The mastoid operation : including its history, anatomy, and pathology / by Samuel Ellsworth Allen.

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ALLEN.

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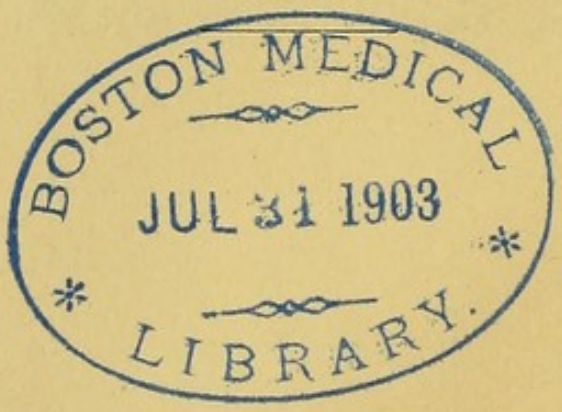

PREFACE.

In the little monograph here presented to the profession, the author does not lay any claim to originality. What knowledge he possesses was obtained at the fountain head, namely, at the clinic of Professor Schwartze, and the results of this instruction, supplemented by considerable thought and anatomical work of his own, are here made public. Of the defects of his literary style the author is only too well aware, but he trusts that the quality of the subject-matter will make up for the lameness in its presentation.

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The Mastoid Operation.

CHAPTER I.

HISTORICAL.

Otology is, properly speaking, a branch of surgery, and this is especially true with regard to that department of the specialty which has to do with the treatment of middle ear suppurations and their complications. Here all treatment is, or should be, purely surgical. The mastoid operation is the name given to those surgical procedures employed in laying open the antrum and cellulae mastoideæ, in the treatment of acute and chronic suppurative diseases of these cavities and of the tympanum itself. The surgical principles which underlie the method are those governing the surgical treatment of suppurations in rigid walled cavities, and it is the aim of this historical sketch to show the

development of the operation in this direction, starting with the earliest and simplest methods, with what hardly can be called operations, and tracing the development down to the present day, where the indications are firmly established and where the most modern surgical ideas prevail.

The first recorded operative opening of the mastoid cells was performed by Johannes Riolanus in 1649. The operation was undertaken for the relief of deafness and tinnitus, caused by obstruction of the Eustachian tube, and with the idea that ventilation of the tympanum was thereby established. Morgangni opposed the operation, probably because he did not believe that the mastoid cells communicated with the middle ear. Valsalva, in 1704, for the first time syringed a cleansing lotion into the tympanum, through an already existing fistula, the fluid escaping through the meatus. The French surgeon J. L. Petit was the first to perform the operation for caries, operating with mallet and chisel in one case, and with a bone perforator in another, in which the cortex was

intact. In both cases putrid pus was evacuated from the cells. A few years later (1776), unaware of Petit's work, Jasser, a Prussian military physician, in sounding the base of an abscess behind the ear, accidentally pushed his sound through the necrotic cortex, and, in syringing, he was greatly astonished and terrified (not being acquainted with the anatomical conditions), at seeing the fluid pass out through his patient's nose. The operation was successful, the patient being freed from his most painful trouble, and convalescing rapidly. Encouraged by the favorable result, he talked his patient into allowing him to operate on the other ear, in which the hearing was much impaired on account of a chronic otorrhœa. As the cortex was here not softened he bored through with a trocar, obtaining a cure of the suppuration and betterment of the hearing. Jasser had a very limited knowledge of the anatomy of the parts, and made no attempt to open the antrum, but contented himself with removing a part of the cortex, and laying open the cells. He directed the trocar to be placed on the

middle of the process "slightly outward where the great cells begin."

The report of his operation created great excitement and raised the hope that a remedy had been discovered for deafness. The indications for the operation were immediately extended to the commonest symptoms of ordinary ear disease, and the results were, of course, not satisfactory. Threatening febrile reaction followed a case operated on by Proet, in 1791, and in the same year, in Copenhagen, occurred the first death. This case became widely known, as it concerned the Baron v. Berger, private physician to the king of Denmark.

Von Berger, then an old man, was troubled with deafness, with most annoying tinnitus and dizziness, and, misled by some of the favorable reports, he requested Professor Kölpin to perform the operation. Warm water injected into the wound failed to flow off through the nose. Fever, sleeplessness, and delirium followed, and he died on the eleventh day. The post-mortem showed purulent meningitis to have been the cause of death. The processus mastoides

was found sclerotic, and the operative canal opening into the cerebral fossa. This disastrous result caused the operation to be abandoned, and although Dezeimeres in 1830 tried to reinstate it, he was unsuccessful, a fatal case preventing the proper reception of his publications.

From the time of its overthrow, due to the death of von Berger, up to the middle of the present century, the best authorities—Itard, Bonnafort, and Rau,—were united in its condemnation.

A few favorable results, published by Forget, in 1849, and later by von Tröltsch and Follin, called attention anew to the operation. [As a forerunner of the activity about to follow, the Irish otologist Wilde may be mentioned. In his work on ear diseases—American edition, published in Philadelphia in 1853—he recommended his well-known periosteal incision, which may be considered the first step in the mastoid operation.]

In 1861, von Tröltsch published in Virchow's Archives, the report of a case operated on in 1858, in which, after making Wilde's Incision, he tremb-

lingly made an opening through the softened bone with a sound. Von Tröltsch concludes the notice of his case with remarks which it may be well to quote here, as they are as pertinent to-day as they were in 1861, giving an especially comprehensive view of the necessities of acute suppurations.

"One of the fundamental principles of surgery, which is slowly gaining ground in internal medicine as well, demands that every retention of pus in the tissues should be given exit to as quickly and as thoroughly as possible, by the doing of which alone can be avoided gravitation abscesses, extension of the inflammation, and the injurious action of the same on the neighboring parts. The principle is to be the more emphasized and brought the more conscientiously into application according to the importance of the tissue and place in which such suppurations occur. I know of scarcely a part in the human organism which, in all directions, is so surrounded by important parts and organs, and in which accumulations of pus should be so carefully avoided, as is the case with the middle ear. Closed

in on one side only by a yielding wall, the drum membrane, and provided with an unusually narrow, and during inflammatory states generally obstructed emissary canal, the Eustachian tube, its bony walls border on every side on formations whose participation in the inflammation is most greatly to be feared. While the drum cavity and mastoid process above are separated from the dura mater and brain, by an exceedingly thin layer of bone, and the internal carotid from the mucous membrane, simply by a thin, often indeed defective bony plate, the jugular vein with its bulb lies closely under the thin mucous membrane of the floor of the cavity, and the labyrinth wall itself offers only a slight opposition to the extension of the process to the inner ear, and thence through the porus acusticus internus, to the meninges; and further, the sinus lateralis is placed on the posterior surface of the mastoid process, and all the parts are either formed or surrounded by diploetic spaces in which blood clots easily arise and thus establish the conditions necessary for secondary thrombosis in the neighboring venous spaces. . . .

Why do we not seek to act here as we would do in less dangerous positions, and providing free exit for the pus thus check all further damage and destruction?"

The operation was now taken up by various surgeons, both here and abroad, among them being Crosby, Turnbull, and Post in this country, Hinton in England, Triquet and Follin in France, and Mayer and Jacoby in Germany. Turnbull, in 1861, reported a successful case, the first in America. After the Wilde's incision he pushed a sound through the cortex, evacuated pus, and some days later removed a sequester. He laid down the rule that the incision be made three-fourths of an inch from the insertion of the auricle, the knife being drawn from below upward, and the chisel, director, or probe inserted in the middle of the incision at an equal height with the opening of the ear, and directed horizontally inward and a little forward.

About the middle of the year 1865, Mayer published a case, the eleventh on record, where

he opened the cells by means of a large trocar, 6 Mm. in diameter, which, shoved through the cortex, provided an exit for putrid pus.

In 1868, Jacoby, of Breslau, published his first mastoid operation, in which he opened the cells by means of a drill, and concluded his publication with a history of the previously recorded fourteen operations. He divided these cases into two classes: First, where, after acute suppuration in the tympanum and processus mastoides, the cortical layer of the latter had become affected. Second, those where inflammatory appearances and purulent breaking down of the cortex were absent to a greater or less extent. In the first class he placed the cases of von Tröltsch (Virchow's Archives, 1861), three cases by Turnbull (Med. and Surg. Reports, Phil., Feb. 1862), a case by Schwartze, two by Pagenstecher, the case of Mayer (Archives, f. Ohrenheilkunde, Vol. I, 226), those by Kessel (1866), J. Hinton's case, and lastly his own. In the second class the cases by Flaiz

(Arch. f. Ohrenheil. II, 228), and the first case of Pagenstecher.

In the first two cases of Turnbull, the pus was evacuated by the Wilde incision, in the last case, a month after the incision, he bored through the cortex with a sharp hollow sound.

In Schwartze's case, the Wilde incision was made, and a few days after the cortex perforated with a hollow sound. In one case, Pagenstecher cut through the cortex into the cells with a cartilage knife, in the other he used a drill. Mayer's and Hinton's cases were operated upon with a trocar and á large quantity of pus evacuated. Kessel's cases were of acute middle-ear suppuration, with mastoid complications, and the operation consisted in breaking through the cortex with the sound in the one, and opening with a trocar in the other, while Jacoby himself used a Middeldorpf's drill. In all these cases there were brain complications except in that of Hinton.

Jacoby gave the following four indications for the operation:

"1st. When appearances arise which indicate that the acute suppuration in the tympanum has gone over into the mastoid, accompanied or not by carious softening of the cortex.

"2d. When the appearances of inflammation in the mastoid are but slight, and when the symptoms do not give way to protracted antiphlogistic treatment.

"3d. Where outward appearances of affection of the mastoid are absent, and where from the accompanying chronic purulent catarrh, limited caries of meatus, amnesia, etc., the supposition of participation of the mastoid is justified.

"4th. Where a chronic middle-ear catarrh refuses to yield to other methods of treatment."

In indication No. 4, we have the first recorded intimation of the advantages of the operation in chronic otorrhœa, without mastoid or threatening symptoms, although Jacoby states that Schwartze had expressed to him in a letter his conviction that in a short time the operation would be extended to such cases. Thus in 1868 we have the first inti-

mation from Schwartze of what he has been laboring ever since to more firmly establish.

In 1870 Agnew operated on a case, where six years before the patient had had an acute otorrhœa with mastoid complications, the Wilde incision had been made, and later the cortex opened by Crosby with a gimlet, evacuating considerable pus. The patient had had an alarming attack with paralysis of the seventh nerve, vomiting, etc., for which Agnew undertook the opening of the mastoid. A half inch trephine was used, - a button of bone three-eighths of an inch thick removed, and the canal then lengthened to five-eighths of an inch through the sclerotic process, without, however, the evacuation of any pus. It is stated that the patient recovered.

In the *Medical Record*, of July 1870, Roosa reported his first cases. In the one, a case of acute mastoid trouble, after Wilde's incision, a sound was pushed through the softened cortex; in the other, also acute, he cut down to the bone, and after search a fistulous opening was discovered which being enlarged allowed the discharge of the pus.

Roosa concluded by giving a history of the operation up to 1870, and formulated the following five indications:

"I. The integumen and periosteum should be freely divided over the mastoid in all cases in which there is pain, tenderness, and swelling in the part. (Wilde).

"II. Such incision should always be made whenever severe pain exists, referred to the middle ear, which is not relieved by the usual means, *i. e.*, leeches, warm water, etc.

"III. An exploratory incision should be made when we have good reason to suspect the existence of caries in this part.

"IV. The mastoid bone should be perforated after such incision whenever the bone is found diseased, or a small fistulous opening should be enlarged. It should also be perforated when we have good reason to believe that there is pus in the middle ear, or mastoid cells which can not find exit by the external auditory canal.

"V. The mastoid should be perforated in the

case of a suppuration of long standing with frequent and painful exacerbations."

He also states that for the performance of the operation a trephine is rarely necessary, the bone being nearly always found softened by disease or fistulous, in the cases requiring an operation. When fistulous, a small gouge is a very good instrument for enlarging the fistula.

Buck published a case (*Medical Record*, 1871), where there was a carious perforation of the upper wall of the meatus, accompanied by pain and cerebral symptoms. He made a counter opening through the cortex with a gouge, and established communication with the meatus. Recovery.

In 1872, D. R. Ambrose of New York operated on an acute case with a trephine. Result doubtful. During the same year five cases were reported from the clinic of Professor Volkmann, where necrotic bone was removed with the sharp spoon, and the recovery greatly accelerated.

In 1873 appeared the now classical work of Schwartze and Eysell. (Arch. f. Ohrenheilkunde,

Bd. VII.) Beginning with a history of the operation up to that time, and with chapters on Anatomy, Physiology, and Pathology, they gave the method of operating, strongly advocating the use of mallet and gouge, and concluded with the report of sixty-three cases, seventeen in the practice of Professor Schwartze.

In all of the cases, however, with the exception of the five later ones, the operation was performed with either a drill or a trephine. The results were far from satisfactory. In but four of the cases could he report healing, with two deaths, five without result, and the rest still under treatment. In January 1874 (*New York Medical Record*) Noyes and Crosby reported four cases—all acute.

Orne Green (*Boston Medical and Surgical Journal*, 1874) published three cases, all acute, two with marked mastoid complications. In one of these cases there was no swelling, or pain on pressure over the mastoid, and the opening was made with a three-sided drill, evacuating about two drachms of inoffensive pus.

It is evident that in this case the opening was made through an outwardly sound mastoid, and Green stated that the operation under such conditions was new; it had, however, as we have seen, been recommended and carried out sometime before by German specialists.

In 1874 (Monatschrift, f. Ohrenheilk., Nov. 1873 to March, 1874), Bezold made public the results of his anatomical studies on the temporal bone and deduced from them the following method of operating.

The incision to be made beginning a little above the point of intersection of the linea temporalis and the line of insertion of the auricle, and carried down in a curve to the upper edge of the lower third of the same, not lower, as it needlessly endangers the arteria auricularis posterior. The bone to be laid bare by means of a periosteum scraper nearly up to the back wall of the meatus, and the center of the artificial opening to lie within a horizontal line passed through the spina, and not less than 5 Mm. back of the line of insertion

of the auricle, with its axis parallel to the meatus. The mallet and gouge were recommended as the best instruments.

Schwartze in 1875 began the publication of his first series of fifty cases. Up to 1873 he had operated but seventeen times; now his cases have increased to fifty, and he has begun to operate for chronic otorrhœa, the mastoid being outwardly healthy and no subjective symptoms present. These publications were concluded in March, 1878, with the following results:

Cases healed, - -	35
Not healed, - -	5
Died, - - - -	10
Total, - -	50

The after-treatment lasted on an average of from six to seven months in acute cases and ten months in chronic cases.

From the results obtained in some of the chronic cases he concludes that by the opening of the mastoid, the most tedious and stubborn cases of caries, even when the pars petrosa is also

attacked, can be completely and permanently cured. In this article he states what follows as to the indications.

The first indication for the operation is in the cases of acute inflammation of the mastoid, with retention of pus in the cells, in which after Wilde's incision or ice treatment, the swelling, pain, and fever do not abate. One should not wait until threatening brain or pyæmic symptoms arise, but the bone must be opened even when the cortex is sound, and free communication with the middle ear established. When nature has already formed, or is seeking to form, an outlet for the pus, as shown by fistulous passages behind the ear, it is always well to operate, enlarge the fistula, and in this way hurry up the cure.

When the meatus presents a carious perforation of its upper posterior wall, or that wall is bulged out into the meatus, indicating disease of the cells above and behind, and provided brain symptoms arise, the opening of an outwardly sound mastoid is undoubtedly indicated.

In such cases the question might be asked whether it might not be sufficient to dilate the fistulous canal by chiseling through the meatus into the antrum. Experience so far was not sufficient to decide the question. The operation is indicated further for the removal of pus retained in the middle ear. Signs of pus retention are pain, fever, and a penetrating fœtor of the secretion continuing in spite of the most painstaking disinfection and cleansing.

Although Schwartze wished to establish the operation as a means of curing long standing otorrhœa, still his results up to this time were so unfavorable that he stated the following in this connection:

"The prophylactic opening of the mastoid, which was recommended with some reserve by von Tröltsch, in the absence of urgent symptoms, as a cure for long standing incurable otorrhœa, and by Jacoby without this reserve, has probably but doubtful justification. It has been shown that the dangers of the operation, when the bone is out-

wardly sound, under the methods now practiced, are still too many, and the anomalies in the formation of the bone, especially in relation to the position of the sinus and middle fossa, too frequently present to render the operation other than questionable. Old and incurable otorrhœas become of moment to but relatively few of those affected; hundreds and thousands run around, and show, with ordinary care, no signs of pus absorption or brain irritation, and grow old and gray. It would be reprehensible to undertake an operation not unattended by danger, under such circumstances, so long as threatening symptoms of pus retention or brain irritation did not present themselves—in other words, where the indicatio vitalis was not present." Further on, however, he qualifies these remarks by saying that, although with the present methods of operating he is unable to classify chronic otorrhœa among the indications, yet he firmly believes that with improved methods it will in a short time be so looked upon.

By this time Schwartze has become a firm ad-

herent to the mallet and gouge, having discarded all drills and trephines. His after treatment was long and tedious, lasting nine or ten months in chronic cases, and consisting in daily irrigation of the canal and middle ear. In most cases a leaden nail was inserted and worn in the canal to prevent its closing.

Such was Schwartze's most interesting publication, without doubt the best work on the subject up to that time, and a work which placed the operation on a firmly established basis.

There were many cases of the operation recorded during the following years, and in 1880, Schwartze began the publication of his second series of fifty cases, concluding in March 1883. His methods were the same as employed in the first series, mallet and gouge being used exclusively. Taking the results of the entire one hundred cases, we have

Cured, - - - -	74
Not cured, - -	6
Died, - - - -	20
Total, - - -	100

In the year 1880, Schwartze says: "The time is not far distant when the operative opening of the mastoid will be as generally accepted by otologists, and performed under just as determined indications, as has been the case for the last ten years with paracentesis of the tympanic membrane."

1885 is the date of Schwartze's book, "The Surgical Diseases of the Ear." In this treatise he gave five indications, which, abridged, are as follows:

I. In cases of acute suppuration of the middle ear with retention of pus in the mastoid cells, where, after antiphlogistic treatment (ice, Wilde's incision, etc.) the swelling, pain, and fever do not subside.

II. In chronic diseases of the mastoid with repeated swelling of the same, or where abscess formations or fistulæ through the skin, or abscesses in the region of the neck or within the meatus, exist, even in the absence of all threatening symptoms.

III. In cases where the mastoid is outwardly healthy, if pus retention or cholesteatomatous formations arise, with symptoms indicating the probable occurrence of dangerous complications.

IV. Where the mastoid is the seat of intense pain which can not be relieved by other means, the mastoid being sound and no middle ear trouble present. Here the removal of a piece of the cortex over the mastoid may be sufficient to permanently relieve the symptoms.

V. As a prophylactic operation, against the lethal results of an incurable middle-ear suppuration, where no signs of pus retention (pain, fever) exist other than a stubborn and persistent fœtor of the secretion, remaining after careful disinfective treatment both through the meatus and tuba. In these cases the antrum should be opened and kept so in order to allow free irrigation of that cavity and the tympanum.

The operation was now pretty firmly established and reports of cases appeared almost incessantly in

most of the medical journals, both at home and abroad.

Hessler in Halle published a series of fifty cases in 1885, and in 1887 Lucæ and Jacobson a series of one hundred cases.

In the sixth edition of his work, which appeared in 1885, Roosa proposes the following regarding the operation:

"I. The integumen and periosteum of the mastoid process should be freely divided in all cases where there is great pain, tenderness, and swelling in this part.

"II. Such an incision should also be made wherever severe pain referred to the middle ear constantly exists, and which is not even temporarily relieved by the use of leeches, poultices, the warm douche, etc.

"III. The bone should be thoroughly examined by aid of such an incision whenever we have good ground for suspecting that the bone is diseased or pus retained in the part.

"IV. The mastoid process should be perforated

after such an incision, whenever the bone is found softened, or if a fistulous opening is discovered, this should be enlarged. It should also be perforated when the suppuration of the middle ear involves the mastoid cells or antrum to such an extent that thorough drainage can not be secured through the membrana tympani or external auditory canal."

In 1889 (Berl. Klin. Wochenschrift, Nos. X–XIII) appeared a paper by Küster, on the treatment of chronic suppurations in rigid walled cavities, in which he dwelt at length on the method of treating chronic otorrhœa. Looking at the matter from a surgical stand-point, Küster stated that the simple opening of the antrum could have but a limited influence on a chronic middle-ear suppuration, and for the reason that the communication between the antrum and the tympanum is small, and in such cases apt to be still further narrowed by granulations or swollen mucous membrane, and thus free irrigation made impossible. The rational treatment must be based on the surgical principle that a diseased bony cavity should be opened up extensively, all diseased

tissue removed, and the source of the suppuration brought clearly to the light. Only when this is done are the surgical requirements fulfilled. Küster therefore proposed to operate by chiseling away the back wall of the meatus, that is, by working down along the side of the meatus, taking away the back wall as he proceeds, till the attic and threshold of the antrum is reached. He thus throws the attic, tympanum, meatus, and the beginning of the antrum into one cavity.

Although Küster's remarks were very àpropos to the subject, his limited number of cases and his evident unfamiliarity with ear examinations reduces considerably the value of his results.

This paper of Küster excited considerable interest and discussion, and von Bergmann, ignorant of the development of the specialty, made some very unflattering statements concerning the treatment adopted by otologists.

Stacke of Erfurt (Berl. Klin. Wochenschrift, 1889), replied to these remarks of von Bergmann and his surgical friends. His paper is a perfect rep-

resentation of the present position of our specialty, and whoever wishes to procure the advanced ideas concerning operative otology, can do no better than to read Stacke's article. He strikes the nail on the head when he says: "Otology is an off-shoot of surgery, and only in close adherence to it and in the true and conscientious observance of its principles is success to be sought for and to be found. . . . . The most important principle is the care for free, unhindered, spontaneous drainage. Incomplete drainage, and as a consequence further and deeper bone disease, is the cause of the difficulty in the healing of middle-ear suppurations."

The older authors recommended the operation only when the most pronounced subjective and objective symptoms were present. Stacke says, substantially: "Every polyp, every granulation is just as suspicious as constant fœtor, headache, and inflammatory swelling of the meatus, and should call for the most careful examination with the sound, as by far the largest number of all chronic, middle-ear suppurations are complicated with bone disease,

and it is just such cases in which lethal complications so often arise, and which therefore require early and energetic surgical treatment."

In the Archives of Otology (Vol. XVII 1888), Ferrer of San Francisco, a pupil of Schwartze, began the publication of cases which his successor has continued. In all, sixty cases have been reported.

Orne Green in December of 1890 (American Journal of the Medical Sciences) published a series of eighty cases, with remarks. He recommends the use of the mallet and gouge for removing the outer layers of the cortex, and the dental engine to enlarge the opening and remove rough edges. One of the advantages of the engine he considers to be the avoidance of the shock to the brain arising from the use of the mallet. This is a purely theoretical consideration however.

Stacke at Halle, in September 1891, read a paper before the otological section of the Association of German Naturalists in which he described a new method of operating. This method will be

thoroughly considered later, when treating of the operation itself.

The contribution of Stacke marks the latest advance of ear surgery, and brings us to a fit point for breaking off from these historical considerations.

CHAPTER II.

ANATOMICAL.

For a complete description of the anatomy of the temporal bone and organ of hearing, the reader is referred to purely anatomical works; only those points which are of importance to the operator will be dwelt upon here.

External meatus.—The external meatus consists of a cartilagenous and an osseous portion, the two divisions being of different lengths and uniting so as to form an obtuse angle, opening downward and forward, the lower margins of the external and internal orifices remaining in the same horizontal plane. From this it follows that in order to straighten the meatus, the auricle must be pulled upward and backward. The lumen of the meatus is elliptical, with the longer axis uniting the superior and inferior walls, and the shorter the anterior and

posterior. A condition which must be borne in mind during every manipulation within the meatus. The cartilage of the auricle is continued without interruption into that of the meatus, and forms the framework of the cartilaginous portion of the latter. This is not a complete tube, but is defective above and back, the space being filled in by a connective tissue membrane, known as the membranous portion of the meatus.

The front wall of the meatus is in relation to the temporo-maxillary articulation, the inner two-thirds of the posterior surface of the joint corresponding to the osseous part of the anterior wall, while the lateral one-third of the joint is in relation to the anterior wall of the cartilaginous meatus. In consequence of this, movements of the joint exercise an influence on the lumen of the meatus. This can easily be demonstrated by inserting the end of the finger into the meatus. On opening the mouth, one plainly feels an enlargement of the tube, while on closing it the pressure of the condyle against the finger is experienced. Still farther lateralward near

the tragus, the posterior border of the parotid gland approaches the meatus. The lower wall of the meatus is in almost its entire length in relation to the retro-maxillary process of the parotid gland. The attic, that addition to the tympanum proper in which the head of the malleus and the greater part of the incus are situated, overlies to a slight extent the most medial portion of the upper wall of the meatus, which, slightly more lateralward, is overlaid by pneumatic cells in communication with the attic and cells of the mastoid region, and with those which sometimes extend forward into the root of the zygomatic process. This pneumatic layer, together with the compact cortical layer of the upper wall, forms a narrow lower, and the lateral wall of the attic. (Recessus epitympanicus). The remaining lateral portion of the cortex of the upper wall is separated from the middle cerebral fossa by cancellous bone, varying from three to eight Mm. in thickness. The meatus is separated posteriorly from the air cells of the mastoid process by its posterior wall, the thickness of which varies from 0. 1.

to 2 Mm. According to Kirchner, the mastoid cells and meatus are brought into communication by means of minute canals, containing connective tissue fibrils and vessels, perforating this wall.

The fact that the upper and posterior walls of the meatus are made up of but a thin cortical layer of bone, overlaid by pneumatic cells in communication with the tympanum, antrum, and cellulæ mastoideæ, is of the greatest importance, as will be seen from pathological considerations given later on. The length of the external meatus from the anterior edge of the tragus to the end of the anterior lower wall, averages, according to Bezold, 35.23 Mm.— of which 14.05 Mm. belong to the osseous, and 21.18 to the cartilaginous meatus. On the upper and posterior edge of the porus acusticus is situated in the great majority of cases, according to Kiesselbach in 82 per cent. in children and 87 per cent. in adults, a bony tubercle, developed from its posterior surface into a spina (spina supra meatum). This spina is of great importance, being the guide in operative attacks on the mastoid. A very valu-

able practical measurement is from the tip of the spina to the tympanic margin of the upper wall of the meatus. This distance, (m n, Fig. 1, page 38), which can easily be taken by hooking the bent end of a sound around the internal margin of the osseous meatus, thus determining the medial measuring point, varies from 12 to 17 Mm. Owing to the position of the axis of the antrum tympanic cavity (C D, Fig. 1), it follows that the distance from the point m. to the external surface, must always be greater than the distance (o p) from the lateral wall of the antrum to the external surface, and we can consider the distance m n as exceeding in every case the depth to which it is allowable to penetrate in operating. The backward prolongation of the posterior root of the zygomatic process forms a more or less plainly marked ridge of bone, running backward and upward—the linea temporalis. Posterior to the spina supra meatum is generally a flat surface of bone, perforated by numerous fine canals.

Processus mastoides.—The mastoid process varies

greatly in its external form and size as well as in its internal construction.

Zuckerkandl, in his contribution to the anatomy of the mastoid, states that its outer form allows of no safe conclusion as to its inward construction, for while generally a small mastoid process contains narrow small air cells, and a large expanded process large cells, yet the direct reverse also occurs quite often. According to him there are two forms of processes.

A. Those which are entirely pneumatic.

B. Those where pneumatic cells and diploetic substance occur together.

Class A may be further divided into:

(1.) Where the entire process is pneumatic, the cells of about the same size, and the compact cortical layer thin, in some places translucent. (2.) Where the process is pneumatic but the spaces small and narrow. (3.) Where the cells are of different sizes, the largest belonging to the squamous portion, more rarely to the petrous portion. (4.) The process is entirely pneumatic, the cells broad and extending to

the level of a horizontal line drawn through the lower wall of the meatus, below which the process is converted into one large cavity. (5.) Those cells belonging to the squamous portion are large, while the pars petrosa is taken up by one cavity reaching to the upper posterior end of the incisura mastoidea. (6.) The process contains but three or four tube like spaces, which, placed close together at the antrum, radiate fan-like through the process.

To class B, consisting of diploetic substance and pneumatic spaces combined, belong the following varieties: (1.) The process up to within three or four Mm. from its apex is filled, in fresh preparations, with dark red diploetic tissue, above which appear abruptly wide pneumatic cells. (2.) The diploetic substance extends into the pars petrosa up to a level with the posterior end of the fissura mastoidea. (3). The pars petrosa and the lower part of the pars squamosa are completely diploetic, while the upper part of the latter contains large pneumatic cells. (4.) The process is completely made up of

small diploetic cells, which extend up to and surround the antrum. This form may vary, giving the process a more or less sclerotic appearance, or there may still be retained a few pneumatic cells in the region of the incisura mastoidea.

In the 250 bones examined, Zuckerkandl found the completely pneumatic process occurring but in 36.8 per cent., the totally diploetic in 20.4 per cent, and the mixed diploetic and pneumatic in 42.8 per cent.

The conditions were also found to vary on the two sides, one side being partly diploetic, and the other completely pneumatic.

From these examinations it follows that a completely sclerotic process is not always the result of previous inflammation, but does occur normally.

The following outline representation of a horizontal section of the temporal bone will serve to recall the position of the various parts and their relations to each other. The internal meatus lies nearly directly medial to the external meatus. The Eustachian tube, tympanic cavity, and antrum also

lie in a direct line, which runs from behind and lateralward, forward and medialward, forming with

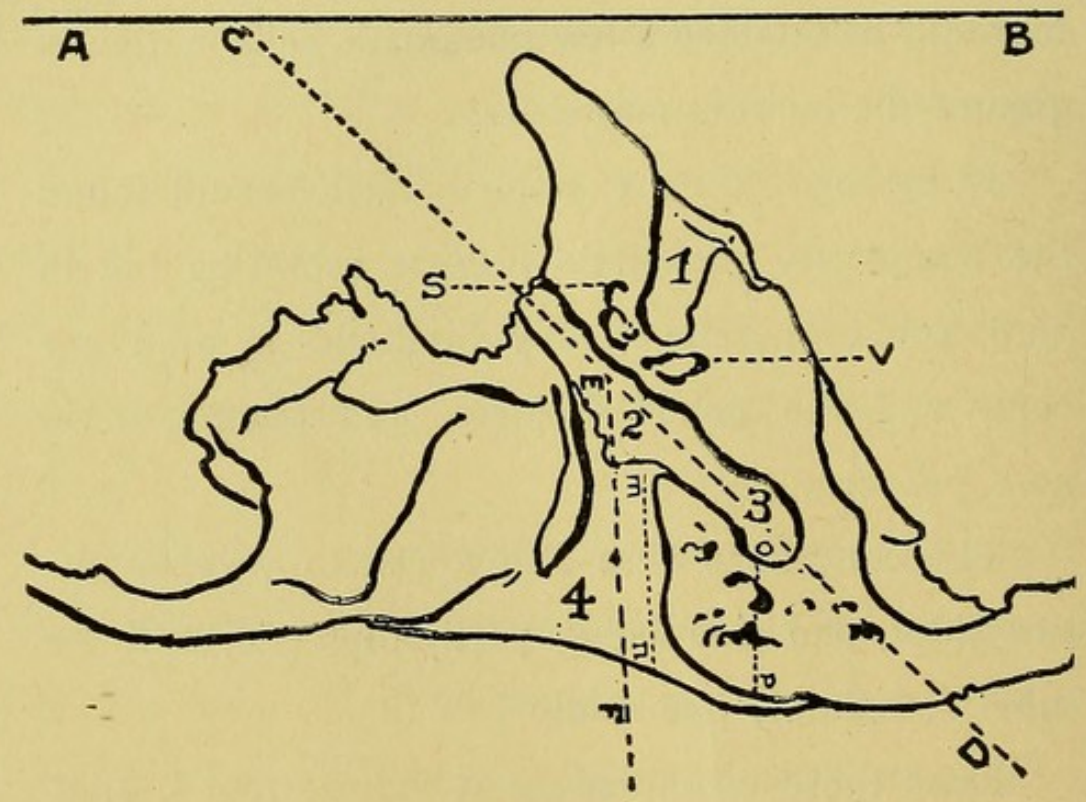

FIG. 1.

A B—Line of medial plane.
C D—Tubal-Tympanic-Antral axis.
E F—Axis of external meatus.
1—Internal meatus.
2—Tympanum.
3—Antrum.
4—External meatus.
S—Cochlea.
V—Vestibule.
m n—Distance from margin of drum to external surface.
o p—Distance from antrum to external surface.

the medial plane an angle of from 45° to 50° (Angle D C B, Fig. 1). This is about the same angle as is formed by the axis of the pyramid, so that the tubal tympanic axis runs about parallel to that of the pyramid. A line drawn along the upper wall of the osseous tubal canal and prolonged backward, strikes the lower border of the entrance into the antrum, and forms with the horizontal an angle of about 30°. The tubal tympanic axis (Fig. 1, line C D) forms with the axis of the meatus a posterior angle of also about 30°. (Fig. 1, angle F E D). The vestibule and cochlea lie medial to the tympanic cavity, the vestibule in the rear, and the cochlea to the front, with the internal meatus wedged in between them. The apex of the axis of the cochlea is directed toward the commencement of the medial wall of the osseous tuba.

The lateral sinus cuts into the inner surface of the mastoid process to a very varying extent, sometimes being, on a level with the antrum, an inch or more posterior to the posterior wall of the meatus, and at other times so close to the surface and to the

meatus as to render the opening of the antrum from without impossible. The accompanying outline drawings (Figs. 2 and 3) show these conditions.

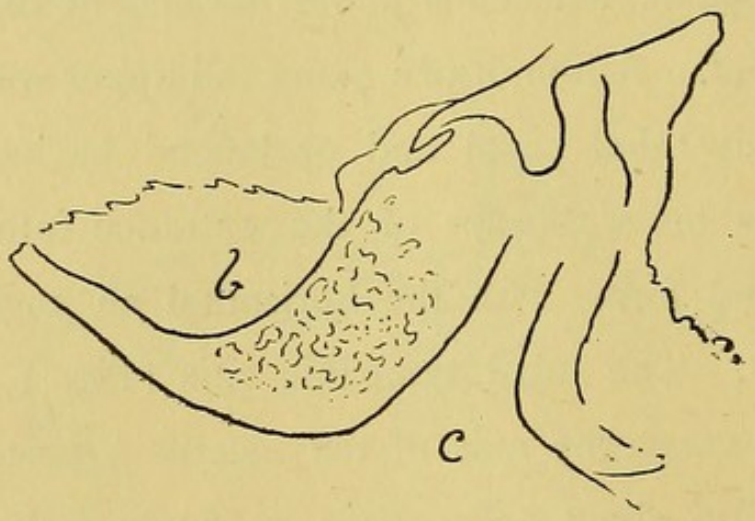

FIG. 2.
b—Sinus. c—Meatus.

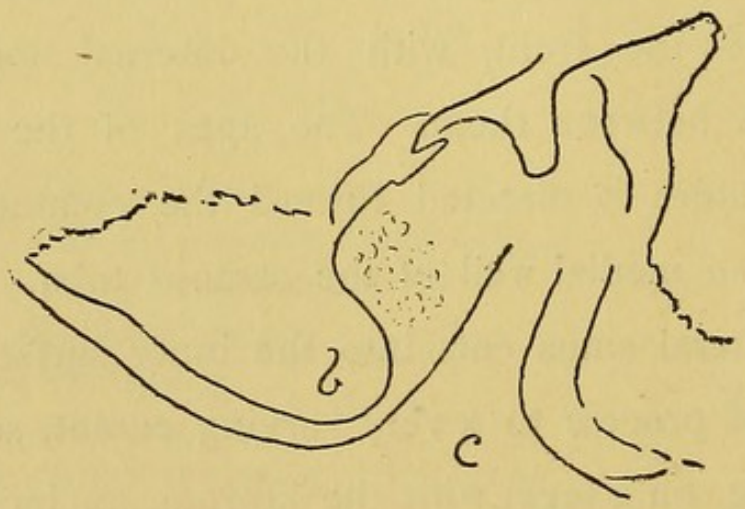

FIG. 3.
b—Sinus. c—Meatus.

The thickness of the bony partition between the upper wall of the meatus and the middle cerebral fossa, taken in a vertical plane passed through the antrum, varies considerably.

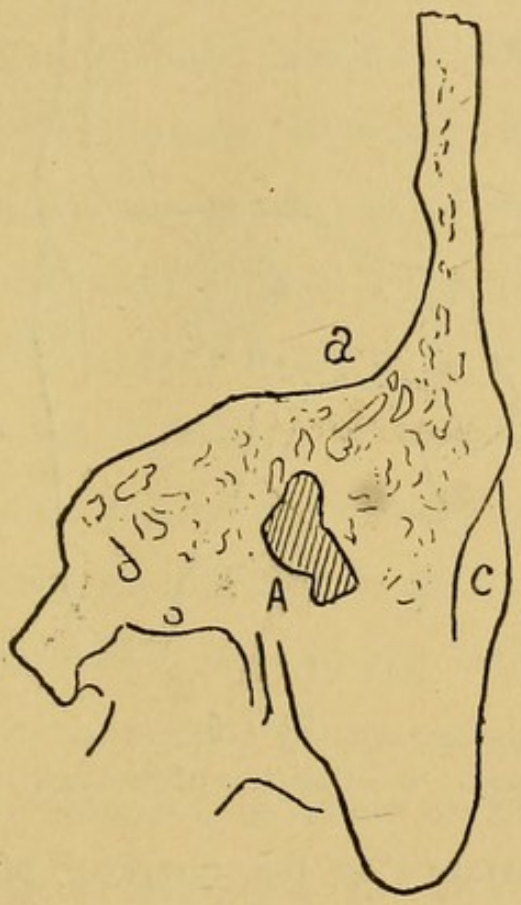

FIG. 4.

a—Middle fossa. c—Position of meatus. A—Antrum.

Fig. 4 shows the fossa (a) situated at a considerable height above the antrum (A) and the meatus (position shown at c).

While Fig. 5 represents a low-lying fossa.

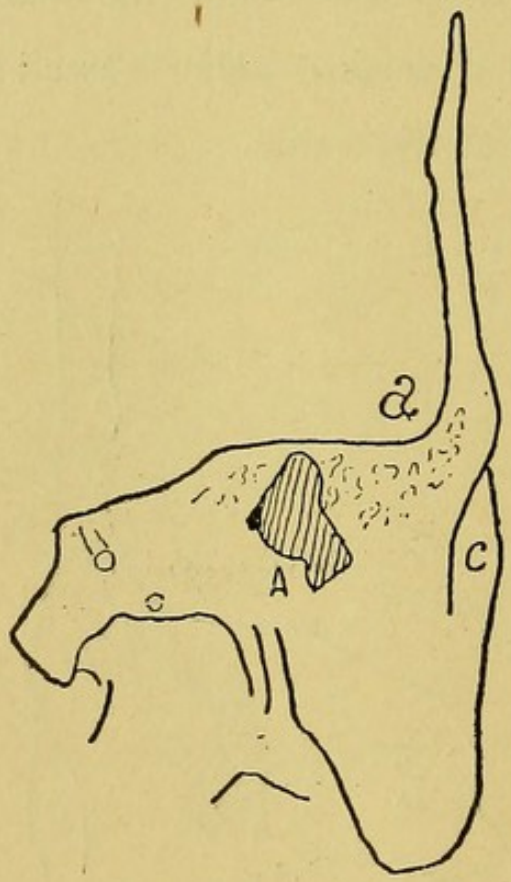

FIG. 5.

a—Middle fossa. c—Position of meatus. A—Antrum.

The importance to the operator of the position of the sinus and the middle cerebral fossa is evident, and many attempts have been made to see if we could not draw some conclusions as regards their positions from the outward conformation of the skull.

Körner in Frankfort in 1886 published in the Zeitsch. f. Ohrenh., XVI, the results of measurements on sixty skulls, and again in 1887 on twenty-eight more. He found that in dolichocephalic skulls [those where the index, that is the result obtained by dividing the distance between the two tubae parietae into the distance from the bridge of the nose to the most prominent part of the occiput, is high, (1.55)] the middle fossa is not as low and the sinus does not lie as far forward as in brachycephalic (where the index is low). In short that in broad heads the sinus and fossa are situated more unfavorably for operating than in long heads.

In 1889, Schülzke took up the subject, and obtained from measurements conducted on sixty skulls results directly opposite to those of Körner. The fossa, according to Schülzke, lies, if any difference is determinable, rather deeper in dolichocephalic than in brachycephalic skulls. In 75 per cent. of the cases, the two fossæ were of the same height; in 13⅔ per cent., the height differed by but 2 Mm., and in 8⅓ per cent., by from 3 to 4 Mm. Körner

found the left fossa higher than the right, Schülzke found that the two sides varied about equally, or if there was any difference, that the lower lying fossa occurred slightly more often on the right side. With regard to the dangerous forward lying sinus, Schülzke found it occurring oftener in dolichocephalic skulls, in direct opposition to Körner.

The contradiction between these two results teaches that we can not, as yet, deduce the probable positions of the sinus and fossa from the external conformation of the skull. Schülzke claims to have found cases where the sinus was close to the posterior wall of the meatus, at a considerable distance from the external surface. I myself, have never seen a forward lying sinus which was not at the same time situated near the surface, as is the case with the bone from which Fig. 3 was drawn. The point is of considerable interest, as will be seen later.

Tympanic cavity.—The tympanic cavity is a pneumatic crevice placed between the labyrinth wall and the drum membrane. Postero-laterally it communicates through the antrum mastoideum with the air

cells of the mastoid process, antero-medialward through the osseous and cartilaginous tuba with the pharynx. One can consider the tympanum as a nearly vertically placed cleft, whose long axis forms, as stated above, an angle of between 45° and 50° with the medial plane. This cleft is bounded by two chief walls, an antero-lateral drum wall and a postero-medial labyrinth wall. These two chief surfaces divert from the vertical position considerably, both being inclined laterally, the outer wall more than the inner, so that the upper ends of both come to lie further lateral than the lower. The inclination of the labyrinth wall amounts to 66–70°, that of the drum to 45–55°. The tympanum proprium (that is, exclusive of the atticus) may be likened to a very low cylinder (Henle), whose basal surfaces are directed nearly vertically, corresponding to the inner and outer walls, while the narrow rim of the cylinder represents the anterior, posterior, superior, and inferior walls. The continuity of this cylinder is disturbed by openings in the upper part of the anterior wall, and the posterior portion of the su-

perior wall, the former admitting the Eustachian tube, and the latter communicating with the atticus and through this cavity with the antrum. The upper wall of the Eustachian tube runs without interruption backward and upward into the roof of the tympanum, and being continued further backward, rises out of the tympanum proper, and becomes the roof of the atticus, and further posteriorly the roof of the antrum. The Eustachian tube, the anterior portion of the tympanum, the atticus, and the antrum are separated from the meninges by a continuous thin plate of bone, known as the tegmen tympani.

If the posterior narrow wall of the tympanum be prolonged upward to the tegmen tympani, through the cavity which above and behind adds itself to the tympanum proper, this cavity will be divided into two parts, a posterior, with roughened surfaces, the antrum mastoideum, and an anterior comparatively smooth walled cavity [recessus epitympanicus, additus ad antrum (Bezold), upper tympanic cavity, atticus], in which lie the greater portion of the incus and the upper half of the malleus.

The attic is, therefore, a cavity placed above the posterior half of the tympanum proper, and communicates freely with the latter between the tendons of the tensor tympani and musculus stapedius. The lower edge of the lateral wall of the attic is formed by the posterior portion of the upper margin of the drum insertion, while medially it is marked off from the tympanum by the more or less prominent ridge formed by the facial canal. The opening into the antrum takes the place of the posterior wall of the attic, or, considering attic and tympanum one cavity, is in the upper half of its posterior wall.

The medial and lateral surfaces of the tympanum are not exactly parallel, but converge inferiorly and anteriorly, so that the breadth of the cavity, in the direction from the drum to the labyrinth wall, is found to be greater posteriorly and above than anteriorly and below. Bezold gives the average depth forward and below as 3.08 Mm., behind and above 6.54 Mm. The distance between the umbo and the most prominent part of the promontorium amounts, according to von Tröltsch, to 2 Mm., according to

Tillany to 1½ to 2 Mm. The lateral wall of the attic diverges laterally as it ascends, so that the breadth of the cavity (at its mouth 3 Mm.), increases toward the roof to 4.5 Mm. If we consider the attic as a part of the tympanum, the height of the latter, consequently greater in its posterior part, amounts to 15 Mm., of which 6 Mm., belong to the attic, and 9 Mm., to the tympanum proper. The height of the anterior wall of the tympanum up to the lower border of the tubal entrance, is 4 Mm. These measurements teach that the two openings which the tympanum possesses, lie considerably higher than the deepest part of the floor (the posterior, 9 Mm., the anterior, 4 Mm.); from which it follows that considerable amount of secretion can form before it reaches the level of an outlet. We have stated that a line drawn from the tubal entrance to the opening of the antrum makes an angle of 30° with the horizontal, and consequently the latter is at a much greater elevation than the former. Concerning the long diameter of the tympanum, the same measured from the lower border of the en-

trance of the tuba to the border of the entrance to the antrum, amounts to about 13 Mm.

The bounding surfaces of the drum cavity are only partially smooth, larger or smaller blind sack-like enlargements or niches occurring disseminated to a considerable extent throughout: in the entire anterior, inferior, and posterior walls, and also on the medial wall below and posterior to the promontory, and in the roof of the attic.

Antrum mastoideum.—The antrum mastoideum is a bean shaped cavity, with a sharply convex medial and a less arched lateral wall, situated in the mastoid process, and communicating through the posterior wall of the atticus, with the attico-tympanic cavity. The roof of the antrum is formed by the tegmen tympani, a direct continuation of the roof of the atticus and anterior part of the tympanum; there exists therefore here no sharp dividing line between it and the tympanum. The lower wall or floor of the antrum, on the contrary, bends sharply around at a right angle to the posterior wall of the tympanum, and runs backward and

downward into the process. This angular bend corresponds to the place of union of the short process of the incus with the tympanic wall, and is about 9 Mm. above the floor of the tympanum. The lumen of the antrum, near its exit into the atticus, is greatly reduced infero-medially by the projecting in of the bony tuberosity formed by the horizontal-semicircular, and facial canals, (Plate II, Fig. X) and in this way is produced what may be called the threshold of neck of the antrum.

The average length of the antrum, measured from the middle of the threshold backward in a sagital direction, amounts to 12 Mm.; the height from the middle of the upper wall vertically downward, to 6.10 Mm., and the breadth or distance between its two chief walls (lateral medial) corresponding to the middle of upper wall, to about 6.50 Mm. The medial wall corresponds to the base of the petrous portion.

The bounding surfaces are not smooth, but every-where broken through by the sieve-like openings of the mastoid cells.

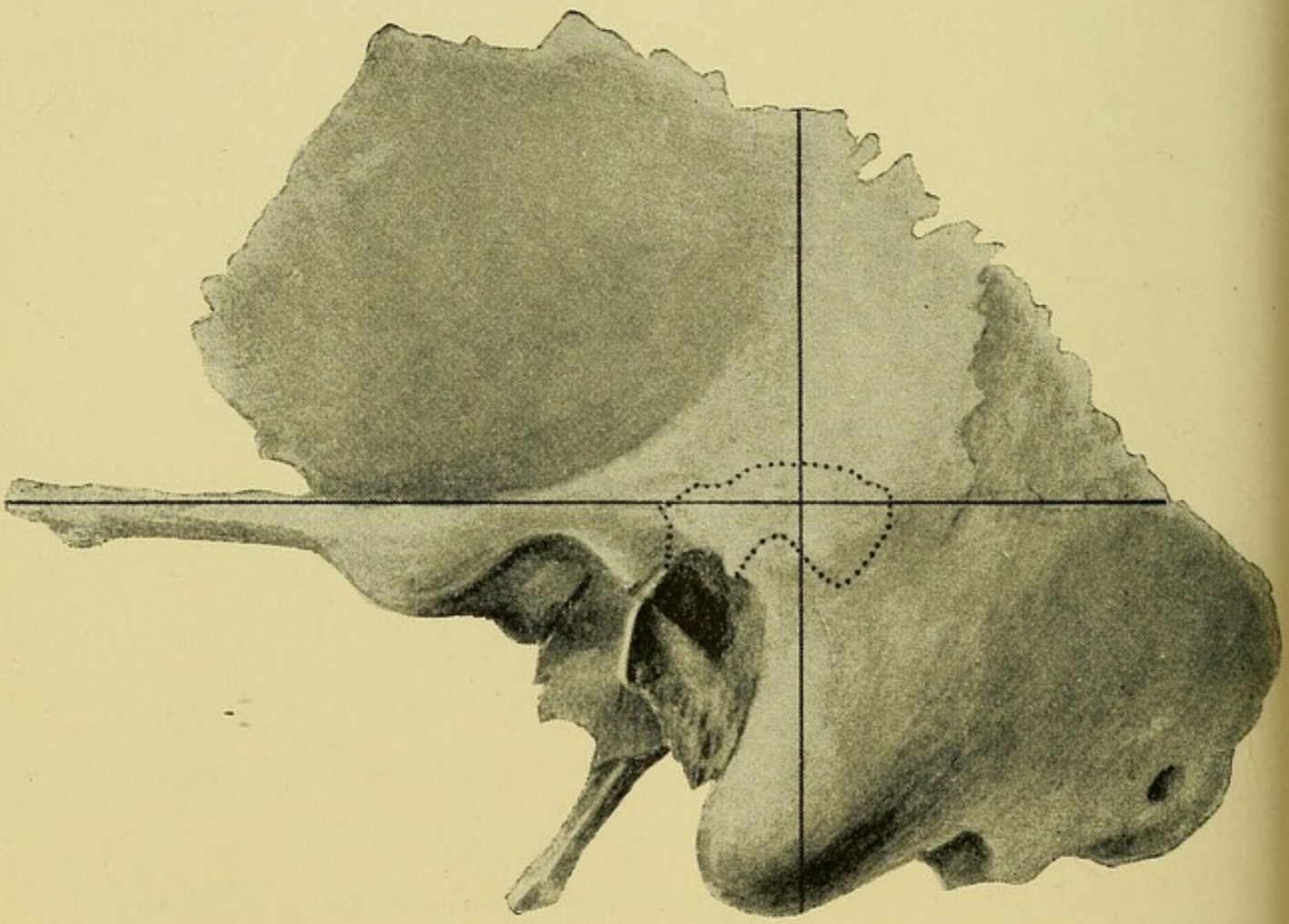

PLATE I.

Horizontal and vertical section lines. Dotted line indicates the boundary of the attic-antrum cavity.

PLATE II.

View of the cut surfaces formed by the vertical section. Black line indicates horizontal sectional plane.

A—Antrum.
B—Horizontal semicircular canal.
C—Superior semicircular canal.
D—Vestibule.
E, Fig. 2—Inferior semicircular canal.
F—Facial canal.
G—External meatus.
L—Internal meatus.
V—Spina.

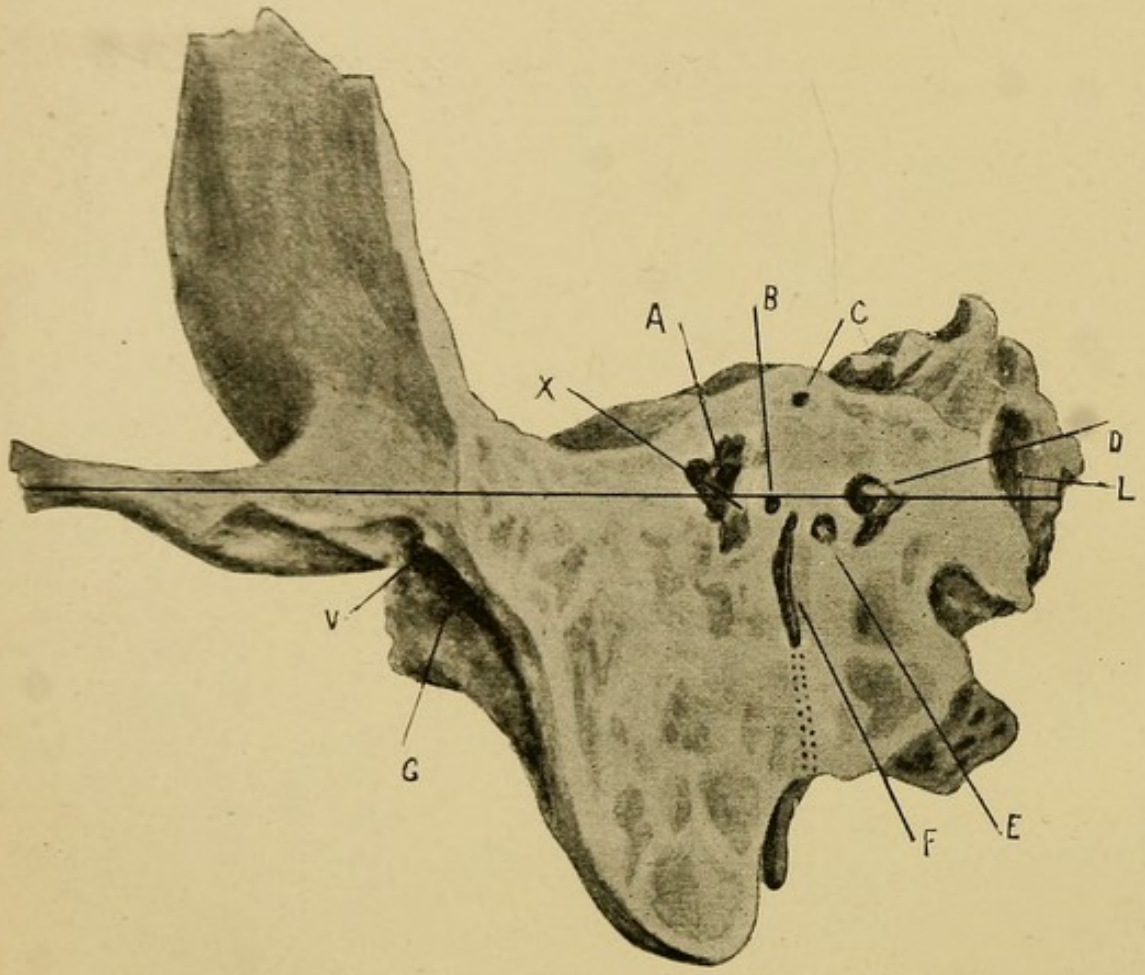

FIG. 1.

PLATE II.

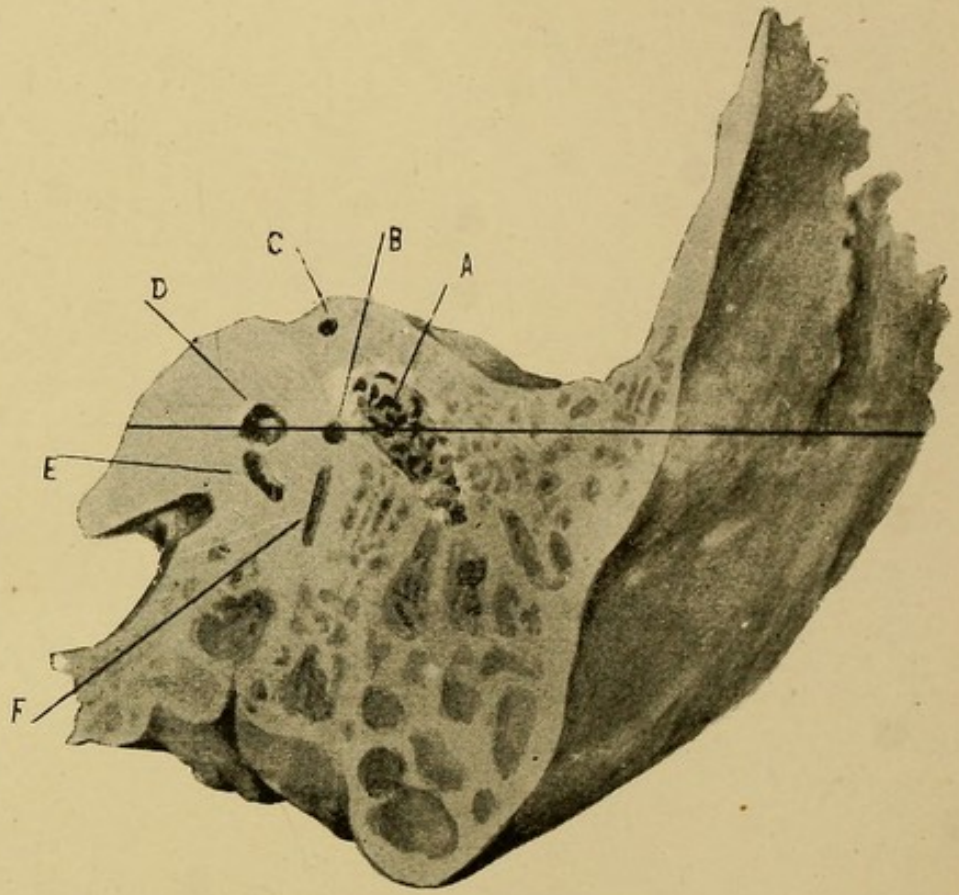

FIG. 2.

The best idea of the position and form of the antrum mastoideum, and of the two bugbears of the operation, the facial and horizontal semicircular canals, can be obtained on dividing the bone into four parts by means of vertical and horizontal sectional planes passed tangent to the posterior and superior walls of the meatus respectively. The position of these planes is shown by the vertical and horizontal lines in Plate I.*

The vertical sectional plane is to pass directly inward, and leaves the pyramid just tangent to the posterior wall of the internal meatus, and, if prolonged, should join with a similar plane from the other temporal bone. Plate II shows the surface thus formed, with the internal meatus (L) left entire on the anterior segment.

The sections from which the drawings were made were cut while the bone was in its position in the skull, and the horizontal and vertical planes are as nearly accurate as it was possible to make them. A line passing just posterior to the meatus and cutting the top of the skull about half an inch anterior to the coronal suture was adopted as vertical.

The horizontal plane cuts through the inferior wall of the internal meatus, opening up this canal. Plate III shows the surfaces formed, the internal meatus (L), owing to the position of the section, showing exclusively in the upper segment.

Sections made in this manner divide the bone into four segments. The lower anterior segment contains the external meatus with its superior and posterior walls cut close to the lumen, thereby disclosing the structure of these most important parts, overlaid as they are by air cells in communication with the attic and cellulae mastoideæ. (These air cells are simply indicated in the plates.)

As regards the facial and horizontal semicircular canals, we find the facial, in its vertical portion, opened by the vertical section (Plate II, Fig. 1, F), while the horizontal semicircular is divided by the horizontal section (Plate III, Fig. 2, B).

The facial nerve entering the internal meatus with the auditory, leaves through an opening at the upper anterior margin of the fundus of that canal, and, therefore, 3 or 4 Mm. above our

PLATE III.

View of the cut surfaces formed by the horizontal section. Black line indicates vertical sectional plane.

FIG. 1.

A—Antrum.
F—Horizontal semicirc. canal.
S—Roof of attic.
B—Vestibule.
K—Cochlēa.
L—Internal meatus.
U—Eustachian canal.
H—Carotid canal.
N—Glenoid fossa.

FIG. 2.

A, K, U, H, N—Same as in Fig. 1.
F—Facial canal.
X—Tuberosity formed by facial and horizontal semicircular canals.
G—External meatus.
V—Spina.

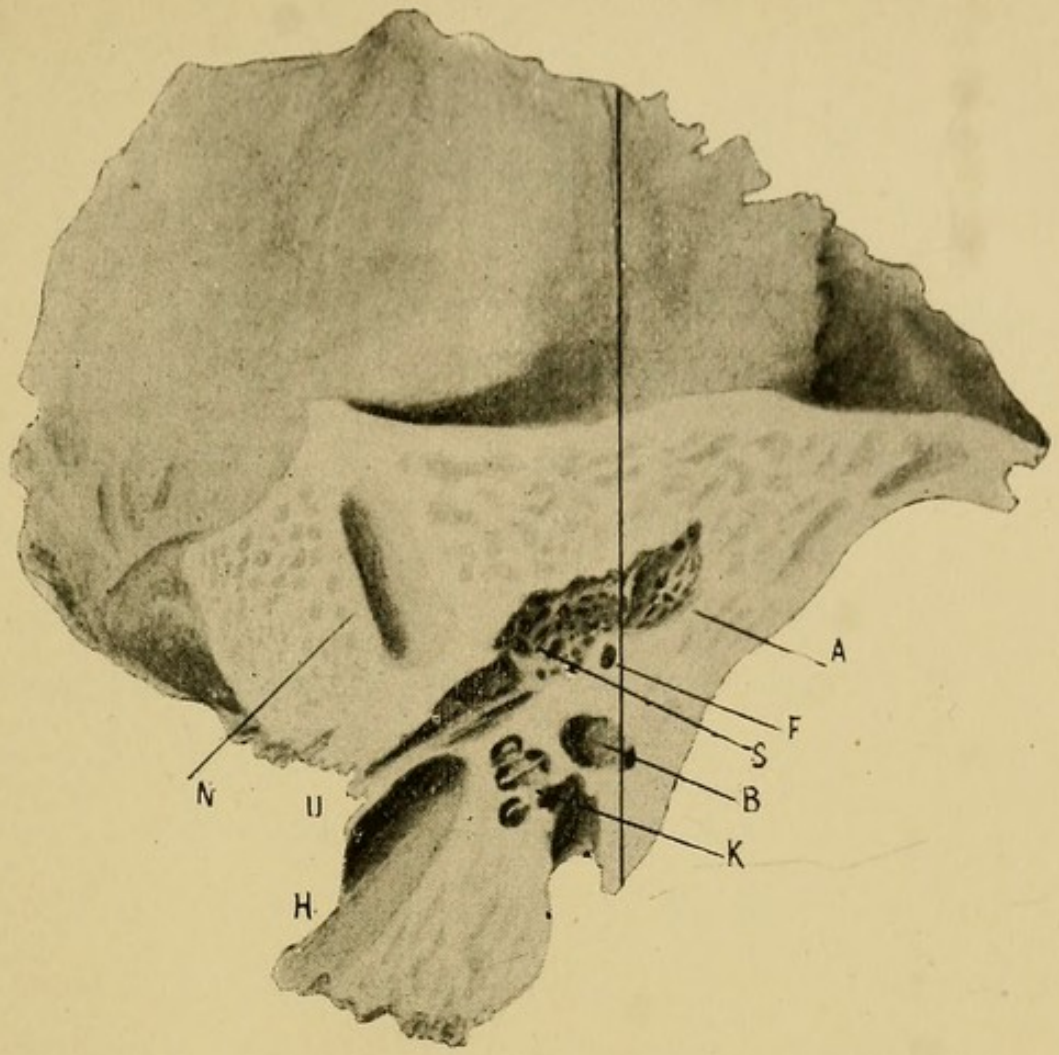

FIG. 1.

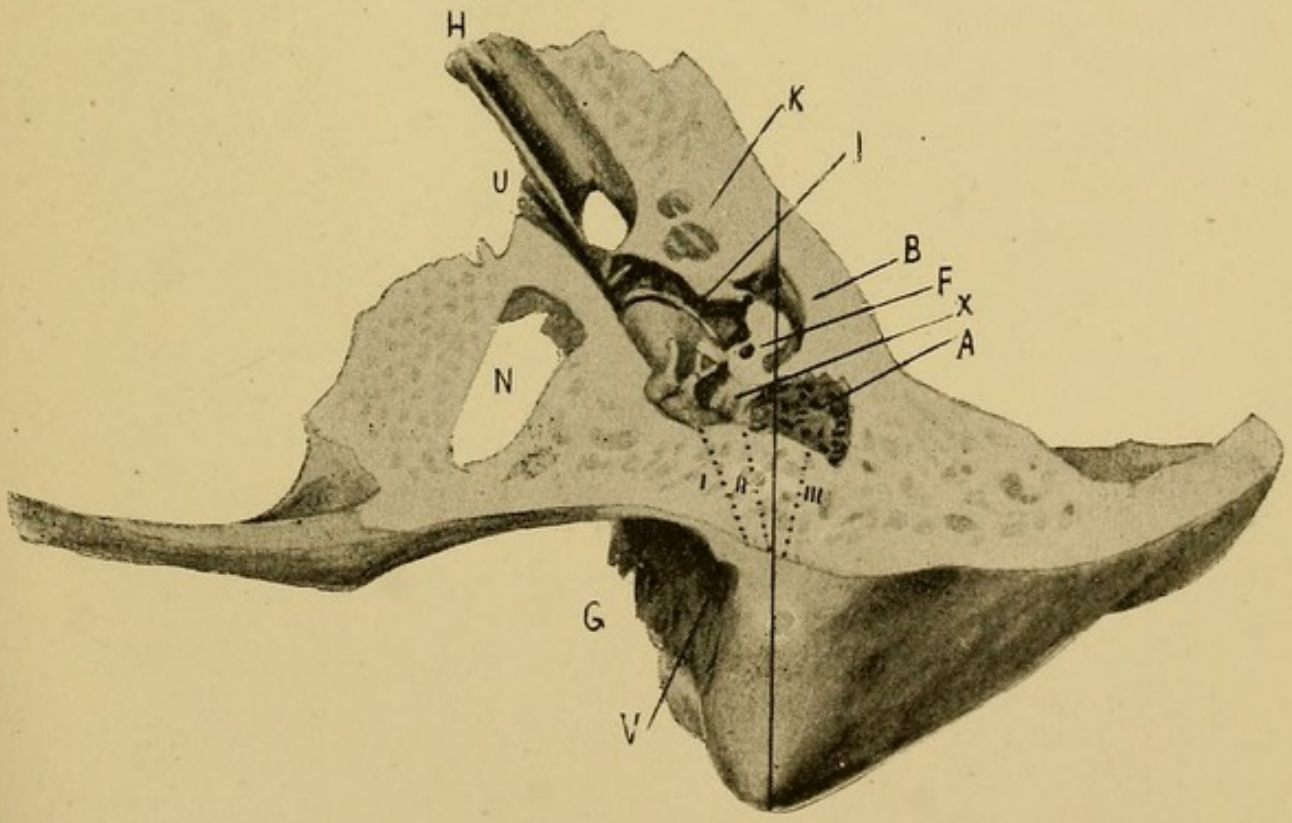

FIG. 2.

PLATE III.

horizontal sectional plane. The nerve in its bony canal passes forward and somewhat lateralward, keeping the same elevation, to the hiatus fallopii, where it makes a sharp right angular bend and passes backward and outward, at the same time curving gradually downward to make its exit at the stylo-mastoid foramen. It skirts along the upper edge of the internal wall of the tympanum and over the fenestra ovalis, forming a ridge which serves as the dividing line between that cavity and the attic. At the hiatus fallopii the canal is 3 or 4 Mm. above our horizontal plane, but curving gradually down as it passes back, it has, after passing over the fenestra ovalis, [a couple of Mm. anterior to the line of our vertical plane (Plate III, Fig. 2, F)], reached this horizonal plane; and, continuing in its course, passes under the antero-lateral portion of the horizontal semicircular canal, and soon reaches our vertical plane and is opened by it. (Plate II, Fig. 1, F.) It then passes downward, still curving slightly forward, and makes its exit at the stylo-mastoid foramen.

The only part of the facial canal which lies as

far lateral as the most lateral portion of the horizontal semicircular canal is that opened by our vertical section.

The horizontal semicircular canal curves round in a semi-circle from its posterior opening into the vestibule, to enter that cavity again near the ampulle opening of the superior semicircular canal. In its course it does not adhere strictly to the horizontal plane and is therefore but partially opened by our horizontal section (Plate II, Fig. 2, B); the remaining portion, being above this plane, is in the upper segment (Plate III, Fig. 1, F).

Plate II, Fig. 1, X, shows plainly the tuberosity formed by the horizontal-semicircular and facial canals, and if we conceive a vertical plane passed tangent to the tuberosity, the facial canal in its entire course will be medial to this plane; a point which is of the greatest importance to us as operators, and which will be brought out later.

On examination of Plates II and III, it will become evident that the horizontal semicircular canal can not be opened without first passing

through the antrum cavity, while the facial canal is vulnerable if our chisel penetrates below the floor of the neck of the antrum farther medialward than the lateral surface of the tuberosity. (Plate II, Fig. X.) If we keep somewhat posterior to our vertical plane, no matter to what depth we penetrate we can not enter the facial canal, as it lies almost entirely in the anterior segment. (Plate II, Fig. 1, F.)

CHAPTER III.

PATHOLOGICAL.

The tympanum, antrum mastoideum, and the pneumatic cells in communication with these cavities, are lined by an excessively thin and closely adherent mucous membrane. The cavities themselves are rough, uneven, and provided with numerous recesses.

The close periosteal connection between the mucous membrane and the bone, and the unevenness of the surface, favoring the retention of the products of suppuration, explain the frequent occurrence of caries and necrosis in suppurative diseases of the aural mucous membrane.

Ulcerative processes, both in acute and chronic otorrhea, frequently take place in the mucous membrane, baring the bone and giving rise to a superficial necrosis, which, as Meyer of Copenhagen (Archives für Ohrenheilkunde, Bd. 21) has pointed

out, is the great cause of the stubbornness of chronic suppurations. Small masses of granulations, in cases of long standing purulent catarrh, are frequently seen springing from the labyrinth wall. These granulations surround small necrotic fragments, hem them in and prevent the desired and necessary exfoliation. Caries here is also favored by the nature and distribution of the blood-vessels, the fine branches of which do not anastomise, but belong to the system of end arteries. The caries is generally quite superficial, as the thin bony wall receives its nutrition from both sides, although it may extend to nearly the entire petrous portion.

The processus mastoides, owing to its cancellous structure and to the facilities it affords for the stagnation and decomposition of pus, is the portion of the temporal bone most frequently affected by caries. The carious process may be limited to the pneumatic cells, the cortical layer remaining intact, and an osseous cavity filled with granulations, decomposing pus and necrotic fragments produced; or, what is much more frequently the case, the

cortical layer participates in the caries, forming an outlet for the pus, either externally toward the surface or internally toward the meninges. The most usual place of exit externally is through the outer surface of the mastoid, either at its base, through the flat area of bone posterior to the spina, or toward the tip; it may, however, escape downward and inward into the incisura mastoidea (so-called Bezold variety of mastoiditis) and sink down between the deep muscles of the neck, causing a dangerous and most unpleasant complication; or it may appear above or on a level with the linea temporalis through a patulous fissura squamosa-mastoidea.

As may be seen by examining the lower anterior segment (as represented in Plates II and III), the upper and posterior walls of the meatus are largely made up of pneumatic cells, with but a thin cortical layer toward the meatus. This portion of the mastoid cortex can be and frequently is broken through and a sub-periosteal abscess produced in the meatus. The characteristic sinking in of the posterior and superior wall, so often observed in cases

of acute mastoid disease, is brought about in precisely the same way as the swelling, redness, and œdema we find over the external surface of the process: the pus has either broken through the cortex and formed a periosteal abscess, or the proximity of the purulent focus has induced a periostitis. In the early days of the mastoid operation, when the sound was the favorite instrument, fistulous passages leading from the surface into the meatus were frequently discovered, showing that the caries had attacked the cortical layer of the meatus, as well as that on the external surface of the process.

On the labyrinth wall the caries may affect the facial canal, causing secondary inflammation and paralysis; or it may allow the pus to escape into the spaces of the labyrinth, and from thence to the meninges. The lower and forward walls of the tympanic cavity very seldom become carious.

Chronic carious processes very often take place in the air cells above and behind the more medial portions of the superior and posterior walls of the

meatus, causing perforation of the cortex, and allowing the granulations around the diseased bone above to grow through the fistulous canals into the meatus. The presence of such granulations—and they are to be recognized in a large proportion of the cases—is a very important diagnostic sign of caries, and they should always be carefully sought for. The diagnosis can be confirmed by passing a sound through the wall of the meatus, along side of the granulations. Very superficial caries often takes place at the line of insertion of the upper-posterior margin of the drum, which then becomes detached and drawn inward, forming an opening through which a sound may be passed toward the antrum. This condition must not be confounded with a carious perforation. Granulations on the superior-posterior wall of the meatus, lateral to the tympanic margin, signifying, as they do, caries of the parts above, the simple cutting off of such granulations at their place of exit can possess but very limited therapeutic value. Rational therapeutics calls for the removal of this wall together with the diseased cells above.

Caries may also produce fistulous canals, radiating out in almost any direction from the tympanum; over the fenestra ovalis into the labyrinth; under the labyrinth toward the carotid canal or even into it; downward and backward into the region of the jugular fossa; or downward through the posterior wall of the tympanum to near the stylo-mastoid foramen.

Caries of the ossicles, especially of the malleus and incus, is of frequent occurrence, but does not concern us here.

Necrosis of the temporal bone is much less frequent than caries. It occurs most often and extends most rapidly in children, following the exanthematous diseases, especially scarlatina. We may have a superficial necrosis in the tympanum, affecting the outer layer of the labyrinth wall, or various sized portions of the cortex of the mastoid, either externally or toward the meatus, become necrotic. In extensive and deeply penetrating processes, the necrosis attacks large sections of the bone; the entire processus mastoides, with the neighboring portion

of the meatus, the annulus tympanicus, the promontory wall with the fenestra ovalis, parts of the cochlea and semicircular canals; and even the entire labyrinth may be exfoliated. After such extensive exfoliation the dura mater becomes greatly thickened, thus protecting the brain, or the cavity fills up with granulations and bone-forming tissue. Loss of substance from the mastoid externally is generally replaced by a depressed cicatrix.

Carious and necrotic affections of the mastoid are generally secondary to purulent inflammations of the tympanum; but sometimes, especially in children after the exanthematous diseases, we have a purulent inflammation of the mastoid with caries and necrosis occurring simultaneously with the inflammation in the tympanic cavity, and due to the same exciting cause.

A primary periostitis of the mastoid process does occur, but is certainly very rare, and it must be borne in mind that a similar condition may be produced by the inflammation of the lymphatic glands over the process, or by a furuncle on the posterior wall of the meatus.

Long continued suppurative inflammation leads to hyperplastic growth in the periosteum and bone marrow; to hyperostosis and to the formation of exostoses. The cortex of the mastoid becomes greatly thickened and its substance sclerotic, so that the pneumatic cells with the exception of the antrum may entirely disappear. The antrum is probably always present even in the most sclerotic processes, although it may be reduced in size and altered in form.

Various authors have given very varying figures as to the depth to which it is allowable to penetrate in seeking to open the antrum. Schwartze speaks of having once reached the antrum at a depth of 2½ Ctm. Normally the antrum lies within 10 or 14 Mm. of the surface (Bezold gives 6 Mm. as the average depth), and a depth therefore of 2½ Ctm. would bring our canal far into the labyrinth. The discrepancy between the results of anatomical measurements and those of operators, is due to the hyperostotic thickening of the cortex, which so often occurs in pathological cases.

It is in cases of sclerosis and thickened cortex that the most difficulty is experienced in opening the antrum, and the foregoing considerations show the comparatively slight aid we can expect from measurements on anatomical preparations. The only really valuable measurement is that from the spina to the posterior-superior margin of the drum, taken as explained in the chapter on anatomy (p. 34).

Exostoses occur most often on the promontory, reducing the size of the tympanum, or about the fenestra rotundum, narrowing this orifice. Exostotic obliteration of the communication between the antrum and tympanum may take place, and in such cases the opening of the antrum fails to establish a connecting passage with the middle ear.

Tuberculosis.—That some of the cases of otorrhœa and caries are due to tuberculosis, has been proven by the finding of bacilli in the secretion. The process begins in the mucous membrane, the bacilli gaining entrance through the Eustachian tube. The resulting inflammation may vary from a diffuse infiltration to a purulent destruction with caries and

necrosis. Whether there exists a primary tuberculosis of the aural mucous membrane has not been determined.

The mucous membrane of the tympanum and antrum, in many cases of otorrhœa, becomes greatly thickened and swollen, the antrum being often filled up with succulent, infiltrated tissue, the stapes entirely imbedded, and the orifice of the Eustachian tube obliterated. This thickening of the mucous membrane is due to augmentation of its connective tissue, and to an increase in the number and size of its vessels. Owing to this condition the stapes is much less liable to dislocation during the operation than would otherwise be the case.

Bands of newly-formed connective tissue often spring across the tympanum, or extend from the ossicles to the walls, sometimes producing completely isolated spaces. The recessus epitympanicus (attic) is very frequently shut off from the rest of the tympanic cavity by the retraction of the malleus and upper segment of the drum, and the connective tissue union between them and the labyrinth wall;

so that suppuration may continue in such inaccessible spaces when brought to a stand still in the other parts. Again the rational therapeutics is suggested, namely, in the conversion of the attic, tympanum, and meatus, or of the attic, tympanum, antrum, and meatus, into one accessible cavity.

Cholesteatoma.—Upon opening the processus mastoides in cases of long-standing otorrhœa we frequently come upon a cavity filled with a peculiar, compact, shining mass. The cavity itself has smooth, dense walls, and may be the size of the normal antrum, or may take up almost the whole of the mastoid process. What are these shining masses, to what do they owe their origin, and what importance have they in diseases of the ear? They have been called cholesteatoma, on account of their similarity with the cholesteatomatous tumors occurring on other bones of the skull (occipital, frontal), or growing from the cerebral membranes. They consist of large epithelial cells, with no visible nucleus, massed together concentrically like the scales of an onion, and with

small collections of cholesterine crystals between the layers. The nature of the cells and their compact arrangement give to the tumors a peculiar mother-of-pearl like glitter, which when once seen can always be readily recognized. Around the masses there is generally a certain amount of suppuration going on, and sometimes they are found broken down and the cavity filled with caseous detritus.

Cholesteatoma occur in the antrum, attic, tympanum, and even in the pneumatic cells off from these cavities. I call to mind a case in Prof. Schwartze's clinic where there was a carious perforation of the posterior wall of the meatus quite a little way from the drum. The operation, which was undertaken to benefit the chronic suppuration, disclosed a cavity (not the antrum) in the mastoid cells opposite the perforation, filled with cholesteatomatous masses.

Considerable diversity of opinion existed up to a few years ago concerning the origin of aural cholesteatoma. Having been found within the tym-

panum in cases of non-perforated drum membrane, and where all signs of inflammation were absent, they were looked upon as heterogeneous epithelial tumors, and considered independent of inflammatory conditions. This is the view advocated by Virchow.

Lucæ, in 1873, published an article in the Archives für Ohrenheilkunde, in which he states the following concerning their production: The mucous membrane over the granulations so frequently arising in chronic otorrhœa becomes altered in character, loses its mucous membrane appearance, and becomes converted into a sort of epidermis. A Malpigian layer is formed and from it, as in the external skin, epithelial cells are produced, shed off, and, owing to the anatomical conformations present, being unable to escape, they collect in these concentrically arranged masses.

Wendt, writing in 1874, stated that the mucous membrane underwent what he called a desquammative inflammation, owing to the irritation produced by the stagnant and decomposing pus. Von Trölsch's idea was that the pus and external influ-

ences brought to bear on the mucous membrane irritated the latter and caused the change from mucous membrane to epidermis, just as all mucous membranes, when exposed to external influences, take on an epidermic character.

Habermann of Prague, in a case of cholesteatoma of the antrum, found that he could trace a strand of epithelium growing in from the meatus through the perforation in the drum, and his view is, that in chronic cases with destroyed or perforated drum, the epidermis grows inward across the tympanic margin, and under irritating influences takes on a proliferating inflammation; the epidermic cells thus produced are piled up into the characteristic masses.

Bezold (Archives für Ohrenheilk., Bd. XXIX), and Steinbrügge (Orth's Pathology) confirm the view of Habermann, as does also Wagenhaüser in his article in Ziegler's Lehrbuch der Pathologie. On the other hand, Kuhn of Strassburg, in a paper read before the Natural History Association at Wiesbaden in September, 1887, expressed it as his opinion that cholesteatoma might after all be real tumors

in accordance with the idea of Virchow and other pathologists. He reported cases in which large cholesteatoma were found, where the suppuration was acute, had lasted scarcely fourteen days, and where, owing to the short duration, the ingrowing of epithelium and the accumulation of desquammated cells could almost certainly be ruled out.

Now, although these cases, and still less those where the masses have been found in the tympanum with unperforated drum, can not be explained by the Habermann theory, still his view must, in the vast majority of cases, be accepted as the correct one, as cholesteatoma are, in the greater number of instances, simply mechanical collections of desquammated epidermic cells.

The question arises as to what difference it makes whether we regard cholesteatoma as simple tumors or as the accumulated desquammated products of abnormally placed epithelium. Practically it is of the greatest importance to us to settle this point, and for the following reasons: If we regard them as tumors, therapeutically their removal is all

that is necessary; while if we look upon them as arising from epithelium in the drum cavity, antrum, or attic, the removal of the mass can have no permanent curative effect; as, the epithelium continuing to desquammate, the cells may collect over again, and the treatment simply relieves the threatening symptoms temporarily. Accepting the Habermann theory, the masses must not only be removed, but every recess and hidden cavity where they can re-accumulate must be laid open, brought plainly into view, and kept so as long as the patient lives.

The antrum, the cavity in which shed-off epithelial cells are most easily retained, forms the most frequent place of lodgment for cholesteatoma. They may also occur in the attic, when that division of the middle ear is shut off from the rest of the tympanum, and even in the tympanum itself in neglected cases.

If cholesteatoma are allowed to remain, their enlargement causes a pressure atrophy of the surrounding bone, with the gradual enlargement of the cavity, till it finally opens into the lateral sinus or

meninges, or the bony wall becomes so thin as to allow the transmission of the inflection inward. Generally in connection with cholesteatoma there is a condensing ostitis, the pneumatic and diploetic spaces in and around the processus mastoides becoming entirely obliterated, and replaced by dense eburnated bone. Irrigation in chronic cases frequently brings away small pieces of these masses when they themselves are entirely invisible, and consequently the wash water should always be examined carefully for these white epidermic fragments, which, if found, are a certain diagnostic sign of cholesteatoma.

Sinus thrombosis, cerebral abscess, and meningitis, as complications of middle ear suppurations, may be brought about in the following manner: (1) The suppuration may be communicated directly to the brain or sinus, or indirectly through the labyrinth, by carious ulceration or necrotic destruction. (2) No caries may be present, the septic matter being conducted by the vessels running between the middle ear and the cerebral fossæ.

(Phlebitis of diploetic veins.) Hence the importance of early removal of pus, as even before caries and necrosis have taken place, there is danger of cerebral complications. (3) The pus may find its exit, especially in children, through the still unclosed sutures and fissures. (4) By pressure atrophy due to the growth of cholesteatoma.

The following histories and descriptions of pathological conditions will serve to illustrate the course which otorrhœa sometimes runs.

Case I.—Concerns an eleven year old boy. Trouble began as an acute middle ear catarrh with intense pain and increase of temperature. On the fourth day occurred spontaneous rupture of the drum, when the examination showed the meatus full of muco-purulent secretion, and a circular perforation about the middle of the membrane. The pain had completely subsided. Twelve days later the perforation was found closed, and the drum bulged out at this point, and for the first time the patient complained of pain in the mastoid process, which outwardly appeared healthy, but which was quite

sensitive to deep pressure. Paracentesis was made and the mastoid painted with iodine. In spite of the copious exit of pus from the tympanum, the mastoid sensibility increased and the swelling became red and œdematous. Painfulness with slight infiltration manifested itself at the angle of the jaw. Fever began, reaching in the evening sometimes as high as 104°. Patient restless at night, sleeping during the day, and complaining but little. Antiphlogistic treatment. A little over a month from the beginning of the treatment a periosteal incision was made, and a very little pus evacuated, the bone being intact and apparently healthy. After the incision the temperature fell, and the subjective symptoms became better. In a day or two, however, the old conditions returned. Brain symptoms became more prominent, and the patient died about two months from the beginning of the trouble. *Post-mortem*—Bone over mastoid unaltered. Dura mater free and presenting no abnormalities whatever, the bone every-where intact. The sinus transversus filled by a thrombus, broken down in the

center. The same condition in the sinus petrosus inferior. The beginning of the vena jugularis filled by a hard, yellow, fibrous mass. In the meatus dried secretion and masses of epidermis. Drum cavity and antrum filled by a brownish-yellow, clear fluid of gelatinous consistency. The mucous membrane thickened, infiltrated, and of a grayish-red color

The process had evidently been limited to the mucous membrane, the bone being found entirely intact, and the septic matter conducted to the sinus through the veins. (Wagenhäuser.)

Case II.—Man; 49 years old. Discharge for eight days from the left ear. Examination showed patient nearly completely deaf; meatus and tympanum filled with fœtid pus; double perforation of the drum. Three weeks after the first examination patient complained of dizziness and stiffness of the neck, and one month from the commencement of the trouble death occurred. *Post-mortem*—Meningitis. Auditory and facial nerves imbedded in exudation. Tuberculosis of the lungs. *Temporal bone*—

Perforations in drum. Tympanum filled with fœtid pus. Mucous membrane swollen and rough. In the region of the fenestra ovalis a carious opening into the vestibule. Stapes easily movable. Antrum containing pus. Canalis semicircularis superior filled with a bloody fluid. At the porus acusticus internus a coating of pus on the dura. This case shows the extension of the purulent processes from the tympanum to the labyrinth and thence to the brain.

The following post-mortem description illustrates carious perforation of the tegmen tympani: Soft parts over and behind the ear greatly thickened. Upon the mastoid a 10 Mm. in diameter subperiosteal abscess, the bared bone discolored. Meatus full of thick pus. Epidermic covering of the upper posterior wall of the meatus much thickened. Drum intact. The tegmen tympani over the antrum shows an irregularly round, jagged opening, the pus lying here directly under the dura. (Von Tröltsch.)

CHAPTER IV.

THE OPERATION.

Proper antiseptic methods of operating are of the greatest importance in the mastoid as in other operations, and therefore a short account of the method adopted in the clinic of Professor Schwartze, as modeled upon that of Professor von Bergmann in Berlin, will here be introduced.

The instruments are sterilized just before use by boiling them for five minutes in a one per cent. caustic soda solution. The alkali owing to its penetrating power increases the germicidal effect of the water and prevents the rusting of the instruments. This sterilization can be accomplished in any vessel in which water can be boiled, and the instruments lowered in easily constructed wire baskets. In Halle a specially constructed apparatus is used. The instruments are to be arranged for use in a large shallow glass dish, which has been carefully cleansed

and rinsed with sublimate solution. The alkaline solution in which they have been boiled is poured over them, and the whole transferred to the operating room.

Both during the operation and after treatment quantities of sterilized cotton and gauze are required. In the Halle clinic a steam sterilizer similar to that used by von Bergmann, is employed. Every afternoon a sufficient amount of gauze and cotton for the operations and treatment of the following day is prepared. The gauze and cotton are steamed for one-half an hour in the sterilizer in tin cases, which can be tightly closed on removal from the apparatus. The gauze, cut up into proper sizes prior to the sterilization, replaces entirely the sponge during the operation, and is the chief component of the dressing applied.

The operator must now seek to put himself in as asceptic a condition as possible. His coat should be removed and his hands and arms, bared to above the elbow, carefully washed and brushed in hot water, with the free use of soap. The brushes must

be clean, that is, after use carefully washed, and kept in sublimate solution continuously at the wash stand. The hands and arms are dried, washed with alcohol, and then submerged for several minutes in sublimate solution. The operator then draws on a freshly washed (boiled) linen coat, reaching to his ankles, and buttoning tightly up around the neck, and is ready to proceed. The assistants must of course sterilize themselves in the same manner. The patient is to be bathed before the operation, especial attention being paid to the thorough cleansing of the head and neck, and dressed in freshly washed linen. All the sheeting, etc., on the table must also have been freshly washed. The patient being on the table, the whole ear, mastoid region, neck, and side of the head should be soaped and brushed, and the hair within a radius of three or four inches from the ear carefully shaved. The parts are rinsed with water and then washed with ether, followed by one to one thousand sublimate solution. Clean towels are placed, one at the lower limit of the field of operation, and the other so as to cover the upper

part of the head and keep the hair from falling upon the operative surface.

Instruments required.—The following instruments should be sterilized and ready for use:—

Scalpels for incising the soft parts; a number of artery forceps; a periosteum scraper; two four-pronged wound retractors, also a single-pronged blunt retractor for holding forward the back wall of the membranous meatus; five gouges in sizes varying from three to ten Mm. in breadth, with a mallet; straight smooth and hooked forceps, for removing broken off pieces of bone; a couple of bent forceps; several flexible probes; sharp spoons of various sizes; a bone-cutting forceps; and, lastly, an ear speculum and a Wilde's snare. The speculum is necessary as it is always advisable to examine the patient thoroughly under the anæsthetic, before proceeding with the operation. It is also well to have a tenotome and paracentesis needle in readiness.

In giving this list of instruments I have made no mention of trephines or drills, because I believe they should be completely abolished from the instru-

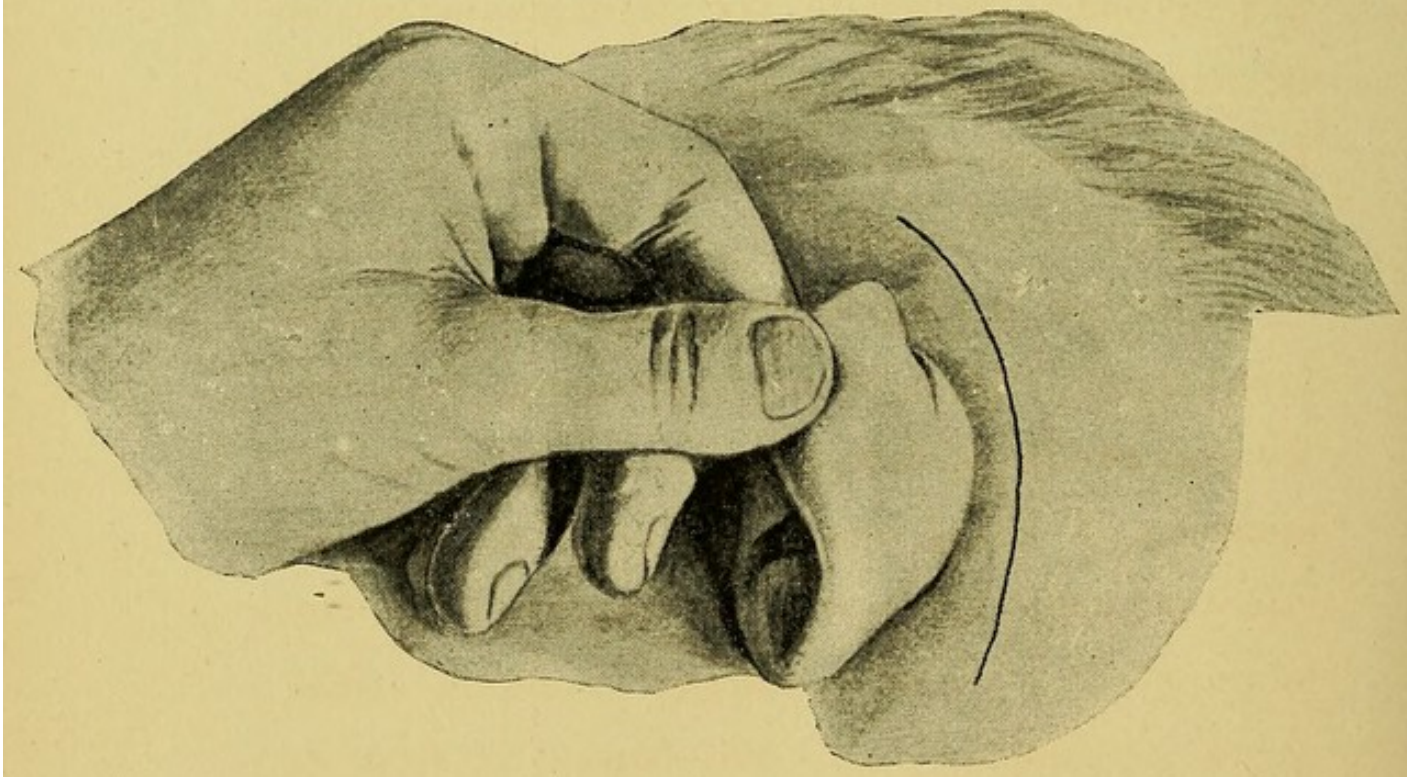

PLATE IV.

Showing the position of the cutaneous incision.

mentarium required for this operation. If we desire simply to remove a button of bone from the cortex of the mastoid in order to puncture an abscess in the cells, why a trephine or drill may do excellent service; but if we are to operate in the manner to be now described, the chisel or gouge is the only instrument with which we can work with both safety and thoroughness.

In describing the operative procedures to follow it will be well to consider first what may be called the typical mastoid operation, that is, the method of operating in laying open the antrum and thereby establishing free communication with the middle ear, in those cases where no carious condition of the cortex or fistulous canals are present to serve as guides. The incision of the soft parts should be made beginning from three-eighths to one-half an inch above the upper insertion of the auricle, and carried, in a curve parallel to and about one-quarter of an inch posterior to its line of insertion, down to the tip of the mastoid process. (Line of incision shown in Plate IV.) If possible, cut at once down

to the bone and make the entire incision with one sweep of the knife. An incision made in this manner gives free and easy access to all the landmarks mentioned in the chapter on anatomy (spina, linea temporalis, superior and posterior margins of the external meatus), and allows the operation to be made as safely and surely as if we had a denuded temporal bone before us. The soft parts with the periosteum having been divided, all bleeding vessels should be ligated, and the field made as bloodless as possible. Where the parts are much thickened and infiltrated it is often impossible to prevent a certain amount of oozing, but with proper care this can always be reduced to a minimum.

With the wound fairly dry, we proceed to lay bare the bone. The parts are pushed forward and backward with a periosteum scraper till at least the anterior half of the mastoid, the posterior wall of the meatus, with the spina supra meatum, and the linea temporalis are brought clearly into view. If the incision is made one-quarter of an inch posterior to the auricular insertion, it is often unnecessary to

disturb the posterior flap, sufficient room being obtained by pushing the parts anterior to the line of incision forward.

The extent to which this can be done and should be done is shown with partial correctness in Plate V. The drawing having been made from an anatomical preparation, the soft parts are somewhat out of position. The bone need not really be bared so extensively posteriorly as is shown in the plate.

With an incision of the length recommended, no matter how infiltrated the parts are, it is always easy to expose a sufficient amount of the bone. *No chiseling should be begun till the spina and linea temporalis are plainly in view, or in case the spina is absent, the posterior and superior margins of the meatus.* By so doing we are always sure of our position and can work with as much certainty as on an anatomical preparation.

This extensive baring of the bone under proper asepsis has no deleterious effect. I have never seen a necrosis to follow except once, in Professor Schwartze's clinic, where, in a poorly nourished

individual the fibers of the temporal muscle were extensively severed. Here followed a sloughing of a part of the superficial layer of the squamous portion. It is however seldom necessary to cut the temporal muscle or the fascia overlying it, as the auricle can generally be pushed forward far enough without this. It also never does to make the incision in the line of insertion of the auricle, or nearer than one-quarter of an inch, as this renders the subsequent suturing of the wound (as is done in the modified Stacke operation) more difficult, and seems to cause the ear to stand out to a more disfiguring extent afterward.

We are now ready to work on the bone, and, if there were no intimidating formations such as a forward lying sinus or a deep-seated middle cerebral fossa, it would be very simple to chisel into the antrum. We would have simply to conceive the position of our two planes (Plate I), and, chiseling directly inward along their line of intersection, or better, somewhat posterior and parallel to that line, we would arrive at the antrum, penetrating its lateral

wall at about the center. This is made plain by Plate I, where the position of the antrum is outlined by the dotted lines. In order, however, to avoid a low fossa we must sink our opening as low as possible, and to avoid a forward lying sinus as far forward as possible; and we therefore can not act as we would if we knew the sinus and fossa to be sufficiently removed to be out of danger, but must proceed cautiously, always expecting and looking out for them.

The safest plan is as follows: With the largest gouge an oval area of bone, twelve to fourteen Mm. in length and eight to ten Mm. in width, is marked out, with its upper margin corresponding to the linea temporalis, and with the spina at about the middle and just anterior to its anterior border. The opening is to be started as near the spina as possible without endangering it during the subsequent chiseling. In this way we conform to the rule which requires our canal to be placed as far forward as possible. When the spina is absent it is always easy to locate its position if we remember that it is

situated at the porus acusticus, two or three Mm. from and about bisecting the angle formed by the intersection of our horizontal and vertical sectional lines; that is, at the junction of the posterior and superior walls of the meatus.

We have now to sink a conical canal into the antrum with the marked out area as its base. In order to avoid the lateral sinus we instinctively keep as near to the posterior wall of the meatus as possible, and sink our canal, using successively smaller gouges as we proceed, inward and slightly forward. The bone must be sprung off in thin layers and the gouge never allowed to work backward. In this way, if the sinus is opened, the bone is simply peeled from it, and its injury is practically impossible. The baring of the sinus when uninjured has no deleterious effect.

The direction of our canal then, in a horizontal plane, being inward and slightly forward, parallel or nearly parallel to the posterior wall of the meatus (direction indicated by the dotted line II, Plate III, Fig. 2), we reach the antrum at its neck at the

point where the tuberosity formed by the facial and semicircular canals protrudes into that cavity. In the vertical plane the apex of the canal must be kept four or five Mm. above the level of the spina, in order to avoid passing below the floor of the neck of the antrum, and, continuing deeper, entering the facial canal. This is shown in Plate II, Fig. 1. The floor of the antrum (just lateral to and below X) being three or four Mm. higher than the spina (V). Theoretically it would be better if we made the opening farther back and reached the antrum along the line III (Plate III, Fig. 2); but in practice the liability of striking the sinus renders this unadvisable, and in nine cases out of ten the operator will find that he arrives at the antrum at its neck. The danger of opening the facial canal lies in the fact, that, in seeking to avoid the sinus and middle fossa, we sink our canal directly toward the nerve. In getting out of the way of the sinus we put our canal in the same vertical plane with the nerve (plane of the sections Plate II), and in

avoiding the middle fossa go so low that we miss the neck of the antrum by passing under it, and if we chisel still deeper, we must of necessity strike the nerve. The point to be observed is, to keep the apex of our canal always well above the level of the spina.

As soon as a cavity, presumably the antrum, is reached, we must insert a bent probe and endeavor to pass it forward and downward into the tympanum, the ability to do which proves the cavity to be in fact the antrum.

It is plain sailing after we have obtained an opening no matter how small, for with a bent sound the lateral walls can be demonstrated and safely chiseled away.

The operator should never be content with a small narrow opening, but ought always to enlarge the canal and endeavor to make the communication as free as possible. A small narrow opening is a constant plague to both patient and physician. Such a canal becomes so easily obstructed by granulations that the irrigation necessary in the

after treatment can not be properly performed, small sequesters or splinters of bone can not escape, and the cure is greatly prolonged; besides obliging the patient to undergo a painful probing and dilatation of the canal before the cleansing fluid can be forced through. This, in such cases, necessary forcible irrigation is contrary to modern surgical ideas, the forced injection of fluid simply driving the septic matter deeper into the tissues. The main thing is to have a perfectly free communication. In enlarging the canal, bone must never be removed without first demonstrating it to belong to the lateral wall of a cavity.

The question arises, supposing we chisel in as directed and strike no antrum, how deep is it permissible to penetrate? No answer suiting every case can be given, as there is no fixed depth to which it is allowable to go, the mastoid in disease being often thickened. If it were not for this pathological increase of the cortex we might give from ten to fourteen Mm. as the average depth of the lateral wall of the antrum, but this indeter-

minate thickening renders all measurements of little value. In acute cases of short duration the antrum will always be found at the depth given, but in old chronic cases no measurement can be considered accurate. What we can say is that we must never go deeper than the distance from the surface to the inner drum margin of the meatus, measured as we have stated (page 34), along the upper-posterior wall.

We often read of cases where, after penetrating to a great depth, no antrum was reached and the operation was abandoned. This at any rate need never happen. The rule should be adopted, that, after penetrating one and one-half Ctm. without striking a cavity, we direct our canal more forward so as to bring its apex over the meatus, when we can easily chisel into the attic, and working backward, guided by a sound, lay open the antrum. The direction our canal would then take is that of the dotted line I (Plate III, Fig. 2). If there is any difficulty in reaching the attic, the membranous meatus may be dislodged from the posterior wall

and pushed forward, or the entire cartilaginous meatus may be turned out, chiseling into the attic thereby becoming perfectly easy.

What has been said above may be taken to apply to the operation through a sclerotic mastoid. If the process is pneumatic the operation is much simpler and safer, the cells serving as guides. Working through such a process is always more comfortable than through a sclerotic one, because, after a careful sounding and probing, the walls of the cells can be safely cut away and the opening easily carried into the antrum.

The operator should make it a rule to precede every use of the gouge, after the cortex is removed, by a careful sounding and probing.

Now as regards opening the lateral sinus. If it is a fact that the sinus when lying far forward also lies near the surface (and I have never seen a case where this was not so), it will be laid bare early in the operation, that is, just after the cortical layer of bone has been removed. Therefore, after removing the cortex, we must always carefully sound posteri-

orly, when, if the process is cellular and we are convinced that the sinus does not lie in close approximation, we can direct our canal more backward, opening up the body of the antrum. In this case we also need not go so high, being required to keep our canal at only a slight elevation above the level of the spina.

Another advantage possessed by a pneumatic process is, that the sinus does not usually lie so far forward as in a sclerotic process; that is, the sinus, when cutting deep into the mastoid, takes the place of the cells, and the part must of necessity be solid, there being no room for cells. This of course does not hold good for a process rendered sclerotic by disease.

Plate V shows the opening made in the typical manner. The sound (S) shown in the plate passes into the neck of the antrum, and strikes against the tuberosity formed by the horizontal semicircular canal. In this preparation the sinus lay near the meatus and was laid bare in operating. The line (b) points to the uncovered sinus and shows the

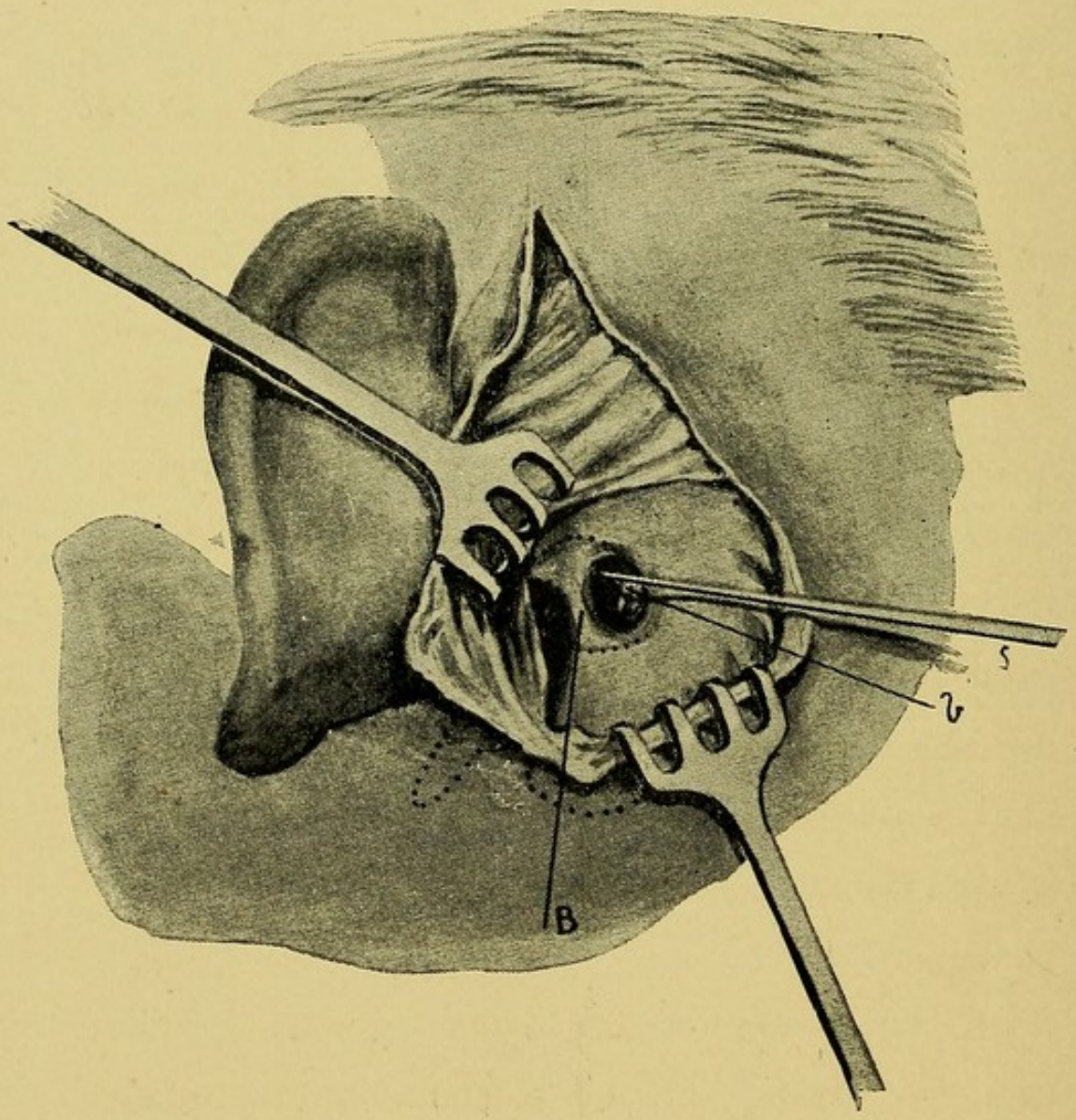

PLATE V.

Showing typical opening.

B—Bridge of bone between artificial opening and meatus.

S—Sound passing into the neck of the antrum.

b—Pointing to the uncovered lateral sinus.

point at which we are to expect to find it when situated far forward.

Having obtained a large free opening into the antrum, in other words having removed its lateral wall, we clean away all ridges and spicules of bone with the sharp spoon, and cleanse the canal with gauze or cotton. The wound is then dusted with iodoform and a drainage tube inserted, or the canal simply stuffed with gauze. If thought best the length of the incision can be shortened by suturing its upper and lower extremities. The best dressing is a mass of sterilized gauze, over which is placed a thick layer of sterilized cotton, and the whole fastened securely by means of a roller bandage.

If our operation has been conducted under thorough asepsis, and the opening has been made free enough, there is nothing to be gained by the irrigation of the wound, even if the antrum were found full of pus. If our opening is made properly, all this can be thoroughly sponged away with pledgets of cotton.

This, the typical mastoid operation, serves simply to remove pus from the antrum or to establish direct communication with the middle ear and allow the better cleansing of that cavity. It is the Schwartze operation for chronic middle ear suppurations, or for acute cases where the process is limited to the middle ear and antrum.

Acute cases with carious perforation of cortex and necrosis.—In these cases the operative procedure is practically the same as described above, modified slightly by the conditions present. If pus swells into view on making the cutaneous incision, it must be sponged away, the bone exposed just as in the typical operation, and the place of carious perforation sought for. If a fistulous canal is found we enlarge it, at the same time directing our opening toward the antrum. Should the cortex be destroyed we must feel around for a sequester, and, after carefully chiseling it loose, remove it with forceps. If the cortex is destroyed and the process filled with granulations, these must first be removed with the sharp spoon, and then, if free communication with the antrum is

not present, that must be accomplished with the gouge. The after treatment is greatly accelerated by the removal of all diseased tissue, and the production of a free opening into the antrum. The energetic use of the sharp spoon in removing granulations and carious or necrotic parts will always be found of the greatest value.

We sometimes make the operation when we have every reason to expect pus and yet find none. In such cases, if the antrum is reached and found empty, it is always well to chisel away a portion of the cortex from the tip of the process and examine that part carefully for pus, as it sometimes happens that the cells at the apex contain granulations and pus when the rest of the process is apparently healthy.

We frequently meet with acute cases where the operation, even when made under proper indications, reveals a perfectly healthy condition of the external surface of the bone. This should however never prevent us from making an exploratory opening into the antrum and cells, as the effect on

the patient of operating on the bone (under thorough asepsis) is little greater than that arising from the periosteal incision, and at the same time the operation exercises a certain revulsive effect on the middle ear suppuration.

In children the antrum lies much nearer the surface than in adults, the meatus is shorter, and its superior and posterior walls flare outward and upward to a considerable extent, thus making the distinction between external surface and meatus much less marked, and causing the spina to appear situated more posteriorly and more on the surface than is the case in adults. Therefore, when operating on children our canal, if placed posterior to the spina, appears to be a great deal farther back than when in the same position on the adult bone. This little peculiarity it is well to bear in mind.

After treatment in acute cases.—The dressing put on after the operation should, if it does not become soaked through and no febrile symptoms arise, be allowed to remain till the fourth day. A dressing once soaked through is no longer aseptic and must

be immediately removed. Its removal is also indicated by the occurrence of fever or intense pain ascribed to the part. At the first change of the dressings, if a large quantity of pus is present, the parts may be gently irrigated, but if possible, it is preferable, for several days, to remove the pus with cotton. From this time on the dressings must be changed every day, and in a week or so daily irrigation with weak antiseptic solutions begun, and the middle ear thoroughly cleansed; syringing through the Eustachian tube being employed if there is much pus in the tympanum. Normal salt solution is the best fluid for injection through the tube, and a weak sublimate solution for the external irrigation. The operative canal must be kept open (dilated with the probe, granulations reduced with caustic, etc.), and the daily treatment continued till the suppuration in the tympanum and in the artificial canal has entirely ceased. The wound can then be allowed to close.

The duration of the treatment varies greatly, sometimes, if the caries is gotten at, and all diseased

bone removed, lasting but from four to five weeks, while in less favorable cases, it may be protracted seven or eight months or longer.

Such is the operation in acute cases, and while I do not mean to say that an acute mastoid suppuration can not be cured by simply removing a piece of the cortex from the tip of the process, thus establishing drainage for the abscess, what I do wish to emphasize is the fact, that the cure is not certain, and, at any rate, will be much more protracted than if we performed the operation thoroughly, and as has been described.

The operation, in cases of long standing otorrhœa which refuse to yield to the ordinary modes of treatment; in cases where cholesteatomatous masses occur; and in all chronic cases operated on for whatever purpose.

Up to within the past year the operation in such cases was the typical one described above, and the after treatment consisted in daily irrigation through the artificial opening and the meatus, supplemented, when necessary, by irrigation through the Eustachian tube. Such treatment is always excessively long

and tedious. In order to maintain a free communication, the leaden nail of Schwartze or some substitute has nearly always to be worn constantly in the canal, granulations have to be frequently destroyed, and the canal dilated with a probe; manipulations which make the after treatment both painful for the patient and exceedingly tiresome for the physician. Such after treatment varies, according to Schwartze's statistics, averaging from eight to ten months, and frequently lasts over a year. Here the opening of the antrum simply allows a better cleansing of the middle ear than could be accomplished through the meatus or through the Eustachian tube, and it is in the therapeutic effect of this free irrigation that the cure is to be looked for.

In 1891, Stacke of Erfurt made public a new method of operating in chronic cases, based upon the surgical principles involved in the treatment of suppurations within rigid walled cavities; namely, upon the complete and free laying open of the cavity, so that it can be scraped out, tamponed, and treated surgically, and the operator not com-

pelled to content himself with a more or less imperfect irrigation.

The method of Stacke is substantially as follows: The cutaneous incision is made a little differently than has been described, the upper part being kept closer to the auricle and carried well around to the front. The lower end must also curve more forward and extend to the tip of the process, the cut, as it were, circumscribing the auricle. The bone being bared as in the typical operation, the membranous meatus is separated from the posterior wall, and, its attachments internally being cut, is in its entirety shelled out of the osseous canal. The bone then appears as in the skeleton. With a small gouge the most medial portion of the superior wall of the osseous meatus (lower lateral wall of the attic) is cut away and the exposed malleus and incus removed. The superior wall is to be chiseled off near the drum insertion, till a bent sound touching the tegmen tympani meets with no resistance on being drawn outward. The probe is then turned toward the antrum, and the posterior wall of the meatus

chiseled away till that cavity is freely opened up. In this way Stacke converts attic, tympanum, antrum, and meatus into one large cavity.

I have performed the operation in this way in the clinic of Professor Schwartze, and know from experience that it is exceedingly difficult to work through the posterior wall of the meatus into the antrum. The antrum is directed away from the meatus, and it is not as if we had simply to remove the projecting lateral wall of a cavity, which could be knocked off with a few blows, as is the case with the lateral wall of the attic. Here we must chisel our way in. If we begin at the neck of the antrum and seek to widen this opening outward, the thickness of the bone to be cut away increases as we proceed (see Fig. 1, p. 38), and we soon have to work in the same manner as if we started from the external surface; which, owing to the narrowness of the meatus, is difficult and requires considerable time.

A much quicker and easier method of accomplishing the same result, and one which has at Halle superseded the original, is as follows: The antrum

is first laid open as in the typical operation. The membranous meatus is then dislodged from the posterior and superior walls, and held forward against the anterior wall by a one-pronged retractor. Our operative field now has the appearance shown in Plate V, with a bridge of bone (B, between the dotted lines) separating the meatus from our opening into the antrum.

This bridge of bone we now proceed to chisel away, and it is evident that its removal will convert antrum, tympanum, and meatus into one cavity. The inner edge of this bridge, corresponding to the outer edge (B), is the lateral wall of the neck of the antrum (Plate II, Fig. 1, A), and, as this wall is much shorter than the edge B, it follows that we remove a triangular-shaped piece of bone, with the apex of the triangle at the neck of the antrum. Directly across from this point is the tuberosity formed by the facial and semicircular canals, and on removing the most medial portion, one must be careful not to plunge across the cavity. If the malleus and incus are present they may be now removed. A bent

sound is next passed into the attic and its lateral wall (superior wall of the meatus) taken away, bringing the attic plainly into view. Of the posterior wall of the meatus, there is now left standing all under a line drawn from the lower end of the bridge (B) to the floor of the neck of the antrum. That is, there is a ridge of bone projecting up between the meatus and the antrum-operative canal cavity. It is of the greatest importance, as will be seen when speaking of the after treatment, to have free access to the antrum from the meatus, to have the lower wall of the meatus slope gradually up into the floor of the antrum. Stacke says that lateralward one can take away as much from the back wall as is necessary to make the lower wall pass uninterruptedly into the lower wall of the antrum. That deep in, however, there must of necessity remain a ridge between the meatus and the antrum. The cleft between these two cavities at this point is bounded above by the tegmen tympani, below by the ridge. "Should one try to widen the cleft downward the injury of the facial canal would be unavoidable."

From what has been said regarding the course of the facial canal, we know that it lies medial to a vertical plane passed tangent to the labyrinth wall (Plate II, Fig. 1, X), and that therefore, all bone which lies lateral to the tuberosity (X) can be safely removed. We are thus enabled, although contrary to what Stacke says, to remove a considerable portion of this ridge medially, and can render the opening between antrum and meatus almost as free as we can more laterally.

The essential point in the operation is to make the antrum and attic accessible from the meatus, and therefore it is of the greatest importance to cut down the ridge as much as possible. We have only to remember that all bone lateral to the easily recognized labyrinth wall can be safely removed.

After the removal of the posterior and superior walls, the bone has the appearance shown in Plate VI, the position of the facial canal being indicated by the dotted lines.

We have now to split horizontally the posterior wall of the membranous meatus well out to the

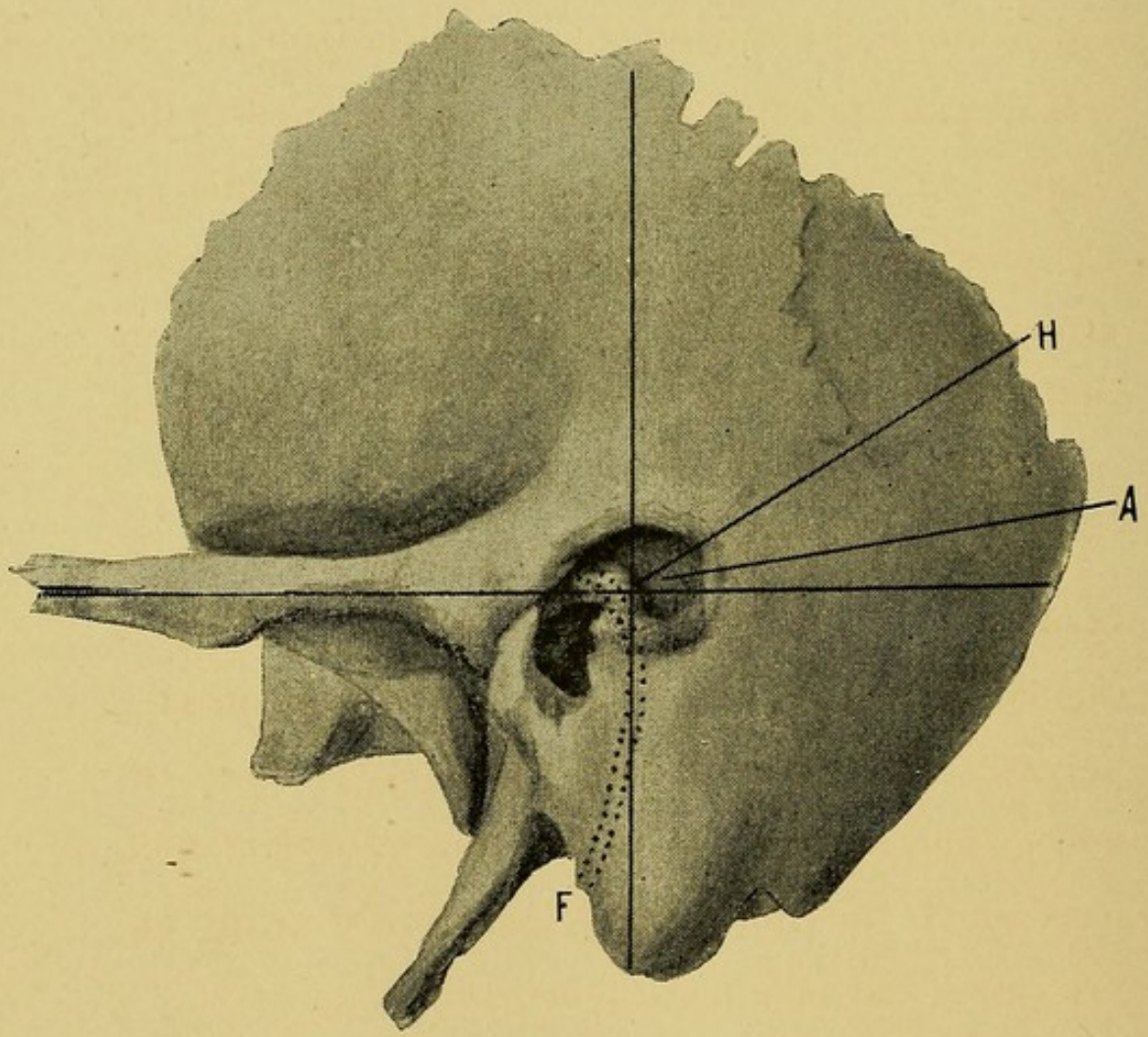

PLATE VI.

Appearance after removing the posterior wall of the meatus.

A—Antrum.

H—Tuberosity formed by facial and horizontal semicircular canals, corresponding to X, Plate II, Fig. 1.

F—Dotted lines indicating the position of the facial canal.

concha, so that when the soft parts are thrown back into position, we can communicate through the external auditory canal with the cavity formed in the bone. At the outer extremity of the horizontal cut we make an incision at a right angle, thus forming a rectangular flap which we proceed to tampon from the meatus firmly into the osseous cavity with small pieces of gauze.

According to Stacke, the tamponing of the membranous meatus into the artificial opening has a double advantage: I. It causes the formation of a persistent skin-covered communication between the antrum and meatus. II. It is a skin transplantation, from which the formation of epidermis over the entire cavity can take place.

After plugging the cavity thoroughly both from the meatus and from behind, the external wound is dusted with iodoform, and, by Stacke, left entirely open, so that the later tamponing, etc., can be done from behind as well as from the meatus. At Halle, in a good many cases the wound is sutured tightly behind, and union by first intention

sought for, the cavities being treated entirely through the meatus.

If the splitting of the membranous meatus is carried far enough outward, it is possible, by pressing the external end of the speculum well forward on to the face, to view the artificial canal clear out to the cortex.

After treatment.—The dressings are to be allowed to remain, if all goes well, till the fifth or sixth day. The daily tamponing which has now to follow must be most carefully carried out. The granulations must be kept down, all attempts of nature to fill up the cavity in the bone strenuously opposed, and every part of the same retained plainly in view. If the tamponing is thoroughly done the epidermis begins to grow out from the edges of the flaps and finally covers over the entire cavity (antrum, attic, meatus, tympanum). When not carefully done, granulations spring up, obstruct the view, imprison sloughing spicules of bone, and can protract the cure for months. Until entirely covered with epidermis, the artificial cavity must be

kept as accessible and of the same size as just after the operation.

Even when the utmost care is taken, minute necrotic pieces of bone become surrounded by granulations, small fistulous canals are formed leading to these dead pieces, around which the suppuration continues even after it has entirely ceased every-where else. Should this occur, the only thing to be done is to dilate the fistulæ with small tampons, using a caustic freely, and in this way seek to facilitate the exfoliation of the sequesters.

The duration of the after treatment varies in these cases also, but is, on an average, as the results so far show, several months shorter than by the old method.

The Stacke or modified Stacke operation is admirably suited to cases where cholesteatomatous masses are found, as the former disfigurement is avoided, and the surgical conditions more perfectly complied with. In these cases, it was formerly the custom of Schwartze to stitch a flap of skin into the canal, made in the typical way, in order to prevent

its ever closing. The tendency of the masses to re-accumulate necessitating a permanent opening, through which the shed-off epidermis could be picked out as fast as formed. In consequence the patient had to go around for the rest of his days with an unsightly hole behind the ear.

The Stacke method leaves no crevices in which the masses can re-form, the cavity can always be examined in all its parts, much more thoroughly than could ever be done by the old method, and there is no visible disfigurement whatever.

The operation of Stacke is a truly radical one, the great cavity in the bone remains as it is, never filling up, and it is therefore only indicated in chronic, otherwise incurable cases. In acute cases the ordinary method is generally sufficient.

Both the typical and Stacke methods seem to have very little influence on the condition of the hearing, if any thing, causing in the majority of the cases, a slight improvement, so that the operation need never be avoided for fear of its injury. If care is exercised, the stapes, imbedded as it gen-

erally is in swollen mucous membrane, is seldom dislocated or fractured.

At the clinic of Professor Lucæ in Berlin the operation in chronic cases is performed somewhat differently. The typical opening is made and the posterior wall of the meatus chiseled way; the opening, however, is made much larger, and much more of the cortex of the mastoid is taken away. The sinus is often laid bare to a considerable extent, the effort being made to roughly chisel out every part which could by any possibility be diseased. There is no cut made in the membranous meatus, the parts being simply pushed back into place, and the cavity behind stuffed with iodoform gauze, and allowed to granulate. With the results of this mode of treatment, its different stages, etc., I am not familiar.

Indications. — The following indications based upon easily recognizable symptoms are the logical outcome of the preceding:

The operation is indicated and should be performed.

I. In all cases of acute otorrhœa, when pain,

redness, and œdematous swelling arise over the mastoid, and do not very soon yield to energetic antiphlogistic treatment (ice, leeches, etc.).—If the symptoms show no abatement after twenty-four to forty-eight hours, the operation must be performed.

II. In acute cases where there is pain in the mastoid region, with redness and swelling on the posterior-superior wall of the meatus, showing that the suppuration in the mastoid region is seeking to make its exit here instead of externally.—Such a condition with even slight affection of the soft parts over the external surface, provided it can be differentiated from a case of simple furuncle, calls for operative interference.

III. When carious fistulous canals exist through the external surface of the process, the canals should be enlarged and all carious or necrotic bone removed.—A carious perforation of the posterior-superior wall of the meatus, expressing the same condition as do external fistulæ, likewise calls for the operation.

IV. When during the treatment of a chronic

otorrhœa, small pieces of the white epidermic masses characteristic of cholesteatoma are discovered in the secretion or wash water.

V. In all cases of otorrhœa, both acute and chronic, when threatening brain symptoms supervene, the operation ought immediately to be performed.

VI. In cases of chronic otorrhœa which do not yield to other remedies (cleansing through the meatus and tube, excision of the malleus and incus); or where there is a persistent fœtor which careful syringing fails to remove; or where, after carefully sponging away the secretion, it is seen always to flow down from above and posteriorly, showing that the disease is situated in the attic or antrum. In this case, if excision of the ossicles fails to effect a cure, the operation should be undertaken.

Although not properly speaking the mastoid operation, the removal of a portion of the cortex is sometimes called for in cases of obstinate neuralgia of the mastoid when all other remedies fail.