2·0; axungia pur. 100·0; balsam Peruv. 5·0) complete cicatrization followed; and as there were still some distinctly pulsating arteries above the ear they were also ligatured subcutaneously. After ten weeks' attendance at the clinique

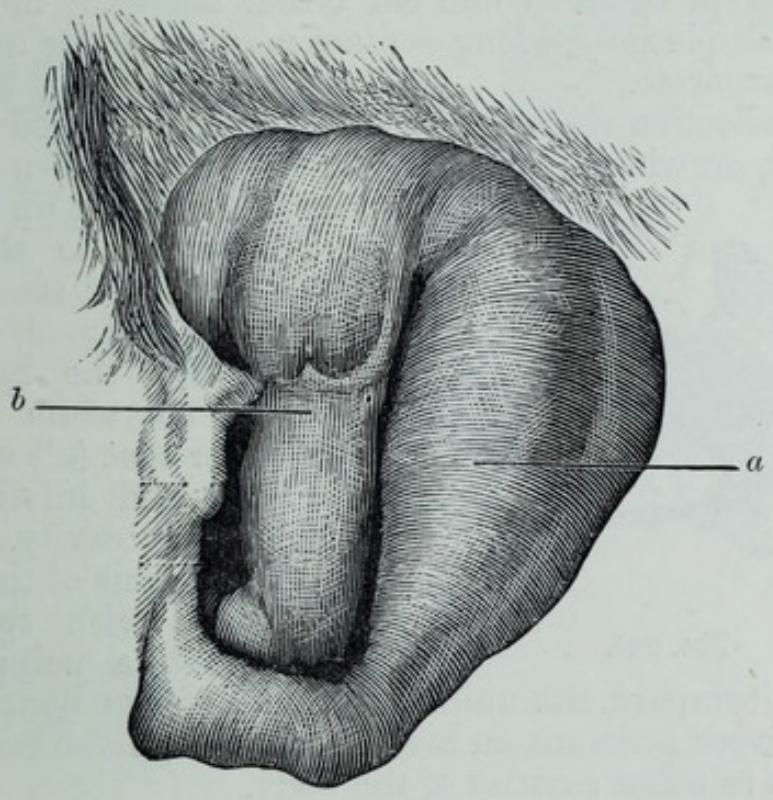

Fig. 219.

the patient was dismissed cured. The auricle had decreased in size two thirds, and was without pulsation; the place of operation was recognizable as a flat, cicatrized mass behind the ear.

b. In the External Meatus and in the Middle Ear.
Aural Polypi.

The pedunculated connective-tissue growths in the ear termed polypi, which are usually developed in the course of chronic suppuration of the middle ear, less frequently in primary inflammation of the external meatus, originate most frequently in the mucous membrane of the middle ear, more rarely in the external meatus and on the membrana tympani. The latter is, however, more frequently the site of polypi than was at one time supposed (p. 214).

The most frequent starting-points of polypi of the middle ear are the inner and superior walls of the tympanic cavity, the covering of the ossicula, more rarely the cells of the mastoid

process and the mucous membrane of the Eustachian tube. In the external meatus their roots spring oftenest from the posterior superior wall of the osseous section near the membrana tympani, or partly on the latter itself, rarely in the cartilaginous portion. On the membrana tympani the root of the polypus arises mostly from the superior posterior section and from Shrapnell's membrane. Very often simultaneous polypous growths are found in the middle ear, on the membrana tympani, and in the meatus.

Aural polypi occur in one ear either singly or multiple. In cases of multiple polypi long contact may cause the union of two originally separate.

In my collection there is the ear of a girl who died from sinus thrombosis, on which (Fig. 220) the one root (*a*) of a polypus (*b*) completely filling up the meatus and extending to the external orifice of the ear, starts from the membrana tympani, and is connected with the malleus and incus (*c*, *d*), while the second and longer root (*a'*) springs from the inner and inferior wall of the tympanic cavity. From the different origins of the two roots it may be with certainty assumed that a polypus of the membrana tympani has united with one of the tympanic cavity from continued pressure, an incident which has also been observed in growths in other cavities of the body.

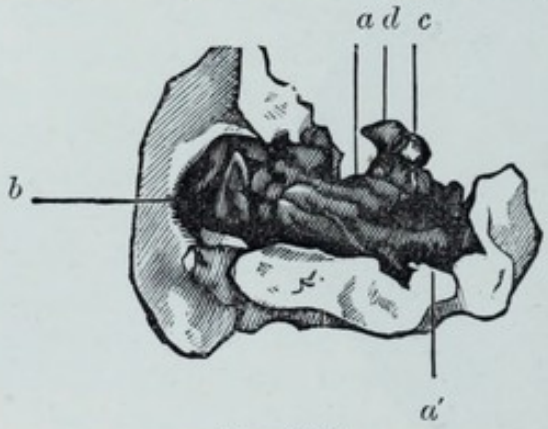

FIG. 220.

The size of aural polypi varies greatly. Most commonly they are about as big as a pea or a large date-kernel, but they may attain a size greater than the longitudinal diameter of the meatus (Fig. 222), so that the tumour projects beyond the external orifice of the ear. On the other hand, it has been already mentioned (p. 407) that microscopically small polypi may occur in the middle ear and on the membrana tympani.

The form of polypi is generally long and club-shaped, more rarely globular or knob-like (Fig. 223). Their surface is smooth or lobulated, glandular and raspberry-like. Frequently in the neighbourhood of the root of large and smooth polypi a number of papillary excrescences are found (Fig. 222). The growth has either a broad base or a thin, pedunculated root.

Structure of Aural Polypi.—When one examines histologically a number of aural polypi one finds on the whole two leading forms, round-celled polypi and fibromata.*

The round-celled polypus (mucous polypus, cellular polypus) consists of a hyaline, homogeneous, myxomatous stroma traversed

* The true myxoma described by Steudener is extremely rare.

by a more or less well-developed fibrous frame-work, in which are enclosed scattered or thickly-set round cells, and sometimes

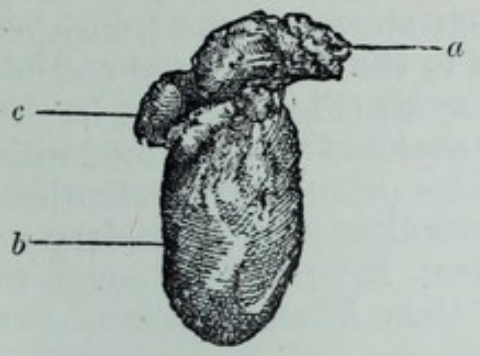

FIG. 221.—FIBROUS POLYPUS OF THE EXTERNAL MEATUS.

a, Root; *b*, Body of the polypus; *c*, Several hard excrescences growing near the root of the polypus. Radical extraction with Wilde's snare.

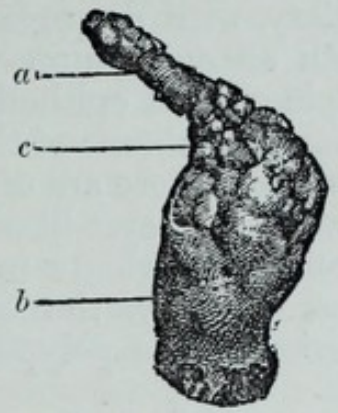

FIG. 222.—FIBROUS POLYPUS OF THE EXTERNAL MEATUS.

a, Root; *b*, Body of the polypus; *c*, Round excrescences of the size of hemp-seed growing on the posterior section of the polypus. Radical extraction by Wilde's snare.

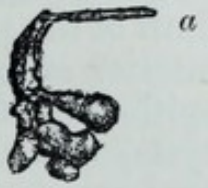

FIG. 223.—LOBULATED BRANCHED POLYPUS OF THE TYMPANIC CAVITY.

a, Root.

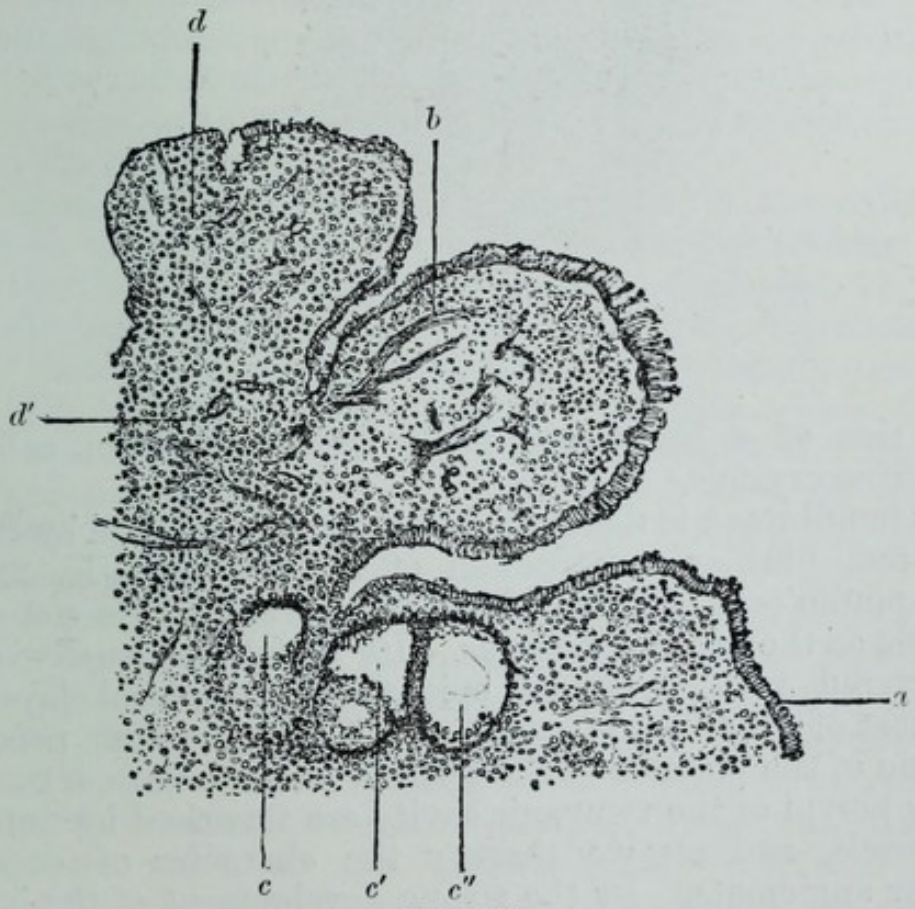

FIG. 224.

also a few spindle cells (Fig. 225). By transformation of the round cells into spindle-shaped cicatrix cells the soft polypus re-

ceives a hard fibrous character. This transformation proceeds usually irregularly from the root to the body of the polypus. The surface of these polypi is seldom smooth, but is commonly glandular, papillary, with deep glandular indentations (Fig. 224). It is covered with an epithelium, which shows all the transition stages from simple ciliated epithelium to the complicated epithelium of the mucous membrane of the mouth (Fig. 224 *a*). In the interior of the polypus there are often enclosed cavities lined with epithelium (*c*, *c*,′*c*,″) and cyst-like spaces (Steudener's retention-cysts) which probably originate in the adhesion of secondary or tertiary growths, whereby the original indentations come to occupy the interior of the polypus. Once I found such a cyst

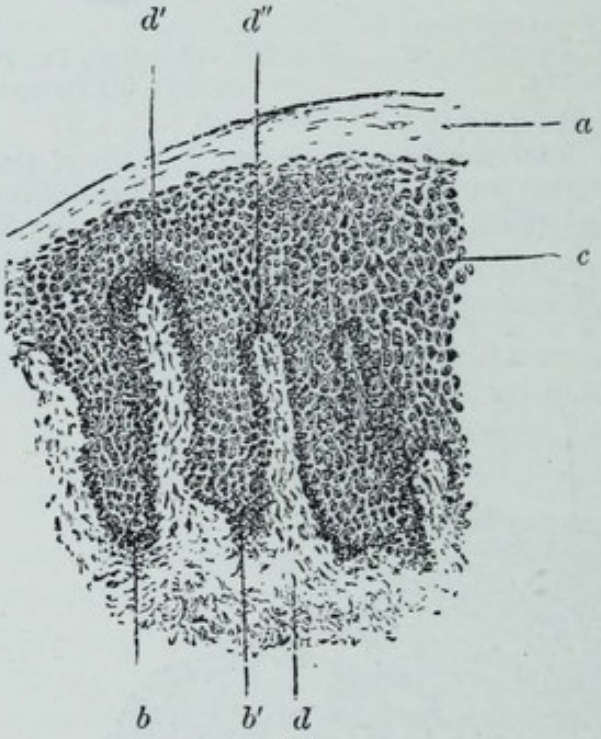

FIG. 225.

of the size of a hemp-seed filled with epithelium cells and cholesterine crystals.

The true fibroma is distinguished from these polypi by the fine long-fibred, fibrillar construction of the stroma (Fig. 225), in which spindle cells are also often interspersed. It is not so rich in vessels as the mucous polypus, Its surface is usually smooth and covered with pavement epithelium in several layers, the uppermost of which (*a*) is cornified. The epithelium penetrates the tissue of the polypus in the form of long cones (*b*, *b*′).

Many polypi of the tympanic cavity are traversed by numerous bloodvessels, and receive thereby the character of cavernous polypi or angiomata. By the strong development of the interstitial tissue the bloodvessels are so contracted in the progress of the case that they partly atrophy, giving to the polypus in longitudinal section a striated appearance.

In some few cases, as shown by the observations of Bezold, Cassells, and Hedinger, branching osseous deposits are found in the tissue of the polypus. As the ossification generally appears near the place of attachment of the polypus, it is probable that the osseous trabeculæ extend into the tissue of the polypus from the osseous floor of the meatus. Isolated ossification (Cassells) and calcification of aural polypi are rare.

The growth of the fibroma proceeds, as a rule, very slowly, that of the mucous polypus much more quickly. I observed one case in which two days after the removal of a polypus from the tympanic cavity, a second transparent mucous polypus 3 cm. long and 5 mm. thick sprang up. The development of polypi without suppuration in the ear is extremely rare; I have only once observed the development of a hard bluish-red tumour of the size of a pea, on the superior wall of the meatus near the membrana tympani, take place several years after exhaustion of suppuration of the middle ear.

Aural polypi may persist for a whole lifetime without injuring the health. Sometimes, however, by offering a mechanical obstacle to the escape of the secretion, they occasion pain on one side of the head, a feeling of pressure and heaviness in the affected side of the head, giddiness and tinnitus. In a case of Schwartze's (*A. f. O.* vol. i.), unilateral paresis and anæsthesia of the extremities of the affected side were cured by the extirpation of several aural polypi. Very often also by stagnation of the secretion, condensed cheesy masses are formed, which may by decomposition lead to caries of the bone and to fatal complications.

In regard to the termination of polypi, it has still to be mentioned that cure by spontaneous shrivelling seldom occurs, while, on the other hand, spontaneous discharge of polypi frequently happens (Toynbee, v. Tröltsch, Moos, Schwartze, and others). According to my observations, it is mostly the larger polypi with smooth surfaces and thin pedicles which are discharged spontaneously from the ear. The death and discharge of the polypus, according to my idea, are caused by its being accidentally rotated on its long axis, the bloodvessels entering the pedicle being thereby twisted.

The diagnosis of aural polypi is not difficult with some practice and with the use of the probe, by which the mobility of the tumour is ascertained. It is possible in but few cases to confound them with those malignant new-formations (see below) which grow out of the tympanic cavity in the form of polypi. The rapid recurrence after repeated removal of the growth, the simultaneous infiltration of the neighbouring lymphatic glands, especially the microscopic appearances, soon reveal the nature of the growth.

It is of great importance, especially in regard to operations, to determine the place of origin of the polypus, as the procedure

varies according as it springs from the meatus, the membrane, or the tympanic cavity. In the case of small or long and thin polypi we are often able, by feeling and moving the growth with the probe, to get a view of the place of origin of its root. When, however, the polypus entirely fills the meatus and only its outer end is visible, finding its root is much more difficult, as it depends on feeling it with the probe. I use a rectangularly curved blunt probe which, in order to measure the distance from the external orifice of the ear, is marked on the anterior end at every 5 mm. The examination is made as follows: the point of the probe is pushed between the polypus and the wall of the meatus, and after passing round the larger circumference of the growth, it is gradually advanced into the deeper parts. When the instrument, at a depth less than the distance of the external orifice of the ear from the membrana tympani, comes against an obstacle which prevents the circular motion of its point, it may be concluded that the obstacle is caused by the root of the polypus.

If at the examination of an aural polypus the point of the probe comes against an obstacle at a depth of 16 mm., it is almost certain that the root of the polypus arises in the external meatus; while in cases in which the obstacle is met with at a greater depth, it is uncertain whether the polypus springs from the meatus, the membrana tympani, or from the tympanic cavity, as sometimes at a depth of 18-19 mm. the point of the probe comes against an obstacle on the superior wall, which is caused by the projecting short process and the handle of the malleus. By the circular movements of the probe we sometimes can make out from the distance of the two places at which the point of the probe is impeded in its movement, what the width of the root of the polypus is. The greater this distance is, the broader the root of the polypus. If on examination the polypus is very movable, there is likely to be a narrow and thin pedicle. When it is not so movable, the root of the growth will be broader, and its separation will naturally be more difficult than that of the thin-pedicled polypus.

Another guide, but also not a sure one, for ascertaining the point of origin of a polypus, is the external appearance of the growth. The pale-red, pearl-grey polypi with smooth or moderately rough surface, spring usually from the meatus; while the sodden, red, vascular raspberry-shaped growths, with villiform, papillated surfaces, most frequently arise in the tympanic cavity. These peculiarities, however, are only of diagnostic value in connection with the result of the examination with the probe.

The prognosis is more favourable in the case of polypi of the meatus, the radical removal of which can be much more surely effected than in the case of polypi of the tympanic cavity, which frequently recur if their root is situated in the depressions of the tympanic cavity inaccessible to instruments. Circumstances of

unfavourable significance are: the repeated occurrence of symptoms of retention of pus, the formation of cheesy masses in the interior of the ear, simultaneous caries in the petrous bone, and the occurrence of pyæmic and cerebral phenomena.

Treatment.—(1.) *Operative Treatment.*

a. Extraction is indicated only in the case of those polypi whose origin in the external meatus has been ascertained without doubt. It is much surer and quicker than the other methods of operation by which the polypus is cut off or ligatured. In the latter case the destruction of the remaining fibrous roots requires a space of several weeks or months, while by extraction the root

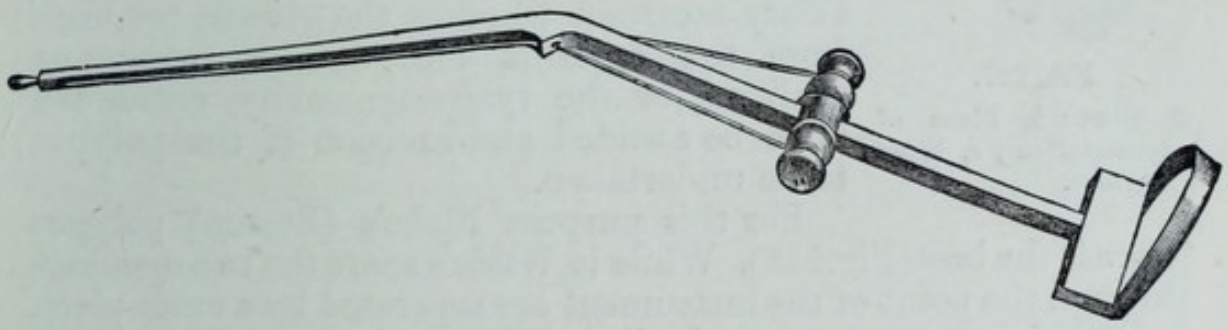

Fig. 226.

is removed with the growth, and cure follows after a few days. Moreover, after extraction recurrences are not so often observed as after excision of the polypus with subsequent cauterization of the root.

Extraction of a polypus of the meatus is effected either by means of dressing-forceps, or better by Wilde's snare (Fig. 226), the latter being pushed over the polypus near the root, and only so far tightened as is necessary to catch the polypus securely. A moderate pull generally suffices to remove the growth completely. This procedure is to be preferred to extraction by dressing-forceps, as the body of the polypus very often consists of soft, young connective tissue, while the root is of a hard nature. If, in such cases, the polypus is caught with the forceps, only some portions of it would be extracted, while by the use of the snare the hard root is constricted and the whole polypus is removed. In the case of polypi soft throughout, extraction with the snare is seldom complete.

b. Ligature.—When a fibrous polypus is so closely connected with the osseous wall that considerable resistance is shown on strong traction, it is proper to use Wilde's snare to constrict the polypus, the instrument after its loop is tightened being turned on its long axis till a greater resistance is felt. Then the wire fastened to the cross-bar is cut through with scissors, and the instrument removed from the ear. By the twisted wire loop left in the ear the passage of blood to the polypus is stopped, thereby

causing its rapid death and discharge. This sometimes follows in the first twenty-four hours, and sometimes not for several days, while it is frequently only the peripheral, constricted part of the polypus that is discharged. Only in some few cases have I observed the simultaneous discharge of the root from the underlying tissues (Fig. 227). If the polypus be not removed at the end of a few days by the use of this wire ligature, by catching the ends of the ligature with the dressing-forceps we may now try to extract the polypus; or in case the obstacle still proves too great, we may increase the twisting of the snare.

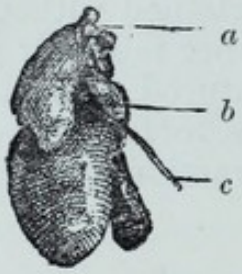

Fig. 227.

a, Root; *b*, Place of constriction; *c*, Wire ligature.

c. Excision.—In the case of large polypi, with roots so deep that we cannot with certainty ascertain whether the growth proceeds from the external meatus, the membrana tympani, or the tympanic cavity, extraction is to be avoided and excision of the polypus to be undertaken.

For this purpose Blake's (Boston) polypus snare is the best (Fig. 228). While in Wilde's snare the two openings through the point of the instrument are separated by a cross-piece, in Blake's instrument there is a movable metal cannula into which

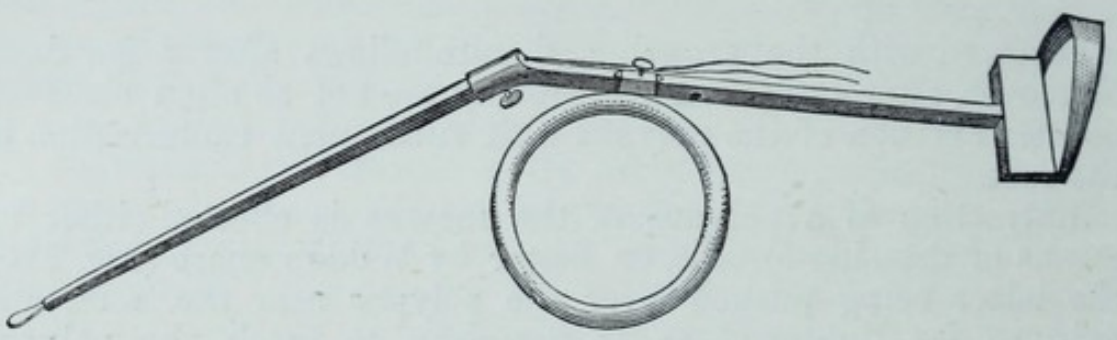

Fig. 228.

the wire loop can be completely withdrawn. Hartmann makes the interior end of the cannula in the form of a narrow compressed slit. Both instruments are to be preferred to Wilde's original one when it is a question of excising fibrous polypi, as the complete severance of the polypus is often prevented by the cross-piece, while, by the withdrawal of the wire into a cannula, the polypus must be cut through; for true polypi of the auditory meatus, on the other hand, Wilde's instrument with the cross-piece must always be used to grasp the growth. In operating with Wilde's instrument it is essential that good wire should be used, because, trifling as it may seem, the success of the operation depends in a great measure upon it.

An annealled steel wire 0·1 mm. in thickness, or a thin platinum wire, is the best for this purpose. A. H. Buck, of New York, recommends malleable steel wire, No. 37. Thin catgut has not been much used instead of wire, on account of its being too

pliable and yielding. The oval form of loop is to be preferred to the round, as the former can be more easily slipped over the polypus. For polypi which spring from the posterior superior wall of the meatus, or from the tympanic cavity, the loop must always be curved downwards before being introduced, so that the anterior section of the loop may glide inwards along the anterior inferior wall of the meatus and the posterior section along the superior wall. In order to pass the loop more easily over the growth, it is well to push the instrument forwards, not directly, but with moderate rotatory movements.

When the snare has been introduced so far that it can be seen from the mark on the instrument that it is near the membrana tympani, the polypus is then cut off by gradually closing the instrument, and removed from the ear with the instrument or by syringing. There is, as a rule, very little bleeding, which may be stopped by repeated injections of cold water. If the bleeding, however, be profuse, the meatus should be stopped with cotton-wool dipped in alum-powder, or with styptic cotton-wool, and the patient should push the plug in with his finger.

After removal of the bulk of the polypus we are in a better position to ascertain whether there are several polypi growing in the interior, how large the remainder of the polypus is, and the seat of the root by probing.

If the growth do not spring from the meatus it must be ascertained whether it proceed from the membrana tympani or from the tympanic cavity. The differential diagnosis is in many cases very difficult.

With large perforations in the membrana tympani, when the gap is not filled up by the polypus, the latter can be traced to the tympanic cavity by careful probing or by the eye alone. When, however, the growth is chiefly embraced by the edges of the perforation, and even, as I have several times observed, literally constricted at the opening, or when with multiple polypi of the tympanic cavity growing out into the meatus through a perforation, polypous growths proceed also from the remnant of the membrane, it is extremely difficult to distinguish between the polypi of the membrane and those of the tympanic cavity. In several cases observed by me, in which the growth appeared seated on the membrane like a fungus, a perforation was seen on the membrane, after the projecting mass had been destroyed, through which the root of the growth could be traced to the inner wall of the tympanic cavity. Similar cases have also been observed by v. Tröltsch. In a preparation in my collection, in which a small compressed tongue-like growth appears to spring from Shrapnell's membrane above the short process, on nearer examination it is seen that the root proceeds from the neck of the malleus and projects through a gap in Shrapnell's membrane into the meatus.

For the removal of intra-tympanic polypi Blake's wire snare with a thinly-made cannula is best adapted. If the perforation is small and the membrane bulged out by the polypus, the former must be widened by an incision in order to allow the instrument to enter the tympanic cavity. The most favourable results are achieved with growths which spring from the inner wall of the tympanic cavity.

Notwithstanding the excellence of the operative treatment with the snare, there are many disadvantages connected with it which must be taken into consideration, especially in operating on polypi of the meatus. The principal disadvantage is that when the loop is used not for evulsion, but for excision of the polypus, the operation is rarely radical, for, with few exceptions, a large portion of the polypus remains behind. This is easily understood when one considers that the loop introduced cannot

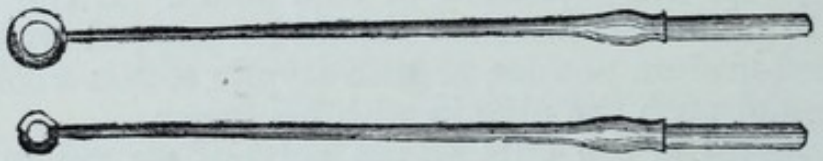

Fig. 229.

be so firmly pressed against the subjacent tissue as to catch the polypus close to its place of attachment.

For such cases I have introduced a method of operating which has proved of excellent service in a great number of cases. It consists in excising the growths by means of a small annular knife, constructed on the same principle as Meyer's instrument for the removal of adenoid vegetations in the naso-pharynx.

The instrument, made of steel, which is here illustrated of its full size (Fig. 229), is 7 cm. long, and carries on its anterior end a concavo-convex ring, whose inner margin is very sharp. The diameter of the ring amounts to 3-3½ mm. for large growths, for small granulations and for very narrow meatuses 1½-2 mm. The instrument is attached to the handle (Fig. 100, p. 286) with a knee-like bend by means of a screw, by which the sharp side of the ring can be turned in any direction, according as the growth is situated on the walls of the meatus or of the tympanic cavity. As the inner section of the anterior inferior wall of the meatus is highly concave in the neighbourhood of the membrana tympani, and growths situated there cannot be reached by the straight annular knife, for operations in that part of the meatus I bend the ring with its convex cutting surface at an obtuse angle to the long axis of the instrument.

The manipulation of the knife is regulated according to the size of the growth. With small, round polypi and granulations in the meatus the instrument is pushed forward to the growth, and its convex surface pressed against the latter till a firm base

is felt. The instrument is then quickly withdrawn, cutting the growth from its base and bringing it with it on the concave surface of the ring, and so removing it from the meatus.

This procedure is suitable not only for polypi and granulations whose size does not exceed the diameter of the annular knife, but also for larger growths. In a considerable number of cases operated upon in my clinique and private practice I have succeeded in completely removing with the annular knife large polypi which filled up the lumen of the meatus, and indeed several times, when only a part of them could be removed by Wilde's snare on account of the narrowness of the meatus in proportion to the diameter of the polypus. The knife is pushed between the polypus and the wall of the meatus to the place whence it arises, then pressed on the root, which is separated by the quick withdrawal of the instrument. For polypi with a very broad base the annular knife cannot be used.

In operating on polypi which, in the neighbourhood of the membrana tympani, are situated on the superior wall of the meatus, it must first be ascertained by carefully feeling with the probe whether the growth is soft and can be easily moved in all directions, or whether a resisting body can be felt in it by direct or lateral pressure, in which case it may with probability be assumed to be the handle of the malleus embedded in granulation tissue (Borberg). Also for smaller polypi springing from the posterior or inferior wall of the tympanic cavity, the annular knife can be used with advantage.

d. The *separation* of the growth *by pressure* is effected by a small, roundish, blunt or sharp scoop (Abel) which is pushed near to the root, and by a quick pressure acting on the polypus from behind, the root is separated from the underlying tissue. This method, however, is only suitable for the removal of thin-pedicled polypi of the meatus not firmly fixed to the subjacent tissue, and in nowise for the removal of large polypi of the membrana tympani and the tympanic cavity. Only for growths from the promontory, which are reached through large apertures in the membrana tympani, can the sharp scoop invented by Oscar Wolf be used with advantage. Thin-pedicled polypi are often separated by brisk syringing and washed out of the ear.

e. Bruising or *crushing* has in the case of large polypi been superseded by the use of the snare. This method, however, can be used in some cases with advantage, as when large portions of polypi remain on the membrana tympani and on the inner wall of the tympanic cavity, which cannot be removed either by the snare, the annular knife, or the sharp scoop, but which are too considerable to be removed by cauterization or by the galvano-cautery on account of the time it would take.

For this manipulation we use small dressing-forceps with a knee-like bend, deeply grooved on their inner surface, the anterior

end being either quite straight or, for growths on the inner section of the anterior inferior wall of the meatus or at the bottom of the tympanic cavity, bent at the edge. The forceps are introduced up to the growths with the blades closed; they are then opened and pushed so far forward that part of the growth enters the grooved scoop of the instrument, which is then quickly closed, crushing the tissue lying between the blades.

When the bleeding is not too great, this procedure may be repeated several times at one sitting, and the crushing must be continued till nothing can be caught with the forceps, there remaining only a flat part of the growth which can be destroyed by cauterization.

f. Galvano-caustic Treatment. The galvano-cautery, according to Jacoby and Schwartze, is chiefly suited for the removal of those fibrous polypi whose separation cannot be effected either

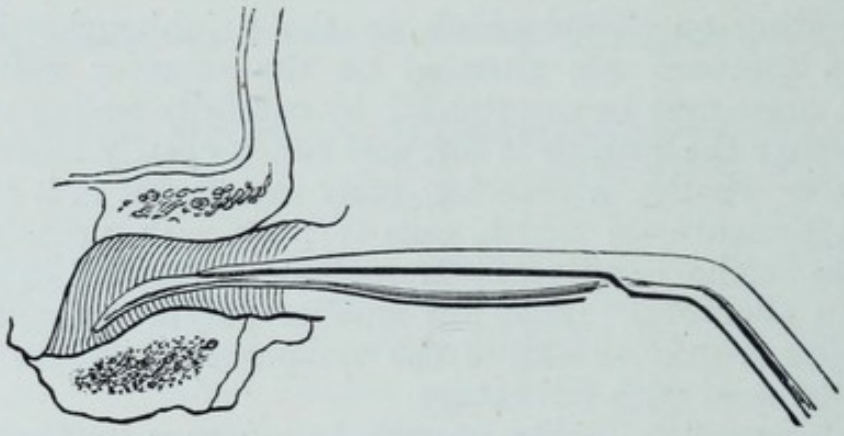

FIG. 230.

with the cold snare or with the knife. But cauterization of remnants of polypi and of small granulations by the galvano-cautery presents many advantages over the caustic remedies to be mentioned later.

The most important advantage consists in the rapid and thorough destruction of the growth, and also in the fact that violent pain is felt only at the moment of action of the red-hot galvano-cautery on the growth, ceasing immediately after the cauterization. Further, on contrasting cauterization by galvanism with the action of strong caustics, it has been observed that with the former there is almost no inflammatory reaction in the meatus, and, according to Jacoby, the tendency of the cauterized growths to shrivel is much less after this than after other methods of cauterization.

For this purpose a simple pointed cautery is sufficient in most cases; but for large growths, or those extending over a surface, flat cauteries rounded in front, and which can be moved in all directions, are to be preferred.

Precautions in the Use of the Galvano-Cautery.—The circuit is

only to be closed when the cautery is in contact with the growth (Jacoby), and after the occurrence of a loud hissing noise the circuit must be again opened in a few seconds. As the cauterization evolves a very warm vapour which affects the walls of the meatus, it is advisable, immediately after every application, to disperse the vapour by blowing into the ear. Before repeating the cauterization the cautery must be thoroughly heated in order to destroy any substance that may be sticking to it. Cauterization may be repeated four to five times at one sitting.

FIG. 231.—HANDLE OF GALVANO-CAUTERY (½ SIZE).

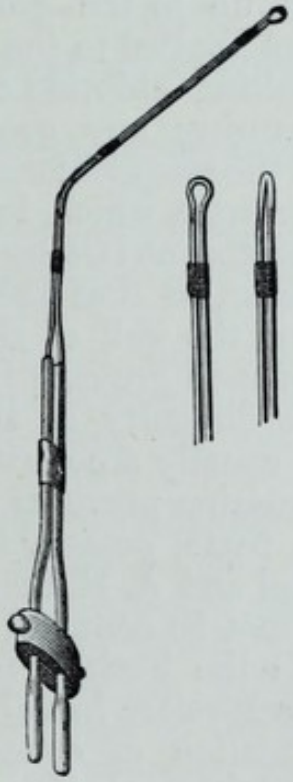

FIG. 232.—GALVANO-CAUTERY (½ SIZE).

Since the brilliant results which I have attained by the alcoholic treatment of polypi and granulations in the ear, I use the galvano-cautery only in a very few cases.

(2.) *Treatment by Medicated Applications.*

a. Destruction of Polypi by Caustics.—One of the caustics most used for the destruction of polypous *débris* and granulations is solid nitrate of silver, melted in the form of a small ball, the size of a hemp-seed, on the point of an angularly-curved steel or silver wire. Cauterization with nitrate of silver without exception occasions pain lasting for hours and even a whole day, and, moreover, has the disadvantage of forming only a superficial crust, and very often before that is cast off just as much new-tissue grows as was destroyed by the caustic.

Chloride of iron acts much more favourably, rarely gives rise to violent pain, penetrates much deeper into the tissue even in hard fibrous growths, and brings about mortification and separation of the dead parts much more quickly. Chloride of iron is most simply applied by means of a probe dipped in the fluid, or by means of a small brush or ball of wadding. The cauterization is repeated when the crust is loosened by syringing. For hard growths I have of late frequently used the crystals of chloride of iron. In order to localize its action and to protect the normal parts of the walls of the meatus, a small piece of it is taken hold of with the forceps and rapidly introduced up to the growth and fastened there by a plug of cotton-wool applied to the neighbouring wall of the meatus. The rapidly melting chloride of iron penetrates into the tissue, and without causing any great pain forms with it a crust. The crystals of the sesquichloride of iron are particularly recommended for hard growths which, involving the entire circumference of the osseous meatus, at last by coming into contact fill up the lumen of the meatus, so that the probe cannot penetrate between the growth and the wall of the meatus or at any other place. The removal of such growths by operative treatment is accomplished with great difficulty, as the separation of the masses from the meatus is usually accompanied with profuse bleeding, which after the first incision prevents the completion of the operation.

Vienna paste, potassa fusa, and nitric acid as recommended by Trampel and A. H. Buck, have been rightly discarded, as their action cannot be confined to the polypus, and by the melting of the caustic the healthy parts of the meatus may be destroyed, leading, as Menière has observed, to caries of the osseous meatus. The application of concentrated solutions of chromic acid in small quantities to the remains of polypi has recently been greatly praised.

b. Alcoholic Treatment.—Rectified spirit of wine has in a great number of cases proved of excellent service for the removal of aural polypi and granulations. Before it is applied the ear must be carefully cleansed and dried by the insertion of little bits of cotton-wool. The warm spirit is then poured into the meatus and allowed to remain in the ear for at least from fifteen to thirty minutes. The drops are to be repeated two or three times a day, and the treatment to be continued without interruption till the polypus has completely shrivelled and disappeared. The duration of treatment varies from two to six weeks and longer.

By this treatment not only are remnants of polypi and granulations destroyed, but also large fibrous polypi filling up the meatus (confirmed in three cases by Morpurgo). A diminution of the growth is often observed for the first time after treatment for two or three weeks.

The advantages of alcohol over the already-mentioned caustics are that its action is more sure and constant, that it forms no insoluble precipitate with the secretion, and therefore causes no injurious after-effects. The alcoholic treatment may be conducted by every general practitioner, and from my experience I am convinced that in the majority of cases operative removal and the use of caustics may be dispensed with.

Alcoholic treatment is specially suited for:

1. Removing the remains of polypi in the external meatus and on the membrana tympani.
2. The treatment of intra-tympanic polypi, which, as we have seen, can seldom be entirely removed by operative means, and frequently recur.
3. Multiple granulations in the external meatus and on the membrana tympani.
4. Diffuse, excessive proliferation of the mucous membrane of the middle ear.
5. Cases in which, on account of mechanical obstruction in the meatus, the removal of polypi cannot be effected with instruments.
6. Avoiding operations in persons afraid of them, and in children in whom surgical treatment meets with great difficulties, and very often can only be undertaken with the aid of anæsthetics.

Among the rare growths in the sound-conducting apparatus must be mentioned enchondroma, originating in the cartilage of the meatus (Launay, *Gaz. des Hôp.* 1861); osteoma in the mastoid process, observed by me in one case, in which it projected with sharply-defined edges beyond the surface of the mastoid process to the size of half a walnut, causing at the same time closure of the meatus by bulging out its posterior wall; cylindroma or myxoma cartilagineum of the cartilaginous meatus (Meckel, von Hemsbach, cited by Schwartze); lipoma on the auricle, and pedunculated warts on the superior wall of the meatus with normal cutaneous covering (v. Tröltsch and the author).

Among these we must also class sarcomata, known as abnormal connective-tissue tumours, which in the majority of cases present the malignant characters of the carcinoma. Roudot (*Gaz. méd. de Paris*, 1875) observed a sarcoma the size of a walnut occupying the lobe and tragus, which developed within twenty years, and was removed by total extirpation. An interesting case of round-celled sarcoma of the middle ear has been described by Hartmann (*Z. f. O.* viii.). In a boy three and a half years of age there developed, within fourteen days after an acute suppuration of the middle ear, polypous growths in the tympanic cavity, which always recurred, notwithstanding repeated removals and galvano-cauterization. Gradually there formed a

diffuse tumour in the region of the ear, the elements of which proved after incision to be those of an ulcerating round-celled sarcoma. Death occurred five months later from marasmus. Post-mortem examination revealed perforation of the bulbous sarcomatous mass towards the cranial cavity, with compression of the temporal lobe. A case of spindle-celled sarcoma growing from the floor of the meatus and simulating a polypus has been described by Robertson (*Transact. of the Am. Otolog. Society*, 1870).

Of mixed sarcomata, the osteosarcoma, springing from the middle ear, has been observed in four cases by Wilde (*l. c.*), Wichart, and Böke (*W. med. Halle*, 1863).

Some pathological formations in the sound-conducting apparatus, not strictly classed with the new formations, might find a place here; for example, the so-called retention-tumour; the milium in the external meatus; atheroma and cysts on the auricle. The latter, seated on the posterior surface of the auricle (Gruber), may reach an enormous size. In a case observed by me the tumour was twice the size of the auricle, and after being opened discharged a yellowish fluid mixed with gritty particles. After partial excision of the follicle and of the cutaneous covering, cicatrization was brought about by repeated cauterization of the wound with solution of nitrate of silver.

There must further be mentioned partial ossification of the auricle, observed by Gudden and Bochdalek; ossification of the inferior cartilaginous wall of the meatus, observed by Jos. Pollak; calcification and the deposition of urates in the cartilage of the ear of gouty patients (Garrod); and the syphilitic gummatous tumour on the mastoid process, first described by Jos. Pollak in the case of a man thirty-nine years of age, who was ultimately cured (*Allg. Wien. med. Ztg.* 1881).

2. *Epithelial New-formations.*

The starting-point of the epithelial new-formation is most frequently the auricle and the external meatus, less frequently the tympanic cavity and the mastoid process. On the auricle the epithelioma is usually developed in the cutis on the upper part of the helix, and spreads from there at first gradually, then very quickly over the greater part of the auricle, the cartilage of which is ulcerated in various places and perforated. In one of my cases, in which cancer commenced at the posterior point of attachment of the auricle, the inner section of the concha was so completely destroyed that the auricle was suspended above and below by two narrow strips of skin.

If an epithelioma of the auricle is not excised at the proper time it spreads, involving the side of the head and neck and the external auditory meatus, then the middle ear, the rest of the bones of the head and the cranial cavity. The destruction of the

cranium, extending up to a fatal termination, reaches such an extent that not only is the middle ear exposed, but also deeper-lying parts of the skull.

In a case communicated by Delstanche *fils* (*A. f. O.* xv.), and which I had an opportunity of seeing, the growth proceeding from the inner surface of the right tragus extended so far that the tympanic cavity and the Eustachian tube, the posterior part of the frontal bone, the wing of the sphenoid bone, and the posterior orbital wall were destroyed and exposed. Symptoms accompanying this destruction were facial paralysis, exophthalmos, amaurosis, loss of taste and smell, and paralysis of the right palatine muscles. Death resulted from the extension of the cancer to the dura mater.

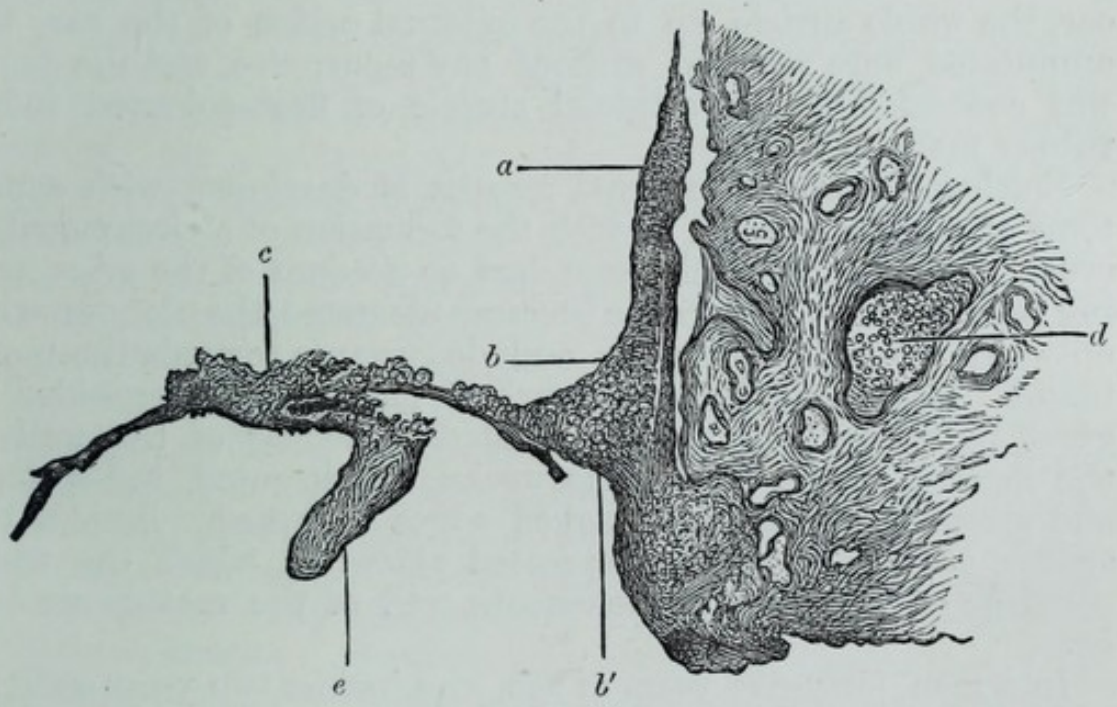

FIG. 233.

In the case of a woman, sixty-four years of age, observed by me, in which an epithelioma of the right auricle involved the external meatus, the cartilage of the latter and its osseous wall were in places laid bare, and death resulted from exhaustion. On microscopic examination I found the greater part of the lining membrane of the meatus (Fig. 233, *a*) infiltrated with cancer-cells. These cells were more especially accumulated at the place where the meatus adjoined the membrana tympani (*b*); smaller infiltrations were found in the cutis of the membrana tympani (*c*) and on its mucous membrane. Rupture of the cancerous masses occurred only at a small circumscribed spot on the membrane (*b'*), even without any extension of the process to the tympanic cavity being visible. A point of interest was the occurrence of numerous cancer-cells in the osseous spaces of the temporal bone (*d*) distant from the primary deposit, a circumstance which explains the

fruitlessness of operative treatment in many apparently local and circumscribed growths.

The treatment of epithelioma of the auricle depends on its extent. If it be confined to a circumscribed part of the cutis, treatment is limited to destruction with lunar caustic or zinc paste, or to scraping it off with the sharp spoon, and subsequent application of fuming nitric acid. For a case of very extensive ulceration partial or complete amputation of the auricle is recommended. The latter operation is always determined upon before the growth has reached the external orifice of the ear, as then it is of no avail, on account of invasion of the neighbouring parts and of the lymphatic glands by the cancer-cells having already commenced. In one of my cases in which, on account of carcinomatous destruction of the external half of the cartilage of the ear, the whole auricle, up to the external orifice of the ear, was amputated, cure resulted without any recurrence, and the defect was concealed by an artificial auricle of flesh-coloured india-rubber made in Paris.

Epithelioma of the external meatus is developed with symptoms of a moist eczema, or with the formation of a circumscribed crust, which is frequently scratched on account of the great itching till ultimately the surface becomes ulcerated, the ulcer growing outwards towards the auricle and downwards towards the membrane. Sometimes the appearance of the growth is preceded by great pulsating pains and a limited loosening of the wall of the meatus, where, after some weeks, an ulcerated, red-spotted, and secreting surface with jagged edges is formed. Besides the spongy growths there are depressed places on which the white cartilage of the ear and the osseous wall of the meatus are laid bare.

In a man, forty-five years of age, who had for two years suffered from deafness, evidently caused by eczema of the meatus, within four months growths at the orifice of the ear had developed, which for eight days had been accompanied with violent pains. Examination showed that there was a soft, glandular, readily bleeding epithelioma at the entrance to the ear; the meatus and the membrana tympani were discharging profusely. After scooping out the growths, and painting the walls of the meatus with zinc ointment, there was a considerable improvement in the hearing. Two years later I found a glandular tumour the size of a small nut ulcerating towards the orifice of the ear, and a second one of the same size behind the auricle on the lower part of the mastoid process. The membrana tympani was perforated, and the cancerous mass penetrated into the tympanic cavity. In a woman, seventy years of age, in whom the growth arose in the middle of the osseous meatus in the form of a node, its ulcerating surface spread over the entire circumference of the meatus and over the membrana tympani, which had been perforated some

weeks previously. After six months' duration facial paralysis set in, followed several weeks later by death with meningeal symptoms. A case with a similar course has been described by Brunner (*A. f. O.* v.). Hedinger (*Krankenbericht*, 1877-79) cured a man, fifty-four years of age, of an epithelioma at the entrance to the ear by scraping it out with a sharp spoon.

According to the observations of Schwartze, Lucae, Kidd, and others, epitheliomata proceeding from the middle ear arise either during an existing suppuration of the middle ear or after exhaustion of carious processes in the temporal bone. For this reason the growths protruding through the perforation of the membrana tympani are at first taken for granulations or polypi, till their rapid recurrence after repeated removal and their microscopic appearances reveal their malignant nature.

A particularly interesting case of this kind has been described by Schwartze (*A. f. O.* ix.). A man, fifty-five years of age, had suffered from scarlatinal suppuration of the left middle ear since childhood. As a consequence caries of the temporal bone occurred, which rendered it necessary to open and scrape out the mastoid process. A short time after the operation granulations sprang from the interior of the meatus and a hard tumour at the same time developed in front of the ear, reaching the size of a pigeon's egg. Subsequently there occurred cancerous infiltration of the neighbouring lymphatic glands and of the parotid, painful ulceration and rapid disintegration of the tumour, with destruction of the auricle, facial paralysis, profuse bleeding, and fatal termination in a year. Post-mortem examination revealed an extensive epithelioma of the temporal bone with destruction of the tympanic cavity, the pars petrosa, and the inferior half of the pars squamosa. Besides, the cancerous destruction had seized upon the neighbouring osseous parts of the head and the transverse sinus, in which there was formed a thrombus reaching to the jugular vein.

Next comes an observation of Lucae's (*A. f. O.* xv.), concerning a man, thirty-seven years of age, who had suffered from otorrhœa since childhood, in whom the polypus-like growths, persistently recurring after removal, were recognised as epitheliomata. Two months after a thorough application of the sharp scoop even to the carious tympanic cavity, two ulcerating tumours formed in front of and behind the ear, through the openings in which water injected into the meatus escaped. Persistent burning pain, hectic fever, and marasmus brought about a fatal termination ten months after the first observation. Post-mortem appearances: ulcerating epithelioma of the right temporal bone, perforation of the petrous bone towards the cranial cavity with carcinoma of the dura mater, purulent meningitis, and abscess of the brain. The appearance of an epithelioma, observed by me, evidently

proceeding from the middle ear, and which invaded the cochlea, will be found described among the growths of the labyrinth.

Toynbee described five cases of cancer of the middle ear; yet, from the report, it is doubtful whether these growths proceeded from the middle ear or from other parts of the temporal bone.

Epitheliomata of the mastoid process have been described by Wilde and Roudot (*Ann. des Malad. de l'Oreille*, etc., 1875). In both cases there was a painful ulcerating tumour over the mastoid process, which extended to the external meatus, and led to facial paralysis by erosion of the Fallopian canal.

Sometimes malignant growths from neighbouring organs invade the temporal bone. Knapp (*Z. f. O.* xi.) speaks of a case of chondro-sarcoma of the parotid, which invaded the tympanic cavity notwithstanding early extirpation, and formed an immense growth involving the whole sound-conducting apparatus. After repeated removal of the masses in the meatus the growth always recurred, terminating fatally after six years' duration. Pomeroy (*Am. Journ. of Otol.* iii.) observed a case of intracranial myxo-sarcoma, which, proceeding from the middle and posterior cranial fossæ, protruded, after destruction of the petrous bone, into the tympanic cavity and the external meatus, and within a short time ended fatally with symptoms of convergent strabismus, oculo-motor and facial paralyses, convulsions, and coma. In several cases of malignant growths on the ear briefly recorded by Toynbee and Wilde, it appears doubtful whether they were not secondary to similar disease in the neighbourhood of the temporal bone. According to Schwartze, secondary growths on the ear most frequently originate in disease of the parotid.

The extension of epithelial cancer of the tongue and of the upper jaw to the Eustachian tube has been observed by me in three cases. These during life presented on the affected side the signs of closure of the tube, a highly concave membrane, and great deafness. Strong subjective noises once occurred; in one case a serous accumulation was found in the tympanic cavity. The tuning-fork on the vertex was always better perceived on the affected side.

The post-mortem examination showed in all the cases an extension of the growth from the upper jaw to the basilar fibro-cartilage and to the connective tissue surrounding the cartilaginous Eustachian tube. The whole tube appeared imbedded and compressed in its fatty, infiltrated surroundings. In microscopic sections, of which I possess a great number from all three cases, the epithelial new-formation is seen in the form of cones and nests filled with compressed epithelial cells, and in some preparations as cancroid nodules reaching close to the cartilage of the tube. The latter itself is not affected at any part by the cancerous masses. In the membranous portion of the tube, on the other hand, scattered cancerous nodules are found, which,

however, do not reach to the epithelium. In addition, the glands of the mucous membrane of the tube show great dilatation.

Neuroses of the Sound-conducting Apparatus.

1. *Otalgia.*

Nervous otalgia is caused either by an affection of the sensory nerves of the external and middle ears, or by disease of the nerve-trunks supplying the organ of hearing. Not unfrequently, pain in the ear has its origin in other parts of the body, as the teeth or larynx.

Otalgia occurs either as a localized ear-disease or as one of the phenomena of a trigeminal or cervico-occipital neuralgia. It is characterized by the complete absence of any signs of inflammation in the ear.

Neuralgia of the auricle is rare, and usually limited to a circumscribed part. On the anterior surface it is due to an affection of the trigeminus (N. auriculo-temporal.), on the posterior surface to an affection of the superior cervical nervous plexus (N. auricular. magn et occipital. minor). Besides the painful point on the auricle, there is often another found on the mastoid process (Valleix's mastoid point). The pain is increased by a light touch or pressure; sometimes, however, it is diminished by stronger compression.

In a case observed by me, in which neuralgia of the auricle had occurred at intervals for eight years, during the attack, without the skin becoming red, a swelling arose on the posterior surface of the tragus, which was very painful on being slightly touched, but not painful on being pressed.

Otalgia of the external meatus can only be recognised as such by localizing the pain in the cartilaginous section; when the pain is seated deep down in the osseous portion, it is not possible to distinguish between otalgia of the auditory meatus and otalgia of the middle ear.

Neuralgia of the tympanic plexus, which consists of branches of the trigeminus and of the glosso-pharyngeal nerves, occurs either as a local neurosis or as a symptom of an affection of the third, more rarely of the second branch of the fifth. In the latter case the otalgia is limited to the middle ear, while in the former the external and middle ears are both affected.

The chief causes of otalgia are: cold, anæmia, hysteria, perineuritis of the nerve-trunks, pressure on them in their course, tumours of the brain, caries of the cranial bones and of the cervical vertebræ. Among the most frequent causes of otalgia are carious teeth, ulcers in the larynx (Gerhardt) and in the neighbourhood of the pharyngeal orifice of the Eustachian canal.

The attacks are characterized by intense rending and piercing

pains in the interior of the ear, which seldom last longer than a few hours, and return generally at irregular intervals. Sometimes otalgia shows a markedly periodic character.

The occurrence of what was called intermittent otalgia by the earlier writers has been observed in recent times by Voltolini, Weber-Liel, and Orne Green. The last-named, in a patient with intermittent fever, observed during every attack, in addition to neuralgia in the area of the trigeminus, the occurrence of symptoms of an acute inflammation of the middle ear (otitis intermittens) which receded with the paroxysms of fever. Intermittent otalgia is to be referred to malarious infection (Intermittens larvata) only when a splenic tumour is present.

During an attack of otalgia there are often subjective hearing-sensations and deafness, and not unfrequently also hyperæsthesia of the skin of the auricle and of the temple, which disappear after the attack. Loud noises near the patient increase the pain in many cases; at the same time there exists a decided hyperæsthesia acoustica.

The course of otalgia is acute or chronic. In the former case, the neurosis lasts for a few days or weeks with irregular, rarely regular, intervals. The course of chronic neuroses is quite uncertain; the attacks often occur at intervals of weeks or months, and the disease may last for years. Chronic otalgia with a distinctly periodical course is rare. In one of my cases the attacks occurred for ten years, regularly every month or every second month on the left side, ending after several hours' duration in a sound sleep. The course of radiating otalgia, or that combined with neuralgia of the trigeminus, depends upon the course of the original disease.

The diagnosis of otalgia and its distinction from an inflammatory pain result from the absence of inflammatory signs in the ear. When a case has been decided as otalgia, it must next be determined whether it is a local neurosis or one of the phenomena of a trigeminal or cervico-occipital neuralgia, or lastly, part of a radiating pain in the ear. The teeth must then undergo minute examination; when there is caries, that may be taken as the probable cause of the otalgia when by pressure on the diseased tooth violent pain is caused. In children particularly, caries of the teeth is the most frequent cause of otalgia. If symptoms of a pharyngeal or laryngeal affection be present, it must be ascertained by a minute examination with the speculum whether the pain proceeds from ulcers in the pharynx or larynx.

The connection of otalgia with neuralgia of the fifth nerve and of the cervical plexus may be ascertained by examination of the known painful points (points douloureux). In affections of the trigeminus the pain is either general or only at a few spots. The otalgia is frequently so prominent, that it is only by ascertaining

the painful points that the existence of an extensive neurosis of the trigeminus is discovered.

The prognosis of otalgia is generally favourable in recent cases and in the periodic forms, even when the affection is one of the signs of trigeminal neuralgia. Further, the prognosis is altogether favourable when the otalgia is due to a carious tooth. It is, on the other hand, unfavourable in the lingering neuralgias of the fifth nerve, especially when the cause lies in a cerebral affection or in an irremediable compression of the affected nerve-trunk. Other unfavourable circumstances are anæmia and marasmus, inveterate syphilis, and tubercular ulcers in the larynx.

The treatment is governed by the cause and the duration of the disease. When dental caries is recognised as the cause of the suffering, the tooth should be extracted at once. In recent otalgia, localized or associated with neuralgia of the fifth nerve —whether the attacks occur irregularly or periodically—sulphate of quinine is used (2 or 3 decigr. three times daily). In the periodic form the quinine (in $\frac{1}{4}$-$\frac{1}{2}$ gram doses) is given two or three times in the course of two or three hours before the attack. The action of quinine is often assisted by the addition of iodide of potassium (1 of quinine to 2 of the iodide).

The iodide of potassium in larger doses is specially indicated when there is a suspicion of syphilis, and when contractions and slight paresis of the muscles of the face occur together, in which case the earache is probably caused by inflammation of the Fallopian canal. During severe attacks it is often necessary to alleviate the pain by the internal or hypodermic use of morphia.

In the chronic forms treatment has seldom any considerable results; sometimes, however, by the use of one or other remedy the attacks become milder and less frequent. The most commonly employed internal remedies are quinine, iodide of potassium, iron (especially in anæmia) and oxide of zinc, the latter either alone or in the form of Meglin's pills (zinc. oxid., rad. valerian., extr. hyoscyam. nigr. *aa* 10·0; ft. 100 pills; the dose to be gradually increased from 1 to 30, and then gradually diminished).

Of external remedies, vesicants to the mastoid process have proved effectual, as have also the endermic inunction of morphia or veratrine ointment, and narcotic plasters. Both in the obstinate acute and in the chronic forms galvanic treatment is indicated, as it very often effects an improvement when all other means fail. In applying galvanism, according to Erb, the copper pole is to be placed on the ear and the zinc pole on the neck. The Faradic current is not to be recommended, on account of the frequent simultaneous hyperæsthesia of the skin.

In several cases in which the pain affected the whole region of the ear, and was increased upon pressure especially between the ramus of the jaw and the mastoid process, corresponding to the

course of the cartilaginous Eustachian tube, after repeated massage I have observed considerable improvement, and even complete disappearance of the earache after some days. I now practise massage over the above area with great benefit in catarrh of the tube, of course in combination with injections of air either by my method or by catheterism.

Sometimes in hemicrania a dull pain arises in the ear and in its neighbourhood, accompanied with hyperæmia and a feeling of heat and burning on the auricle and temple. Eulenburg and Möllendorf, who term this form hemicrania angio sive neuro-paralytica, trace it to an affection of the sympathetic nerve.

Anæsthesia of the nerves of the ear affects most commonly the auricle, especially the expansion of the fifth nerve on its anterior surface. It seldom occurs as an independent affection, but more frequently as one of the phenomena of a diminished sensibility of the affected half of the head, especially in cerebral diseases.

Anæsthesia of the external meatus is little known. On the other hand, as I have elsewhere mentioned (*W. m. W.* 1863), a decrease in the sensibility of the mucous membrane of the middle ear, especially in the chronic adhesive processes without secretion, is by no means uncommon.

Motor Neuroses.—Under this heading are to be ranged:

1. *Spastic Contractions of the Muscles of the Auricle*, which are most frequently a part of a facial spasm (tic convulsif), less often an independent neurosis. In a case observed by Romberg, in which the motor neurosis was limited to the auricular branches of the facial nerve, repeated contractions of both auricles took place daily, the upward and downward motions lasting from five to ten minutes. The fact that by syringing the external meatus, as observed by Voltolini, spastic contractions of the muscles of the auricle may be reflexly set up, I can confirm from wide experience.

2. *Spastic Contractions of the Intrinsic Muscles of the Ear.*—The few observations hitherto recorded (Schwartze, Lucae, Schappringer, Brunner, and the author) relate to spastic contractions of the tensor tympani. They may be recognised either by a distinctly visible movement on the membrana tympani or by inserting a manometer into the meatus, in which at every contraction of the muscle a negative oscillation of the enclosed fluid will be seen. The contractions manifest themselves subjectively by a loud cracking sound which is objectively perceptible, or by a dull throbbing in the ear. The hearing-tests applied by me in one case showed that during the contractions the hearing-distance is diminished, deep tones become deadened and indistinct, and high ones ascend about one quarter of a tone.

From the fact that during strong contractions of the orbicularis palpebrarum contractions of the stapedius are set up (Lucae), Gottstein believes (*A. f. O.* xvi.) that in a case of

blepharospasm observed by him, in which during the attack a rushing noise was heard in both ears, the latter was caused by a clonic spasm of the stapedius.

3. *Clonic Spasm of the Muscles of the Eustachian Tube.*—This has been observed by Schwartze, Brunner, Todd, and myself in a few cases. In two of my cases the cracking sound caused by the contractions of these muscles was like the irregular ticking of a watch a great distance off, continued during sleep, and could not be suppressed by efforts of the will. At every sound a corresponding contraction could be perceived on the velum palati. The noise stopped when the velum palati was raised with the finger. One case was cured by galvanic treatment.

Injuries of the Sound-conducting Apparatus.

Lesions of the auricle are classified according as they are caused by stabs, blows, cuts, tears, or contusions. Their importance depends on the severity of the wound and on the extent of the injury. Superficial bruises confined to the skin always heal without visible consequences, while deep-seated lesions affecting the perichondrium or the cartilage, as we have seen in othæmatomata, have as their consequence severe hæmorrhage, inflammation, and deformity of the auricle. The course of incised wounds of the cartilage of the ear, as occurring in fights, duels, etc., is most favourable, in so far as even in large breaches of continuity (v. Tröltsch, Trautmann) after the edges of the incision have been united by means of the interrupted suture and antiseptic treatment, in the most cases cure has been effected. Less favourable are the terminations of tears, bruises, and bites,* as after sloughing of the injured cutis ulcers may form from exposure of the cartilage, the cicatrization of which is generally associated with swelling and deformity of the auricle (Kirchner). Burnett and Knapp have observed cases of splitting of the lobe by violent tugging at an ear-ring.

Injuries of the external meatus affect more frequently the osseous than the cartilaginous section. Lesions of the cartilaginous meatus are either confined to itself or combined with those of the auricle. In one of my cases there occurred, in consequence of a fall, a fracture of the inferior wall of the cartilaginous meatus with great bleeding at the ear, which healed without suppuration. The lining membrane of the cartilaginous section, seldom the cartilage itself, is most frequently injured by rough attempts at extraction of foreign bodies, without deep-seated changes remaining behind.

* According to E. Hoffmann (*Lehr. der gerichtl. Med.* 1881) the auricle is frequently bitten off in the Tyrol, as he in a seemingly short space of time had three such cases to treat.

Injuries of the osseous meatus may be caused by direct or indirect violence. Direct injuries affect either the lining membrane of the meatus alone or the osseous wall as well. Here also violent attempts at extraction of foreign bodies must be looked upon as amongst the chief causes. Then the meatus is often injured by solid objects introduced to scratch it in severe pruritus, often indeed from the fact that while scratching the arm is accidentally pushed and the instrument is driven against the wall of the meatus. Cassells (*Glasg. Med. Journ.* April, 1876) records a case of injury at the place of union of the cartilaginous and osseous sections from the stab of a steel pen, causing not only traumatic otitis externa, but also inflammation of the mastoid process. Limited fractures of the osseous meatus from direct violence are very rare.

Fractures of the external meatus from indirect violence are much more frequent; they are due either to fractures of the skull caused by blows, kicks, or falls, extending to the walls of the meatus, or to injuries caused by violent blows on the lower jaw, by which its articular process is driven with great force against the wall of the meatus.

The locality of the lesion depends on the site of the injury. Violence on the top of the head usually causes fissure of the superior wall of the meatus; on the back of the head, fissure of the posterior wall of the meatus; and a blow on the lower jaw causes injury of the anterior wall. On the latter, by indirect violence, not only do fissures arise, but also comminuted fractures, so that pieces of bone may be discharged or extracted from the meatus (Jakubasch, *M. f. O.* 1878; Trautmann, *A. f. O.* xv.; Kirchner, *Verh. der phys.-med. Ges. in Würzb.* N. F. vol. xvi.). Burnett (*Am. Journ. of Otol.* ii.) observed in three cases caries and necrosis of the injured anterior wall of the meatus after accidents to the lower jaw. Kirchner affirms, moreover, that from injuries to the lower jaw inflammations of the lining membrane of the meatus and of the middle ear may arise without fracture of the osseous walls of the meatus.

The terminations of fractures of the meatus are either recovery without subsequent deformity, or caries and necrosis of the affected wall with exfoliation of sequestra and permanent stenosis. Fissures on the posterior wall lead to traumatic inflammation of the mastoid cells, which may end fatally by complication with thrombosis of the sinus. In like manner fissures on the superior wall may terminate fatally from meningitis, when the dura mater has at the same time been injured. An interesting case of recovery from fissure of the superior wall of the meatus may here be briefly related:

P. E., aged twenty-nine years, received on the 24th July, 1881, so severe a blow from a club on the left side of the head that he immediately became unconscious. When he came to himself

twelve hours afterwards, he was quite deaf, and bleeding continued from the left ear for some days after the injury. Fourteen days later there was a considerable improvement in the hearing on the left side, while the right ear remained deaf, showing evidences of returning function only after some months. On examination on the 24th November I found the left membrane intact; and stretching from the posterior superior margin of the annulus tympanicus to the place of union of the cartilaginous with the osseous meatus there was a sulcus $1\frac{1}{2}$ mm. broad, widening outwards, which on being probed proved to be nearly 1 mm. deep. Hearing-distance for the acoumeter, $\frac{1}{2}$ m.; for speech, nearly normal. The right membrana tympani was unchanged; acoumeter, on contact; speech, $\frac{1}{8}$ m.; the perception for the tuning-fork from the vertex was stronger on the left. Subjective noises only on the right; unsteady gait with the eyes shut.

In this case a fissure was made in the superior wall of the left meatus by the blow on the left side of the vertex, which healed with a depression on the bone without leaving any disturbances, while by contrecoup concussion of the right labyrinth resulted with permanent deafness.

On the whole fractures are seldom confined to the meatus, but are usually complicated with fissures of the superior and inner walls of the tympanic cavity, of the mastoid process, of the pyramid of the petrous bone, and of the base of the skull.* In the majority of these cases the membrana tympani is ruptured, and the injury is accompanied by profuse bleeding (p. 229). If the fissure extends to the capsule of the labyrinth, or to the cranial cavity, there results an abundant serous discharge from the ear, which possesses the chemical properties of the cerebro-spinal fluid.

Complicated injuries of the latter kind terminate, as a rule, fatally by the occurrence of meningitis. The possibility of recovery, even in cases with serious clinical symptoms, must not, however, on that account be excluded.

Schwartze (*A. f. O.* xvii.) describes a case in which the left ear was injured with a knitting-needle, the membrana tympani, and probably also the anterior section of the tegmen tympani, and the dura mater being perforated, and in which, immediately after the injury, there was, without hæmorrhage, an abundant serous discharge (cerebro-spinal fluid) from the ear, lasting for eight days, and accompanied by giddiness, headache, delirium, and fever. Notwithstanding the unfavourable prognosis the patient recovered after seven months, with permanent tinnitus, deafness, and headache. Körner (*A. f. O.* xvii.) records a case of gunshot-wound, in which the projectile entered close behind the external

* Buck (*Am. Journ. of Ot.* ii.), judging from fourteen of his cases, affirms that fractures of the temporal bone most readily occur at the place of union of the squamous, tympanic, and petrous portions.

orifice of the ear, and after destroying the membrana tympani, stuck at the entrance of the antrum mastoideum. Through fracture of the wall of the labyrinth there was a discharge of cerebro-spinal fluid, with the same symptoms as in the previous case. Recovery took place in five weeks without the projectile having been removed. A case of fissure of the pyramid, of the superior wall of the meatus, and of rupture of the membrana tympani (by a blow from the shaft of a cart), with discharge of cerebro-spinal fluid, which ultimately recovered, has been related by Trautmann (*A. f. O.* xiv.).

An injury of the mastoid process by direct violence has been described by Cassells (*Glasg. Med. Journ.* April, 1876). A girl, seven years of age, from a kick from a horse on the right side of the head, received a fracture of the mastoid process communicating with the meatus, out of which gushed a stream of blood as thick as a finger, very probably from the lateral sinus. Recovery resulted after exfoliation of several splinters of bone.

An interesting case of gunshot-wound of the Eustachian tube is related by O. Wolf (*A. f. A. u. O.* ii.). The projectile entered beneath the zygomatic arch through the left superior maxilla into the tube, and remained wedged there. On account of profuse bleeding from the nose, the carotid had to be ligatured. There were present symptoms of occlusion of the tube, a highly concave state of the membrana tympani, deafness, and subjective noises, which were only temporarily improved by repeated paracentesis of the membrane.

In a case observed by me, in which the projectile penetrated the parotid, the meatus, and the mastoid process, and reappeared at the posterior portion of the latter, the sequelæ of the injury were stricture in the middle of the meatus, a salivary fistula discharging into the external meatus, and facial paralysis.

To the rarer injuries of the hearing-apparatus belong fractures of the handle of the malleus. They are caused by direct violence on the membrana tympani, and may either, as in the cases described by Menière (*Gaz. méd.* 1856), the author (*Beleuchtungsbild. d. Trommelfells*, p. 119), and Turnbull (*The Med. and Surg. Rep.* Philadelphia, 1879), heal by formation of callus, or remain ununited, as in a case of Weir's (*Transact. of the Am. Otol. Soc.* 1870), and in one of mine, in which the fracture was caused by the extraction of a foreign body seven years previously. The site of the fracture was found in the middle of the handle, and the lower end of the fracture formed with the superior portion of the handle an obtuse angle open towards the front. On examination with Siegle's speculum the lower end of the fracture seemed to move outwards, while the upper portion of the handle remained immovable. The hearing-distance for speech had diminished to $\frac{1}{3}$ m. Since the extraction of the foreign body the patient had suffered from stuttering.

Among the mechanical injuries of the sound-conducting apparatus are reckoned those caused by thermic and chemical influences. By the penetration of hot fluids into the ear the walls of the meatus are much less affected than the membrana tympani. In two cases described by Bezold (*A. f. O.* xviii.) there remained, after the protracted suppuration of the middle ear caused by the scalding, a persistent perforation of the membrana tympani, while the inflammatory phenomena in the external meatus disappeared after a short time. After the dropping of hot fluids into the meatus, v. Tröltsch (*l. c.*) has observed diffuse otitis externa arise, combined with inflammation of the membrana tympani. Opitz (*Allg. mil. Ztg.* 1865) found in recruits scabbing of the walls of the meatus owing to the introduction of hot vapours of burning wax and tallow.

Wederstrandt (*Am. Journ. of the Med. Scienc.* 1852) describes a case of burning by pouring melted lead into the meatus, as sequelæ of which deafness and facial paralysis occurred.

It is now sufficiently well proved that the action of cold, especially of cold water, may give rise to inflammation of the ear. Trautmann noted the occurrence of perforative inflammation of the middle ear in rabbits after injections of cold water.

Among injuries by chemical agents must be mentioned: cauterization of the ear with nitric (Morrison) and sulphuric acids (E. Hoffmann and the author), with liq. ferri sesquichlor. (Urbantschitsch), with caustic alkalies, nitrate of silver, chloroform, and ether.

A case of Wreden's affected a woman, who, in a state of syncope, had caustic ammonia poured into her nose, from which the substance penetrated through the tube into the middle ear. Soon afterwards, with great pain, subjective noises, and deafness, there set in a copious bloody and afterwards serous discharge from the ear, which ceased after three weeks. As the result, Wreden found the lower half of the cicatrized membrana tympani adherent to the inner wall of the tympanic cavity. Weintraub has observed in recruits cauterization of the cartilaginous meatus by solid nitrate of silver terminate in stricture.

For giving a medico-legal opinion as to lesions of the sound-conducting apparatus there are no general rules, as the injuries are so varied that scarcely ever are two cases alike. Therefore, in estimating the lesion, it is necessary to consider the nature of the violence in the given case and the extent of the injury, and to pay particular attention to the result of the latter.

The medical profession, in judging of injuries of the ear, generally proceed in the same way as in the case of other injuries, *i.e.*, according to §§ 152 and 156 of the Austrian Penal Law, and to discuss separately:

1. Whether the injury causes a disturbance of the health

(disease in the vulgar sense) or incapacity for business, and how long the former or latter has continued.

2. Whether the injury was severe. Later indications will be passed over when the clinical symptoms were serious, or when noteworthy effects remained.

3. If the latter is the case, further explanation is required—(*a*) Whether, in the case of a secondary deformity, it is to be regarded as 'permanent' and 'striking' in the sense of § 156; and (*b*) whether, when a disturbance of the hearing ensues, it is to be regarded as 'loss' or 'permanent impairment of hearing' in the sense of the same law.

In estimating injuries of the auricle, deformities of it resulting from lesions are particularly considered. Contusions, stabs, and blows, even extensive disturbances of its attachment, which, as we have seen, may heal by first intention, are to be regarded as slight injuries, as they do not leave behind any remarkable change in the form of the organ. On the other hand, all injuries by which, in consequence of inflammation, breaking down, necrosis, and exfoliation of the cartilage and shrinking and deformity of the auricle occur, are to be termed serious on account of the disfiguration; and it has still to be decided whether the latter is to be considered 'permanent and striking' in the meaning of the Penal Law, as in that case a sharp punishment is imposed.

The estimation of lesions of the external meatus depends upon whether the injury is confined to its lining membrane alone, or causes at the same time a fracture of its osseous walls. In the former case the injury will be called slight on account of the favourable termination. With fracture of the bone, on the other hand, particularly with splintering of the anterior and fissure of the posterior wall, the injury will in so far, on account of the consecutive inflammation leading to stricture of the meatus or to extensive ostitis mastoidea, be called serious, as by these complications the injured person is not only rendered unfit for business for more than twenty days,* but very often has his hearing permanently impaired.†

In the estimation of injuries of the tympanic cavity and those complicated fissures of the temporal bone in which the pyramid, the walls of the tympanic cavity, and of the external meatus, and the base of the skull come within the range of the lesion, the time of the examination is of chief importance. Within the first few days after its occurrence a definite opinion on the nature of an injury can only be given when the latter is combined with such serious symptoms of a simultaneous lesion of the brain that an unfavourable termination may be foreseen. When, on the

* Austrian Penal Law on crime, transgression, and trespass, 1852, § 152.

† The estimation of injuries of the membrana tympani has already been discussed (p. 235).

other hand, no symptoms of immediate danger are present, a definite prognosis should be postponed till such time as the termination and result of the lesion can be finally determined. We have seen, on the one hand, apparently slight injuries of the temporal bone lead to permanent disturbances and even to a fatal termination; and, on the other, severe fractures, with profuse bleeding from the ears and even with discharge of cerebro-spinal fluid, heal up. It has been sufficiently well proved that the period within which the results of such injuries —when they do not cause a fatal termination—run their course, so that the process may be regarded as concluded, is usually very long. In the majority of these cases the injury is represented as serious in so far as there remains a lengthened disturbance of function and a permanent weakness of hearing. Also those lesions which have as their result a salivary fistula in the auditory meatus or paralysis of the facial nerve, must be termed serious, on account of the permanent injury to health, even when they are not associated with any disturbance of hearing.

The estimation of injuries caused by chemical and thermic agents depends on the result of the ulceration in the auditory meatus, the extent of the destruction of the membrana tympani, the consecutive suppuration in the middle ear (caries and necrosis of the temporal bone), and the degree of the disturbance of hearing remaining. What has already been said about the estimation of injuries holds good here also.

Ear Disease and Life Assurance.

To the medico-legal aspects of injuries of the sound-conducting apparatus we will add some remarks on life assurance in the case of people with ear disease. Although this theme has already been discussed by v. Tröltsch, Cassells, Hedinger, Urbantschitsch, Trautmann and others, there has, as yet, been no consensus of opinion as to what class of people with ear disease should be admitted without dangering the interests of the assurance company, and what class should be refused. The views, also, as to the conditional acceptance, that is the admittance to life assurance with increased premium in certain forms of ear affection, have not been clearly stated.

The following statement can by no means be taken as final on this subject, but should rather serve to pave the way to its being completely elaborated, so that, after the most prominent specialists have agreed on it, it may be used by assurance companies as the regulation for the acceptance of persons with ear disease.

The following affections of the ear are to be regarded as of no importance by life-assurance companies, as they neither influence the length of life of the assurer nor contain the germ of a dangerous disease: 1. All malformations of the auricle and of the

external meatus, including congenital atresia of the latter. 2. The various forms of inflammation of the auricle, furunculosis of the auditory meatus, the slighter forms of otitis externa diffusa, eczema limited to the auricle and the external meatus, and exostosis and contractions of the meatus when they are not associated with suppuration. 3. All affections of the middle ear, which run their course without suppuration or perforation of the membrana tympani, in which the degree of the disturbance of hearing and complication with an affection of the labyrinth are out of the question. 4. All disturbances of the hearing which can be traced to a localization of the affection in the labyrinth. 5. Those exhausted suppurations of the middle ear in which the perforation in the membrana tympani becomes closed by cicatrization, whether it has become adherent to the inner wall of the tympanic cavity or not.

All persons in whom examination proves the presence of the following affections of the organ of hearing, are to be unconditionally rejected: 1. Ulceration of the auricle and of the external meatus, due to the crumbling away of an epithelioma. 2. Lupous affections of the external ear, as experience shows that individuals affected with lupus do not live long. 3. Contraction and exostosis of the external meatus associated with suppuration. 4. Chronic purulent inflammation of the external meatus with exposure of its osseous walls. 5. Chronic suppuration of the middle ear with perforation of the membrana tympani, especially (*a*) with formation of granulations and polypi in the tympanic cavity; (*b*) with desquamative processes in the middle ear (p. 451); (*c*) with symptoms of caries in the temporal bone; (*d*) with paresis or paralysis of the facial nerve; and (*e*) with formation of fistulæ on the mastoid process. 6. All affections of the ear associated with giddiness and unsteady gait, when these symptoms cannot be traced with certainty to an affection of the organ of hearing, and when the possibility of a cerebral affection cannot with certainty be excluded.

A conditional acceptance, *i.e.* with increased premium, may be permitted in the case of those in whom, in consequence of a former suppuration of the middle ear, a persistent perforation (dry) remains in the membrane, as in these cases the suppuration returns more easily than when the opening is closed by cicatrization. The acceptance of such cases is rendered more difficult by the co-existence of chronic naso-pharyngeal catarrh or chronic pulmonary catarrh.

Not to be absolutely rejected, but to be deferred until the affection be completely removed, are: 1. All acute and chronic eczemas and diffuse inflammation of the external meatus, which extend deep into the canal and contract it. 2. Those suppurations of the middle ear which have lasted only a few weeks or months and admit of the possibility of a cure. If it is a case of curable

ear-discharge, favourable results may be foreseen after several weeks' rational treatment. Should the otorrhœa not cease after proper treatment, the case is to be rejected. Cases which have been deferred for a time must be examined by a specialist, and it must be proved that their ear affection has been cured for at least three months. 3. All syphilitic ear affections in the presence of further symptoms of general syphilis (exanthems, pharyngeal ulcers, glandular swellings), as well as with simultaneous giddiness and staggering gait. When, on the other hand, the deafness has existed for years since the syphilis and all symptoms of the general affection have disappeared, the life may be accepted without fear, when no other circumstances forbid it, such as the suspicion of a syphilitic affection of the brain.

From what has been said, it is seen that the medical adviser of an assurance company is justified in rejecting those cases in which examination by the aural speculum shows great changes in the external meatus and on the membrana tympani (granulations, polypi, fistulæ, otorrhœa with perforation of the membrana tympani, and so on); that, on the other hand, in all cases of ear-disease in which the decision of the assurance company as to passing the life depends on a subtler objective examination of the organ of hearing, the case must be decided by a specialist.*

* To the already mentioned text-books and manuals on ear disease, we must add: Clarence J. Blake, *A Form of Obstruction of the External Auditory Canal.* From the *Archives of Clinical Surgery*, June, 1877; Clarence J. Blake, *Living Larvæ in the Human Ear. New York Archives of Ophthalmology and Otology*, 1872; Cassells, *Myringomycosis Aspergillina* (*Fungus Ear Disease*). Repr. from the *Glas. Med. Journ.* 1875; Hagen and Hallier, *Ein neuer Ohrpilz. Otomyces Hageni;* R. Hagen, *Zwei weitere Fälle von Ohrpilzen;* Hassenstein, *Alkoholbehandlung des Aspergillus glaucus im äusseren Gehörgange;* Charles H. Burnett, *The Growth of the Fungus Aspergillus in the Human Ear*—Repr. from the *Philad. Med. Times;* Clarence J. Blake, *Parasitic Growths in the External Meatus;* John Roosa, *On the Affections of the External Auditory Canal—The Med. Record*, No. cxliii., 1872; John Roosa, *On Bony Growths in the Meatus Auditorius Externus*—from the *New York Med. Journal*, March, 1866; Alb. Burkhardt-Merian, *Ueber Fremdkörper im Ohre—Corresp.-Blatt f. schweiz. Aertze*, No. xx., 1874; Loewenberg, *Ueber fremde Körper im Ohre und eine sichere und gefahrlose Methode, dieselben zu entfernen—Sep.-Abdr. aus der Berl. klin. Wochenschrift*, No. ix. 1872; Wilh. Kirchner, *Ueber Ohrpolypen — Dissert.* München, 1878; R. Hagen, *Ueber Ohrpolypen von Dr. H. G. Klotz—Prakt. Beitr. z. Ohrenheilkunde* iv. Leipzig, 1868; Bonnafont, *Sur deux Observations des Polypes fibreuses du Conduit auditif externe*—Extr. de *l'Union médicale Ach.* 1864; Jul. Ad. Hessel, *Ueber Ohrpolypen—Dissert.* Halle, 1869; Edw. H. Clarke, *Observations on the Nature and Treatment of Polypes of the Ear*, Boston, 1867; E. Zaufal, *Paukenhöhlenpolyp bei imperforirtem Trommelfelle — Prager med. Wochenschrift*, No. xxvi. 1876; Adam Politzer, *Operatives Verfahren bei Ohrpolypen — Wien. med. Wochenschr.* No. xvi. 1879; Oscar Wolf, *Unterbindung der Arteria carotis communis wegen Schüssverletzung mit lebensgefährlicher Blutung—Sep.-Abdr. aus dem Arch. für Augen- und Ohrenheilkunde*, ii. vol. ii. div. 1872; Cassells, *Ear Disease and Life Assurance*—Repr. from the *Brit. Med. Journal*, 1877; R. Hagen, *Der seröse Ausfluss aus dem äusseren Ohre nach Kopfverletzungen*, Leipzig, 1866.

DISEASES OF THE SOUND-PERCEIVING APPARATUS (DISEASES OF THE INNER EAR).

I.—ANATOMY OF THE INNER EAR.

The inner ear or sound-perceiving apparatus comprises the central origin of the auditory nerve, the trunk of the auditory nerve, and its expansion in the labyrinth. According to the customary anatomical representation we begin with the description of the labyrinth.

A. The Labyrinth

consists of the osseous capsule and the membranous labyrinth enclosed by it.

1. *The Osseous Labyrinth*

is divided into the vestibule, the three semicircular canals, and the cochlea, to which may be added the internal auditory meatus.

a. The Vestibule forms an irregular, elliptical cavity, 4-5 mm. in diameter, whose walls merge into each other without any well-defined demarcation (Fig. 234 *a*). Its lateral wall, chiefly directed downwards, is formed in great part by the fenestra ovalis closed by the foot-plate of the stapes. On the median and inferior walls are placed two depressions separated by the crista vestibuli, and destined for the reception of the two saccules of the vestibule: the anterior the recessus hemisphericus, and the posterior the recessus hemiellipticus. On the posterior, and partly also on the superior and inferior walls of the vestibule, lie the mouths of the semicircular canals, three larger ampullar orifices and two smaller embouchures. On the anterior inferior wall is placed the entrance of the cochlea into the scala vestibuli.

On the crista vestibuli as well as on the floor of the two recesses are situated the so-called maculæ cribrosæ, each with a number of foramina intended for the passage of the fibres of the vestibular nerve. The macula cribrosa superior is destined for the passage of the nerves of the utricle and of the ampullæ of the anterior vertical and the horizontal semicircular canals, the macula cribrosa media for the nerves of the

saccule, and the macula cribrosa inferior for the nerves of the ampulla of the posterior vertical semicircular canal.

b. The Semicircular Canals.—The semicircular canals, which lie in the osseous mass of the petrous bone behind the vestibule with their planes standing perpendicularly to each other, enclose

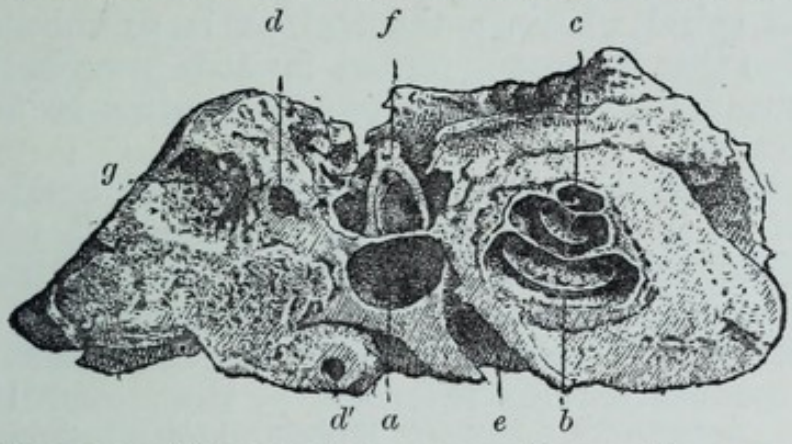

FIG. 234.—HORIZONTAL SECTION THROUGH THE PETROUS BONE OF A NEW-BORN CHILD. (TWICE THE ACTUAL SIZE.)

a, Vestibule; *b*, Base of the cochlea; *c*, Cupola of the cochlea; *d*, *d'*, Sections of the superior semicircular canal; *e*, Internal auditory meatus; *f*, Stapes; *g*, Antrum mastoideum.

a solid angle. They are distinguished as the superior, the posterior or inner, and the horizontal or external semicircular canal. The convexity of the superior (frontal) semicircular canal (Fig. 235 *c*) is turned towards the upper surface of the pyramid, and forms there a circumscribed bulging, the highest point of which, however, does not correspond exactly to that of the semicircular canal. The convexity of the inner (sagittal) semicircular canal (*e*) is turned backwards, and its plane lies nearly parallel to the posterior wall of the pyramid. The convexity of the external or horizontal semicircular canal (*g*) is also turned backwards, and its external portion bulges out on the inner wall of the tympanic cavity behind the Fallopian canal.

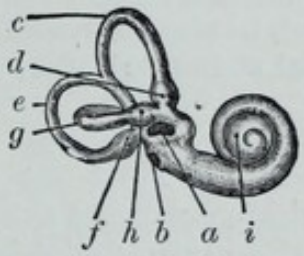

FIG. 235.—CAST OF THE OSSEOUS LABYRINTH.

a, Fenestra ovalis; *b*, Fenestra rotunda; *c*, Superior semicircular canal; *d*, Ampulla of the same; *e*, Posterior semicircular canal; *f*, Its ampulla; *g*, Horizontal semicircular canal; *h*, Its ampulla; *i*, Cochlea.

Each of the three semicircular canals begins with an ellipsoidal dilatation, 1½-2 mm. in size, the so-called osseous ampullæ of the semicircular canals (Fig. 235 *d*, *f*, *h*). The canals open by only two orifices into the vestibule, as the superior (*c*) and the posterior (*e*) canals before discharging unite in one common canal.

c. The Cochlea.—The cochlea (Fig. 236 *i*) presents a canal, 28-30 mm. long, gradually tapering towards its upper end, turn-

ing $2\frac{1}{2}$ times round its axis, and on cross-section showing the form of a garden snail. In the macerated preparation the cavity of the cochlea communicates with the vestibule by a spacious opening and with the tympanic cavity by means of the fenestra rotunda.

With its spiral windings the cochlea is so imbedded in the petrous bone that its base is turned inwards towards the internal auditory meatus and its apex (cupola) outwards towards the tympanic cavity.

On a vertical section of the cochlea (Fig. 236), besides the cross sections of its spirals one sees the modiolus (*b*), which begins with a broad basis upon the internal auditory meatus and becomes gradually narrower till the neighbourhood of the cupola is reached. It is developed from a connective-tissue substance, while the cochlear capsule is formed by the primordial cartilage. Moos and Steinbrügge found full-grown cartilage-cells in the cochlear capsule, and I also found cartilage elements in the supporting trabeculæ connecting the modiolus with the cochlear capsule.

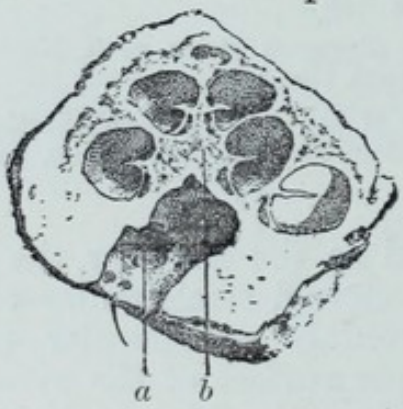

FIG. 236.—SECTION OF THE OSSEOUS CASE AND OF THE MODIOLUS OF THE COCHLEA WITH THE LAMINA SPIRALIS OSSEA.

a, Internal auditory meatus; *b*, Modiolus.

The axis of the modiolus (Langer), in the direction from the base to the cupola, is traversed by numerous nervous and vascular canals. The central canal of the modiolus runs in its centre from the base to the apex; on the external surface, encircling the modiolus, runs the canalis spiralis sive ganglionaris (Rosenthal), which contains the ganglion spirale. From the external surface of the modiolus rises a vertical osseous plate directed towards the lumen of the canal of the cochlea, which, beginning between the fenestra rotunda and the vestibular orifice of the cochlea, proceeds spirally to the cupola, and there ends in the pointed hamulus, the lamina spiralis ossea. It serves for the insertion of the membranous spiral lamina, which will be described later. By it the cochlear canal is divided into two divisions, the superior of which (scala vestibuli) communicates with the vestibule, while the inferior (scala tympani) ends at the fenestra rotunda closed by the membr. tymp. secund. The scalæ communicate with each other at the apex of the cochlea through the helicotrema of Breschetius.

All the spaces of the labyrinth are lined by a layer of connective tissue intermixed with fine elastic fibres.

d. The Internal Auditory Meatus varies in regard to its length and width. Its course from the opening on the posterior surface

of the pyramid is directed backwards (Fig. 234 *e*). The inner end is divided into a superior and an inferior fossa by a diagonal ledge. In the anterior part of the superior depression is situated the entrance to the Fallopian canal, and in the posterior part the opening of the passage for the vestibular nerves. In the inferior fossa (fossa cochleæ Fig. 236) are seen the spirally arranged orifices (tractus spiralis foraminulentus) at the base of the cochlea for the entrance of the fibres of the cochlear nerve.

2. *The Membranous Labyrinth.*

The membranous labyrinth, lying in the osseous capsule just described, consists of the saccules of the vestibule, the three membranous semicircular canals, and the membranous portion of the cochlea.

a. The Saccules of the Vestibule.

Of the two saccules of the vestibule, the one connected with the semicircular canals (Fig. 237 *a*) is termed the utricle, and the other communicating with the canal of the cochlea the saccule. The utricle, the larger and longer, is imbedded in the recessus hemiellipticus, and communicates immediately with the semicircular canals by five foramina. The saccules and the semicircular canals surrounded by perilymph contain the so-called endolymph. The walls of the utricle are in places fastened to the vestibular wall by means of loose connective tissue, and only free from the osseous wall below and towards the foot-plate of the stapes (Steinbrügge). There is here a somewhat larger space in the vestibule filled with perilymph.

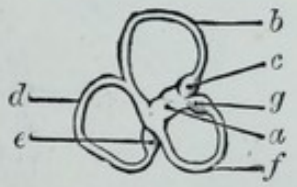

FIG. 237. — MEMBRANOUS LABYRINTH.

a, Utriculus; *b*, Superior semicircular canal; *c*, Its ampulla; *d*, Posterior semicircular canal; *e*, Its ampulla; *f*, Horizontal semicircular canal; *g*, Its ampulla.

The utricle consists of a fibrillar substantia propria, which is externally bounded by a vascular layer of connective tissue, and internally by an angular pavement epithelium. On the median side of the utricle its wall appears, to the extent of 2 mm., yellow, thickened and opaque (macula acoustica) by the deposition of crystalline calcareous concretions (otoconia). The twigs of the vestibular nerve here reach the utricle and become connected with those ciliated, cylindrical cells which are seated on the inner, swollen-up places of the macula acoustica.

The saccule, of smaller circumference and roundish in form, lies in the anterior inferior section of the vestibule in front of the entrance to the scala vestibuli of the cochlea. On its median wall is situated the macula acoustica, while on its anterior wall a thin membranous canal (canalis reuniens) discharges, through which the saccule communicates with the ductus cochlearis of the cochlea.

b. The Membranous Semicircular Canals.

Their form (Fig. 237), with the three ampullary dilatations at the origin and the two embouchure openings, corresponds exactly with that of the osseous semicircular canals. Each ampulla possesses, like the utricle, a sharply-defined yellow spot permeated with otoconia, and on its inner side there is an elevation (crista acoustica) which is covered with ciliated auditory cells connected with the auditory nerve. The diameter of the membranous semicircular canal amounts to nearly one-fifth of that of the osseous, as is seen from Fig. 238.

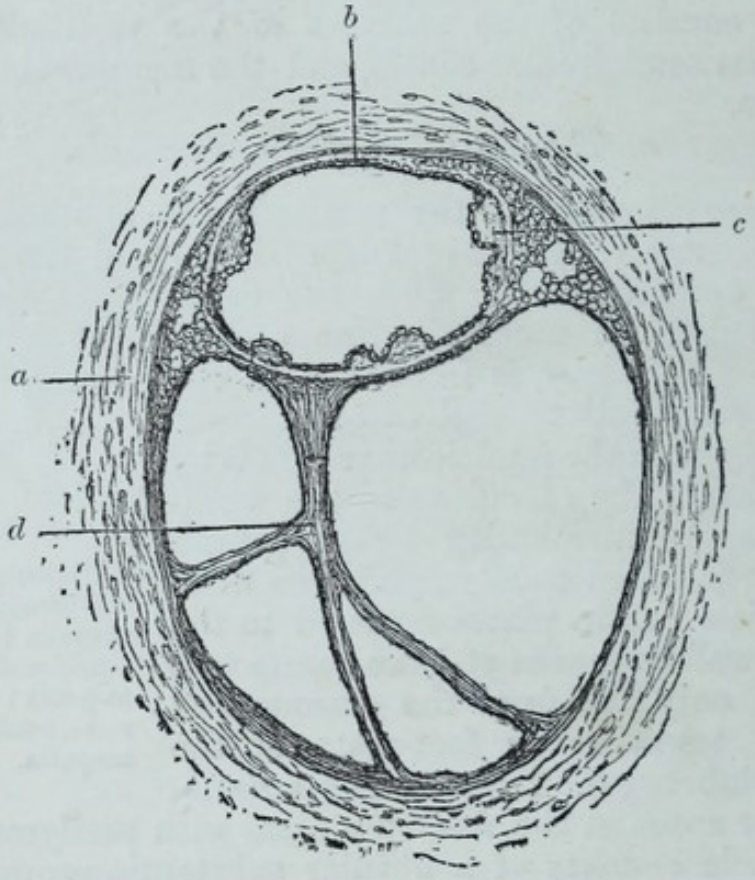

FIG. 238.—SECTION OF THE OSSEOUS AND MEMBRANOUS SEMICIRCULAR CANALS.

a, Osseous semicircular canal; *b*, Place of attachment of the membranous semicircular canal; *c*, Elevations on the inner surface of the membranous semicircular canal; *d*, Vascular connective-tissue bands.

The membranous semicircular canals do not float, as was formerly thought, in the spaces of the osseous canals filled with perilymph, but are (Fig. 238) fastened by a part of their wall to the osseous canal, consequently stationary (Kölliker, Rüdinger). From the free part of the membranous canal numerous vascular connective-tissue ligaments (*d*) proceed to the periosteum of the osseous canal. On the inner surface of the semicircular canals arise numerous papillary elevations (*c*) covered with epithelium, which are wanting on the adherent parts of the canal (*b*) (Rüdinger). They increase considerably the superficial capacity

of the semicircular canals. Nerve elements have not been proved to occur in these canals.

c. The Membranous Structure and the Terminal Apparatus of the Auditory Nerve in the Cochlea.

The terminal apparatus of the cochlear nerve, generally called the organ of Corti, lies on the membranous spiral lamina, which

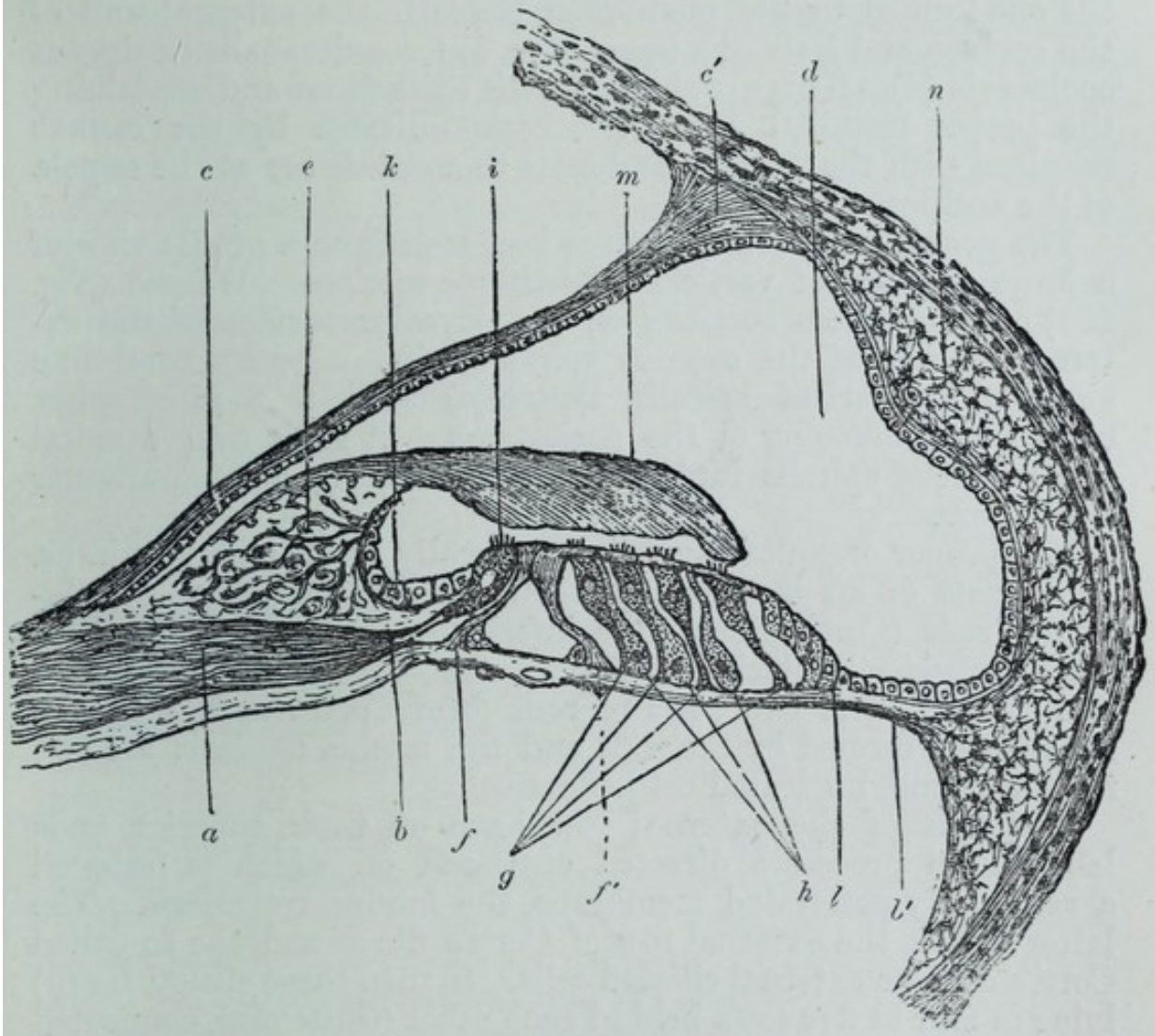

FIG. 239.—DIAGRAMMATIC REPRESENTATION OF THE CANALIS COCHLEARIS, WITH THE TERMINAL APPARATUS OF THE COCHLEAR NERVE.

a, Lamina spiralis ossea, with the fibres of the cochlear nerve; *b*, *b'*, Lamina spiralis membranacea; *c*, *c'*, Membrana Reisneri; *d*, Canalis cochlearis; *e*, Huschke's tooth—crista spiralis; *f*, Inner pillar of Corti's organ; *f'*, External pillar; *g*, Corti's cells; *h*, Deiters's cells; *i*, Inner ciliated cells; *k*, Cells of the sulcus spiralis interior; *l*, Claudius's cells; *m*, Corti's membrane; *n*, Ligamentum spirale accessorium.

springs from the free edge of the lamina spiralis ossea (Fig. 239, *b*) and is inserted on the projecting ligamentum spirale (*b'*) of the opposite wall of the cochlea. There are three sections on the membranous spiral lamina: the inner, which is perforated in numerous places for the passage of the fibres of the cochlear

nerve (zona perforata); the middle section, which bears the organ of Corti (zona arcuata); and the external finely striated portion (zona pectinata).

We have seen that the cochlear canal is divided by the spiral lamina into the scala vestibuli and the scala tympani. The scala vestibuli is again divided by the membrana Reisneri (*c*), extending from the upper surface of the lamina spiralis ossea obliquely to the external wall of the cochlea, into two divisions, of which the one formed by the membrana basilaris, the external wall of the cochlea and Reisner's membrane, is termed canalis or ductus cochlearis (*d*). This canal, lined with epithelium and containing the proper terminal apparatus, communicates by the canalis reuniens with the saccule, and ends in a *cul-de-sac* at the cupola of the cochlea.

The position of Corti's organ is best seen from a profile view of a large number of vertical microscopic sections. We see (Fig. 239) on such cross sections on the superior surface of the external section of the osseous spiral lamina, a cock's comb-like swelling (*e*) (crista spiralis, Huschke) with a toothed edge, caused by thickening of the periosteum. It roofs over a spiral canal (sulcus spiralis int.), which is covered by a quadrangular epithelium.

The proper organ of Corti lies externally to the sulcus spiralis. It consists of an inner (*f*) and an outer (*f'*) layer of lightly-swung rods (Corti's fibres), the inferior ends of which stand on the membrana basilaris, while their superior ends are connected like joints. The two rows of rods form Corti's arch. In the lower angle formed by the rods and the lamina basilaris are two rows of round, nucleated cells (floor-cells).

The rods of the external row have on their superior ends lamelliform processes directed outwards, on which is fastened a reticularly perforated membrane, the lamina reticularis. The latter covers the external row of Corti's fibres and the so-called Corti's cells or external ciliated cells. In man these structures (*g*) lying in four to five rows behind each other (Gottstein), connected with the terminal fibres of the auditory nerve by small nervous processes, are fastened by their inferior, thin elongated ends (Gottstein's basal processes) to the membrana basilaris, while the superior, broad ends, provided with acoustic cilia, project through the openings of the lamina reticularis. A row of inner ciliated cells (*i*) is in front of the sulcus spiralis int. immediately in front of the inner pillar of Corti's organ. Deiters's cells (*h*) are connected with Corti's cells by their broad ends directed downwards. External to the last row of Corti's cells lie Hensen's supporting cells, which pass into the epithelium of the external wall of the ductus cochlearis.

Corti's organ is covered by the firm, striated Corti's membrane (*m*). The latter arises beside Reisner's membrane in front

of Huschke's swelling, and ends, according to general opinion, at the external boundary of Corti's cells, while, according to Henle and Loewenberg, it is inserted on the ligam. spiral. access. (*n*) of the external wall of the ductus cochlearis.

Aquæductus Vestibuli et Cochleæ.—The aqueduct of the vestibule arises as a thin, membranous tube from the utricle in the immediate neighbourhood of the embouchure of the superior and posterior semicircular canals, then proceeds through a thin osseous canal to the posterior wall of the pyramid, and opens into a spacious *cul-de-sac*, covered by the dura mater, and which is connected with the endolymphatic spaces of the labyrinth (Zuckerkandl, Weber-Liel). The aqueduct of the cochlea arises in the scala tympani in the neighbourhood of the fenestra rotunda, and opens into the cranial cavity by an orifice to be found near the lower edge of the pyramid. It effects the immediate communication of the arachnoid space with the perilymphatic fluid of the labyrinth.

Bloodvessels of the Labyrinth.

The arteries of the labyrinth come from the art. auditiv. int. (art. acoust. central., Sapolini), running from the art. basilar., and entering the internal auditory meatus with the auditory nerve. A small branch of it enters the vestibule, supplies its lining membrane and the membranous semicircular canals, and sends smaller branches to the saccules and the ampullæ, and an arch-shaped vessel coursing along the concavity of the membranous semicircular canals. Another branch of the art. auditiva (art. cochl.) sends vessels into the modiolus and into the lam. spiral. oss. on the lining membrane of the cochlear wall. One of its small branches runs spirally in the canalis spiralis, and supplies the ductus cochlearis with capillary ramifications.

The Veins of the Labyrinth.—The veins of the vestibule and of the semicircular canals are collected in the vena aquæductus vestibuli, which discharges into the sinus petrosus. The veins of the cochlea discharge by means of the vena aquæduct. cochl. into the vena jugularis. The anastomosis of the labyrinthine vessels with those of the tympanic cavity is effected, as I have already pointed out (p. 48), by the osseous vessels running in the external wall of the labyrinth.

B. The Auditory Nerve.

a. The Central Course of the Auditory Nerve.

The central course of the auditory nerve, notwithstanding the labours of Stilling, Schröder v. d. Kolk, L. Clarke, O. Deiters, Meynert, Huguenin, and C. Roller, is still far from being fixed.

If a section through the pons in a human brain close to the superior margin of the auditory nerve be prepared by Huguenin's method, a picture, such as is represented in Fig. 240, is obtained with a low power. We see internally to the two divisions of the peduncles of the cerebellum (*a*) a nervous strand (*e*), the auditory nerve running through the whole transverse section. It divides at its superior end, where it strikes on the fourth ventricle (*g*) into two sections, an external (*s*) and an internal (*d*). The fibres of the external (*s*) end in groups of ganglion cells, which are distributed through the funiculus cuneatus et gracilis (*b*), and are named the external nucleus of the auditory nerve. This contains a considerable number of ganglion cells. The inner section of the fibres of the auditory nerve (*d*) is connected with groups of ganglion cells

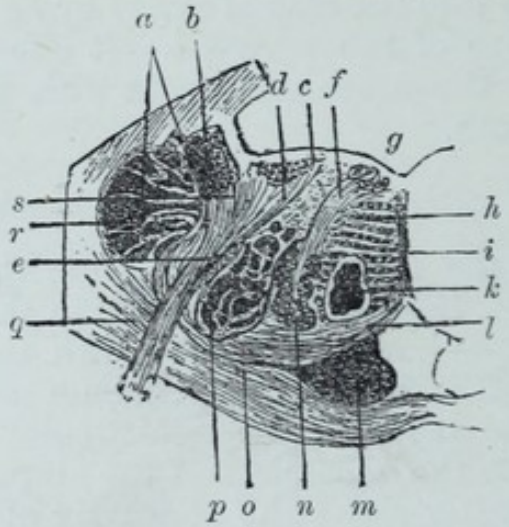

FIG. 240.—CROSS SECTION THROUGH THE PONS VAROLII AT THE UPPER MARGIN OF THE AUDITORY NERVE.

a, Pedunculus cerebelli; *b*, Funiculus cuneatus et gracilis; *c*, Internal nucleus of the auditory nerve; *d*, Root of the auditory nerve from its inner nucleus; *e*, Auditory nerve; *f*, Facial nerve; *g*, 4th ventricle; *h*, Motor strands of the medulla oblongata; *i*, Raphe of the medulla oblongata; *k*, Superior olivary body; *l*, Fibræ arcuatæ; *m*, Pyramids; *n*, Nucleus of the facial nerve; *o*, Empty space between the pons and the medulla oblongata; *p*, Ascending root of the trigeminus; *q*, Transverse fibres of the pons; *r*, Corpus restiforme; *s*, Root of the auditory nerve from its outer nucleus.

which lie on the floor of the fourth ventricle, and form the so-called internal nucleus of the nerve (*c*).

On transverse section, lower down towards the spinal cord, one gets a view like that represented in Fig. 241. We see on the external margin of the auditory nerve a new formation, which rests partly on the auditory nerve, partly on the inferior border of the restiform body (*r*). It consists of a group of large ganglion cells with few processes, which is called the anterior nucleus of the auditory nerve (*t*).

In transverse sections, made still lower through the medulla oblongata at the level of the inferior margin of the auditory nerve (Fig. 242), appears another new formation, which covers the anterior nucleus of the auditory nerve, and bears the name

striæ medullares (*u*). This formation, after covering the anterior nucleus of the auditory nerve from the outside, passes round the peduncle of the cerebellum upwards, and then, after it has passed the sinus rhomboideus as the striæ medullares, either enters directly into the raphe, or ends externally from the latter.

The root fibres of the auditory nerve are: 1. The striæ medullares. 2. The nerv. intermed. Wrisbergi. 3. The proper auditory fibres.

On the connection of the three roots, and the three nuclei of the auditory nerve with each other, and with the remainder of the brain, the following data are found in the authors cited:

1. The striæ medullares run on the external margin of the medulla oblongata round the anterior nucleus of the nerve, and the peduncle of the cerebellum to the sinus rhomboideus, which

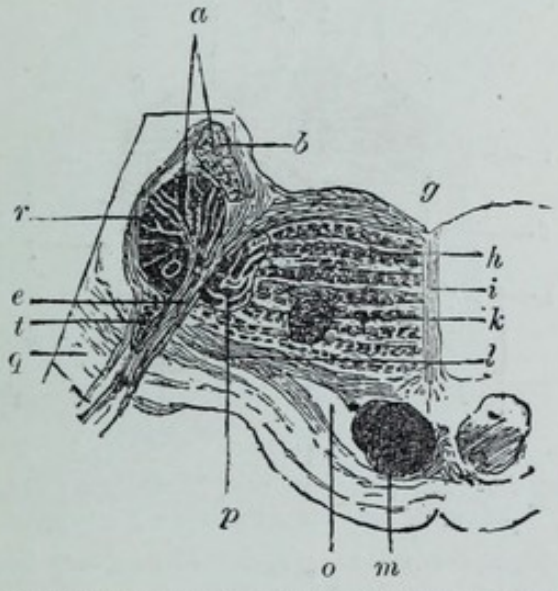

FIG. 241.—CROSS SECTION THROUGH THE PONS, LOWER THAN FIG. 240.

t, Anterior nucleus of the auditory nerve; *e*, Auditory nerve; *r*, Corpus restiforme. The other letters as in Fig. 240.

they bridge over obliquely so as to sink in the neighbourhood of the raphe into the parenchyma of the medulla oblongata. Here they cross over the middle line in order, according to Meynert, to become connected with the fibræ arcuatæ of the opposite side. The striæ medullares represent, therefore, the connection between the auditory nerve of the one, and the cerebellum of the other side.

2. The intermediate nerve of Wrisberg joins, on the external side of the auditory nerve, the medulla oblongata, and loses itself in the anterior nucleus of that nerve; its further connections are unknown.

3. The large root of the auditory nerve is divided into five subdivisions: (*a*) a bundle from the corpus restiforme; (*b*) one from the external nucleus of the nerve, and (*c*) one which belongs to the so-called inner nucleus of the nerve; (*d*) and (*e*) root fibres

of the one auditory nerve, which pass into the external nucleus of the auditory nerve of the other side, and on which Meynert distinguishes a high and a low tract.*

b. The Stem of the Auditory Nerve, and its Expansion in the Labyrinth.

The auditory nerve enters from the medulla oblongata along with the facial nerve into the internal auditory meatus, and separates itself on the floor of the latter into two branches: the vestibular branch, which enters the vestibule and gives out branches for the utricle and the ampullæ of the semicircular canals, and the cochlear branch, whose fibres enter the cochlea. A small branch of the same supplies the saccule and the

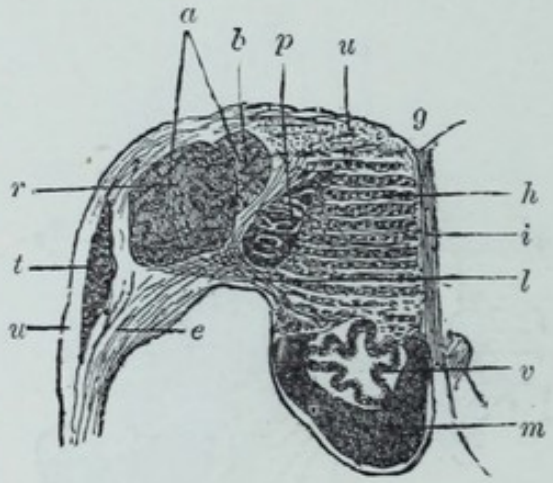

FIG. 242.—TRANSVERSE SECTION THROUGH THE MEDULLA OBLONGATA, AT THE LOWER MARGIN OF THE AUDITORY NERVE.

u, Striæ medullares; *v*, Inferior olivary body.

ampullæ of the membranous semicircular canals. In the roots and stem of the auditory nerve are interspersed numerous ganglion cells.

According to Arnold the auditory nerve is connected with the intermediate nerve of Wrisberg (nervo tredicesimo of Sapolini) and with the facial nerve by fine nerve-fibres. At the place of connection between the facial and vestibular branch there is a greyish-red swelling containing numerous ganglion cells, the so-called intumescentia ganglioform. Scarpæ.

Expansion of the Auditory Nerve in the Cochlea.—The bundles of the cochlear branch enter through the orifices of the tractus spiralis foraminulentus partly immediately to the first turn of the cochlea, and partly into the nerve canal of the modiolus, and thence to the lamina spiralis ossea. Between the fibrous bundles

* C. Roller describes an ascending root of the auditory nerve, which, lying in the middle line beside the restiform body, rises out of the medulla oblongata and joins itself to the roots of the auditory nerve at their exit from the medulla oblongata. According to Roller, the external root of the auditory nerve draws its fibres from the funiculus cuneatus.

of the modiolus and of the spiral lamina there is on the periphery of the modiolus a large ganglion layer (zona ganglionaris), which lies in the well-defined oval canal of Rosenthal (Fig. 243). In the inferior section of this ganglion layer the nerve bundles (*b*, *b'*, *b''*) enter in several places, in order, after numerous connections with the ganglion cells at the superior end of Rosenthal's canal, to penetrate into the lamina spiralis.

In the spiral lamina the nerve bundles, which have numerous cross anastomoses forming a plexus with their non-medullated fibres, run between the two osseous lamellæ to the habe-

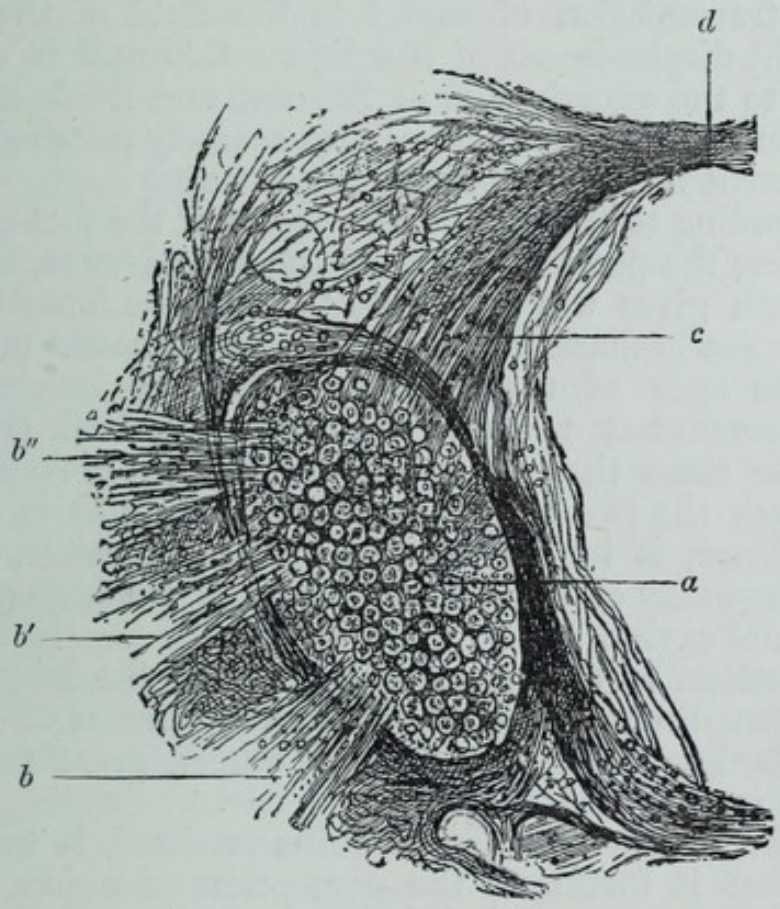

FIG. 243.—SECTION OF ROSENTHAL'S CANAL AND THE GANGLION SPIRALE.

a, Ganglion cells of the ganglion spirale lying in Rosenthal's canal; *b*, *b'*, *b''*, Three separate nerve bundles of the cochlear branch entering into the ganglion spirale; *c*, Nerve bundle coming from the superior pole of the ganglion spirale; *d*, Entrance of the latter into the lamina spiralis ossea. (After a preparation in my collection.)

nula perforativa of the inferior surface of the basilar membrane, thence through the numerous openings on the superior surface of the latter to the ductus cochlearis, and, according to Waldeyer and Gottstein's observations, they end in numerous very fine and in parts knotty fibres, in connection with the internal ciliated cells (Waldeyer's internal radiating fibres) and with Corti's cells, or the external ciliated cells (Gottstein's external radiating fibres) through the openings of Corti's arch.

Physiological Observations.

Sound-waves are conducted from the membrana tympani to the labyrinth by means of the foot-plate of the stapes; the sound-waves transmitted at the same time from the membrana tympani to the air of the tympanic cavity and from that to the membrane of the fenestra rotunda at the cochlea are of secondary consideration compared to those which are conducted through the ossicular chain to the labyrinth.

By the transmission of sound to the fluid of the labyrinth only a slight displacement of the liquor Cotunnii is occasioned. According to the experiments of Burnett and Buck it is greater for low than for high tones, the latter scarcely causing a measurable movement in the fluid of the labyrinth.

Corresponding to the inward movement of the foot-plate of the stapes during the positive phase of the sound-wave, the fluid in the labyrinth gives way especially towards the fenestra rotunda. The membrana basilaris of the cochlea, on account of the resistance at the apex of the cochlea, is thereby bulged out and expanded somewhat towards the scala vestibuli (Helmholtz). That at the same time, by sound-vibrations, a movement of the fluid through the two aqueducts of the labyrinth is effected, as Hensen affirms, is in my opinion scarcely possible, on account of the narrowness of the aqueducts and of the strong resistance in the cranial cavity.

The functions of the separate sections of the labyrinth have not yet been discovered, although by the labours of Helmholtz, Hensen, Ranke, Hasse, Exner, and others, great progress has been made in that direction.

As to the function of the sacculus vestibuli, it was formerly thought that it furthered the perception of noises, while the cochlear apparatus served for the perception of tones. This hypothesis appears to be refuted by the results of experimental examinations of the vibrations of the nervous expansion in the labyrinth. Ranke on microscopic examination of living heteropodes, during the action of sound observed the auditory cilia of the acoustic apparatus vibrating rapidly and moving towards the otoliths situated in the aural vesicle. Hensen observed in his experiments on crabs, that during the action of tones a certain number of cilia vibrated to certain tones. This experiment confirms the statement that we can perceive not only noises but in a limited degree also tones by the terminal apparatus on the macula and crista acoustica of the saccules and ampullæ, which may be regarded as analogous to the structures provided with auditory cilia in the lower animals.

The function of the otoliths may consist in a damping of sound.

The physiological significance of the semicircular canals has not yet been made out, notwithstanding numerous experimental investigations on this subject. The question of their relationship to the hearing function is still a subject of controversy. While formerly the solid angle which the semicircular canals standing perpendicularly to each other form, was believed to determine the capability of the organ of hearing to recognise the direction of sound, many physiologists regard these canals as of no importance for the perception of sound, but as an organ for co-ordinated movements.

The fundamental experiment, upon which the last opinion is based, was performed by Flourens. He observed, after division of the semicircular canals in pigeons and rabbits, considerable motor disturbances, which convinced him that these canals were the central organ for co-ordinated movements. It was seen from his, as well as from the later experiments of others, that separation of the horizontal semicircular canal is followed by lateral movements of the head with nystagmus and turning of the body round its vertical axis; that after injury of the sagittal semicircular canal, pendulum-movements of the head forwards and backwards and an inclination of the body backwards take place; and that, lastly, after injury of the superior semicircular canal, the animal falls forwards.

Notwithstanding numerous control-experiments, the views as to the significance of the symptoms after injury of the semicircular canals are very different.

While Goltz, Mach, Curschmann, Spamer, Breuer, and Crum-Brown, look upon the semicircular canals as the organ of the sense of equilibrium, and Cyon regards them as the organ of the sense of space, Loewenberg refers the symptoms mentioned to a reflex transmission of the irritation caused by the injury to the motor nerves of the thalamus opticus. In direct opposition to the views of these authors are the data of A. Böttcher, A. Tomaszewicz and Baginsky, which lead to the inference that all disturbances after injury of the semicircular canals proceed from a simultaneous injury of the cerebellum. Moos agrees with these latter (*Mening. cerebro-spin. epid.* 1881) on the basis of numerous observations made on patients. He agrees also with the opinion of Lussana and Berthold, according to which the disturbance of co-ordination after injury of the semicircular canals is called forth by the reflex transmission of the irritation from the ampullary nerves to the cerebellum, so that, as Stefani and Weiss affirm, a physiological connection exists between the ampullary and vestibular nerves and certain parts of the cerebellum. This view is supported by the results of experiments by irritative disturbance of the lateral lobes of the cerebellum, of the posterior part of the lobes of the cerebellum, and of the anterior part of the vermis superior cerebelli, by which the same pheno-

mena are brought about as by injury of the horizontal, the sagittal, and the superior semicircular canals respectively. Hogyes (Pflüger's *Archiv*, vol. xxxvi.) affirms that the vestibular terminations of the auditory nerve are a peculiar end-apparatus which regulates, according to the position of the head and body, the movements of the eyes and probably also those of all the muscles for the preservation of equilibrium.

That those symptoms are occasioned by irritation and not by destruction of the ampullary nerves is confirmed by Lussana's experiment, in which, after careful separation of the semicircular canals without coincident irritation of the ampullar and vestibular nerves, and even after destruction of the entire labyrinth, no disturbances of co-ordination were observed; further, in the experiments of Brown-Séquard and Schiff, the recognised symptoms were caused by irritation of the auditory nerve after injury of the semicircular canals, while the phenomena did not follow section of the nerve.

As to the function of the cochlea and of the separate parts of the complicated terminal apparatus, we have only hypotheses to go upon. Helmholtz is of opinion that the cochlea, as opposed to the vestibule and the semicircular canals, has a higher *rôle*, viz., the analysis of tune. Which part of Corti's organ, however, corresponds functionally to the stratum bacillosum of the retina, has not yet been ascertained. Helmholtz has abandoned his early idea that Corti's rods were the terminal apparatus of the auditory nerve, since more recent discoveries have contradicted it. Hasse found in birds, which possess the power of hearing musical tones and speech, that Corti's rods were wanting, while Corti's cells were developed. These cells, bearing on their upper ends auditory cilia (external and internal ciliated cells), in number estimated by Waldeyer at about 2,000, are now regarded as the terminal apparatus of the cochlea, since the direct connection of this structure with the terminations of the cochlear nerve was proved by Waldeyer and Gottstein

According to Hensen the membrana basilaris is the part of the cochlea from which the vibrations of the labyrinthine fluid are transmitted to Corti's cells. He bases this idea upon the fact adduced by him and Hasse, that the membrana basilaris is not of an equal width all over, but increases from the lowest winding of the cochlea to the cupola. According to Helmholtz, who confirms this statement, the membrana basilaris presents a system of cords corresponding to its stripes, of which for certain tones only a limited number vibrate. The perception of the high tones, therefore, is caused by the inferior section of the membrana basilaris, and the deep ones by the superior parts; and the observation made by Moos on atrophy of the auditory nerve in the first turn of the cochlea is also in favour of this. The co-vibration of a group of fibres must not, however, be considered

as isolated or clearly defined. It is more in accordance with the fact adduced by Helmholtz that, with an increasing height of tone, perception follows not in interrupted succession, but in gradual progression, probably because at every vibration of a certain group of fibres the neighbouring fibres also vibrate slightly.

Lastly, there remain to be mentioned some physiological peculiarities of the acoustic terminal apparatus.

By noises as well as by tones after-perceptions may be called forth in the ear; that is, perceptions of sound continuing for a short time after the action of the objective source of sound. Preyer remarks upon peculiar after-perceptions following the prolonged action of a tone, particularly upon the distinctly continued perception of pulsating noises. While Fechner regards after-perceptions as pictures of the memory, Urbantschitsch terms them positive after-images, being similar to the after-images of the eye. The latter observed in his experiments with low and high pitched tuning-forks, distinct after-perceptions in young people, almost never in persons over thirty. The intensity of the after-perception, which begins 10-20 seconds after the objective tone has ceased, and lasts sometimes $\frac{1}{2}$-1 minute, is always less than that of the objective tone. On the theory that these are positive after-images, it remains unexplained that they, as I have convinced myself, can only be noted in but a small number of individuals with sound ears.

The energy of the perception of the auditory nerve, as Dove first proved, is lessened after short action of the sound; the ear, as he expresses it, becomes wearied. Urbantschitsch found in his experiments that decrease in the perception takes place for the tone or group of tones which has struck upon the ear; but immediately thereafter other tones can be distinctly heard.

If a tone be conducted to both ears by means of a tube with two branches, the perception (acoustic picture), according to Purkinje and Thompson, is situated in the middle of the back of the head. More recent experiments differ a little from this, in so far as Plumendon has placed the region of perception in the forehead. Urbantschitsch, who has introduced the term 'subjective field of hearing' for this perception, found that the perception is sometimes also situated in the region of the naso-pharynx, and that the site of the subjective field of hearing varies not only in different individuals and with different tones, but that also in the same individual distinct lateral oscillations are observed in consequence of subjective changes in the intensity of acoustic perceptions.

As to the communications made by Urbantschitsch (Pflüger's *Archiv*, vol. xxv.) on the concord and discord of acoustic perceptions, I must remark that I have already pointed out these peculiarities of the acoustic apparatus at p. 165.

Of the physiological importance of the separate nuclei and roots of the auditory nerve little is known, and we need not enter into the various hypotheses, which are based upon certain reflex-phenomena proceeding from the auditory nerve, and further upon the fact that the N. vestibuli and N. cochleæ proceed with separate roots from the medulla oblongata in sheep and horses (Horbaczewski).

Of much greater interest is the recent hypothesis based on clinical observation and experiment (Munk, Ferrier) of the existence of a sensory centre of the auditory nerve in the temporal lobe of the cerebrum at a spot, however, whose anatomical connection with the nuclei and roots of the nerve has not yet been proved. Ferrier (*The Functions of the Brain,* German Translation by Prof. Obersteiner, 1879) observed on electric irritation of the superior temporal convolution on the exposed brain of cats, dogs, and monkeys a sudden elevation of the auricle of the opposite side, and on destruction of the temporal lobe deafness of the opposite ear. Munk arrived at the same results, which indicated a decussation of the fibres of the auditory nerve in the brain, by experiments on dogs (*Acad. d. Wissensch.* in Berlin, 1881). According to Munk, if the parts of the temporal lobe termed 'hearing-spheres' were removed, and the hearing organ of the same side destroyed, the animal would be totally deaf, and in a short time also dumb (?). Munk further believes, from a series of experiments, that the posterior part of the hearing-sphere serves for the perception of low tones, and the anterior section of the same in the neighbourhood of the fissure of Sylvius serves for the perception of high tones. That on the upper surface of the cerebral hemisphere there is no centre directly connected with the auditory nerve, follows from the experiments of Goltz, who, after destroying the cortex, observed no alteration in the hearing.

II.—DISEASES OF THE LABYRINTH, OF THE AUDITORY NERVE, AND OF THE CENTRAL COURSE OF THE NERVE.

Introduction.

The great advance in our knowledge of the pathology of the external and middle ears within the last ten years has not been equalled by that made in the pathology of the internal ear. On the contrary, in regard to the knowledge of anatomical changes and the diagnosis of the diseases of the internal ear, we are still at the beginning, notwithstanding the considerable number of interesting clinical and post-mortem observations made in recent times. The reason for this is that we have rarely an opportunity of making a thorough anatomical examination of the ears of

those who, having been clinically examined during life, present the phenomena of an affection of the nervous apparatus. Therefore it is that we possess, on the one hand, a series of interesting clinical observations of diseases of the inner ear, without being able to refer them with certainty to their anatomical changes; and, on the other hand, we have a large series of interesting post-mortem appearances of the internal ear, of which but a very small fraction refer to cases which were carefully examined during life.

Hence the great difficulty of a description of the diseases of the internal ear, which would in a very small measure correspond to the clinical necessity, and, therefore, a satisfactory study of the subject can only be made when by more numerous post-mortem investigations clinical observations can be brought into harmony with the anatomical changes. In the present incomplete state of our knowledge we must confine ourselves to the consideration of the diseases of the nervous apparatus partly on its anatomical and partly on its symptomatic side, without being able to assert that the anatomical and symptomatic bases overlap each other on every side.

The diseases of the internal ear are divided into primary and secondary affections. The primary affections—so far as can be judged—are out of proportion more rare than the secondary ones. Among the earlier observers nervous deafness formed a large percentage of their cases, as they classed all disturbances of the hearing, in which the examination of the membrana tympani and of the Eustachian tube gave a negative result, in the category of primary diseases of the auditory nerve (cf. Kramer, *Ohrenkrankh.* 1849). By the important investigations of Toynbee, however, the territory of 'nervous deafness' was considerably contracted, as in the majority of such cases with negative objective appearances the cause of the disturbance of hearing was referred to anchylosis of the stapes.

Diseases of the acoustic apparatus are caused by external influences (cold, injury, concussion) or by general and organic diseases. It is in the train of affections of the middle ear, however, that pathological changes specially develop in the internal ear. They must not always, however, be taken for secondary processes in the labyrinth and in the auditory nerve, for without doubt the affection of both sections of the ear may be frequently due to the same cause (p. 325).

Acute reactive inflammations of the middle ear are seldom combined with a simultaneous affection of the labyrinth. The development of the latter may be attributed to disturbances of nutrition, which are transmitted from the middle ear to the labyrinth by means of the anastomoses in the external wall of the labyrinth. The affection is characterized by great deafness with loud subjective noises, sometimes also combined with giddi-

ness and disappearance of perception for the acoumeter and the tuning-fork through the bones of the head (p. 392).

More frequently functional disturbances within the region of the auditory nerve are found in chronic, non-purulent affections of the middle ear. In the secreting forms the labyrinth, with few exceptions (to which belong particularly syphilitic catarrhs), remains intact. In the adhesive processes, on the other hand, particularly in the slow forms ending in anchylosis of the stapes, which develop without previous secretion, disturbances within the range of the auditory nerve appear not only after long duration, but frequently at the very beginning, and these may be regarded as simultaneous affections caused by the same trophic disturbances.

More rarely are functional disturbances in the apparatus of the auditory nerve, decreased perception of the nerve and subjective noises observed in the purulent perforative inflammations of the middle ear, and yet anatomical changes in the labyrinth appear more frequently in these processes, than, judging from the clinical phenomena, one would expect. Particularly in those suppurations in which the spongy substance of the pyramid of the petrous bone in the neighbourhood of the capsule of the labyrinth is affected with caries, extravasations of blood are found in the semicircular canals and in the cochlea, while during life no remarkable functional disturbances indicated the presence of such great changes.

Frequent causes of deafness from primary disease of the auditory nerve are those general and infectious diseases, such as typhus, scarlatina, syphilis, parotitis epidemica (Moos, Roosa, Hessler, Buck, Brunner), and others, which lead to disturbances in the centres or in the expansion of the auditory nerve, by the action of morbid blood.

In judging of so many disturbances of hearing it is of importance to note that amongst the nerves of sense the auditory nerve is the most 'impressionable,' that is, its function is more frequently impaired by general diseases and by chemical changes in the blood in infectious diseases than that of the optic, the gustatory, the olfactory, or the sensory nerves. The anatomical changes in the auditory nerve apparatus in the infectious diseases are, however, little known. In some cases hyperæmia and ecchymosis, in others small-celled infiltration of the membranous labyrinth, and in variola true suppuration (Moos), have been observed.

It is also known that the auditory nerve is more frequently affected by medicines circulating in the blood than the other nerves of sense. It is necessary only to mention the well-known effects of quinine, salicylic acid, morphia, and chloroform, which exercise a temporary but often also a lasting influence on the function of the auditory nerve, as in large doses or after long use

they give rise to subjective noises and deafness, and much more rarely to blindness.

According to Kirchner (*Berl. klin. W.* 1881), who after feeding rabbits with quinine found hyperæmia and hæmorrhage in the mucous membrane of the tympanic cavity and in the labyrinth, the pathological changes in the ear caused by quinine or salicylic acid may rank as vaso-motor disturbances, which bring about engorgement and exudation in the ear. Knapp (*Z. f. O.* vol. x. p. 279) in cases of blindness and deafness caused by large doses of quinine observed excessive paleness of the disc of the optic nerve with almost complete invisibility of the retinal vessels; and he believes that a similar state in the cochlea causes deafness, but this was not confirmed by Kirchner's experiment.

Of organic diseases those of the brain and its membranes are most frequently accompanied by disturbances of hearing, especially epidemic cerebro-spinal meningitis, hydrocephalus, acute and chronic encephalitis, cerebral tumours, less frequently diseases of the spinal cord. These are due either to the transmission of inflammatory processes from the cranial cavity to the labyrinth and the trunk of the auditory nerve, or to pressure on the auditory nerve and the bloodvessels supplying the labyrinth, and lastly to those diseases of the brain and medulla oblongata by which the nuclei and roots of the auditory nerve are drawn within the range of the disease.

Disturbances of function are further caused by stoppage of the circulation of the blood in the vessels of the head. In this case the anomalies of hearing may be traced to diseases of the heart and lungs, and to many forms of struma.

It was known to early writers that disturbances of hearing occurred in the course of affections of the stomach, liver, kidneys, and uterus. On the whole, however, according to my experience, this is much seldomer the case than is generally supposed; for I have often found in cases in which there was supposed to be a connection between the organic disease and the ear affection, that the fundamental cause is palpable changes in the middle ear. But even in the case of admitted disease of the auditory nerve, it must not on that account alone be connected with the organic disease, for aural and organic diseases may develop quite independently of each other. Notwithstanding, interchanges between those organic diseases and the organ of hearing cannot be denied. It has not yet been proved whether they, as is supposed, are caused by reflex transmission through the vagus and the spinal cord, or by changes in the sympathetic nerves. Certain it is that in a series of cases in the course of chronic organic diseases general disturbances of nutrition are developed in the organism, such as anæmia, hydræmia, and marasmus, of which the deleterious influence on the whole nervous system is well-known, and which doubtless by acting on the slightly

resistant auditory nerve may occasion an irritation or paralysis of it.

There may be found in the earlier writers allusions to the connection between certain organic diseases and ear affections. Sand (cited by Lincke) observed that in a man suffering from a gastric ulcer the pain radiated from the stomach to the ear. On the same authority Hippocrates is said to have proved the connection between disease of the liver and affections of the right ear. The connection between the uterus and the ear, also, which has received great attention in recent times, is said by Lincke to have been known to early physicians (Ebersbach (1725), Lanzoni, Gohl). In recent times there are observations on the same subject by Scanzoni, Benni (Warsaw), Gellé, Baratoux, and others. In several cases of suppressed menstruation Benni observed a vicarious exudation and bleeding from the middle ear. Baratoux (*Des Affections auriculaires et de leurs Rapports avec celles de l'Utérus*, Paris, 1881), from his own and Gellé's observations, comes to the conclusion that in the presence of purulent inflammation of the middle ear the occurrence of menstruation may aggravate the local affection, and in amenorrhœa vicarious bleeding from the ear may occur. Moreover, in consequence of suppressed menstruation and at the menopause cases of giddiness are observed associated with subjective noises and vertigo, which can be traced to an arterial fluxion in the vessels of the labyrinth.

Lastly, mental affections may also cause diseases of the auditory nerve apparatus. Although on the whole rare, such occurrences have been confirmed by experience, and in my own practice I have observed several cases of temporary or permanent tinnitus or of deafness caused by fright; for example, by an alarm of fire or by sudden grief. This is easily understood when one considers that mental affections are among the most powerful irritants of the vascular nerves (the constrictors and dilators of the vessels), that consequently, by a sudden disturbance of the circulation of the auditory nerve and its expansion, disturbances of nutrition (ischæmia, hyperæmia, stasis) may be brought about, manifesting themselves by symptoms of irritation or of paralysis.

Hereditary predisposition to diseases of the auditory nerve, as the numerous cases of inherited deafmutism prove, cannot be denied. On the whole, however, it is less commonly of etiological moment than in the affections of the middle ear.

Diseases of the internal ear occur more frequently in children than in adults. This is explained by the frequent occurrence in childhood of those forms of disease which are so frequently complicated with ear disease, such as the acute exanthems, acute hydrocephalus, epidemic cerebro-spinal meningitis, etc. Further, as an important anatomical element in the causation, it must be mentioned that the anastomotic connections between the middle

ear and the labyrinth on the one hand, and between that and the cranial cavity on the other, are more numerous in children than in adults; and further, that in the child's ear through the aqueducts there is a greater communication between the labyrinthine fluid and the cerebro-spinal cavity than in that of the adult. For this reason, as clinical experience shows, inflammatory processes in the middle ear and in the cranial cavity are much more frequently transmitted to the labyrinthine cavity in children than in adults. That the auditory nerve in childhood offers less resistance in febrile and infectious diseases than in later years has been placed beyond doubt by clinical observation.

While in middle age the frequency of diseases of the auditory nerve diminishes, in old age it again increases. As the anatomical basis of these disturbances of hearing in old age, retrograde changes in the auditory nerve and in its expansion are given (senile metamorphosis), atrophy, fatty degeneration, deposition of corpora amylacea, and chronic endarteritis.

The frequent occurrence of affections of the labyrinth in certain occupations, as in artillerymen, riflemen, smiths, locksmiths, coopers, etc., in consequence of intense or continued action of sound, has already been mentioned.

Affections of the auditory nerve attack, in the majority of cases, both organs of hearing, either simultaneously or at a shorter or longer interval. Disease of the auditory nerve is rarely localized permanently in one ear. According to my experience this is oftenest the case in unilateral paralysis of the nerve caused by a violent noise. As in affections of the middle ear, so in unilateral affections of the nerve, the danger of transmission to the other ear is the greater the higher the degree of disturbance of hearing. Similarly in cases in which disease of the formerly normal ear is added to a unilateral deafness, there is an unusually rapid decrease in the function of hearing. In what way the affection of one ear proceeds to the other has not yet been proved. The anatomical fact that the root-fibres of the one auditory nerve pass over into the external auditory nucleus of the other side (Meynert), permits the assumption that probably degenerative processes of the one auditory nerve may seize upon the centre and stem of the nerve of the other side.

The symptoms of affections of the auditory nerve manifest themselves partly as irritative phenomena, among which are reckoned first subjective sensations of hearing, then hyperæsthesia acoustica, giddiness, vomiting, and disturbances of equilibration, partly as paralysis-phenomena, consisting in diminution of the sharpness of hearing or in total deafness. In most cases symptoms of paralysis and irritation are combined.

The disturbances of hearing in the affections of the internal ear develop sometimes very quickly and sometimes very slowly. In some forms of disease, as in apoplectiform Menière's disease,

labyrinthine syphilis, cerebro-spinal meningitis, and in traumatic concussion of the labyrinth, the function of hearing is often quite suddenly or within a few days totally destroyed. In other chronic forms, on the other hand, particularly in those slow processes with retrograde changes in the auditory nerve and in the labyrinth, which, as we have seen, so often develop in the chronic adhesive processes in the middle ear, the hearing gradually but irregularly decreases. Long stationary intervals may follow a period in which the deafness progressively increases, or the slow course may be interrupted by sudden exacerbations.

The oscillations in the acuteness of hearing are generally slighter and less frequent in affections of the auditory nerve than in affections of the middle ear. Among causes affecting these are external influences, bodily illness, mental excitement, night-watching, strained attention while hearing (Toynbee), the use of alcoholic liquors, etc. I have already mentioned in my investigations on propagation of sound, etc. (*A. f. O.* i. p. 346, 1864), that in pathological cases oscillations in the quality of perception of the auditory nerve occur.

The subsequent conditions and terminations of diseases of the internal ear depend partly on their cause and partly on the intensity of the pathological changes. That a series of pathological processes in the labyrinth and in the auditory nerve may recede with complete re-establishment of the function of hearing is placed beyond doubt by clinical observation. On the whole, however, return to the normal state is rarer than in the affections of the middle ear. This is sufficiently proved by the slight resistance offered by the auditory nerve, particularly by its terminal organ in the labyrinth, to the action of disease-products. Hyperæmia in the labyrinth, the serous saturation of its structures, and probably small-celled infiltration also, may recede without leaving a disturbance of hearing behind. On the other hand, from clinical observation it is very probable that deep-seated changes, such as purulent inflammations, great effusions of blood, retrograde changes, etc., lead to a more or less rapid incurable disorganization of the auditory nerve with destruction of the function of hearing.

The prognosis of affections of this nerve depends on their cause, their duration, and intensity. It is unfavourable in the majority of cases. This applies particularly to sudden apoplectiform deafness, high degrees of affection of the nerve developing in the train of infectious diseases, cerebral disturbances of hearing, and slow affections of the labyrinth complicated with sclerosis of the mucous membrane of the middle ear.

A more favourable prognosis, on the other hand, is permitted in recent rheumatic paralysis, in slight concussions of the labyrinth, and in a limited sense in syphilitic affections of the latter.

Diagnosis of the Diseases of the Auditory Nerve.

The study of affections of the auditory nerve presents great difficulties in a considerable number of cases. This applies not only to the differential diagnosis between diseases of the middle ear and of the nervous apparatus, but also to decided affections of the nerve, in so far as it is often impossible to determine whether the disease is in the labyrinth, in the trunk of the nerve, or in its central course. Moreover, it must be remembered that affections of the middle ear and of the labyrinth are frequently combined, and that in such cases it cannot be determined what portions of the symptoms present and of the disturbance of hearing is to be attributed to the affection of the middle ear, and what to the disease of the labyrinth.

The diagnosis of affections of the auditory nerve depends chiefly on a consideration of certain symptoms and disturbances of hearing, and on the result of the functional examination. The latter is the most important, as Lucae rightly observes, because in most cases the detailed functional examination gives the first indication of an affection of the nerve.

To test the function of hearing we use the watch, the acoumeter, various tuning-forks, and other musical instruments, and lastly also speech. For the details of this examination the reader is referred to the Tests for Hearing, p. 162; the following are the results of the functional examination in diseases of the auditory nerve.

Testing with the Watch and the Acoumeter.—The determination of the hearing-distance by the watch and the acoumeter serves only to settle the difference of the disturbance of hearing on the two sides, and for judging of the degree of the disturbance of function. A determinate relation between the fixed hearing-distance and the hearing-distance for speech has not been obtained by examination.

Testing the power of perception for the watch and the acoumeter through the bones of the head is of more importance.* It must, however, be pointed out that diminution or suspension of perception through the bones of the head does not exclude the presence of an obstacle to the conduction of sound, but that this symptom appears very often in the chronic adhesive processes in the middle ear, in which the diminished mobility of the ossicles alone suffices to diminish the perception through the bones. A slight weakening of the perception of sound through the bones of the head must not be regarded as a symptom of an affection of the auditory nerve. In every case, however, in which a loud source of sound, for example the acoumeter, is but faintly or not at all heard through the bones of the head, one is justified

* This applies only to individuals who have not passed their sixtieth year (p. 175).

in assuming an affection of the nerve, without being able to determine whether it is primary or combined with an affection of the middle ear.

Testing with Tuning-forks.—Testing with tuning-forks is indispensable for the diagnosis of affections of the auditory nerve. As the power of perception for high and low tones appears altered to various degrees, it is better to use tuning-forks of different tones for testing the hearing. In my practice I use, besides the C tuning-fork with 512 vibrations, a C fork pitched in the bass and one pitched in alt. an A″. Lucae uses for testing the conduction of sound through the air very high tones in the fourth marked octave F $\sharp\sharp$ 4).

Sound-conduction through the Air.—In regard to the perception of the tuning-fork through the air, Bonnafont has already pointed out (*Compt. Rend. de l'Acad. des Sciences,* Mai, 1845) that in nervous deafness the power of perception for high tones first decreases, while low tones can be quite well perceived. His statements were confirmed by Moos and Lucae on the basis of post-mortem examinations of some cases of disease of the labyrinth examined during life, in so far as in affections of the auditory nerve the former attributed a particular diagnostic significance to failure of perception for high tones, the latter to failure of perception for low tones.

Although a certain diagnostic value must be attributed to this method of examination, still the diagnosis of an affection of the auditory nerve should not be based upon its result alone, for very often low tones are also better perceived than high ones in affections of the middle ear, and *vice versâ,* in undoubted affections of the labyrinth the perception of low tones sometimes more quickly decreases than that of high tones.

Perception of the Tuning-fork through the Bones of the Head.—As to the perception of the tuning-fork through the bones of the head, we know that the key-note of the tuning-fork, placed on the vertex, is better perceived on the affected side in cases of obstacles to the conduction of sound; and on the other hand, in affections of the nerve not combined with disease of the middle ear, it is more strongly perceived on the unaffected side. Although in a series of cases of obstacles to the conduction of sound, the tone of the tuning-fork may be perceived through the bones of the head more loudly by the better-hearing ear, yet the failure of perception for the tuning-fork on the affected ear—obviously only with simultaneous regard to other circumstances indicating an affection of the nerve—is of important diagnostic significance.* This method of examination gives, however, more certain indications than Rinne's experiment, recommended in

* The examination is sometimes rendered difficult by patients not being able to determine whether they hear or feel the tuning-fork (pp. 182-184).

recent times by Lucae for differential diagnosis between affections of the middle ear and those in the nervous apparatus.

Rinne's Experiment.—This experiment consists in setting a tuning-fork (pitched in the bass C) on the vertex or on the mastoid process, and allowing it to vibrate till the note is no longer heard; the prongs of the fork are then brought close to the ear, and in normal circumstances the tone will be heard again (positive experiment). In those disturbances of hearing in which Rinne's experiment turns out positive, according to Lucae there is an affection of the internal ear. When, on the other hand, it is negative—that is when the fork, removed from the bones of the head and brought in front of the ear, is no longer heard—there is a disturbance in the sound-conducting apparatus. The latter does not exclude, however, a simultaneous affection of the nervous apparatus.

This, in some cases, certainly valuable method, if employed alone gives just as uncertain information concerning an affection of the auditory nerve as those already mentioned. In numerous cases in which the objective examination determined the presence of an affection of the middle ear with and without perforation of the membrana tympani, I found a positive result of Rinne's experiment; while again in other cases in which the whole combination of symptoms and the other methods of testing were in favour of an affection of the labyrinth, the experiment resulted negatively. But in failure of perception for the watch and the tuning-fork through the bones of the head, however, the diagnosis of a nervous affection will always be supported by the positive result of Rinne's experiment.

Gellé's Experiment.—Lucae's observation, that by compression of the air in the external meatus, perception for the watch and the tuning-fork through the bones of the head is diminished, was used by Gellé (*Transactions of the Intern. Med. Congress, London,* 1881) in the performance of an experiment, by which, according to his statement, the differential diagnosis between affections of the middle ear and of the labyrinth can be made. If the air in the meatus is condensed by means of the rarefying apparatus described on p. 300, the tone of a tuning-fork, brought into contact with the india-rubber tube or the bones of the head, will be decidedly weakened.* If an obstacle to the conduction of sound exist, in a case of anchylosis of the stapes, for example, according to Gellé, the tone remains unchanged during the experiment; if, on the other hand, the labyrinth is affected and the stapes movable, at every condensation there will be a feeling of giddiness and noises in the ear—in a word, symptoms of an increase of pressure in the labyrinth.

Since, however, Gellé has omitted to note, that at every inward

* According to my experiments, it was most noticeable when the tuning-fork C = 512 during the experiment was held close to the ear.

curvature of the membrana tympani by condensation of air in the tympanic cavity, there is also pressure exercised on the membrane of the fenestra rotunda, that therefore, even in cases of fixture of the stapes, the labyrinthine pressure can be increased by this experiment, and that further, dulling of the tones in this experiment is caused by the increased tension of the membrana tympani, therefore that degree of diagnostic value cannot be attributed to this method which its author demands for it. The facts repeatedly confirmed by me, that in the majority of middle ear affections not combined with great deafness, the tone of the tuning-fork is also weakened by condensation of air in the external meatus, and that, on the contrary, in affections of the labyrinth, with great disturbance of hearing, the tone of the tuning-fork often remains unchanged, witness against the trustworthiness of this method.

In regard to the prognostic significance of the examination with the tuning-fork, Bonnafont is of opinion that with failure of perception for the tuning-fork, recovery, or a material improvement in the hearing, is not conceivable. I can confirm this opinion in the case of chronic affections of the auditory nerve. In recent affections, on the other hand, as I have several times observed, recovery may occur although the tuning-fork is not perceived through the bones of the head. According to Moos, the return of perception for high tones may be regarded as a favourable sign.

Testing with Musical Tones.—Besides using the tuning-fork, it is recommended to examine the perception of the ear for other musical tones, especially when the result of the previous examination is doubtful. This is done by means of an harmonium, a piano, or pitch-pipes used by musicians for tuning their instruments, consisting of four reed-pipes with the tones G, D, A, E, of which G is used for testing the low, and E the high tones. For testing with very high tones, besides the tuning-forks in the fourth marked octave, Galton's whistle and König's steel cylinder are used.

The result of this method of testing the hearing frequently agrees with that of the tuning-fork, but not unfrequently the results of testing with various musical instruments in regard to the better perception of low and high tones are completely contrary.

Testing with musical tones of various heights is of diagnostic importance in so far as the presence of partial tone-defects may be detected. Moos observed in an orchestral conductor sudden deafness for low tones (bass deafness) in consequence of a concussion of atmospheric pressure acting upon both ears; Schwartze observed in a musician permanent loss of perception for high tones in consequence of the whistling of a locomotive; Burnett likewise observed deafness for high tones above C‴ in a lady forty-four years of age, who had suffered from otalgia since child-

hood; and Gottstein observed want of perception for high tones above C‴ in a man aged forty-seven years. In an orchestral conductor aged fifty-one years, examined by me, in whom noises in the ears had commenced a year previously, and attacks of giddiness came on later, total deafness set in very quickly, first on the right side and then on the left. On testing with musical tones it was found that he heard only the low tones on the left ear, but on the right the whole scale, still in the middle the B and F were quite wanting. The absence of single tones in the middle register is rare. If, in such cases, the ear be provided with the corresponding Helmholtz's resonator, it is found that there is rarely total deafness, but only a lessened perception for the tones indicated. Although such tone-defects probably indicate an affection of the nerve, they by no means exclude the simultaneous existence of an obstacle to the conduction of sound. This is seen from a case described by Magnus (*A. f. O.* ii.), in which the tones F, F♯, G, G♯, A♯, B in the first-marked octave were not heard, the cause being supposed to be partial paralysis of the organ of Corti. Post-mortem examination revealed anchylosis of the stapes and calcification of its foot-plate. Concerning the finer changes in the labyrinth there are no details.

Audiphone.—Recently, experiments on the diagnostic value of the audiphone have been undertaken.* The improvement in the hearing which is in some cases effected by it cannot be regarded as a sign of the existence of an obstacle to the conduction of sound, as in several cases of undoubted affection of the labyrinth I have also observed a marked increase of the hearing-distance on the application of the audiphone to the upper incisor teeth. The microphone is of as little diagnostic value in its present form.

Testing the Hearing for the Understanding of Speech.—Functional testing for the understanding of speech is of no service in the diagnosis of an affection of the labyrinth. It is not yet known whether the perception of single vowels or consonants is especially lessened in affections of the nervous apparatus. Even total deafness for speech is no sure sign of paralysis of the nerve, as cases occur in which, after the use of the air-douche or after the application of the artificial membrana tympani (p. 496), the formerly complete inability to understand speech for a short distance returns, when the deafness was also partly caused by increased labyrinthine pressure from the side of the tympanic cavity. Yet, total deafness for speech forms along with the other symptoms an important element in the diagnosis of an affection of the labyrinth.

Transference.—Numerous experiments in recent times have shown, that in certain forms of hemiplegia and hemianæsthesia, particularly in hysterical individuals, after the application of a

* The description of the audiphone is to be found in the section on Hearing Instruments, at the end of this work.

magnet or of a piece of metal to any part of the affected side, the paralysis or anæsthesia transfers itself in a short time to the corresponding part of the unaffected half of the body. The mobility or sensibility returns simultaneously in the parts of the affected side that have been touched. After removal of the magnet the former state returns.

The phenomena of transference were also observed by Charcot and Gellé in unilateral affections of the ear. The action of the magnet is most pronounced in hysterical people, in whom, during the experiment, the deaf ear hears, and the formerly normal ear becomes temporarily deaf. Urbantschitsch was able, in the case of an hysterical patient, to induce the phenomena of transference with the magnet, as well as by the inhalation of nitrite of amyl, and by the exhibition of a skull.

The results of the experiments which I have recently performed with the magnet have been of no diagnostic value, as the phenomena of transference occur in the affections of the middle ear as well as in those of the auditory nerve. In the majority of cases the magnet placed on the mastoid process and on the anterior region of the ear has no effect. In many cases of unilateral ear disease the subjective hearing-sensations transfer themselves to the opposite side, to return again to the diseased ear after removal of the magnet. Much more rarely is it observed that during the experiment there is an increase of the power of hearing in the diseased, and a decrease in the normal ear. On the other hand, several times in bilateral ear affection I observed an increase in the hearing-distance on the more affected side on placing the magnet on the less affected ear.

Condition of the Membrana Tympani, and Examination of the Eustachian Canal.—The examination of the membrana tympani and of the Eustachian tube is of diagnostic value only when the results are negative and the cases recent. In cases of disturbance of hearing of recent, sudden origin and of high degree, should the membrana tympani be found normal, and the Eustachian tube permeable throughout, an affection of the auditory nerve may with great probability be regarded as the cause of the disturbance, especially when, at the same time, it is indicated by the hearing-tests. In chronic cases, on the other hand, the normal state of the membrana tympani and the permeability of the tube afford no diagnostic help, as such negative conditions often occur in anchylosis of the stapes (p. 337).

The presence of coarser changes on the membrana tympani, with symptoms of an affection of the auditory nerve, points generally to an affection of the middle ear and of the labyrinth. Lucae, however, rightly observes that palpable structural changes on the membrana tympani are no sure criterion of the existence of an obstacle to the conduction of sound; for, with a markedly morbid appearance of the membrana tympani, in some cases he

has found no change in the tympanic cavity as the cause of the disturbance of hearing, but changes in the labyrinth, facts which I can confirm from my own experience.

Influence of Condensation of Air in the Middle Ear on the Change in the Acuteness of Hearing.—It has been supposed till now that, in diseases of the nervous apparatus, no change is effected in the hearing-distance by inflation of the middle ear, and that consequently when the hearing-distance is increased after inflation, the diagnosis must be an affection of the middle ear. This supposition is erroneous. In many cases, where the whole complex of symptoms and the course of the disturbance of hearing indicated an affection of the nerve, I found an increase, more rarely a decrease, in the hearing-distance after condensation of air in the middle ear, and also after rarefaction of air in the external meatus. The reason of this is quite apparent, when it is considered that through tension-changes in the middle ear, oscillations of pressure are produced in the labyrinth which, without doubt, have an influence on the acuteness of hearing. As a rule, however, the change in the hearing-distance, after inflation in an affection of the nerve, is very limited; therefore, when the increase is considerable in doubtful cases, the affection may be regarded as one of the middle ear.

Condensation and rarefaction of the air in the external meatus (p. 299) by which, as we have seen, fluctuations of the pressure of the labyrinthine fluid are caused, have also, as I have frequently shown, an influence on the hearing-distance in affections of the auditory nerve, but by no means in the same degree as in anomalies of tension in the middle ear.

Diagnostic Value of the Labyrinthine Symptoms.—The diagnostic interpretation of the already sketched (p. 689) complex of symptoms in affections of the auditory nerve is beset with difficulties, when we have to determine whether they are caused by a primary affection of the nerve, or secondarily by an affection of the middle ear, or lastly by an affection of the brain. We have seen that, in affections of the middle ear also, violent noises in the ears, disturbances of hearing, dizziness, and disturbances of equilibration may be called forth by hyperæmia transmitted to the labyrinth, or by increase of pressure in consequence of clogging of the fenestræ of the labyrinth, and that similar symptoms may also occur in diseases of the brain. Consequently the so-called labyrinth symptoms alone are of as little value for fixing the diagnosis as the points already discussed. The same applies to the development and course of the disturbance of hearing, of which I seldom receive trustworthy accounts from patients.

Examination of Disturbances of the Central Nervous System.—In conclusion, it is of importance to note that in all cases of disturbance of hearing, in which suspicion of an affection of the

central nervous system is awakened by the complex of symptoms, a minute examination of the sensibility and mobility of both sides of the body, of the state of innervation of the facial, hypoglossal, and trigeminus nerves, of the state of the tendon reflexes, and further, of the fundus oculi, etc., should be undertaken.

From what has been said it is therefore clear that neither the enumerated diagnostic guides, nor the peculiarity of the subjective symptoms, and of the course of the disturbance of hearing alone, are sufficient for determining the diagnosis of an affection of the nerve. On the other hand, experience shows that only the total impression given by the results of the above methods of examination, together with the causative conditions of the disturbance of hearing, with the peculiarities of the course and symptoms of the disease, can determine the diagnosis of an affection of the auditory nerve.

Special Division.

1. *Hyperæmia of the Labyrinth.*

Hyperæmia of the labyrinth is but rarely limited to that section of the ear, being generally combined with congestion of the middle ear and of the cranial cavity.

The greatest hyperæmia of the labyrinth occurs, according to clinical and anatomical observations, in acute purulent inflammation of the middle ear with violent reactive phenomena, especially in the scarlatinal and typhoid forms. On the dissection of such cases, the congestion is found to be greatest on the external wall of the labyrinth, and in the first winding of the cochlea, and the redness seldom spreads equally over the whole lining membrane of the labyrinth, on the saccules, the semicircular canals, and the lamina spiralis.

As causes of labyrinthine hyperæmia we must mention: the acute exanthemata, typhus, mumps, pneumonia, meningitis, and encephalitis; tumours of the base of the brain, which impede the exit of blood from the inner ear; congestion of the head in consequence of diseases of the heart and lungs; angioneurotic congestions in the vessels of the head (caused by the sympathetic nerve); intra-cranial affections of the trigeminus and of the medulla oblongata (Baratoux); lastly, the use of certain medicinal substances, as quinine, salicylic acid, and especially nitrite of amyl.

Hyperæmia of the labyrinth, according to its intensity and duration, causes temporary disturbances of nutrition or permanent anatomical changes. Among the latter may be reckoned the pigment-exudations in the labyrinth, which are seen so often in chronic inflammation of the middle ear, the deposition of cal-

careous salts, and the thickening of the membranous structure of the labyrinth.

The clinical symptoms of hyperæmia of the labyrinth in its more intense forms are subjective noises, giddiness, stupefaction, feeling of fulness in the ears, and dizziness, nausea, vomiting, and unsteadiness of gait. During the continuance of the congestive symptoms, the inner section of the osseous meatus and the vascular leash of the handle of the malleus are often found injected, a state which indicates a general congestion of the ear. (See my *Beleuchtungsbilder des Trommelfells*, 1865, p. 38.) Sometimes this is combined with redness of the face and of the auricle. Without doubt, however, hyperæmia of the inner ear may exist without perceptible injection of the external ear and of the membrana tympani. The hearing-function is either not at all altered, or only temporarily so.

The diagnosis of hyperæmia of the labyrinth may be looked upon as probably correct, when, besides the above subjective symptoms, the objective proof of an excess of blood in the ear is found in the state of the membrana tympani. Hyperæmia of the labyrinth, combined with temporarily recurring congestion of the brain, is distinguished from Menière's disease, with which the symptoms have much similarity, by their rapid subsidence without permanent destruction of hearing.

More difficult is the differential diagnosis between hyperæmia of the labyrinth and of the brain, as by congestion of the brain, as well as by irritation of the acoustic centres, similar symptoms may be occasioned. It is, therefore, only when there is objective proof of an excess of blood in the ear that the existence of hyperæmia of the labyrinth can be absolutely determined; but the possibility of a simultaneous hyperæmia of the brain participating in giving rise to the combination of symptoms is always also to be borne in mind.

In acute inflammations of the middle ear, simultaneous hyperæmia of the labyrinth may be inferred, when, besides loud subjective noises and deafness, perception for the watch and the acoumeter through the bones of the head is absent, if those phenomena in spite of inflations and removal of exudation from the tympanic cavity do not recede immediately, but only later with the decrease of the inflammation of the middle ear.

Hyperæmia of the labyrinth, developed in the course of infectious diseases, cannot be diagnosed. The cause of the disturbance of hearing will be presumed to have been hyperæmia of the labyrinth or of the acoustic centres, possibly with serous saturation and small-celled infiltration of the structures, if during convalescence the normal function of hearing returns.

The treatment depends on the cause. If the symptoms occur without congestion of the brain, redness of the face, and increased

temperature of the head, but with decided injection of the vessels of the handle of the malleus, an endeavour is made to alleviate the symptoms by derivation to the mastoid process. Sometimes the repetition of an alcoholic embrocation is sufficient (spirit aromat., spirit. formicar., spirit. sinapis., āā 30·0.; sig. a teaspoonful to be rubbed in every hour) to lessen the intensity of the noises and the attacks of giddiness. In more obstinate cases the skin over the mastoid process is laid bare by a fly-blister and anointed with tartarated-antimony ointment. Where symptoms of congestion of the brain are absent, after the use of local bleeding I have often observed an increase of the giddiness and noises.

If symptoms of hyperæmia of the labyrinth occur simultaneously with decided signs of congestion of the brain, cold applications to the head (of which the best is Leiter's apparatus), alcoholic embrocations behind the ears, warm foot-baths, purgatives, and in more severe cases local bleeding at the mastoid process, are recommended. As such attacks return at longer or shorter intervals, everything which might occasion a recurrence of the congestion should be guarded against. For such patients a regular mode of living should be prescribed: several hours' exercise in the open air daily, a simple, easily digested diet, and restrictions in the use of alcoholic and carbonated liquors, as well as of tobacco, which should be only very moderately indulged in. When there is an inclination to constipation the use of mild mineral aperient waters is to be recommended (Ofner, Hunyadi Janos, Püllna). Sometimes cold friction is very advantageous, while, on the other hand, affusions to the head and cold douches are decidedly injurious. In angioneurotic forms galvanization of the sympathetic is indicated. When subjective noises predominate, large doses of bromide of potassium are useful, and in great giddiness sulphate of quinine in ½-1 gram. doses is of great service.

2. *Anæmia of the Labyrinth.*

Anæmia of the labyrinth is most frequently a part of a general anæmia. The irritation and paralysis of the auditory nerve induced by it occur usually after sudden anæmia, as after childbirth, great loss of blood, severe acute diseases, more rarely in chlorosis and in anæmia caused by chronic diseases. Anæmia of the internal ear is seldom the result of an angioneurosis (vascular spasm) due to the sympathetic, a point upon which we will again touch in speaking of neuroses of the internal ear.

Anæmia localized to the labyrinth may depend upon an impediment to the circulation in the internal auditory artery.

Such impediments are aneurism of the basilar artery, growths projecting from the dura mater or the brain into the internal auditory meatus and compressing the internal auditory artery; further, emboli of the artery, which as Friedreich observed in one

case, caused sudden deafness; and lastly, the contraction of the artery caused by atheromatous deposits. It is probable that this condition, under the name of chronic endarteritis, frequently extends in elderly people into the vessels of the labyrinth and there forms the foundation of disturbances of hearing. In a man, aged seventy, who had suffered for a number of years from loud subjective noises combined with moderate deafness, after sudden death caused by rupture of the aorta, it was found that besides extensive chronic endarteritis there were deposits in the basilar artery, from which the condition extended into the internal auditory artery.

Disturbances of hearing arising in the course of great losses of blood are doubtless to be traced to anæmia of the nervous apparatus of the ear. Anæmia of the labyrinth must also have a share in this as well as anæmia of the central source of the auditory nerve. In recent cases the anatomical changes are certainly very insignificant and very transitory. This is confirmed by the necroscopy of a case of deafness, after great loss of blood, observed by Urbantschitsch, in which no anatomical changes were seen either in the brain or in the organ of hearing. Whether in chronic anæmia retrograde changes develop in the auditory nerve, must be shown by further examination.

The symptoms of anæmia of the internal ear after sudden great loss of blood and in the angioneurotic form, are intense noises in the ears and great deafness, accompanied by giddiness, fainting-fits, and vomiting. The whole complex of symptoms is similar to that of sea-sickness, and can be partly traced to simultaneous anæmia of the brain. The phenomena recede more or less quickly with the disappearance of the anæmia. In disturbances of hearing associated with chronic general anæmia, the most prominent symptoms are subjective noises and deafness. These often vary with the varying contents of the bloodvessels of the head, as with congestion after joyful emotions, after the use of alcoholic liquors, and in the recumbent position. Abercromby's case, cited by Lucae, is very interesting; it is that of a man aged thirty, debilitated by an affection of the stomach, who was deaf while sitting or standing, but could hear quite well when he was in a horizontal position.

The treatment of anæmia of the internal ear depends on its cause. The aural symptoms after great loss of blood require no local treatment, as they recede with the disappearance of the general anæmia. In the angioneurotic forms the internal use of bromide of potassium and of quinine, and galvanization of the sympathetic in the throat, are recommended. In chronic general anæmia, besides strengthening diet and residence in Alpine air, the internal use of easily-digested iron remedies, such as mineral waters containing iron, is to be advised, and when circumstances permit of it, a course of iron baths is of good service.

3. *Hæmorrhage into the Labyrinth.*

The Apoplectic Form of Menière's Disease.

Small extravasations in the labyrinth occur as a consequence of severe and rapidly-developed hyperæmia, most frequently in the course of typhus, variola, scarlet fever, and mumps (Toynbee), with or without simultaneous ecchymosis on the mucous membrane of the middle ear. The rupture of the bloodvessels is favoured by atheromatous degeneration of the arteries and by chronic congestive hyperæmia from disease of the heart.

The sites of the ecchymoses are most frequently the lamina spiralis and the external surface of the modiolus, more rarely the saccule of the vestibule and the ampullæ. The extravasated blood may be absorbed, or the blood-colouring matter may remain as granular or flaky pigment.

Larger effusions of blood into the labyrinth result: (1) From fractures of the skull and fissures of the petrous bone. In one case observed by me (*A. f. O.* vol. ii.), in which a fissure proceeding from the back of the head passed through both petrous bones, total deafness set in with symptoms of the apoplectic form of Menière's disease, in consequence of a great effusion of blood into the cavity of the labyrinth. Lucae observed after fissure of the petrous bone simultaneous effusion of blood into the labyrinth and into the tympanic cavity. (2) From severe concussion of the skull, as is proved by a case of gunshot-fracture of the mastoid process observed by Moos (*A. f. A. u. O.* vol. ii.), in which without lesion of the labyrinth an effusion of blood was found in it. (3) From extensive carious processes in the temporal bone, particularly from caries and necrosis of the pyramid of the petrous bone (Knapp). In several such cases, in which the capsule of the labyrinth was not injured, I found a few sections of the labyrinth, especially the cochlea, covered with blackish-brown extravasated blood. In a man who died from otitic meningitis, in whom the capsule of the labyrinth was not eroded, on microscopic examination of the labyrinth I found the superior semicircular canal (*a*), including the ampulla (Fig. 244), partly filled by effused blood (*b*), which surrounded the membranous semicircular canal (*c*), also filled with blood. The vestibule and cochlea were quite free. (4) From diseases of the brain and its membranes, particularly from meningitis. In a case, described by Moos (*Z. f. O.* vol. ix.), of deafness in the course of a hæmorrhagic pachymeningitis, there were found on both sides on different parts of the labyrinth, on the utricle, Rosenthal's canal, between the folds of the lamina spiralis ossea and the zona dentata, smaller and larger hæmorrhagic infiltrations, following the course partly of the veins and partly of the nerve fibres. Lucae found in a boy four years old, who had become totally deaf in the course of tuber-

cular basilar meningitis, hæmorrhagic inflammation in the semicircular canals and vestibules of both ears.*

The results of labyrinthine hæmorrhage are: absorption, in which, according to Moos, the lymph passages also take part; inflammation, with its termination in suppuration (case of the author's) or in organization of the exudation, or, lastly, in atrophy and degeneration of the epithelium, the connective tissue and the nervous elements, with an abundant formation of granular cells, hyaline corpuscles and pigmentary deposits.

According to Moos, the pigmentary metamorphosis of the ex-

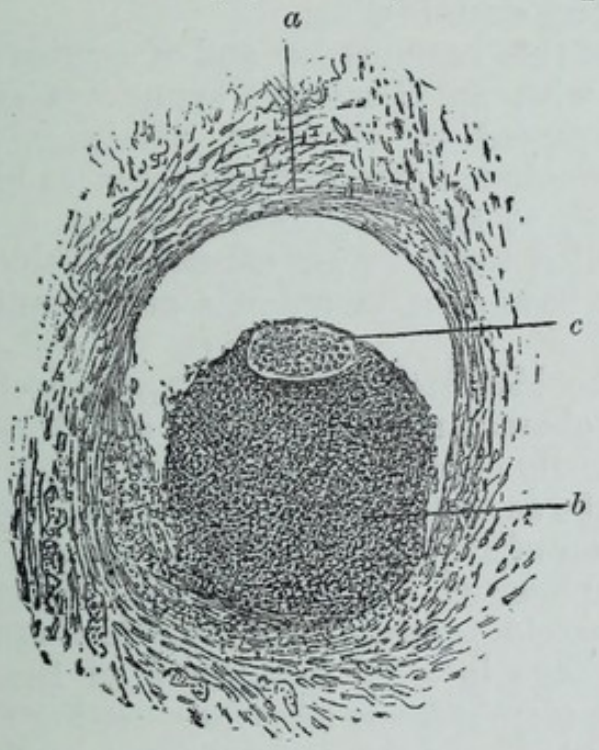

FIG. 244.

a, Section of the osseous semicircular canal; *b*, Extravasated blood; *c*, Section of the membranous semicircular canal.

travasated blood in the labyrinth is sometimes extra-cellular, sometimes intra-cellular (through cells containing blood-corpuscles). The form and colour of the pigment present the same varieties as in other situations. Since in normal circumstances also, pigment is frequently found in the cochlea in various quantities, it is only great accumulations of pigment in the labyrinth that are of pathological importance (Schwartze).

The *functional disturbances* to which extravasations of blood into the labyrinth give rise, are but little known on account of the extremely scanty records of post-mortem examinations of cases,

* Whether labyrinthine hæmorrhage can be caused by pathological changes in the vasomotor centre, clinical and anatomical observations alone can show. In favour of the possibility of such an occurrence are the experiments of Laborde and Duval (Baratoux, *Pathogénie des Affections de l'Oreille*, Paris, 1881), who, after repeated puncture in certain parts of the medulla oblongata, found an effusion of blood in the cochlea.

the course of which had been minutely observed during life. The first detailed clinical observation with a post-mortem report was published by Menière (*Gaz. Méd. de Paris*, 1861); it concerned a young girl, who, in consequence of exposure to cold at the time of her catamenia, became completely deaf, with symptoms of violent attacks of giddiness and vomiting, and who died on the fifth day afterwards. The necroscopy showed the brain and spinal cord to be unchanged, but the semicircular canals filled by a reddish, plastic exudation, extending somewhat into the vestibule, while the cochlea was normal. The cause of death was not explained by the post-mortem examination.

On the basis of this examination and of a series of other clinical cases, in which with apoplectiform symptoms sudden deafness occurred, accompanied by dizziness, vomiting, and subjective noises, Menière concluded that in these cases we have to deal with a peculiar disease of the labyrinth, in which a combination of symptoms is called forth by an effusion of blood or an acute exudation, as we have seen in animals after injury of the semicircular canals.*

Although, since Menière's publication, apoplectiform deafness, accompanied by characteristic symptoms as described by him, has often been clinically observed and described by aural surgeons, there is still doubt as to the correctness of strictly localizing the above combination of symptoms in the labyrinth.

Moos has emphasized the fact that, in his case of gunshot injury of the mastoid process with total deafness, notwithstanding the hæmorrhage into the periosteum of the internal cavity and in the whole membranous labyrinth, neither subjective noises nor giddiness existed; and these symptoms were also absent in the case, described by Lucae, of hæmorrhagic inflammation of the labyrinth in the course of a tubercular basilar meningitis. On the other hand, a case of Oscar Wolf's (*Z. f. O.* vol. ix.) shows that Menière's combination of symptoms may also be caused by cerebral diseases, the cause of the case in question having been found to be a tumour in the amygdala of the cerebellum and a second swelling in the cerebral cortex.

Although it is not permissible to take the post-mortem appearances of Menière's isolated case as the anatomical basis of apoplectiform deafness observed so frequently, yet, on the other hand,

* In a case observed by me (*Allg. Wien. med. Ztg.* 1862) of a woman, aged fifty-six years, who, fourteen years previously, became suddenly deaf with symptoms of apoplectiform Menière's disease with temporary unconsciousness, post-mortem examination showed an osseous growth on the external wall of the labyrinth, the origin of which was with probability referred to a hæmorrhage of the periosteum at that place. On the left, the osseous growth had quite grown over the fenestra ovalis and become adherent to the stapes-plate; on the right, the anterior part of the fenestra ovalis was free from the osseous mass, the stapes was movable. Power of hearing nil on the left; on the right, speech understood quite close to the ear. Nothing is known as to the origin of the exostoses in the vestibule described by Platner (cited by Schwartze) and Toynbee.

the number of cases of effusion of blood into the labyrinth, without Menière's combination of symptoms, is too small to allow of the assertion that the affection is not principally caused by a bleeding or exudation into the labyrinth. Then it is not the bleeding and exudation alone, but their effect on certain structures of the membranous labyrinth that testify to the occurrence of the phenomena. It can be easily imagined, that where, through the effusion, the ampullary nerves are irritated, Menière's symptoms will appear in a decidedly high degree, while they may be quite wanting when the effusion of blood does not act immediately on the vestibular and ampullary nerves.

These considerations may justify the discussion here of this clinically interesting form of disease. While we admit that a series of symptoms, as they appear in Menière's disease, may be due to various changes in the organ of hearing and in the brain, we must state that we designate by the term Menière's disease, only cases of sudden apoplectiform deafness occurring with the already mentioned symptoms; but in recent times all disturbances of hearing associated with subjective noises and giddiness have been called Menière's disease or Menière's complex of symptoms, disturbances of hearing, which, as we have seen, are also frequently observed in accumulations of cerumen through vegetations in the external meatus (Hilairet), in affections of the middle ear, in many temporary congestions of the labyrinth and brain, after injuries and in tumours of the brain.

Symptoms and Course of Menière's Disease. — Menière's disease occurs either with the symptoms of an apoplectiform congestion of the brain or a decided apoplectic attack. It begins either with giddiness, tinnitus, an inclination to vomit or actual vomiting, staggering gait and great deafness, or with sudden loss of consciousness, which returns, however, in a short time with paleness of the face and cold perspiration, also bilateral (seldom unilateral), deafness accompanied by great noises, and on trying to rise there is an inclination to vomit, great giddiness and inability to walk steadily.* Knapp observed, after the attack, temporary dimness of vision, and Moos transitory hemiopia with horizontal line of separation.

The affection mostly attacks strong robust individuals with previously normal hearing; but rarely there exist for a longer or shorter period before the attack, tinnitus, slight giddiness, and deafness. Brunner considers great heat as the cause of such attacks. In one of my cases the attack occurred during exposure to the excessive heat of the sun while walking. Gottstein ob-

* The loss of consciousness is, according to Bull, possibly only the effect of mental depression. The oppression and asphyxia, as well as the vomiting, are traced by Moos and McBride to reflex action through the vagus. Hughlings-Jackson accounts for the excessive paleness, the cold perspiration, unconsciousness and vomiting, by the intimate relations of the nuclei of the auditory nerve with those of the vagus and the spinal accessory.

served three cases of apoplectiform deafness; once combined with tabes, and twice with leukhæmia.

Examination of the ear shows usually a negative condition of the membrana tympani and of the Eustachian tube, and a minute examination of the nervous system shows no disturbance of function in the region of the cerebral and spinal nerves.

The function of hearing is either completely destroyed or so impaired that only very loud noises in the immediate neighbourhood of the ear can be perceived; perception through the bones of the head for the watch and the acoumeter is always absent. The tuning-fork placed on the vertex is either not heard at all, or very indistinctly so in bilateral affections, and in unilateral affections it is always heard only in the normal ear. Three cases of deafness for certain tones, observed by Knapp, are very interesting.

The course of Menière's disease depends on the intensity of the affection. Of the alarming phenomena at the beginning the unconsciousness and vomiting pass away first, while the giddiness and disturbance of equilibrium, as a rule, diminish after some days, only so far that the patient can walk a little way, either assisted or by the help of a stick. As a rule, the body inclines towards the affected side in walking. The disturbance of equilibrium appears most noticeable in the dark and in walking with closed eyes, even in the slighter degrees the same unsteadiness of gait appears as is observed in high degrees of ataxia. I can confirm from my own experience the observation made by Guye, that in the beginning of the disease the handwriting becomes completely changed like that of a trembling old man. With the decrease of the dizziness, and the staggering in the gait, the writing regains gradually its former character. Besides the symptoms mentioned, in the first week of apoplectiform deafness there are mental depression, slowness of thought, and weakness of memory.

In patients in whom no relapse occurs after the first attack, the giddiness and disturbance of equilibration gradually disappear after some weeks or months. The staggering in the gait may continue for years, according to various observations (according to Nave, over ten years). The loud singing and hissing in the ears and head after some time decrease in violence, but may also continue unabated throughout the whole lifetime, even with total deafness. The deafness remains mostly unchanged, and only in a very few cases is there a slight improvement, which remains permanent or undergoes impairment after some months or years. Sometimes the affection ceases after the first attack without relapse, but I have seen cases in which, after several days, or even after weeks or months, new attacks of giddiness and vomiting occurred with increase of the other symptoms.

The *diagnosis* of Menière's disease depends on the already described combination of symptoms, and on the absence of symptoms of paralysis in the area of the other cerebral and spinal nerves. In these cases, therefore, the diagnosis of an affection of the brain is not feasible according to Menière, as in no other organ than that of hearing are symptoms of paralysis observed, which would not be possible if the nuclei of the auditory nerves were affected, since then from the neighbourhood of the centres of other cerebral nerves these would also be involved in the lesion. Yet I must agree with v. Tröltsch that, especially in those cases in which, some time even before the attack, tinnitus, a feeling of pressure and fulness in the ears, frequent attacks of giddiness and stupefaction, or a slight degree of deafness were present, the diagnosis without any further evidence ought not to be given as Menière's disease. This must be particularly observed because, as has already been said, periodical attacks of tinnitus and vomiting, combined with giddiness, are also often met with in diseases of the external meatus and of the tympanic cavity, in congestions of the head and the ear, in commencing diseases of the brain, and in the development of tumours of the brain.

From what has been said, therefore, I believe that the diagnosis of Menière's disease can only be made with certainty when it occurs without premonitory symptoms and in a marked degree, and when the surgeon can examine the ear a short time after the attack. If in a previously normal-hearing individual sudden hardness of hearing or deafness sets in with the phenomena of an apoplectic attack, and the gait becomes uncertain and staggering, but without paralysis in the areas of other nerves, and an examination made a short time afterwards shows a normal membrana tympani and a perfectly permeable Eustachian tube, one can with great probability conclude that an affection of the labyrinth is present. While an affection of the tympanic cavity, occurring suddenly with great deafness and the other anomalous phenomena, is characterized by a quick and abundant plastic or muco-purulent exudation, and distinctly perceptible changes on the membrana tympani and in the permeability of the tube will be present. After a lengthened period, however, the diagnosis becomes very difficult, as the products of the acute affection of the tympanic cavity may disappear without leaving any abnormal condition of the membrana tympani or in the tube, and the high degree of functional disturbance may be caused by an intercurrent stiffening of the ossicles.

The *prognosis* of Menière's disease is unfavourable in so far as in the cases hitherto communicated complete cure or considerable improvement has been extremely seldom observed. It is only in recent affections, in which the function of hearing is not quite destroyed, that the possibility of improvement is not ex-

cluded. In total deafness of months' or years' duration, however, the prognosis is absolutely unfavourable.

At the beginning of the affection *treatment* is directed to the removal of the troublesome phenomena in the head. Cold bandages on the head, alcoholic embrocations behind the ear, sinapisms on the neck and on the calves of the legs, bathing the skin with lukewarm vinegar-water, and slight derivations to the intestinal canal, have proved the most suitable remedies for the alleviation of the violent symptoms. The diet is at first to be restricted, and it is recommended in the serious forms, in which even slight movements or the stretching of the body suffice to give rise to severe giddiness and vomiting, to allow the patient to lie on his back with the head moderately high.

Of internal remedies, quinine and iodide of potassium have proved of most service in relieving the giddiness and other head-symptoms. The action of quinine, as recommended by Charcot, must, however, be carefully watched in each case, as sometimes by moderate doses the opposite effect is caused, *i.e.*, great excitement and increased tinnitus. The beneficial action of quinine is more rarely seen in apoplectiform Menière's disease than in the diseases of the ear combined with giddiness and tinnitus, which, without justification, are termed Menière's disease by many specialists. The iodide of potassium should be given in quantities of ½ to 1 gram. daily for at least three or four weeks, always, however, after having first tried quinine for eight or ten days. In recent cases after the cessation of the violent symptoms, about the second or third week subcutaneous injections of a 2 per cent. solution of muriate of pilocarpin (4-10 drops daily) are recommended as furthering absorption.

In general there is little to be expected from local treatment. It may be tried after the cessation of the severe symptoms of excitement, and in the second or third week of the affection. We are limited to the injection of 8-10 drops of a warm solution of iodide of potassium (0·3 in 20·0) through the catheter into the tympanic cavity, whence the drug reaches the fluid of the labyrinth partly through the medium of the bloodvessels, partly by diffusion through the membranes of the fenestræ ovalis and rotunda. The injections are continued for three or four weeks every second day, and, in addition, embrocations of the ointment of iodide of potassium or of iodoform on the mastoid process should be used for a longer time. In a case of right-sided apoplectiform Menière's disease, combined with total deafness, in which this treatment was first tried six weeks after the first attack, and continued for four weeks, there was an improvement in the hearing for loud speech of 2½ metres. In a second case, in which treatment commenced ten days after the commencement of the affection, there was an improvement of the hearing, after three weeks' treatment, of ⅙ meter. Treatment by electricity (see later) is not suitable at

the beginning of the affection, as it increases the giddiness and tinnitus, and even after the cessation of these symptoms, only weak currents should be used at first. When, after fifteen or twenty sittings, no result is attained, all further attempts should be discontinued. In many cases a course of sulphurous or iodine waters is of some service. Even when no improvement is effected in the hearing, in many cases the treatment exercises a favourable influence on the head-symptoms and on the temper of the patient.

Some remarks on giddiness (*vertigo ab aure læsa*), which so often accompanies diseases of the ear, may be of service here. Notwithstanding the numerous treatises on this, it is still a subject of controversy. While, on the one hand, owing to Flourens's experiment, giddiness is regarded as the result of a pathological irritation of the vestibular and ampullary nerves, Lucae, supported by Baginsky's experiment, believes that this symptom of cerebral disturbances may be caused by the oscillations of pressure in the subarachnoid cavity, transmitted from the fluid of the labyrinth through the aqueducts, whereby irritation of the auditory, the abducent, and optic nerves, lying at the base of the brain, is brought about. On the irritation of the last-mentioned nerve depends the simultaneous nystagmus and the disturbance of vision.

As we have seen, this problem has not yet been solved by physiological experiments; it now remains to be asked if clinical experience does not afford a guide to its solution. In fact, a series of long-known observations shows that the vertigo so often observed in diseases of the ear, in the majority of cases proceeds from the labyrinth. We have seen that, not unfrequently, by moderately strong injections into the auditory meatus, particularly in perforation of the membrana tympani, and, further, sometimes after inflation of air into the middle ear, and on contact of the probe with the free stapes (Lucae, Bonnafont, the author), the most violent attacks of vertigo may be occasioned. The theory that in such cases, by sudden compression of the labyrinthine fluid, a part of it may be sent through the aqueducts towards the subarachnoid space, and that the attacks of vertigo arise through oscillations of pressure in the cranial cavity, is inadmissible, when it is considered that only a very small quantity of fluid can get through the aqueducts to the arachnoid space, that the intra-cranial pressure itself forms a considerable hindrance to the passage of the labyrinthine fluid into the cranial cavity, and that it is scarcely conceivable that the increase of the large mass of cerebro-spinal fluid by a few drops should occasion such great disturbances of equilibration.

If, then, we abstract those affections of hearing preceded by disturbances of equilibration which are caused by cerebral affections, the conclusion is clear that in most cases in which in disease of

the sound-conducting apparatus or of the labyrinth, giddiness and disorders of equilibration occur, these are to be traced to an irritation of the vestibular and ampullary nerves.*

The pathological changes in the ear, in which vertigo and disturbances of equilibration occur, have been already repeatedly discussed. It still remains, however, to be added, that angioneurotic disturbances of the circulation in the vessels of the head may also be combined with pronounced attacks of vertigo and co-ordination disturbances (see the sections on Hyperæmia, Anæmia, and Neuroses); but that in such cases it cannot be determined whether the combination of symptoms is caused by a central or a peripheral irritation of the auditory nerve, or by immediate action on those parts of the cerebellum, the irritation of which, as we have seen, gives rise to the same form of co-ordination disturbances as irritation of the vestibular and ampullary nerves. All forms of vertigo and disturbances of equilibration which are combined with an affection of the hearing cannot, therefore, without anything further, be diagnosed as proceeding from the ear. This conclusion is also arrived at from the observation of cases in which attacks of vertigo and staggering, combined with tinnitus and deafness, may exist for a long time as symptoms of a subsequent affection of the brain.

The attacks of vertigo occurring in aural patients—excluding apoplectiform Menière's disease—appear at irregular intervals, very seldom periodically. The latter form is described by Giovanni Longhi as 'vertigine auditiva miasmatica' in the marshy districts of the Lomellina (Upper Italy). In the intervals, which may last for weeks or months, the patients are either entirely free from all abnormal sensations or have the feeling of giddiness and the unsteadiness of gait in but a slight degree. The attacks return either without any known cause or after bodily exertion, quick turning of the head, bending or rising up suddenly, after emotional excitement, etc. The onset of the vertigo is preceded, as Guye has remarked, by a sense of rotation round the vertical axis, and then from before backwards round the horizontal axis. During the attack, the staggering in the gait increases to such a degree, that the patient, when not supported, falls in the direction of the affected side. In slighter degrees the disturbance is particularly marked when the patient tries to walk in the dark or with closed eyes. The subjective noises and the deafness, as a rule, increase during the attack. In the angioneurotic forms and in commencing affections of the brain, the disturbance of hearing may completely disappear after the attack.

As to the treatment of these symptoms, the same holds good as

* McBride (*Med. Times and Gaz.* 1881) recognises a cerebral centre, by the irritation of which the giddiness is caused. The irritation may proceed not only from the ear, but also from the eye, stomach, or brain: whence the distinction is made, according to the source, into aural, ophthalmic, or stomachic vertigo.

has been said on the treatment of hyperæmia and anæmia of the internal ear and of Menière's disease. In the first place, the cause—when it can be found—must be considered. When the membrana tympani is highly concave, or when there are cicatricial adhesions between the membrana tympani and the inner wall of the tympanic cavity, conditions, therefore, which may indicate an overweighting of the stapes and an increase of the intralabyrinthine pressure as the cause of the symptoms, we should endeavour to diminish the pressure by rarefying the air in the external meatus. In this way the vertigo is lessened in many cases during the application. Should this manipulation not succeed, or its success not last long enough, then we are justified in trying incision of the tense posterior fold of the membrana tympani or of the tightly-extended cicatrix. In several cases, I have succeeded in lessening the intensity of an attack by such a very simple operation.

With a negative condition of the middle ear, rarefaction of air in the external meatus, in some cases, also renders good service. Therefore, this procedure may always be carefully tried with gradual decrease of pressure. Among the internal remedies recommended, are quinine in doses of $\frac{1}{2}$ gram. per day (Charcot) for a long time, bromide of potassium, and iodide of potassium when there is a suspicion of syphilis. Galvanism to the sympathetic is recommended in the angioneurotic form.

4. *Inflammation of the Labyrinth* (*Otitis Interna*).

Primary inflammations of the lining membrane and of the membranous structure of the labyrinth are very rare, and up to the present time have only been observed in some few cases. Of more frequent occurrence are secondary inflammations caused by purulent inflammations of the middle ear extending to the cavity of the labyrinth. In such cases, in the cavity of the labyrinth, which is laid open by caries and filled with pus, the saccule of the vestibule, the ampullæ, and the semicircular canals, are found thickened, greyish-red, and in parts ecchymosed, the lining membrane of the cochlea, the modiolus, and the lamina spiralis being injected and ecchymosed. In one case, besides those changes, I found a polypous growth proceeding from the vestibule, which penetrated into the tympanic cavity through a carious defect of the promontory, and became connected with a polypus springing from the inferior wall of the tympanic cavity.

Secondary purulent inflammations of the labyrinth have been occasionally observed (Heller, Lucae, Merkel) in cerebro-spinal meningitis. Lucae found in a child which died of meningitis, a hæmorrhagic inflammation of the labyrinth; Moos in the infectious diseases and in variola, found small-celled infiltration of the

membranous labyrinth. That the latter changes may become quite resolved, is apparent from the clinical observation of cases of typhus, scarlatina, etc., in which deafness occurring during the disease disappears again during convalescence, the function of hearing returning to its normal state.

Of chronic inflammation of the labyrinth, a rare clinical event, the following are the terminations hitherto recognised: Connective-tissue proliferation on the lining membrane of the osseous labyrinth; hyperostosis and calcareous deposits on the same; proliferations of reddish, juicy connective-tissue masses filling up the labyrinthine cavity (Schwartze); condensation of the saccules and ampullæ; deposition of pigment, cholestearine and calcareous salts in the latter; atrophy of the membranous labyrinth; and fatty degeneration of Corti's organ.

Clinical observations on primary inflammations of the labyrinth with records of the post-mortem appearances are very scarce.

As primary acute purulent inflammation of the labyrinth Schwartze describes a case (*A. f. O.* vol. xiii.) which affected an anæmic woman, aged thirty-two, with constitutional syphilis, who had suffered for several weeks from right hemicrania, vertigo, tinnitus and vomiting. The membrana tympani was inflamed. Paracentesis of the membrane was performed without discharge of pus; after some days a rapid increase of temperature, violent delirium, and trismus occurred, with a fatal termination with symptoms of meningitis. Post-mortem appearances: Purulent meningitis, a purulent accumulation in the neighbourhood of the Gasserian ganglion between the dura mater and the petrous bone. The auditory nerve and the internal auditory meatus normal, as also the tympanic cavity. The cochlea, vestibule, and semicircular canals filled with sero-purulent fluid; great vascular injection in the semicircular canals and ampullæ; circumscribed extravasations on the latter. The utricle and the saccule reddened, swollen, and infiltrated with pus.

According to Schwartze the intact state of the auditory nerve is in favour of the idea of a primary inflammation of the labyrinth, as are also the early onset of pain in the ears and staggering in the gait and the later occurrence of cerebral symptoms. Lucae is of opinion that, notwithstanding the absence of an apparent anatomical connection between the two affections, the impression cannot be altogether set aside, that the labyrinthine inflammation arose from the meningitis.

Voltolini has directed the attention of aurists to an ear-affection occurring in children, which he terms acute inflammation of the labyrinth. The affection comes on very suddenly in previously quite healthy individuals, with fever, great inflammation of the face, and vomiting, followed by unconsciousness, delirium, and convulsions. These symptoms completely disappear after some days, but total deafness and staggering in the gait remain

for a long time. The phenomena during the acme of the affection are very similar to an acute meningeal disease. While, however, a meningitis ending in deafness terminates as a rule after several weeks, the serious symptoms of the disease in question disappear in a short time, so that very often in four or five days all the functions are normal, with the exception of the deafness and the staggering gait. The difference in the duration of the groups of symptoms is the basis of Voltolini's support of the diagnosis of a primary inflammation of the labyrinth.

The recognition of this as a special form of disease was, as we have seen, based only upon a group of symptoms, and, therefore, it was natural that on the side of the otologists, particularly Moos, Knapp, and more recently Gottstein, doubt was entertained of its significance, and with justice, in so far as the theoretical assertions have not been confirmed by the pathological appearances.

Voltolini's conclusion, that an intra-cranial affection, which leads in a few days to total paralysis of the auditory nerve, must necessarily cause disturbances in the course of other cerebral nerves, that, therefore, a central cause of the deafness in these cases must be excluded, does not appear sufficiently sound to determine the diagnosis of an acute inflammation of the labyrinth. As to the assertion that in a series of Voltolini's cases a meningeal affection lay at the foundation of the group of symptoms, confirmation is found in Gottstein's observation, that in the course of epidemics of meningitis abortive forms occur in which the initial symptoms recede after a few days, either with complete recovery or leaving deafness as a sequel. The latter may be caused either by simultaneous purulent inflammation of the labyrinth transmitted from the cranial cavity, or by an affection of the stem or nucleus of the auditory nerve. The absence of simultaneous disturbances in the areas of other cerebral nerves in these cases is explained by the already mentioned extreme susceptibility of the auditory nerve, which may be permanently altered by a very slight injury, to which the other cerebral nerves could offer sufficient resistance.

However, the occurrence of a primary inflammation of the labyrinth with the group of symptoms described in children, is not to be recognised all at once. The following case, minutely examined by me, is the only example hitherto of this form of inflammation, which from repeated check-observations of the post-mortem appearances can claim the right of being called a distinct form of disease.

The case was that of a boy who, according to his father, became deaf at the age of two and a half years, during a feverish complaint which lasted fourteen days. The most prominent symptoms during the illness were great restlessness, repeated eclamptic attacks, and a discharge from both ears, which is said to have

continued till the age of six or seven. The boy, who was able to get up after fourteen days, showed no staggering in his walk, and it was only five or six weeks later that it occurred to the father that the child had lost both hearing and speech.

After completing his seventh year he was admitted to the deaf and dumb institution at Vienna, where he died at the age of thirteen from an acute peritonitis. To loud conversation he was completely deaf, without the least perception of sound; he had good mental faculties, but his utterance sounded hoarse, his disposition was gentle, and he showed great activity while at play. No unsteadiness was exhibited by the boy either in walking or in any other movement.

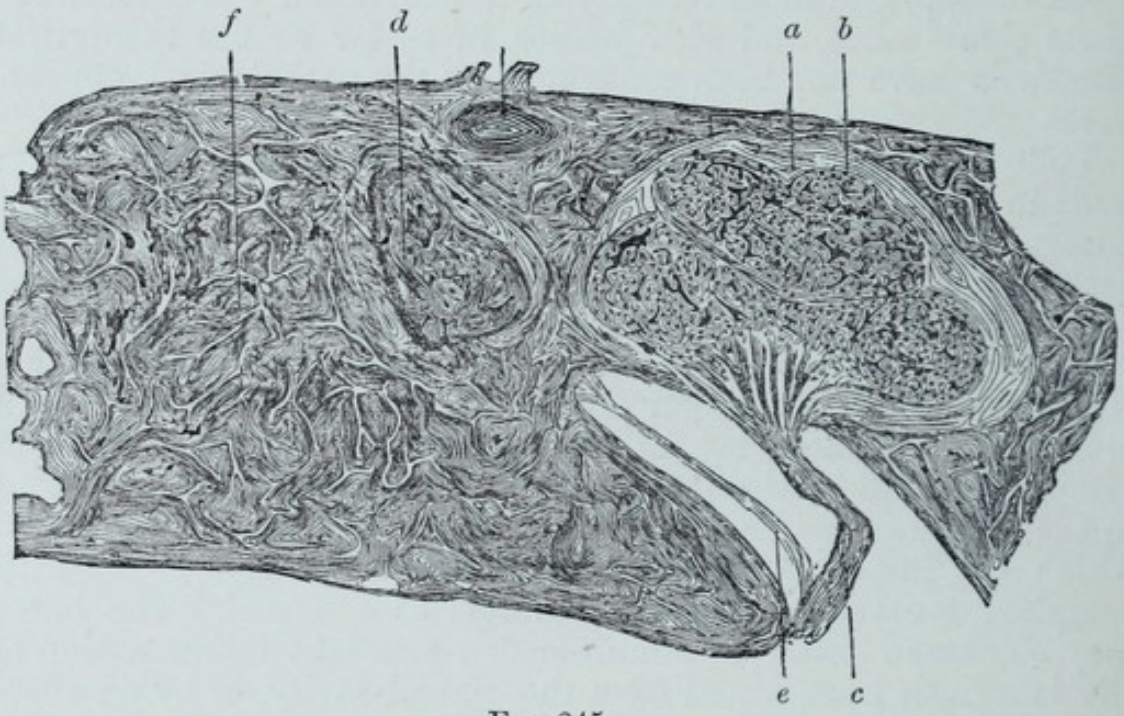

FIG. 245.

The necroscopy gave the following result: Both membranes were normal without any sign of previous disease. The mucous membrane of the tympanic cavities was everywhere fine and thin, without any perceptible pathological change. The malleus and the incus were freely movable. The stapes, on the other hand, was fixed and immovable on both sides. The niche of the fenestra rotunda was indicated by a small fossa, the base of which was formed not by the proper membrane, but by a solid osseous mass.

Examination of the decalcified labyrinth gave the following results: In horizontal sections through the whole petrous bone the absence of the cavities termed scala vestibuli and scala tympani was immediately observed by the naked eye. These cavities were filled up by a mass which was distinctly different from the capsule of the cochlea.

The capsule of the cochlea (Fig. 245, *a*) was intact and demarcated from the overlying portion of the petrous bone by its paler colour and by the peculiarity of its metaplastic osseous tissue.

The coils of the cochlea could be plainly distinguished throughout. The cavity of the cochlea (*b*) was entirely filled with new-formed osseous tissue, which bore the character of periosteal bone. The new-formed bone was traversed by numerous vessels which ran parallel to the surface of the coils. The bone corpuscles were placed parallel to the axis of the vessels, the modiolus was also replaced by an osseous mass of the same structure. In sections of every coil of the cochlea there was noticed at some places a dark stripe corresponding to the laminæ spiralis ossea et membranacea, which must be regarded as the residuum of the spiral plate. The auditory nerve (*c*) entered with its normally arranged medullated and non-fatty nerve-bundles into the modiolus, but its fibres continued only a short distance into the new-formed

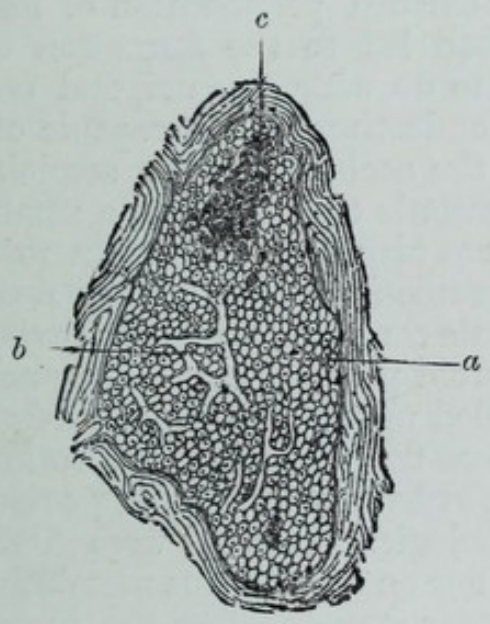

FIG. 246.

osseous mass. At the place of their entrance into the modiolus there was an accumulation consisting of adipose and dark granulations.

The vestibule (*d*) formed on section a small rectangular triangle, on which the foveæ hemispherica et hemielliptica could no longer be defined. It was especially on the side of the cochlea that contraction by the same hyperplastic process had taken place, yet not to such an extent but that a distinct lumen remained. The lining membrane (Fig. 246, *a*) of the contracted vestibular cavity was covered by a round epithelium and traversed by vessels (Fig. 246, *b*). The nerve of the vestibule (Fig. 245, *e*) proceeding in a curve to the vestibule was also medullated. In one preparation a small heap of otoliths (Fig. 246, *c*) was met with in the vestibule; in some places it was seen that these arose in the interior of cells by secretion of carbonate of lime.

The semicircular canals (Fig. 245, *f*) were completely absent; what corresponded on the section to their lumen could be seen neither with the naked eye nor with a low magnifying power.

The parts could be recognised only with a high magnifying power owing to the peculiar structure of the new-formed osseous tissue completely filling up the canals. This was the same as the osseous formation found in the cochlea, but the sharp margin of the semicircular canal could not be distinguished.

When in this case we observe more closely the origin of the deafness and the anatomical condition, there can be no doubt that the original process consisted of a bilateral acute purulent inflammation of the labyrinth, which in its first stage had given rise to the symptoms of fever, restlessness, and convulsions. The discharge of pus most probably took place through the fenestra rotunda into the tympanic cavity and thence outwards after perforation of the membrane. By the inflammation of the lining membrane of the labyrinth proliferation of its connective tissue was set up, which had led to the formation of periosteal bone. We have also here to do with a centripetal osseous hyperplasia extending from the endostium of the capsule of the labyrinth, by which the whole of the cochlea and the semicircular canals were filled up and the vestibule contracted to a small cavity; the foot-plate of the stapes was also firmly adherent to this osseous mass. Similar changes are sometimes found as the result of chronic suppurations of the middle ear in the tympanic cavity, more frequently, however, in the mastoid process, where the pneumatic cell-spaces are so completely filled up by ossifying connective tissue that the whole process becomes transformed into a solid osseous mass.

The fact that, notwithstanding the long existence of the purulent discharge, pathological changes were found neither on the membrana tympani nor on the mucous membrane of the tympanic cavity, must not appear strange, after the numerous clinical and pathological observations of perforative suppurations of the middle ear, which prove that even after long continuance of the inflammation, the pathological changes in the sound-conducting apparatus may completely recede.

Panotitis.

This name is applied to that form of disease of the ear in which the middle ear and the labyrinth are either seized simultaneously by the inflammation or the one very quickly after the other.

It occurs chiefly in children, either as an idiopathic affection or in the course of scarlatinal diphtheritis, and then always on both sides, and leading after a short duration to total deafness.

The idiopathic form begins with high fever, to which are often added eclamptic attacks with or without unconsciousness. Its duration varies from a few hours to several days. After the return of consciousness the individual affected is totally deaf; and then after a few days, rarely before the return of conscious-

ness, a discharge from both ears sets in with perforation of the membrana tympani. In all cases the affection has been combined with staggering in the gait.

This form of disease may be illustrated by the description of a few cases.

In a child aged six, the affection commenced with high fever, on which there supervened, after some hours, a convulsive attack with unconsciousness. Sudden deafness set in after thirty-six hours. On the tenth day, after the fever had abated, a bilateral ear-discharge commenced, which ceased after fourteen days. Four days later an abscess formed behind the right ear, which was opened and healed up in a short time. Five months after the commencement of the affection, the result of examination on the right side was: dry perforation behind the handle of the malleus; on the left side at the same place there was a cicatrix on the membrana tympani adherent to the inner wall of the tympanic cavity. The function of hearing was completely destroyed for every kind of tone or noise.

In a boy three years old there had occurred, three weeks before the first examination, high fever and headache without affecting the consciousness. After two days with the abatement of the fever there commenced a slight bilateral ear-discharge. The parents at the same time observed that the child had become totally deaf, and that he staggered so much in walking that after a few steps he fell. Result of objective examination: Perforation of both membranes; total deafness without a trace of perception of sound.

A girl, aged three years, became suddenly very feverish during the night of the 15th April, 1879. Towards morning unconsciousness set in, which lasted for fourteen days, with slight convulsive attacks and cervical contraction. After return to consciousness she was totally deaf, and staggered in walking. In the eleventh week a discharge set in from the left ear, which ceased three weeks before the first examination on 5th June, 1880, which showed on the right side: highly concave inflamed membrana tympani; on the left, dry perforation in the anterior inferior quadrant; and total deafness, as in the two former cases.

There can be no doubt that in these cases the middle ear and the labyrinth have been attacked by inflammation. Whether the process appeared simultaneously in both sections, or sooner in the one than in the other, cannot be determined, as their commencement was not observed. The late appearance of the ear-discharge (eleven weeks after the beginning of the affection in the third case) would seem to indicate that the suppuration proceeded from the labyrinth and was transmitted to the middle ear after bursting through the fenestra rotunda or ovalis.

The prognosis of this form of inflammation is unfavourable. The internal use of iodide of potassium, long-continued embrocation with iodine and iodoform ointments behind the ear, the

water and bath cures at the iodine baths of Hall, are always without effect.

To the diphtheritic form of panotitis belong those cases in which total deafness sets in in the course of scarlatinal diphtheritis. Moos indicated some years ago that the deafness in such cases is caused by a coincident small-celled infiltration of the membranous labyrinth. Whether the disturbance of function is not also caused by a purulent inflammation of the labyrinth, must be determined by further examinations. This form has been often clinically observed, and Blau (*l. c.*) has recently published a very interesting case of it.

A short time ago I had an opportunity of observing an interesting case of diphtheritic panotitis. A girl, eight years of age, became ill five months ago with scarlatinal diphtheritis. On the eighth day a bilateral ear-discharge set in, and on the same day also total deafness. Her walk was unsteady only during the first week after cessation of the diphtheritis and no longer. Objective result: On the right, perforation of the membrana tympani and polypous growths in the tympanic cavity; on the left, extensive destruction of the membrana tympani; on both sides profuse blenorrhœa. Function of hearing quite destroyed for every kind of sound and noise.

The case of aural affection in variola vera described by Moos (*Histol. Veränderungen des Labyrinths bei Infectionskrankheiten*, p. 245) may be termed panotitis. Besides purulent otitis media the semicircular canals, ampullæ, and saccule appeared to the naked eye thicker than normal and of a citron-yellow colour. Microscopic examination showed an abundant formation of connective tissue between the osseous and the membranous labyrinth, infiltration of the connective tissue with pus cells, numerous pus cells in the saccule, and still more in the semicircular canals and ampullæ. The lamina spiralis on both sides was covered with pus cells. Auditory nerve not involved.

5. *The Syphilitic Diseases of the Internal Ear.*

Syphilitic diseases of the labyrinth often develop simultaneously with the secondary cutaneous or throat affection (once within my experience on the seventh day after the primary infection), but often months or years after the primary affection, either with a new outbreak of syphilitic symptoms (in one of my cases with gumma on the head after twenty-one years), or when no sign of syphilis is observable on the body. Syphilis of the labyrinth may also occur as the only symptom of an as yet unexhausted general syphilis.

The anatomical changes in syphilis of the labyrinth are but little known. Whether in recent cases there is a plastic exudation in the labyrinth similar to that in syphilitic iritis has not been

proved. The reddish colour of the labyrinthine fluid, described in one case, has no scientific value, as, apart from the fact that by rupture of the labyrinthine capsule and entrance of blood from the neighbouring diploe spaces, such a colour may be artificially produced, the minute details of the histological changes in the membranous labyrinth are wanting. Little is known of the inveterate forms. In a syphilitic individual, aged thirty-seven, in whom intense subjective noises, attacks of vertigo and headache, suddenly commenced without considerable disturbance of hearing, considerable deafness having set in shortly before death, which occurred a year and a half afterwards, Moos (*Virch. Arch.* vol. lxix. p. 313) found at the autopsy: condensation of the periosteum of the vestibule, the foot-plate of the stapes raised and immovable, the connective tissue between the membranous and the osseous labyrinth infiltrated with small cells and hyperplastic, Corti's arch and cells especially considerably infiltrated, the zona pectinata and the periosteum of the lamina spiralis ossea less strongly infiltrated; the ampullæ and the membranous semicircular canals were alike greatly infiltrated, the auditory nerve normal. Moos was of opinion that this was a case of inflammation transmitted from the cranium to the labyrinth by the connective tissue of the bone and of the periosteum.

A case observed by me concerned a man, fifty years of age, who had been deaf for ten years in consequence of a syphilitic affection. On the right membrana tympani, two broad ligament-like stripes proceeded downwards at an acute angle from the inferior end of the handle; on the left there was moderate dimness of the membrana tympani. The right ear was totally deaf for speech; on the left side sometimes a few words were understood; perception through the bones of the head was absent. Death resulted from phthisis pulmonalis. Post-mortem appearances: The ligament-like stripes on the membrana tympani were condensations and elevations of the epidermis, the mucous membrane of the tympanic cavity and the ossicles were normal on both sides. On decalcified sections of the cochlea the ganglion cells in Rosenthal's canal were morbidly changed. The cells were partly round and granular, without a distinct nucleus, partly oval and angular bodies, in some of which only was a nucleus observed. The modiolus exhibited in parts a reticular structure. On the spiral membrane, in the vestibule, and on the semicircular canals, no changes were visible which could be termed pathological.

The changes in the bloodvessels in syphilis, described by Heubner, have not yet been observed in the vessels of the internal ear. There are as few observations on anatomical changes in the stem and in the nucleus of the auditory nerve.

Symptoms.—The most prominent subjective symptom is

tinnitus, which in many cases is very pronounced. Subjective noises are seldom entirely wanting. Pain in the interior of the ear, with tinnitus and deafness, I observed in only one case, without objectively perceptible inflammatory phenomena on the membrana tympani. On the other hand, attacks of vertigo, with disturbances of equilibration, are frequent, and the ear-affection is often prefaced by these symptoms.

The objective examination reveals either a normal state of the membrana tympani, or changes which proceed from an existent or exhausted affection of the middle ear. Twice I have found peculiar sharply defined whitish patches on the membrana tympani. The Eustachian tube is normally pervious or swollen, and contracted by a simultaneous affection of the naso-pharynx, or, in ozæma, blocked by crusts. I have several times found the lymphatic glands over the mastoid process greatly swollen.

The disturbance of hearing is in most cases of high degree up to total deafness. The affection is seldom unilateral; in bilateral affections the one ear is usually more affected than the other. The hearing-distance for the watch and the acoumeter is very small even in slight cases, in severe cases it is nil. Perception through the bones of the head is lessened or quite absent; in unilateral affections the tuning-fork is only perceived by the normal or better-hearing ear; in bilateral total deafness perception for the tuning-fork is quite wanting. When the sounds are conducted through the air high notes are not so well heard as low ones; Rinne's experiment frequently turns out positive in labyrinthine syphilis without simultaneous affection of the middle ear (Roosa, p. 693), only, however, in cases in which the hearing-disturbance is not great.

Course and Terminations.—The course of syphilitic affections of the labyrinth, according to the unanimous observations of v. Tröltsch, Roosa, Schwartze, Knapp, Moos, Buck, and myself, is characterized by the rapid development of disturbance of hearing. I have seen cases in which deafness was almost complete on the third day after the commencement of the disturbance of hearing. The deafness not uncommonly, however, comes on gradually, to remain the longer stationary, till after weeks or months it becomes suddenly worse. That even slight concussions of the head are sufficient to bring about an aggravation (v. Tröltsch, Urbantschitsch, Gruber), I can confirm from my own observation. Oscillations in the hearing-distance are rare. When improvement or recovery results, it does not happen all at once, but gradually. In progressive improvement the perception through the bones of the head also returns. In one of my cases the perception for the acoumeter from the ear towards the forehead increased gradually.

Diagnosis.—The diagnosis can be given with certainty as labyrinthine syphilis, when the disturbance of hearing has

rapidly developed with the symptoms detailed, and when perception for sound through the bones of the head is wanting, and at the same time symptoms of secondary syphilis are present on other parts of the body, or when there can be no doubt of its former presence from the history. In young people especially, the rapid development of the disturbance of hearing, with the absence of objective symptoms of an affection of the middle ear, is sufficient to raise the suspicion of labyrinthine syphilis. In several such cases, in which the primary infection was denied, I was able on minute examination to prove general syphilis to be the foundation of the disturbance of hearing. Even in those cases, in which an affection of the middle ear exists at the same time, from the manner of development of the disturbance of hearing, and the absence of perception through the bones of the head, in connection with an existing or exhausted syphilis, a specific affection of the labyrinth may be with probability inferred. The diagnosis becomes more difficult when the disturbance of hearing develops gradually and not till some years after the termination of the syphilis, as in such cases the possibility of the development of an adhesive process in the neighbourbood of the stapes, quite independent of an exhausted syphilis, cannot be excluded.

Those forms of syphilitic affection of the labyrinth are to be regarded as hereditary, which develop in childhood with great or total deafness, the foundation of which has hitherto been referred to scrofula. The affection of the labyrinth is often combined with adhesive processes in the middle ear, and with great parenchymatous opacity of the cornea, proceeding from a chronic keratitis, the syphilitic nature of which has been demonstrated by oculists, and recently by Prof. Horner (Gerhard, *Kinderkrankheiten*) of Zürich, and Prof. Knapp (*Z. f. O.* ix.).

Recently Kipp has collected a series of cases in which disturbances of hearing caused by hereditary syphilis were combined with parenchymatous keratitis, and one case with syphilitic iritis. The symptoms given by Kipp were sudden deafness, vertigo, disturbances of equilibrium, subjective noises, naso-pharyngeal catarrh, and sometimes also catarrh of the middle ear. The statement that slight changes may be present on the membrana tympani, I cannot from my own observations confirm.

The *prognosis* is in most cases unfavourable, generally, however, more favourable in recent than in old cases. The degree of deafness does not always determine the amount of restoration of the normal function of hearing, as sometimes after total deafness recovery may take place, while slighter forms, notwithstanding energetic anti-syphilitic treatment, often remain incurable and may even become worse through time. I have seen cases in which deafness developed during treatment by inunction. Unfavourable prognostic circumstances are: advanced age, anæmia,

marasmus, incurable general syphilis, simultaneous adhesive processes in the middle ear, and stricture of the Eustachian tube. The above-mentioned hereditary forms, combined with opacity of the cornea, are also unfavourable. According to Schwartze, the prognosis is more favourable in the case of bilateral syphilitic affections than in that of unilateral.

Treatment.—The treatment of labyrinthine syphilis is the same as that of general syphilis. In its slighter degrees, the iodine cure is sometimes sufficient. In the majority of cases, however, it is insufficient and less effective than mercurial inunction. In recent cases I have had several favourable results from the subcutaneous injection of a 2 per cent. solution of muriate of pilocarpin in increasing doses of from 4 to 12 drops. This treatment should be first used, and iodine or mercury resorted to, should the pilocarpin injections have no marked effect after eight to fourteen days.

General treatment may besides be supplemented by injections of a solution of iodide of potassium into the tympanic cavity, and by embrocations of iodoform* or mercurial ointments behind the ear. In several cases, in which a marked improvement of the hearing was not attained, either by local or by general treatment, a satisfactory result was obtained from the use of a course of the waters of an iodine or sulphur bath.†

The following case will serve as an interesting example of recovery from severe labyrinthine syphilis.

A. L., twenty-two years of age, was admitted to my clinique on 17th November, 1879, and stated that formerly she could hear quite well, but four weeks previously she had become suddenly quite deaf in both ears. On being pressed, she denied all syphilitic infection. Result of examination: moderate opacity and inward concavity of the membrana tympani; hearing-distance for the acoumeter 0; perception through the bones of the head wanting; speech understood on the right side close to the ear, on the left only some words spoken through the trumpet. Examination of the genitals revealed: a papulous syphilide at the entrance to the vagina and on the anus; the patient confessed having had a rash on her body six or seven weeks previously, which disappeared in fourteen days. The diagnosis was therefore given as syphilitic affection of the labyrinth. At the beginning, treatment consisted in the injection of a solution of iodide of potassium (1 in 15) into the tympanic cavity. As, after seven days, there was only a slight improvement of $\frac{1}{3}$ metre on the right side for loud speech, embrocations of mercurial ointment were applied to the mastoid process, which were stopped after twelve days on account of erythema of the skin. Hearing-distance for speech on the

* Dr. Jos. Pollak has recently recommended for the removal of the offensive smell of the iodoform the addition of ol. geranii (1 drop to 50 gram. iodoform).

† Papers on aural syphilis up to 1869 have been compiled by Schwartze in his *Beiträge zur Pathologie und pathologischen Anatomie des Ohres, A. f. O.* vol. iv.

right side, ½ metre. Then, for twenty days, the internal administration of iodide of potassium (up to 1½ gram. daily) was tried, till the commencement of iodism. Hearing-distance on the right for the acoumeter, 4 cm.; speech, 2 metres; on the left, for speech, 1 metre. As examination of the genitals showed the continuance of the papules, the inunction of 2 gram. of mercurial ointment daily was commenced. After fourteen days the patient distinctly heard a loudly-ticking watch laid on the bones of the head; the hearing-distance for speech had increased to 3·5 m., and on the left 1·5 m. The inunction was continued from that time for five weeks, till the syphilis was cured; and on her dismissal she could hear on the right side the acoumeter at a distance of 1 m., whispered speech nearly normally; on the left, the acoumeter at 10 cm., loud speech at 3 m.

Schwartze cured one case of bilateral paralysis of the auditory nerve after syphilis, by inunction; and in a second case, one ear was cured by internal iodine treatment.

Rickety changes in the labyrinth are but little known, and we only possess one exact observation by Moos and Steinbrügge (*Z. f. O.* xi.), which will be briefly related here: At the necroscopy of a deaf and dumb idiot affected with general hyperostosis of the cranium, there were found hyperostoses on the inner wall of the tympanic cavity, great contraction of the internal auditory meatuses, ossification of the annular ligament, and a portion of tissue in the right cochlear capsule near the fovea hemispherica, consisting of cartilaginous cells and fibrous cones slightly coated with calcareous deposit, changes which are to be regarded as rickety, according to Virchow. At the same time there were found congenital malformations, bilateral imperfect ossification of the Fallopian canal; on the left side absence of the foot-plate of the stapes, and in its place an osseous mass, which passed directly into the osseous substance of the labyrinthine capsule. On the right, instead of the crura of the stapes, slipper-shaped cones were seen, ossified only at their external periphery, between which was lodged a highly cellular connective and adipose tissue.

6. *Diseases of the Auditory Nerve.*

Clinical observations on diseases of the stem of the auditory nerve and its expansion are so scarce that we must limit ourselves to the enumeration of its hitherto recognised anatomical changes.

Hyperæmia of the neurilemma of the auditory nerve is very often present in congestion of the meninges, particularly in meningitis, encephalitis, in aneurism of the basilar artery, but especially in engorgements of the vessels of the brain.

Ecchymosis on the stem of the auditory nerve has been observed in fractures of the petrous bone, in scurvy, and once in fatty degeneration of Corti's organ (Moos).

Purulent inflammation and infiltration of the auditory nerve were observed in purulent basilar meningitis, in epidemic cerebro-spinal meningitis, and in suppuration spreading by caries and necrosis of the petrous bone or by traumatic fracture of the latter.

Hypertrophy of the stem of the auditory nerve, caused by infiltration and proliferation of the neurilemma, is very rare. I have found it in extensive caries of the petrous bone simultaneously with nodose thickenings on the facial nerve.

Atrophy of the auditory nerve is much more frequently met with. It seldom develops in consequence of contraction of the basilar and internal auditory arteries, more frequently as a result of apoplectic and inflammatory processes on the floor of the fourth ventricle, and in the neighbourhood of the nucleus and roots of the auditory nerve; lastly, in diseases of the cerebellum and in hydrocephalus internus. A case observed by me affected a young man, who, with symptoms of hydrocephalus, in the course of several years became paralysed in all his extremities; he became quite blind and deaf, and died with symptoms of marasmus. The necroscopy revealed a tumour (osteosarcoma) originating in the sella turcica, hydrocephalus, dilatation of the ventricles, atrophy of the cerebral substance, great thinness of the cranial bones, the origin of the optic nerve flattened, no change, however, in the eye itself; the internal auditory meatus was enlarged to three times its size; the auditory nerve, together with the facial, made up a thin thread-like nerve-bundle; the membrana tympani was thickened, and attached by firm connective-tissue adhesions to the inner wall of the tympanic cavity; the ossicles moved with difficulty; in the cochlea there were abundant depositions of amorphous pigment.

Shrivelling of the auditory nerve, as atrophy from pressure till the nerve-stem is completely separated, is observed in tumours of the brain and tumours on the base of the skull, which either press on the point of emergence of the auditory nerve or grow into the internal auditory meatus. In a case described by Böttcher (*A. f. A. u. O.* ii.), of a tumour of the brain (fibrosarcoma) which penetrated into the internal auditory meatus to the modiolus, the auditory and the facial nerves were atrophied to a thin cord, the nerve-bundle in the modiolus and in the lamina spiralis disappeared and the nerve-canals were filled up by connective tissue; and besides, Böttcher found atrophy of the stratum cellulosum and of the external and internal ciliated cells. Pressure-atrophy of the nerve is further caused by excessive stricture of the internal auditory meatus. This is developed especially in extensive osseous deposits on the tabula vitrea of the internal surface of the skull, and in consequence of periostitis ossificans syphilitica (Zeissl).

It is known that disturbances in the region of the auditory

nerve occur in affections of the spinal cord, and particularly in tabes, still their anatomical basis has not yet been sufficiently investigated. While Erb (Ziemssen's *Handbuch*, p. 142), in some cases of tabes, found definite atrophy of the auditory nerve, and Wernicke grey degeneration of the auditory nerve, to be the cause of the progressive deafness in tabes and in disseminated sclerosis, Lucae (*A. f. O.* ii.) could find no changes in the auditory nerve in grey degeneration of the spinal cord.

Besides atrophy of the auditory nerve caused by affections of the central nervous system, atrophy may also supervene on peripheral changes in its terminal expansion in the labyrinth. Among such changes are the purulent inflammation which follows carious perforation of the labyrinthine capsule, and the deposition of caseous exudation (Haighton). In my case of osteogenesis in the cavity of the labyrinth, the auditory nerve was unchanged.

O. Weber (*Pitha und Billroth*, i.) found in destruction of the labyrinth fatty degeneration of the auditory nerve, and transmission of the same to the central parts.

The view, that in long-continuing deafness atrophy from inaction must affect the auditory nerve, has not yet been corroborated by experience, the stem of the nerve being often found unchanged, not only in long-continuing anchylosis of the stapes, but also in congenital deafmutism.

Schwartze, in a case of bilateral anchylosis of the stapes, observed atrophy of the nerve only on one side, while the other nerve presented a normal appearance.

On the other hand, secondary atrophy in the expansion of the nerve in the labyrinth and in the stratum cellulosum of the cochlea, according to my observations, occurs more frequently. An interesting, carefully observed case of atrophy of the nerve in the first coil of the cochlea is related by Moos and Steinbrügge, and is briefly as follows:

It occurred in the right ear of a mason, sixty-three years of age, who died from carcinoma of the stomach, and of the right anterior central convolution of the brain. He had suffered for eight years from bilateral deafness, the right ear being the worst, and continual tinnitus. The ear affection was said to have commenced suddenly. The result of an examination of the hearing, fourteen days before death, was total deafness on the right side for loud speech, while Politzer's acoumeter was heard when held close to the ear; on the left side the hearing-distance for loud speech was 3 metres; the A′ tuning-fork was heard only on the left side when placed on the forehead, but the C′ and E′ tuning-forks were heard on the right. The watch placed on the temple was not heard in the right ear. When the sounds were conducted through the air, the A′ tuning-forks were not heard at all on the right, and C′ was only perceived when held close to the ear.

Apart from the deafness for speech on the right side, there was loss of perception for high tones, while for those from E′ downwards there was still perception when conducted through the bones, and for tones such as C′ when conducted through the air.

The post-mortem examination of the sound-conducting apparatus gave, as the cause of the deafness, on the right side decreased mobility of the stapes in the fenestra ovalis. The subjective noises could also be traced to that cause, if an increase of the intra-aural pressure were allowed to exercise a causative influence.

Of greater interest was the finding on microscopic examination of the labyrinth of a quantitative atrophy of the nerves in the region of the first coil of the cochlea, while those of the second and last coils were normal. The atrophy was observed in vertical as well as transverse sections. There was also a considerable enlargement of the perivascular lymphatic sheath within the lamina basilaris membranacea of the cochlea, probably the consequence of persistent engorgement of the intra-labyrinthine lymphatic system.

From these appearances, the author conjectures that the atrophy of the nerves in the first coil of the cochlea was caused by inactivity. It recalls C. Burnett's experiment, conducted under Helmholtz, by which it was proved that, with artificially increased labyrinthine pressure, vibrations, carried by means of the sound-conducting apparatus to the fluid of the labyrinth, act less powerfully on the membrana tympani in the case of high tones than in the case of low tones.

The theory is as follows: In long-continued increase of the intra-labyrinthine pressure, caused by immobility of the stapes, the labyrinthine fluid is set in motion only by a few weak sound-waves belonging to the deeper tones, so that the fibres of the zona pectinata destined to vibrate along with the higher tones, as well as Corti's cells belonging to these fibres and the terminal nerve fibres in the first coil of the cochlea, remain inactive. Thereby there arises an atrophy of the nerves in the coil, such as is observed after the extirpation of a neuroma or after amputations of the extremities, termed atrophy from disuse.

In the foregoing case probably the lymphatic engorgement aided the atrophy of the nerves, if Kühne and Rumph's experiments are worth anything, according to which, nerves which have lost their normal connection can be easily dissolved by lymph.

Should this acceptation of the case be right, perception for high tones must, in a great many cases of deafness, disappear sooner than that for low tones.

Not less important is the atrophy of the stratum cellulosum found in the spiral canal of the cochlea (Rosenthal's canal), which brings about the connection of the nerve-bundles entering the

cochlea with those in the lamina spiralis. This change is very prominent in the following case of mine:

The patient was a boy, aged nine years, who, when three years of age, was seized with attacks of convulsions, without any known cause, which recurred daily for a year. The attack, combined with tinnitus, lasted a quarter of an hour, after which he usually fell asleep. During that period no disturbance of hearing was observed in the boy. But after a year he became totally deaf during an acute illness, which lasted eight days, combined with unconsciousness. From that time the convulsions ceased, but the child could not walk for a long time after. His teacher in the deaf and dumb institute affirmed that he did not show the slightest sign of perceiving sound. Death resulted in consequence of acute encephalitis.

The necroscopy showed the right membrana tympani, the lining membrane of the middle ear, and the ossicles to be normal, and the stapes movable. In the left membrana tympani there was a large perforation, only the peripheral part of the membrane remaining as a narrow ledge; two small sharply defined calcareous spots were situated in the remnant of the membrane before and behind the short process. The mucous membrane of the tympanic cavity was pale, not thickened, and without secretion; the stapes was normally movable. There was thus on the left ear a persistent gap in the membrana tympani, caused by an exhausted suppuration of the middle ear, of which the history is wanting.

In horizontal sections of the decalcified labyrinth there are the following changes: on the inferior coil of the cochlea, and at the place of transition from the first to the second coil, there is in Rosenthal's canal (Fig. 247, *a*) a small number of round or angular bodies (*b*), which resemble round cells in size and form. After a minute examination, however, it is seen that these are the remains (nucleus) of the stratum cellulosum, its cells having in great part disappeared, and only a small portion remaining as shrivelled granular cells (*cf.* the illustration of the normal stratum cellulosum in Fig. 243, p. 679). The cavity of Rosenthal's canal is traversed by a fine network, in which only a few traces of nervous tissue are to be seen. The nerve-bundle (*c*) entering into the lamina spiralis ossea from Rosenthal's canal has completely disappeared. Huschke's teeth are no longer visible. On the lamina spiralis membranacea there are the remains of the epithelium, and the place where Corti's cells lay is marked by a somewhat elevated layer of epithelium. In the vestibule there is a thickened membrane connected with the foot-plate of the stapes, corresponding to the external wall. The striæ acousticæ are weakly developed; there are no anomalies present in sections of the auditory nuclei and roots.

Whether, in this case, the atrophy of the stratum cellulosum

and of the nerve expansion in the cochlea were caused by an inflammatory process in the labyrinth during the acute general disease passed through five years previously, or whether it was a case of atrophy from disuse, it would be difficult to say. That the absence of specific irritation of the auditory nerve alone does not necessarily have as a consequence atrophy of the stratum cellulosum and of the nerve-bundle in the cochlea, has been proved by the dissection of several cases of congenital deaf-mutism, in which I have found the stratum cellulosum in the cochlea and the nerve expansion in the lamina spiralis perfectly normal.

Along with atrophy of the auditory nerve are to be grouped

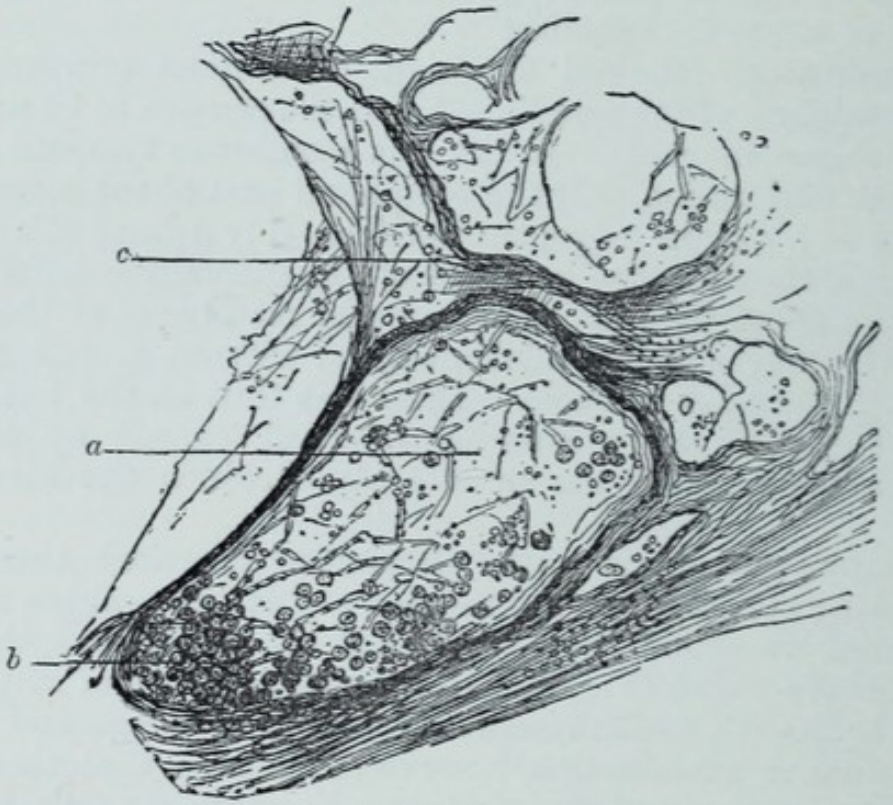

FIG. 247.

some other degenerative processes, the most important of which will be briefly mentioned.

Colloid degeneration of the auditory nerve was found by Moos in the necroscopy of an idiot with complete deafness on the right side, and on the left deafness of a high degree and hallucinations of hearing, with simultaneously existing anchylosis of the ossicula and osseous closure of the fenestra rotunda.

The occurrence of amyloid bodies in the auditory nerve was proved by Meissner (*Z. f. pract. Med.* 1853), Förster (*Atlas der path. Anat.* 1856), Hubrich (*A. f. Psych. u. Nervenkr.* v.), Voltolini (*Virch. Arch.* Vols. xix., xx., xxii.), Lucae, the author, and others. This acquires the significance of a degenerative process only in the case of a particularly large accumulation of corpora amylacea, as, according to Schwartze, they are also found in normal auditory

nerves in various quantities, and only cause fatty degeneration and atrophy of the nerve fibres when the accumulation is unusually large. From the history of a fatal case, Moos considers the amyloid accumulation to be a secondary process, caused by long-continued disturbance of the function of the auditory nerve.

Calcareous deposits in the periosteum of the internal auditory meatus and in the neurilemma of the auditory nerve were found by Böttcher (*Virch. Arch.* vol. xvii.) repeatedly in middle-aged people. Moos is of opinion that in a case with similar post-mortem appearances, the symptoms of disturbance of hearing, observed during life, subjective noises and convulsions in the facial region, may be referred to that.

New-Formations in the Internal Ear.

Primary new-formations in the internal ear are much more rare than the secondary ones, which involve the labyrinth and the auditory nerve from the middle ear or cranial cavity.

As to the primary new-formations of the labyrinth, the accounts of them in literature are so deficient and of so little scientific value, that we can merely mention them.

There are some positive communications on a few primary new-formations occurring on the stem of the auditory nerve, but they have only a pathological interest, as there are no exact clinical observations regarding them. Among recognised primary new-formations of the auditory nerve are to be mentioned sarcoma and the so-called neuroma. The former were repeatedly seen by Förster (*Wurzb. med. Z.* iii.), and in one case by Voltolini (*Virch. Arch.* xxii., cited by Schwartze, p. 130). The neuromata described by Virchow (*Geschwülste*, ii.) and Klebs (*Prag. Vierteljahrschr.* 1877) belong in the majority of cases to the gliomata.

In the overwhelming majority of cases the new-formations of the internal ear are to be regarded as secondary, extending to the labyrinth or the stem of the auditory nerve from the middle ear or the cranial cavity.

Of the new-formations of the external and middle ears, it is for the most part the epitheliomata and the malignant round-celled sarcomata that involve the petrous bone and the labyrinth. There are no exact histological observations on the character of the extension of the new-formation in the labyrinth; the following case of secondary epithelioma of the cochlea will therefore be briefly recorded:

The patient, forty-seven years of age, was brought, in the beginning of July, 1880, to the sick ward of the general poor-house, with an ulcerating growth, the size of a nut, behind the ear, and cancerous masses growing out of the external orifice of the ear. Its history had been as follows: The patient, after a long period

of outdoor treatment, was admitted to the infirmary in December, 1879, suffering from chronic purulent inflammation of the middle ear, with perforation of the membrana tympani and polypus of the right ear, as well as a tumour behind the ear of the size of a nut. After removal of the polypus, the state of the patient was so much improved that he was dismissed in February, 1880, and again treated as an outdoor case. Rapid enlargement of the tumour behind the ear, increase of the otorrhœa, and commencing glandular infiltration, rendered his re-admission necessary. Examination revealed an ulcerated lobular tumour on the mastoid process the size of a hen's egg, covered with fetid pus, and connected with another tumour which was growing out of the meatus. The growths were recognised as epithelioma. By an incision in the tumour on the mastoid process a considerable quantity of putrid pus was discharged. Notwithstanding that relief, in a few days a collateral œdema of the eyelids developed, as well as distinct facial paresis and rapid increase of the growth with violent pains, which were only relieved by morphia injections.

After four weeks in hospital, febrile erysipelas of the right side of the face set in, and having spread over the hairy scalp, receded after ten days. The patient was dismissed at his own desire, and three weeks afterwards was re-admitted to the infirmary in a weak, somnolent state, and died in a few days with symptoms of compression of the brain. Post-mortem appearances: Epithelial carcinoma of the squamous portion of the temporal bone, of the external auditory meatus, and of the tympanic cavity; rupture of the growth through the tegmen tympani into the cranial cavity, and compression of the temporal lobe. The pars pyramidalis was greatly infiltrated with cancerous masses and movable. The posterior section of the pyramid as well as the interior of the mastoid process were carious.

Microscopic examination of the labyrinth gave the following result:

The apex of the cochlea turned towards the tympanic cavity was opened by cancerous destruction of the inner wall of that cavity (Fig. 248, *a*), the cancerous growth thereby entering into the interior of the cochlea. The lamina spiralis in the second and third coils was here and there broken through, and the scala tympani as well as the scala vestibuli were partly filled up by an accumulation of cancer-cells (*b*) seated partly on the external wall of the cochlea and partly on the lamina spiralis and on the modiolus.

Of particular interest was the condition of the first coil of the cochlea: the laminæ spirales ossea et membranacea were intact; on the scala vestibuli there were on both sections of this coil, on the external wall of the ductus cochlearis, a group of cancer-cells, which extended along the membrana basilaris up to Corti's organ (*c*, *c'*). The elements of the latter were infiltrated with a number

of cancer-cells. The scala tympani of the one side was quite free; on the other side, however, there was a lobulated cancerous tubercle (*d*) on the external and inferior wall of the cochlea, which almost filled up two-thirds of the scala tympani. Across the latter there was drawn a connective-tissue cord, connected with the loosened connective-tissue lining membrane of the inner wall of the cochlea.

In some sections the cancerous mass had broken into the internal auditory meatus, in which also the stem of the auditory nerve had become infiltrated with the cancerous growth. The vestibule was also eroded on the side of the tympanic cavity; its membranous structures, however, remained intact, as also

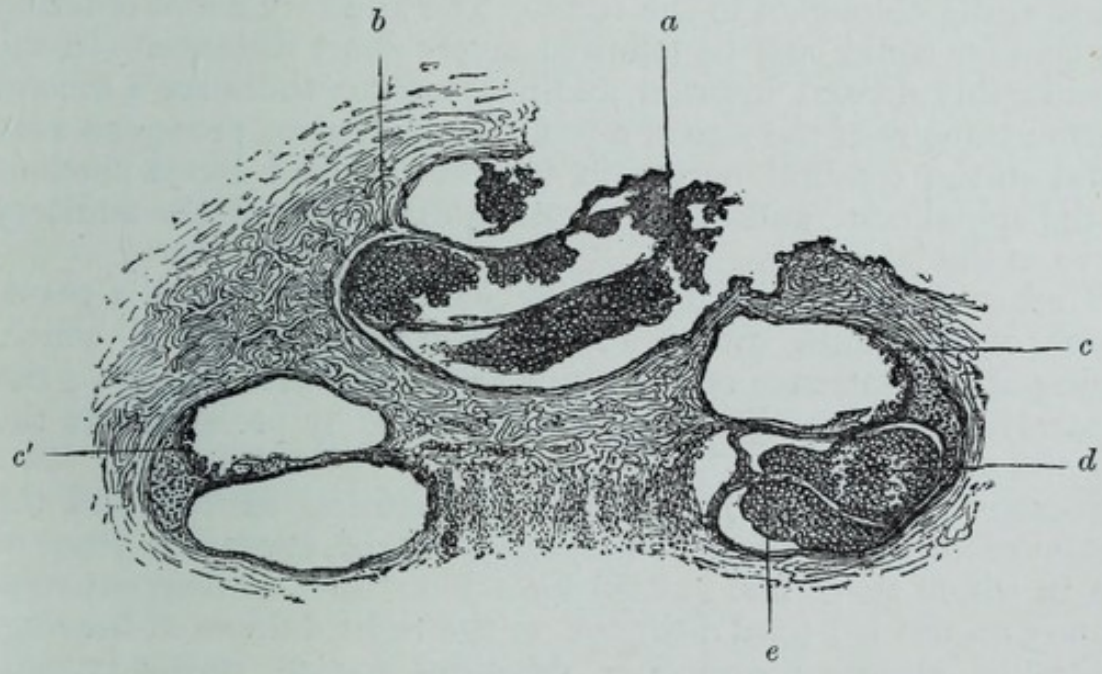

Fig. 248.

the membranous semicircular canals, which were in places filled up and surrounded by a homogeneous, translucent mass.

The growths which invade the stem of the auditory nerve or the labyrinth from the cranial cavity are more common. The observations hitherto made relate chiefly to sarcoma of the dura mater and of the brain.

In a man, sixty-six years of age, who died of pneumonia, and who had become deaf after otorrhœa during typhus, Burkhardt-Merian (*A. f. O.* xiii.) found a fibrosarcoma of the dura mater which had involved the labyrinth. It originated above the place of union of the inferior petrosal sinus with the jugular fossa, where it divided into two branches, one entering the vestibule as a round cord through the enlarged aqueduct of the cochlea, while the other proceeded under the floor of the internal meatus, partially encircling the necrosed cochlea, to the tunica adventitia of the carotid. In the contracted meatus and in the tympanic

cavity there were numerous granulations, while the superficial petrosal sinus was obliterated by a connective-tissue thrombus.

Field describes a case of sarcoma the size of an orange, on the posterior surface of the petrous bone and on the internal auditory meatus, spreading from the dura mater and destroying the auditory nerve.

In a woman, aged forty-seven, who was suddenly attacked, after a cold, by anæsthesia of the left side of the face, weakness of vision in the left eye, lachrymation, ptosis, headache, vertigo, and deafness, and who died a year later with symptoms of suffocation, Moos (*A. f. A. u. O.* iv.) found a round spindle-celled sarcoma the size of a walnut on the external side of the left porus acousticus internus, which was connected with the crus cerebelli and pushed the medulla oblongata to the right. The auditory nerve entering the tumour could only be followed a very short distance. In the considerably dilated internal auditory meatus there lay a second uneven tumour of the size of a pea. Degenerative processes were found on the cerebral nerves, in the cervical and dorsal portions of the spinal cord, and in the terminal expansion of the auditory nerve in the labyrinth.

Virchow (*Geschwülste*, ii., cited by Schwartze) describes a psammoma of the dura mater, of the size of a mulberry, which, arising at the entrance of the porus acousticus internus, gave rise to paralysis of the auditory and facial nerves by pressing into the internal meatus.

Stevens (*Z. f. O.* viii.) describes the clinical history and the post-mortem appearances in the case of a girl, seventeen years of age, in whom there had existed for a long time convergent strabismus, on the left total deafness, on the right dulness of hearing, imbecility, clumsy movements, drawling speech, unsteady gait, weakness and weight in the right extremities, and pain on the left forehead and occiput, and death resulted after four weeks of coma. There was a globular sarcoma of the cerebellum having bulbous elevations, the sarcoma occupying half of the right side of the cerebellum, from which a process entered the internal meatus. The auditory nerve was lost in the tumour, so that the connection of its peripheral fibres with their central origin was interrupted.

Among the rare growths in the region of the internal ear are reckoned the cavernous angioma of the petrous bone first observed by me. A similar observation has not hitherto been recorded.

The case was that of F. N., an innkeeper's daughter, aged twelve years, who had suffered for a year and a half from right otorrhœa and periodical bleedings from the ear. For several weeks right facial paralysis had existed. On admission there was found a bluish-red polypoid growth, which bled profusely on the slightest touch, and reached to the middle of the external meatus; there was great deafness, and perception for the tuning-

fork through the bones of the head was greater on the affected side. The removal of the polypus with Wilde's snare was followed by unusually profuse bleeding, which could only be stopped by repeated styptic tamponade. Recurrences of the growth rapidly took place, and at each removal some profuse hæmorrhage occurred. The facial paralysis and the existence of roughness on the bone on the posterior wall of the meatus indicated the presence of a carious process in the temporal bone complicated with the formation of polypi.

After remaining two months in my clinique, difficulty of breathing and cyanosis set in, and increased steadily till the third day, when death ensued, with symptoms of suffocation.

Post-mortem Appearances. — The middle of the posterior osseous wall of the auditory meatus was perforated by two irregular openings the size of half a lentil, leading to the cavity of the mastoid process. Through these openings a tumour of the size of a pea, and a smaller one, bluish-red in colour and smooth in surface, grew into the meatus. On the posterior half of the membrana tympani there was an oval perforation, through which some ragged growths penetrated. In the upper section of the gap the exposed incu-stapedial articulation was visible.

At the base of the skull, corresponding to the whole of the right petrous pyramid, there was an irregular, tuberculated, ovoid tumour about the size of an orange, projecting forward into the right middle cranial fossa, and backwards into the posterior cranial fossa, with its smaller circumference turned towards the apex of the petrous pyramid, and its broader one towards the squamous portion of the temporal bone (Fig. 249, *e*). The anterior circumference of the tumour was hard as bone, and firmly united with the superior surface of the petrous bone pyramid. On the external parts of the tumour lying near the squamous portion of the temporal bone, numerous pointed osseous ridges could be felt, while the remaining parts of the tumour were spongy.

The base of the tumour, by which a portion of the orifices of exit of the vessels and nerves at the base of the skull were displaced, was formed by the superior and posterior pyramidal surfaces and the inner surface of the pars mastoidea. The entrance of the porus acoustica internus was perceptible on the inner section of the tumour as a funnel-shaped orifice of the size of half a lentil, the canal itself being very greatly contracted. The auditory and facial nerves were thin, and of a pale grey colour. On a section through the petrous bone, parallel to the posterior surface of the pyramid (Fig. 249), the osseous mass of the latter was found traversed by numerous small and large cavities (*a*), from the walls of which round and irregular excrescences grew into the lumen of the cavities. From the upper section of the pyramid of the petrous bone (*b*) there arose a

radiating osseous framework (*c*) composed of strong osseous lamellæ, to the upper edge of which a large cavernous compartment was attached (*d*). The latter consisted of numerous large and small cavities, separated by fibrous septa, and containing liquid blood and coagula. After removal of the latter, numerous thread-like connective-tissue strands were seen in the cavities, with here and there tuberculated swellings.

As the preparation, being unique, was placed in the pathological museum, a minute examination of the labyrinth could not be undertaken, especially as the saw-cut fell chiefly to the inside of the cochlea and the vestibule. The sections of the superior and the posterior semicircular canal were intact.

The microscopical examination of the polypus, removed from

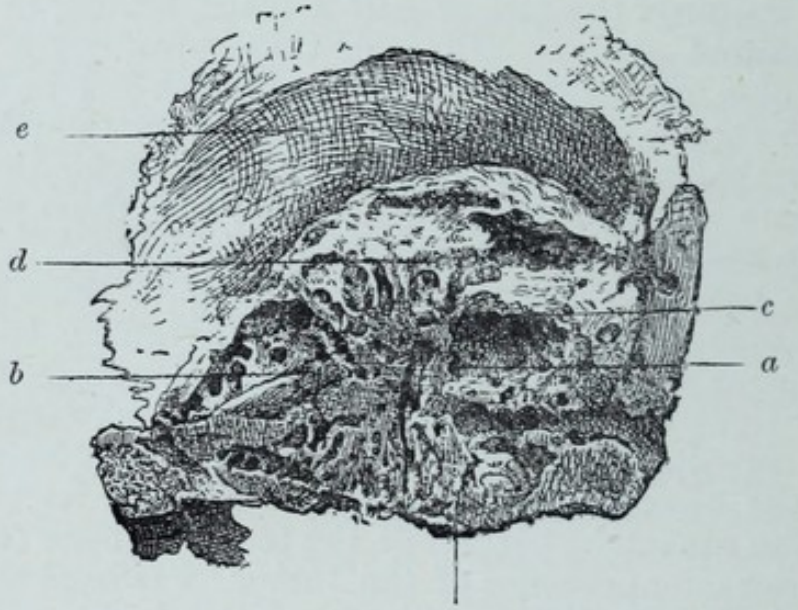

FIG. 249.

the auditory meatus, showed it to be a cavernous angioma which was connected with the growth in the petrous bone, in its tissue osseous trabeculæ being found similar to those in the large angioma of the petrous bone.

Examination proved the starting-point of the growth to be the lateral sinus, which communicated with the cavities of the cavernous angioma.

The inferior halves of the right temporal and occipital lobes were deeply impressed, corresponding to the tumour; the cerebellum and the medulla oblongata were laterally compressed and much pushed towards the left side.

Paralysis of the auditory nerve from pressure will be discussed along with the cerebral disturbances of hearing.

Neuroses of the Acoustic Apparatus.

1. *Hyperæsthesiæ.*

Under this head we have ;

1. Acuteness of hearing (oxyecoia). This is characterized by a periodical striking increase of the acuteness of hearing, either for every kind of tone and noise or only for certain sounds. During such phases, which last usually one or two hours, the persons affected are able to hear and understand speech or music from greater distances than usual, or from distant rooms—for example, from the next flat—while other normal-hearing individuals in their company only hear them indistinctly.

Oxyecoia is very seldom met with, and in older authors but little trustworthy information is to be found on this neurosis. According to my observation, it affects chiefly excitable people without any other disturbances of hearing, especially during mental excitement and slight congestion of the brain after partaking of spirituous liquors. Several times a temporary acuteness of hearing has set in after cessation of a slight catarrh of the tube and tympanic cavity. Almost always the affected person exhibited excessive sensibility for noises. Moos observed acuteness of hearing in one case as the forerunner of an intra-cranial affection of the auditory nerve, and Urbantschitsch the same in a man at the beginning of a febrile attack, and with great mental disturbance.

2. Hyperæsthesia acoustica, consisting in an unpleasant painful sensation in the ear, caused by tones or noises, has been minutely discussed in the introduction to the special division (p. 197).

3. The subjective sensations of hearing, to which we have just referred as having been described in detail (pp. 192, 339), in affections of the internal ear must be regarded as irritated states of the auditory nerve, which are caused by hyperæmia or anæmia, as well as by the effect of the many enumerated pathological products in the labyrinth and on the stem of the auditory nerve, and are almost always combined with paresis of the auditory nerve (deafness).

That form of subjective noises is to be regarded as a true neurosis which is termed ' nervous tinnitus,' or ' tinnitus without deafness.' It occurs mostly in excitable, nervous persons, during mental strain, after grief, in states of exhaustion, anæmia, after child-birth, after shocks from noises, and sometimes also in perfectly healthy individuals. In one case in which the symptoms existed at the same time with increased sensibility to light, the cause lay most probably in irritation of the brain.

The character of the noises varies considerably, but ringing, hissing, and singing are the most frequently complained of. The sensation never reaches such intensity as in the subjective sensations of hearing combined with disturbances of hearing.

Nervous tinnitus may disappear sooner or later, but may also continue during the whole of life without disturbance of function. In regard to diagnosis, it must be observed that noises which are originally regarded as nervous, not unfrequently turn out afterwards to be the forerunners of deafness developed within months or years, or of a cerebral affection.

Tinnitus without deafness proves very obstinate to every kind of treatment. As several observations (Gottstein and the author) have been made of cure by Politzerization, this should be tried in every case; but when the result after several trials is negative, it should be discontinued, as not unfrequently it causes an increase of the noises. The introduction of the vapours of sulphuric ether and chloroform, injections of solutions of strychnia (1 in 60) (Kramer) into the middle ear, blistering on the mastoid process, and electricity have all proved ineffectual.

Subjective sensations of hearing are sometimes reflexly excited from other nerves. It is most frequently affections of the expansion of the trigeminus, less frequently of the facial, which are associated with temporary or permanent subjective noises. They are to be regarded as reflex symptoms, when the noises begin during an attack of face-ache or tooth-ache and again disappear with it. I can also affirm from my own experience, that by irritation of the parts of the skin supplied by the trigeminus on the external region of the ear, *i.e.* by brushing or shaving, subjective noises can be got rid of (Benedikt). In one of my cases, that of a person with musical training, the sensation of certain musical tones could be called forth by rubbing the skin on the external orifice of the ear as well as by an act of swallowing.

2. *Pareses and Paralyses.*

The paralytic states of the auditory nerve, in which there is impairment or absence of the function of hearing, are, as already explained, induced by anatomical changes in the labyrinth, in the stem of the auditory nerve and in its central course. But there is no doubt, from clinical observations, that functional paralyses of the auditory nerve occur, in which there are no apparent anatomical changes.

Besides the already described forms of disease of the internal ear (hyperæmia and hæmorrhage, inflammation, syphilis, degenerative processes, injuries, etc.) which cause paralysis of the auditory nerve, the following forms are to be clinically distinguished:

1. *Angioneurotic Paralysis of the Auditory Nerve.*—This extremely rare form of disturbance of hearing is characterized by sudden pallor of the face, immediately followed by nausea, vertigo, tinnitus and dulness of hearing, symptoms which entirely disappear after a few minutes, with the return of the normal colour

to the face, without leaving the slightest disturbance of hearing.

The following characteristic case is from my practice: L. F., thirty-six years of age, became dull of hearing on the right side, in consequence of scarlatinal suppuration of the middle ear in childhood, with destruction of the membrana tympani. The left ear was quite normal till within six months ago. At that time the patient was attacked in his office by nausea and vertigo, which, however, soon disappeared. Some days later he was awakened out of sleep by severe vertigo, rustling and stupefaction, which disappeared after the application of cold bandages. Since that time, the almost daily recurring attacks have taken the following form, according to the description of the patient: with the sensation as though something were rushing to the head, the face became suddenly pale, and such violent vertigo set in that he was obliged to steady himself by holding to something. At the same time, a loud boiling sound, like that of a steaming kettle, and a feeling of confusion in the left ear, with a high degree of deafness occurred, without the least loss of consciousness during the attack. After a few minutes, the subjective noises ceased, the face became slightly red, the vertigo and feeling of confusion passed quickly away, and the normal acuteness of hearing returned.

This statement of the patient I confirmed by the observation of such an attack. The forerunner of the attack was slight nausea, which caused the patient to announce its onset; instantly I observed excessive paleness of the face, and at the same moment the hearing-distance for the acoumeter was determined as over 3 metres; half a minute later the hearing-distance diminished to 1 cm., and the patient could only with difficulty understand what was said in his immediate vicinity. This lasted for about two minutes; the paleness of the face then disappeared, the subjective noises became weaker, and a tolerably rapid increase in the hearing-distance for speech and the acoumeter took place. Five minutes later, the normal hearing returned, with the disappearance of the stupefaction and confusion in the head.

From these symptoms angioneurosis of the internal ear, due to the sympathetic, was diagnosed, and galvanization of the sympathetic in the throat was ordered. After eight days' use of the electricity, the attacks remained away for some days; and by continued treatment they returned less frequently and with less intensity, till after some months they ceased altogether. Whether in this case the group of symptoms proceeded from the labyrinth or from the central course of the auditory nerve, could not be determined.

2. *Rheumatic Paralysis of the Auditory Nerve.*—Although in older works on diseases of the ear, mention is made of rheumatic affections of the ear (Triquet, Toynbee, Erhard), there are very

few trustworthy observations of cases which could with justice be reckoned as rheumatic affections of the labyrinth.

The first case, communicated by Moos (*A. f. A. u. O.* i.), affected a girl, nineteen years of age, who was attacked by hyperæsthesia of the organ of hearing, shortly followed by total deafness and tormenting subjective noises, seven weeks after acute articular rheumatism ushered in by violent nervous and cerebral phenomena, the noises soon disappearing without improvement in the hearing. The examination with the speculum gave a negative result. The hearing became gradually normal with the use of the constant galvanic current.

Bing (*W. m. W.* 1880) relates the case of a woman, aged forty-seven, in which, after exposure to a draught, complete deafness set in on the right side with subjective noises, and on the left considerable dulness of hearing, without any morbid change being found on the membrana tympani. The vibrations of the tuning-fork placed on the top of the head were perceived only on the left side. Inflations into the middle ear remained without influence on the hearing-distance. Recovery took place within eight days under the internal administration of iodide of potassium, and the application of vesicants to the mastoid process.

Bing bases his diagnosis of acute rheumatic affection of the auditory nerve, on the rapid occurrence of the disturbance of hearing, on the absence of objective signs in the middle ear, and on the rapidly favourable course.

In a case examined by me, that of a man, fifty-one years of age, who had suffered from rheumatism attacking the various articulations and muscular parts one after the other, there suddenly occurred loud noises and excessive dulness of hearing on the right side without vertigo. After four weeks' duration of the disturbance of hearing examination showed: a negative condition of the membrana tympani and of the Eustachian tube; greatly diminished acuteness of hearing for the acoumeter and speech; lessened perception for the acoumeter through the bones of the head; no perception for the tuning-fork through the bones of the head in the affected ear; and a positive result of Rinne's experiment.

3. *Hysteric Paralysis of the Auditory Nerve.*—Peculiar sensations in the organ of hearing are not uncommon in hysterical subjects. Patients complain frequently of a feeling of constriction and pressure in the ears, of purling, gushing, and crawling in the interior of the meatus, and of increased sensibility to noises without any perceptible disturbance of hearing.

On the other hand, deafness of undoubtedly hysteric character is very seldom met with, according to the observations hitherto made, perhaps even more seldom than hysterical amblyopia. They are characterized by marked oscillations in the function of hearing, and the rapid change of the accompanying symptoms

(v. Tröltsch). There always exists simultaneously anæsthesia or hyperæsthesia of the opposite side. The whole of the phenomena may disappear periodically, or by the action of transference a rapid transfer of the acoustic paralysis and all the other symptoms to the opposite side may take place (p. 695). A particularly interesting case of hysteric disturbances of hearing may be related here. It is recorded by Habermann (*Prag. med. Wochenschr.* 1880), and was that of a boy, fifteen years of age, in whom the symptoms of Menière's disease, progressive deafness and blindness, hyperæsthesia of the olfactory nerves, furious headache in turns with complete apathy and insensibility, hyperæsthesia followed by anæsthesia of the right side of the head, and the phenomena of transference, were held to indicate an hysterical affection. Permanent cure is said to have been achieved by the application of pieces of gold to the region of the ear (metallo-therapeutics), and the internal administration of chloride of gold. Ouspensky observed two cases of hysterical deafness with hemianæsthesia of the head and troublesome tinnitus. In one case there existed at the same time perforation of both membranæ tympanorum after scarlatina, loss of taste and smell, and periodically returning hearing. In both cases the deafness disappeared, and in one the anæsthesia immediately after galvanization of the cervical sympathetic. A case observed by me, which I had an opportunity of examining along with Prof. Rosenthal in 1877, in Scholz's wards in the General Infirmary, was that of a young woman, twenty-five years of age, who was attacked, after great mental emotion, with a gradually increasing left hemiplegia and hemianæsthesia. Rosenthal (*A. f. Psych.* ix. 1) expressed himself, with regard to the examination of the ear made by me, on the then existing symptoms in the following manner: 'The paralytic sensation involved the area of the left trigeminus (its outer and inner branches), as well as of the occipital nerve up to the middle line. The left eye had lost its sensibility and its power of vision (the ophthalmoscopic appearances being normal), the left ear the sense of hearing and the perception of sound conducted through the bones (in the absence of an affection of the middle ear, Politzer). In the left nostril smell was completely gone, and taste from the left half of the tongue. In the left half of the tongue weak solutions of sweet, sour, salt, and bitter substances were distinctly distinguished.' Rosenthal confirmed the loss of galvanic excitability of the left half of the body. In its further course (five months of illness) there was total motor and sensory paralysis of all the extremities, and bilateral amblyopia; but (first on the left and then on the right) sensibility gradually returned, till the patient was able to leave the hospital after nearly a year's residence.

At a later examination in February 1879, the hearing-distance

on the right side for the acoumeter was 8 cm., for whispered speech 1 m.; on the left for the acoumeter = 1 mm., for whispered speech 2 m. Perception through the bones was normal, on the left with hyperæsthesia for the tones of the acoumeter. In the month of April on the right, acoumeter = 2 m., whispered speech = $3\frac{1}{2}$ m.; on the left, acoumeter = 9 cm., whispered speech = 2 m. There was an alternate increase and decrease of the hearing-distance observable in both ears. Every time after Politzerization the hearing-distance was nearly doubled.

Urbantschitsch, who examined the case for the first time some months later (September, 1879, *A. f. O.* xvi.), found on the left total deafness, amblyopia, and hemianæsthesia, and absence of galvanic reaction in the auditory nerve; on the right some diminution of the hearing-distance. On the approach of a horse-shoe magnet to the right mastoid process, within five to eight minutes the phenomena of transference set in (p. 695), so that deafness, amblyopia, and anæsthesia changed to the right side. At this examination, first the perception of high tones, and later that of low ones, was said to have commenced in the left ear.

Besides the enumerated forms of paralysis of the auditory nerve, paralytic states are sometimes clinically observed (rapid deafness of one or both ears with negative objective appearances), which cannot be classed with any of the forms of disease hitherto mentioned, on account of the absence of determined causes and the want of the usually so frequent accompanying symptoms, such as subjective noises, vertigo, and disturbances of equilibration. Whether in such cases we have to deal with anatomical changes, or only with functional paralysis of the nerve, cannot be ascertained for want of anatomical data. To the occurrence of pure functional disturbances the rapid disappearance of the disturbances of hearing in some cases would testify.*

Lastly, we must speak of that form of disease of the auditory nerve which may be termed sympathetic paralysis. It was formerly thought that in unilateral affections of the ear combined with excessive dulness of hearing, and indeed also in chronic inflammations of the middle ear as well as in diseases of the auditory nerve, sooner or later a disturbance of hearing, with or without tinnitus, developed in the other previously normal ear, which in the absence of objective symptoms pointed to paralysis of the auditory nerve. This applies to rapidly increasing deafness, while in the case of a progressive decrease of hearing, the possibility of slow inflammation in the neighbourhood of the fenestra ovalis with termination in anchylosis of the stapes had to be kept in view. The anatomical foundation of the sympathetic paralysis has already been mentioned in the introduction (p. 689).

* The temporary deafness may be classed here, which Scanzoni repeatedly observed after the application of leeches to the vulva, at the same time with general irritation of the vessels and eruptions of urticaria.

Treatment of Paralysis of the Auditory Nerve.—This depends upon the cause and the duration of the affection, as well as on the degree of disturbance of hearing and its accompanying symptoms. In recent cases the patient—whether the affection be characterized by tinnitus and increased sensibility of hearing or not—is recommended to avoid all loud sounds, and to remain in a quiet, noiseless room. With a negative state of the membrana tympani and of the Eustachian tube, at first all local treatment of the middle ear by inflation of air or vapours or injections and the use of electricity are to be avoided, as they often render the condition worse.

On the other hand, a marked improvement in the hearing is sometimes observed after the use of purgatives, stimulating foot-baths, vesicants on the mastoid process followed by the endermic embrocation of an irritant ointment, after the action of the vapour of sulphuric ether (by inserting into the orifice of the ear pledgets of wadding saturated with a mixture of equal parts of sulphuric ether and glycerine), after free perspiration, which is most quickly effected by the subcutaneous injection of 4-10 drops of a 2 per cent. solution of muriate of pilocarpin, and after large doses of iodide of potassium ($\frac{1}{2}$ gram. daily). A favourable result from these remedies, however, is not always certain, for even in recent cases the hearing may spontaneously become more or less deteriorated.

The chances of great improvement are less the longer the deafness has lasted. In cases, however, in which the affection dates back only some weeks or months, endermic embrocations of strychnia (4-6 drops of a mixture of 1 of strychnia to 10 of glycerine) may be tried on the denuded cutis of the mastoid process, iodide of potassium may be taken internally, or, in the absence of subjective noises, strychnia (0·07 in 10·0 aqu. dest., 3-5 drops three times daily) and the local introduction of vapour of sulphuric ether (pure or with the addition of $\frac{1}{10}$ of liq. ammoniæ) through the catheter into the tympanic cavity may be used, in order to act on the terminal expansion of the auditory nerve. Should these prove fruitless, galvanism may be tried.

The older aural surgeons distinguished between two forms of nervous deafness, the irritative, in which the disturbance of hearing was combined with subjective noises, and the torpid form, in which dulness of hearing existed without tinnitus. The latter form is said to originate spontaneously or to grow out of the former. The description of the irritative form given by Kramer, Rau, Wolf, and others, corresponds almost exactly to the group of symptoms of what we call sclerotizing inflammation of the middle ear. Its treatment consisted in the internal use of small doses of belladonna, digitalis, valerian, and the introduction of the vapours of an aqueous solution of extract of hyoscyamus, of water, acetic ether, and chloroform through the

catheter into the middle ear. For the torpid form the internal use of valerian, arnica, camphor, strychnia, and externally sinapisms and moxæ on the mastoid process (Bonnafont), and the introduction of sulphuric and acetic ether vapours into the tympanic cavity were recommended.

Electric Treatment of Functional Disturbances of the Internal Ear by means of the Constant Current.—For galvanic treatment of the ear we require a Siemens-Halske battery, consisting of twenty elements and provided with a commutator, the ear-electrode being variously formed, according to the method of application. Three methods are distinguished: (*a*) the internal arrangement, in which the external meatus is filled with a weak solution of common salt, into which the ear-electrode is dipped; (*b*) the external arrangement, in which the moistened ear-electrode is placed on the lobe or on the edge of the external orifice of the ear; (*c*) galvanization by means of an electric sound introduced into the Eustachian tube. As a rule I use the external arrangement, as the frequent pouring of fluid into the external meatus often gives rise to inflammatory irritation.

Galvanization of the ear is so performed that the anode is used as the ear-electrode, while the cathode is laid on an indifferent place, for example, on the palm of the hand or on the neck. To elicit the irritability of the auditory nerve in a given case gradually increasing constant currents are used, in order to ascertain the slightest strength by which a reaction of the nerve or stronger painful sensations, vertigo, etc., are induced. For therapeutic purposes, besides the increasing and decreasing of the current in some cases, Volta's alternative (repeated changing of the current) can be used.* Decided indications for the one or the other of the methods cannot be given, as Volta's alternative may at one time be effective when the other would not, and *vice versâ*. In every case, therefore, trial determines the use of the one or the other method.

Benedikt uses Volta's alternative locally, combined with galvanization of the sympathetic, on the ground that reflexes can be transmitted to the auditory nerve from the vaso-motors, a conclusion which is contested by Erb. Ladreit de Lacharrière recommends cross-conduction of the electric current, by having the electrodes placed in both auricles, for removing congestive states in the labyrinth.

The action of the galvanic current on the auditory nerve depends chiefly on the number of elements employed, on the fulness and constancy of the battery, and on the individual irritability of the patient. In addition, however, numerous external relations and local contingencies play an important *rôle*, such as abnormal dryness or moistness, hyperæmia or anæmia of the parts, obstacles to the condition of sound in the ear, as accumulations of cerumen,

* The rheostate and the galvanometer, indispensable for physiological experiments, are superfluous for therapeutic purposes.

pus, or fluid, and further, the state of the membrana tympani and of the tympanic cavity, in so far as the current can be modified so as to overcome the hindrance to conduction. Lastly, as Hitzig remarks (*A. f. O.* v.), it must be kept in mind that the comprehension of acoustic sensations varies with the intelligence and individuality of the patient and the sensibility of the normal auditory nerve, which varies within certain limits.

Frequent, but not constant, symptoms of the electric irritation of the ear are: stinging pains and burning in the external meatus, facial twitchings, sensations of taste, subjective noises and sounds, giddiness, nystagmus, and subjective perceptions of light. Sometimes on galvanization of one ear, subjective sounds occur in the ear to which the electrode is not applied.

According to Brenner, the normal auditory nerve always reacts to the galvanic current, and in quite a definite way, with sound-sensations, the regular occurrence of which for a certain strength of current, and their constant relation to the direction of the current and its opening and closing, he has employed to establish a law for the electric reaction of the normal auditory nerve.*

Brenner's law runs: When the cathode (Ka) is in the auditory meatus, there occurs on closure of the circuit (S) a loud sensation of sound (K′), which continues (D′) during the closure and ceases with the opening of the circuit (O). When the anode (A) is in the auditory meatus, neither on closure nor during the continuance of the closure of the circuit is there any reaction, but on opening it a weak sensation of sound is experienced.† If in any affection of the organ of hearing with the due number of elements and with a similar condition of the circuit, this reaction of the auditory nerve is present, then, according to Brenner, the nerve is normal, and the seat of the affection must be sought outside of it. The deviation from the normal formula may, according to Brenner, be quantitative or qualitative, as either (1) the auditory nerve reacts to an abnormally low number of elements (hyperæsthesia), or to an abnormally high number (dysæsthesia); or (2) the reaction of the nerve to the anode and the cathode, and to opening and closing of the circuit, deviates from the formula; or (3) the two abnormal states may be combined. In

* Brenner's experiments were performed by the above-described internal arrangement with six to eight Wollaston's elements.

† Brenner's formula runs as follows:

Ka S K′.	A S —.
Ka D Kkk.	A D —.
Ka O —.	A O K.

[Where Ka = Katode (the negative pole).
,, A = Anode (the positive pole).
,, S = Schliessung, *i.e.* closing of the circuit.
,, O = Oeffnung, *i.e.* opening of the circuit.
,, D = Dauer, *i.e.* duration or continuance of the circuit.
,, K = Klangempfindung, *i.e.* sensation of sound.

The addition of an accent to a letter indicates intensification, while the small letters indicate feebleness of sensation.—TRANSLATOR.]

all such cases, treatment is directed to the endeavour to reach the normal formula, or to come as near it as possible, by regular galvanization of the nerve. Here the individual excitability of the auditory nerve comes into consideration. Brenner distinguishes a primary excitability (E I.), indicated by the number of elements to which the nerve still barely reacts. If this strength of current is in action for a long time, the nerve is soon excited by a smaller number of elements, secondary excitability (E II.), and then also by repeated change of current reaction of the nerve is caused by a still slighter strength, tertiary excitability (E III.). By systematic galvanic irritation of the nerve in the manner described, the normal formula should be reached in the majority of cases.

Schwartze (*A. f. O.* i.) and Benedikt (*Wr. med. Pr.* 1870) dispute the general validity of Brenner's data, as, on the one hand, Brenner's normal formula is not always corroborated by perfectly normal-hearing individuals, while on the other it may be present in proved affections of the nerve.

Galvanization of the ear was also recommended for diagnostic purposes, and to ascertain increased (hyperæsthesia) and decreased (dysæsthesia) irritability of the auditory nerve. The diagnosis of hyperæsthesia of the nerve is made when to very weak currents a reaction is obtained, while paralysis of the nerve is recognised when, notwithstanding the application of very considerable currents, which cause twitchings in the region of the facial nerve, no subjective sensations of hearing occur (Moos, *A. f. A. u. O.* ii.). Against this Wreden gives cases (*Petersb. med. Ztschr.* 1873), in which with a hearing-distance for the watch of $\frac{1}{2}$ to 1 metre, no subjective sensations of tone could be obtained even by the strongest currents.

In regard to the curative action of the galvanic current on the organ of hearing, the views of specialists differ greatly, as some attach great importance to the results of galvanization of the auditory nerve, while a large number of observers are of opinion that this has no lasting influence on the improvement of hearing and the subjective noises. My accumulated experience indicates that galvanic treatment effects a lasting improvement in the function of hearing only in a few cases, and complete removal of the subjective noises extremely rarely; but that very often after longer or shorter treatment the intensity of the subjective noises and their annoyance are lessened for a long time, and that besides, the head-symptoms accompanying ear diseases (heaviness, pressure, giddiness, stupefaction) are either quite removed or greatly improved. It must, however, according to other observers, be mentioned, that aggravation also is sometimes produced by galvanic treatment, the subjective noises becoming more intense, and even after a few sittings great general excitement being induced.

Injuries of the Internal Ear.

The injuries of the internal ear are the result either of direct or of indirect violence. Direct injuries are those which are caused by the penetration of the injuring body (projectiles, sharp instruments) through the external meatus and the membrana tympani into the cavity of the labyrinth. Such injuries are very rare, and have already been referred to (p. 661).

The traumatic affections of the inner ear caused by indirect violence are much more frequent. They are divided into two groups. The first comprises those lesions which are caused by the immediate action of the violence on the bones of the head and the transmission of the shock to the internal ear, while the second group is composed of the concussions of the terminal acoustic expansion, produced by sudden condensation of air in the external meatus or by the action of loud noise.

Violence applied to the bones of the head may act on the internal ear in two ways: (1) by the extension of a cranial fissure to the petrous bone; (2) by transmission of the concussion to the labyrinth without actual injury of its osseous shell.

Fissures of the petrous bone complicated with injuries of the skull are seldom limited to that portion, but are usually combined with fissures of the tympanic cavity and of the external meatus. With regard to those forms preceded by severe hæmorrhage from the ear, discharge of serous fluid, tinnitus, vertigo, and deafness, the reader is referred to the description p. 661.

That a fissure of the skull may be continued to the labyrinth without involving the middle ear and the external meatus, is proved by the case of a man, aged forty years, who became totally deaf after a fall on the back of the head, with symptoms of noises in the ears, vertigo, and staggering in the gait, and died seven weeks after the injury with meningeal symptoms. Dissection revealed a ragged fissure of the occipital bone, which continued through both labyrinths and ended close to the inner wall of the tympanic cavity. The left labyrinthine cavity was filled with a dark red mass like coagulated blood; the right labyrinth contained purulent, crumbling extravasation, which penetrated thence through the internal meatus and caused a fatal basilar meningitis. No sign of an injury was perceptible on the dura mater.

Brunner (*Z. f. O.* x.) published a case, in which, after a fall on the forehead, there occurred total bilateral deafness with violent subjective noises, temporary disturbances of equilibrium, and a serous discharge from the nose. The diagnosis was a fissure of the base of the skull. Whether, in this case, the disturbance of hearing was caused, as in mine, by a fissure of the petrous bone or only

by propagation of the concussion to the labyrinth, could not be ascertained.

Moos described a case of probable fissure of the petrous bone, caused by a stab from a knife between the eye and ear directed towards the squamous portion of the left temporal bone, on which there supervened paralysis of the facial and auditory nerves and temporary irritation of the oculomotor and vagus nerves. By the use of iodide of potassium and electricity the facial paralysis improved, and the power of hearing gradually returned first for high, then for low tones, and lastly also for speech. Moos is of opinion that the fissure extending from the squamous portion of the temporal bone passed through either the porus acousticus internus or the facial canal and the osseous capsule of the cochlea. The earlier return of perception for high tones is explained, according to him, by absorption of the discharged exudation taking place sooner in the inferior coil of the cochlea (compare Helmholtz's theory, p. 682) than in the upper parts of the same.

That after the application of great violence to the bones of the head without fissure of the bone, excessive disturbance of hearing, subjective noises, giddiness, and staggering in the gait may arise, has been sufficiently proved by experience. The anatomical changes in the labyrinth in such cases are not yet known, but it is probable that hæmorrhage (ecchymosis) frequently occurs, while in other cases paralysis and irritation of the expansion of the auditory nerve may be independently occasioned by the concussion.

The terminations of such concussions of the acoustic apparatus are either permanent disturbance of hearing with or without subjective noises, or recovery. Concussion of the skull has a particularly deleterious influence in those cases in which an ear disease with disturbance of hearing already exists, as even slight concussion may lead to aggravation of the latter.

Blau (*A. f. O.* xv.) records the case of a man, twenty-seven years of age, who had been deaf in the right ear from childhood owing to an affection of the ear during measles, and who became totally deaf within two hours after a violent blow on the top of the head, the symptoms being roaring noises in the head, ringing of bells, staggering gait, and vomiting. Under the administration of iodide of potassium and derivatives the symptoms disappeared, and in three weeks the patient recovered his former power of hearing.

A very interesting and perhaps unique case of recovery from total deafness caused by concussion of the skull was observed by me. It was that of a man from Aleppo, aged twenty-one, who was brought to me by Dr. Raphael Cohen on 5th July, 1869, and who eleven months previously, on going through a low door, fell down insensible from knocking his head against the door-post.

Consciousness returned after some hours, with headache, tinnitus, and dulness of hearing, which increased at the end of the fourth week to total deafness. His state had remained unchanged for ten months. Examination showed a negative state of the membrana tympani, a permeable Eustachian tube, and deafness to every kind of noise. The diagnosis was traumatic concussion of the labyrinth, and the prognosis was necessarily unfavourable on account of its long duration and the high degree of disturbance of hearing. The treatment, carried out at the earnest desire of the patient, consisted in injections of a lukewarm solution of iodide of potassium (0·5 in 20·0) into the tympanic cavity. On the third day of the treatment the patient commenced to understand a few words spoken in the immediate neighbourhood of his right ear; from that time the hearing-distance increased a very little on each side till the twentieth day, when a slight headache set in, which caused the patient to keep his room for three days. During the night of the twenty-third day he was suddenly awakened by a violent attack of giddiness, followed by a feeling of concussion in the head, and such a sudden improvement in the hearing that he could hear the ticking of a distant watch. In surprise the patient sprang out of bed in order to inform Dr. Cohen, who slept in an adjoining room, of the occurrence, so that the latter might judge for himself. When he was presented to me on the following day by Dr. Cohen, I found the hearing-distance on both sides to be normal. What was the nature of the anatomical changes in the acoustic apparatus caused by the concussion, whether it was a concussion of the labyrinth generally or a lesion of the central course of the auditory nerve, could not be ascertained from the symptoms. The total bilateral deafness and the simultaneous return of the function of hearing to both ears, were in favour of the latter view. The restoration of hearing must be regarded as incidental, and not as the result of treatment.

With regard to the concussion of the acoustic terminal apparatus by sudden condensation of air in the external meatus or by the action of loud noise, the former is most frequently occasioned by a blow on the ear, the latter by violent detonations (as of cannon, guns, pistols, etc.). In cases of condensation of air caused by a box on the ear, the action on the labyrinth is more intense in those cases in which the membrana tympani remains intact, as the whole force of the concussion is transmitted by the foot-plate of the stapes to the labyrinth, while, when rupture of the membrane follows, a great portion of the active force is expended in causing the rupture. The same holds good for concussions of the labyrinth caused by detonations, which are not combined with rupture of the membrana tympani.

On the anatomical changes in the labyrinth, caused by the violent action of sound, there are so far no observations. It is,

however, probable that in the majority of cases it is a question of an excessive concussion of the labyrinthine fluid, by which the terminations of the auditory nerve undergo a sudden change of position, in consequence of which they are partly paralysed, and partly thrown into an abnormal state of irritation.

The symptoms of the labyrinthine concussion vary according to the intensity of the condensation of air or of the sound. Detonations in the immediate neighbourhood of the ear, and in confined spaces, *e.g.* in covered shooting-stands, are particularly injurious.

In slight degrees of labyrinthine concussion there arises a moderate degree of stupefaction, combined with a subjective singing noise, which again disappears after some hours or days. In severe concussions, on the other hand, great deafness immediately sets in, accompanied by loud subjective noises, confusion in the head, and giddiness. After some days, as a rule, the subjective noises diminish, without any improvement being observed in the function of hearing. Marked hyperæsthesia acoustica almost always exists, and the sensation of a shrill, metallic additional-sound in the presence of objective noises (Blau, Brunner).

The perception of sound through the bones of the head is lessened or quite wanting, according to the disturbance of hearing. The vibrations of the tuning-fork from the vertex are always more strongly perceived by the normal ear. This result of the hearing-test, in connection with the cause of origin and the negative appearance of the membrana tympani, determines the diagnosis of concussion of the labyrinth.

The termination of severe concussions of the labyrinth is in very few cases recovery, which results only gradually after weeks or months; in most cases a considerable disturbance of hearing, seldom total deafness, remains. The latter may develop progressively out of an originally very moderate disturbance of hearing.*

Certain occupations (locksmiths, coopers, tinsmiths), in which continuous noises act upon the ear, cause an irritation and paralysis of the auditory nerve in consequence of the loud constant action of the sound (see p. 190). Gottstein and Kayser (*Bresl. ärztl. Zeitschr.* 1881) among the blacksmiths and smiths examined by them very rarely found normal hearing; in 28 per cent. there was a considerable diminution or total absence of perception through the bones of the head.

A medico-legal decision as to the presence of concussion of the labyrinth is possible only in those cases in which there exists at the same time a fissure of the temporal bone extending to the external meatus, where lesion of the labyrinth can be

* The treatment of labyrinthine concussions is similar to that of paralysis of the auditory nerve (see the section on Neuroses of the Internal Ear).

inferred from the discharge of cerebro-spinal fluid or from the absence of perception of sound through the bones of the head. Those concussions of the labyrinth, on the other hand, caused by direct violence to the skull or by detonation, in which the external auditory meatus and the membrana tympani are both normal, are quite beyond the scope of a medico-legal decision, because: (1) proof cannot be given that the acoustic paralysis present is the consequence of the presumed injury; and (2) even when the action of violence has been established, it cannot be ascertained whether the acoustic paralysis were not already in existence before receipt of the injury.

As the attention of specialists has of late been directed to the so-called signal-deafness in railway servants, the result of the investigations undertaken on this subject will be briefly given here. Since Duchesne of Paris drew attention, in the year 1857, to the frequent occurrence of deafness and subjective noises in engine-drivers, the subject has recently undergone a thoroughly scientific examination, initiated by the communications made by Moos at the Milan Otological Congress.

Moos sought for the cause of the disorders of hearing in engine-drivers in the continual severe shaking to which they are exposed, and the persistent straining of the ear, in the piercing draughts, and the continued irritation of the pharynx by the inhalation of injurious vapours escaping from the engine. He found the anatomical basis of the dulness of hearing, in the majority of cases, to be the chronic sclerotizing form of inflammation of the middle ear, and this was afterwards confirmed by Schwabach and Pollnow (*A. f. O.* xvi), Hedinger (*Deutshe med. Wochenschr.* 1882), and Güterbock.

As the dangers of railway traffic which arise from this excessively frequent progressive diminution of hearing in engine-drivers and stokers are, according to Moos, very great, he proposed that the directors of railways should have at periodical intervals of two to three years the ears of their servants thoroughly examined by a specialist. Hedinger's opinion is quite opposed to that of Moos; from his own practical observations, he affirms that railway travelling is not at all endangered by a moderate decrease of hearing in the engine-men, as the acoustic signals, which must be understood by railway officials, are so loud that it is only when the hearing is very defective that they cannot be heard. Güterbock (*Vierteljahrschr. für öff. Gesundheitspfl.* 1882) arrived at similar conclusions from his own examinations.

In conclusion, some remarks may here be made on *simulated dulness of hearing and deafness.* The importance of the subject, both in medico-legal practice and for army surgeons entrusted with the examination of soldiers and of those liable to be called out for active service, sufficiently explains the many endeavours

to devise a trustworthy method of examination, by which it could be ascertained with certainty whether in a given case genuine or simulated dulness of hearing or deafness has to be dealt with.

According to the observations made by Brigade-surgeon Chimani on men liable to serve, the simulation of absolute deafness is less frequent than that of unilateral or bilateral dulness of hearing. This is explained by the fact that the total deafness of an individual is generally known, and the truth concerning it more easily ascertained by inquiry than in the case of dulness of hearing, more especially when the latter affects only one ear. In really existing defects dulness of hearing is most frequently exaggerated.

The method of testing for the detection of simulation must always be preceded by the examination of the membrana tympani and of the Eustachian tubes. If considerable changes are found, which indicate an affection of the middle ear, in such cases the principal requirement is to ascertain the degree of disturbance of hearing, as the capability or the incapability of soldiers depend upon that.*

The difficulty is greater in cases in which there are no objective indications of an affection of the middle ear, as then we are limited to the investigation of a circumscribed affection of the fenestræ of the labyrinth or of the nerve, the diagnosis of which is often surrounded with great difficulties.

A number of methods of examination have been proposed for the detection of simulated disturbances of hearing with negative conditions of the middle ear, and these will be briefly described.

It must, however, be remarked at the outset, that even although the premises are very excellent upon which several of the methods are based, only very few of them can stand the test of experience, especially when a cunningly devised plan of dissimulation has to be overcome, as is so frequently the case.

The procedure varies according as the dulness of hearing or deafness simulated is unilateral or bilateral. In cases in which a unilateral deafness is said to exist, it must first be ascertained whether the affected ear is quite deaf or capable of hearing to a certain degree. In the latter case, by closing the other ear and bandaging the eyes, the hearing-distance of the deaf ear must be

* In the presence of inflammatory changes in the external and middle ears, it must be noted whether these are not artificially produced and maintained in order to escape military duty. According to Chimani, these affect almost exclusively the external meatus, less frequently the middle ear, and never the internal ear. Artificial inflammations of the external meatus and of the membrana tympani are mostly caused by cauterization, and are distinguished from those spontaneous affections by the peculiar form of the disease as well as by its course, the artificial inflammations healing in a very short time, when all further irritation has been rendered impossible by means of a bandage. Sometimes also foreign bodies are intentionally inserted into the external meatus either to feign a disease of the ear, or in cases of pretended dulness of hearing to pass through the testing process the more easily.

measured by the acoumeter or by a loud clock-work, *e.g.* a metronome, and the test must be repeated several times in succession. If the hearing-distance on repeated measurement varies but little, dissimulation may be excluded, as a normal-hearing ear is not able to judge of the distance of a source of sound within certain limits. Great differences in the distances given by the various measurements will, however, immediately excite suspicion. This method, which Dr. Chimani has at my suggestion used for a number of years, is preferable to the similar examination by speech, on account of the constancy of the source of sound. Chimani attaches great importance to repeated testings on different days and to the short duration of the testing, the results being accurately noted each time.

Chimani (*W. m. W.* 1869, No. 33) and Moos used the following proceeding with advantage for the detection of unilateral feigned dulness of hearing. A vibrating tuning-fork of large size is alternately held at an equal distance from each ear, and naturally the sound is better heard by the sound ear. The vibrating fork is then placed on the middle line of the vertex of the head or on the front incisor teeth, and the question put to the individual under examination, In which ear is the tone better heard ?

'The really deaf person (suffering from an obstacle to the conduction of sound),' says Chimani, 'will without hesitation declare that he hears the tuning-fork solely or much more loudly with the affected ear, while the malingerer usually considers a moment and then affirms that he can make out no difference between the loudness in the one ear and in the other, and believes it is the right thing when he says the tuning-fork is heard only by the healthy ear, and not at all by the diseased one. The external meatus of the healthy side is then closed with the finger, and the vibrating tuning-fork again placed on the top of the head; the actually deaf person will say that the tuning-fork is better heard on the stopped ear, or it may be that he cannot distinguish by which ear it is more distinctly heard. The malingerer will state immediately that, now the sound ear is closed, the tone is no longer heard, or only faintly so, by the open and diseased ear.'

A complicated, but in some cases successful, procedure has been proposed by Lucae, and turned practically to account by Teuber. The contrivance consists of two metal tubes inserted through a wall separating two rooms, and each leading to an india-rubber tube provided with a side-branch; the india-rubber tubes are intended for the ears of the person to be examined, while the two side-tubes are destined for two witnesses, who have to check the statements of the patient. On rapidly speaking alternately into the two metal tubes, a person really deaf in one ear only hears the echoes of the words perceived by the normal ear, while the malingerer is not able to separate the quickly, changing impression on the right and left ears, and words which

were spoken through the tube corresponding to the deaf ear will be said to have been heard.

Based on the same principle, L. Müller's method is simpler (*Berl. klin. Wochenschr.* 1869). He uses two tubes, through which words are spoken into both ears at the same time. When unilateral deafness really is present, the patient will only repeat what has been spoken into the healthy ear, while when there is simulation, the malingerer becomes confused, and will repeat the words spoken into the seemingly deaf ear also. To avoid mistakes in using this method, a low voice must be employed.

The method employed by Lucae to discover pretended unilateral deafness with Quincke's interference-apparatus is of no practical value.

Cammon's binaural stethoscope, used by David Coggin in one medico-legal case (*Z. f. O.* viii.) for detecting simulated unilateral deafness, is as sensible as it is simple; he expresses himself upon it as follows: 'The patient affirmed that he was deaf of the left ear. I therefore inserted a tightly-fitting wooden plug into the right caoutchouc tube, and then put the two caoutchouc tubes into the metal ones. When I tried the instrument on myself, I found that words spoken could not be understood by the right ear. After the patient had adjusted the stethoscope, he repeated without hesitation the words which I had whispered into the bell of the instrument, which served as a mouth-piece. The tube containing the plug was then taken out of the right ear, which was firmly closed by pressure on the tragus. When I again spoke into the stethoscope, which was still in connection with the left ear, the patient positively assured me that he could no longer distinguish the words. He was of course aware that the tube through which he had before heard was no longer in connection with the right ear.'

Preusse's method for the detection of feigned unilateral deafness, by the use of two telephones, in so far as it rests on the view that the total acoustic picture of two equal and simultaneous acts of sound on the two organs of hearing is transferred to the back of the head, has no practical value. Whether the telephone in the manner of Lucae's contrivance can be used with effect, must be ascertained by accurate examination. In many cases the telephonic contrivance has the advantage of greater simplicity, and on account of the great distance of the source of sound from the person examined, excludes the possibility of a mistake being made as to the immediate transmission of sound.

In feigned bilateral dulness of hearing the acoumeter or the metronome is used for deciding the hearing-distance, as each ear can be examined separately, the eyes being closed and the examination conducted just as for simulated unilateral dulness.

It is more difficult to unmask pretended bilateral total deafness. The largest contingent of this class of malingerers is furnished by

those who are called out for the first time. As physical tests of hearing are of no use in these cases, various devices must be resorted to in order to discover the deceit. Whether the man can be wakened out of sleep by a moderately loud call, seems to me the surest experiment. But as in total deafness motor reflexes may be elicited by the concussion of loud sounds, care must be taken not to go too near the person concerned, and not to call too loudly. In some cases, as Burkhardt-Merian observes, the expression of the malingerer's face, when offensive remarks are made behind his back by a third party, may reveal the deceit. The trick of telling the individual to go, that he is unfit for duty, is stale, and therefore scarcely effective.

In the majority of cases, this, as well as numerous other proposed methods, is of no avail, as very often one has to do with proficient swindlers, who adhere obstinately to their firmly-laid plan of dissimulation.

The experience and the practised eye of the examiner, acquired through many years' practice, are not to be undervalued as qualifying him to discover dissimulation, by gathering a series of proofs from apparently insignificant circumstances. The glaring contradictions made by a number of malingerers on repeated examination, in regard to the cause of origin and course of the disease, are often sufficient to raise suspicion. Chimani attaches great importance to the observation of the individual himself, his mental faculties, his temperament, the peculiarity of the expression of his face, and of his speech, all which, taken in connection with the results of the hearing-tests, lead in most cases to the detection of malingerers.

Cerebral Disturbances of Hearing.

Diseases of the brain and its membranes are oftener combined with disturbances of hearing than has been hitherto supposed. Even in the new and larger works on the diseases of the central nervous system, notwithstanding careful description of the disorders of the other nerves of sense, there is but scant and faulty information on the participation of the ear in these pathological processes. It is only in very recent times that great attention has been paid to this subject, so that the number of cases carefully examined clinically, in which the disturbance of hearing had been observed and followed from its very commencement, is too small to form the basis of a pathology of the cerebral disorders of hearing.

These disorders are caused either by affections of the acoustic centres; or by morbid processes in the brain or its membranes involving the nucleus, the roots, or the stem of the auditory nerve; or, lastly, by extension of inflammatory processes from the cranial cavity to the labyrinth.

Of the disturbances of hearing in consequence of meningeal affections, those after the termination of simple meningitis are on the whole rare. As anatomical bases of the deafness there have been recognised purulent inflammation of the ependyma and softening of the floor of the fourth ventricle, purulent infiltration, and afterwards fatty degeneration and shrivelling of the stems of the auditory nerve. In some cases in which the labyrinth has been examined, no pathological change has been found in it.

Deafness appearing in simple meningitis is perceived immediately after the return of consciousness between the third and eighth weeks of the disease, or it develops more or less rapidly during convalescence. It is only in exceptional cases that the disturbance of hearing is combined with unilateral or bilateral blindness, strabismus, and with paralysis of other nerves. Children become, as a rule, quite deaf, and after months still exhibit an unsteady gait. In adults, on the other hand, there is rarely total deafness; but there often remain subjective noises and disturbances of hearing of various degrees, which very seldom completely disappear. Some time after convalescence a considerable improvement sets in, which, however, is followed in the course of months, or even years, by progressive increase.

Disturbances of hearing are much oftener observed as sequelæ of epidemic cerebro-spinal meningitis. Among the anatomical changes which in this form of disease are associated with disturbance of hearing are: softening or thickening of the ependyma of the fourth ventricle, purulent infiltration and softening of the auditory nerve (Knapp), embedding of the latter in meningeal exudation (Schwartze) and later shrivelling of the nerve stem, and lastly purulent inflammation of the membranous labyrinth, the origin of which can be traced to transmission of the inflammation either along the sheath of the auditory nerve (neuritis descendens) or through the aqueducts.

Heller (*Deutsch. Arch. f. klin. Med.* vol. iii.), in a man, aged forty-two years, who died from cerebro-spinal meningitis, found both tympanic cavities filled with pus, and pus in the vestibule also. The membranous semicircular canals, the ampullæ, and the lamina spiralis of the cochlea, were covered with pus-cells. In a woman, aged forty-five years, who also had died of purulent cerebro-spinal meningitis, Heller found numerous punctiform ecchymoses on the lamina spiralis, which was infiltrated with pus. The auditory nerves were embedded in pus.

In the case of a man, forty years of age, observed by Lucae (*A. f. O.* vol. v.), along with purulent cerebro-spinal meningitis there was purulent infiltration of the auditory nerves, the sacules, ampullæ, and semicircular canals.

The above post-mortem appearances comprise the whole material upon which is based the recognition of purulent inflamma-

tion of the labyrinth in cerebro-spinal meningitis. But although the importance of these appearances, especially in regard to the explanation of the disturbances of equilibrium remaining after epidemic cerebro-spinal meningitis (Moos) must be admitted, it is scarcely to be doubted that in simple meningitis as well as in the epidemic form, deafness and disturbances of equilibrium may be caused by the pathological changes in the cranial cavity alone, without a simultaneous affection of the labyrinth. Of the development of the disturbances of hearing in the course of the disease I possess no special experience, as neither in Vienna nor in its neighbourhood has the epidemic form of cerebro-spinal meningitis hitherto appeared. Our numerous observations, indeed, only affected such cases as were brought to Vienna from the provinces, weeks or months after the disease had terminated. The statements of the parents or the physicians in regard to the time of the onset of the disturbance of hearing were seldom of any value, as deafness in children may be so easily overlooked for a long time. Generally, however, my notes agree with those of Moos and Knapp, in so far that, in the majority of cases the deafness commenced in the first or second week, rarely several weeks or months after the disease.

According to existing observations on the origin of the ear affection, the intensity of the disease appears to have less influence than its epidemic character. While very severe cases have often occurred without any disturbance of hearing, total deafness has frequently set in in the slighter so-called abortive forms, in which the patients, during an epidemic, complain for a few days of depression, headache, stiffness of the neck, or where the violent symptoms (fever, vomiting, convulsions, unconsciousness, contractions of the neck) so decrease that the patient can get out of bed in two or three days.* On the other hand, from the communications received from doctors who had opportunities of observing large epidemics, it seems that in many epidemics disturbances of hearing occur only exceptionally, while in others most of those who escape with their life are deaf.

Similar observations have been made in various parts of Germany. Dr. Roth, in Ziemssen's *Handbuch* (vol. ii. p. 530, cited by Moos), observes that in the Bamberg Deaf and Dumb Institution forty-two pupils, admitted from the district of Oberfrank in the year 1874, became deaf and dumb from cramp in the neck. The town of Bamberg itself, in which the epidemic is said to have been very severe, presented only four cases. Of nine cases admitted in 1875, eight had become deaf in consequence of cerebro-

* Such cases, therefore, are only to be regarded as abortive forms of epidemic cerebro-spinal meningitis (Gottstein), when they occur during an epidemic of the disease. Whether, in sporadically observed cases, a meningeal affection or an inflammation of the labyrinth is at the bottom of the rapidly disappearing complex of symptoms, can only be ascertained by future anatomical examinations.

spinal meningitis, and in 1876 the same disease sent eight more cases.

Deafness after epidemic cerebro-spinal meningitis is bilateral in the majority of cases. When the two ears are unequally affected, the one ear is generally quite and the other very deaf.

The most striking symptom accompanying the deafness is the staggering gait. Moos observed it in half of his cases; according to my notes disturbance of equilibration was present in more than two-thirds of the cases. It lasted the longer the younger the individual was at the time he was attacked by meningitis. In the majority of cases the unsteady gait disappears gradually after three or four months, but it may continue over a year.

Subjective noises exist in most cases. Moos affirms that adults and youths frequently complain of tinnitus. There is, however, no doubt but that subjective noises occur more frequently in children than is generally supposed. The reason why that has been so little taken notice of hitherto is because, according to my experience, subjective noises are much less troublesome in children than in adults, and, therefore, children seldom speak of them until asked about them.

In some cases the deafness is complicated with unilateral or bilateral disturbance of vision, with disturbances of speech, and paralysis in other nerve areas.

The prognosis of the deafness left by epidemic cerebro-spinal meningitis is generally unfavourable. There is very seldom complete recovery. Moos has rightly observed, however, that the percentage of cured and improved cases attended by the general practitioners dwelling in the place during the epidemic, is much greater than that observed by the specialist to whom the patient is taken weeks or months after the epidemic. Cases of deafness, in which during convalescence or several weeks later the power of hearing so improves in one or both ears that speech can be understood at a short distance off, are not often met with. According to Moos, circumstances of favourable prognostic import in regard to improvement in the hearing are, subjective noises during convalescence and the perception of high musical tones. The return of hearing for speech is not always permanent, as I have observed total deafness set in again after months or years.

The treatment of cerebro-spinal deafness is almost always unsuccessful. In recent cases, however, an attempt must be made to bring about the absorption of the as yet unorganized exudation. For that purpose iodide of potassium (0·5-1·0 gram. per day) or iodide of ammonia (ammon. iodid. 5·0, mist. gummos. 100·0; Syr. cort. aur, 15·0, sig. one table-spoonful three times a day) should be prescribed, and the application of an iodine or iodoform ointment on the mastoid process, and when

circumstances permit it a course of some iodine spa used both internally and externally. The internal and external exhibition of strychnia has hitherto been without effect, and likewise electricity, which Moos only uses in those cases in which a certain degree of hearing remains.

On the disturbances of hearing, observed by Moos, in pachymeningitis hæmorrhagica, there are no other observations on the pathological changes in the labyrinth than those on p. 702. Kremiansky's observation points to the extension of the meningeal process along the vessels into the labyrinth, as according to it the chronic pachymeningitis followed the course of the middle meningeal artery.

Disturbances of hearing proceeding from affections of the brain are caused by many pathological processes. The most important of these are: hæmorrhage, emboli and embolic softening, encephalitis, chronic sclerosis, acute and chronic hydrocephalus, gummatous and tubercular accumulations, and new-formations in the brain and at the base of the skull.

The occurrence of disturbances of hearing in these processes depends less upon the extent than upon the seat of the pathological accumulation. While with extensive morbid accumulations in the brain substance (abscesses, hæmorrhagic accumulations, growths) disturbances of hearing are often absent, they are very pronounced with pathological changes of small size, when these affect the acoustic cortical centre in the temporal lobe, the connection of the latter with the acoustic nucleus, the acoustic nucleus itself, or the central fibrous course of the auditory nerve.

Disturbances of hearing proceeding from apoplexy of the brain have hitherto been rarely observed. According to Moos, they occur most frequently in hæmorrhage in the pons and in the cerebellum. According to the observations of Itard, Oppolzer, Andral, v. Tröltsch, and Nothnagel, subjective noises are often the forerunners of apoplexy. Deafness is seldom described in connection with encephalitic deposits and extensive abscesses in the cerebral hemispheres.

Wernicke and C. Friedländer observed a case of total bilateral deafness due to symmetrical gummatous soft deposits in the region of the corona radiata of both temporal lobes, complicated with temporary aphasia.

Acute hydrocephalus internus often causes great disturbances of hearing. These are the result of inflammatory changes on the floor of the sinus rhomboideus, which lead to softening and shrivelling of the nucleus of the auditory nerve. That in acute dropsy of the ventricles of the brain the anatomical changes in the acoustic nuclei may completely recede, is proved by those cases in which total deafness and also blindness, arising in the course of the disease, have completely disappeared. Acute as

well as chronic hydrocephalus internus frequently occasions permanent bilateral deafness and deafmutism. Meyer found (*Virch. Arch.* xiv.) in a person congenitally deaf, but with normal hearing organs, the residue of a fœtal ependymitis in the form of knotty and nodular thickenings of the ependyma of the sinus rhomboideus, with obliteration of the striæ acousticæ and destruction of the commencement of the auditory nerve. In chronic hydrocephalus the deafness is occasioned by atrophy of the origin and of the stem of the auditory nerve from pressure (see case on p. 724).

We come now to those peculiar disturbances of hearing which are occasioned by pathological changes in the temporal lobe (cf. Munk's experiment, p. 684). In several cases recorded by Wernicke, Kahler and Pick, Broadbent, and others, in which dissection revealed great changes in the left temporal lobe, it was observed during life that the patients although hearing speech were not able to understand it. This led Wernicke to the conclusion that the centre for the sense of hearing lay in the cortex of the left temporal lobe, and that there also the excitations of the auditory nerves are united to form sound-pictures, and the acoustic representation of words. When this centre is paralysed —with an otherwise normal condition of the ear and of the auditory nerve—impressions of sound could still be perceived, but spoken words could not be understood, a condition which was named 'sensory aphasia' by Wernicke, and 'word-deafness' by Kussmaul. The surprisingly frequent coincidence of word-deafness with disease of the first convolution of the left temporal lobe (like aphasia with lesion of the third left frontal convolution) makes it more than probable that the acoustic representation, or picture of words, is formed principally in the left temporal lobe and in the aforesaid convolution. This opinion, first stated by Wernicke, has since been supported by the observations of Kahler and Pick, Kussmaul, Huguenin, Fritsch, N. Weiss, Drozda, and others. The results of clinical observations, however, and also of physiological experiments (Munk's experiments), showing that after destruction and even extirpation of the cortex of the temporal lobe the understanding for what is heard may be recovered, are by no means in favour of a sharp limitation of the acoustic cortical centre; they lead rather to the conclusion that other groups of ganglion cells presiding over the hearing function must exist in the cortex of the brain, by means of which patients as well as animals experimented on begin again to learn to hear after the loss of the proper hearing centre.

According to Stricker (*Vorlesungen*, part iii. 1880) word-deafness is not only associated with lesions of the temporal lobe, but is also an essential symptom of destructive processes in Broca's speech-island (third left frontal convolution). Since Stricker,

from his investigations, has come to the conclusion that word-pictures are purely motor in nature, and are elicited by the transmission of excitation from the various sensory centres (in the hearing of speech from the hearing-centre, in reading from the seeing-centre), therefore, by destruction of the motor-centre of speech, word-deafness and word-blindness, along with agraphia and alexia, must necessarily occur, as the seeing and hearing impressions are no longer able to call forth the corresponding word-pictures in the paralysed centre of speech.

According to this, word-deafness, arising from lesion of the first temporal convolution, may be explained by the fact that the conduction of acoustic stimulations from the side of the hearing-centre to the motor-centre for speech is destroyed, and, therefore, can no longer form word-pictures.

Some interesting clinical and pathological observations may here be briefly given: Wernicke (cited in Hasse's *Krankh. d. Nervensyst.*), in the case of a female patient, seventy-five years of age, who was generally taken for deaf on account of her want of understanding for words and speech, at the necroscopy found the whole first and a part of the second left temporal convolution transformed into a whitish yellow soft mass, owing to preceding embolism of the artery of the Sylvian fossa. Clinical records and careful testing of the hearing cannot be obtained in the case of decaying and decrepid old people. Kahler and Pick (*Prag. Vierteljahrschr.* 1879), in the case of a woman, aged forty-two, who was word-deaf, having two years previously, after violent headaches, lost both speech and hearing, and later exhibited signs of mental disturbance, found encephalitic deposits in both temporal lobes. In another case observed by them, the anatomical basis of the word-deafness consisted in compression of both temporal lobes, but especially of the left one, by exudation after hæmorrhagic pachymeningitis. Broadbent (*Lancet*, 1878) mentions a case of extensive embolic softening of the left surface of the brain, especially of the first and second temporal convolutions, and of the gyrus angularis, with anæsthesia of the right half of the body without paralysis, inarticulate speech, and evident sensory aphasia. Fritsch (*Wr. med. Pr.* 1880) observed a case of word-deafness, in which dissection showed softening of the left inferior parietal lobe, of the first and second temporal convolutions, and of the posterior convolution of the island of Reil. In a case, observed by Holländer, of aphasia and word-deafness in a man, aged fifty-four, dissection showed as their cause a large tubercle with softening in the left temporal lobe, and a soft deposit in the occipital lobe of the same side. In Kussmaul's *Störungen der Sprache* (Leipzig, 1877) there is a very interesting account of Dr. Lordat, who, after his recovery from a long-existing aphasia, said that during the continuance of the disease words spoken fell meaningless on his ear, and that he

was not able to understand anything printed or written. In a woman, aged fifty-one years, observed by Holländer in Meynert's clinique, in whom aphasia was combined with total deafness, the disturbance of hearing gradually receded while the aphasia remained unchanged.

Of cerebral diseases tumours of the brain are most frequently associated with disturbances of hearing, which are due to pressure on, pulling, separation (Brückner), or disorganization of, the central course or stem of the auditory nerve. Paralysis from pressure is principally caused by growths in the posterior section of the base of the brain and of the cranium, originating in the dura mater and the pia mater, and by tumours of the brain itself pressing towards the base. The most common tumours are the sarcoma, myxoma, glioma, and carcinoma, psammoma, and cholesteatoma being more rare.

The statistics of Calmeil, which place the frequency of disturbances of hearing in tumour of the brain at one in nine, and of Ladame, who recorded such disturbances seventeen times among one hundred and seventy-five cases, scarcely give the proper proportions, as unilateral deafness is very often overlooked by clinicians; and, further, in the majority of cases it was not ascertained whether coincident changes in the sound-conducting apparatus were not the true cause of the deafness. From Ladame's compilation, however, it is noteworthy that tumours of the pons are most frequently accompanied by disturbances of hearing, while tumours in the parietal and occipital lobes and in the fourth ventricle have not once caused deafness. The latter cases can only be explained on the ground that no pressure has been exercised by the growth on the nuclei of the auditory nerves.

The most prominent symptoms of the changes within the area of supply of the auditory nerve, caused by cerebral tumours, are: subjective noises, vertigo, and dulness of various degrees up to total deafness, with which, as a rule, the subjective noises are lost. In the majority of cases the deafness is unilateral (Cruveilhier, Wernicke), but cases are not uncommon in which bilateral deafness is caused by pressure on the opposite half of the brain or by extension of the tumour to the other side. Concomitant symptoms are giddiness, feeling of pressure and pain on the half of the head corresponding to the seat of the tumour, and sparks before the eyes; in its further course there develop marked functional disorders of the optic and other nerves of sense, motor and sensory paralysis in the region of the cerebral nerves (in one of my cases there occurred xerosis, with ulceration of the cornea). The order of the appearance of the separate symptoms depends upon the place of origin and the direction of the growth of the tumour. Then, in a series of cases, disturbances of sight and paralysis in other nerve areas precede the deafness. In the majority, how-

ever, the latter forms the initial symptom of the tumour of the brain.

In unilateral tumours of the cerebellum, there is very often bilateral deafness, according to Schwartze, even when no direct pressure is exercised by the tumour on the nerve of the other ear.

Two years ago I had an opportunity of witnessing an interesting case of right-sided deafness and left-sided dulness of hearing, caused by a tumour in the right half of the cerebellum. The case was that of a waiter, twenty-four years of age, who had often suffered from headaches since childhood. He observed, in May, 1880, a decrease in the hearing-power of the right ear. Soon thereafter, he was attacked by headache, vomiting, weakness of sight, and, some months later, by paresis of the right facial, giddiness and tinnitus. In the beginning of September, after excessive vomiting, there suddenly set in unconsciousness and sopor, motor disturbances in the muscles of the neck and of the upper extremities, gradual blindness, and several weeks later bilateral exophthalmos, decidedly stronger on the left side.

On examining the ears in October, I found both membranes normal. The acoumeter was heard on each side on contact only, but much more faintly on the right side. Hearing for speech on the right = 0, on the left = 1½ metre. Perception for the acoumeter through the bones of the head was weaker on the right side than on the left. High-and low-pitched tuning-forks were heard through the air faintly on the right side, but perfectly on the left; all tuning-forks were perceived from the vertex of the head by the left ear only.

In its further course, repeated violent vomiting, unconsciousness and general paralysis set in. Death ensued on the 19th November, 1880.

A post-mortem examination, made on the following day, gave these results: the convolutions of the brain were greatly flattened, and the sulci effaced; the corpus callosum was much bulged out and fluctuant; the ventricles of the brain were enlarged to twice the normal size; the foramen of Monro was the size of a pea; the septum pellucidum was very thin and transparent, and there was a gap as large as a bean in its posterior half. The interior of the right hemisphere of the cerebellum was occupied by a cyst larger than a goose's egg, the upper, under and middle walls of which were formed by the substance of the brain 3 mm. in thickness, while at the side of the hemisphere the cyst was bounded only by the arachnoid stretched over it. The inner surface of the cyst was lined by a very thin layer of transparent gelatinous tissue, which was most abundant towards the side of the hemisphere, and appeared pigmented in places or infiltrated with capillary hæmorrhages. The contents of the cyst were composed of a clear, aqueous serum. Microscopically, the tissue on

the cyst-walls appeared to be myxomatous, with abundant intercellular substance between the star-shaped cells.

With this case is classed a second, affecting a young man, aged twenty-five, with scrofulous cicatrices on the neck, who had suffered for seven years from a discharge from the left ear, but whose hearing had been normal on the right side. Some months previously, dulness of hearing set in on the right side, with severe headache and weakness of sight. Two months previously, total deafness suddenly occurred, which only gradually improved.

The result of the examination was: on the left, complete destruction of the membrana tympani, malleus and incus adherent to the inner wall of the tympanic cavity; on the right, the condition was normal. On account of the stupor of the patient, accurate testing of the hearing was impossible, and it could only be ascertained that speech on the right was understood at a distance of 3 metres, while on the left it was not understood at all; the low-pitched tuning-fork, from the vertex, could only be perceived on the right. Death ensued from marasmus and general paralysis.

Result of Post-mortem Examination.—The right half of the cerebellum was greatly enlarged, and its inferior and median surfaces so much bulged out that the medulla oblongata and the inferior vermiform process of the cerebellum were displaced towards the left. The latter and the median surface of the left hemisphere were greatly flattened. The enlargement of the right hemisphere was caused by a cavity in its substance filled with a thin brown fluid, the longitudinal diameter of which measured 8 cm. and the transverse 9 cm. The inferior wall of this cyst, chiefly formed by the cortex, was so thin at one part that it tore during examination. The inner surface of the cyst was partly yellowish-white, partly yellowish-brown, and smooth; but at one point there projected a somewhat nodular growth 4 cm. in length and about 3 cm. in height, formed of a gelatinous, slightly transparent, yellowish tissue, not distinctly demarcated from the surrounding tissue. In the sinus rhomboideus, the striæ acousticæ were on the right side indistinct, and on the left flattened. The ventricles of the brain were greatly distended by clear serum. The two auditory nerves and the optic tracts were diminished in size, transparent, and grey.

The right ear was normal; the appearance of the left agreed with that recognised during life, and the ostium tympanicum tubæ was closed by an osseous plate.

Diagnosis.—Sarcoma of the right hemisphere of the cerebellum, with formation of a cyst-like cavity in the substance of the cerebellum, which had become pigmented by hæmorrhage.

The *diagnosis* of deafness caused by tumours of the brain is but seldom possible, particularly in that stage in which, beyond

the disturbance of hearing, there are no symptoms of irritation or paralysis discernible in the areas of distribution of other nerves. At that time the differential diagnosis is difficult, as dulness of hearing, combined with tinnitus and attacks of giddiness, with a negative condition of the middle ear, may be occasioned by an affection of the labyrinth as well as by a central lesion. In both cases, high and low pitched tuning-forks, placed on the vertex of the head, are heard only by the normal or better-hearing ear. An important guide for the diagnosis of such cases, in my experience, is the testing of perception for the watch and the acoumeter through the bones of the head. While in affections of the labyrinth, even with only a moderate degree of dulness of hearing, perception through the bones of the head is either greatly decreased or quite absent, in disturbances of hearing caused by tumours of the brain perception is intact, and only defective when the dulness of hearing is very great.

Further, the diagnosis is attended with great difficulty in the absence of other symptoms of cerebral compression, if an affection of the middle ear exists at the same time, which, as we have seen, may also run its course with vertigo and a staggering gait.

A case observed in my clinique in 1877 affords a striking example of this kind. It was that of a young woman, twenty-six years of age, who had suffered for years from suppuration of the left middle ear, combined with subjective noises and vertigo. After some months' treatment the ear-discharge was cured, and the patient was dismissed with a perforation in Shrapnell's membrane and an adherent cicatrix behind the handle of the malleus. Notwithstanding the great improvement in the hearing, tinnitus and vertigo remained unabated. When the patient presented herself at the clinique some months later, on account of giddiness, increasing vertigo, and disturbances of equilibrium, suspicion was aroused to the presence of a central lesion, but there was still the possibility of the phenomena being caused by increase of pressure in the labyrinth (in consequence of the adhesive process in the neighbourhood of the stapes).

The diagnosis of a tumour of the brain could only be made with certainty when the patient, some months later, was admitted to the general infirmary with bilateral weakness of vision, great dulness of hearing, and paresis of the extremities. In the course of several months she became quite blind and deaf, the paralysis of the extremities increased rapidly, and on 16th December, 1878, she died with symptoms of general paralysis.

Result of Post-mortem Examination.—In the triangle on the right half of the pons Varolii and the right crus cerebelli ad pontem, which is formed by the places of origin of the trigeminus, facial, auditory, and abducent nerves, there was situated a somewhat nodular, oval, superficial tumour, the size of a goose's egg, proceeding from the meninges, which on section was whitish,

transparent, and vascular, and enclosed some cysts of the size of peas filled with clear serum. By this tumour the right half of the pons Varolii, the right crus of the cerebellum, and the right crus of the cerebrum were flatly compressed. In like manner the right pyramid and olivary body of the medulla oblongata, and above them the anterior third of the inferior surface of the right hemisphere of the cerebellum, were compressed. Of the nerves, the abducent was displaced towards the middle, the trigeminus, facial, and auditory crossed at the external circumference of the tumour. The latter nerves were greatly compressed, their fibres being pressed out from each other.

Microscopic examination showed that the tumour consisted of mucous tissue, which had partly undergone fatty degeneration.

The disturbance of hearing may be traced with more certainty to a tumour of the brain, when at the same time the already described signs of paralysis of other nerves present themselves in a pronounced form. In cases not very advanced slight degrees of facial paresis and anæsthesia of the skin of the affected half of the head should be paid particular attention to, as they may easily be overlooked in a superficial examination.

Moos (*Virch. Arch.* lxviii.) has communicated some cases of great deafness with coincident affection of the trigeminus, which he referred to a cerebral disease. The deafness was as a rule bilateral. The phenomena on the part of the trigeminus, which preceded those of the auditory nerve, varied from the most violent neuralgic pains to complete anæsthesia, always affected its sensory root, and were mostly unilateral. The auditory affection commenced with excessive subjective noises, which, became, however, weaker with the increasing paresis of the auditory nerve, and completely disappeared with its total paralysis. The deafness was either sudden or showed a protracted character. Only in one case did recovery take place under the use of the constant current.

The occurrence of trophic disorders of the middle ear in consequence of intracranial affections has been proved by repeated clinical observations, and Benedikt and the author (*Wr. med. Woch.* 1865) have pointed out the causative connecting-link between affections of the brain and of the middle ear. Recently Moos and Steinbrügge (*Z. f. O.* xi.) have observed the formation of a pigmented membrane, extending over the whole of the mucous membrane of the middle ear, in consequence of hæmorrhagic pachymeningitis.

In favour of the occurrence of trophoneurotic disorders in the middle ear are the experiments of Gellé, Berthold, and Baratoux, who observed inflammatory changes (hyperæmia and purulent exudation) in the middle ear after cutting through the central root or stem of the trigeminus. Kirchner and Aschenbrandt (*Festschrift Würzburg,* 1882) have recently proved experi-

mentally that an increased mucous secretion in the middle ear is also caused by irritation of the trigeminus.

The occurrence of mental reflexes in consequence of diseases of the organ of hearing requires to be mentioned. Köppe (*A. f. O.* vi.) was the first to draw attention to the fact that mental disturbances (melancholia, hallucinations, suicidal attempts, attacks of mania) may be reflexly called forth by pathological changes in the organ of hearing, in the presence of a congenital or acquired pathological tendency of the brain. In two cases described by him (one of suppuration of the middle ear, one of accumulation of cerumen) the mental disturbance disappeared when the ear affection was cured. Therefore, in patients mentally deranged who show symptoms of ear disease, an attempt should be made to act upon the brain disorder through local treatment of the ear.

Malformations of the Organ of Hearing.

The malformations of the ear are in so far of interest to the aurist, that they frequently form the foundation of deafness—*i.e.*, deafmutism. They either occur with malformations of other organs, or are confined to the organ of hearing. Of the latter the bilateral anomalies of formation are full of significance. The malformation affects only some parts of the ear, or the whole organ. Thus with an excessive malformation of the external and middle ears, the internal ear may be normal, and also with arrest of development of the labyrinth, the tympanic cavity and the external ear may be perfectly formed.

Anomalies of formation of the auricle are very frequent, and exhibit either an excess or a defect of formation. Among the first are reckoned congenital excessive enlargement of the auricle, the occurrence of two (Knapp) or more (Cassebohm, Langer) auricles on one side (polyotia), and the so-called auricular appendages (Virchow) which project as isolated portions of cartilage in front of the tragus or beneath the auricle in the form of round or longish prominences. Excessive formation is generally confined to the auricle, while arrest of development is as a rule combined with similar defects in the auditory meatus and the middle ear, less frequently in the labyrinth (Cassells).

Fig. 250.

Defective formation of the auricle occurs either as a total absence of it, or as a stunting and shrivelling of the cartilage, lastly as a malformation of one or other of its sections. The changes of form thus caused are manifold; the auricle appears sometimes as a rudimentary membranous swelling or cartilaginous cone, sometimes hook-shaped or spirally curved (Knapp), or

rolled together like a paper-bag (Zaufal, D. Hunt), or as a cauliflower excrescence (Moos and Steinbrügge); further as the so-called cat's-ear, and most frequently, as in Fig. 250, as a longish cartilaginous swelling.

Among the malformations of the external meatus must be mentioned the rarely met with excesses of development, such as immoderate dilatation and a double condition of the canal. In the latter anomaly there is, as in Velpeau and Macauln's cases (*The Specialist,* London, 1881), behind the proper auditory meatus a second blind canal, without any connection with the other; or there may be two separate canals, which, as in Bernard's case (*Journ. d. phys. exp. de. Magendie,* iv.), after a short course unite to form a common canal.*

The defects in the formation of the auditory meatus are more frequent, which are combined usually with defects in the auricle, with partial or entire absence of the middle ear, and often with arrest of development of the bones of the head (Mich. Jäger, Moos and Steinbrügge, Zuckerkandl, and others). They take the form of congenital contractions, often of atresia, which is either osseous or membranous. Sometimes all sign of an auditory meatus is absent (Robb, *Am. Journ. of Otol.* iii.; Hessler, *Stat. Ber. A. f. O.* xvi.). In place of the external orifice of the ear there is either a shallow depression or a short blind canal (Welcker, *A. f. O.* i.; Zaufal, *Prag. med. Wochenschr.* i.; Knapp, *Z. f. O.* xi.).

In the case of a malformation of the right ear, dissected by me, besides a rudimentary auricle, I found the auditory meatus represented by a fibrous cord 1 cm. long, entire absence of the cavity of the middle ear, and the ostium pharyngeum tubæ indicated only by a small fossa. The osseous and membranous labyrinths were perfectly formed, and the expansion of the auditory nerve with Corti's organ was normal.

The most important malformations of the membrana tympani are the following: congenital absence of the membrane, which always appears in connection with arrested development of the external auditory meatus and of the middle ear, and congenital perforations, which are observed at the anterior superior pole in the region of Shrapnell's membrane, generally bilateral and combined with cleft palate (v. Tröltsch).

A congenitally double condition of the membrana tympani appears doubtful, and, as Schwartze rightly observes, it may be

* The branchial-canal fistulæ (fistula aur. congen.) must here be mentioned, which, according to examinations made by Urbantschitsch, Schwabach, Kipp, and Kratz, have no connection with the development of the auditory meatus. They appear as short blind canals, lined with epithelium, and secreting a milky fluid; they discharge by a roundish orifice in the skin, visible below or in front of the tragus, and they communicate neither with the auditory meatus nor with the tympanic cavity. Sometimes there follows a cystic enlargement of the branchial fistula. In several cases they were proved to be hereditary (Kratz). The anomaly is generally bilateral; in two cases observed by me it only affected the left ear.

that, in the cases described by Duverney, Giampietro, and others, a membranous new-formation in the external auditory meatus has been mistaken for a second membrane.

The most important anomalies of formation of the tympanic cavity are its rudimentary development with contraction to the diameter of the head of a probe (Moos and Steinbrügge, *Z. f. O.* x.), and its complete absence. Besides these there occur partial defects of development, such as contraction (in a preparation of mine), or complete closure of one or both fenestræ of the labyrinth, and absence of the eminentia stapedii.

The following malformations of the ossicles have been described: abnormal increase or decrease in size, coalescence of all the bones to form one (columellar formation, Toynbee), union of both crura of the stapes to form one common rod proceeding from the centre of its foot-plate, and the complete absence of one or more of the ossicula.

Malformations of the Eustachian tube are usually combined with those of the external meatus and of the tympanic cavity, sometimes also with cleft palate (Gruber). A congenital dilatation to 3-4 times its normal size has been described by Coek (*Med. chir. Trans.* xix., cited by Schwartze). Cassells (*Glasg. Med. Journ.* April, 1876), besides contraction of the osseous auditory meatus, has also found contraction of the osseous tube. Total absence of the Eustachian tube, with simultaneous absence of the external meatus and of the tympanic cavity, has been observed by Moos and Steinbrügge, and in one case by me also.

Along with partial or complete absence of the external and middle ears, there are, as a rule, also defects in the mastoid process, extending even to its entire absence (Michel, *Gaz. med. de Strasbourg*). Sometimes, even when the formation of the other parts of the temporal bone is normal, this process is so shrivelled as to form a short solid tubercle.

Among the malformations of the internal ear, which occur either with simultaneous defects in the sound-conducting apparatus or with normal conditions of the latter, there have been described: complete absence of the labyrinth (Michel, Schwartze), absence of one or all of the semicircular canals (Bochdalek, Toynbee, Voltolini, Brenner, and others), rudimentary development of the same (Triquet), absence of the vestibule and of the cochlea (Montain), or of a single coil of the latter (Hyrtl), absence of the modiolus or of the lam. spiralis (Nuhn, Bremer), opening of the fenestra rotunda into the vestibule, dilatation of the aqueducts (Hyrtl), absence of the auditory nerve only with simultaneous absence of the labyrinth (Michel), and lastly, absence or imperfect development of the striæ acousticæ and of the nucleus of the auditory nerve.

The above malformations of the internal ear are combined, as a rule, with total deafness. On the other hand, with defective

development of the sound-conducting apparatus, and at the same time normal development of the internal ear, perception for sound is present in various degrees. In atresia of the external meatus hearing for speech may be present, which is effected either by means of the bones of the head or by the Eustachian tube.

In unilateral absence of the external and middle ears, the state of the labyrinth on the same side can be ascertained by examinations with the tuning-fork. When the vibrations of the fork from the vertex are better perceived by the malformed ear, it shows that the development of the labyrinth is normal; when, on the other hand, the tuning-fork is only heard by the normal ear, it is probable that there is a defective development of the internal ear also on the malformed side.

In unilateral absence of the auricle, combined with atresia of the meatus, examination of the movements of the velum palati during phonation should never be omitted. If the movement of the palatine arches is symmetrical, it may with probability be inferred that the development of the Eustachian tube and of the middle ear is normal. If, on the other hand, the half of the palate on the malformed side exhibits diminished movement, as I have repeatedly observed, it may justly be assumed that the tympanic cavity and the Eustachian tube are defective, in so far as they are combined with a defective development of the muscular apparatus of the palate and tube.

Operative interference in congenital atresia of the external meatus is only allowable when it has been with certainty ascertained by careful examinations that it is a case of a congenital thin-walled septum at the entrance to the ear, when by applying the ear-trumpet to the closed part speech can be understood, and by catheterism of the Eustachian tube the stream of air can be heard in the middle ear by means of the otoscope. When the atresia extends far inwards, on the other hand, so that the auditory meatus cannot be made out or only as a solid cord, operation must be avoided as irrational and dangerous.

Deafmutism.

The absence of the power of speech in consequence of congenital or acquired deafness is termed deafmutism. The most frequent causes of congenital deafness are: heredity, including direct transmission from the parents as well as indirect transmission from forefathers, and marriage between blood-relations.

Direct transmission, according to Hartmann's investigations, is on the whole rare. Much more frequent is indirect transmission, which has been proved by Hartmann in 68 per cent. of his cases. In this case there is transmission of a defective constitutional tendency, which must also be supposed to account for the

occurrence of congenital deafness in several children of the same family, without apparent hereditary tendency. Kramer describes one family in which six sons were born deaf and five daughters with perfect senses, while the parents were both healthy. I myself saw in one family, in which there existed no hereditary disposition, four deaf-mutes out of ten brothers and sisters. The highest number of deaf-mutes hitherto observed in one family, in which there was no hereditary disposition, was eight.

The statements of authors on the influence of close intermarriages on congenital deafness vary, for Boudin attributes the cause of deafmutism to consanguinity of the parents in 25 per cent. of the cases, Mitchell in 6 per cent., Hartmann in 8·1 per cent. Whether unfavourable social relations favour the frequent occurrence of deafmutism is questionable; the frequency of the imperfection is very marked among the inhabitants of mountain districts, and may probably be traced to the great number of their close intermarriages.

Acquired deafmutism is not so often caused by primary affections of the ear as by intra-cranial processes and general diseases. First in importance are epidemic cerebro-spinal meningitis, simple meningitis, and hydrocephalus; then the acute infectious diseases, typhus, scarlatina, diphtheritis and measles; and, lastly, primary diseases of the ear, particularly inflammation of the labyrinth (p. 711), panotitis (p. 716), and traumatic injuries of the auditory nerve.

The numerical proportion of congenital to acquired cases of deafmutism varies according to the author and the country. The recent statement, that the two forms occur equally often, cannot be accepted as definite, as even by an accurate examination by a specialist in a series of cases, it cannot always be ascertained whether the deafmutism is hereditary or acquired. That the data given in deaf and dumb institutions are quite untrustworthy, is seen from the fact that the author, in a number of cases said to be congenital deaf-mutes, has found changes in the ear (extensive perforations, adhesions of the membrana tympani, etc.), which showed without doubt that the deafmutism had been acquired.

When deafness is acquired within the first four years of life, dumbness almost without exception occurs. If deafness arise between the fourth and seventh years very frequently the power of speech is lost. Sometimes, however, in the case of intelligent children who had already learned to read, it is possible, by careful attention on the part of those having charge of them, to ward off the development of dumbness. Deafness acquired after the seventh year seldom leads to dumbness.*

* On dumbness without deafness, see the interesting article *Mutisme*, by Krieshaber, in the *Dictionnaire encyclopédique des Sciences médicales*, vol. xi.

The statistics of deafmutism, as collected by the methods developed within recent times,* can alone claim scientific precision, the older statistics not being of scientific value on account of the incompleteness of their mode of compilation. In the following data, taken from Hartmann's excellent work, *Taubstummheit und Taubstummenbildung*, we will confine ourselves to the principal features of the statistical results. According to the statistics hitherto collected, among 10,000 inhabitants there were 7·77 deaf-mutes. Of the separate countries, the Netherlands and Belgium were the lowest, with 3·35 and 4·39; and Switzerland the highest, with 24·5. The number of deaf-mutes in the Austrian Alpine districts was particularly large; in Carinthia, among 10,000 inhabitants, there were 44·1; in Salzburg, 27·8; in Steiermark, 20·0 deaf-mutes. The average number in Germany was 9·66 and in Austria 9·7.

The pathological anatomy of deafmutism is still very incomplete, notwithstanding the considerable number of post-mortem records. The changes, especially in the central course of the auditory nerve, forming the foundation of deafmutism, are almost unknown.

Anatomical foundations of congenital deafness have been found in the following: bilateral atresia of the auditory meatus and of the tympanic cavity; absence of the fenestræ of the labyrinth; arrested development (p. 767) in the labyrinth and in the course of the auditory nerve, and intra-uterine inflammatory processes in the middle ear (Moos, Gellé).

The chief anatomical changes causing acquired deafmutism are: bilateral acquired atresia of the auditory meatus; purulent inflammation of the middle ear terminating in exfoliation of the ossicula; caries and necrosis of the labyrinth; tight adhesions and anchylosis of the sound-conducting chain; chronic non-purulent catarrh terminating in obliteration of the tympanic cavity by new-formed masses of connective tissue (Schwartze) and in the adhesion of the ossicula with the walls of the tympanic cavity; inflammatory and retrogressive changes in the labyrinth (p. 728); destruction of Corti's organ and parenchymatous neuritis of the auditory nerve (Baratoux); the filling up of the cavity of the labyrinth with osseous masses (p. 713), and sequelæ of meningeal and cerebral processes in the auditory nerve and in the sinus rhomboideus (p. 758).

Besides the anatomical changes already described by me (p. 727), in deaf-mutes, there still remain two interesting conditions to be mentioned, which I think of describing more fully. In a man sixty-one years of age, said to have been born deaf and dumb, the following conditions were noted: a normal state of the external and middle ears, the membrane of the fenestra rotunda very thin and very movable; hydrocephalus internus chronicus;

* See Wilhelmi's *Taubstummenstatistik der Provinz Pommern und des Reg.-Bez. Erfurt.*

pachymeningitis chronica; striæ acousticæ faintly developed; the stem of the left auditory nerve was gelatinously degenerated. In a girl, eleven years of age, said to have been born deaf, I found the right membrana tympani cicatrized, the body of the incus (*a*) embedded in masses of connective tissue, and the niche of the fenestra rotunda (*b*) filled up with connective tissue. On the left side, in front of the malleus, there was an oval perforation 2½ mm. in size; the long process of the incus on both sides was one-third longer than normal, and was rectangularly bent in the middle (*c*); the stapes (*d*) on both sides was fixed with connective-tissue growths.

Whether secondary changes (atrophy from disuse) may arise in the sensory cortical centre of the temporal lobe in hereditary or long-continued acquired deafness, has not yet been ascertained; the condition of the brains of seven deaf-mutes examined by me

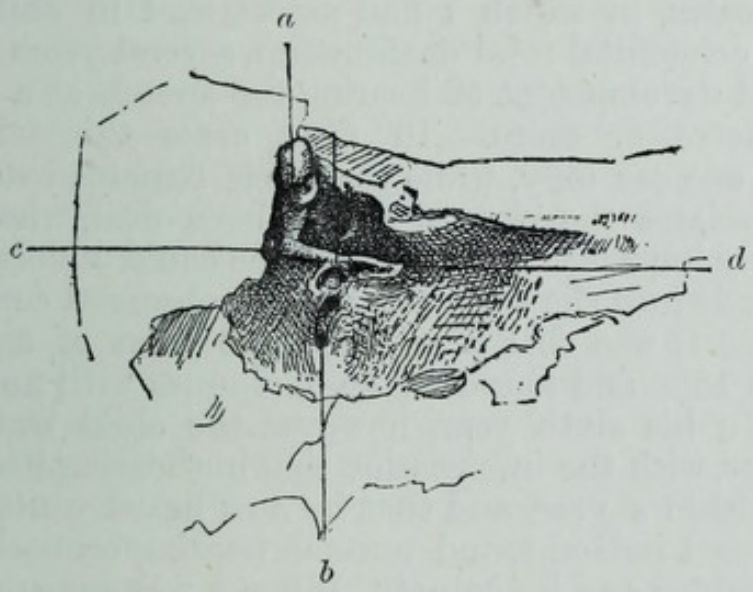

FIG. 251.

is against the existence of such processes, as I did not find any deviation from the normal state in that lobe.

When examining a deaf-mute it must be ascertained by a careful testing of the hearing, whether total deafness exists for every kind of sound or whether there is perception for noises and tones. With entire absence of perception of sound the deaf and dumb child will not move when loud sounds are made behind his back—for example, by clapping the hands, ringing a bell, whistling, trumpet-blowing, and so on—while with perception of sound the child will turn his head in the direction of the source of sound. The perception of sound through the bones of the head must also be tested, by placing high- and low-pitched tuning-forks on the vertex and on the mastoid processes. In complete absence of perception of sound the features of the child's face remain unchanged; on the other hand, there is a slight smile when the tone of the tuning-fork is perceived.

If by the tests mentioned perception of sound is proved to

exist, each ear should be separately tested as to the hearing of vowels and of speech. It has been observed that many deaf-mutes, and more frequently those deaf-born than those who have acquired deafness, repeat some vowels spoken into the ear, particularly *a*, *o*, and *u*, less frequently the consonants (oftenest *b*, *p*, and *r*). By long practice simultaneous touching of the external region of the ear appears to favour the perception of the vowels and consonants.

Toynbee, de Rossi, and Hartmann have examined the power of hearing in a large number of deaf-mutes, and according to the latter there were in one hundred cases 60·2 per cent. with total deafness, 24·3 per cent. with perception of sound, 11·2 per cent. with hearing for vowels, and 4·3 per cent. with hearing for a few words.

In my experience the *prognosis* of congenital deafmutism is more favourable than that of the acquired. In a considerable number of cases, in which I had ascertained in childhood the existence of congenital total deafmutism, several years later there was observed development of hearing for speech at a distance of $\frac{1}{3}$ to $1\frac{1}{2}$ metre, or more. In most cases this improvement appeared in one ear only, while the other remained deaf. Hartmann also relates the case of a girl, born deaf, whose hearing spontaneously improved so much that she could understand words spoken directly into the ear. I have only observed complete cure in one case. It was that of a boy, three years of age, who was examined in 1862 and found to be deaf-mute with no perception of sound. In his sixth year, however, the child was presented by his mother, with the information that his hearing had gradually developed within a year, and that he now heard quite well. On careful testing I indeed found normal hearing on both sides, but speech was faulty and indistinct. When I was consulted in 1878 by the youth, then nineteen years of age, I found normal hearing on the right side, but on the left the membrana tympani was perforated in consequence of suppuration of the middle ear of a year's duration; the hearing-distance for the acoumeter was $\frac{1}{3}$ metre, for whispered speech 1 metre, and for speech normal.

On the other hand, I have not observed improvement of the hearing in a single case of total deafness acquired in consequence of scarlatina or diphtheritic processes of the middle ear, or after meningitis and hydrocephalus.

The question of *treatment* of deafmutism can be raised only in those cases in which the objective symptoms of disease of the middle ear are pronounced. In those forms especially in which, in consequence of a congenital middle-ear catarrh or one which had occurred in the first year of life and been overlooked, such a high degree of deafness had developed that the learning of speech had become impossible, I have not unfrequently obtained favourable results by Politzerization methodically employed. My experience in this way agrees with similar observations of other

specialists. Therefore, in deaf children with a highly concave membrana tympani or signs of an accumulation of mucus in the middle ear, inflations should be immediately tried, and only discontinued when no result is obtained after several weeks' treatment. In deafness caused by scarlatinal and diphtheritic ulcerative processes in the middle ear and labyrinth, by panotitis, and by intra-cranial diseases, all treatment remains fruitless.

Of great importance for the education of deaf-mutes is the systematic deaf-and-dumb instruction, commenced as a rule in the seventh year. By that means the deaf-mute acquires not only the power and faculty of expressing his thoughts both by speech and by writing, but also receives a certain degree of mental culture. By careful training this is the more easily attained, as the majority of deaf-mutes—contrary to what was formerly believed—are sensible and well endowed mentally.

The Spanish priest, Pedro Ponce, who lived in the second half of the sixteenth century, is said to have been the founder of the teaching of the deaf and dumb. In 1778 the Abbé de l'Epée in Paris, and Heinicke in Leipzig, founded deaf and dumb institutions. But while in France, till quite recently, the instruction was carried on by the language of signs and gestures, in Germany articulate speech was always more cultivated. The advantages of the latter over the sign-language are so great, that it is almost incomprehensible how anyone in recent times can uphold the use of gestures. In fact, in institutions articulate speech is being more and more cultivated, and the members of the Milan International Otological and Deaf-mute Congress of 1880 expressed the opinion, that the only proper method of instructing the deaf and dumb was by articulate speech.

Some deaf-mutes learn to speak so distinctly that they can without difficulty be understood by everyone. Others, again, speak so indistinctly that it is only by great attention and constant intercourse with them that their meaning can be gathered. Even in the case of those who can be easily understood there is an unpleasant harshness of utterance, as the deaf-mute has no guide to the modulation of his voice. This is usually very marked in the case of those who are totally deaf, while those who possess in a slight degree perception for sound, for vowels, or for speech, can speak more intelligibly and less unnaturally.

Hearing-Instruments for the Deaf.

The hearing-instruments which are used in the many forms of excessive dulness of hearing aim at collecting the sound-waves and conducting them in a concentrated form to the ear, thereby rendering social intercourse more easy.

The apparatus is the more effective the greater the surface by which the sound-waves are caught and reflected on the membrana tympani.

For conversation between two the best thing is a tube, ⅔ to 1 metre long, made of a closely compressed spiral wire encased in a layer of leather and covered with a closely-spun woollen tissue (Fig. 252). Its olive-shaped ear-piece for insertion into the external meatus is either straight or angularly curved. Its mouth-piece has the form of a cup or of a common speculum. Conical hearing-tubes decreasing from the mouth-piece to the ear-piece are more effective than those of the same width all through. In using the tube the mouth-piece is brought close to the mouth of the person speaking, and, as a rule, the usual tone of voice is loud enough to be heard by the listener. Too loud speaking cannot be borne, on account of the generally coincident hyperæsthesia acoustica and the giddiness in the head.

Ear-trumpets or funnel-shaped instruments (30-50 centimetres, *i.e.* 12-20 inches, in length) made of metal are not so good for near conversations, on account of the metallic sound the voice acquires. This unpleasantness is done away with in instruments

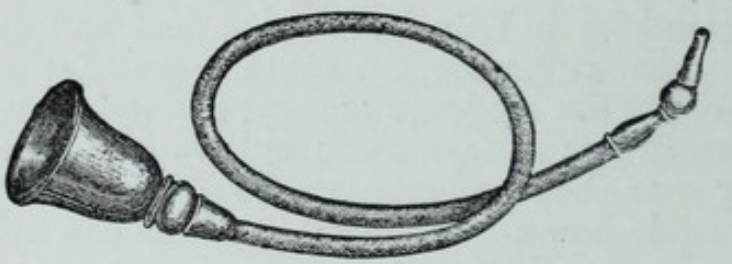

Fig. 252

made of vulcanite, which, when made in several pieces fitting together, on account of their light weight may be carried in the pocket.

For hearing at greater distances, trumpet-shaped tubes with wide mouth-pieces directed forwards, or paraboloid hearing-cups, are better suited. These consist (Fig. 253) of a parabolic metal cup, from the focal point of which the sound-waves are collected by a second sound-collector projecting into the cup and connected with the ear-piece. Fig. 254 is a modification of the same instrument, with two parabolic bowls turned against each other, and provided with a long ear-piece. Similar instruments of smaller size, but on the same principle, have recently been made less conspicuous by inserting them into the upper end of a walking-stick or umbrella, from which the short ear-piece projects laterally.

Burkhardt-Merian has lately constructed a metallic ear-trumpet of separate pieces fitting together, which, according to his brief communication, 'approaches the problem of copying the human auricle, and especially the tragus, according to the results of Politzer's physiological studies in that relation (p. 64).'

Instead of the funnel-shaped orifice in almost general use for

ear-trumpets (which has a meaning only in the case of trumpets and other similar instruments), the outer margin, like the helix of the auricle, is turned concavely inwards, thereby forming a suitable obstacle to the reflection of the sound-waves outwards, an occurrence which weakens the effect of any instrument.

Further, since with a fully open mouth-piece a large number of the sound-waves entering are again reflected outwards, an attempt has been made to imitate the function of an elongated tragus by fixing a thin metal plate bent at an obtuse angle in the greatest concavity of the terminal portion of the ear-trumpet. It is soldered at the top, but at its outer edge there is a fissure of about 1 cm. left open for the entrance of the sound-waves.

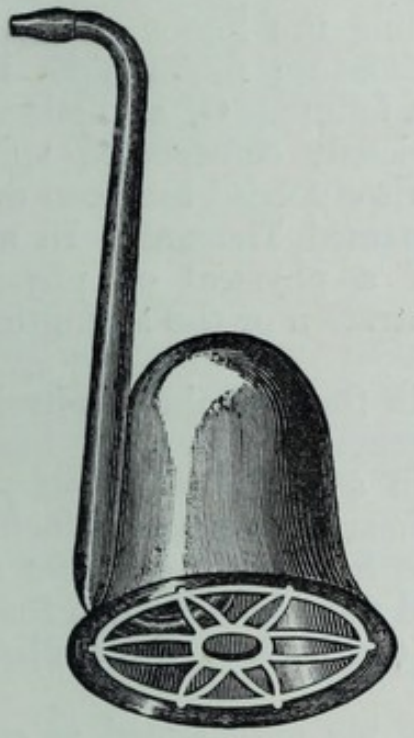

FIG. 253.

FIG. 254.

By the use of this instrument it is said that consonants are better heard, and speech therefore more easily understood, than with any other.

From the great variety of hearing-instruments and their markedly different effects in one and the same individual, in any case in which such an instrument is required it is best to let the patient try a number of them, and then choose the one with which he hears best. It has already been mentioned that many persons very dull of hearing can hear better without an ear-trumpet, therefore through the bones of the head, than with one.

The number of those who prize ease of social intercourse so highly that they pay no regard to the discomfort and conspicuousness of large ear-trumpets, is very small. Notwithstand-

ing the advantages possessed by large instruments, they are generally discarded on account of conspicuousness in a large company.

The ideal of all deaf people has always been a small instrument which could be worn unobservedly in the ear, and render at the same time the same service as the largest instrument. This problem has not yet been solved, and will not be so easily.

The small instruments, recommended under so many different names, of which Abraham's is best known to the public, have proved utterly worthless.* They consist of a straight, short, narrow, silver tube, with a flat funnel-shaped extremity, which keeps the instrument from falling into the osseous meatus. Such tubes, as v. Tröltsch rightly observes, serve only one object, that of dilating or keeping open a very contracted cartilaginous meatus. With a normal width of the auditory meatus they are absolutely of no use; but they very often give rise to a decrease in the hearing-power by contracting the lumen of the meatus. The experiment of putting a miniature microphone into the interior of such tubes has been a failure. Of as little value as the straight ones are those variously constructed spiral and coiled tubes, of which the 'Apparitor Auris' has been especially recommended by an American, named Tiemann. In all those instruments there is a want of a physical or physiological principle as a basis for the concentration or the strengthening of sound.

By some casual experiments in the domain of physiological acoustics, I was led to the construction of a small hearing-instrument, by the use of which in a number of deaf people a considerable improvement in the hearing was ascertained.

In principle it was based on the fact (see p. 62) that a source of sound acting on the ear is heard more loudly when the surface of the tragus is enlarged towards the back by the application of a small solid plate.

The instrument constructed by me only aimed at enlarging the surface of the tragus backwards, in order to lessen, if possible, the loss of sound-waves arising by reflection outwards from the concha, *i.e.* to conduct a larger proportion of sound to the auditory meatus than is done by the naked ear.

The small instrument (Fig. 255) has the form of a hunting-horn, whose narrower inner end (*a*) is inserted into the auditory meatus, while its outer broader part lies on the auricle so that its opening (*b*) is directed straight back against the concha. The size of the instrument varies according to the width of the auditory meatus, and the size of the auricle or concha. Three different sizes are sufficient for all cases. The larger instruments

* See Schwabach's article *Hörröhren* in Eulenberg's *Real-Encyklopädie der medicin. Wissenschaft.*

measure 2½ cm. in length, 12 mm. in diameter at the outer opening, and 5 mm. at the inner. The smaller ones are about 2 mm. less, and the smallest 3 mm. At first I had them made of glass, but now of red vulcanite. The instrument is introduced as follows: with the wider opening pointing upwards, the small end is pushed into the external meatus, and then it is turned in the auricle so that the large opening looks backwards towards the concha, and is pushed towards it.

Recently I modified the instrument slightly, and thereby greatly increased its power. Having proved that the concave section of the instrument directed inwards was not only superfluous, but even impeded the reflection of the sound-waves from the concha, I removed the inner segment of the tube to the extent of about one-third of its circumference, and at the same time enlarged the width of the surface curved outwards (Fig. 256).

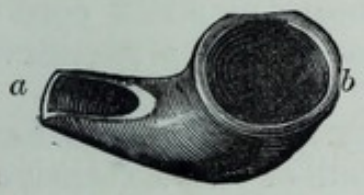

FIG. 255.
Actual size.

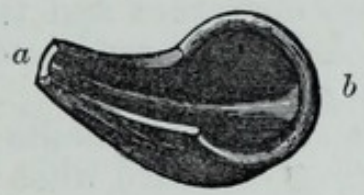

FIG. 256.
Actual size.

By the introduction of the instrument into the auditory meatus the waves of sound were in some degree prevented from falling directly into the meatus when the source of sound lay in a lateral direction, as could be proved by measuring the hearing-distances. When, however, the sound came towards the face, or vertically towards the auricle, the reflection of sound was perceptibly strengthened by the instrument.

In everyday life, however, we make the most of our two ears, and in speaking with other people, in reading aloud, in the theatre, in concerts, etc., the face is turned towards the source of sound. It is for this position that the little instrument is specially adapted.

With regard to the amount of improvement in the power of understanding speech caused by the application of this instrument, according to the experiments hitherto made, the hearing-distance, on an average, is at least doubled. In more than one-fourth of the cases it had no influence on the hearing-distance; in several cases it caused a decrease.

The otophones recommended by older aurists, consisting of two curved elastic strips of metal, which, when placed on the mastoid process pressed the auricle out from the head and directed its anterior surface vertically towards sound-waves coming from the front, are generally of very little use. The same may be said of the concave hearing-shells, which are placed above the edge of the cartilage of the ear to catch sound-waves.

In later years, various apparatus have been constructed to improve the hearing by increasing the conduction of sound through the bones of the head. Those are, the audiphone, the dentaphone, and the rod-shaped sound-conductor of G. Paladino.

Rhodes's audiphone (termed osteophone by Thomas) consists of a flexible plate of vulcanite or pasteboard well lacquered, 25-30 cm. long and 20-25 cm. broad, in the form of a four-cornered spade or fan. The lower margin is for the handle, the upper one is provided with a little metal plate for laying on the teeth or on the zygoma. By pressing the instrument on the anterior upper row of teeth, a curved surface with its convexity forwards is formed, from which the sound-waves falling on it are conducted through the bones of the head to the labyrinth.

For more convenient management, audiphones are being constructed in separate pieces, jointed together, which receive the necessary curvature and tension by means of a silk cord (Turnbull). A piece of moderately thick pasteboard often serves the same purpose.

FIG. 257.

The results obtained by the audiphone have not fulfilled what was expected of it. Extensive trials have been made by Knapp, Lennox-Brown, Joly (Lyon), and others, who affirm that the audiphone only effects marked improvement in a small percentage of cases of excessive hardness of hearing, and that its effect is far inferior to that of the ear-trumpet (Knapp).

That statement I can confirm from my own experience. The audiphone is most effective in deafness after exhausted suppuration of the middle ear, less effective in the sclerotizing inflammations of the middle ear. In the latter I have repeatedly observed striking improvement in the hearing from use of the hearing-plate. Similar observations have been made by Burkhardt-Merian. In affections of the nerve the improvement in hearing is seldom marked.

Still less useful is the dentaphone. It consists of a box open in front, like a watch-case, which contains a plate capable of vibrating, to which is attached a short cord. By catching the cord with the teeth, the plate becomes tense, and sound-waves falling upon it are conducted through the bones of the head to the labyrinth.

Paladino's rod-shaped sound-conductor (fonifero) consists (Fig. 257) of a straight, flexible or firm rod, one-half to two-thirds of a metre long, to the one end of which (*a*) is fixed a thin small circular band of metal, while the other end (*b*) bears a small, slightly concave

metal plate. The metal arc is placed on the larynx of the party speaking, and the small metal plate on the teeth or ear of the deaf person, so that speech is immediately transmitted by the rod to the bones of the head, and from these to the labyrinth. The instrument may be sometimes used with advantage in those patients who cannot hear speech through the trumpet, but can understand loud speech in the immediate neighbourhood of the ear without the ear-trumpet.*

* Besides the books mentioned and the references made in the text, the following remain to be mentioned: Guilelm. Ziegel, *De aurium morbis nervosis*, Dissert. Berolini, 1848; James Hinton, *On some of the Affections classed as Nervous Deafness*, from Guy's Hospital Reports, 1867; Wilh. Kroll, *Ueber Schwindelzufälle bei Ohrenkrankheiten*, Dissert. Halle, 1872; Voltolini, *Die Krankheiten des Labyrinthes und des Gehörnerven, Abh. d. schles. Ges. naturw.-med. Abth.* 1862, i.; G. Reichl, *Otitis acuta intima sive labyrinthica, die acute Entzündung des häutigen Labyrinthes, Berl. klin. Wochenschr. Nr.* 24, 1870; H. Knapp, *Klinische Analyse der entzündlichen Affectionen des inneren Ohres, Sep.-Abdr. a. d. Archiv f. Augen- u. Ohrenheilkunde*, ii. Bd., i. Abth., Carlsruhe, 1871; John Roosa, *Syphilis of the Cochlea (cochlitis), The Med. Record*, No. 47, 1876; Franz Nave, *Die Ménière'sche Krankheit*, Dissert. Breslau, 1877; Albert H. Buck, *Syphilitic Affections of the Ear, Amer. Journal of Otology*, Jan. 1879; Böke, *Ueber totale Taubheit bei Kindern in Folge einer sporadisch auftretenden Erkrankung des Centralorgans, Pester med. Presse*; Hillairet (J.-B.), *Lésions de l'Oreille interne, Action réflexe sur le Cervelet et les Pédoncules, Compt. rend. de la Soc. de Biol.* 3 série, t. iii. p. 181, 1861; Charcot, *Vertigo ab aure læsa, Gaz. des Hôp.* 1874, p. 73; Field (G.-P.), *Nervous Deafness, Med. Press and Circular*, Dec. 19, 1877; Gottstein, *Ueber den Ménière'schen Symptomencomplex, Zeitschr. f. Ohrenheilk.* Bd. ix. p. 37, 1880; Guye, *Du Vertige de Ménière, Rev. mens. de Méd. et de Chir.* t. iv. p. 356, 1880; Raynaud (M.), *Du Vertige auriculaire, Rev. méd. franç. et étrang.* t. i. p. 545, 1880; R. Hagen, *Der seröse Ausfluss aus dem äusseren Ohre nach Kopfverletzungen*, Leipzig, 1866; Oskar Wolf, *Unterbindung der Arteria carotis communis wegen Schussverletzung mit lebensgefährlicher Blutung, Sep.-Abdr. a. d. Arch. f. Augen- u. Ohrenheilkunde*, ii. Bd., ii. Abth. 1872; Cassells, *Ear Disease and Life Assurance*, Repr. fr. the *British Med. Journ.* 1877; Carl Barrie, sen., *Ueber die Herstellung des Gehörs bei Taubstummen*, Hamburg, 1838; Antonius Nuhn, *Commentatio de vitiis quæ surdomutitate subesse solent*, Dissert. Heidelberg, 1841; J. Toynbee, *The Deaf and Dumb, their Condition, Education, and Medical Treatment*, London, 1858; J. Toynbee, *A Case of Deaf Dumbness, of more than Twenty Years' Duration*, Repr. fr. the *Proceedings of the Roy. Med and Chir. Society*, 1858; Clarence J. Blake, *On the Etiology of Acquired Deafmutism having especial Reference to the Effects of Scarlet Fever, The Boston Med. and Surg. Journal*, No. 25, 1870; Laurence Turnbull, *Education of Deaf and Dumb*, Extr. fr. the *Transact. of the Intern. Med. Congr. Philadelphia*, 1877; Arth. Hartmann, *Ueber Taubstumme, Sep.-Abdr. aus der Deutschen med. Wochenschrift*, pp. 48, 49, 1877; Cassells, *Thoughts and Suggestions concerning the Education of Deaf Children*, Repr. fr. the *Edinburgh Med. Journal*, February, 1878; J. R. Davy, *Relation of the Sense of Hearing to Voice and Speech as Regards Deaf-mutes, The Cincinnati Lancet and Observer*, No. i. 1878; E. de Rossi, *Relazione sopra l'ospicio dei sordomuti di Roma*, Roma, 1878.

APPENDIX.

A COLLECTION OF THE THERAPEUTICAL FORMULÆ OCCURRING THROUGHOUT THIS WORK,

IN A FORM FOR EASY REFERENCE.

CHRONIC INFLAMMATION OF THE MEMBRANA TYMPANI (p. 227)

Solutions:

1. Sulphate of zinc, 1 : 100. Instil 10 drops, tepid, into the ear.
2. Acetate of lead, 1 : 100. " " " "
3. Crystallized nitrate of silver, 8 : 100. Instil 10 drops, tepid, into the ear, or paint the membrane.

ACUTE INFLAMMATION OF THE MIDDLE EAR (p. 253).

I. *Internal Treatment.*

1. Acetate of morphia in doses of $\frac{1}{13}$ grain (p. 254).
2. Chloral hydrate in doses of 23 to 38 grains.
3. Mixture of 10 parts of infusion of lime flowers (Austrian Pharmacop.) with 5 parts of Mindererus' spirit, 40 parts of syrup of orange-peel, and 150 parts of distilled water. Dose: 2 tablespoonfuls hourly (p. 256).

II. *External Treatment.*

Mixtures:

1. Tincture of opium with water, 1 : 100. Soak linen and apply to ear.
2. Watery extract of opium in expressed oil of hyoscyamus (Aus. Ph.), 8 : 100. Soak cotton-wool and apply to ear.

Solution of acetate of morphia in olive oil, 2 : 100. Soak cotton-wool, etc.

CATARRH OF THE MIDDLE EAR (p. 278).

Solutions:

1. Sal ammoniac, 10 : 100. Inject 5 or 6 drops into Eustachian tube (p. 293).
2. Bicarbonate of soda, 30 : 100. Inject 5 or 6 drops into Eustachian tube (p. 293).
3. Sulphate of zinc, 2 : 100. Inject 8 or 10 drops into Eustachian tube (p. 294).

4. Argilla acetica Burowii. Mix solution of crude alum, 1 : 4, with solution of acetate of lead, 1 : 10. Filter and increase the bulk by about one half with distilled water. Keep in a well-closed vessel. Inject 8 or 10 drops into Eustachian tube (p. 295).

Diseases of the Naso-Pharynx (p. 312).

I. *Solutions for Weber's Nasal Douche.*

1. Common salt, 1 : 100 (p. 315).
2. Bicarbonate of soda, 1 : 100.
3. Equal parts of above solutions.
4. Permanganate of potash, weak.
5. Salicylic acid, weak.

II. *Medicated Solutions for pouring into the Nose* (p. 315).

1. Common salt, concentrated (p. 316).
2. Diluted Ischl or Kreuznach brine water.
3. Tannin in tepid water, 10 : 100.
4. Tannin and sulphate of quinine in tepid water, 30 and 1 : 300.
5. „ salicylic acid in tepid water, 30 and 3 : 300.
6. Sulphate of zinc, 1 : 600.
7. Crude alum.
8. Acetic argillaceous earth = acetate of alumina.
9. Carbolic acid.
10. Nitrate of silver, 10 : 100.
11. Take of a mixture of equal parts of the salicylate, bicarbonate, and chlorate of soda, as much as will lie on the point of a knife, and dissolve in about an ounce of water. Mix this solution with an equal quantity of warm water, to which 2 or 3 drops of unrectified oil of turpentine have been added.

Adhesive Affections (p. 354).

I. *Vapours* (p. 357).

Steam, sal ammoniac, carbonate of ammonium, iodine, iodic ether, acetic acid, acetone, pyroligneous acid, tar, turpentine, different balsams and resins, camphor, gases, *e.g.* carbonic acid and hydrogen.

II. *Solutions for Injection.*

1. Caustic potash, 1 : 400 (p. 357).
2. Caustic soda, 5 : 300 (p. 358).
3. Lithium carbonate, 1 : 300.
4. Sal ammoniac, 5 : 400.
5. Common salt, 5 : 150.
6. Bicarbonate of soda, 5 : 100.
7. Borax, 5 : 200.
8. Iodide of potassium, 5 : 150.
9. Nitrate of silver, 2 : 300.
10. Corrosive sublimate, 1 : 100.
11. Chloral hydrate, 1 : 30.
12. Acetic or lactic acid, 1 to 5 : 40.
13. Muriatic acid, 1 to 3 : 40.
14. Bicarbonate of soda and glycerine, 5 and 20 : 100.

Subjective Noises accompanying Adhesive Processes (p. 363).

I. *Vapours.*

Sulphuric ether, acetic ether, chloroform, mixture of sulphuric ether with ethylene chloride (anæsthetic Dutch liquid, Ger. Ph.), 6 : 4.

II. *Embrocations* (p. 364).

1. Aromatic spirit (Aus. Ph.) and spirit of mustard (Aus. Ph.), equal parts. Rub in 20 drops behind the ear.
2. Spirit of red ants (Ger. Ph.) and Hoffmann's balsam (Aus. Ph.), equal parts. Rub in 20 drops behind the ear.
3. Watery extract of opium and pure glycerine, 4 : 100. Use 20 drops as above.
4. Olive oil and chloroform, equal parts. Use 20 drops as above.
5. Pure glycerine and tincture of belladonna, 2 : 1. Use 20 drops as above.

Solution of acetate of morphia in glycerine, 2 : 100. Use 20 drops as above.

III. *For Painting the Meatus.*

1. Tincture of valerian, 2 parts; sulphuric ether, 1; glycerine, 12 (p. 365).
2. Tincture of valerian, 4 parts; sulphuric ether, 1; glycerine, 20.

IV. *Internal Medication.*

1. Bromide of potassium in doses of 15 to 30 grains.
2. Hydrobromic acid in doses of 10 to 15 drops, three times daily.
3. Iodide of potassium in doses of 7 to 15 grains.

V. *Inunctions to be Applied over the Mastoid Process.*

1. Iodide of potassium, 20 parts; emollient ointment (Aus. Ph.), 200; pure iodine, 1.
2. Iodoform, 8; emollient ointment (Aus. Ph.), 200; oil of peppermint, 100 drops.

Internal and External Medication of Adhesive Affections.

I. *Internal* (p. 370).

1. Calomel in doses of $1\frac{1}{2}$ or 3 grains.
2. Bichloride of mercury in doses of $\frac{1}{33}$ grain, thrice daily.
3. Solution of strychnine in iron wine, 1 : 2000.
4. Oil of turpentine.
5. Iodine preparations; *e.g.*, iodide of potassium up to 15 grains daily.

II. *External.*

1. Concentrated solution of nitrate of silver. Paint the external meatus.
2. Tincture of iodine. Paint the external meatus.
3. Iodine ointments. Apply over the mastoid process.
4. Solution of sulphuric ether in glycerine, 10 : 100. Paint the external meatus.

Acute Purulent Inflammation of the Middle Ear (p. 398).

I. *Insufflation* (p. 401).

About 1¼ grains of boracic acid in powder.

II. *Solutions* (p. 402).

1. Sulphate of zinc, 1 : 100. Instil 10 to 15 drops, tepid.
2. Acetate of lead, 1 : 100. " " "
3. Nitrate of silver, 1 : 100. " " "
4. Bicarbonate of soda, 1; glycerine, 8; distilled water, 16. Use as above (p. 404).

Liquor ferri muriatis on point of probe. Touch granulations (p. 403).

Chronic Purulent Inflammation of the Middle Ear (p. 459).

I. *Solutions for Syringing the Meatus* (p. 462).

1. Powdered boracic acid.
2. Glauber's salt, 5 : 100.
3. Alcoholic solution of salicylic acid, 10 : 100 (p. 463).
4. Permanganate of potash, 5 : 100.
5. Carbolic acid, 2 or 3 : 100.
6. A teaspoonful of the 50 per cent. carbolic spirit in 3 or 4 ounces of water.
7. 4 or 5 drops of oil of turpentine in 6 or 7 ounces of water.

II. *For Removing Inspissated Masses.*

1. Warm water.
2. Bicarbonate of soda, 1; glycerine, 8; distilled water, 12. Instil 10 to 15 drops (p. 464).
3. 2 per cent. solution of carbolic acid mixed with a little glycerine for spray.

III. *Antiseptic Treatment* (p. 470).

Insufflations:

1. Boracic acid finely powdered.
2. 1 grain of carbolic acid added to about 15 grains of finely powdered boracic acid (p. 471).
3. Mixture of 2 parts of powdered boracic acid and 1 of salicylic acid (p. 473).
4. Iodoform.

Solutions:

1. Carbolic acid in glycerine or olive oil. Apply on cotton-wool (p. 472).
2. Carbolic acid, 1 part; rectified spirit of wine, 15; distilled water, 15. Instil 15 to 20 drops.
3. Carbolic acid, 2 to 3 : 100.
4. Salicylic acid, $\frac{1}{3}$: 100 (p. 473).
5. Alcoholic solution of salicylic acid, 2 to 10 : 100.
6. Thymol, $\frac{1}{2}$: 100.
7. Borax, 4 : 100.

8. Mixture of 4 per cent. solution of borax with 5 per cent. solution of salicylic acid.
9. Permanganate of potash, ·4 to 2 : 100.
10. Weak solution of powdered benzoic acid.
11. Mixture of 1 part of tincture of iodine with 15 parts of spirit of wine.

IV. *Alcoholic Treatment.*

Mixture of equal parts of alcohol and distilled water. Pour into the meatus moderately warmed and leave in for 10 or 15 minutes.

V. *Caustic Treatment* (p. 474).

Solution of nitrate of silver, 6 to 10 : 100. Instil 15 to 20 drops.

VI. *Astringents* (p. 476).

1. Sulphate of zinc, 1 to 2 : 100.
2. Acetate of lead, 1 to 2 : 100.
3. Sulphate of copper, $\frac{1}{2}$: 100.
4. Liquor ferri muriatis, 1 : 300.
5. Crude alum, 3 : 200.
6. Acetate of zinc, 1 : 100.
7. Alum in form of powder. Insufflate into the ear.

GRANULAR SUPPURATION OF THE MIDDLE EAR (p. 481).

I. *Cauterants* (p. 482).

Nitrate of silver and chloride of iron.

II. *Embrocation* (p. 487).

Iodoform and oil of fennel, of each 2 parts; vaseline, 20 parts. Apply by rubbing over the mastoid process.

THE ARTIFCIAL MEMBRANA TYMPANI (p. 492).

Boracic acid, salicylic acid, an astringent, water, weak glycerine (about 1 : 30), vaseline, alcoholic solution of boracic acid mixed with a little glycerine, solution of acetate of aluminium. Use for preparing the artificial membrane as the case requires (p. 494).

CARIOUS PROCESSES IN THE TEMPORAL BONE (p. 544).

I. *External Treatment.*

1. Boracic or carbolic solution. Syringe the meatus.
2. Warm water or weak solutions of borax, boracic acid or carbolic acid. Syringe the tympanic cavity through the Eustachian tube.
3. Iodoform in powder. Insufflate after scraping the diseased bone (p. 545).

II. *Internal Treatment* (p. 546).

1. Iodide of potassium in doses of $7\frac{1}{2}$ to 15 grains.
2. Solution of iodoform, 1 : 300. Dose : 5-10 drops thrice daily.

3. Mineral water, containing iodine, along with iodine baths and the use of simple thermal springs (p. 547).

Facial Paralysis (p. 547).

I. *Internal Treatment.*

Iodide of potassium and iodoform as above.

II. *External Treatment.*

Ointments containing iodine or iodoform with the addition of morphia or the liquid extract of opium. Apply over the mastoid process and in the vicinity of the ear.

Otitic Meningitis and Cerebral Abscess (p. 547).

I. *External Treatment.*

Cold bandages, bags of ice or Leiter's cooling apparatus, along with antiseptic cleansing of the ear.

II. *Internal Treatment.*

Narcotics, subcutaneous injection of morphia, calomel and enemata; stimulants, as camphor, ether and wine.

Inflammation of the Cell-Spaces of the Mastoid Process (p. 561).

1. Leiter's cooling apparatus (Fig. 204).
2. Tincture of iodine. Paint the mastoid process.
3. Mercurial ointment. Rub over the mastoid process.
4. Solution of carbolic acid, 1-2 : 100. For cleansing (p. 573).
5. Weak solution of boracic acid. For cleansing.
6. Solution of resorcin. For cleansing.
7. Iodoform powder. Sprinkle the cavity of the mastoid process after operation. The offensive smell of the iodoform is best allayed by placing half a tonka bean in the powder, or by adding 15 or 30 minims of the tincture of the bean to 60 or 80 grains of the powder (p. 574).

Ceruminal Plugs (p. 582).

1. Warm water. Forcibly syringe with 4 or 5 ounces to remove plug.
2. Warm water. Instil into meatus to soften cerumen.
3. Weak glycerine, warmed. As above.
4. Oil, warmed. As above.
5. Solution of bicarbonate of soda, 1 part; simple distilled water and pure glycerine, 10 parts. As above.

Cessation of Ceruminal Secretion (p. 583).

1. Vaseline. Paint the cartilaginous meatus.
2. White precipitate ointment, 2 : 100. Paint as above.

Eczema of the Ear (p. 586).

Ointments.

1. Emollient ointment (Aus. Ph.). Paint part affected.
2. Vaseline.
3. Hebra's diachylon ointment (Aus. Ph.).
4. Equal parts of the ointment of carbonate of lead and emollient ointment (Aus. Ph.).
5. Equal parts of simple diachylon ointment and vaseline.
6. Boracic acid and vaseline, 1 : 15.
7. Ointment of the oxide of zinc, 1 : 30.
8. Pagenstecher's ointment, composed of precipitated peroxide (yellow oxide) of mercury and vaseline, 30 grains to the ounce.
9. Cold cream.
10. Weak precipitate ointment, 2 : 150.
11. Tar ointment, composed of oil of beech-tree, 10 parts ; glycerine, 5 ; and emollient ointment (Aus. Ph.), 40.
12. Carbolic ointment, 1 : 40.
13. White or yellow precipitate ointment.
14. Wilson's ointment (benzoic acid, 1 part; simple ointment, 30 parts ; strain and add oxide of zinc, 5 parts).
15. Oil of cade and vaseline, 1 : 40.

Solutions.

1. Acetate of lead or Goulard's lotion. Apply on compress.
2. Lunar caustic, 1-3 : 100, concentrated or solid (p. 587).
3. Tincture of butcher's broom.
4. Carbolic spirit, 1 : 30.
5. Alcoholic solution of boracic acid, 1 : 20.
6. Potash soap in spirit.

Oils, etc.

Sweet, olive and cod-liver oils, oil of butcher's broom, tar, soft soap, balsam of Peru, cade oil and glycerine, 1 : 25. (Powder for moist surfaces, *e.g.* intertrigo).

Internal Remedies.

Iron, iodine and arsenic.

Herpes Zoster (p. 588).

I. *Internal Treatment.*

Narcotics or subcutaneous injection of morphia.

II. *External Treatment.*

Sprinkle with powder or anoint with the ointment of the acetate or carbonate of lead.

Lupus (p. 589).

1. Lunar caustic, solid. Apply after using sharp scoop.
2. Solution of lunar caustic, 50 : 100. Cauterize part.
3. Iodized glycerine, 1 : 2. Paint part.
4. Concentrated carbolic acid. Pencil part.
5. Soft soap. Rub part.

6. White precipitate ointment, 10 : 100. As above.
7. Iodide of mercury ointment, 1 : 5-15.
8. Pyrogallic acid and vaseline, 1 : 10.
9. Chloride of zinc. Use after scarification.

Chronic Hyperæmia (p. 590).

1. Cold compresses with Goulard's lotion.
2. Anointing with vaseline.

Hæmorrhage in the Auricle (p. 593).

1. Goulard's lotion.
2. Carbolic or salicylic wadding after opening tumour.

Dermatitis (p. 595) and Perichondritis (p. 596) of the Auricle.

1. Cold compresses with Goulard's lotion and tincture of opium, 200 : 10.
2. Carbonate of lead, diachylon, boracic and zinc ointments.

Gangrene and Noma of the Auricle (p. 596).

Nitrate of mercury. Cauterize after removal of the necrosed parts.

Follicular Inflammation of the External Auditory Meatus (p. 599).

1. Narcotic Embrocations (p. 256).
2. Mixture of opium water (Ger. Ph.) and distilled water, 4 : 12. Soak cotton-wadding and introduce into meatus.
3. Longish piece of lard covered with mixture of acetate of morphia, 2 parts; boracic acid, 10; and vaseline, 200. Introduce into meatus.
4. Warm raisin boiled in milk. Apply to meatus.
5. Carbolic acid and glycerine, 1 : 30. Apply to meatus with brush.
6. Boracic acid in powder. Insufflate into meatus.
7. Alcoholic solution of boracic acid, 1 : 20. Instil into meatus.
8. Lunar caustic. Touch furuncle.
9. Carbolic solution, 5 : 100. Inject 2-5 drops into furuncle.
10. Carbolic glycerine. Anoint furuncle after incision.
11. Boracic acid solution. Instil into meatus after incision.
12. White precipitate of mercury and emollient ointment (Aus. Ph.) or vaseline, 3 : 120. Anoint meatus every second day after disappearance of furuncle.
13. Boracic acid and vaseline, 1 : 20. Use as above.
14. Alcohol. Paint the meatus.

Diffuse Inflammation of the Auditory Meatus (p. 603).

Solutions.

1. Zinc. Instil into ear.
2. Lead. „ „
3. Lunar caustic, concentrated. Instil into ear.
4. Boracic acid, spirituous, 1 : 20. Instil into ear.
5. Boracic acid and glycerine. Instil into ear.

Boracic acid in powder. Insufflate into ear.

Otitis Externa Hæmorrhagica (p. 604).

Boracic acid in powder. Fill the meatus after opening the vesicles and cleansing.

Croupous Inflammation of the External Auditory Meatus (p. 605).

Boracic acid as above, after removal of croupous membrane.

Diphtheritic Inflammation of the External Auditory Meatus (p. 607).

1. Lime water. Fill the meatus. Leave in for 15 or 20 minutes, and then syringe with a weak solution of boracic acid. Afterwards, fill the meatus with finely-powdered boracic acid.
2. Carbolic acid and glycerine, 1 : 15. Touch affected parts.
3. Carbolic acid and spirit, 1 : 20. Touch affected parts.
4. Alcoholic solution of boracic acid, 1 : 20. Fill the meatus several times daily.

Syphilitic Inflammation of the External Ear (p. 610).

1. Lunar caustic. Cauterize granulations.
2. Concentrated solution of chromic acid. Cauterize granulations.
3. Solution of corrosive sublimate, 1 : 300. Paint growths after reducing them.
4. Tincture of iodine. Use as above.
5. Calomel. Dust condylomata, and afterwards paint with solution of nitrate of silver, 1 : 100.
6. Tincture of iodine. Paint ulcerated part, and afterwards apply camphorated oil.
7. Mercurial plaster. Plug meatus.

Parasitic Inflammation of the External Auditory Meatus (p. 614).

1. Rectified spirit. Pour into ear from a warmed spoon, after syringing, and keep in for about a quarter of an hour. Repeat twice daily.
2. Boracic acid in powder. Insufflate into or fill the meatus.
3. Spirituous solution of boracic acid, 1 : 20. Instil into ear.
4. Boracic acid and oxide of zinc, equal parts. Instil into ear.
5. Solution of permanganate of potash, 1-2 : 100. Instil into ear.
6. Carbolic acid (free from creosote) in oil or glycerine, 3 : 100. Instil into ear.
7. Spirituous solution of tannin, 50 : 100. As above.
8. Spirituous solution of salicylic acid, 2 : 100. As above.
9. Chlorinated lime in distilled water, 0·7 to $1\frac{1}{2}$: 350. As above.
10. Solution of hyposulphite of soda, 2 : 300. As above.
11. Fowler's arsenical solution. As above.

Pityriasis Alba (p. 615).

Solution of corrosive sublimate, 1 : 100. Paint lining membrane of meatus.

CONTRACTIONS OF THE EXTERNAL AUDITORY MEATUS (p. 616).

1. Conical resistant cotton-wool pads impregnated with acetate of lead.
2. Compressed sponge-tents.
3. Laminaria-tents.

EXOSTOSES OF THE EXTERNAL AUDITORY MEATUS (p. 620).

Iodine and mercurial preparations when syphilitic (p. 621).

EXTRACTION OF FOREIGN BODIES FROM THE EAR (p. 629).

1. Boracic acid in powder. Insufflate into the ear to allay swelling of meatus.
2. Spirituous solution of boracic acid. Instil into the ear as above.
3. Oil or glycerine mixed with some drops of petroleum, turpentine, or an ethereal oil. Instil into ear to remove insects (p. 632).

CONNECTIVE-TISSUE NEW-FORMATIONS ON THE AURICLE (p. 633).

1. Aseptic silk threads dipped in chloride of iron. Insert through the tumour.
2. Nitric acid. Brush the tumour.
3. Caustic ointment composed of nitrate of silver, 2 parts ; pure lard, 100 ; and balsam of Peru, 5 (p. 635).

AURAL POLYPI (p. 643).

1. Cold water. Inject after extraction to stop bleeding.
2. Cotton-wool dipped in alum-powder. Insert into meatus as above.
3. Styptic cotton-wool. As above.
4. Nitrate of silver. Melt in form of ball on end of steel or silver wire, and touch polypous *débris*, etc. (p. 647).
5. Chloride of iron. Apply to growths by probe, brush, or ball of wadding ; or the crystalline form, especially of the sesquichloride, may be applied directly to the part (p. 648).
6. Concentrated solution of chromic acid. Apply to remains of polypi.
7. Rectified spirit of wine. After cleansing and drying the ear, instil warmed into the meatus, and allow to remain in for 15 to 30 minutes. Repeat two or three times a day.

EPITHELIAL NEW-FORMATIONS (p. 652).

1. Lunar caustic. Apply to growth.
2. Zinc paste. As above.
3. Fuming nitric acid. Apply after scraping with sharp spoon.

OTALGIA (p. 657).

I. *Internal Treatment.*

1. Sulphate of quinine in doses of 3 or 4½ grains, three times daily. Doses of 4 to 8 grains two or three times in the course of two or three hours before the attacks of periodic otalgia.

2. Iodide of potassium often assists the action of quinine in the proportion of 2 of the former to 1 of the latter.
3. Iodide of potassium in large doses, if syphilitic.
4. Morphia, internally or hypodermically.
5. Iron, especially in anæmia.
6. Oxide of zinc.
7. Meglin's pills (oxide of zinc, valerian root, and extract of hyoscyamus; of each, 154 grains; make 100 pills). The dose to be gradually increased from 1 to 30, and then gradually diminished.

II. *External Treatment.*

1. Vesicants to the mastoid process.
2. Endermic inunction of morphia or veratrine ointment.
3. Narcotic plasters.

HYPERÆMIA OF THE LABYRINTH (p. 699).

1. Alcoholic embrocation, composed of equal parts of aromatic spirit (Aus. Ph.), spirit of ants (Ger. Ph.), and spirit of mustard (Aus. Ph). A teaspoonful to be rubbed in, over the mastoid process, every hour.
2. Ointment of tartarated antimony. Apply over the mastoid process after laying bare the skin by a fly-blister.
3. Cold applications to head, warm foot-baths, purgatives and local bleeding at the mastoid process, if complicated with congestion of the brain.
4. Bromide of potassium in large doses, for subjective noises.
5. Sulphate of quinine in doses of 7 to 15 grains, for great giddiness.

ANÆMIA OF THE LABYRINTH (p. 701).

1. Bromide of potassium.
2. Quinine.
3. Iron in mineral waters and baths.

MENIÈRE'S DISEASE (p. 708).

1. Cold applications to the head.
2. Alcoholic embrocations behind the ear.
3. Sinapisms to neck and calves of legs.
4. Lukewarm vinegar-water to bathe skin.
5. Laxatives.
6. Quinine.
7. Iodide of potassium in doses of 7 to 15 grains daily for three or four weeks.
8. Solution of muriate of pilocarpin, 2 : 100. Inject 4 to 10 drops daily subcutaneously.
9. Solution of iodide of potassium, 3 : 200. Inject 8 to 10 drops tepid through the catheter into the tympanic cavity. Repeat every second day for three or four weeks.
10. Ointment of iodide of potassium. Rub in over the mastoid process.
11. Ointment of iodoform. Use as above.
12. A course of sulphurous or iodine waters.

Vertigo (p. 711).

1. Quinine in doses of 7½ grains daily, continued for a long time.
2. Bromide of potassium.
3. Iodide of potassium, if suspicion of syphilis.

For other treatment, see preceding three diseases.

Syphilitic Disease of the Internal Ear (p. 722).

1. Mercurial inunction behind the ear.
2. Iodide of potassium in large doses.
3. Solution of muriate of pilocarpin, 2 : 100. Inject 4 to 12 drops subcutaneously.
4. Solution of iodide of potassium. Inject through catheter into tympanic cavity.
5. Ointment of iodoform. Rub in behind the ear. (The addition of 1 drop of oil of geranium to about 13 drachms of iodoform is recommended for the removal of its offensive smell.)
6. A course of the waters of an iodine or sulphur bath.

Paralysis of the Auditory Nerve (p. 741).

1. Purgatives, stimulating foot-baths and vesicants on the mastoid process, followed by the endermic embrocation of an irritant ointment.
2. Mixture of equal parts of sulphuric ether and glycerine. Saturate pledgets of wadding and insert into the orifice of the ear.
3. Solution of muriate of pilocarpin, 2 : 100. Inject 4 to 10 drops subcutaneously.
4. Mixture of strychnia and glycerine, 1 : 10. Apply endermically 4 to 6 drops over the mastoid process.
5. Iodide of potassium.
6. Solution of strychnia, 7 : 1000. Dose : 3 to 5 drops three times daily, only in absence of subjective noises.
7. Vapour of sulphuric ether (pure or with the addition of $\frac{1}{10}$ of liq. ammoniæ). Introduce through the catheter into the tympanic cavity.

Labyrinthine Concussion (p. 748).

The treatment is similar to that of paralysis of the auditory nerve (p. 741).

Cerebro-spinal Deafness (p. 756).

1. Iodide of potassium in doses of 7 to 15½ grains daily.
2. Mixture of 5 parts of iodide of ammonia, 100 parts of mixture of gum arabic (Ger. Ph.), and 15 parts of syrup of orange peel. Dose : one tablespoonful three times a day.
3. Iodine ointment. Apply over the mastoid process.
4. Iodoform ointment. As above.
5. A course of an iodine spa.

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