Operative Dentistry

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THE

AMERICAN TEXT-BOOK

OF

OPERATIVE DENTISTRY.

IN CONTRIBUTIONS BY EMINENT AUTHORITIES.

EDITED BY

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WITH THE CONSENT OF THE CONTRIBUTORS

THIS BOOK IS DEDICATED TO

JAMES TRUMAN, D. D. S.,

THE CHARACTERISTIC OF WHOSE LONG PROFESSIONAL CAREER HAS BEEN THE INCULCATION OF THE PRINCIPLES UPON WHICH THE WORK IS BASED.

PREFACE TO THE SECOND EDITION.

THE preparation of a text-book upon Operative Dentistry, composite in its authorship, was regarded by the Editor as a tentative experiment the value of which could only be determined by the test of practical experience. The cordial reception of the work by dental teachers and its extensive use by students afford encouraging evidence that a work so planned and executed was needed.

The increasing tendency to specialization in dentistry has rendered still more remote the possibility of adequately presenting the entire field of operative dentistry through the medium of a single volume of individual authorship; hence the composite method, whereby the several departments are set forth by experts in each case, seems likely to afford the most generally satisfactory result.

The Editor is fully aware of the importance which attaches to the work of harmonizing the treatment of the individual subjects and of so coördinating them that conflicting views shall not confront the student, and thus interfere with his advancement into an untrodden field; a recognition of this factor has served as a guiding motive both in the preparation and the revision of the work.

Specialization in operative dentistry has not reached the point where it may be deemed best to limit the field of text-book treatment to its technical procedures and relegate the allied subjects to separate volumes; hence the chapter upon Dental Embryology has been retained and the subject extended to include so much of Dental Histology as bears directly upon operative procedures, and it is anticipated that the admirable chapter by Professor Noyes will prove an acceptable addition. The chapter upon Porcelain Inlay work has been rewritten in the light of the most recent developments of that rapidly progressing field of study. The formal treatment of Asepsis and Antisepsis, which is the basis of an added chapter by Professor Truman, needs no apology; the importance of a thorough appreciation of the *rôle* played by oral bacteria in the causation and transmission of disease is self-evident, as a recognition of the bacterial factor in oral conditions has become a *sine qua non* of successful dental practice. In the present edition the text has been thoroughly revised, a large number of illustrations and much new matter have been added, and the treatment of the whole subject brought into harmony with the latest development of thought in the field which it covers.

The Editor desires to thank his colleagues in the educational field for many helpful criticisms and suggestions received since the first appearance of the work. These have been largely utilized in its revision. His thanks are also due to the several contributors for their generous coöperation and acquiescence in such alterations as have seemed desirable for the betterment of the work.

The death of Dr. H. H. Burchard, who was so closely associated with this work both as a contributor and as a helpful guide in the preparation of the first edition for the press, creates a vacancy in the ranks of American dental writers which will be generally deplored, and especially so by his collaborators in the present work. Ill health made it impossible for him to take part in the present revision, but his contributions being based upon sound scientific principles needed but minor amendments, which the Editor has endeavored to supply in the spirit of the author.

E. C. K.

October, 1900.

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INTRODUCTORY.

A STUDY of the advances which have of recent years taken place in the field of Operative Dentistry will reveal, besides the important additions to our knowledge in the shape of novel methods and improved technique, a vastly more important advance manifested in a better and more general understanding of scientific principles, and the application of dental science to dental art, resulting in a more rational practice. Especially is this true in regard to the etiology of dental and oral pathological conditions, and the *rationale* of the modes of treatment indicated for the morbid states constantly confronting the dental practitioner.

The modifications in surgical methods and the greatly improved results which are the outgrowth of modern scientific studies in bacterial pathology, while they have made a considerable impress upon dental operative methods, have not, however, received that universal practical acceptance among dental operators which their immense importance demands. There is no field of special surgery in which the importance of exact knowledge with respect to aseptic and antiseptic treatment is more marked than in the practice of dentistry. The dental operator is continually confronted with septic conditions, so that precise knowledge of their origin, causes, phenomena, and treatment are essentials to the legitimate practice of the profession.

The performance of any operation, and especially those which are classified as capital, with unclean hands or infected instruments would in the present stage of surgical art be regarded as criminal malpractice. It should be so considered in dentistry. The loss of a patient's life as the result of surgical septic infection is no longer permissible. Lack of antiseptic precautions in certain dental operations may directly lead to and as a matter of fact has been the cause of fatal results. It has been shown conclusively[1] that a large variety of pathogenic micro-organisms are almost constant inhabitants of the oral cavity. In addition to the numerous forms which bring about an acid reaction, there are many specified organisms which produce in inoculated animals pyemia and septicemia in their several clinical classes. But while the dental practitioner is not often called upon to face the issues of life

[1] W. D. Miller, *Dental Cosmos*, November, 1891.

and death in the course of his work, his responsibilities as related to the issues with which he does deal demand of him the same care and thoroughness in order to attain the character of result which the possibilities of modern dentistry require of him. In the following pages the importance of asepsis and antisepsis in dental operations is constantly impressed upon the mind of the student.

By the term *asepsis* is specifically meant the condition under which are excluded those influences or causes which induce infection by pathogenic micro-organisms; when a tissue or surface has been rendered germ-free it is said to be in an *aseptic* condition. By *antisepsis* is meant the means by which the septic state is combated or the aseptic state is attained.

Under the aseptic condition repair of tissues takes place normally without interference, wounds and injuries heal with a minimum of disturbance, and the inflammatory concomitant is of the simple traumatic type, without suppuration or tendency to diffusion.

The aseptic state, in many operations in the mouth, is not readily attainable and cannot be maintained for any length of time; but in all operations which involve the pulp and pulp chamber, as well as the periapical region through the pulp canals of teeth, strict aseptic conditions, as regards external infection, are perfectly attainable through exclusion of the oral secretions by means of rubber dam, the use of suitable disinfectants, and sterilized instruments. It is the class of operations here alluded to which are most prolific of disturbance from infective inflammations caused by ignorant or careless manipulation.

The time is at hand, if indeed it has not already arrived, when purulent inflammations following dental treatment will be regarded with the same condemnation of the dentist as of the general surgeon. The operative section of this work is written in full recognition of the principles here indicated.

OPERATIVE DENTISTRY.

CHAPTER I.

MACROSCOPIC ANATOMY OF THE HUMAN TEETH.

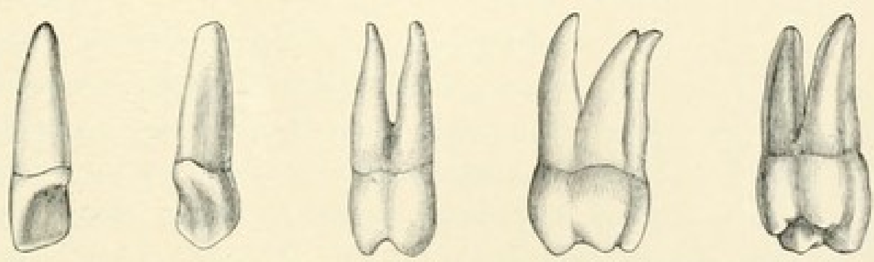
By Alton Howard Thompson, D. D. S.

1. **Definition.**—The teeth may be properly defined as hard, calcareous bodies situated in that portion of the alimentary canal near the anterior or oral extremity. In man they are confined to the oral cavity and are supported by the maxillary bones only. In the lower vertebrates they may be scattered over all of the bones and cartilages surrounding the mouth.

2. **Function.**—The main function of the teeth is the mechanical subdivision of substances used for food, preparatory to their digestion ; these organs therefore belong to the alimentary system. The elements of their function are prehension, incising, crushing, mastication, and insalivation. For the performance of these various offices, different forms of teeth are found in the denture of man. In lower animals food-habit induces the evolution of many various and extreme forms of the teeth.

The secondary offices of the teeth in man are as adjuncts in vocalization and articulate speech ; they also bear an esthetic relation to the mouth and face.

Fig. 1.



The formation of single teeth from the single cone and its repetition in complex teeth.

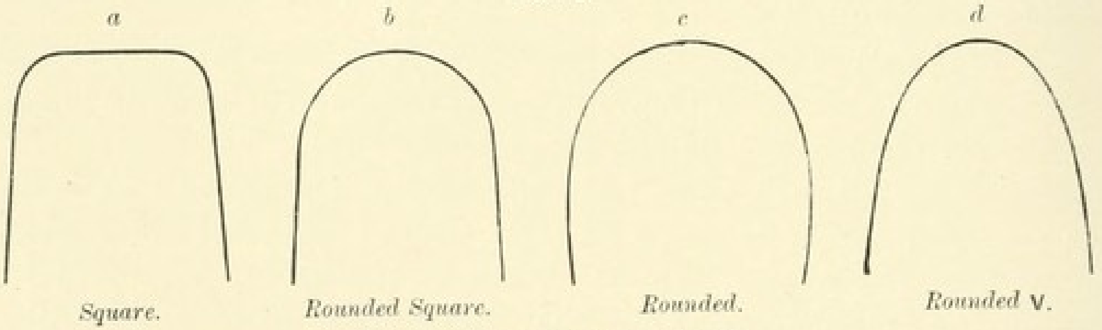
3. **Mechanical Design.**—All tooth forms are evolved by modification from a *simple cone*, which is the primitive, typal form. The teeth of fishes and reptiles are but simple cones, and those of higher mammals are modifications of the single cone or combinations of two or more cones

fused together. Thus in man the incisors are formed of a single cone, the truncated apex of which is compressed to form the wide cutting edge (Fig. 1, *a*). The canine or cuspid is a single cone, the apex of which is compressed into a trihedral point, or pointed pyramid (*b*). The bicuspids are composed of two cones fused together, the forms of the cones being quite distinct the entire length of the tooth, as in the upper bicuspids (*c*). The typal upper molar is formed by the addition of the third cone to the bicuspid form, as plainly noticed in the three roots and the primitive three cusps (*d*). The usual quadricuspid form is made by the addition of a cingule. The lower molar consists of four cones, which may be plainly distinguished by an analysis of its elements (*e*). Each cone in the structure of a tooth is surmounted by a cusp or tubercle. Extra cusps above the number of primary cones are but cingules or undeveloped cusps.

In the genesis of tooth forms, therefore, the complex teeth, as the bicuspids and molars, are formed by the repetition and addition of cones and their accompanying cusps, both laterally and longitudinally of the jaw.

4. **The Dental Arch.**—The teeth of man are arranged around the margins of the upper and lower jaws in close contact, and have no

Fig. 2.



The main types of the dental arch.

interspaces between them. The basal arch is a graceful parabolic curve, with some variations which lead from the round arch to the incomplete parallelogram or even to a well-defined V shape. These variations may be classified as follows:

First: The SQUARE ARCH (Fig. 2, *a*). This is found usually in persons of strong osseous organization, of Scotch or Irish descent—*i. e.* of Gaelic extraction—and is probably derived in the first instance from a dolichocephalic people. The squareness is more or less dependent upon the prominence of the large canines, which stand out very markedly at the angles of the square. The incisors present a flat front and project slightly, with little or no curve of the incisive line. The bicuspids and molars fall backward from the canines with no perceptible curve. The two sides are quite parallel, but sometimes there may be a slight divergence toward the cheek at the rear. This is the low form of arch which appears in the apes and some low races.

Second: The ROUNDED SQUARE (Fig. 2, *b*). This is the medium arch and is the form usually met with in ordinary, well-developed robust Americans. The canines seem to be only so prominent as to give character to the arch without a resemblance to the arches of the lower animals. The incisors are vertical and the line curves slightly from one canine to the other. The bicuspid-and-molar line curves slightly outward from the canine and converges at the rear.

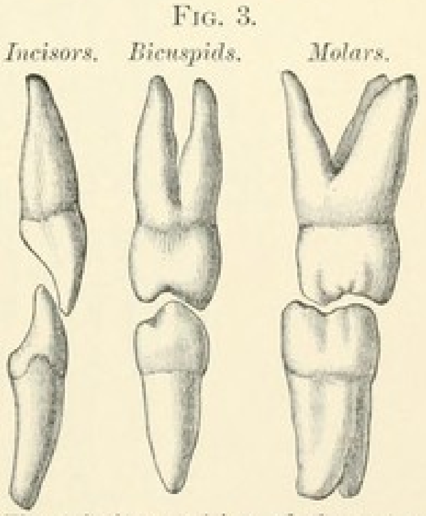
Third: The ROUNDED ARCH (Fig. 2, *c*). This is the circular or "horse-shoe" arch. It is nearly semicircular, the ends curving inward at the rear, the outlines of the arch tracing a decided horse-shoe shape. The canines are reduced to the level of the arch, so that there is no prominence of these teeth. The bicuspids and molars follow the line of the curve. This arch is quite characteristic in some races, as the brachycephalic South Germans.

Fourth: The ROUNDED V (Fig. 2, *d*). In this form the round arch is constricted in front or narrowed so that the incisors mark a small curve whose apex is the centre. It is the arch of beauty and is that most admired in women of the Latin races.

These are but the basal forms of the dental arch. Ordinarily, modifications of these types occur in all degrees; it is the variations, the composites, which are most met with.

5. **The Occlusion of the Teeth.**—The upper teeth describe the segment of a circle larger than that of the lower teeth; so that the edges of the anterior teeth above close over those below, and the buccal cusps of the grinding teeth above close outside of the buccal cusps of the lower teeth (Fig. 3). By this arrangement the buccal cusps of the lower grinders are received into the depressions or sulci between the buccal and lingual rows of the cusps and tubercles of the superior molars and bicuspids, and the lingual cusps of the upper grinders are received into the sulci of the lower grinders. By this arrangement the whole of the morsal surfaces of these teeth are brought into contact in the several movements of mastication, thereby rendering the performance of this function more effective.

FIG. 3.

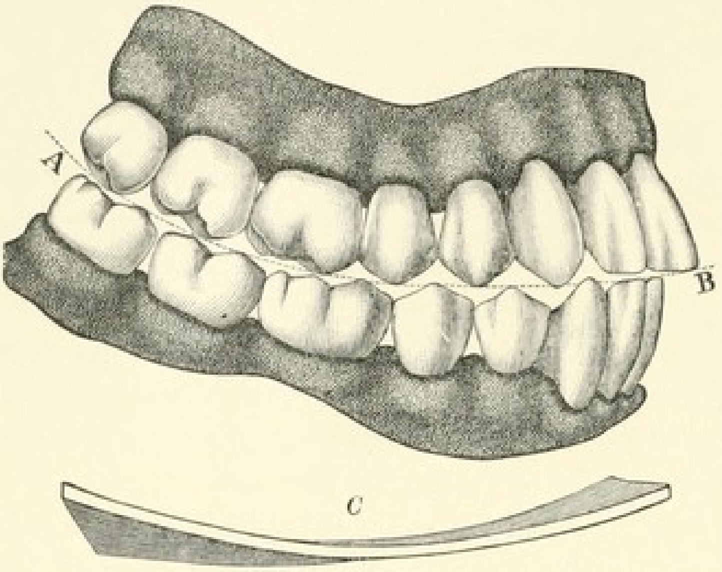


The relative position of the upper and lower teeth in occlusion.

Then, again, the upper incisors usually close over the lower for one-third of their length. This allows of the shearing action by which the incisive function is performed as the edges of these teeth are drawn past each other.

The *line of the horizon of occlusion* (Fig. 4, *A–B*) presents a decided curve from front to rear, of greater or less degree in different forms of the arch. Thus it is high at the incisors, curving downward at the bicuspids, reaching its lowest point at the first molar; it curves upward rapidly at the second molar, and is highest, again, at the third. In the rounded arch the plane is more flattened, and it exhibits the extreme

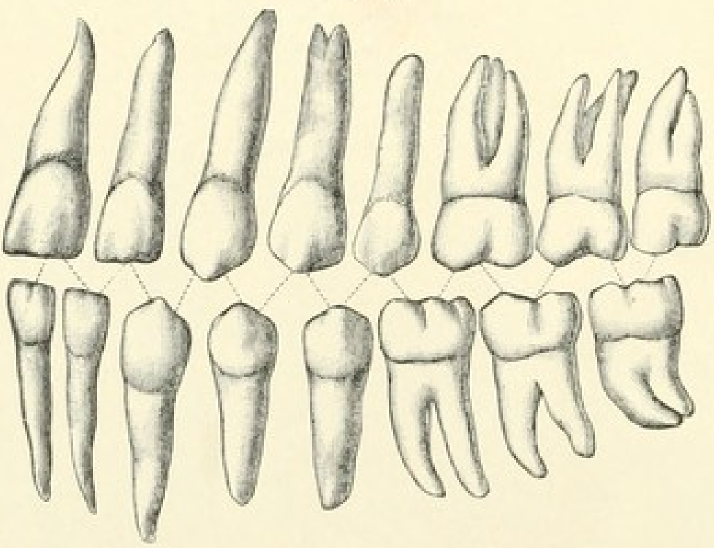
Fig. 4.



The horizon of the line of occlusion and plane of occlusion.

downward curve in the square arch. Between these extremes there is of course every variety of modification. The form of the plane of occlusion is shown in Fig. 4, *C*.

Fig. 5.



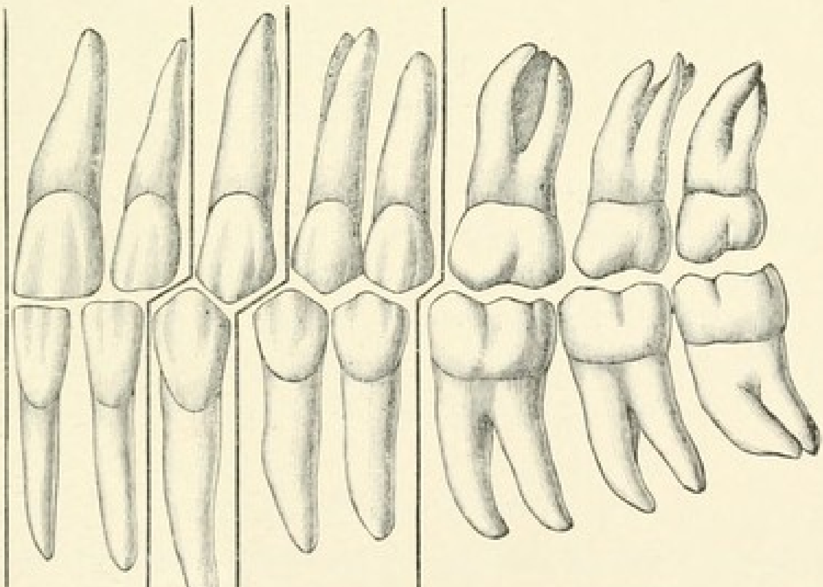
The apposition of the upper and lower teeth.

The tendency of the bolus of food is toward the lowest part of the curve at the region of the lower first molar, so that the extraction of this tooth always affects the performance of mastication.

In the apposition of the teeth of the opposite jaws the mechanical arrangement is such that the dynamics of mastication is subserved and the greatest effectiveness secured (Fig. 5). Thus the morsal surface of the upper central incisor is opposed to all of that of the central incisor below and to the mesial half of the lateral; the upper lateral opposes the distal half of the lateral below and the mesial face of the canine; the upper canine, the distal half of the face of the lower canine and the mesial half of the first bicuspid; the upper first bicuspid opposes the distal half of the lower first bicuspid and the mesial half of the second; the upper second bicuspid opposes the distal half of the lower second bicuspid and part of the lower first molar: the upper first molar opposes the distal part of the lower first molar and the mesial half of the second; the upper second molar opposes the distal half of the lower second and part of the third; and the upper third covers the remainder of the lower third molar.

By this method of apposition the teeth are so arranged that two teeth receive the impact of half of two of the opposite jaw, thus distributing the force of occlusion and ensuring the safety and strength of the teeth. This "break-joint" arrangement permits each tooth to bear two opposing ones, and also helps to preserve the alignment.

FIG. 6.



The classes of the teeth, comprising the left half of a full denture.

Then again, if one tooth be lost, the opposing teeth still rest against two teeth, one at each side of the space. The normal condition of the articulation is rarely preserved, however, as mutilation usually disturbs it; the teeth move on account of the force of occlusion, and effective mastication is more or less destroyed.

6. **Number and Classes of the Teeth.**—Man has thirty-two teeth, divided into four classes, viz.—(1st) INCISORS, (2d) CANINES or CUSPIDS, (3d) PREMOLARS or BICUSPIDS, and (4th) MOLARS (Fig. 6). This is expressed by the dental formula as follows:

$$i. \frac{2-2}{2-2}, \ c. \frac{1-1}{1-1}, \ bi. \frac{2-2}{2-2}, \ m. \frac{3-3}{3-3} = 32.$$

(1) The **incisors** are eight in number, four above and four below,—two on each side of the median line. The two next to the median line are called the *central incisors*, the ones next to them distally, the *lateral incisors*.

(2) The **canines** are four in number, two above and two below,—one on each side immediately approximating the lateral incisor on the distal side.

(3) The **bicuspids** are eight in number, four above and four below,—two on each side approximating the canines on the distal side. The first of these next the canine is called the *first bicuspid*, the one next to it on the distal side the *second bicuspid*. The same designation applies to both upper and lower bicuspids.

(4) The **molars** are twelve in number, three on each side of each jaw, approximating the second bicuspid on the distal side. The molar next to the second bicuspid, both above and below, is called the *first molar;* the next one distally is called the *second molar;* the next one distally, and the last tooth in the jaw, is called the *third molar* or "wisdom tooth" (*dens sapientiæ*).

Functionally, the incisors are formed for cutting, as their name implies; the canines for prehension and tearing (for which purpose this tooth in lower animal forms is often excessively developed). It also serves in guiding the bite. The bicuspids are the crushing teeth, and the molars are formed for grinding, triturating and insalivating the food.

THE INCISORS.

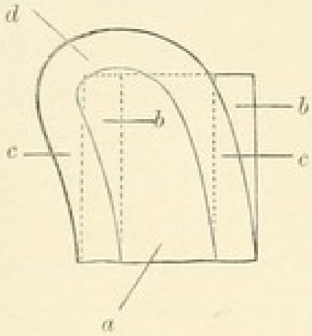
7. **The Upper Central Incisor.**—This is the first tooth in the dental series in man. It is situated in the front of the mouth, next to the centre of the arch, which is the mesial border of the intermaxillary bone. In adult man these bones fuse with the anterior borders of the right and left superior maxillary bones. Their junction with each other marks the centre of the dental arch.

The *general form* is that of a truncated cone with its top flattened out to form the cutting edge.

Its *function* is to cut or incise food, hence its name from the Lat. *incisus*, "to cut into."

The *mechanical structure of the crown* is a matter of importance. It will be observed that it consists of several elements: first, a broad cutting blade (Fig. 7, *a*) supported by two strong lateral columns (*b*) on each side, and that these columns are upheld by two strong marginal

Fig. 7.



The mechanical design of the crown of the upper central incisor: *a*, the blade; *b*, the two columns supporting the blade; *c*, the marginal ridges acting as guys, bracing the columns; *d*, the basal ridge as the base of attachment for the guys.

Fig. 8.

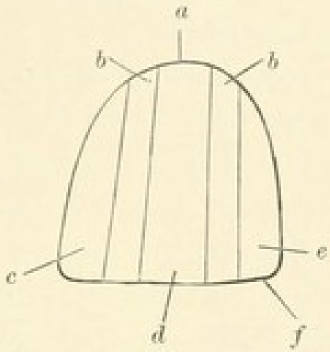


Diagram of the labial face of the upper central incisor.

ridges (*c*) leading up from the lower ridge (*d*). These ridges are *buttresses*, which guy and uphold the columns which contain and carry the blade. Hence, when these ridges are destroyed by caries or in operating, the support of the column is lost and the blade readily breaks away.

The *form of the crown* is spade-like, or a compressed-wedge shape, the edge being quite thin and the thickness increasing rapidly to the base. It is slightly bent toward the lingual side, or much curled over in some cases.

The *labial face* is imperfectly square or oblong, the cervical margin being rounded (Fig. 8, *a*). It is convex from side to side, but only slightly so from cervix to edge. Two shallow depressions or furrows extend the length of the face perpendicularly (*b*) dividing it into thirds, called *lobes*,—the mesial, (*c*), median (*d*) and distal lobes (*e*). These furrows and lobes are quite conspicuous when the tooth is erupted, but are abraded by age and the wear of use and dentifrices, until the face becomes smooth. The mesial margin is a little longer than the distal so that the cutting edge slopes upward toward the distal side (*f*).

Fig. 9.

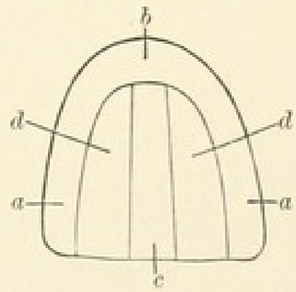
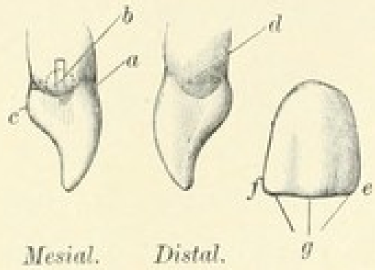


Diagram of the lingual face of the upper central incisor.

The *lingual face* is smaller than the labial, being on the inner and smaller curve of the crown, and is narrower from side to side (Fig. 9). It is triangular in outline, being wide at the edge and narrow and rounded at the base or cervix. The marginal ridges (*a*) are high and conspicuous, and extend from the basal ridge to the edge on the mesial and distal margins of this surface. The basal ridge (*b*) is a strong elevation continuous with the marginal ridges at the base of the crown. It is sometimes developed into a raised cusp, the ridge at the base of which forms a cingulum. A ridge or lobe (*c*) extends from the basal ridge to the centre of the edge, uniting with the median lobe from the labial face to form the median tubercle. A depression or fossa (*d*) is found on each side of the median lobe between it and the marginal ridges, or, when the lobe is low or entirely absent, these fossæ may be continuous. A *fault* or *fissure* at its junction with the basal ridge forms the seat of caries in teeth of low structure.

The *mesial* face (Fig. 10) is a rather long triangle in shape, with a concaved base at the cervix of the tooth (*a*), and a long point toward the edge. It is nearly straight in a longitudinal direction, but rounded and convex transversely. It is longer than the distal face, the edge descending in that direction. The enamel line dips downward into this face, and there is a depression above it (*b*) which sometimes extends upward on the root. The point of contact with the opposing tooth is near the cutting edge.

Fig. 10.



The mesial and distal faces and edge of the upper central incisor.

The *distal* face is also triangular in outline (Fig. 10) but it is more curved in the longitudinal axis, so that this surface is convex in all directions. It is most curved in the transverse direction. The enamel dips downward into the surface (*d*), as in the mesial, but there is not so much of a depression above this line. The point of contact is one-third of the distance from the angle (*e*).

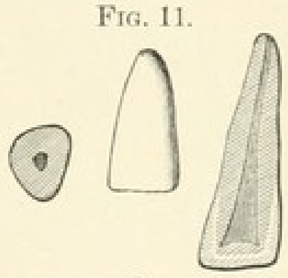
The *edge*, or *morsal* margin, of the crown is formed by the compression of the top of the truncated primitive cone. It is quite wide and square except at the distal corner, which is rounded. The angle with the mesial face is acute (Fig. 10, *f*). When the tooth is first erupted, the edge has three prominent tubercles (*g*), which correspond to the ridges on the labial and lingual faces. These are soon worn off with use, so that the edge usually looks straight. The pitch of the edge is toward the median line.

The *neck* of the central incisor is a rounded pear-shape in outline, the labial half being wider (Fig. 11, *a*) than the lingual. There is not much constriction of the tooth at the neck. The enamel edge curves upward on the root on the labial and lingual sides, and dips downward on the mesial and distal faces. It terminates abruptly on all sides, especially on the lingual, where a considerable ridge is sometimes raised (Fig. 10, *c*).

The *root* is cone-shaped and tapering (Fig. 11, *b*). The rounded pear-shaped section continues almost to the end.

The *pulp chamber* is spacious and open, and of the general form of the tooth (*a* and *c*). The radical portion of the canal gives free access, but the flattened coronal portion is difficult to cleanse. In young teeth the cornua or horns of the pulp may project far toward the angles (*c*).

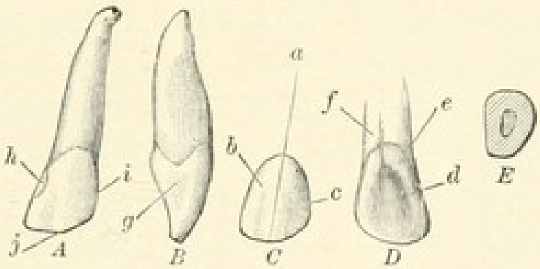
Fig. 11.



The root of the upper central incisor.

8. **The Lateral Incisor.**—This tooth approximates the central incisor on its distal side, and is also implanted in the intermaxillary bone. It is of similar spade-like form and of the same architectural design as the central, modified by the distal half being more rounded in every direction. As the crown is narrower than the central, the destruction of the marginal ridges on the lingual face weakens the edge still more, so that it breaks off more easily. The crown is narrower in the mesio-distal diameter than the central, but, still almost as wide labio-lingually, the relative difference of thickness in the two directions is more apparent. The tooth has the appearance of being compressed mesio-distally. The thickness increases rapidly from the edge to the neck (Fig. 12, *B*).

Fig. 12.

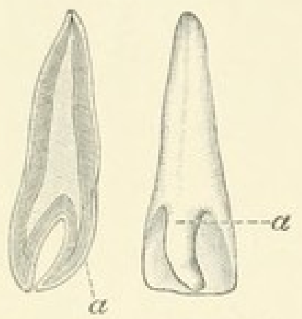


The upper lateral incisor.

The *labial face* (Fig. 12, *C*) is more rounded than that of the central. It is half incisor and half canine (*a*), the mesial half toward the central incisor resembling that tooth (*b*), and the distal half toward the canine resembling it (*c*). The mesial angle of the edge is quite acute, while the distal angle is rounded and obtuse. The three lobes may be well developed, similar to those on the central incisor, but are usually indistinct, although the central ridge is prominent.

The *lingual face* (Fig. 12, *D*) is much depressed, but less concave than that of the central incisor. The marginal (*d*) and basal ridges (*e*) are quite prominent. The basal ridge is often raised into a prominent cingule or talon, an exaggerated example of which is shown in Fig. 13, which is a revival of the basal talon found in the apes,—and the insectivora. This cingule occurs more frequently on the lateral incisor than on any other of the anterior teeth. The depression above it is often the location of a fault, a fissure or pit, which becomes the seat of caries. The basal ridge is sometimes cut by a fissure which leads down quite upon the neck of the tooth (Fig. 12, *f*).

Fig. 13.



Showing unusual development of the cingule or basal talon on an incisor. (From case reported by Dr. W. H. Mitchell, *Dental Cosmos*, vol. xxxiv. p. 1036.)

Sometimes the entire surface is full and rounded without any concavity whatever.

The *mesial face* (*g*) is of triangular form similar to that of the central incisor. It is rounded toward the edge labio-lingually, but flattened at the neck, with a depression at the enamel line which leads upward upon the root. The labial angle is sometimes the seat of a depression (*h*), which gives the angle a hook shape. The depression varies in width and depth and may become the seat of caries. The point of contact with the central incisor is at the junction of the lower with the middle third of the length of the face.

The *distal face* is more convex in all directions and resembles the canine in form, being in harmony with the general form of the distal half of that tooth. From cervix to edge it is rounded and the contact eminence in the middle third is very full (*i*). From this point it rounds off rapidly to the edge. The upper third is depressed rapidly toward the cervix, with a considerable depression at the enamel line leading off to the distal groove on the root.

The *edge* is divided into two portions by the prominent tubercle (*j*) in the middle which terminates the prominent central ridge of the labial face. The mesial half is straight, like that of the central. When worn, these features disappear and the edge becomes almost straight. The pitch of the edge, like that of the central, is toward the median line.

The *neck* is much flattened mesio-distally, and is of a compressed pear shape, or flattened oval on section. The enamel margin pursues the same course as on the central incisor, rounding upward toward the root on the labial and lingual sides and dipping downward on the distal and mesial. It does not terminate so abruptly as that of the central incisor, and presents less of a ridge at the gingival margin.

The *root* is commonly longer than that of the central incisor, is narrower, flattened mesio-distally (Fig. 12, *A*, *B*). It tapers gradually, not rapidly like the root of the central incisor. It is a flattened oval on section (E). Sometimes there is a hook at the end, curved distally. Grooves sometimes occur on the mesial and distal sides.

The *pulp canal* is flattened in conformity to the shape of the root, but is readily entered if the root be straight.

The lateral incisor is very irregular as to form, presenting various degrees of deformity or abnormality, and may sometimes be reduced to a mere peg. It is also erratic as to eruption, being sometimes suppressed, not appearing for several generations of a family. It follows the third molar in the frequency of its irregularities both as to form and frequency of non-eruption.

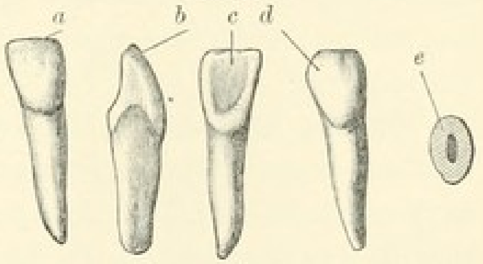
The third incisor of the primitive typal mammal sometimes reappears in man, and is known as a supernumerary. It rarely assumes the proper incisor form and position in the arch, but usually erupts within the arch and is a mere pointed-peg-shaped tooth.

9. **The Lower Incisors.**—These are most conveniently described as a group, as they are very similar in form, having but slight variations between the central and lateral incisors to be noted.

They are located in the anterior portion of the lower jaw, upon each side of the median line, opposite the incisors above. Their function is the same as that of the upper incisors, the cutting of food, which they perform by opposing the upper. The lower central opposes only the central above; the lateral, both the upper central and lateral incisors.

The **lower central incisor** is the smallest tooth in the dental series. It is of spade-like form (Fig. 14), the crown being a double wedge shape (*a*, *b*). The first wedge (*a*) is observed on viewing the crown from the front, the widest portion being at the morsal edge and the point at the cervix. The second wedge is observed from the side (*b*), the widest part being at the neck and the point at the morsal edge of the crown. The edge is thin, but the labio-lingual diameter increases rapidly to the cervix, which is the widest part. The crown is widest mesio-distally at the edge, but diminishes to the neck, which is scarcely more than half the width of the edge. The tooth cone is therefore compressed in one direction at the edge, and in another at the cervix. The mechanical elements are the same as those of the upper central, but with the parts less strongly marked.

Fig. 14.



The lower incisor.

The *labial face* is a long wedge shape (*a*), the widest part at the edge and narrowing to the cervix. It is usually straight, or nearly so, longitudinally, and straight across the edge, but round and convex at the neck and the cervical half. Sometimes vertical ridges are found on these teeth when they are first erupted, but these soon wear off.

The *lingual face* is depressed and concave from edge to cervix (*c*), but less so from side to side. The marginal ridges are often well marked. In the lateral incisor the fossa is often more marked and the marginal ridges more distinct.

The *mesial* and *distal* sides are of wedge-like form, straight from edge to cervix and widening in the same direction. A depression runs across the neck just above the enamel line.

The *neck* is much compressed disto-mesially, and the root partakes of this flattening through its entire length. The section presents a compressed oval (*e*). The enamel line dips downward on the labial and lingual sides, and curves upward on the mesial and distal, in a manner characteristic of the incisors.

The *edge* is perfectly straight from side to side, after the three tubercles, found when first erupted, are worn off.

The *root* is flattened like the neck, and frequently a groove runs the entire length on the mesial and distal sides. Occasionally complete bifurcation results, which recalls the form of this tooth found in lower animals.

The *pulp canal* (*e*) is of similar form to the root, and is flattened and thin, so that it is often difficult to effect an entrance to it with instruments.

The **lateral** is similar in form to the central incisor, but is wider at the edge and the distal corner of the edge is slightly rounded (*d*). In all other features it resembles the central incisor.

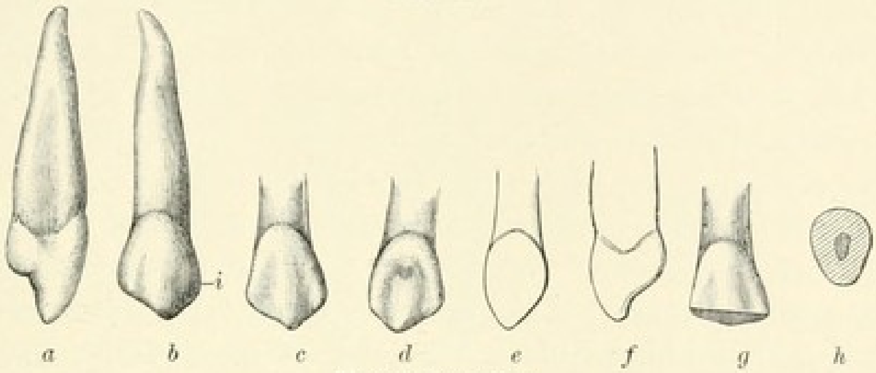
The Canines or Cuspids.

10. **The Upper Canine.**—This is the third tooth from the median line and approximates the lateral incisor on its distal side. It is the first tooth posterior to the intermaxillary suture and is imbedded in the maxilla proper. It is commonly said to form the spring of the arch, and conveys the impression of great strength, as is indicated by its strong implantation. It is more strongly implanted, and by a longer and larger root, than any of the other teeth. Zoologically it is the largest tooth in the dental series, but in man is much reduced from its prototype, the larger carnassial canine of lower animals, especially the carnivora. It is the principal prehensile tooth, and is therefore first in order of function in the dental series.

The canine in man preserves the typal form, for its mechanical structure is still that of a single cone, brought to a point (Fig. 15, *a*). This is the earliest form of teeth found in the lower vertebrates, the fishes and reptiles, which present only simple conical teeth in all parts of the jaw. It has an older history than any other tooth, and still bears the marks of the many changes through which it has passed in the course of its evolution.

The *crown* has a spear-head shape (*b*), hence the name, cuspid, by which this tooth is frequently designated, from the Lat. *cuspis*, "point, pointed end." It is constructed essentially for piercing and tearing. The central cusp or point is braced in all directions; the edges leading up to it both mesially and distally (which serve for cutting as well), the

FIG. 15.



The upper canine.

strong labial ridge coming downward from the cervix (*c*) to the median ridge leading up on the lingual surface (*d*), all support it in the office of prehension and the laceration of flesh.

The *labial face* (*b*) presents the outlines of the spear shape, more or less rounded in different cases. Starting from the well-defined cusp just in front of the central axis of the tooth, it widens sharply for about one-third of its length, whence it narrows gradually to the gum line, which is fully rounded. In some cases the mesial and distal angles are rounded and the outlines are more of a leaf shape (*c*). The surface is slightly rounded mesio-distally, so that the sides slope roundly or flatly away from the central ridge. This ridge descends from the middle of the cervical margin, curving slightly forward and then backward to the point of the cusp (*c*). This curve recalls the curving shape of this tooth in the Felidæ. It is usually a sharp, prominent ridge, but may be reduced and rounded so as to be scarcely perceptible. The three lobes of the surface are imperfectly marked,—the central ridge dominating and dwarfing the lateral ones. The lateral furrows on each side of the central ridge separating it from the lateral lobes are more or less marked, especially toward the edge. Wear reduces in time the prominence of the lobes and ridges and obliterates the furrows.

The *lingual face* is of similar spear shape (*d*), but is more flat. It is rarely concave. The thickness of the crown increases gradually to the lateral prominences, which gives a blade-like edge, then rapidly to the shoulder at the base. A strong vertical ridge extends from the cusp to the basal ridge (*d*), with a slight concave depression on each side. The basal ridge is well marked and sometimes develops into a cingule, more or less marked. The marginal ridges lead up on each side only so far as the lateral protuberances. They are not strongly marked as a rule. The fossæ on each side of the vertical median ridge, between it and the marginal ridges, may be quite deep but are usually shallow and ill defined.

The *mesial* face in outline is not unlike the central incisor, but its contour is very different, for it is more or less rounded in all directions, and the lateral eminence in the lesser third makes this part especially full (*i*). From this point the surface is depressed roundly to the enamel line at the neck, where a depression of greater or less depth is found. It is somewhat flattened at the cervix. The point of contact is at the eminence, which touches the lateral incisor.

The *distal* face is of similar form to the mesial, except that it is more full and the eminence more pronounced, which gives the increased width of the crown on that side. The surface descends rapidly toward the neck and is rounded labio-lingually. The point of contact with the first bicuspid is on the lateral protuberance.

The *morsal* edge presents a prominent cusp which is almost central to the long axis of the tooth. The side facets slope away, but still retain their cutting edge (*b*). The distal side of the edge is longer than the mesial, by reason of the increased size of the distal protuberant angle. The sharp point is soon worn off to a rounded cusp, and, as wear increases with age, it may be reduced to a straight surface between the mesial and distal protuberances (*g*).

The *neck* is a flattened oval on section, or the lateral direction of the labial portion may be greater than that of the lingual (*h*). The enamel line preserves the same curves as on the incisors, *i. e.* rounding upward on the labial and lingual surfaces and dipping downward on the mesial and distal. The enamel terminates gradually with but a slight ridge, unless it should be on the lingual side. A depression occurs on both mesial and distal sides above the curve, which may lead up as a groove on the root.

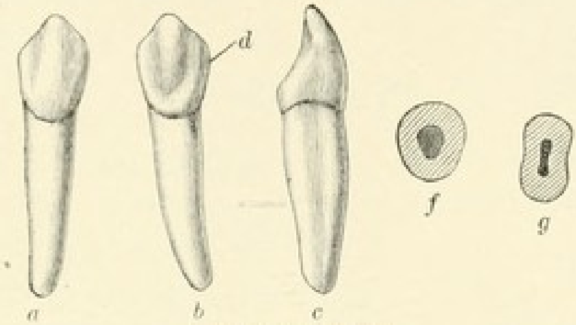
The *root* is longer than that of any other tooth, and it is at least one-third larger than that of the central incisor. It is of a rounded trihedral form, or irregularly conical. It is usually straight, and tapers to a slender point, which may be curved or very crooked. In well-arranged dentures, where it has erupted naturally, it is usually straight.

The *pulp canal* is large and open, of the same form as the tooth, and easily entered. It is regularly formed except in those cases where the root is curved, and even in these it can be filled if not too crooked, as it is so open and accessible.

11. **The Lower Canine.**—This is similar to the upper in form and outline, except that it is somewhat smaller, more slender, and more rounded in form (Fig. 16, *a*). It differs also in being more compressed

mesio-distally and in being flattened in the neck and root. The crown leans backward on the root so that the mesial face is almost straight the entire length of root and crown. It forms the spring of the lower arch, and is strongly built to oppose the strong upper canine in the act of prehension and tearing. It opposes the mesial surface of the canine above and the distal surface of the upper lateral incisor.

FIG. 16.



The lower canine.

The *labial face* is a long oval (a), the cusp being blunt and the neck rounded while the mesial side (c) is flattened. The lobes are indistinct and the central ridge rounded from side to side. The entire face is inclined inward to accommodate the occlusion. The crown in many cases presents the appearance of being blunt toward the distal side.

The *lingual face* (b) is flat, sometimes cup-shaped, and the marginal ridges are not prominent. The central ridge sometimes stands out strongly. The basal ridge is weak and is rarely developed into a cingule. The crown increases gradually in thickness from the point to the neck.

The *morsal surface* presents a mere rounded eminence ; the cusp may be sharp in childhood, but usually it is soon reduced by wear. Sometimes it remains sharp and prominent. The lateral edges are not developed, but are mere ridges leading down to the lateral faces, which are not prominent, except the distal (d), which is often full.

The *mesial face* is quite flat, and straight with that face of the root. The eminence is not marked. It is rounded only at the eminence, but flattened at the cervical third (c).

The *distal face* has the most prominent eminence (d), the crown being bent in that direction. The cervical third of this face is flat. It descends rapidly from the eminence.

The *neck* is usually oval (f) or, when compressed, spindle-shaped upon section (g), being depressed on the mesial and distal sides at the origin of the grooves running up on the root. The enamel line is not so variable as on the incisor, but more nearly on a level on all four aspects.

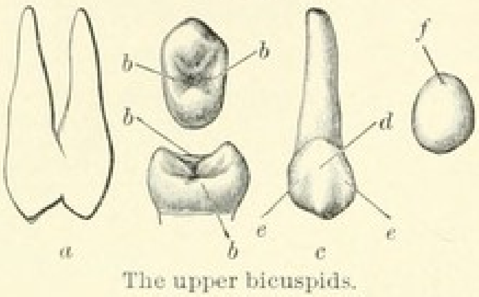
The *root* is long, flattened, and tapering (*a*, *b*, *c*). It is shorter than that of the upper canine. It is grooved on the mesial and distal sides,—so much so as to tend toward bifurcation. This, indeed, sometimes happens in man, thereby recalling the form usual to the primates and some other lower animals.

The *pulp canal* is of the same general form as the root, often presenting the spindle shape on section. It is somewhat difficult to enter on account of its flattened shape and narrowed channel.

The Bicuspids.

12. **The Upper Bicuspids.**—The upper bicuspid is formed by duplication of the primitive cone and cusp in a transverse direction (Fig. 17, *a*). Viewed from the standpoint of comparative dental anatomy, the external cone is the *canine cone*—and to this is added the internal or *bicuspid cone*, the tooth being a double canine. The bicuspids are the first of the complex teeth. The internal cusp is formed by the raising of the inner primitive cusp of the canine and the development of a root to support it. The distinctive feature of the architecture, therefore, is its formation from two cones, and this makes it a weak tooth as regards its mechanical structure and resistance to mastication, for the binding of the bases of the cones and cusps depends upon the connecting power of the two marginal ridges (*b*, *b*), and when these are destroyed the cones readily part and split off.

Fig. 17.



The upper bicuspids.

The bicuspids in man are homologous with the premolars of the quadrumana and other lower mammals. They succeed and displace the molars or grinders of the deciduous set. They are placed next after the canines in both jaws, and midway between the cutting and grinding teeth. Their function is the crushing of food preparatory to mastication.

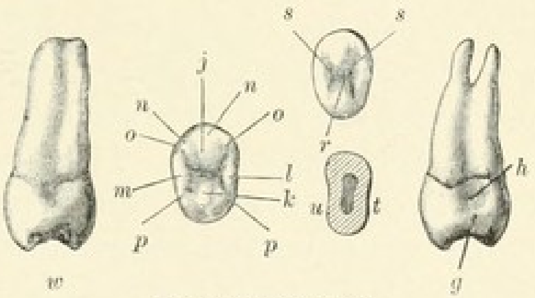
The **upper first bicuspid** approximates the canine on the distal side.

The *buccal face* (*c*) is of spear-head shape, similar to that of the canine. This is more apparent in some lower mammals than in man, in whom it is much reduced and rounded, so as to give usually the appearance of a long, rounded oval. The buccal cusp (*c*) rises sharply and prominently from the lower centre of the face, from which a strong ridge (*d*) leads up to the cervical border. The mesial and distal lobes (*e*, *e*) are rarely conspicuous, and the furrows between them and the central ridge lead but half way up the crown. The lobes sometimes have prominent points at the morsal margins which in lower mammals become pronounced cingules. The buccal marginal ridges descend from the points of the cusp to the points of the lateral lobes. The distal ridge is usually longer than the mesial. The cervical border is rounded and oval from side to side.

The *lingual face* (*f*) is full and rounded, more or less straight perpendicularly and rounded mesio-distally. It is convex in both directions. The lingual cusp rises over it full, but is blunt and round; the marginal ridges are rounded, not angular, and curve sharply round to meet the mesial and distal marginal ridges.

The *mesial face* (Fig. 18, *g*) is wide and flat transversely, full at the morsal surface at the marginal ridge, which is prominent, and descending flat to the cervix, where a depression (*h*) occurs which extends well up the face.

FIG. 18.



The upper bicuspids.

The *distal face* is of similar form, but is rather more convex and the portion at the marginal ridge more prominent. The depression from the root does not extend so far up on the face.

The *morsal surface* shows an abrupt change from that of the canine next to it, as it presents two distinct cusps or points instead of one. One cusp is on the buccal margin (*j*) of the crown, and one on the lingual (*k*), and they are named the *buccal* and *lingual* cusps. The buccal cusp is sharp and prominent, and is not unlike the single canine cusp. The lingual cusp is broader and more rounded—indeed it is preferable to term it a tubercle.

The outline of the morsal surface is imperfectly quadrate and is bordered by well-marked marginal ridges, named as follows:

The *mesial* marginal ridge (*l*), bordering the mesial face of the crown; the distal marginal ridge on the distal side (*m*), the *buccal* marginal ridges (*n*) descending from the point of the buccal cusp to meet the buccal terminations of the distal and mesial marginal ridges at the angle formed by the junction with the buccal lateral lobes (*o*), and the *lingual* marginal ridges (*p*), descending from the lingual tubercle to meet the lingual termination of the mesial and distal marginal ridges.

The *triangular* ridges descend from the cusps toward the centre of the tooth and unite at the central groove. In defective teeth they do not fuse, leaving a fault or fissure which becomes the seat of caries. This groove or sulcus extends from one lateral marginal ridge to the other mesio-distally (*r*) and widens into the mesial and distal sulci at each end. The triangular grooves (*s*) run from the mesial and distal sulci toward the mesial and distal angles, dividing the marginal ridges from the triangular. They also become the seat of caries in imperfectly formed teeth.

The *neck* of the first bicuspid is compressed or spindle-shaped (*t*), the enamel line rising on the buccal and lingual sides and dipping down on the mesial and distal. The enamel margin tapers off gradually on to the root. A wide, deep depression usually occurs (*u*) on the mesial side of the neck, leading to the groove on the root. On the distal face this is not so well marked.

The *root* is much flattened mesio-distally, with a decided groove extending up both sides. This grooving tends to cause bifurcation of the root, which actually occurs in one-third of the cases, especially in persons of strong build. This bifurcation is a persistent relic of lower forms of the premolars, as in the apes.

The *root canal* is flat at the neck, and nearly always bifurcated, even when the root is not separated. This is readily seen by holding a bicuspid having one root, up to the light, when the central portion will be observed to be translucent. The usual bifurcation necessitates the search for both canals in every case in treating this tooth.

The **upper second bicuspid** (*w*) approximates the first on the distal side, and is similar to it in every way, except that it is usually smaller and more rounded in all directions. The sharp features, conspicuous ridges, etc. are not so strongly marked. The cusps are reduced, the ridges more rounded, and the morsal face more flattened, and it is often wrinkled. The triangular ridges are more likely to be united, thus making the crown stronger. The crown is thinner mesio-distally. The neck is more rounded or oval.

A most conspicuous difference is in the *root*, which is narrower labio-lingually, is more rounded, and is rarely bifurcated. It is sometimes cylindrical or cubical in form. It is disposed to be turned, and is often crooked. The *pulp canal* is single and readily entered.

13. **The Lower Bicuspids.**—These are placed next after the lower canines on the distal side. In form they are not truly bicuspid, for the first is unicuspid and the second is tricuspid in the pure typal forms; but they are arbitrarily termed bicuspids on account of their position as compared with the upper bicuspids, which are typically bicuspid.

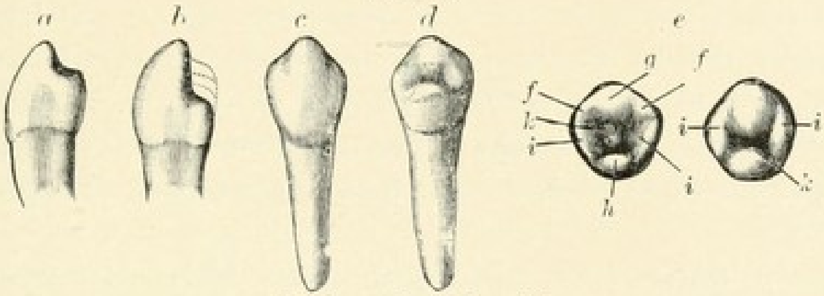
The architectural form of these teeth is that of the single cone, the crown being augmented in various directions by the addition of cingules to the primitive cusp.

The **lower first bicuspid** is a well-formed transitional tooth, for it grades from canine to bicuspid and is typically composite. It more closely resembles a canine than a bicuspid in its usual form, because the inner cusp is almost suppressed and is rarely as large as the outer one (Fig. 19, *a*). In fact, it looks like a canine with a cingule raised upon its inner face. This cusp is really a cingule, for it is rarely raised to the full height of a cusp.

It varies much in size from a mere point on the basal ridge (*b*) on through various degrees of development, up to a full cusp as large as the buccal cusp, when the tooth becomes a true bicuspid. The tooth is therefore essentially a primitive unicuspid premolar, of the form of this tooth in some of the lower primates.

The *buccal face* (*c*) is caniniform, or a long oval in outline with the cusp rising as an abrupt point above it. The angle of the junction of the marginal ridges may stand out prominently. The face

FIG. 19.



The lower first bicuspid.

curves markedly toward the lingual side, so that the buccal cusp becomes central to the long axis of the tooth (*a*). The cervical border is rounded at its margin and convex from side to side. The lobes are not marked.

The *lingual face* (*d*) is convex from side to side and straight vertically, but is not perpendicular, as it is directed toward the lingual side. Its height depends upon the height of the lingual cingule, which varies from a mere buccal ridge through various degrees up to the full-sized cusp.

The *mesial* and *distal surfaces* are of similar form, convex from side to side (*a*, *b*) slightly flattened at the cervical border and flaring out to meet the full marginal ridges, which are round and prominent. The prominence of these ridges and the inward inclination of the lingual face gives the crown a decided bell shape, tapering to the neck (*d*).

The *morsal surface* (*e*) is peculiar and differs from every other tooth in its great variability and the extremes which it may present, from being a full bicuspid to a mere canine. This face is nearly circular in outline, the widening of the lateral surfaces by the spreading of the marginal ridges (*f*, *f*) adding to the width. The buccal cusp (*g*) is large and prominent, and is also drawn toward the centre of the tooth to accommodate the occlusion. Sometimes it is high and sharp when the lingual cusp is reduced, and is low and blunt when the latter is enlarged,—appearing to have an inverse ratio in size to the inner cusp. The lingual tubercle or cingule varies much in size, from a mere point on the basal ridge, above the cervical border, to a pronounced cingule, a larger cingule, a small cusp, then a full cusp, the basal ridge (*h*) being raised with it. The ridges are the mesial and distal marginal ridges (*i*, *i*), which are bowed out round and full and are always pronounced; the buccal marginal ridges (*f*, *f*), leading down from the buccal cusp to form an angle with the mesial and distal marginal ridges; the basal ridge, when the lingual cingule is lowered (*b*); and the triangular ridge of the buccal cusp, which is always large and when the inner tubercle is reduced leads down as a high central eminence. The lingual cingule, as a rule, possesses no triangular ridge.

The central groove usually crosses the central ridge (*k*), but not always, being often bowed around its lower termination. Sometimes the ridge is crossed by a sulcus. The groove terminates in a sulcus at each end, with slight triangular grooves branching up on the buccal cusp.

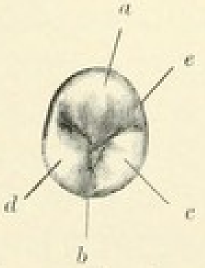
The *neck* is usually oval on section, being much constricted, the crown flaring upward from the cervical portion, giving the crown the well-known bell shape. The enamel line dips but slightly, being usually level on all four sides. The buccal border sometimes presents a prominent ridge.

The *root* is single, long, tapering and may be nearly round, but is usually flattened mesio-distally. It is sometimes thick the greater part of its length, and terminates in an abrupt, round, blunt apex (*c*, *d*). It is very liable to be crooked. It is rarely bifurcated and does not present grooves on its lateral faces.

The *pulp canal* is constricted and flattened at the neck, and the backward inclination of the teeth makes it difficult to enter. The possibility of the root being crooked and the peculiarity of its anatomical relationships[1] also increase the uncertainty of treatment, which makes the pulp canals of the lower bicuspids difficult to deal with.

The **lower second bicuspid** approximates the first on its distal side. It resembles the first as regards the general form of the crown, its tapering bell shape, the constriction of the neck, and the shape of the root. In all these features there is little difference between these teeth, and the description of the first will apply also to the second bicuspid.

Fig. 20.



The morsal surface of the lower second bicuspid.

The *morsal surface* (Fig. 20), however, differs very materially from that of the first. This is circular in outline like the first, and the buccal cusp is full and rounded (*a*), but the inner cusp is divided by a groove (*b*) running over it, into two parts, so that it is really divided into two tubercles. This makes the lower second bicuspid in its typal form a tricuspid tooth; so that it differs from the lower first, which has but one cusp, and from the others, which have but two cusps. The

[1] See page 606, Chapter XXI., on Extraction of Teeth.

lingual tubercles vary much in size, so that one may be suppressed and the tooth seem bicuspid. The mesial lingual tubercle (*c*) may be of large size and be developed at the expense of the distal (*d*); this may be a mere cingule on the distal marginal ridge and appear on the distal side, but it is always present.

The morsal groove (*e*) is triangular in design, passing between each of the three tubercles. A well-marked triangular ridge descends from each of the cusps.

The tricuspid form of the morsal surface of this tooth is, of course, a reproduction of the trituberculate premolars of the lower primates, and of still lower mammals, although the triangular form of the crown is lost in man.

The Molars.

14. **The Tuberculate Teeth.**—Molar teeth appear early in the scale of vertebrate life; mere crushing teeth are found in fishes and slightly tuberculate teeth in the reptiles. The grinders are of simple form in the lowest vertebrates. The *Bruta* have simple, flat-crowned molars, which are undifferentiated and used merely for crushing. Tuberculate molars appeared early in the placental mammalia, the trituberculate molars being found in numerous fossil species, which are the typal form and forerunners of the tuberculate molars in the higher mammalia. The simple-crowned tooth with a single tubercle (*haplodont*, Cope), becomes duplicated and doubled, with a crown supporting several tubercles (*bunodont*). The transition from simple to complex teeth is accomplished by the repetition of the type in different directions and the addition of cusps and roots both laterally and longitudinally of the jaw. The upper molar is formed by the addition of the third cusp to the bicuspid type and has three roots, which support three or four tubercles. Lower molars consist of four cones which support four or five tubercles. The lower molar is therefore the more complex tooth. The bicuspid is more complex than the canine, the upper molar than the bicuspid, the lower than the upper molar.

The molar teeth of man are bunodont in form, *i. e.* they have simple rounded tubercles on the grinding face. They are of simple and primitive type, and indeed are most like the molars of the bears and other omnivorous animals. They are not highly specialized like those of the carnivora on the one hand with high sharp blades for cutting flesh, nor like those of the herbivora on the other, which are extended laterally for grinding tough vegetable fibre. They are of low organization as regards their functional development.

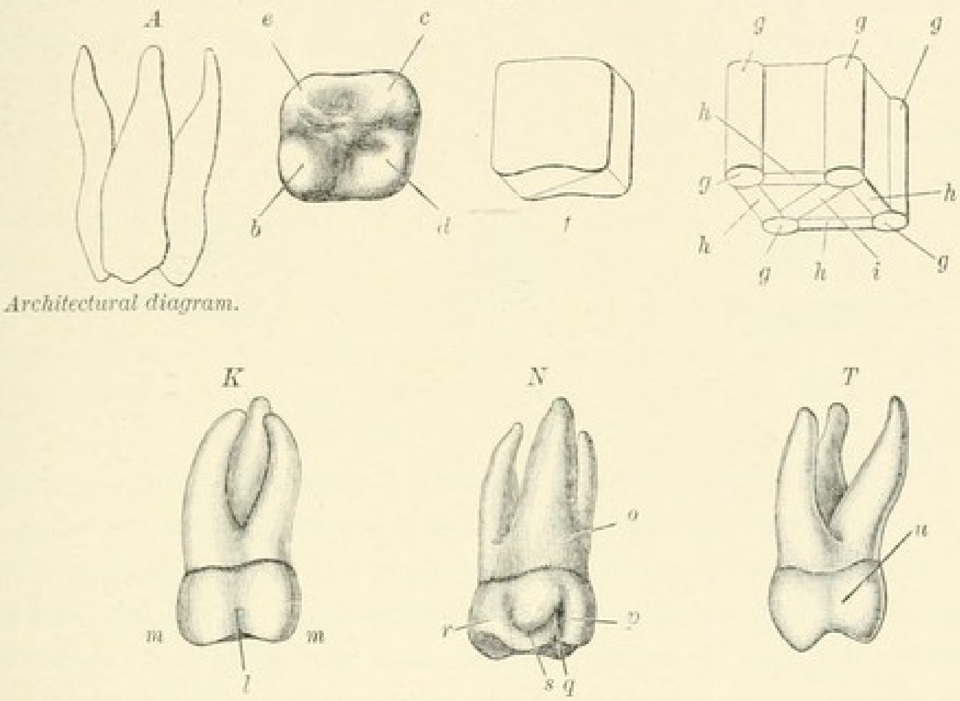
The molars in man are twelve in number, three on each side of each jaw, and are placed at the rear of the arch, opposite the strong triturating muscles, for the purpose of crushing and masticating food. They are important factors in alimentation and contribute to the function of digestion by preparing food for the stomach. Their loss impairs this function seriously and leads to derangement of the stomach by over-taxing it with imperfectly masticated food-substances.

15. **The Upper Molar.**—The typical upper molar is formed by the fusion of three cones, as is plainly observed in the three roots and the three tubercles (Fig. 21, *A*). The tricuspid molar, therefore, is a primitive form, and is rarely seen in man, the normal form being quadrituberculate. The fourth additional cusp, the disto-lingual (*b*), is merely a supplemental cusp added to the crown. An upper molar is, therefore, composed of three tubercles, and a cingule which has not yet developed a root to support it. The trituberculate molar is the primitive form of this tooth, the quadrituberculate appearing later, and is found in only a few living forms, as some of the lemurs and the insectivorous and carnivorous mammalia. In man there is sometimes a reversion of the upper molar to the trituberculate form, which is a marked degeneracy in the form of this tooth. In an analysis of this tooth, therefore, the mesio-buccal tubercle (*c*) is the canine cusp ; the mesio-lingual, the bicuspid cusp (*d*) ; the disto-buccal, the molar cusp (*e*), and the disto-lingual is but a supplemental cusp,—it is not a true cusp, as it has no root to support it.

The *architecture of the upper molar* presents some interesting features. We observe that the crown is in a general way a geometrical form, a cube (*f*), when perfect and symmetrical. It is suggestive of symmetry, but when taken with the root form is not quite perfect, for it is supported on three roots instead of four to correspond with the four tubercles at the four corners. So it lacks the " harmony of adequate support," which is a cardinal principle in architecture. But the crown separately is a symmetrical form, a cube, although the angles are rounded off and the corners and points are toned down and not acute. We notice that there are four strong columns, one at each of the four corners (*g*). They are connected on the four sides by the marginal ridges acting as strong connecting arches (*h*). These arches are related to the columns of the crown, and both are impressively proportioned. The cusps may be likened to the capitals of the columns, and the descending marginal and triangular ridges to the cornice, gathered together to form the capitals. The triangular ridges may be considered girders (*i*), binding the four together and also bracing the square obliquely. Or, the four triangular ridges running to the centre may be regarded as half-arches or buttresses, supporting the roof vault,—the grinding face. Other elements could be marked out in an architectural study of the crown of this tooth, showing its beautiful design and symmetry.

The upper first molar approximates the second bicuspid on its distal side. There is a marked and abrupt change in form, as the molar has double the number of cusps of the bicuspid,—being formed like two bicuspids fused together. The four tubercles mean an extension of surface and a further adaptation to functional requirements. The crown is large and cubical in form, and more or less rounded.

FIG. 21.



The upper molar.

The *buccal face* (*K*) is wide and rounded. It is twice the width of the bicuspids. It is broadest at the morsal margin, narrowing upward to the cervix, where it is widely rounded or arched. A vertical depression, the buccal groove (*l*), extends from the cervical border to the morsal margin, dividing the face into two oblong rounded eminences, the mesial and distal *buccal lobes* (*m m*).

The *lingual face* (*N*) is more rounded than the buccal, the cervical portion being the most convex (*o*), the mesial and distal sides being depressed toward the single lingual root. The morsal half is divided by the lingual groove (*q*), which descends over the lingual marginal ridge between two lobes, the mesial (*r*) and distal (*p*), which are usually much rounded. The morsal half of the face curves toward the grinding surface. The mesial lobe sometimes presents the lingual cingule (*s*), a sort of fifth tubercle of greater or less size. A groove branches from the lingual groove and extends over, between the cingule and crown.

The *mesial face* (*T*) is flat longitudinally, descending from the marginal ridge to the cervix in a nearly straight line. Bucco-lingually it is convex, nearly flat at the marginal ridge, and rounded at the cervix, being depressed toward the lingual root. Sometimes a depression from the bifurcation of the mesio-buccal and lingual roots extends part way up on the face (*u*).

The *distal face* is similar to the mesial except that it dips more toward the cervix, and is, perhaps, more rounded toward the lingual root.

The *morsal surface* (Fig. 22) is the most important part of this tooth, and shows features that make it interesting and unique. The abrupt

Fig. 22.

The morsal surface of the upper first molar.

change from the bicuspid form is notable, for there are presented four cusps, a doubling of the number; the outline of this face presents a square form with tubercles at each corner, the mesio-buccal (*a*), the disto-buccal (*b*), the mesio-lingual (*c*), and the disto-lingual (*d*); the latter is erratic and may be either pronounced or quite reduced in size.

There are four marginal ridges—the mesial (*e*), buccal (*f*), distal (*g*) lingual (*h*), the oblique (*i*), and the four triangular ridges (*j*). The oblique ridge connects the mesio-lingual with the disto-buccal tubercle and is really the remnant of the marginal ridge of the tricuspid molar; the fourth cusp, the disto-lingual, being raised up on the disto-lingual side. The four triangular ridges descend from the four tubercles toward the centre of the tooth, the oblique ridge being formed by the fusion of the triangular ridges of the mesio-lingual and disto-buccal cusps.

There are two fossæ (*k*), one mesial and the other distal to the oblique ridge. Sometimes the latter is cut by a groove or sulcus (*l*) which extends from the mesial to the distal fossa. Sometimes by the reduction of the disto-lingual lobe and cusp, the mesial fossa is extended and becomes central to the crown. A groove extends from the mesial fossa over the buccal marginal ridge (*m*) quite on to the buccal face, dividing the mesial from the distal buccal lobes. A groove also extends over the lingual marginal ridge (*n*) down upon the lingual face, dividing the lingual lobes. When this groove becomes a fissure, caries ensues and the disto-lingual cingule readily breaks away, this cingule being a weak feature in the mechanical design of this tooth; cutting the distal marginal ridge also weakens this cusp. The triangular grooves branch from the two fossæ on to the cusps, dividing the triangular from the marginal ridges.

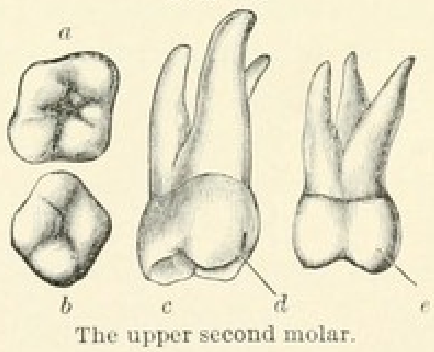
The *neck* of this tooth is of rounded rhomboid form on section (*o*), widest at the buccal side. The enamel is almost level on all four sides, dipping downward slightly on the mesial and distal. A depression occurs at the bifurcation of the buccal roots, and an inward inclination on the mesial and distal sides.

The *roots* are three in number (Fig. 21), two on the buccal side, which are small and flat or round, and one on the lingual side, which is large and rounded. The roots are usually separated, but may be found united, by a septum of cementum, in various directions. The mesio-buccal root is the larger of the two buccal roots, and forms a second turning-point or spring of the arch. All the roots are slightly bent and may be very crooked.

The *pulp chamber* branches into three canals, one in each root. The lingual canal is large and open and is readily entered. The canals of the two buccal roots are small and fine, and, with the possibility of crookedness in the roots, present the most difficult problems as to treating and filling found in the whole denture.

The **upper second molar** is similar to the first in some respects but very different in others. It is rather smaller, is not usually full and square, but disposed to become rhomboid in form (Fig. 23, *a*, *b*), by disto-mesial compression.

Fig. 23.



The upper second molar.

The *buccal face* is similar to that of the first molar, and the same description will apply to it. If any difference is found it is that the face is strongly compressed from front to back, and the disto-lingual cusp is more reduced as a constant feature.

The *lingual face* (*c*) is different from that of the first molar in that by the suppression of the disto-lingual tubercle (*d*) and the distal lobe, the mesio-lingual lobe is enlarged so that it occupies the entire face, which is full, rounded, and convex (*e*). It is rarely divided into two lobes as in the first molar, owing to the enlargement of the mesial lobe and the pushing backward of the oblique ridge, which throws the lingual groove on to the disto-lingual angle (*d*); or the groove may be absent altogether.

The *mesial* and *distal* faces are similar in form to those of the first molar, being perhaps more flattened.

The *morsal face* is similar to that of the first molar, except that the tubercles are less pronounced and the distal ones are reduced in height to accommodate the upward curve of the line of occlusion at this point. The disto-lingual cingule is smaller than that upon the first molar, and is often barely marked. This throws the oblique ridge more to the distal side and enlarges the mesial fossa. The various grooves are the same as on the first molar, except that one, the lingual, may be lost.

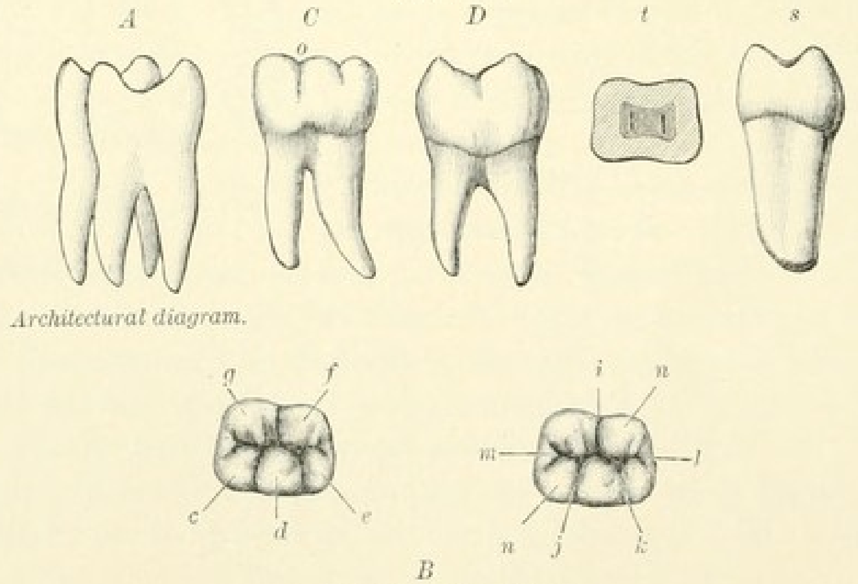
The *neck* is less regular in outline than that of the first molar, as the crown varies so much in shape. It is more flattened mesio-distally and depressed toward the roots.

The *roots* are the same in number and general form as in the first molar, but spread less and are more irregular in form. They may converge or be crooked, or may be fused together. This makes the pulp canals more difficult to treat. Sometimes the three roots are completely fused, as in the third molar, and the canals may coalesce ; or the canals of the two buccal roots may run into one. The irregularity and uncertainty of the form of the roots make this tooth difficult to deal with in treating its pulp canals.

16. **The Lower Molars.**—The **lower first molar** approximates the lower second bicuspid on its distal side. It is the first of the true grinders of the lower jaw and the largest tooth in the dental series. Unlike the upper molars the transverse diameter is less than the mesio-distal. The greater width is found across the base of the disto-buccal tubercle. The crown is square or trapezoidal in form, depending on the size of the fifth tubercle. Being quinquituberculate, the crown is broadened by the multicuspid grinding face. The buccal face is inclined toward the centre of the tooth, for its morsal half, to accommodate the occluding teeth.

Architecturally, the tooth is formed of four cones (Fig. 24, *A*), and

Fig. 24.



The lower first molar.

may be roughly divided into four quarters. There are four primitive cones with their tubercles and one cingule in the structure.

The *morsal* surface (*B*) is trapezoidal in outline, the buccal line being the longest. The buccal angles are acute, while the lingual are rounded and obtuse.

There are five *tubercles*, two on the lingual margin and three on the buccal. They are named the mesio-buccal (*c*), median buccal (*d*), disto-buccal (*e*), disto-lingual (*f*), and mesio-lingual (*g*). These tubercles are less obtuse and more rounded than those of the other grinding teeth, the mesio-buccal usually being the largest, the others are not so prominent, rarely raised and sharp.

The *ridges* are: the marginal ridges—buccal, distal, lingual, and mesial—and the five triangular ridges descending from the five tubercles toward the centre of the tooth.

The *grooves* and *sulci* upon the morsal surface are very irregular. A deep sulcus traverses the face from the mesial to the distal marginal ridge. A groove runs off toward the lingual side, dividing the lingual cusps (*i*), sometimes cutting the lingual marginal ridge, but rarely reaching over on the lingual face. A groove runs toward the buccal side, dividing the mesio-buccal from the median tubercle (*j*), cutting the marginal ridge and extending over quite on to the buccal face. This groove often becomes the seat of caries owing to the enamel structure being faulty. Another groove extends toward the disto-buccal angle (*k*), dividing the median from the disto-buccal tubercle, and rarely extends over on to the buccal face. A groove may extend distally cutting the distal marginal ridge (*l*), and one mesially cutting the mesial marginal ridge (*m*), but these are not usually marked. The triangular groove running up on each side of the triangular ridges (*n*) divides these from the marginal ridges. Supplemental grooves may divide the triangular ridges again. The pits at either end of the sulcus may become the seat of caries through faulty formation.

The *buccal face* (*C*) is an irregular trapezoid in form, the morsal margin being longest; the mesial and distal sides converge toward the cervical border, which is rounded. The morsal margin is broken by the three tubercles rising upon it. The buccal face is convex in all directions, that from the morsal to the cervical borders being the most marked owing to the morsal half converging toward the centre of the tooth. The buccal groove (*o*) leading over from the morsal face, divides the face into two lobes which are full and rounded. Sometimes the disto-buccal groove cuts off another lobe, thus making three lobes on the buccal face. These grooves sometimes lead to the cervical border, but usually terminate in the middle of the face in a pit, which may become the seat of caries through faulty formation of the enamel.

The *lingual face* (*D*) is wide, rounded, smooth and convex, rather straight perpendicularly, leaning in the lingual direction. It forms a sharp angle with the morsal surface, which is surmounted with two tubercles. Sometimes, but rarely, the lingual groove passes over on to this face.

The *mesial* and *distal faces* (*s*) are wide and flattened transversely, but convex vertically. They are trapezoidal in outline, the morsal border being longer. The cervical border is more convex, and dips toward the neck of the tooth.

The *neck* (*t*) is very regular in outline and contour. It is approximately square with all four sides depressed in the centres. The mesial and distal are depressed at the origins of the grooves leading down upon the roots; the lingual and buccal are depressed at the bifurcation of the roots, the depression, which is wide and deep, extending up on to the neck, especially upon the buccal side. The enamel line is quite irregular, dipping down on the lingual and buccal, and leading well up on the mesial and distal sides.

The *roots* are two in number, placed with their longer diameter transversely to the jaw. They are wide bucco-lingually, and flat and narrow disto-mesially, being situated distally and mesially to the crown. The posterior is formed of the two posterior cones, and the anterior of the two anterior cones (*A*). This is plainly shown in the formation of the roots, which are grooved both distally and mesially, and in the tendency to bifurcation, which sometimes actually occurs. They divide close to the crown, so that the grooves of bifurcation extend well up on the neck. The distal root is thicker and more rounded than the mesial, the latter being more flattened, with the grooves deeper, and it is more often bifurcated. Both are deflected from the median line.

The *pulp canal* is shaped like the roots, with two main branches. The distal branch is the larger, being round and open, as the root is more rounded. The mesial branch is flat and spindle-shaped, being difficult to enter, and usually having two sub-branches following the buccal and lingual divisions of the root. These sub-branches are small and hair-like and troublesome to enter.

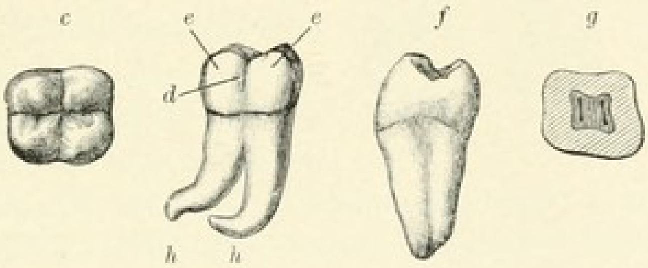
The **lower second molar** (Fig. 25) differs from the first in many respects. It is of the same general form, but is more quadrangular, as it has but four tubercles. It is more rounded and symmetrical than the first, the four cones and four primitive tubercles being well marked. The absence of the fifth tubercle leads to most of the differences between the second and the first molar.

The *morsal face* (*c*) has but four tubercles, one at each corner of the face, differing from that of the first molar, which has five. The fifth tubercle rarely appears in the higher races of mankind, but is sometimes found in the low and savage races, and occurs regularly in the apes. It is not uncommon in the negro, but is absent as a rule in the European races. The tubercles are symmetrical, rounded and obtuse, the lingual being, however, sharper than the buccal.

The *sulci* describe a cruciform shape, separating the four tubercles symmetrically from each other. The buccal groove sometimes continues on to the buccal face, rarely to the lingual. The triangular grooves run up on the morsal triangular ridges. The marginal ridges are well marked, the mesial and distal being often divided by grooves. The triangular ridges are usually well marked, leading to the centre of the tooth. They are full and strong.

The *buccal face* (*d*) is convex and of more regular form than that of the first molar. It is divided into two lobes (*e*, *e*) by the buccal

FIG. 25.



The lower second molar.

groove (*d*), which is rarely deep. A pit is often found in the centre of the face, which may become the seat of caries. The face is curved toward the centre of the tooth, as in the first molar.

The *lingual face* is similar to that of the first molar, but may be more rounded toward the morsal border. It is symmetrically convex in both directions.

The *mesial* and *distal faces* (*f*) are similar to those of the first molar except that, the crown being smaller, they may be more perpendicular, but are well rounded.

The *neck* (*g*) is more regularly formed than that of the first molar, the margin of the enamel line being quite as irregular. It may be more constricted.

The *roots* (*h*, *h*) are similar to those of the first molar, but are more rounded in shape, are usually crooked, and on that account difficult to treat.

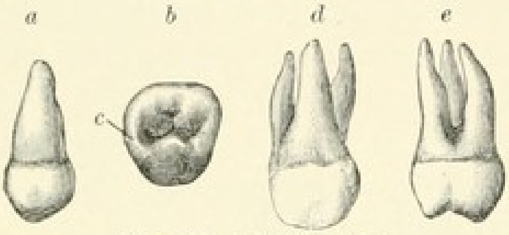
The *pulp canals* are similar to those of the first molar, but the tendency to crookedness renders treatment quite difficult. The direction of irregularity of form is so uncertain that no rule can be applied to it.

17. **The Third Molars.**—The upper and lower third molars can best be described together, on account of their similar eccentricities. They are very irregular as to the time and to the frequency of their appearance in civilized man. About one-half of the individuals of European races

erupt them at the normal period, *i. e.* seventeen to twenty-one years of age. In one-fourth they erupt at irregular intervals to the thirtieth year, and in the remainder they may appear later, or the first, second, third, or all of them, may be absent altogether. In one series of forty adult skulls observed, twelve had one or more absent. The absence and other erratic peculiarities of these teeth sometimes seem to be hereditary and can be traced in families through several generations.

This tooth is often reduced in size and may be a mere peg (Fig. 26, *a*). It is of very irregular form in civilized races, but is as large and as well formed as the other molars in most races low in the ethnological scale. The contraction of the jaws through disuse has much to do with the maldevelopment of this tooth, and it is often so cramped for room as to produce distressing irritation which necessitates its removal. Impaction and malposition of the third molars render them difficult of extraction and are the fruitful source of many serious lesions. (See the chapter on Extraction of Teeth.)

Fig. 26.



The upper third molar.

The **upper third molar** is more or less similar to the other upper molars when perfect and well developed, but it is very erratic as to form and structure.

This tooth, when well formed, is of trituberculate form (*b*), the disto-lingual cingule being suppressed. This cingule diminishes gradually from the first molar, in which it is well formed, to the second, where it is reduced, then to the third, where it is almost or entirely absent. The oblique ridge thus becomes the posterior marginal ridge (*c*), as in the typical trituberculate molar. The three tubercles are reduced and rounded. The sulci usually degenerate into fissures, as the formation of this tooth is notoriously faulty. The enlarged mesial fissures thus become the seat of extensive caries.

The *buccal face* resembles that of the first and second molars, but is more rounded.

The *lingual face* (*d*) is full and rounded, with but a single lobe, owing to the reduction or absence of the disto-lingual tubercle.

The *mesial face* (*e*) is similar to that of the second molar, but reduced, and the *distal face* is round and short, as no tooth succeeds it in the rear.

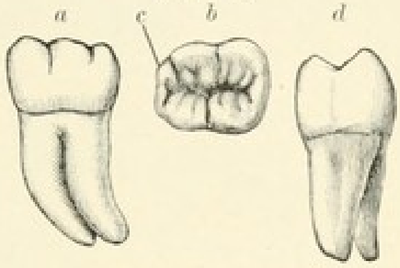
The *neck* is constricted and tapers toward the conate roots. It is of a rather rounded triangular shape.

The three *roots* of the upper molars are, in the third, usually more blunt, conate, short in form, and may curve backward. In lower races and sometimes in individuals having strong osseous organizations, the typical three molar roots are found. Sometimes there are multiple roots, which are likely to be curved in various directions and may have decided hooks.

In the large conate root, the *pulp canals* usually coalesce, but in cases in which the root is divided there will also be division of the pulp chamber.

The **lower third molar** is similar to the other lower molars in general form (Fig. 27, *a*), but is probably not so erratic and not subject to such extreme variations. The crown is quadrangular in section, the angles rounded.

Fig. 27.



The lower third molar.

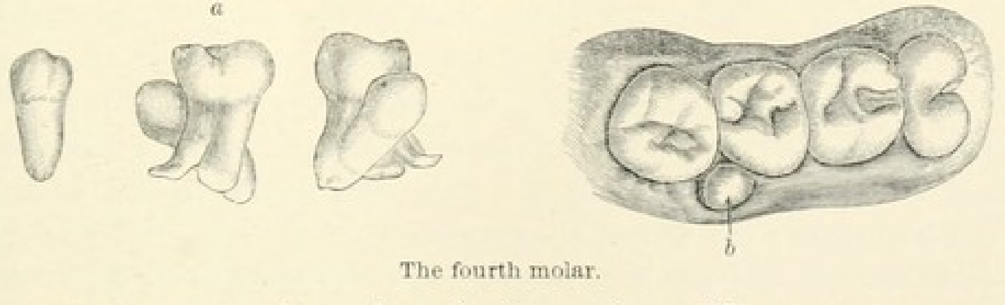
On the *morsal face* (*b*), there are four principal tubercles as in the second molar, but this may be supplemented by the extension of the disto-marginal ridge into a cingule or heel (*c*). This heel is rather erratic; it may be large or small, thus modifying the size of the morsal surface. Sometimes the face is wrinkled and, like this tooth in the orang utan, the sulci exhibit the cruciform shape similar to that of the second molar. The many grooves leading away from the main sulcus may be imperfect and become the seat of caries. The buccal groove running from the morsal on to the buccal face (*a*) is very subject to imperfection.

The four *lateral faces* are similar to those of the second molar, except that the distal is more convex and full, and often very prominent if the fifth cingule is well developed.

The *neck* is of similar shape to that of the second molar.

The *roots* are similar to those of the other lower molars, but generally smaller as compared with the crown (*d*). They are usually divided like the others, but the two may be fused together, or be closely opposed. In either case they are usually projected distally more or less, leading backward into and under the ramus, thereby rendering extraction of this tooth difficult and dangerous, especially where the maxilla is of

Fig. 28.



The fourth molar.

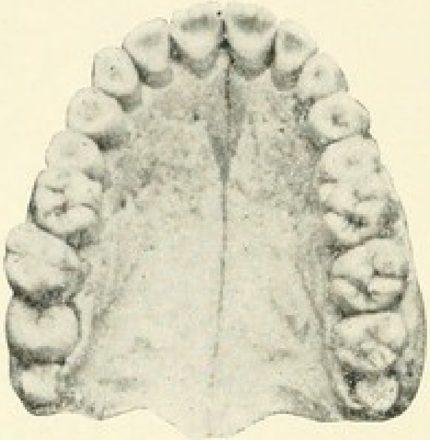
dense structure or where there is impaction. The roots are usually more rounded, especially the distal one, than those of the other molars.

The *pulp canals* are generally divided, whether the root is or not.

As the roots are usually crooked, the difficulty of entering them is increased, as the canals follow the form of the roots.

Fourth molars sometimes appear as supernumerary teeth, and are either fused to the upper third molar in a variety of uncouth forms (Fig. 28, *a*) or erupt separately as mere peg-shaped teeth between the buccal faces of the second and third molars (*b*) or at the distal aspect of the latter tooth. The fourth molar rarely appears as a full molar, except in some of the large-toothed races, as negroes, Australians, etc., and then usually in the lower jaw. Among the negroes in Africa the fourth molar is sometimes found in full form as a typical molar.

FIG. 29.



Negro jaw with fourth molar.

THE DECIDUOUS TEETH.

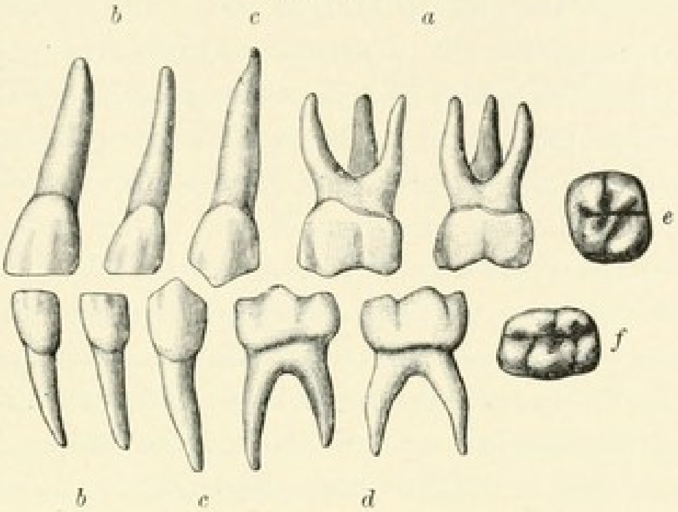
18. The DECIDUOUS TEETH are those which appear in infancy and serve the purpose of dental organs during the first years of the development of the individual, until the jaws and their environment are ready for the larger, permanent teeth to come into place. They bear a direct relationship to the conditions of the digestive apparatus and the food required at that early stage. The food of infancy being simple and requiring little mastication, the deciduous set are small and insufficient for the reduction of more resisting substances. As these foods come to form part of the dietary, the larger teeth of the permanent set appear, and perform the duties of higher functional activity.

The *crowns* of the deciduous teeth resemble, in a general way, those of the permanent teeth which succeed them, except the deciduous molars (Fig. 30, *a*, *d*), which are very different from the bicuspids of the permanent set which displace them.

The **incisors** of both jaws precede the analogous teeth of the same series of the permanent set. They are similar in form, but reduced (*b*), and do not have the main features so characteristically marked. They are infantile in form and function. The roots of these teeth are resorbed at from the fifth to the ninth year, when the permanent incisors come into place, beginning with the lower centrals.

The **canines** (*c*) of both jaws are still more reduced from the strong,

FIG. 30.



The deciduous teeth.

full form of their permanent successors, and are but little more specialized than the incisors. They are of the same general form as the permanent canines, but much less developed.

But in the **deciduous molars** are found some important features which mark distinctive differences. They are of true molar form as compared with the permanent molars, but they occupy the place of the bicuspids. There are no bicuspids in the deciduous set, the molars being of full molar pattern (*a*, *d*).

The deciduous molars of both jaws are of irregular, quadrangular form on the morsal surface, diverging rapidly outward to the neck, which presents a large buccal ridge standing out at the margin of the enamel, and is rounded off suddenly to the neck, which is much contracted. This thick ridge is characteristic of the deciduous molars and is absent in those of the permanent denture. It is somewhat more prominent and bulging on the buccal than on the other faces. In adjusting ferrule crowns to these teeth, the gold need not be carried beyond this ridge but burnished over it slightly.

The *morsal surface* (*e*) of the upper deciduous grinders presents the characteristic pattern of the upper molars, four tubercles, oblique ridges, etc., but reduced and contracted. A distinctive feature is that the marginal ridges and angles are more acute and sharp than in the permanent molars. Sometimes the two lingual cusps are reduced to one and the lingual border is rounded and crescentic.

The second molar is larger than the first and the morsal surface is wider.

The transverse diameter of the crowns of the upper molars is the longest.

The LOWER MOLARS (*d*) are similar to the permanent molars in pattern, but are more irregular as to the contour of the morsal surface (*f*). The tubercles may be higher than in the upper molars, and the triangular ridges more marked. The central fossa may be large and wide, or divided by the triangular ridges. The second molar is five-lobed, unlike the second permanent molar, which has but four cusps. The morsal face is decidedly trapezoidal in outline, the mesio-distal diameter being greater than the transverse.

The *roots* of the deciduous molars are similar to those of the other molars, except that they are very divergent to accommodate the crown of the advancing bicuspids. They are thin and long, and difficult to enter and fill. The pulp chamber is large and open in the crown; as a consequence of this caries soon reaches the pulp. Treatment and filling of the canals is difficult and uncertain.

The Variations of Tooth Forms.

19. The teeth *may vary quite extensively* from the typal forms which have been described, and these variations may be due to a number of causes. Through all degrees of variation, however, the type is still preserved, unless the tooth form is quite destroyed by pathological causes.

The general causes of variation may be enumerated as follows:

(1) Incompleteness of development.
(2) Reversion to primitive types.
(3) Temperamental impress.
(4) Pathological lesions.

(1) Under **incompleteness of development** may be grouped all those varieties of stunted growth which are the effect of disuse and the consequent effort of Nature to reduce and suppress the teeth as useless parts. The third molar teeth suffer most from these suppressive attempts of Nature in the effort toward economy of growth; next to these teeth, the upper lateral incisors are most frequently affected by reduction of size, stunted growth and suppression. Other teeth are rarely affected, or but very slightly, by this influence, except in rare cases.

(2) Under the second head, **reversion to primitive types**, we have a variety of interesting phenomena in the form of parts of the human teeth which seem to be a zoological legacy. These consist of conspicuous features which reappear and seem to recall forms of the teeth observed in some of the lower animal orders, especially the quadrumana and insectivora.

Among these features may be mentioned the curved upper central incisor with the prominent cingule on the lingual-buccal ridge, making a notch which recalls the incisors of the moles; the prominent cingule on the lingual face of the lateral incisor, which is not uncommon and recalls the form found in the insectivora and some of the quadrumana; the extra-long, curved canine, with extra-large median ridges, which recalls the large forms of this tooth in the baboons and in the carnivora; the double root sometimes found in this tooth is also a reversion to the insectivorous type; the three-rooted bicuspid is a quadrumanous reversion; the upper tricuspid molar is a primitive typal form, leading back to the lemurs and beyond them to the early typal mammals found in fossil formations; the notched and grooved incisor recalls the divided incisor of the *Galeopithecus;* the double-rooted lower incisors and canines recall insectivorous forms; the unicuspid lower first bicuspid is an insectivorous type and is often quite marked in man; the fifth cusp on the lower second molar is a quadrumanous reversion; the wrinkled surface of the lower third molar is like that of the orang.

There are other features that might be named illustrating the workings of the *law of atavism,* by which parts once lost in evolution may reappear and be reproduced.

(3) Under the third head, **temperamental impress,** may be noticed those differences of form and structure which have relation to the dominant temperament in the constitution of the individual. Great differences exist between the teeth of different persons, and these are mainly dictated by *temperament.*

The teeth of the *primary basal temperaments* present the following physical peculiarities, which are characteristic of the particular temperament:

The BILIOUS TEMPERAMENT presents teeth that are of a strong yellow; large, long, and angular, often with transverse lines of formation, without brilliancy, transparency, and of but slight translucency; firm and close set and well locked in articulation.

The SANGUINE TEMPERAMENT has teeth that are symmetrical and well proportioned, with curved or rounded outlines, and round cusps; cream color, inclined to yellow, rather brilliant and translucent; well set, and occlusion firm.

The NERVOUS TEMPERAMENT has teeth which are rather long, the cutting edges and cusps long and fine; color pearl-blue or gray, very transparent at the apex; the occlusion very penetrating.

The LYMPHATIC TEMPERAMENT presents teeth that are pallid or opaque, dull or muddy in coloring; large, broad, ill-shaped, cusps low and rounded; the occlusion lose and flat.

Of the *binary combinations*·

The SANGUINEO-BILIOUS has teeth which are large, with strong edges and large cusps ; color dark yellow, and quality good.

The NERVO-BILIOUS has teeth that are long and narrow, with long cusps ; color yellowish or bluish or both combined ; the enamel strong, the dentin soft.

The LYMPHO-BILIOUS has teeth that are large, with thick edges and short thick cusps ; yellowish in color ; enamel of good structure and polish, and dentin fair.

The BILIO-SANGUINEOUS has teeth of average size, round arch, well-developed cusps and edges ; rich dark-cream color ; excellent in quality.

The NERVO-SANGUINEOUS has teeth of average size, good shape, round arch, good edges and cusps ; rich cream color ; enamel and dentin of excellent structure.

The LYMPHO-SANGUINEOUS has teeth of more than average size, shapely edges and cusps, rounded arch ; color grayish cream ; enamel and dentin fairly good.

The BILIO-NERVOUS has teeth variable in size and form, sometimes broad, again very long with more pointed and long cusps ; the color generally bluish ; enamel fairly good, dentin soft and sensitive.

The SANGUINEO-NERVOUS has teeth of average size, good shape, round arch ; color grayish blue ; soft and frail.

The BILIO-LYMPHATIC has teeth usually large, with thick edges, short thick cusps, and flat arch ; color yellowish ; quality good.

The SANGUINEO-LYMPHATIC has teeth of more than the average size, broad round arch ; color gray ; enamel and dentin poor.

The NERVO-LYMPHATIC has teeth of average size, good shape, average length, rather round arch ; color bluish gray ; soft and poor.

Combinations of the binary temperaments are of the most common occurrence in individuals, but there is usually one basal temperament that preponderates over the others and gives its characteristic to the teeth as a predominating influence.

(4) Under the fourth head, **pathological lesions**, are to be included all those disturbances of nutrition which eventuate in faulty formation of the teeth, whether due to specific hereditary diseases, mere malnutrition, idiosyncrasies, predispositions, defective functional life, etc. But this leads beyond the province of this chapter into the field of special pathology.

CHAPTER II.

THE EMBRYOLOGY OF THE DENTAL TISSUES.

By R. R. Andrews, A. M., D. D. S.

A clear understanding of the minute structure of the teeth can only be had through a study of the complex processes through which the tissue elements have had their origin or have derived their forms. The teeth do not belong to the bony skeleton of the body, but, like the hair, nails, etc., are parts of the dermal system.

The origin of the tissues of the teeth is from two of the three germinal layers of the blastoderm, the epiblastic and mesoblastic layers. A transverse section through the blastoderm of a chick shows that the epiblast, or outer layer, is formed of cells like columnar epithelium; their shape is probably due to lateral pressure of adjoining cells. It is from this layer that epithelium is formed, and epithelial tissue is the origin of the enamel. The mesoblast, or middle layer, is composed of cells said to be derived from both hypoblast and epiblast, but principally from the latter.[1] They are merely nucleated structures, containing granules, the nuclei of the future cells of the connective tissues. In this state they have no cell-limit or wall; as they grow older they accumulate around themselves formed material. Only in maturer stages do these cells develop, on their surfaces, an optically distinct membrane or other structure. It is from the cells of the mesoblast that the embryonic connective tissue which forms the *dentinal papilla* originates.

Development of the Jaws.

As stated by Prof. Sudduth,[2] the first indication of the formation of the oral cavity is seen very early in the life history of the embryo. The superior maxilla arises from three separate points: on either side of the embryonic head a process springs from the first pharyngeal arch. The processes pass downward and forward, and unite with the sides of the nasal process. From the frontal prominence, the third process, the incisive, grows downward and fills in the space between the ends of the two preceding processes. By a union of these three processes the superior maxillæ are completed. The inferior maxilla is formed by buds growing from the first pharyngeal arch; these buds grow rapidly until

[1] The three layers of the blastoderm are also designated as ectoderm, mesoderm, and entoderm respectively.

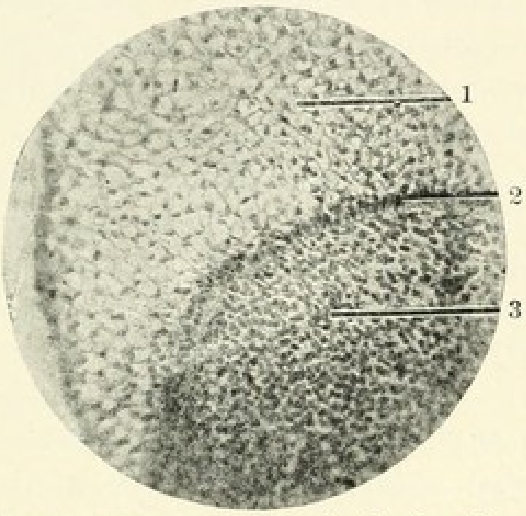
[2] *American System of Dentistry*, vol. i. p. 550.

union occurs at the median line. The central portion of the arch thus formed, very soon after the union of the two lateral processes, becomes differentiated into a cartilaginous cord or band, which serves to strengthen the embryonic jaw. This is Meckel's cartilage. It is formed of two parts arising from the mallei of the ears and traversing both sides of the embryonic jaw to the point of union. While the jaw-bone is forming, Meckel's cartilage disappears by absorption ; some authorities believe it becomes ossified, forming part of the inferior maxilla.

The Embryonic Mucous Membrane.

If at a time just previous to tooth formation a section across the lower jaw is cut, it will be found to consist of a central mass of embryonic connective-tissue cells edged on every surface by the innermost layer of the epithelium. This covering of epithelium is the Malpighian or mother layer, most important to the dental histologist, because from it originate the enamel organs of the teeth, as well as the bulbs of the hair and the epithelium of the glands. Thus early the Malpighian layer consists of cells somewhat like those of the connective tissue within, but they stain more deeply and are really epithelial cells, having their origin from the cells of the epiblast. This Malpighian layer is, again, everywhere covered by epithelial cells, which are continually formed by it.

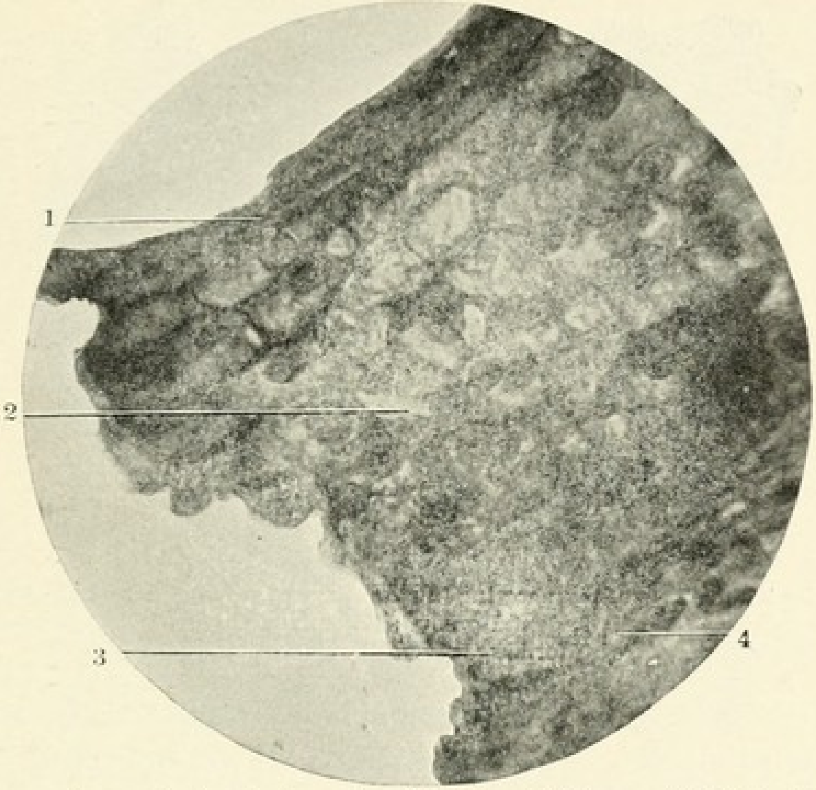
Fig. 31.



Section of jaw, embryo of pig, showing the appearance of mucous membrane before the formation of the enamel organ : 1, epithelium ; 2, stratum Malpighii ; 3, embryonic connective tissue.

When the tissue is older, the cells of the stratum Malpighii become columnar or prismatic in shape, standing somewhat vertically over the embryonic tissue beneath. They have large round nuclei, and some authors have stated that they have no cell-wall. Just without these are larger cells, sometimes called youthful cells, and external to these the cells are larger and are more polygonal in form, representing the cells in their middle life, in which the cell-wall has increased in thickness, while the nucleus is found to be smaller. Those cells on the outer surface are the aged cells, consisting almost wholly of formed material. They in time lose their vitality, having undergone changes, until, from the fresh mass of protoplasm, they finally become thin, lifeless scales, which in adult tissue are constantly cast off during the life of the individual. They are reproduced from the cells of the stratum Malpighii.

FIG. 32.



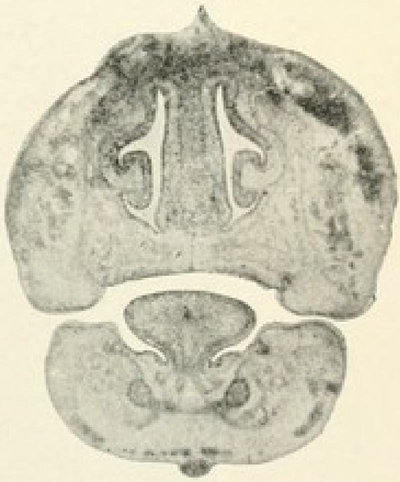
Section of jaw, embryo of pig, showing the epithelium highly magnified: 1, oldest epithelial cells; 2, the younger cells; 3, the infant layer, the stratum Malpighii; 4, the embryonic connective tissue.

The epithelium, as has been stated, is derived from the epiblast, and is developed considerably earlier than is the embryonic connective tissue beneath.

THE DENTAL RIDGE AND DENTAL GROOVE.

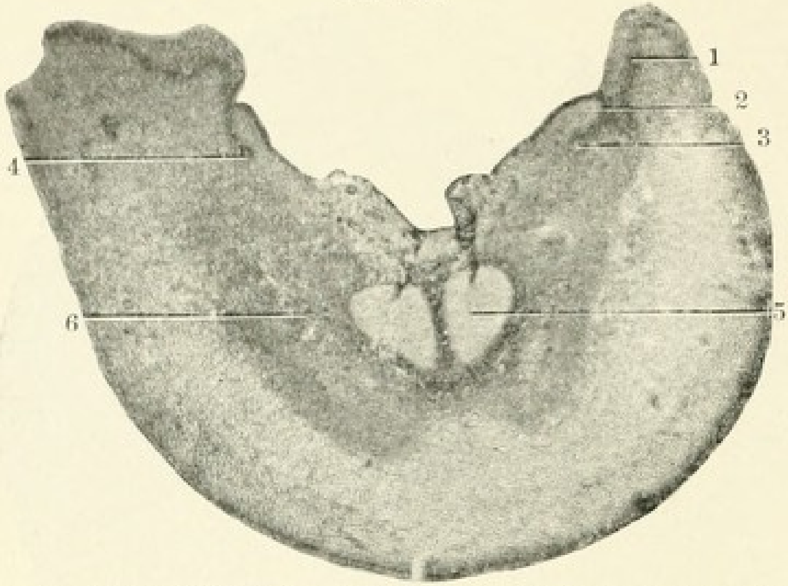
On that portion of the jaw which is to become the alveolar border, between the fortieth and forty-fifth days, there is seen a growth of cells, which looks as though it had been pushed up in the form of a smooth ridge. If a section is cut across the jaw at this time, and examined, it will be found that this ridge consists of a mound of epithelial cells which some writers have called the MAXILLARY RAMPART. This growth of cells is seen to have had a more energetic growth inward into the substance of the embryonic tissue than it has had outward, so that a groove containing epithelium is formed around the entire upper border of the jaw, and in this condition has been called the TOOTH BAND.

FIG. 33.



Section through the jaws of human embryo, showing developing enamel organs. (Section by Dr. Sudduth.)

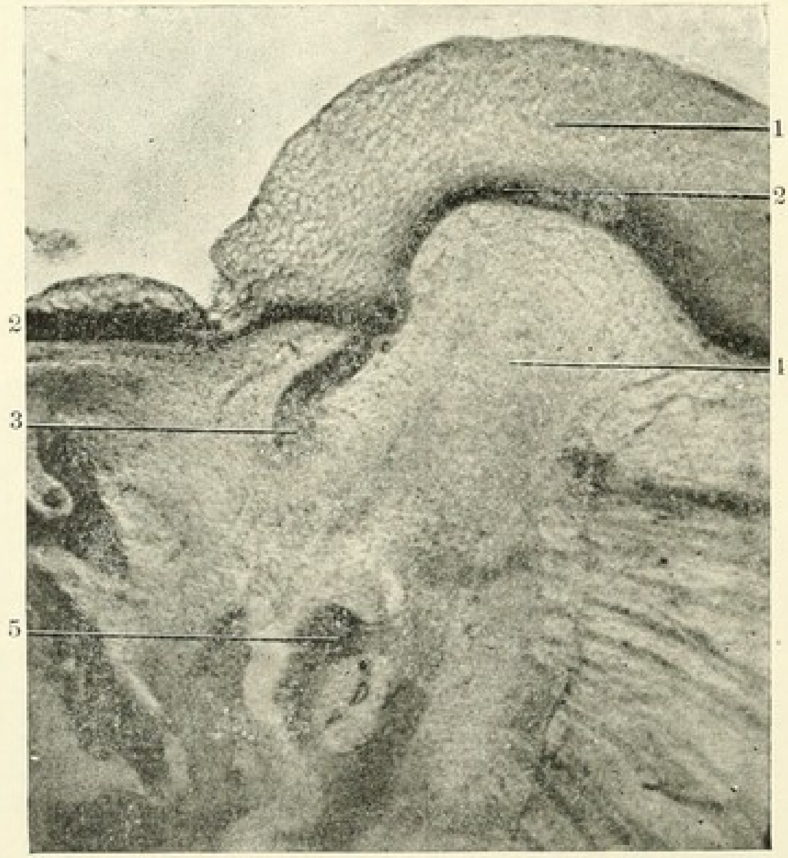
FIG. 34.



Section of lower jaw, embryo of pig, showing the first stage of growth in enamel organ: 1, epithelium; 2, stratum Malpighii; 3, dental groove; 4, commencing growth of temporary enamel organ; 5, Meckel's cartilage; 6, forming bone of jaw. (Section by Dr. Sudduth.)

The cells of the layer next the embryonic connective tissue are always more or less columnar. They are directly derived from, and are a part of, the stratum Malpighii. It was the loss of this epithelial tissue, per-

FIG. 35.

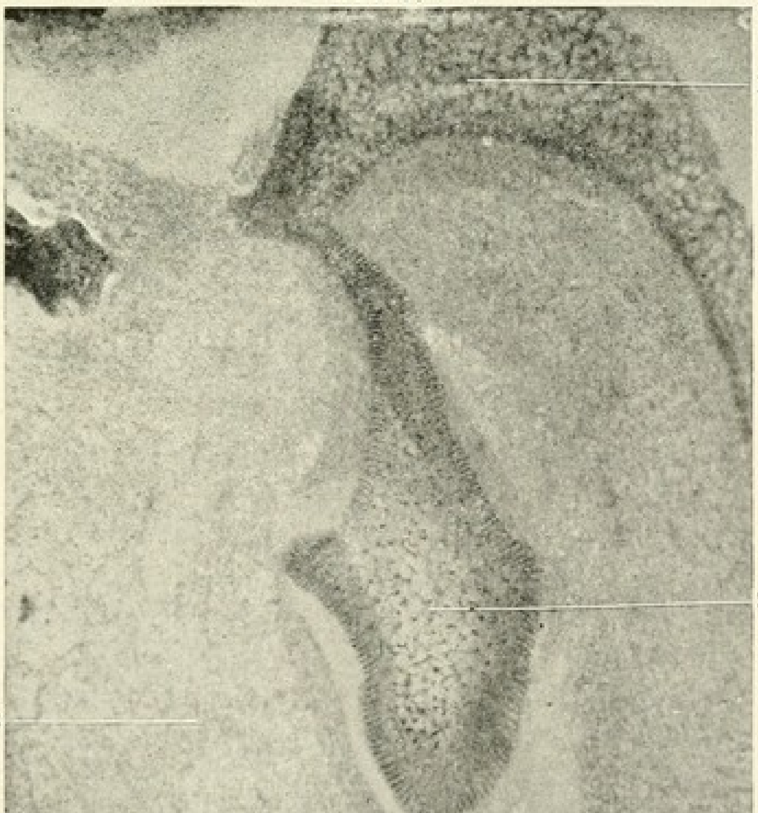


Section of jaw, embryo of pig, showing growth of enamel organ: 1, epithelium: 2, stratum Malpighii: 3, first stage in growth of enamel organ of temporary tooth; 4, embryonic connective tissue; 5, developing bone of jaw.

Fig. 36.

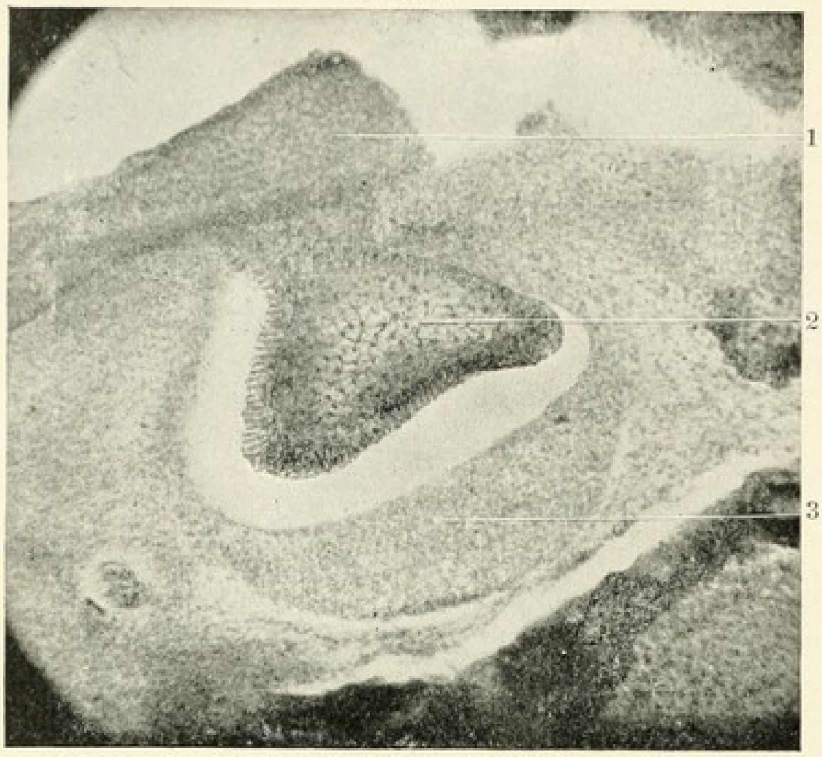
Section of jaw, embryo of pig, showing growth of enamel organ: 1, epithelium; 2, Malpighian layer: 3, second stage in growth of enamel organ; 4, embryonic connective tissue.

Fig. 37.



Section of jaw, embryo of pig, showing growth of enamel organ: 1, epithelium; 2, second stage in growth of enamel organ; 3, embryonic connective tissue.

FIG. 38.



Section of jaw, embryo of pig, showing growth of enamel organ and zone of dentin-forming tissue: 1, epithelium; 2, enamel organ; 3, zone of dentin-forming tissue.

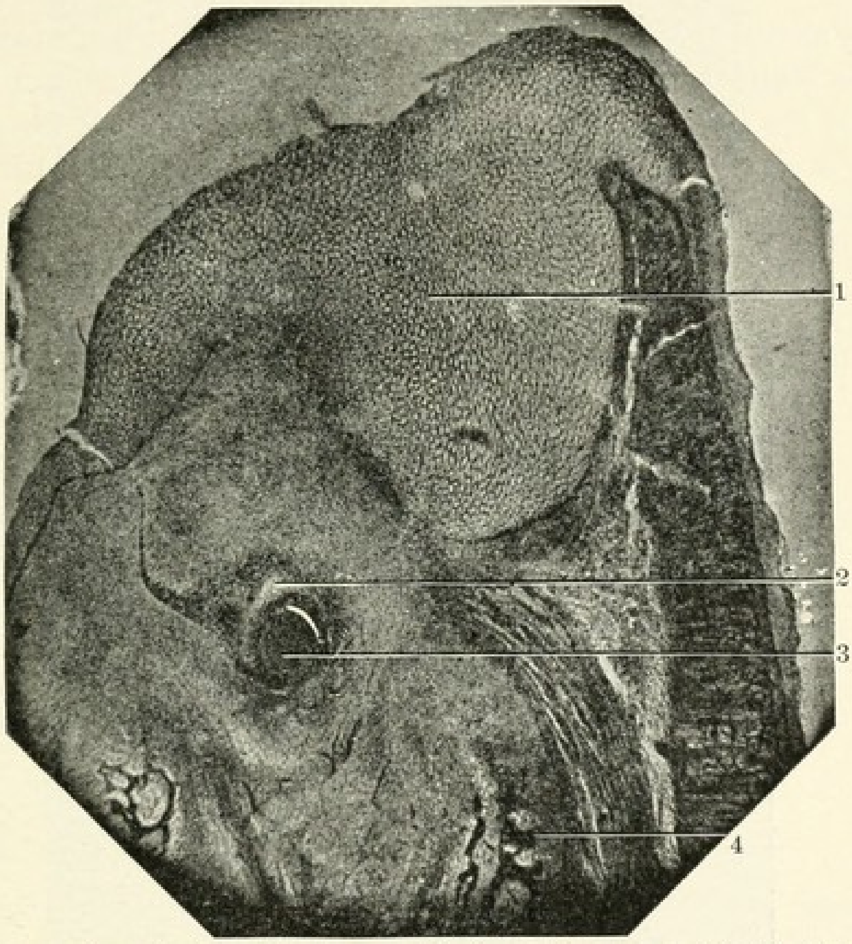
FIG. 39.

Section of jaw, embryo of pig, showing growth of enamel organ and first stage in growth of dentin germ: 1, epithelium; 2, enamel organ; 3, dentin germ. (The enamel organ has been pushed away from the dentin by the knife in cutting the section, leaving a space between the two.)

haps by the action of too powerful reagents, which led Goodsir and his followers to describe the appearance of an open groove. The Goodsir theory had no foundation in fact, because no such open groove ever existed in that situation.

The various foldings found in embryonic tissue no doubt are an expression of an economic provision on the part of Nature in caring for

Fig. 40.



Section of jaw, embryo of sheep, showing growth of enamel organ and dentin germ: 1, large mass of epithelium; 2, enamel organ; 3, dentin germ; 4, growing jaw.

the tissue that is to be taken up by the expansion of the parts during its growth, as eventually they are all smoothed out. Röse's models[1] show that the original inflection (stratum Malpighii) at an early stage divides into two portions, one of which, the outer, is nearly perpendicular and is intimately connected with the formation of the lip furrow, whilst that immediately under consideration passes almost horizontally backward into the tissue beneath.

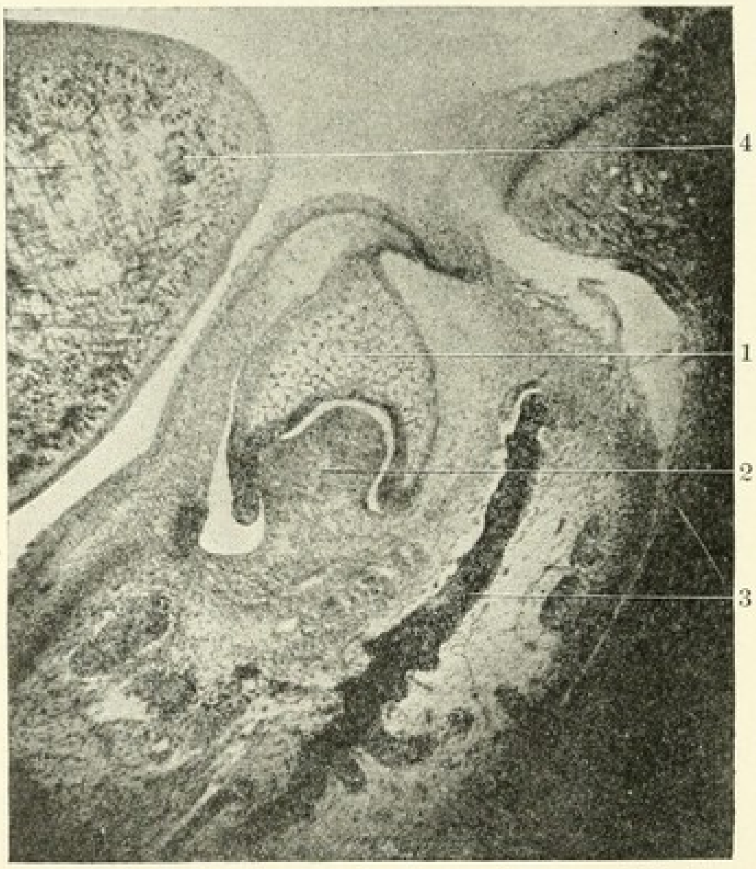
At about the forty-eighth day, from the lingual side of this groove, at a point where a tooth is to be formed, a portion of the stratum Malpighii is found growing into the embryonic connective tissue, in

[1] *Models of Developing Teeth and Jaws.* By Carl Röse, M. D.

shape somewhat like a bud, and this is the first indication that a tooth is to be developed—the commencing growth of the ENAMEL ORGAN. This ingrowth increases, and assumes the shape of a tubular gland, pushing its way into the connective tissue. It may now be called an EPITHELIAL CORD, and at the end farthest from the epithelium proper a growth of cells takes place, this part expanding from the multiplication of cells within, which causes it to assume the form of a Florentine flask.

Just at this time, at a point somewhere between this expanding part and the Malpighian layer above, a budding takes place from this cord, which is the commencing growth of the *enamel organ of the permanent tooth*. A change is taking place in the embryonic tissue just under the flask-shaped enamel organ ; a very active growth of cells is seen to be

FIG. 41.



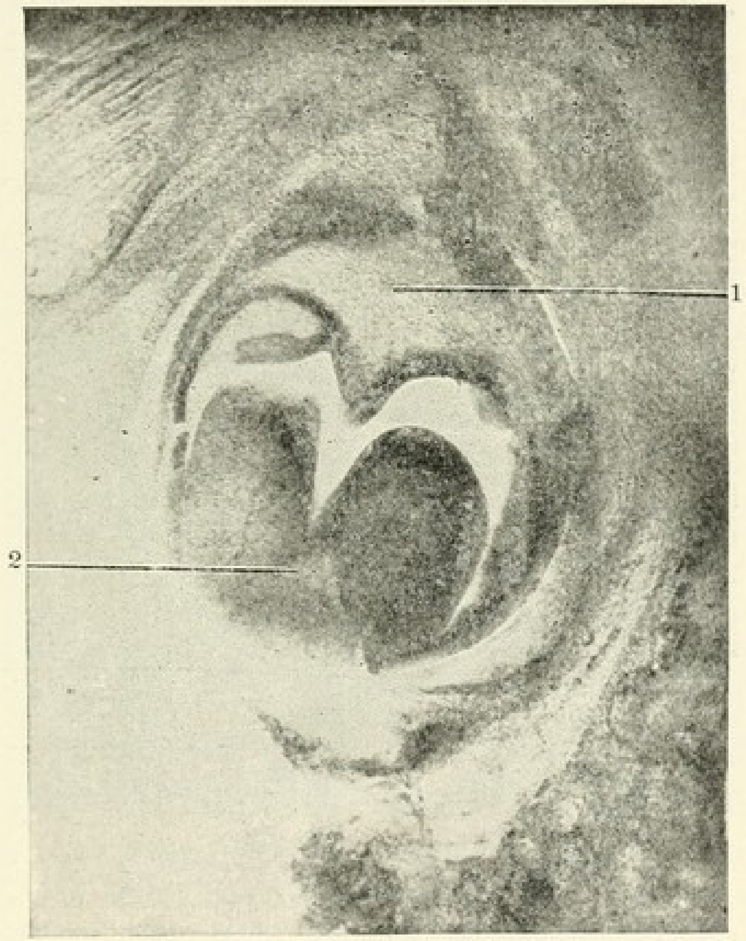
Section of jaw, embryo of pig, showing growth of enamel organ and dentin germ: 1, enamel organ; 2, dentin germ; 3, growth of jaw; 4, tongue.

going on, and this activity results in the formation of a *papilla*, the first stage in the growth of the DENTIN GERM.

As the enamel organ enlarges by an increase of cells within it, the borders of its base grow inward, covering the dentinal papilla like a cap or hood, enclosing it at its base. The cells within the enamel organ are seen to have changed; they are no longer like epithelial formations, but form a reticulum and have a stellate appearance when seen in section.

While the change in form of the central cells of the enamel organ is taking place, the dentin germ is assuming the form of the future tooth-point. From the base of the dentin germ, connective tissue is being

Fig. 42.

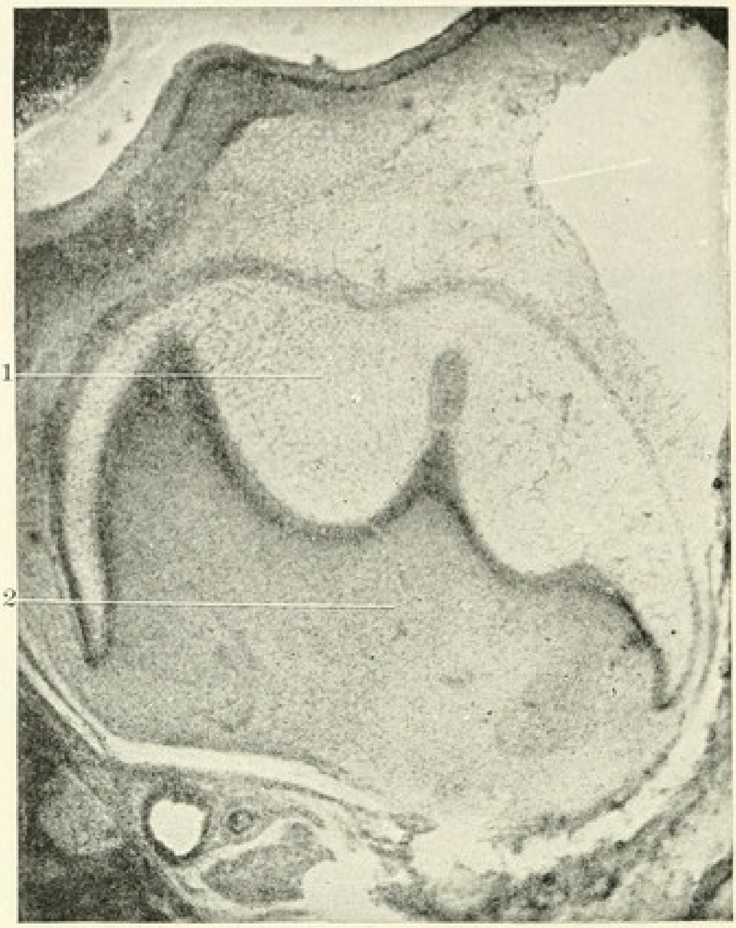


Section of jaw, embryo of pig, showing development of temporary molar tooth: 1, enamel organ; 2, dentin germ.

formed around the enamel organ, like the outer walls of a bag, this layer being the wall of the DENTAL SACCULUS; and when the enamel organ is nearly enclosed, the epithelial cord that connects it with the Malpighian layer breaks up into epithelial clusters; some of which wander toward the Malpighian layer, while others cluster to the wall of the sacculus, where it is supposed they become absorbed. In their origin the sacculus and dentin germ are identical, springing as they do from the embryonic connective tissue.

At this time there is no evidence of a basement membrane. When the enamel organ and dentin germ become enclosed in the sacculus, it and its contents become the dental follicle, at which period calcification is about to commence.

FIG. 43.



Section of jaw, embryo of pig, showing development of temporary molar tooth: 1, enamel organ; 2, dentin germ.

THE ENAMEL ORGAN.

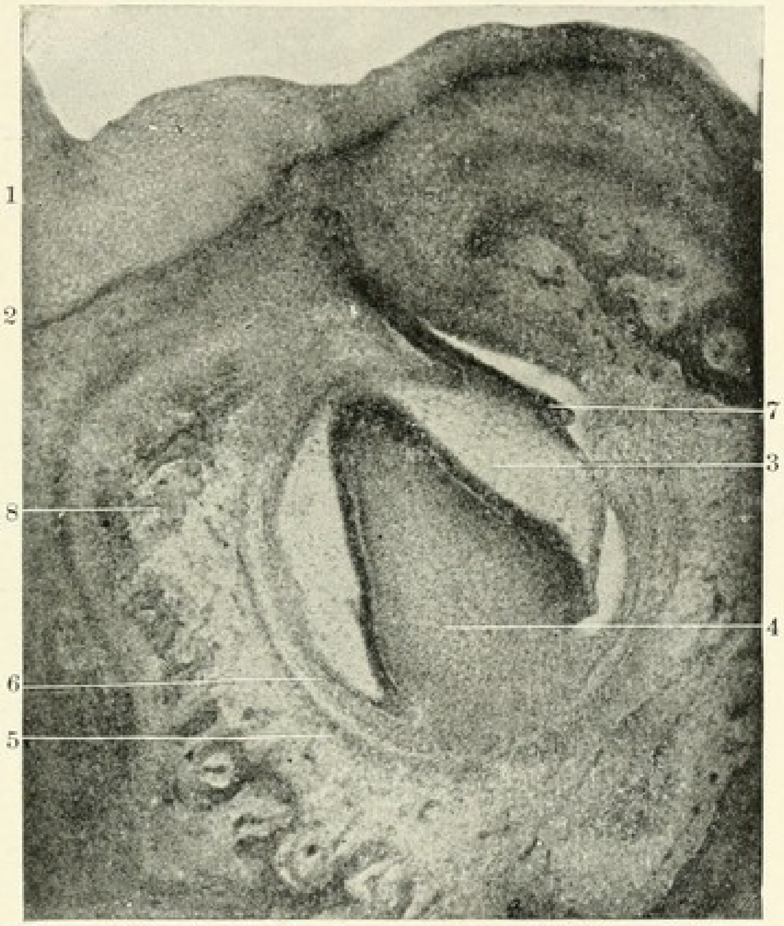
The **enamel organ** is now in its perfected state. On examination it is found to be composed of three distinct cellular forms. The essential layer is the ameloblastic layer of columnar cells which rests upon the dentin germ. These are the cells that are to become the *enamel cells* or *ameloblasts*. They have become changed by pressure into very symmetrical hexagons, four or five times as long as they are broad, with a distinctly marked nucleus in the part farthest away from the dentin germ. Only the sides of the cells are said to have membranes: they are without covering at either end. These cells are longer just over the point of the dentin germ and are shorter as they approach its base, being here very much like those of the outer layer, the external epithelium of the enamel organ.

This outer layer is composed of cells which are *roundish*, a little longer than they are wide, and seem to be losing their columnar form. Indeed, soon after calcification has commenced these cells disappear.[1]

[1] It is a question what becomes of them. Some authorities think that they are the origin of Nasmyth's membrane, but this is very doubtful, for investigation shows that

Just within these two epithelial layers there is found the second important layer of cells, and this layer has been named the *stratum intermedium* (see Fig. 55). The cells of this layer are intermediate in shape

FIG. 44.



Section of jaw, embryo of pig, showing development of dental follicle and first stage in the growth of the permanent enamel organ; also the formation of walls of the sacculus: 1, epithelium; 2, Malpighian layer; 3, enamel organ; 4, dentin germ; 5, outer wall of sacculus; 6, inner wall of sacculus; 7, bud of enamel organ of permanent tooth; 8, growing jaw.

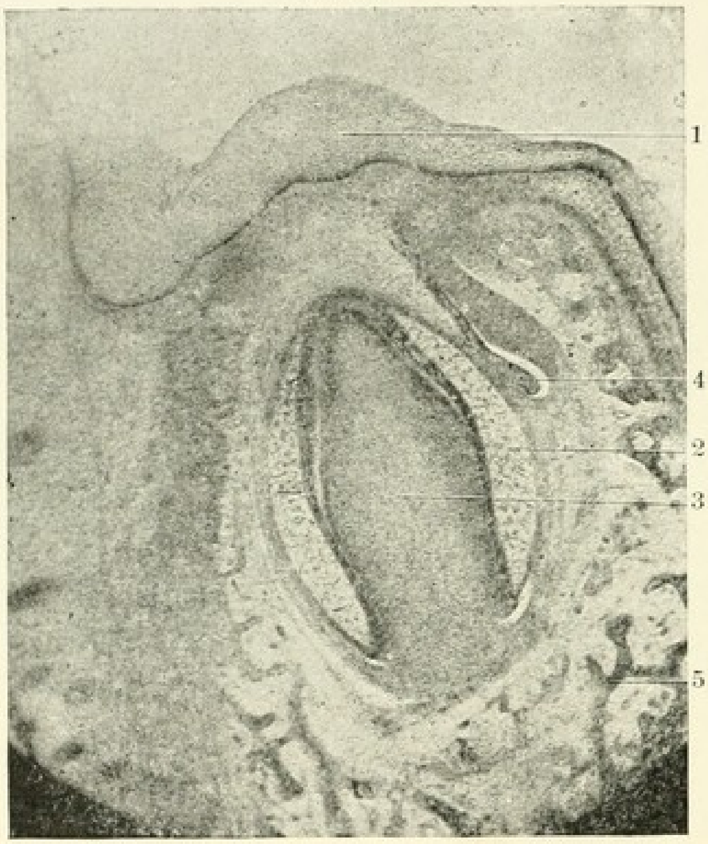
between the ameloblasts and those of the stellate reticulum. The layer was first described by Hanover, and is thought to be a supplying and nourishing layer to the ameloblasts. Over these they remain, while everywhere else they disappear as calcification progresses. It is probable that they give birth to new enamel cells as the circumference of the enamel layer increases by growth. By careful examination it will be found that they are connected by minute processes with the enamel cells and also with the stellate cells of the central portion. Dr. Lionel Beale first made the statement that a vascular network lies within the stratum intermedium. This fact has recently been confirmed by other English

they are completely lost some time before the completion of the calcification of the enamel. Just after a layer of dentin has been formed, everywhere upon its surface are seen the enamel cells, ready to form the enamel, and no trace of the outer epithelium can be seen. It has disappeared from that part in the perfected enamel organ.

workers, for Tomes mentions the fact that Prof. Howes and Mr. Poulton have demonstrated this vascular network in the stratum intermedium of the enamel organ of the rat.

Dr. J. Leon Williams, in an article on "The Formation and Structure of Dental Enamel,"[1] demonstrates with his photo-micrographs the existence of this vascular network in the stratum intermedium of the rat which had been previously seen by these English observers, but it is to be remembered that this vascular network forms after the outer

Fig. 45.



Section of jaw, embryo of pig, showing development of dentin germ and enamel organ of permanent tooth: 1, epithelium; 2, enamel organ; 3, dentin germ; 4, budding of enamel organ of permanent tooth; 5, developing jaw.

portions of the enamel organ have disappeared, and only when the connective tissue of the jaw is in contact with the cells of the stratum intermedium.

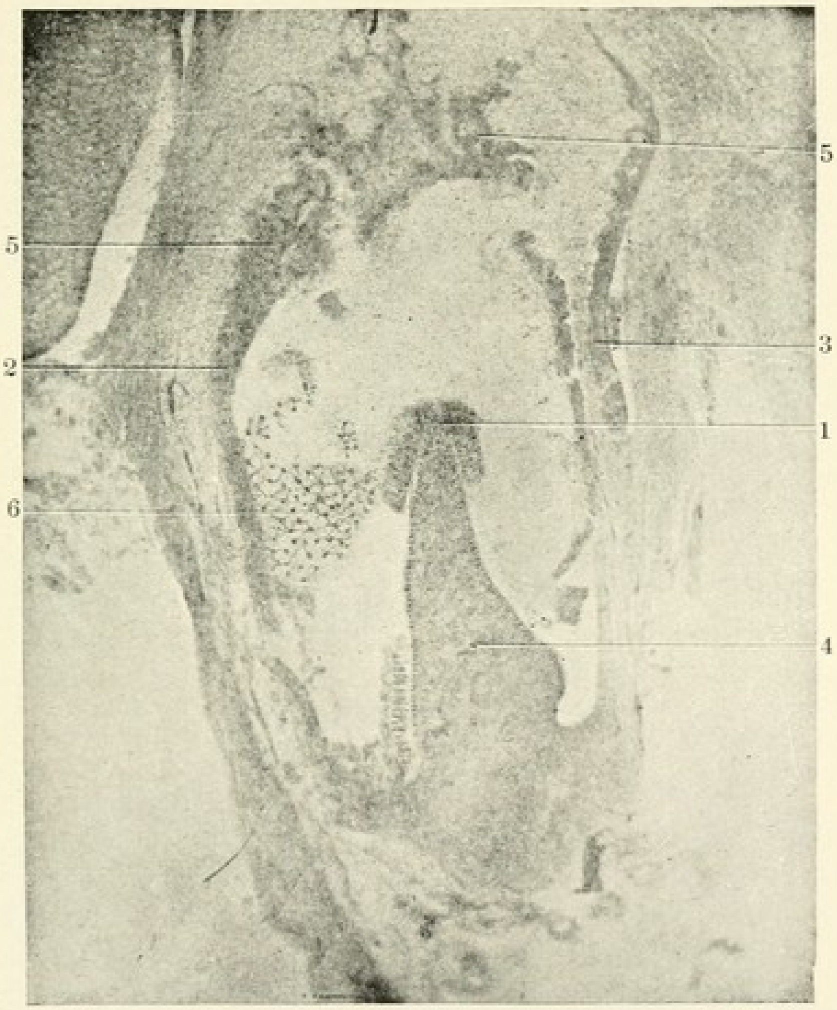
The third form of cells fills up the central portion; they appear star-shaped, and have been called the *stellate reticulum* of the enamel organ. Between the cells is to be found a fluid rich in albumin; the consistence of this is somewhat like a jelly; indeed, enamel organs have been called enamel jelly or enamel pulps. Tomes states that the function and destination of the stellate reticulum is not very clear. Enamel can be very well formed without it, as is seen among reptiles

[1] *Dental Cosmos*, February, 1896.

and fish, and even in mammalia it disappears prior to the completion of the enamel. It has been supposed to have no more important function than to fill up the space subsequently taken up by the growing tooth. Kölliker does not agree with this. He states that the stellate reticulum is certainly of great importance in the building up of enamel, and, owing to its richness in albumin and the gelatinous mass in its meshes, is, figuratively speaking, a pantry from which the enamel membrane (the ameloblasts) derives the material for its growth,—being some distance from blood-vessels.

The cells of the stellate reticulum are characterized by the great length of their communicating processes. Dr. Sudduth thinks that

Fig. 46.

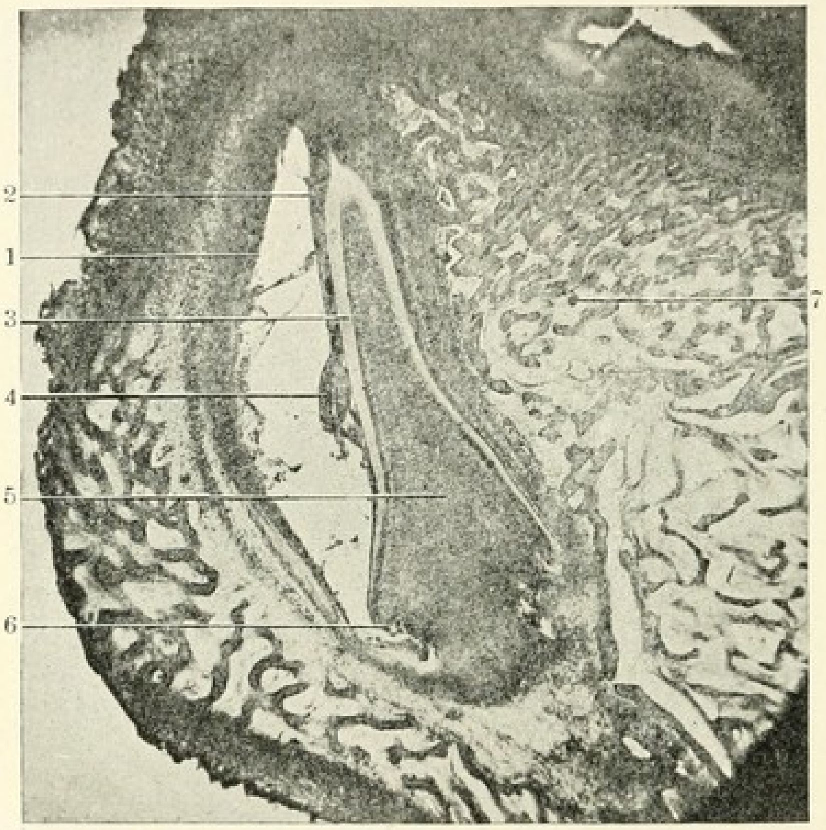


Section of jaw, embryo of sheep, showing development of dentin germ: 1, layer (portion of) of ameloblasts; 2, external epithelium of enamel organ (most of the stellate reticulum has been washed out); 3, enamel organ of permanent tooth; 4, dentin germ; 5, whorls of epithelial cells caused by breaking up of neck or cord of enamel organ; 6, part of stellate reticulum.

this appearance is largely due to shrinkage. He says: "I fully believe that if we could examine these cells at once before any shrinkage occurs, we should be able to prove the fact that in life they are not stellate but large polygonal cells." Dr. Williams has shown[1] that this supposition of Dr. Sudduth is a fact. In his photo-micrographs he has clearly demonstrated the cell contents filling in the spaces between the stellate tissue. He shows them to be very perfect nucleated cells lying in the so-called stellate reticulum, which is really the slightly modified cell wall.

The "stellate reticulum," then, may be regarded as a storehouse of

FIG. 47.



Section of jaw, embryo of pig, showing developing tooth (section teased away from tooth to show the fold in the enamel substance): 1, enamel organ; 2, enamel substance not yet calcified; 3, layer of formed dentin; 4, a fold in the enamel substance; 5, dentin pulp; 6, folds at base of dentin germ; 7, developing bone.

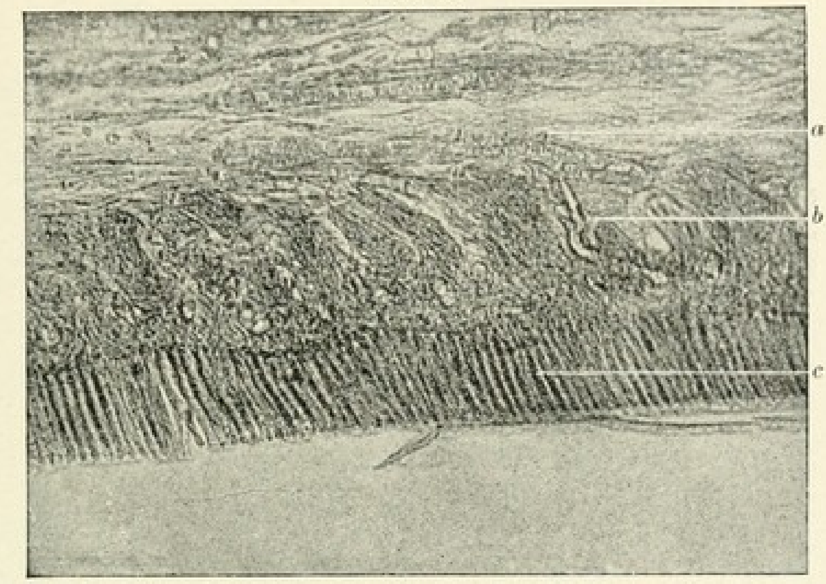
the calcium salts from which the first-formed layers of enamel are supplied. That calcium salts exist in the meshes of the stellate reticulum may be proven by placing a drop of dilute nitric acid on the slide when it passes under the cover-glass. The globules or granules which were noticed there disappear as the acid reaches them, and bubbles accumulate and are forced out from under the glass cover. After the calcifying process commences and enamel is forming, the calcium salts are supplied by a rich plexus of blood-vessels now in direct contact with the cells of the stratum intermedium, all other portions of the enamel organ having disappeared from this part. Indeed, it is difficult to demonstrate clearly the cells of the stratum intermedium after any

[1] *Dental Cosmos*, February, 1896.

considerable portion of the enamel has been formed; they appear to have been lost in the connective tissue which is everywhere above them.

The origin of the *enamel organs of the permanent teeth* may be de-

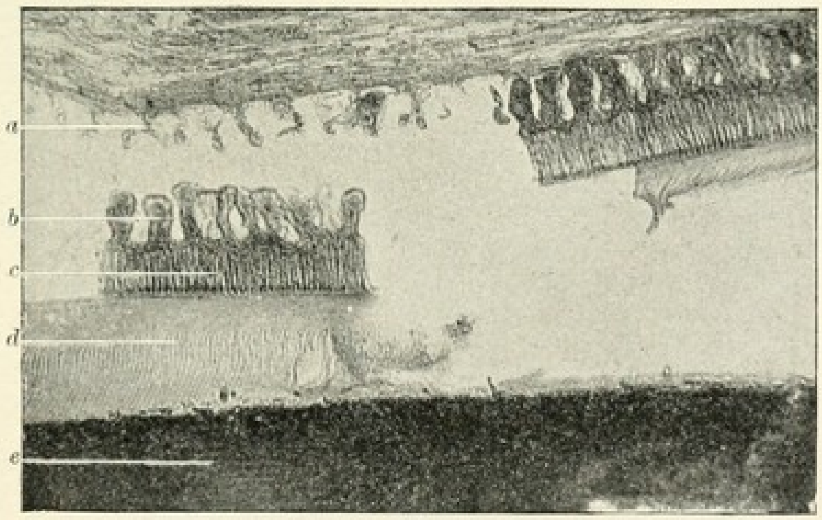
Fig. 48.



Section of incisor of rat (× 175): *a*, blood-vessels with corpuscles *in situ*; *b*, branch of same descending to supply capillary loops about secreting papillæ; *c*, ameloblasts. (Dr. J. Leon Williams' specimen.)

scribed in general as follows: From the neck of the enamel organs of the twenty deciduous teeth, midway between the stratum Malpighii and the temporary enamel organ, growths in the form of buds are being

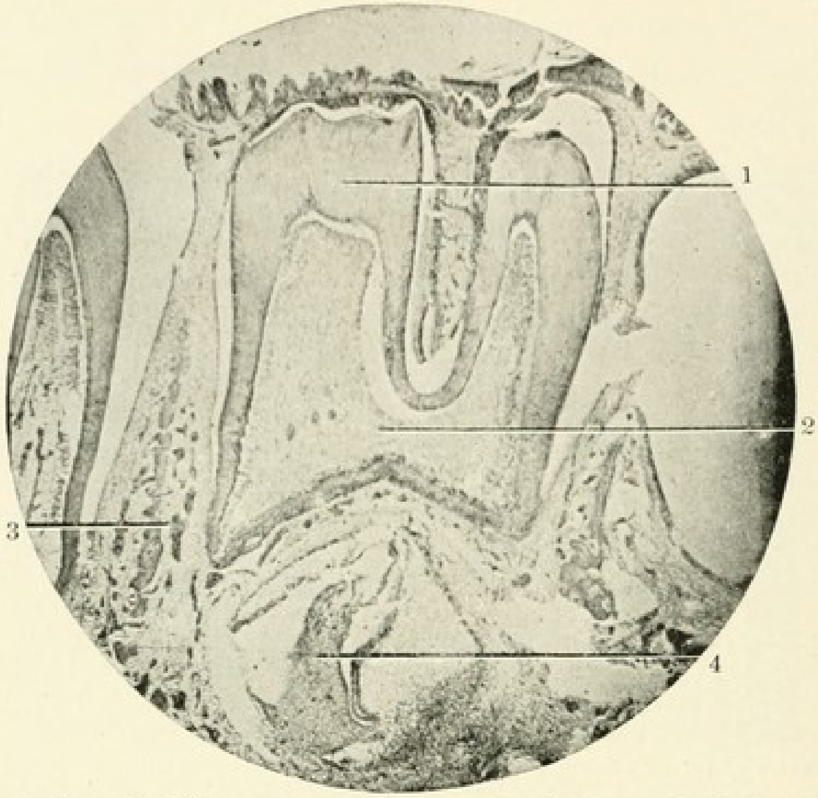
Fig. 49.



Section of incisor of rat (× 80): *a*, capillary loops torn out of secreting papillæ; *b*, secreting papillæ after removal of capillary loops; *c*, ameloblasts; *d*, enamel; *e*, dentin. (Dr. J. Leon Williams' specimen.)

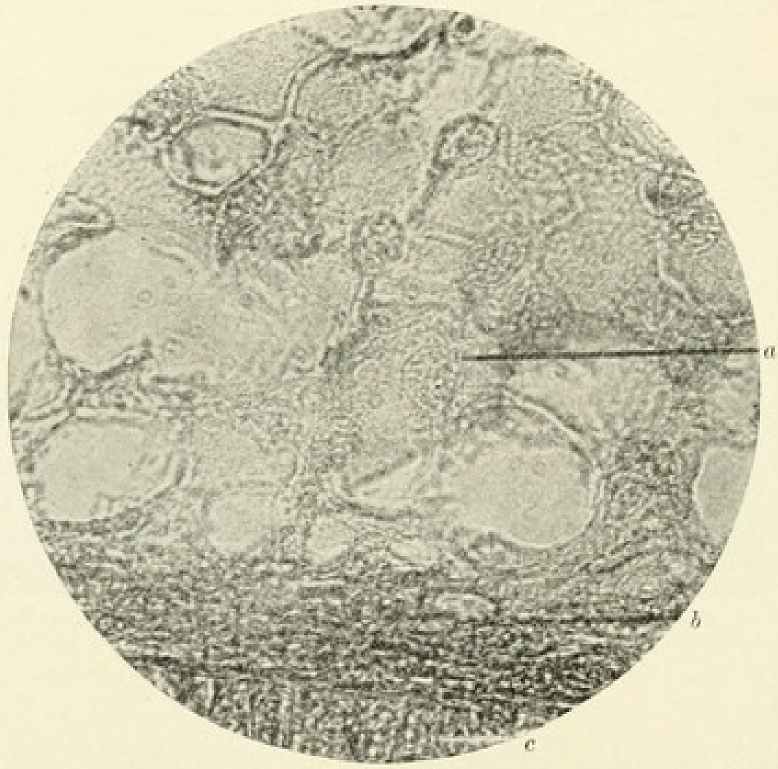
formed, increasing in length, and these result in the formation of the enamel organs of the permanent teeth, their growth taking place on the lingual surface of the temporary teeth. Soon after this, the tem-

FIG. 50.



Section of jaw, embryo of rabbit; permanent tooth seen developing under the temporary molar: 1, enamel of temporary tooth; 2, dental pulp; 3, developing alveolar wall; 4, permanent dentin germ. (Section by Dr. Sudduth.)

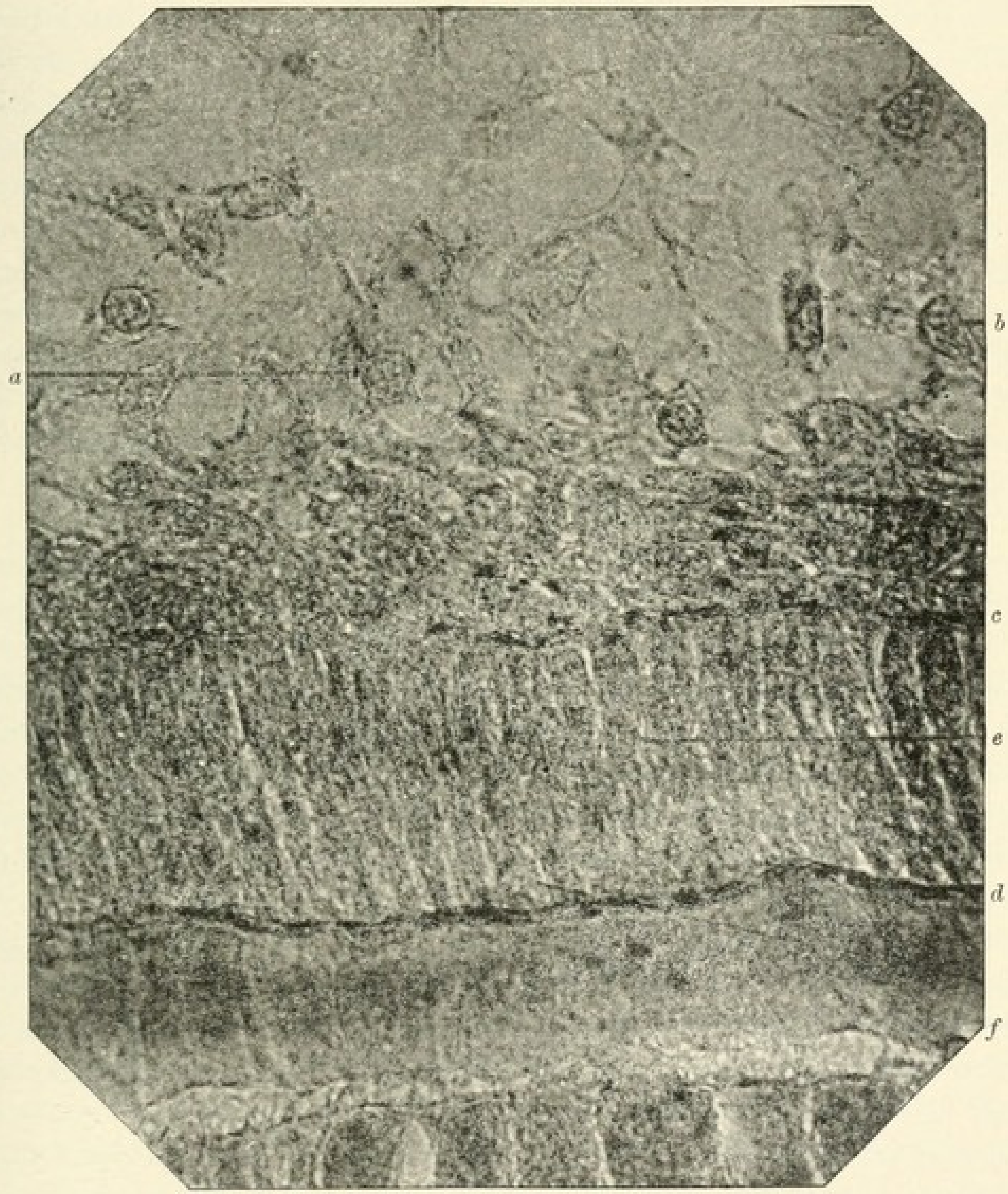
FIG. 51.



Section of developing tooth of human embryo (× 1000): *a*, large nucleated cells of middle layer (reticulum) of enamel organ; *b*, stratum intermedium; *c*, ameloblasts. (Dr. J. Leon Williams' specimen.)

porary enamel organ becomes separated from its cord. Between the temporary enamel organ and the permanent enamel bud, the cord of the temporary enamel organ is seen to be breaking up and losing its connection with the stratum Malpighii; while the cord for the per-

FIG. 52.



Section of developing tooth, embryo of calf (× 1000): *a*, *b*, nuclei of reticulum of enamel organ, showing spongiose character; *c*, outer ameloblastic membrane; *d*, inner ameloblastic membrane; *e*, *f*, enamel globules faintly showing nuclear network. (Dr. J. Leon Williams' specimen.)

manent tooth appears as a continuation of the Malpighian end. The cord for the permanent incisor in the human embryo is formed about the fifth month, and while descending into the embryonic connective tissue assumes a spiral form of growth, as do the necks of most of the enamel organs of the permanent teeth, growing down to take their positions under the temporary teeth, where they go through all the changes that have been spoken of in describing the growth of the temporary enamel organ. Dr. Sudduth says that as a rule the cords for the permanent molars arise directly from the epithelium of the mouth, that is, the Malpighian layer. Other authorities state that the first permanent molar only is from the Malpighian layer, as is the enamel organ of the temporary tooth. Bödecker is the author of the statement that all the permanent molar teeth are an offspring of the enamel organs of the second temporary molar tooth. The enamel organ of the second permanent molar is an outgrowth from the first permanent molar; the enamel organ of the third permanent molar being an outgrowth from that of the second. Von Brunn holds that the primary function of the enamel organ is that of determining the form of the future tooth. He goes so far as to assert that its calcification into enamel in some animals is a secondary function taken on later. In support of this opinion, he says that enamel organs are universal, even where no enamel is found. He holds that wherever dentin is to be found, there is an antecedent "form-building" investment of enamel organ.

The Dentinal Papilla.

The **dentinal papilla**, or, preferably, the **dentin germ**, has its origin in the embryonic connective tissue of the jaw. Sometime about the second month of fœtal life, as the enamel organ of the first-forming teeth assumes its flask-like shape, and the cells within its central portion are seen to be differentiating, just under it is noticed an area of dense tissue, in shape somewhat like a crescent. It is distinctly outlined by its dense and active cell-multiplication. This is the first indication of the commencing growth of the dentin germ. As the enamel organ enlarges, and assumes the shape of a surrounding cap, a papilla-like growth takes place coincidently with it. About the ninth week it assumes the pointed form of the future incisor. With these changes the outer layer of the connective-tissue cells next the enamel cells will be found to have changed their form, and to have assumed a very distinct columnar appearance, forming a layer somewhat like the enamel cells, but broader. This layer has been falsely called a membrane, "membrana eboris" or membrane of the ivory. It is not a membrane, and all recent authorities ignore it as such. If the tissue has been carefully prepared, minute glistening bodies are seen, under the higher powers of the microscope, within the substance of the germ. These are *calcospherites*, and are seen everywhere near the odontoblastic layer in the dentin germ, as well as in the enamel organ, near the enamel cells. They are mostly minute globules. Some are larger than others, caused undoubtedly by several merging together. They indicate that the process of calcification is about to begin, and are constantly present while it is going on, throughout the process of the formation of the tooth.

Dr. Sudduth is authority for the statement that there is no real union between the dentin germ and the enamel organ. There exists no intimate connection between the two surfaces other than that of perfect adaptation to each other: vessels or nerves have never been demonstrated to pass from one to the other. The relation is analogous to that sustained by the epithelium and dermal layers of the mucous membrane of the oral cavity, from which they have their origin. Bödecker, on the other hand, states that there is a connection between the two. He says that when the enamel organ is detached from the papilla—as it frequently is, in sections—its outer surface appears beset with an extremely delicate fringe, the true connection between the papilla and the enamel organ.

The Dental Follicle.

The walls of the dental sacculus have their origin in the area of tissue which is so plainly marked by its increasing growth, seen just under the enamel organ while in the shape of a flask. At this early stage are seen, from the outer edges of this area of tissue, encircling processes which, as the dentin germ forms, grow rapidly up, surrounding the enamel organ on all sides (see Fig. 53). Some authorities have stated that the dental sacculus does not wholly cover the enamel organ, but in the collection of the writer are specimens where its walls are seen to completely cover the dentin germ, so that it apparently is wholly enclosed. The bone of the jaw is now forming rapidly about it (making a nest, as it were, in which the sacculus and its contents, now the *dental follicle*, rest. The cells within the tissue of this sac are found to have separated by growth into two layers. They have not changed their form, but remain connective-tissue cells. The outer layer is seen to be much denser and very much more vascular than the inner one, and this is to form the dental periosteum; the inner one is said to form the cementum of the root.

This differentiation of a portion of the dental sac into a softer and looser tissue, but little firmer than that of the stellate reticulum of the enamel organ, has been thought by Magitôt to be sufficiently pronounced to justify him in calling it a distinct organ,—the "cement organ." But the existence of such an organ is doubted by many authorities. Prof. Sudduth is of the opinion that the tissues of the sacculus do not arise wholly from the base of the dentin germ, but largely from a condensation of the fibrous connective tissue in which the enamel organ lies. The follicular wall just over the surface of the enamel organ is oftentimes found in folds. These have been called "papilliform eminences," and are seen to be projecting into or near the enamel cells. To this appearance some authors attach considerable importance, but it is

FIG. 53.

Section of jaw, embryo of pig, showing dental follicle: 1, dental follicle, consisting of enamel organ, dentin germ surrounded by the sacculus within the substance of the jaw; 2, jaw-bone; 3, tongue; 4, papillary layer of tongue.

doubtful if it has any significance. It, like the folds in many other embryonic tissues, is to be taken up by the expansion of the part by growth.

In regard to the cement organ, Tomes says: "In those creatures which have cementum upon the roots of the teeth only, no special covered organ exists; but osteoblasts, which calcify into cementum, are furnished by the tooth sac."

The gubernaculum is a thin fibrous cord of dense tissue, connecting the permanent tooth follicle in its bony shell with the gum tissue just back of the neck of the corresponding temporary teeth. It is a structure of no importance.

Calcification.

Calcification is a process by which organic tissues become hardened by a *deposition of salts of calcium* within their substance. In the intercellular tissue and in the substance of the cells themselves, these salts are deposited by the rich blood supply always near. They are deposited in minute particles and in such fine subdivisions as to make it difficult to demonstrate many of them even with the higher powers of the microscope. The intercellular substance, either a protoplasmic or gelatinous fluid or semifluid, contains the calcium particles. In it they change their nature chemically, uniting with the albuminous organic substance of the part, and form small globular bodies which have been called calco-spherites; and these, blending or coalescing at the point of calcification, form a substance called calco-globulin. This calco-globulin, which is a lifeless matter, has been deposited through the cells into the gelatinous substance, where, by a further hardening process, it becomes the fully calcified matrix.

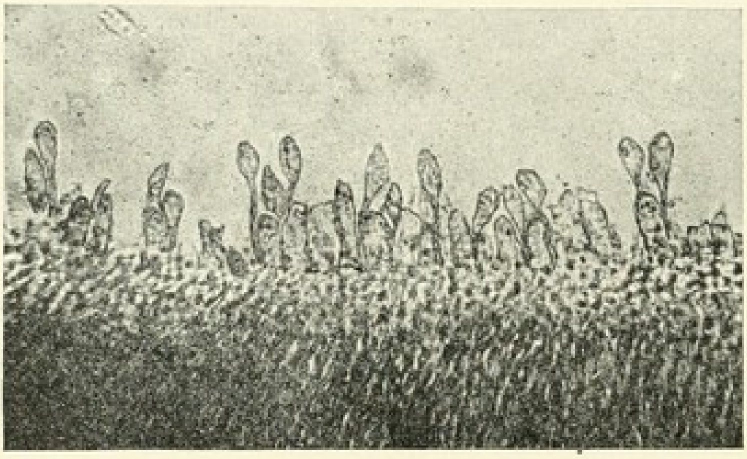
Mr. Rainey, and later Prof. Harting and Dr. Ord, have devoted much time to the study of this substance. Mr. Rainey found that if a soluble salt of calcium be slowly mixed with another solution capable of precipitating it, the resultant calcium salt will go down as an amorphous powder, and sometimes as minute crystals. But when the calcium salts are precipitated in gelatin, the character of the calcium salts is materially altered. Instead of a powder, there were found various curious, but definite, forms quite unlike the crystals or powder produced without the intervention of the organic substance. Mr. Rainey found that if calcium carbonate be slowly formed in a thick solution of albumin, the resultant salt has changed in character; it is now in the form of globules, laminated, like tiny onions, which coalesce into a laminated mass. In this Mr. Rainey claims to find the clue for the explanation of the development of shells, teeth, and bone.

At a more recent date, Prof. Harting took up this line of investigation and found that other calcium salts would behave in a similar manner. The most important addition to our knowledge made by Prof. Harting lay in the very peculiar constitution of the "calco-spherite," by which name he designated the minute globular forms seen and described by Rainey. Mr. Rainey found that albumin actually entered into the composition of the globule, since it retained its form even after the action of acids. Prof. Harting has shown that the albumin left behind after treatment of a calco-spherite with acid is no longer ordinary albumin; it is profoundly modified, becoming exceedingly resistant to the action of acids. For this modified albumin he proposes the name "calco-globulin." Microscopic glistening globules like those described above are constantly seen at the edges of tissue where enamel, cementum, dentin, or bone are to be formed or are forming. Robin and Magitôt have described isolated spherules of calcium salts as occurring abundantly in the young pulps of human teeth, as well as those of other animals, and Tomes suggests that perhaps all deposits of calcium salts commence in this way. These microscopic globular bodies are *calco-spherites.*

CALCIFICATION OF THE DENTIN.

Although the enamel organ is first formed, with its layer of ameloblasts all ready to commence the process of calcification, it is at the tip and within the substance of the *dentin germ* where this process really begins. The papilla has assumed the form of the point of the future tooth crown; the cells everywhere upon its outer surface—the

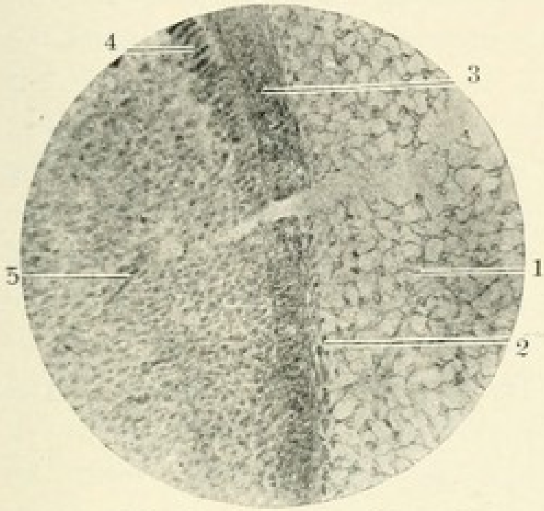
Fig. 54.



Section of growing tooth of calf at birth, showing the layer of odontoblasts and fibril cells attached to the forming dentin.

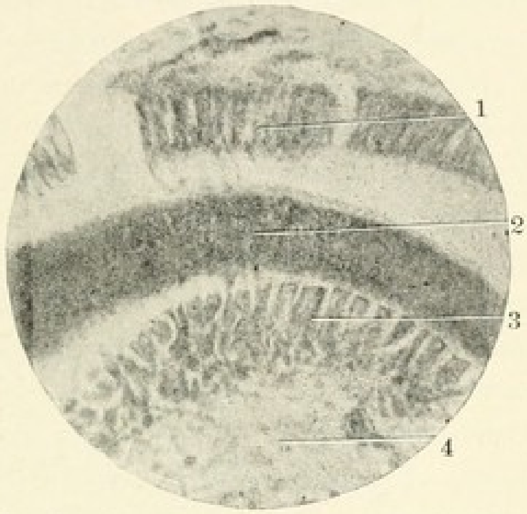
odontoblastic layer—are found to be actively at work forming the first cap of dentin. They are seen to be imbedded in a transparent and structureless gelatinous substance, in which small globular masses are already forming. The cells are clearly defined, being somewhat broader than the ameloblasts just above them, and like them are seen to be in a single layer, which has been named the "membrana eboris," but it is not a true membrane (see Figs. 55 and 56). The cells are found to vary in form, according as the formation of the dentin is actively going on or not. During the period of their greatest activity they are broad at the end directed toward the dentin cap, so as to look almost abruptly truncated, having as many as three or four, in some instances as many as six, dentinal processes proceeding from a single cell, Boll having counted as many as six. The cells are finely granular, and are, according to Waldeyer and Boll, destitute of membranes. The nucleus is oval and lies in that part of the cell farthest from the dentin, and is sometimes prolonged toward the dentinal processes so as to be ovoid or almost pointed. The dentinal process passes into the canals of the

FIG. 55.



Section of developing tooth, embryo of pig: 1, stellate reticulum of enamel organ; 2, stratum intermedium; 3, internal epithelium of enamel organ (ameloblasts); 4, forming odontoblasts; 5, pulp tissue.

FIG. 56.



Section of jaw, embryo of pig: 1, ameloblasts showing Tomes' processes: 2, layer of formed dentin; 3, odontoblasts; 4, pulp tissue. (Section by Dr. Sudduth.)

dentin, and it frequently happens that the layer of odontoblasts is slightly separated from the dentin in making a section, when these processes, which constitute the dentinal fibrils, may be seen stretching across the interval in great numbers. Intermediate between the permanently soft central fibrils and the general calcified matrix is that portion which immediately surrounds the fibril, namely, the dentinal sheath.

In 1891 Mr. Mummery noted, as the dentin was forming, the appearance of connective-tissue fibers, or bundles of fibers, just in advance of the main line of calcification. Their high refractive index suggested their partial calcification, the processes being continuous from the formed dentin to the general connective tissue of the dentin germ. He found in a young developing tooth a distinct reticulum of fine fibers passing between and enveloping the odontoblasts. By careful focussing, he saw these fibers gathered into bundles and incorporated with the matrix substance of the dentin, out of which they seemed to spring. The origin of these fibers seems to be from connective-tissue cells, which are found everywhere in the formative pulp next the odontoblastic layer, and also, as he has demonstrated, between the odontoblasts themselves. These fibers are the scaffolding on which the tooth matrix is built up; they are incorporated in the matrix of the dentin, and form really the basis of its substance.

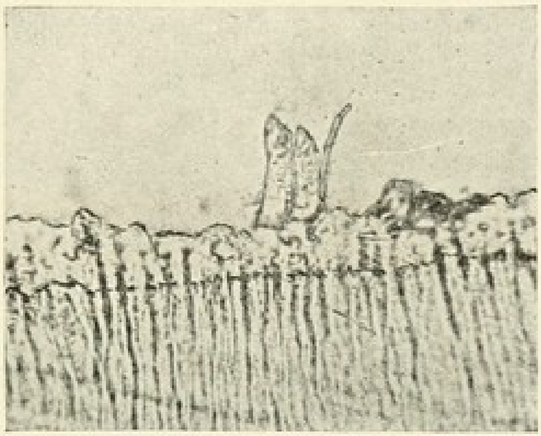
The odontoblasts are modified connective-tissue cells that superintend the deposition of the calcific material which is to form the calcified matrix. The thickening of the dentin is by successive deposits of this material in the form of layers which calcify. Fibrils from the odontoblasts remain within the formed and forming dentin as the persistent organic contents of the canals. This forming of the dentin is at the expense of the dentin germ, which is thus gradually reduced until it becomes, when the tooth is fully formed, its pulp. Thus it is seen that dentin is a secretion in the form of calcific material coming from the abundant blood supply in the pulp tissue near the odontoblasts. The material is given out from the cells in a globular form (calco-spherites) into a protoplasmic fluid, or semifluid, found everywhere against the calcifying dentin. In this substance is the scaffolding of fine connective-tissue fibers spoken of by Mr. Mummery, of London. The calco-spherites meeting against the formed dentin coalesce into a layer of calco-globulin, and this, becoming fully calcified, forms an additional layer of dentin, and the process continues until the tooth is formed.

By the deposition of calcium salts into the protoplasmic layer calco-globulin is formed, and by its calcification the dentin tissue becomes a homogeneous mass, penetrated by many parallel canals filled with the persistent dentinal fibrils. Beside these parallel canals with their fibrillar contents many lateral canals are seen branching off from the main canals and anastomosing with neighboring canals.

Exceptions may be taken to many of the statements of histologists in this field; many or most mistakes are traceable to faulty methods of technique. Processes which involve the securing of specimens while they are yet warm are greatly preferable. These are placed in a quarter of one per cent. to one-half of one per cent. solution of chromic acid, which is changed several times a day, for three or four days. At the end of this time the edges of the dentin which were calcified are found to be sufficiently softened to make a number of sections. The teeth are then taken from the acid solution, washed in distilled water, placed in a solution of gum arabic for several hours, and next transferred to a solution of alcohol to abstract the water. Paraffin and lard are melted together and poured into a convenient mould. When this clouds in the process of cooling, the tooth, which has had its outer surface dried as much as possible with bibulous paper, is placed in it and the whole allowed to cool. The microtome for this purpose should permit the immersion of both tissue and knife when the sections are cut. These sections float off in the fluid, and remain there until used. Sections are cut until the calcified tissue is reached. The sections are placed in distilled water for a few minutes to dissolve out the gum, and then mounted in glycerin jelly. The difference in the appearance in the tissue prepared by this method is marked. It is seldom necessary to stain tissues which are to be studied under the higher powers of the microscope.

The *dentin matrix* is mainly a connective-tissue calcification, and it should be remembered in examining sections of forming dentin that

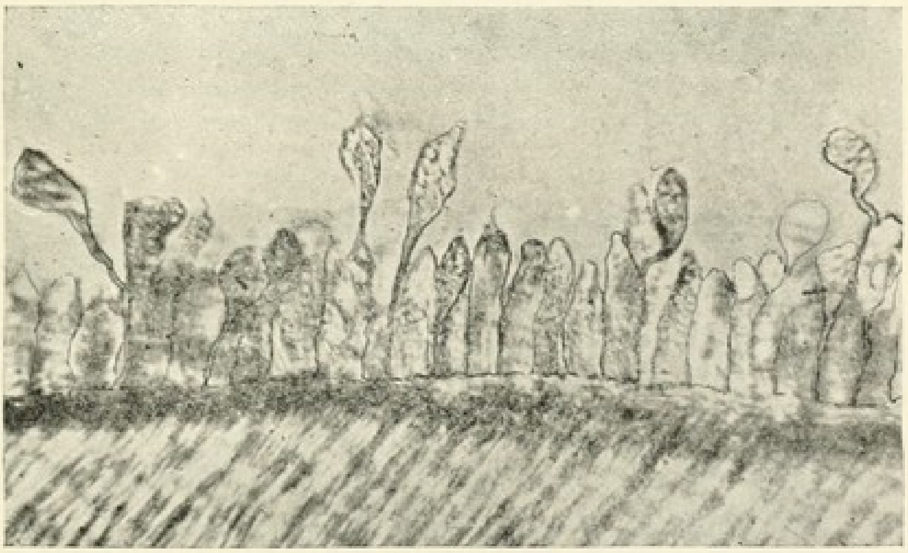
Fig. 57.



Section of growing tooth of calf at birth, showing the formed dentin, the layer of calco-globulin and two odontoblasts; a fibril is seen at the side of one of them.

sections are seen at that stage of growth at which the death of the part left it. In some the odontoblasts are seen square and abrupt against the calcified matrix, having no appearance of other tissue between them.

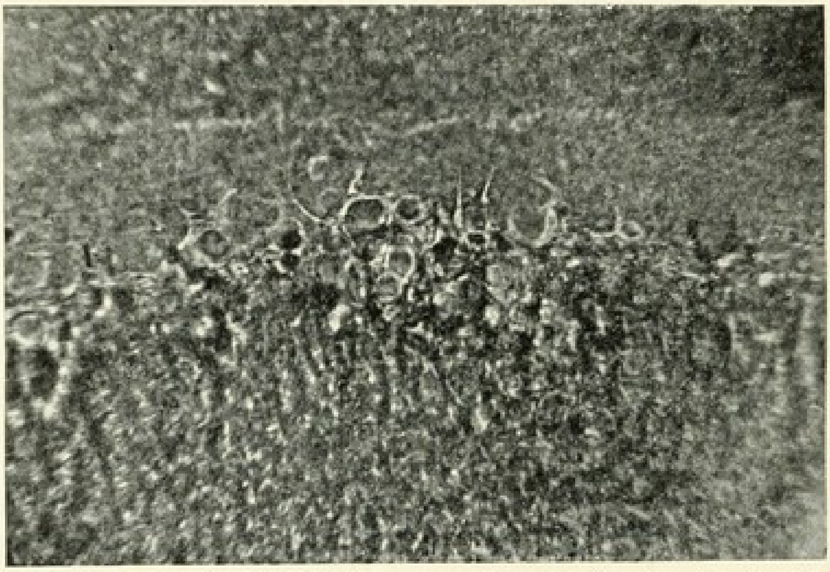
Fig. 58.



Section of growing tooth of calf at birth, showing the layer of odontoblasts square and abrupt against the forming dentin; some of the fibril cells, or dentin corpuscles, that are pear-shaped, are seen running between them.

In others the odontoblasts are seen square and abrupt against a layer of a fibrous, gelatinous tissue, which is seen to be filling with globular masses (Fig. 57). This layer is between the odontoblasts and the calcified matrix. A section from another embryo will show a different picture. Here is seen a layer of mostly pear-shaped cells, not quite against the calcified matrix, showing their fibrils drawn out and running into the canals of the matrix (Fig. 58). There is no appearance of a gelatinous layer, while here and there against the calcified matrix are what appear to be used-up odontoblasts, only portions of them showing. The cells in this picture rarely show more than one fibril running into the canals of the matrix. Again, a section from another tooth will show layers of calco-globulin merging together and forming a new layer of the matrix, and, in this, parts of the odontoblasts seem to lose their identity (Figs. 59–61). An important fact not to be lost sight

Fig. 59.

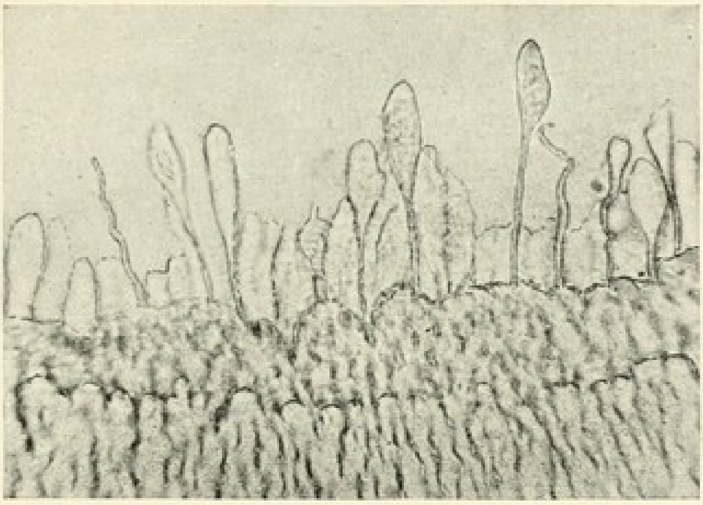


Section of developing tooth of calf at birth: cross section showing first-forming layer of dentin matrix. The calco-spherites are seen forming a layer of calco-globulin which by further calcification is to become the matrix.

of is that all of these appearances indicate the different stages in the growth of the dentin matrix. Conclusions cannot be drawn from any one of them, so all must be studied. These appearances are not found at the early stages alone; they are also seen when the matrix is nearly formed.

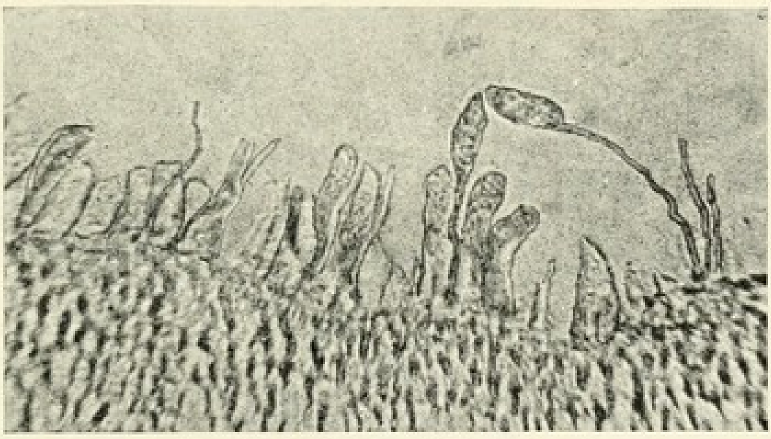
The odontoblasts are masses of protoplasm without membranes, and are at a certain stage of growth square and abrupt against the matrix (Fig. 58). It is an easy matter to find among them, and immediately adjacent, large numbers of pear-shaped cells, tapering into the dentinal fibril. The odontoblasts, when calcification is active, are scarcely more than masses of protoplasm, filled with minute globules (Fig. 62). The fibrils which appear to come from them, described by Tomes as pulp, lateral, and dentin processes, originate probably from a fibril-

FIG. 60.



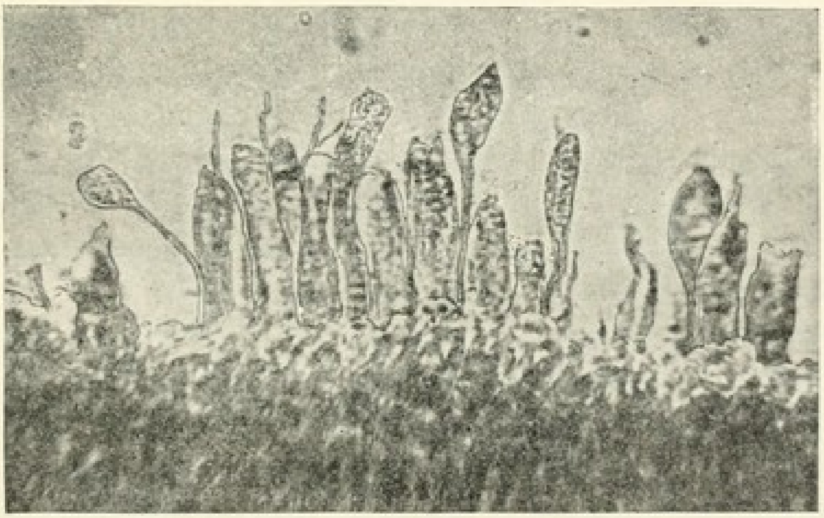
Section of growing tooth of calf at birth, showing fibrils, fibril cells and odontoblasts; also the layer of calco-globulin and the forming dentin.

FIG. 61.



Section of growing tooth of calf at birth, showing fibrils, fibril cells, and odontoblasts. The pulp has been teased away, leaving these cells clinging to the formed dentin.

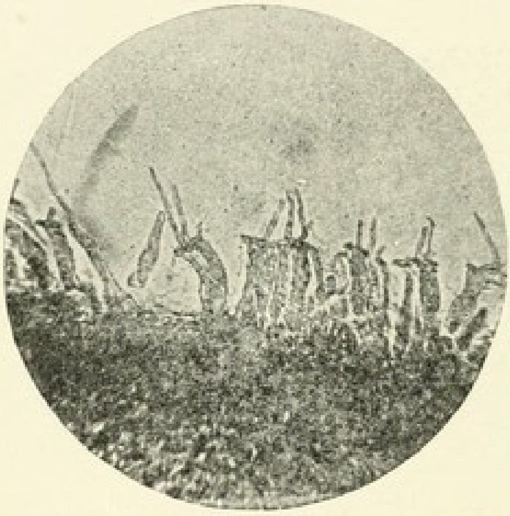
FIG. 62.



Section of growing tooth of calf at birth, showing odontoblasts and fibril cells.

forming cell. These pass through the soft substance of the odontoblasts (protoplasm) and seem to be a part of them, but in fresh, young sections the so-called processes move in the substance of the odontoblasts by pressure on the cover-glass, and the fibril may be traced to a pear-shaped cell beyond (Fig. 62). There will usually be found as many processes going out from sides or ends of the odontoblasts toward the pulp as there are going into the matrix from the dentin end of the cell. In cross sections of the odontoblasts, delicate light spots are seen in the substance, which are probably the cut fibers. When the layer of odontoblasts is teased away from the forming dentin, fibrils are seen bridging the gap, apparently offshoots from the odontoblasts; but on careful examination there will usually be found a decided line of demarcation across the fiber at the point where it meets the square end of the

Fig. 63.



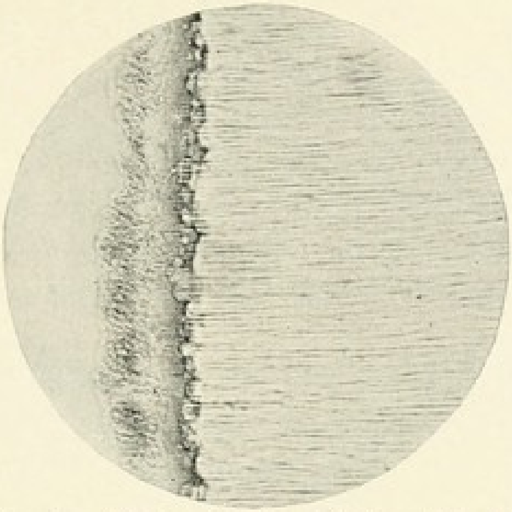
Section of growing tooth of calf at birth; odontoblasts that were square and abrupt against the forming dentin, showing the line of demarcation between the cell and the fibril. They are attached to the pulp.

odontoblast (Fig. 63). This line seems to show that the fibril was not continuous with the protoplasm of the cell. Other sections which have been separated by teasing, show odontoblasts having their side masses of protoplasm drawn away from the fibril which apparently has run through it. Some of this protoplasm is left upon the fibril, giving it a ragged appearance as it passes from a canal in the matrix across to the separated pulp tissue, bridging the gap.

The pear-shaped cell has perhaps a more important function than the odontoblast proper. It is to supply the life and nourishment to the whole of the calcified matrix, as the bone corpuscle within its lacuna supplies life and nourishment to bone and cementum.

Minute calcium globules or calco-spherites are seen to be arranging themselves against the already formed matrix, where they collect in large

Fig. 64.



Section of human tooth, showing globules of calco-globulin which have been deposited in the gelatinous layer by the odontoblasts; these have been pulled away in making the section. (Section by Mr. Mummery.)

Fig. 65.

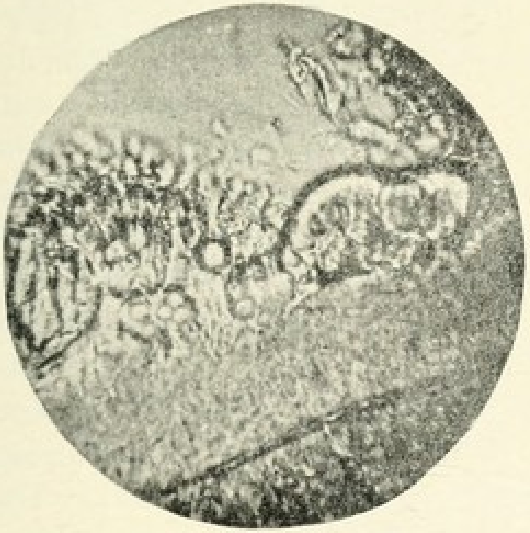


Fig. 66.

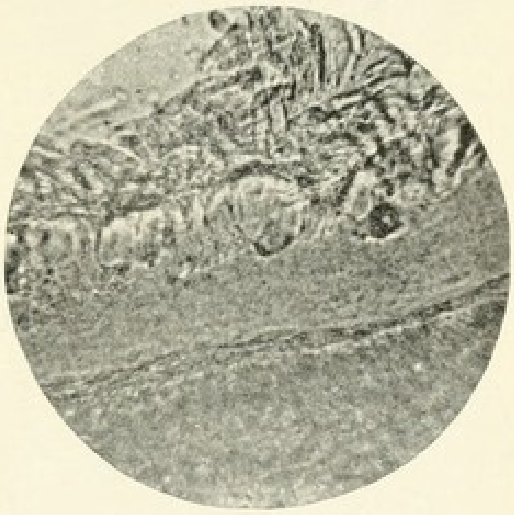
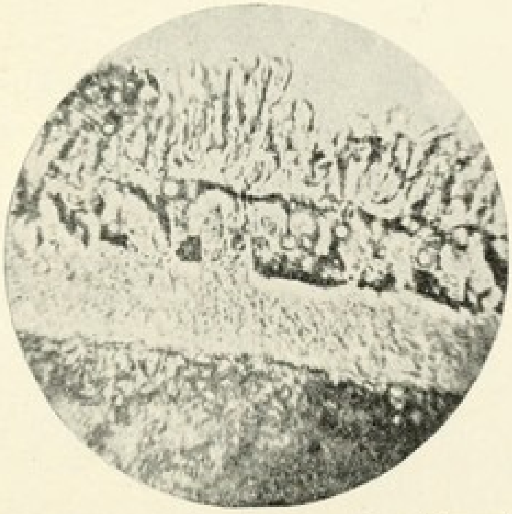


Fig. 67.



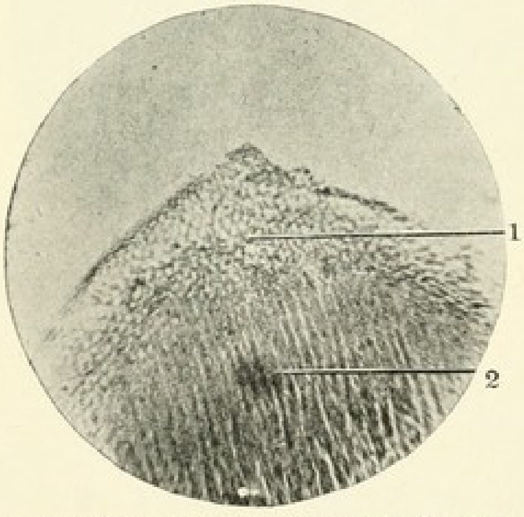
Sections of growing tooth of calf at birth, showing formation of layer of masses of calco-globulin to form layer of dentin.

numbers, and lose their individuality by merging into one another, forming larger globules, of various shapes and sizes (Fig. 64), seeming to take into their substance portions of the odontoblast. These globules enlarge until they reach their typal width, expand laterally, meeting and coalescing with others. The minute globules are seen within the odontoblasts of different sizes, all having a glistening appearance, something like fat globules in cells. The early layers formed by the globules are about the width of the band of formative cells. (See Figs. 65, 66, 67).

CALCIFICATION OF THE ENAMEL.

The statement made by Tomes and others that enamel is formed by the actual conversion of the enamel cells into the enamel rods is an erroneous one. The enamel cell does not calcify; it superintends the laying down of calcific material which is to form the rod. For the earliest deposit of enamel the calcium salts are stored in the meshes of the so-called stellate reticulum, and as the first enamel forms, the enamel organ proper disappears at this point. Only the two innermost layers remain; these are the layer of the columnar cells (ameloblasts) over the forming enamel, and a layer of cells somewhat resembling connective-tissue cells (the stratum intermedium) over these. The two layers are separated by what appears to be a line of tissue which has been called a membrane. The embryonic connective tissue of the jaw is now in direct communication with the stratum intermedium, and a rich blood supply is developing near the point of juncture. The function of the cells of the stratum intermedium is supposed to be the supplying of new cells to the ameloblastic layer as they may be needed by the increase in the circumference of the enamel, as new enamel is formed; to furnish the organic fluid in which the calcium salts are deposited; and to supply the fine network of fibers, the scaffolding upon which the enamel rods are to be built. Prof. Sudduth is the authority for the statement that enamel is nothing more or less than a coat of mail supplied by Nature to protect the dentin.

FIG. 68.

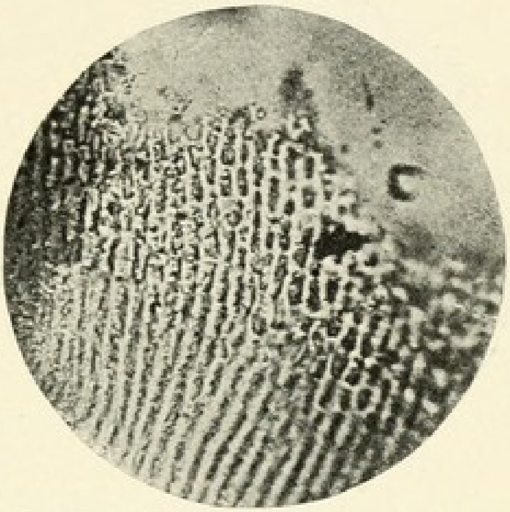


Section of human developing tooth, showing calcification of enamel: 1, globules of calco-globulin deposited on dentin cusps from the enamel cells; 2, dentin (the enamel cells have been cut away in preparing the section).

Enamel cells that have been properly prepared and not shrunken will be seen filled with minute globules. The authorities who speak of granules of calcium salts have described them as seen in the shrunken cells in the tissue as it is usually prepared. They are really globular, though minute. If, just as calcification commences, a few drops of dilute nitric acid be placed on the slide near the edge of the cover-glass, the liquid will, by capillary attraction, run under, and these refractive granular bodies in the stellate reticulum will disappear, as will

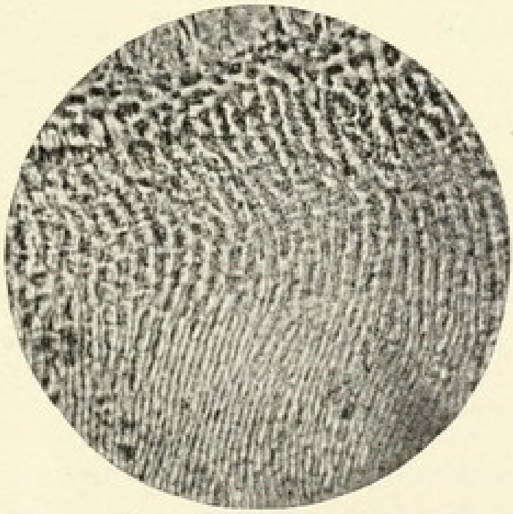
Fig. 69.

Fig. 70.



Sections from growing tooth of calf at birth, showing how enamel rods are formed from the globular masses of calco-globulin.

Fig. 71.

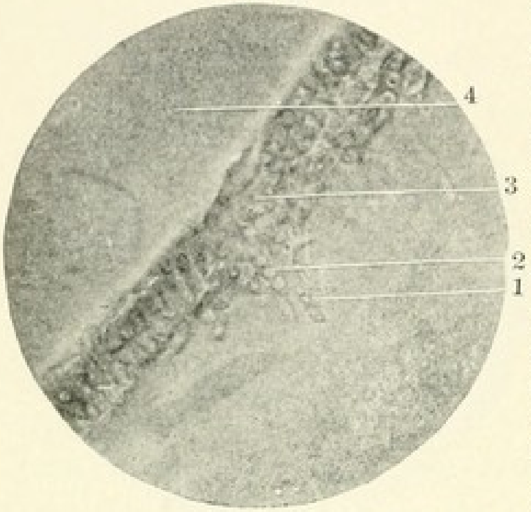


Same as Figs. 69 and 70.

those that are in the enamel cells themselves. Large numbers of small bubbles will accumulate, and force themselves out from under the cover-glass. This would seem a positive demonstration of the presence, in the stellate reticulum and enamel cells, of calcium carbonate just previous to commencing calcification. In teasing off portions of active enamel cells, we find the surface of the dentin on which it is being formed covered with layers of globules that have been deposited there by the enamel cells (Fig. 68). These, given out from the cell continually, form the enamel rods. One rod is separated from another by a protoplasmic cement substance.

Dr. Graf Spee says that when the tissue is properly prepared—and he lays great stress on this point—at the time of the formation of the enamel, the globules are always to be found. Their entire absence at earlier stages is an indication that these globules are an enamel substance. He gives to them the name "enamel drops," and says he saw these "enamel drops," when enamel is to be formed, appear only in the half of the enamel cells which rests on the dentin; afterward they were to be seen farther up in the cell, but not quite to the region of its nucleus. Many of them were so small as to be scarcely measurable, and they are always spherical. Great numbers of them are collected at the periphery, and appear here either to be completely merged or to fuse together. The lower part of the cell contains the larger "enamel drops," which merge without sharp boundaries into the substance of the enamel rods. This then appears as a part of the enamel cell, in which the originally isolated "enamel drops" have run together into a continuous mass, and the growth of the enamel rod, once begun, appears to take place by the addition of new "enamel drops."

Fig. 72.



Section of developing tooth of calf at birth, showing first-forming layer of enamel. The globules of calco-globulin are seen arranged in lines where rods are to be formed: 1, enamel cells containing calco-spherites; 2, globules arranged to form rods; 3, first-forming layer of enamel; 4, dentin.

The minute globular forms described by Dr. Spee are calco-spherites; the larger ones, his "enamel drops," are globules of calco-globulin which are to form the rods (Fig. 72).

Appearances of calcified fibers projecting beyond the line of calcification are seen when studying sections of forming young enamel, and these are evidences that fine processes of fibers from the cells of the stratum intermedium pass down through and among the ameloblasts to the forming enamel beneath. These are probably the processes which Mr. Tomes saw and described as connecting the enamel cells with the stratum intermedium. If one separates slightly the enamel cells from the stratum intermedium the parted cells will have the appearance of broken processes or fibers, and we may be able to see fibers crossing from the enamel cells to the stratum intermedium.

A longitudinal section of a human tooth at birth, just after the process of calcification in the enamel has begun, will show, between the enamel cells and the formed enamel, a thin layer which has been called, by earlier investigators, the *membrana præformativa*. It was misunderstood then: it is not a membrane. It is the latest deposition of enamel from the enamel cells, composed of globules or masses of calco-globulin; and around these globules there seems to be a fibrous network. Connecting with this fibrous network, and running to the formed enamel beneath, are innumerable thread-like processes, in appearance like fibers. There are indications of fibers which have been broken on the upper portion of this thin layer; these appear as though they had been broken off in the separation of the layer from the enamel cells. In a longitudinal section of the tooth of a calf at birth, when the recently formed layer of enamel is still in contact with the fully calcified enamel, this younger portion may be teased off, exposing to view what appear to be fibrils standing out from the surface. These have apparently been drawn out from the only partially calcified new tissue. In other sections this appearance is more marked. They may appear so large that it is probable they have been enlarged either by the action of reagents or by calcific matter clinging to a fiber, if one is there, and they are undoubtedly partially calcified. They are very much coarser than the fine fibrils seen between the enamel cells. Deeper within, these processes are seen to surround the globules or masses which have been deposited by the enamel cells, and which are forming the rods. In other sections from the tooth of the calf the younger layer of forming enamel shows a network of fibers; they are surrounding the recent deposition of globules. It is only in this layer that this appearance is clearly shown; this network in more fully formed enamel cannot be seen, yet a distinct network is always visible in the layer first deposited. It is probable that these processes have their origin among the cells of the stratum intermedium; that they pass either within or between the enamel cells, and thus on, to form a very fine fibrous substructure, throughout which are deposited the globules which are to form the future enamel rods. When the calcification of the rod is complete, the calcium salts have been so densely deposited as to entirely obscure the appearance of any fiber.

To sum up: there probably exists in developing enamel, as has already been found in developing bone and dentin, a fibrous substructure on and throughout which the enamel globules are deposited. After the enamel is wholly formed, this structure seems to be wholly blotted out in the dense calcification of the tissue (Figs. 73, 74). In sections of completely formed enamel the writer has been unable to trace it, although the methods of those who claim to have seen it have been faithfully followed. In regard to a protoplasmic reticulum

Fig. 73.

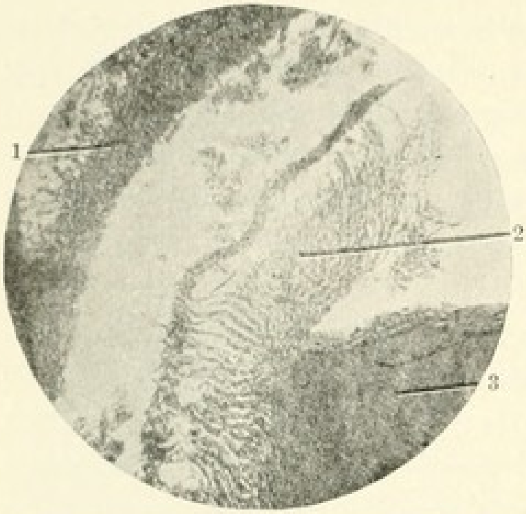
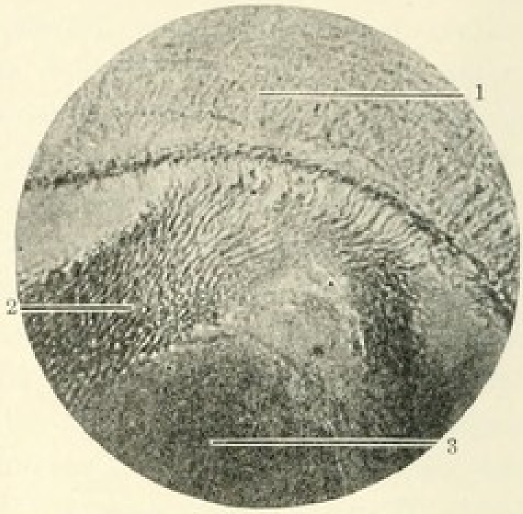


Fig. 74.



Sections of very young enamel (human), showing the appearance of a fibrous structure: 1, enamel cells; 2, newly forming enamel; 3, dentin.

of living matter in formed enamel, it is undemonstrable. Klein states that it is improbable that nucleated protoplasmic masses are contained in the interstitial substance of the enamel of a fully formed tooth.

CALCIFICATION OF THE CEMENTUM.

In the year 1858, Magitôt, a French histologist, claimed to have found within the follicle of a developing tooth a special organ for the development of the cementum. In 1861 Robin and Magitôt made a presentation of the same facts. With the exception of these authors, no other authority has recognized the presence of this special organ; while Kölliker, Waldeyer, Herz, and others had formerly denied its existence. Although there are appearances, in a fully formed follicle, of a tissue between the calcifying dentin germ and the outer covering of the sacculus, which might admit of the supposition of the existence of such an organ, it cannot be traced with certainty. The appearance may be noted in sections from embryos of the pig and calf. At a later stage when the crown is further developed there are also to be seen infoldings of the tissue at the base of the germ which may develop into a special organ for the formation of the cementum, as stated by Magitôt; but in teeth more matured, where the cementum has already commenced its growth, there are no indications of a special organ.

If the developing tooth is examined just after the cementum has begun to form, its matrix will be found to be made up of masses looking like scales of a tissue found everywhere on the borderland of calcification. It is calco-globulin, and has been formed from globules. At this early stage the calcific material is in the osteoblasts, and is given from them to the dentin, where a thin layer is forming. The osteoblasts are filled with minute, glistening globules. As the growth continues, these cells appear to fuse into the cementum already formed. At the neck of the tooth outside this layer, which is forming the matrix of the cementum, a row of cells is seen which, according to Rollet, resembles an epithelium. They are really new osteoblasts or cementoblasts filled with the minute glistening bodies. Just exterior to these cells, roundish nucleated cells with innumerable processes are seen slightly resembling a stellate reticulum. Outside of these is a connective-tissue layer which will become the periosteum. This slight amount of stellate tissue is probably what has been called the special cement organ. Across the developing matrix of the cement are found numerous connective-tissue fibers seen and described by Sharpey and named after him Sharpey's fibers. They become calcified within the matrix. As the cementum grows thicker we find infolded within its substance nucleated bodies which appear to be connective-tissue cells. They appear larger than the osteoblasts and are forming the regular lacunæ of the cementum. Their function is to give nourishment to the matrix of the cementum, anastomosing with one another by means of many fine canals, many of which run in the direction of the termination of the dentinal canals as though connecting with them. They are not as regular as those in true bone, and are often very much larger. The processes of these cells anastomose with the dentinal canals through the interglobular spaces of the so-called granular layer of Tomes. Thus the matrix of the cementum is formed from the cementoblasts which have become filled with calcific material from the blood supply everywhere near. They rest against already formed dentin and become merged into a layer of calco-globulin, which in turn becomes calcified into the first layer of cementum. Layer after layer is formed, and this gives to the cement the peculiar laminated appearance so often seen in it.

The Dental Pulp.

The tooth pulp is that which remains of the dentin germ after calcification is completed. It is very generally but erroneously called the "nerve." In the young tooth it is composed of connective-tissue matrix which contains the nerves and vessels supplying the dentin. These are more numerous near the odontoblastic layer, the nerve fibers appearing to terminate here. The odontoblasts cover the surface of pulp like an epithelium. Just within these is a layer of cells consisting of a comparatively pale and transparent zone, and this has been called the *basal layer of Weil.* It is described as consisting of fine connective-tissue fibrils which communicate with the processes of the odontoblasts. Von Ebner doubts the existence of this layer, as does Röse.

CHRONOLOGY OF TOOTH DEVELOPMENT. (*From* MAGITÔT—*Comptes Rendus, 1874*).

STAGE OF THE EMBRYO.			TEMPORARY DENTITION.					PERMANENT DENTITION.					
Its length from the vertex to the heel.	Total weight.	Corresponding age.	Central Incisor.	Lateral Incisor.	1st Molar.	2d Molar.	Cuspid or Canine.	Central Incisor.	Lateral Incisor.	Cuspid or Canine.	1st Premolar or Bicuspid.	2d Premolar or Bicuspid.	1st Molar.
Inches.	Grains.												
1.18	46.2 to 53.9	7th week.	At this date one observes at the edge of the jaw of the embryo only the epithelial eminence and the epithelial inflection of Kölliker. The superior maxillary and intermaxillary bones are not united, and the inferior maxillary arch contains Meckel's cartilage only, without any trace of bone. It is in the course of this 7th week that the epithelial bands (enamel organs) of the temporary teeth are successively formed in the order of their designation.					No trace of the follicles.					
1.18 to 1.57	154 to 184.8	9th week.	At this date appears in juxtaposition with the downward extremity of the epithelial band the first trace of the dentin bulb. This stage occurs nearly simultaneously for the whole series of the temporary follicles.					No trace of the follicles.					
1.57 to 2.36	693 to 739.2	10th week.	At this period the wall of the follicle detaches itself from the base of the bulb and rises up its sides. This stage occurs in the same order as the preceding.					No trace of the follicles.					
5.90 to 7.08	1540 to 1848	15th week.	The wall of the follicle continues its development. The epithelial germ commences its transformation into an enamel organ.										Appearance of the enamel germ springing from the epithelial inflection.
7.08 to 7.48	1848 to 2772	16th week.	The wall of the follicle is closed. The epithelial band is broken and the follicle is thenceforward without any connection with the epithelium of the surface.					Appearance of the epithelial band derived from the neck of the enamel organ of the corresponding deciduous tooth.					

7.87 to 8.26	2772 to 3388	17th week	Central Incisor. Appearance of the cap of dentin.	Lateral Incisor.			Cuspid or Canine. Appearance of the cap of dentin.		Appearance of the bulb.
8.26 to 9.44	3394 to 3858	18th week 4 months.			1st Molar. Appearance of the dentin cap.	2d Molar.			Appearance of the wall of the follicle.
9.84 to 10.63	4322 to 6945	20th week.	Dimensions in vertical height of the cap of dentin.					Appearance of the dentin organ.	Enclosure of the wall and rupture of the band.
			0.059	0.059	0.039	0.039	0.059		
12.59 to 13.77	15434 to 23152	25th week 6 months.	0.07	0.07	0.054	0.054	0.07	The wall of the follicle which appeared after the 21st week has already acquired a certain distinctness.	Appearance of the cap of dentin.
14.56 to 15.35	23152 to 30868	28th week 6½ months.	0.093	0.093	0.078	0.078	0.093	The wall of the follicle continues its development; the epithelial germ commences its transformation into an enamel organ.	The cap of dentin is from 0.003 to 0.007 inch in height.
15.74 to 16.53	30868 to 38585	32d week 7¼ months.	0.113	0.113	0.093	0.093	0.113	Continuation of the same developmental processes.	The cusps of dentin which originate upon the several apices of the dentin organ have coalesced.
17.32 to 18.50	38585 to 46302	36th week 8½ months.	0.118	0.118	0.109	0.109	0.118	Continuation of the same developmental processes.	The cap of dentin is from 0.004 to 0.039 inch in height.
18.71 to 20.47	46302 to 54019	39th week 9 months.	0.136	0.136	0.118	0.118	0.136	Closure of the wall of the follicle. The cap of dentin has not appeared; its formation only takes place in the 1st month after birth.	The cap of dentin is from 0.039 to 0.078 inch in height.

In a recent paper on the Histology of the Pulp, by Erwin Hoehl, he states that the cells of the pulp show in the different life periods characteristic differences in form and number. Three kinds are found, which arise from one another by metamorphosis in the following way: (1) Round cells with large nucleus and scanty protoplasm. (2) Irregularly shaped cells with many freely anastomosing processes. (3) Spindle-shaped cells with the same character as the foregoing. The changes of the cell form begin at the periphery and proceed toward the centre of the pulp. The outermost peripheral layer of the branched cells contains the elementary or *primary* odontoblasts. Centralward from these is a cell layer which, with reference to the function of its elements, is called the conjugation cell layer. The *secondary* odontoblasts arise by conjugation of the primary odontoblasts with the conjugation cells, and they form the dentin. The conjugation processes probably cease only with the completion of growth in the tooth.

Of the peripheral processes of the primary odontoblasts the larger one represents what will be the future *dentin fibril*. The increase of cells seems to be dependent upon the development of the capillaries, inasmuch as more cells are found where the distribution of capillaries is most dense, *i. e.* on the periphery of the pulp. The gradual decrease of the number of branch cells in the centre of the pulp during the course of development is because only trunk vessels are found here. In the place of these destroyed cells we find a delicate cellular network which is probably derived from the numerous anastomoses of the cell processes. Next to or just within the odontoblastic layer is seen a bright zone variable in width; this is the so-called *Weil's layer*. Between this and the fibrous or central portion of the pulp is an intermediate layer which forms a contrast with the delicate fibrous elements of Weil's layer, and in this way Weil's layer is made visible.

The ground substance of the pulp by a certain method of treatment shows a dense interlacing of fibrillæ which are arranged parallel to one another and seem to run in the direction of the axis of the tooth.

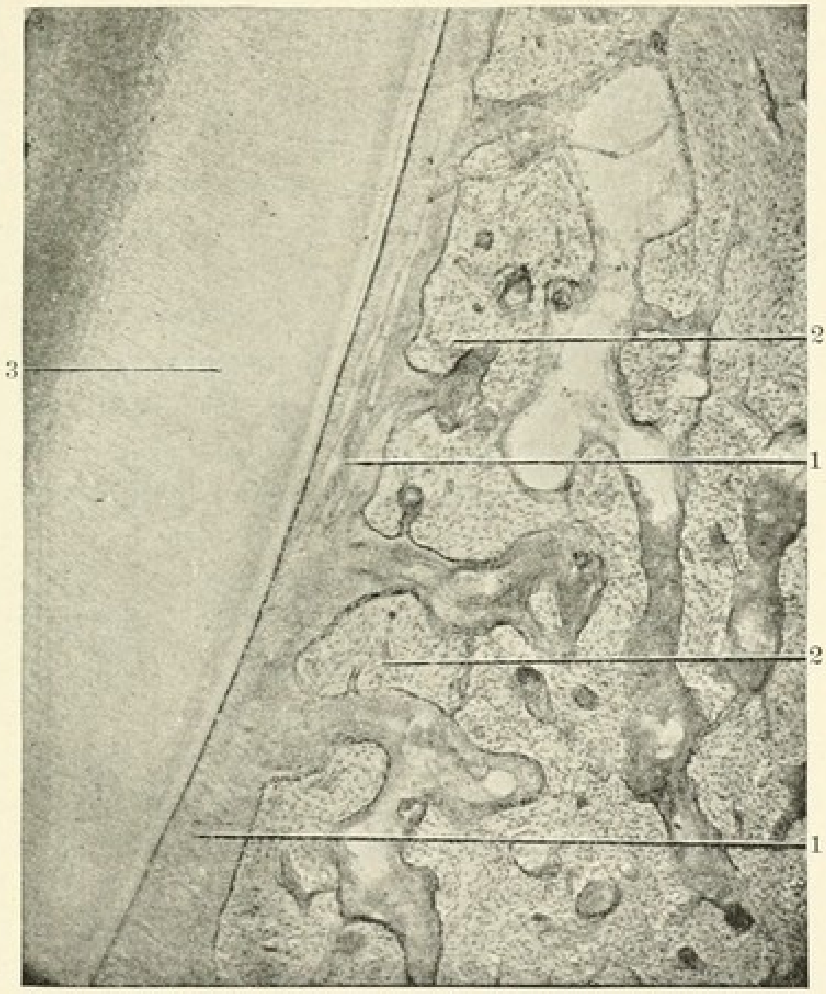
The Gum.

Gum tissue is the same as that of the general mucous membrane of the mouth. It is more dense because it is bound down to the bone by numerous fibers of its own, and it is also united with the periosteal tissue which spreads into it in every direction. Numerous large single and compound papillæ are seen. The blood supply is abundant, but nerve tissue is not often found. The histological appearances which look like young enamel organs are the glands of Serres. Near developing teeth epithelial clusters are frequently seen, the remains of the disappearing necks of the enamel organs. The cells of the stratum Malpighii of the epithelium are seen to be in columns, and from these new cells are formed, which flatten and lose their vitality as they near the outer surface, where they are given off as lifeless scales.

The Pericementum or Alveolo-dental Membrane.

This is a formation of fibrous connective tissue, having its origin from the outer layer of the sacculus (Fig. 75). It differs from the gum tissue in that it is not so dense. Tomes speak of it as having a rich supply of nerve fibers.

Fig. 75.



Alveolar dental membrane (section from jaw of kitten): 1, alveolar dental membrane; 2, bone of alveolus; 3, dentin.

The pericementum passes into the gum at the tooth neck, where it is thicker than at any other part. It is seen to be everywhere connected with the periosteal membrane of the alveolar process. The general direction of its fibers is across, slightly wavy, downward from the alveolus to the tooth root. In the young tooth there are no breaks in the continuity. There is no appearance of two separate membranes, one for the root and the other for the alveolus; but simply a membrane common to both surfaces.

The pericementum forms an elastic membrane and acts as a cushion to lessen the concussion when the teeth come together during mastication. Its connective-tissue fibers are seen to pass into the cementum, and within that substance are supposed to be Sharpey's fibers. Where the cementum is thicker it is rich in cellular structure. The pericementum, then, connects with the cementum by its fibers; these in turn connect with the branches of the cement corpuscles, through these with the granular layer of Tomes, and thence on to the fibrils of the dentin.

Nasmyth's Membrane.

Concerning this structure Tomes states that—

"Under the name of Nasmyth's membrane, enamel cuticle, or persistent dental capsule, a structure is described about which much difference of opinion has been, and indeed still is, expressed. Over the enamel of the crown of human or other mammalian teeth, the crown of which is not coated by a thick layer of cementum, there is an exceedingly thin membrane, the existence of which can only be demonstrated by the use of acids, which causes it to become detached from the surface of the enamel. When thus isolated it is found to form a continuous transparent sheet, upon which, by staining with nitrate of silver, a reticulated pattern may be brought out, as though it were made up of epithelial cells. The inner surface of Nasmyth's membrane is, however, pitted for the reception of the ends of the enamel prisms, which may have something to do with this reticulate appearance. It is exceedingly thin, Kölliker attributing to it a thickness of only one twenty-thousandth of an inch. But, nevertheless, it is very indestructible, resisting the action of strong nitric or hydrochloric acid, and only swelling slightly when boiled in caustic potash. Notwithstanding, however, that it resists the action of chemicals, it is not so hard as the enamel, and becomes worn off tolerably speedily, so that, to see it well, a young and unworn tooth should be selected."

The writer's investigations lead to the inference that the membrane is nothing more than the layer of cells of the internal epithelium of the enamel organ, the ameloblasts, which, having performed their function, have filled with calco-globulin and have partially calcified, becoming somewhat like that tissue which we find on the borderland of calcification.

It is probable that the lacunæ found occupying a fissure between the cusps of the teeth, in the enamel, are nothing more than a little of the connective tissue which has become infolded and ossified before the eruption of the tooth.

CHAPTER III.

DENTAL HISTOLOGY WITH REFERENCE TO OPERATIVE DENTISTRY.[1]

By Frederick B. Noyes, B. A., D. D. S.

The development of our knowledge of the cell has had a most profound effect upon the entire practice of medicine; in fact, the progress of modern medicine dates from the studies of cell biology, the germ theory of disease being only one of the phases of this development. In terms of the cell theory the functions of the body are but the manifest expression of the activities of thousands or millions of more or less independent but correlated centres of activity: if these centres or cells perform their functions correctly, the functions of the body are normal; but if they fail to perform their office, or work abnormally, the functions of the body are perverted. In the last analysis, then, all physiology is cell physiology; all pathology cell pathology. To modern medicine histology, or the cell structure of the organs and tissues of the body, together with cell physiology, is the rational foundation of all practice. This is as true for the dentist as for the physician so far as regards all of the soft tissues of the mouth and teeth that he is called upon to treat and handle. With caries of the teeth, the disease which most demands the attention of the dentist, the case is somewhat different. Caries of the teeth is an active destruction, by outside agencies, of formed materials which are the result of cell activity (the tissues themselves being passive). The cellular activities of organs and tissues of the body may have an influence, but this is only in producing those conditions of environment which render the activities of the destructive agents efficient in their action upon tooth tissues. Though the enamel and dentin are passive, we can understand the phenomena of caries only as we understand the structure of the tissues; and not only must the treatment of caries be based upon a knowledge of the structure of the tissues, but the mechanical execution of the treatment is facilitated by that knowledge. In the preparation of cavities the arrangement of the enamel wall is determined by our knowledge of the direction of enamel prisms in that locality, and to a certain extent

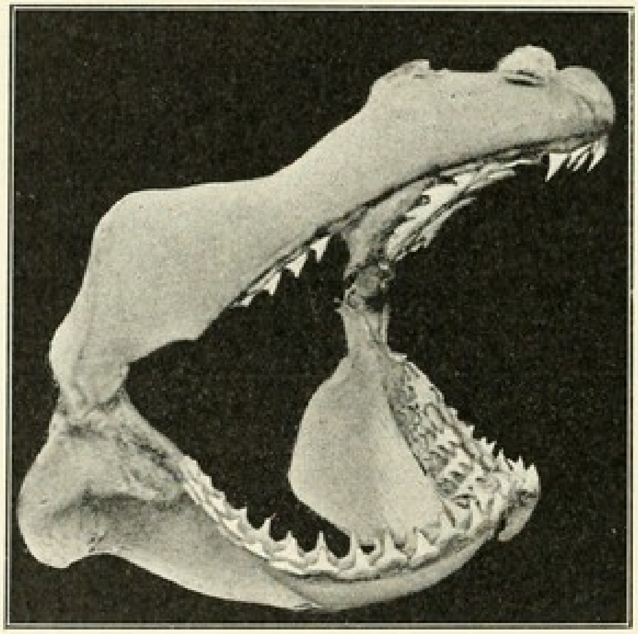
[1] In the preparation of this material I am indebted to Dr. G. V. Black for the use of his large and valuable collection of microscopic slides, and for much advice and many suggestions.

the position of the cavity margins must be governed by our knowledge of the structure of the enamel. In the execution of the work a minute knowledge of the direction of enamel rods becomes the most important element in rapidity and success of operation.

From the standpoint of comparative anatomy, the teeth are found to be not a part of the osseous system, but appendages of the skin, and are to be compared with such structures in the body as the nails and the hair. The teeth are a part of the exo-skeleton, and their relation to the bones of the endo-skeleton is entirely secondary, for the purpose of strength, the bone growing up around the tooth to support it.

If we examine the skin of such an animal as the shark, we find the entire surface covered with small calcified bodies which are really

FIG. 76.



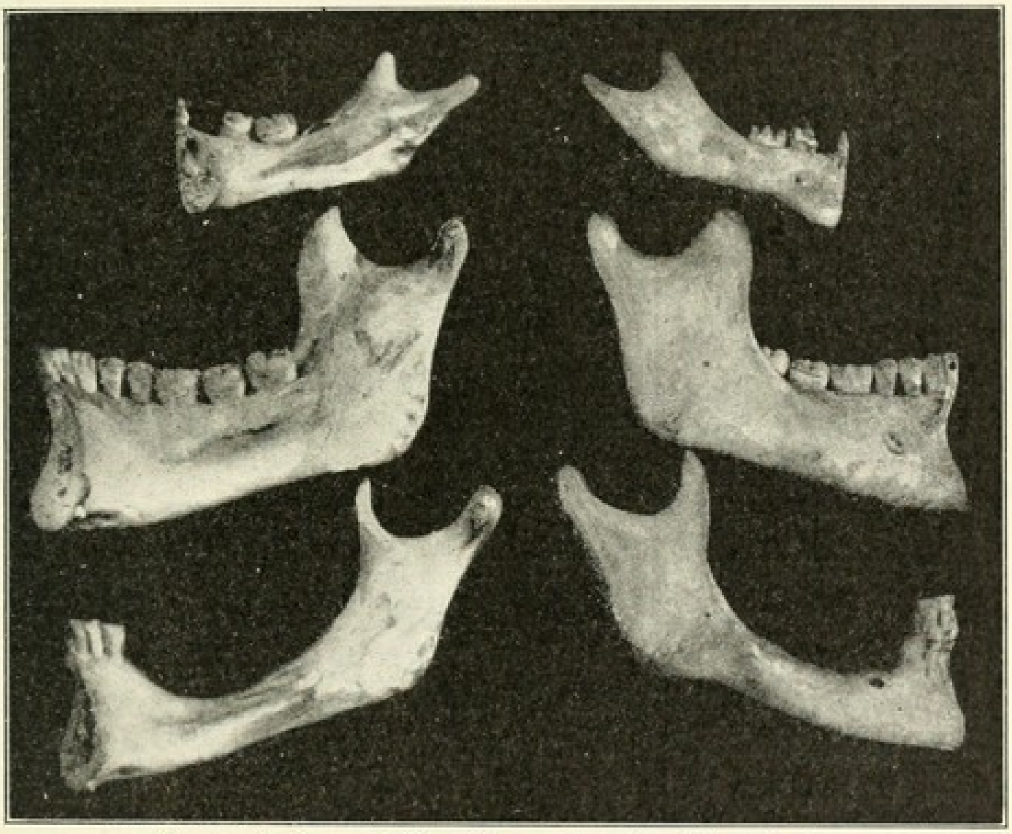
Shark's skull (*Lamna cornubica*), showing succession of teeth.

small simple cone-shaped teeth. The mouth cavity is to be regarded, when viewed in the light of its development, as a part of the outside surface of the body which has been inclosed by the development of the neighboring parts, and the dermal scales or rudimentary teeth which were found in the skin covering the arches which form the jaws have undergone special development for the purposes of seizing and masticating the food. In the simplest forms there is only a development in size and shape of these scales, and they are supported only by the connective tissue which underlies the skin. These teeth are easily torn off in the attempt to hold a resisting prey, and, as in the shark, they are constantly being replaced by new ones (Fig. 76). In the more highly developed forms there is a growth of the bone of the arch forming the jaw upward around the bases of these scale-like teeth, to support them more firmly and render them more useful.

If we compare the structure of the hair with that of the tooth, we find in the case of the hair a horny structure formed by epithelial cells resting upon a papilla of connective tissue; in the case of the tooth, a calcified structure formed by epithelial cells resting upon a papilla of connective tissue which is also partially calcified.

The relation of the bones of the jaws to the teeth is entirely a secondary and transient one. The bone grows up around the roots of the teeth to

Fig. 77.



Changes in the mandible with age; buccal and lingual view.

support them, and is destroyed and removed with the loss of the teeth or the cessation of their function. In this way the development of the alveolar process takes place around the temporary teeth; all of this bone surrounding their roots is absorbed and removed with the loss of the temporary dentition, and a new alveolar process grows up around the roots of the permanent teeth as they are formed. This development of bone around the roots of the teeth leads to the changes in the shape of the body of the lower jaw, increasing the thickness above the mental foramen and the inferior dental canal. When the teeth are finally lost this bone is again removed and the body of the jaw is reduced in thickness from above downward (Fig. 77). These phenomena are of importance in their bearing upon the causes and treatment of diseased conditions of the teeth, particularly those which involve the supporting tissues.

Dental Tissues.—The human teeth are made up of four tissues (Fig. 78):

1. The *enamel* covers the exposed portion of the tooth, or crown, and gives the detail of crown form. Its function is to protect the tooth against the wear of friction.

2. The *dentin* forms the mass of the tooth and determines its class form, the number of cusps and the number of roots being indicated by the dentin form.

3. *Cementum* covers the dentin beyond the border of the enamel, overlapping it slightly at the gingival line and forming the surface of the root. Its function is to furnish the attachment of the fibers of the peridental membrane, which fastens the tooth to the bone.

4. The *pulp* or soft tissue filling the central cavity in the dentin is the remains of the formative organ which has given rise to the dentin. Its functions are the formation of dentin and a sensory function.

In describing the structure of the teeth and the arrangement of the structural elements of the tissues directions are described with reference to three planes:

The mesio-disto-axial plane, a plane passing through the centre of the crown from mesial to distal and parallel with the long axis of the tooth.

The bucco-linguo-axial plane, a plane passing through the centre of the crown from buccal to lingual and parallel with the long axis of the tooth.

The horizontal plane, at right angles to the axial planes.

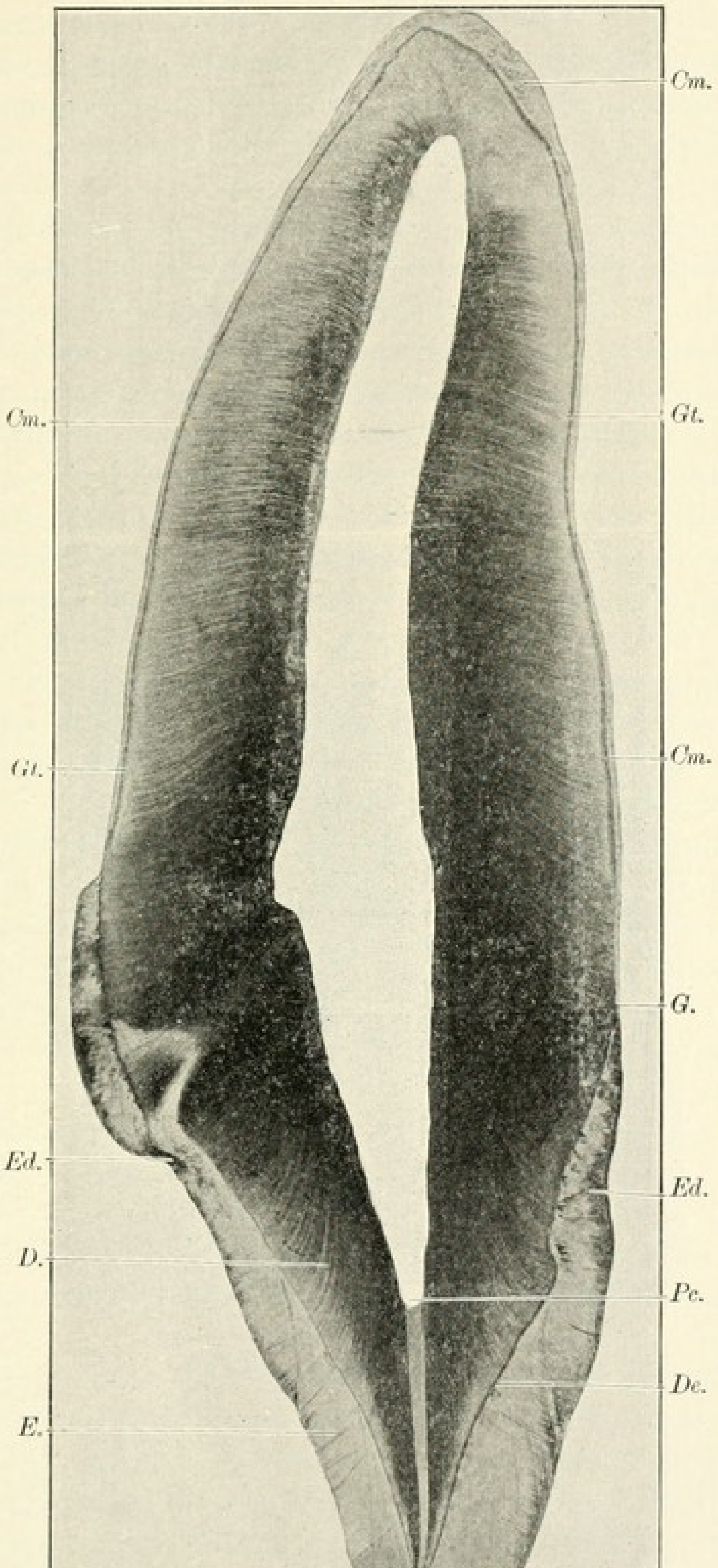
The Supporting Tissues.—The human teeth are supported on the maxillary bones, their alveolar processes growing up around the roots of the teeth, so that the roots fit into the holes in the bone. The calcified structures of the tooth and the bone are not, however, united, but the roots are surrounded by a fibrous membrane, the *peridental membrane*, or *pericementum*, which fastens the tooth to the bone.

Enamel.

The enamel differs from all other calcified tissues in the nature of the structural elements of which this tissue is made up, in the degree of calcification, and in origin, being the only calcified tissue derived from the epiblast.

The enamel is formed from an epithelial organ derived from the epithelium of the mouth cavity and indirectly from the epiblastic germ layer, while all other calcified tissues are products of the mesoblast. In the case of bone and dentin the formative tissue is persistent. It

FIG. 78.



Ground section of a canine: *E*, enamel; *Cm*, cementum; *D*, dentin; *Pc*, pulp chamber; *Dc*, dento-enamel junction; *Ed*, enamel defect; *G*, junction of enamel and cementum at the gingival line; *Gt*, granular layer of Tomes. (Reduced from photomicrograph made in three sections.)

is possible in the bone at least, therefore, to have degenerative and regenerative changes, or the removal of part of the calcium salts and their replacement through the agency of the formative tissue; while in the enamel no such regenerative change is possible, as the formative tissue disappeared when the tissue was completed and before the eruption of the tooth.

The enamel is the hardest of human tissues. Chemically it is composed of the phosphates and carbonates of calcium and magnesium and a very small amount of the fluorids, water, also a very small amount of organic matter if any.[1] The enamel in the natural condition, bathed in the fluids of the mouth, contains a considerable amount of water. If dried at a little above the boiling-point of water, it gives up part of it and shrinks considerably, so as to crack in fine checks. If heated almost to redness, it suddenly gives off from 3 to 5 per cent. (of the dry weight) of water with almost explosive violence. These facts were demonstrated some years ago by Charles Tomes,[2] and account for most of what was formerly recorded as organic matter in old analyses.

If we observe under the microscope the action of acids upon thin sections of enamel, when the inorganic salts are entirely removed, the structure of the tissue vanishes, there being no trace of organic matrix left as in the case of bone or dentin. In the growth of bone and dentin the formative tissue produces first an organic matrix (see Chap. II., p. 74) in the form of the tissue, and into this the inorganic salts are deposited, combining with the organic substances of the matrix. This union is comparatively weak, however, for by the action of acids the combination is broken up and the inorganic salts are dissolved; or by heat the organic matter is removed, and in either case the form of the tissue will be maintained.

In the case of the enamel, the formative organ produces organic substances containing inorganic salts, and the substances are arranged in the form of the tissue after the manner of a matrix; but finally under the action of the formative organ all of the organic matter is removed and substituted by inorganic salts, whatever organic matter is

[1] Von Bibra gives the following analysis of enamel:

Calcium phosphate and fluorid	89.82
Calcium carbonate	4.37
Magnesium phosphate	1.34
Other salts	.88
Cartilage	3.39
Fat	.20
Total organic	3.59
" inorganic	96.41

[2] *Journal of Physiology*, 1896.

found in the fully formed tissue being the result of imperfect execution of the plan.

The enamel is composed of two structural elements, the ENAMEL RODS, or prisms, sometimes called enamel fibers, and the INTERPRISMATIC or CEMENTING SUBSTANCE, both of which are calcified. It is to the arrangement of these structural elements that the characteristics of the tissue with which we are most concerned in operative procedures are due.

While both the prisms and interprismatic substance of the enamel are calcified, or, better, composed of inorganic salts, the two substances —that is, the substance of the rods and the substance between the rods —show markedly different properties both chemical and physical. If treated with acid, the interprismatic substance is acted upon more rapidly than the rods, so that the latter become more conspicuous. By this means sections of the enamel may be etched to render it easier to study the direction and arrangement of the rods. If the action of the acid is carried far enough, the rods will fall apart before they are them-

FIG. 79.

Enamel rods isolated by caries. (About 465 ×.)

selves entirely dissolved. Fig. 79 is from the débris in a carious cavity, and shows rods isolated by the action of the acids of caries.

The interprismatic substance is not as strong as the rods, so that in splitting or breaking the enamel the tissue separates on the lines of the cementing substance, occasionally breaking across a few rods but following their general direction, the lines running between rods, not at their centres.

In cleaving the enamel the chisel does not enter the tissue separating rod from rod, but the edge engages with the surface, and the force applied at an acute angle with the direction of the rods fractures the tissue in the lines of least resistance. If the edge be keenly sharp, it will enter the tissue slightly, and then the bevel acts as a wedge in addition to the force applied to the shaft of the instrument; but if the edge be dull, it will rest across the ends of many rods, will not engage with the surface, and the force applied will break and crumble the tissue but will not cleave it.

The enamel rods, or prisms, are long, slender prismatic rods or fibers, five- or six-sided, pointed at both ends and alternately expanded and constricted throughout their length. They are from 3.4 to 4.5 microns[1] in diameter, some of them apparently reaching the entire distance from the surface of the dentin to the surface of the enamel; but as the diameter of the rods is the same at their outer and inner ends, and as the crown surface is much greater than the surface of dentin covered by enamel, there are many rods which do not extend through the entire thickness. These short rods end in tapering points between the converging rods which extend the entire distance. To express this in terms of development: as the formation of enamel begins at the surface of the dentin, the increasing area of crown surface requires more ameloblasts, and as new ameloblasts take their place in the layer the formation of new enamel rods begins between the rods which were previously forming. These short rods are most numerous over the marginal ridges and at the points of the cusps, and will be considered more fully in connection with those positions.

In ground sections cut at right angles to the direction of the rods[2] the tissue has the appearance of a mosaic floor, the outline of the rods being more distinct if they have been marked out by treating the section slightly with acid (Fig. 80). In longitudinal sections (Fig. 81) the sides of the rods are not smooth and even like the sides of a lead pencil, but are alternately expanded and constricted. They are well illustrated by taking balls of soft clay and sticking them together one above another to form a rod, then putting a number of rods together so that by mutual pressure they take hexagonal forms. This illustrates also the manner of growth of the tissue in formation. The expansions and constrictions can be seen in rods that have been scraped from a cleaved surface of enamel, but better by isolating rods by the slight action of dilute acid (Fig. 82).

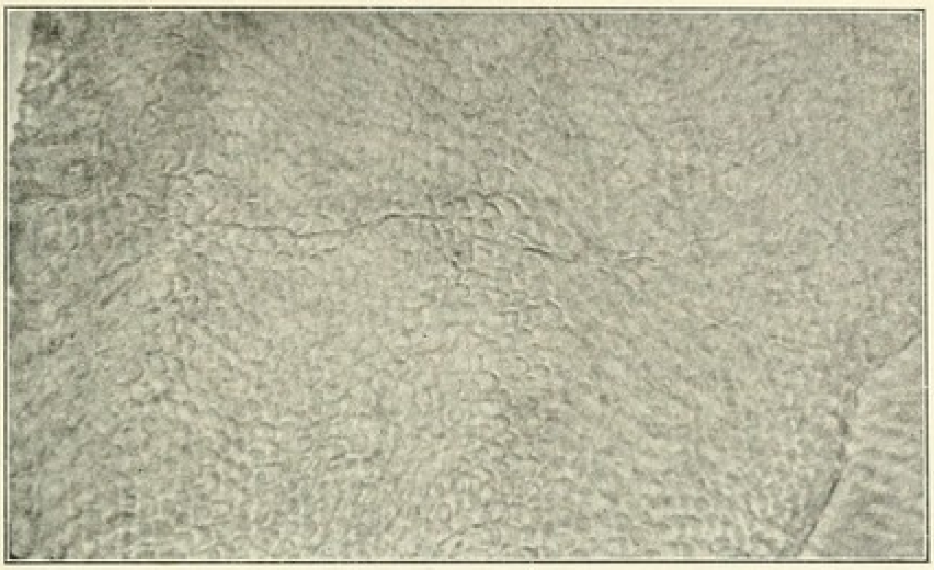
In the construction of the tissue the rods are so arranged that the ex-

[1] A micron is the unit of microscopic measurement, and is equal to one one-thousandth of a millimeter.

[2] In describing the direction of enamel rods they are always considered as extending from the dentin to the surface, and the angle is formed at the surface of the dentin with the locating plane, either horizontal or axial.

pansions of one rod come opposite to the expansions in the adjoining rods, and do not interlock with their constrictions. This arrangement

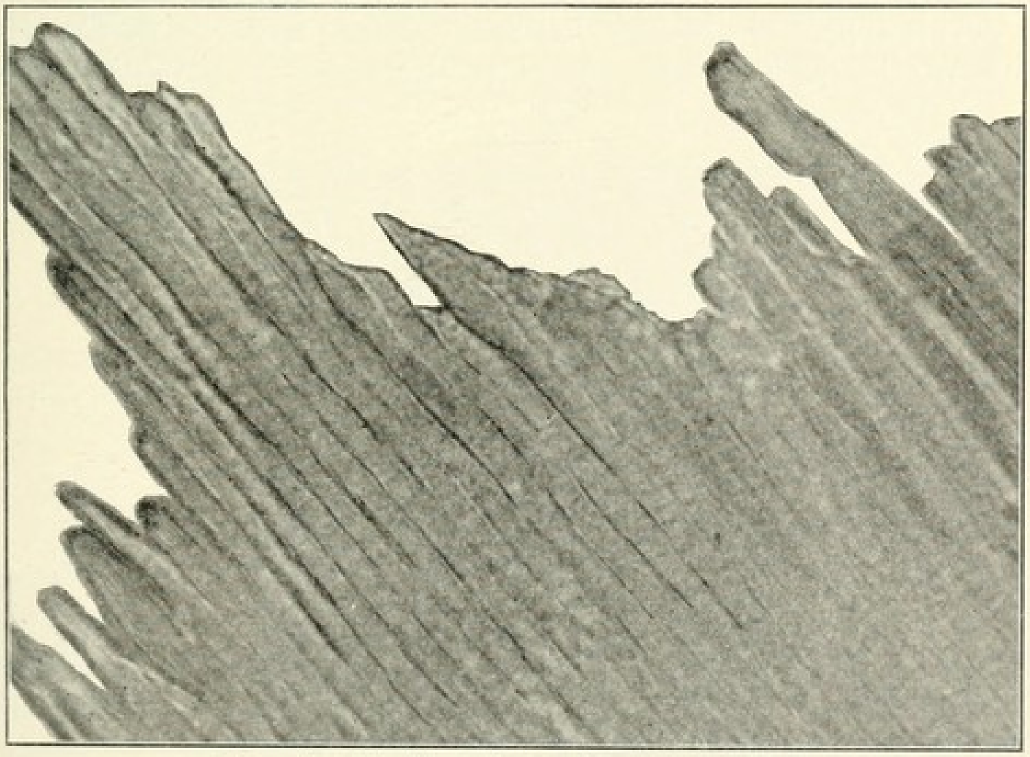
Fig. 80.



Transverse section of enamel rods. (About 80 ×.)

leaves alternately a greater and a less amount of cementing substance between them.

Fig. 81.



Enamel rods in thin etched section. (About 800 ×.)

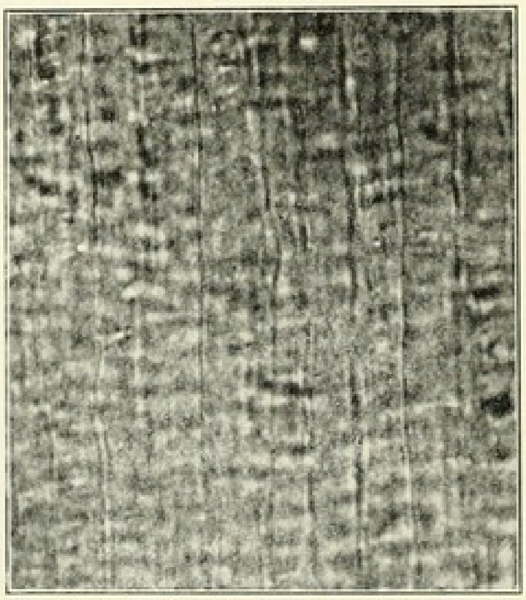
When observed under the microscope, the enamel rods show a characteristic appearance of light and dark lines running across them. These markings are similar to the striations of voluntary muscle fibers, and are described as the striation of the enamel. It is seen not only in isolated rods (Fig. 79), but also in sections ground in their direction (Fig.

Fig. 82.

Enamel rods isolated by scraping. (About 800 ×.)

83). This appearance of striation in the enamel is caused by the alternate expansions and constrictions of the rods refracting the light like a

Fig. 83.



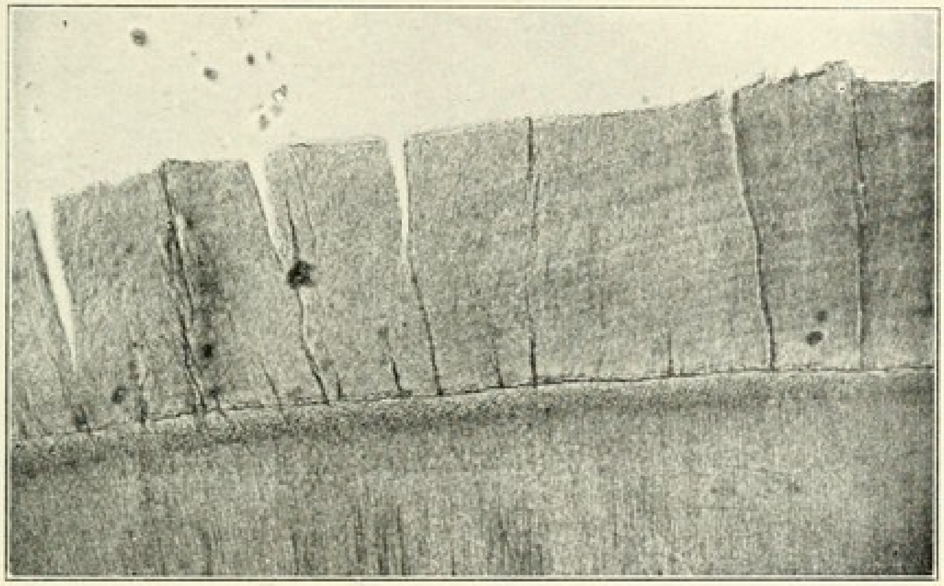
Enamel showing striation. (About 1000 ×.)

lens. In sections the expansions in adjoining rods are opposite to each other, the difference in the refracting power of the prismatic and interprismatic substances producing the same effect.

The appearance of striation is the record in the fully formed tissue of the manner of growth, each dark stripe, or expansion, in a rod representing a globule of partially calcified material. The ameloblasts build up the rods by the addition of globule after globule, surrounding them with a cementing substance and completing the calcification of both. In this sense the striation of the enamel may be said to record the growth of the individual rods.

While the enamel is a very hard substance when its structure is complete and perfect, its most striking physical characteristic is a tendency to split or crack in the direction of its structural elements when a break has been made in the tissue. While it is difficult to cut across the rods or make an opening on a perfect surface, if a break has been

Fig. 84.

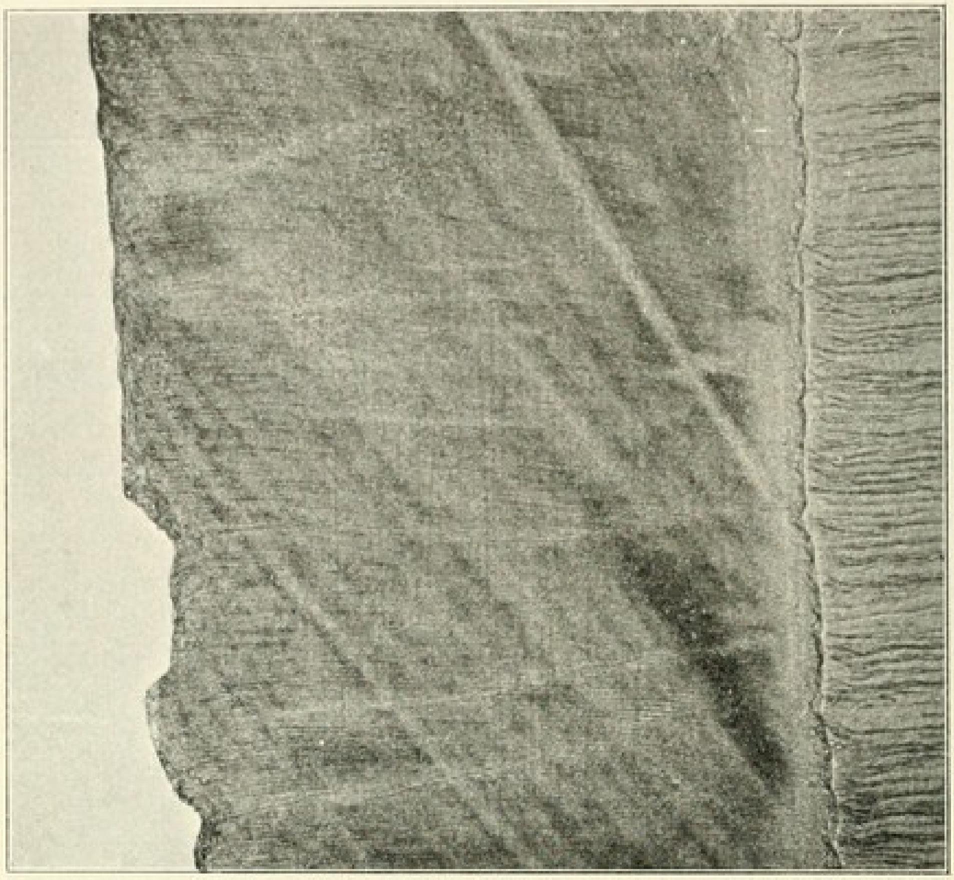


Enamel showing direction of cleavage. (About 70 ×.)

established it is comparatively easy to split off the tissue from the sides of the opening when the rods lie parallel with each other. Fig. 84 shows a field of enamel illustrating the way in which the tissue splits or cleaves in the direction of the rods.

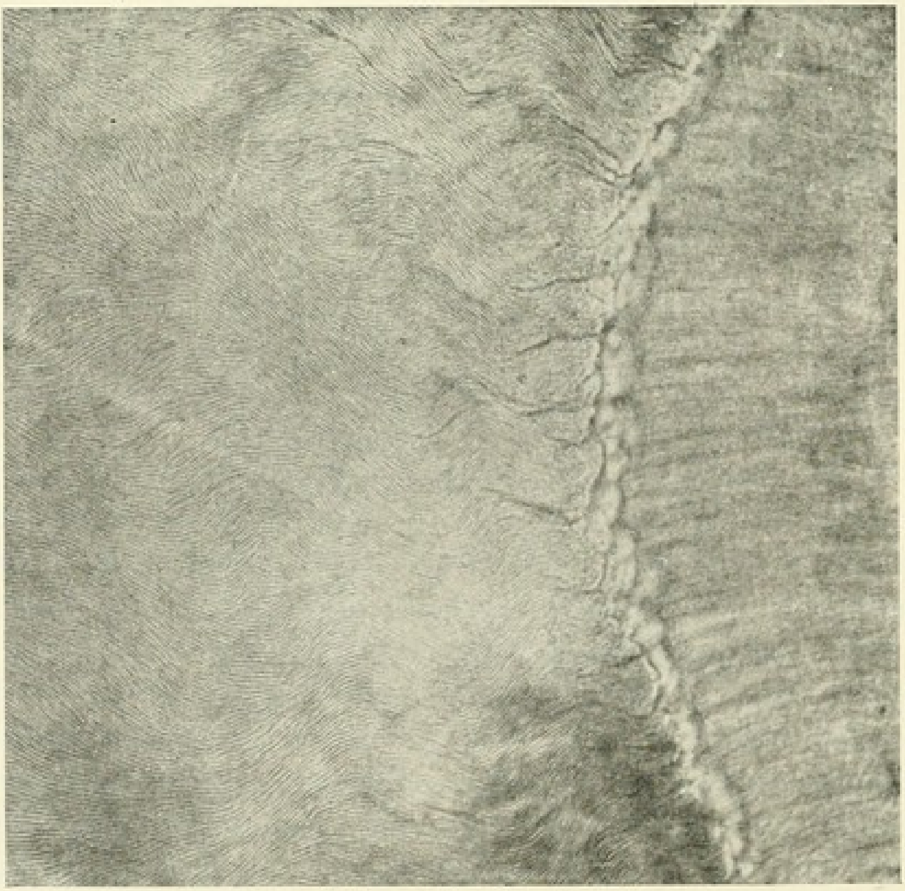
Upon the axial surfaces the enamel rods are usually straight and parallel with each other, except where there has been some flaw or disturbance in development; but upon the occlusal surface, although sometimes straight, they are very often much twisted and wound round each other, especially at their inner ends. This difference in the arrangement of the rods causes the greatest difference in the feeling of the tissue under cutting instruments. Such a specimen of enamel as shown in Fig. 85 can be cut away easily, the tissue breaking through to the dentin and splitting off in chunks; while a specimen like Figs. 86 and 87 will not cleave if supported upon sound dentin. If the outer

FIG. 85.



Straight enamel rods. (About 80×.)

FIG. 86.

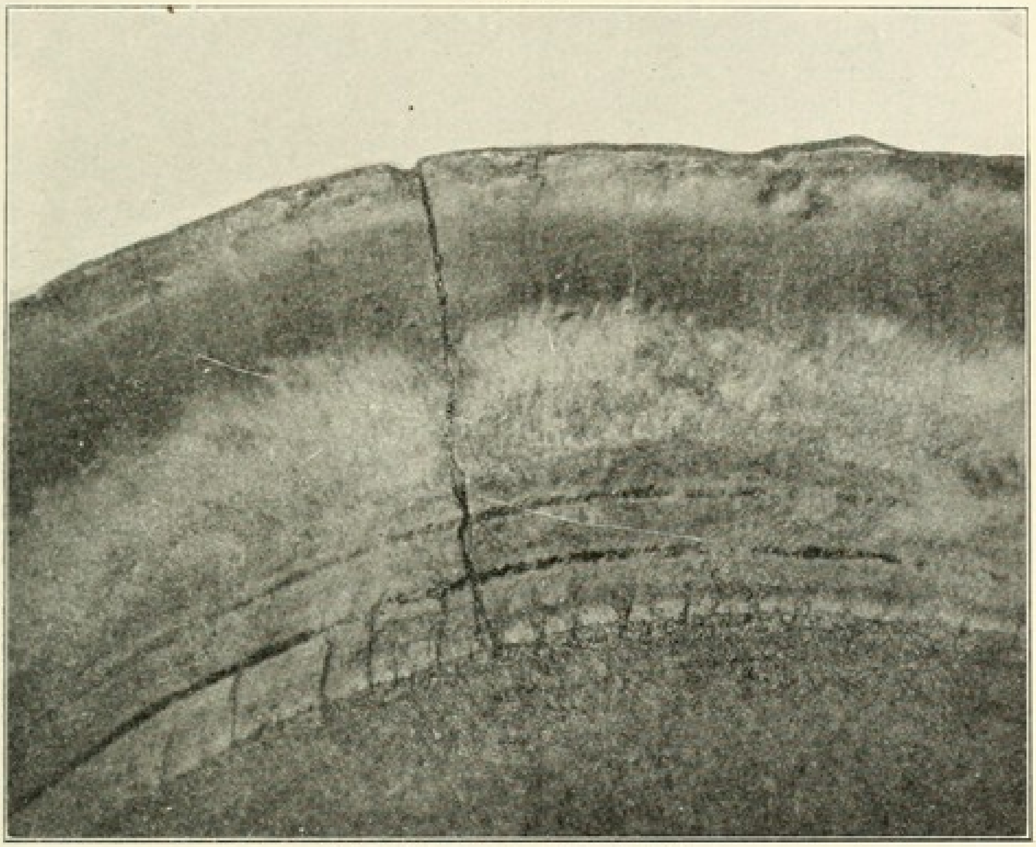


Gnarled enamel. (About 80×.)

ends of the rods are straight, they will split part way to the dentin (Fig. 87); but where they begin to twist round each other they will break across the rods. If the dentin is removed from under such enamel, it will break in an irregular way through the gnarled portion.

From a study of the arrangement of the enamel rods in the formation of the crown it is apparent that the plan is such as to give the

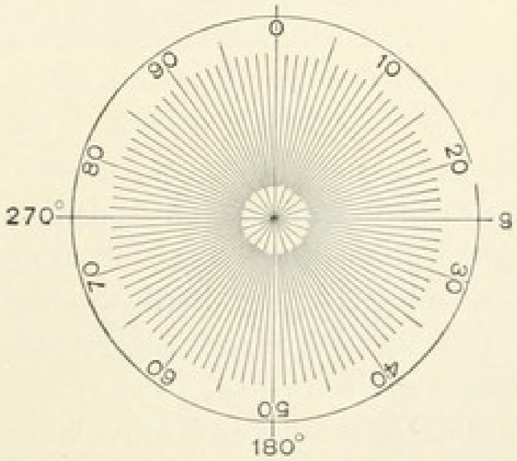
FIG. 87.



Gnarled enamel. (About 50 ×.)

greatest strength to the perfect structure, and may be likened to an arch. At the gingival border the rods are short and are inclined apically 6 to 10 centigrades[1] (20° to 35°) from the horizontal plane. These short rods

[1] In the Centigrade division the circle is divided into one hundred parts, each called a centigrade. One centigrade is equal to 3.6 degrees of the astronomical circle, 25 centigrades to 90 degrees, 12½ centigrades to 45 degrees. The cut gives a comparison of the two systems of measuring angles.



Centigrade division.

are overlapped for a short distance by the cementum. This inclination grows less and less, and at some place in the gingival half of the middle third of the surface they are in the horizontal plane. At this point they are also usually perpendicular to the surface of the enamel. Passing from this point they become inclined more and more occlusally from the horizontal plane, at the junction of the occlusal and middle thirds about 8 to 12 centigrades (28° to 40°) in bicuspids and molars, and 8 to 18 centigrades (28° to 65°) in incisors and canines. In the occlusal third the inclination increases rapidly, and often the outer ends of the rods

Fig. 88.

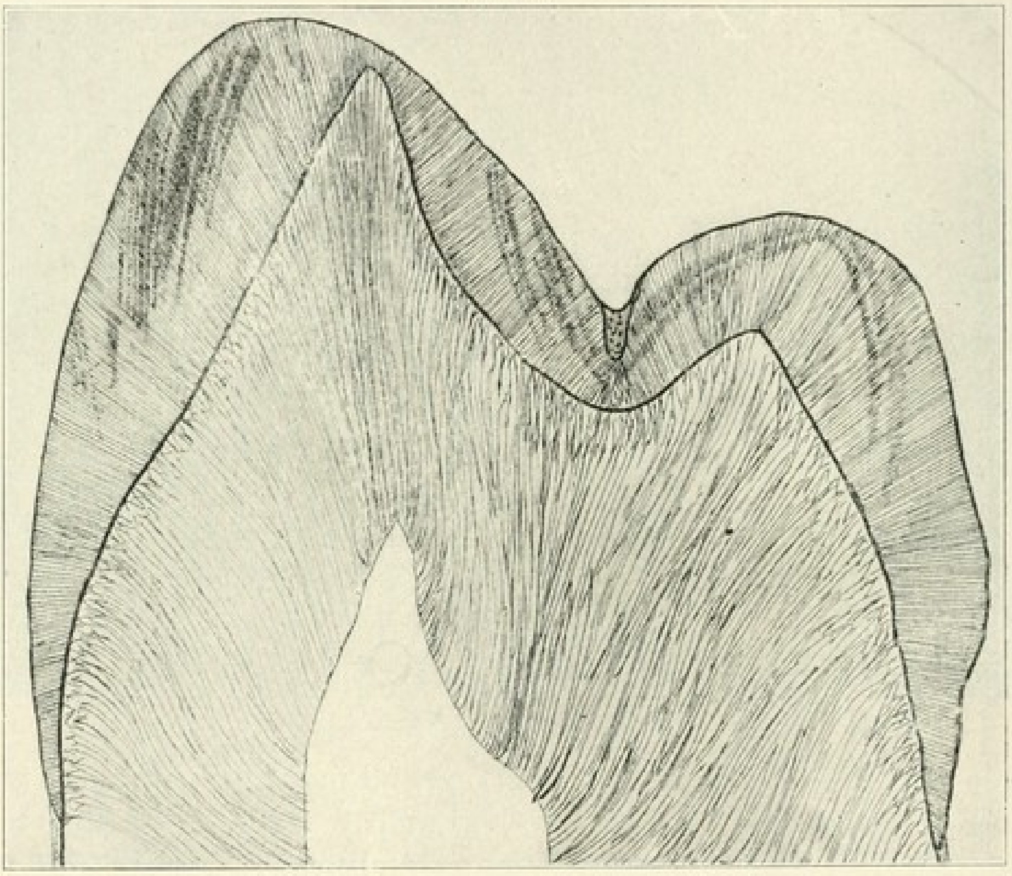
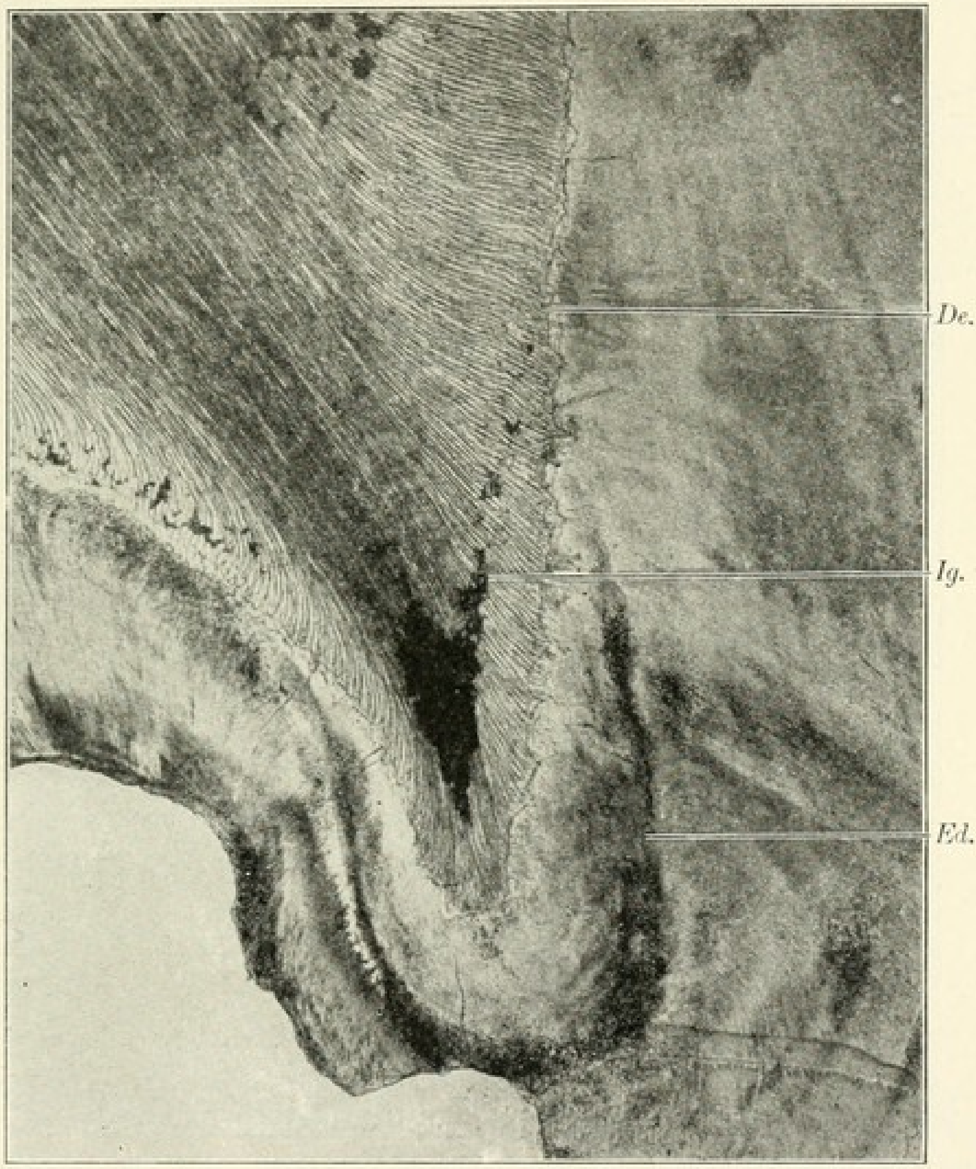


Diagram of enamel rod directions, from a photograph of a bucco-lingual section of a superior bicuspid.

are inclined more than the inner ends. Over the point of the cusps and the crest of the marginal ridges the rods reach the axial plane, though they are often very much twisted about each other in the inner half of their length. This position does not always correspond with the highest point of the cusp, but is inclined slightly axially from that position, and corresponds with the highest point of the dentin cusp.

Passing down the central slope of the cusp, or ridge, the rods become again inclined away from the axial plane toward the groove, or pit, leaning toward each other where the two plates meet. The degree of inclination of the rods on the central slope of the cusps depends upon the height of the cusps; the higher the cusp the greater the inclination from the axial plane. Fig. 88, a diagram from a photograph of a bucco-lingual section of a superior bicuspid, shows the plan of arrangement and illustrates the arch principle in the construction.

FIG. 89.

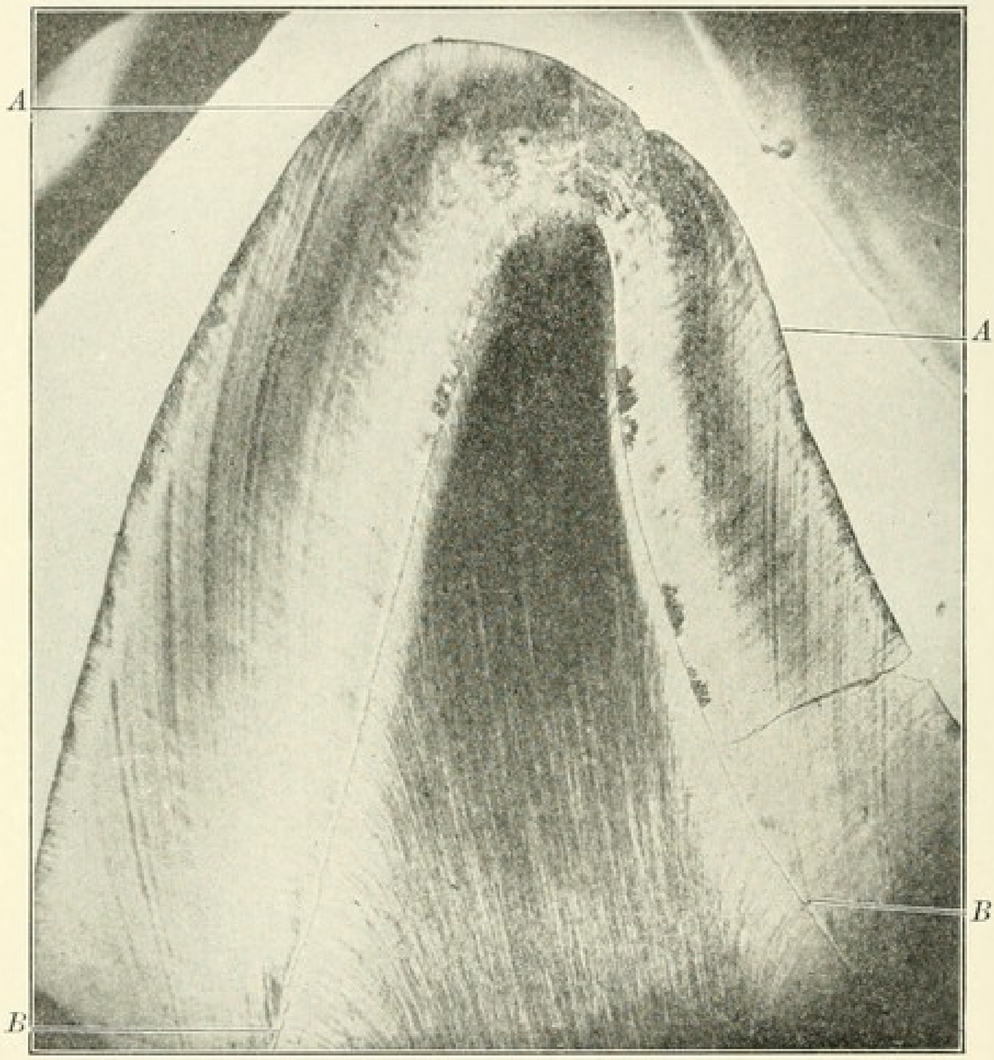


Stratification of enamel; the cusp of a bicuspid: *De*, dento-enamel junction; *Ed*, enamel defect showing in the heavy stratification band; *Ig*, interglobular spaces in the dentin. (About 40 ×.)

In the study of longitudinal sections of the teeth, one of the most conspicuous structural features is the stratification bands, or *brown bands of Retzius*. These bands are not parallel with either the outer surface of the enamel or the dento-enamel junction. They begin at the tip of the dentin cusps and sweep around in larger and larger zones. These stratification bands are better seen in comparatively thick sections, and are caused by the varying amount of pigment deposited with the calcium salts in the development of the tissue. They record the growth of enamel of the crown as a whole, as each line was at one time the surface of the enamel cap. These stratifications, or, better, incremental lines, are shown in Figs. 89–91.

At the time the rod at *A* (Fig. 90) was completely formed the rod at *B* was just beginning to form at its dentinal end. From this it would

Fig. 90.



Incisor tip showing stratification or incremental lines. Rods at *A* were fully formed at the time the rods at *B* were beginning to form. (About 50 ×.)

seem that any structural defect due to imperfect development would not follow the direction of the enamel rods from the surface to the dentin, but would follow the stratification lines; and if these structural defects influenced the penetration of caries, we should expect to have the direction of penetration modified. Fig. 89 shows a structural defect in the enamel over a cusp following the stratification band, and it will be noticed also that there is a structural defect in the dentin at a corresponding position.

HISTOLOGICAL REQUIREMENTS FOR STRENGTH IN ENAMEL WALLS.

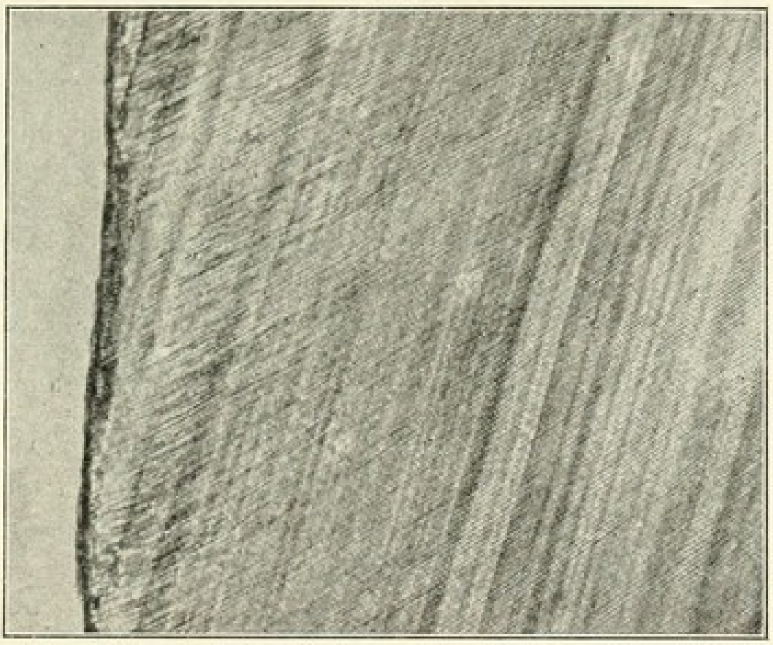
1. The enamel must be supported upon sound dentin.

2. The rods which form the cavo-surface angle must run uninterruptedly to the dentin and be supported by short rods, with their inner ends resting on the dentin and their outer ends abutting upon the cavity wall, where they will be covered in by the filling material.

3. That the cavo-surface angle be cut in such a way as not to expose the ends of the rods to fracture in condensing the filling material against them.

The first step, then, in the preparation of an enamel wall is to determine the direction of the enamel rods by cleavage with a chisel or hatchet.

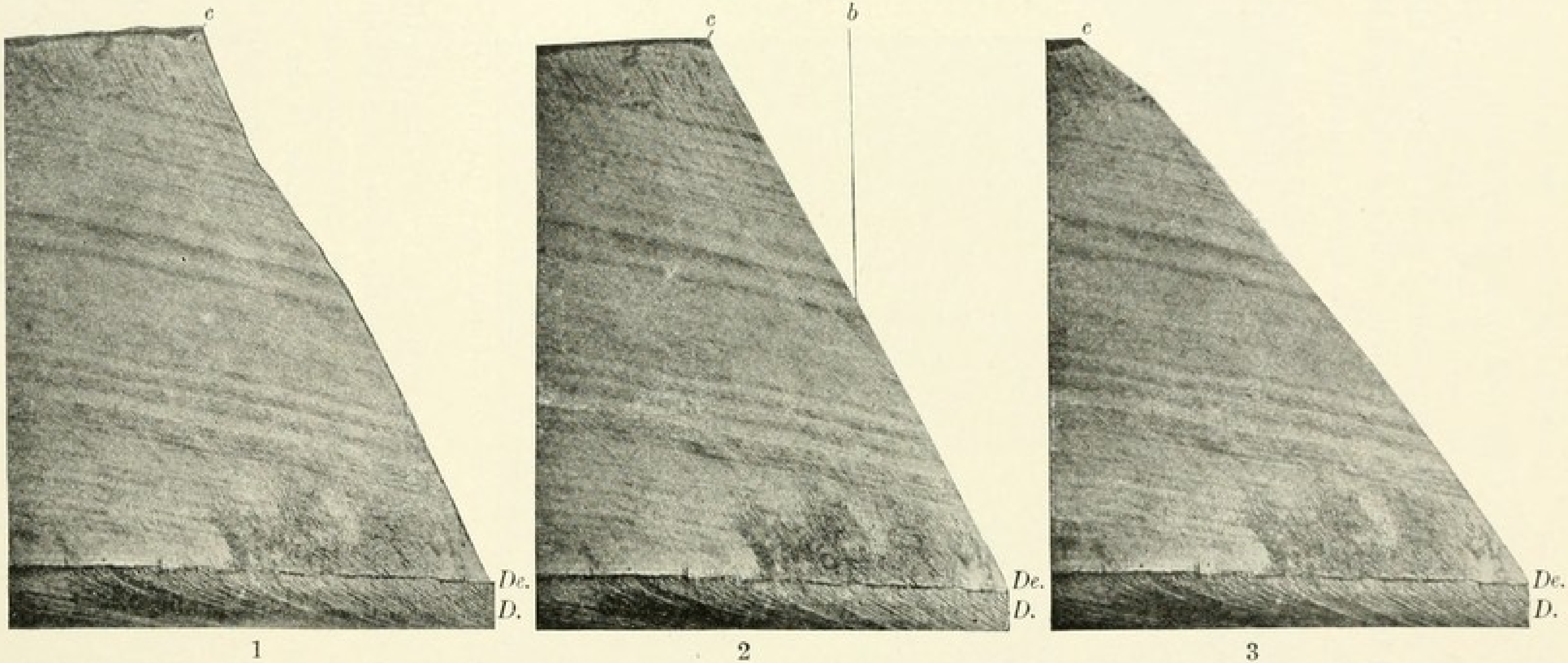
Fig. 91.



Enamel showing both striation and stratification. (About 80 ×.)

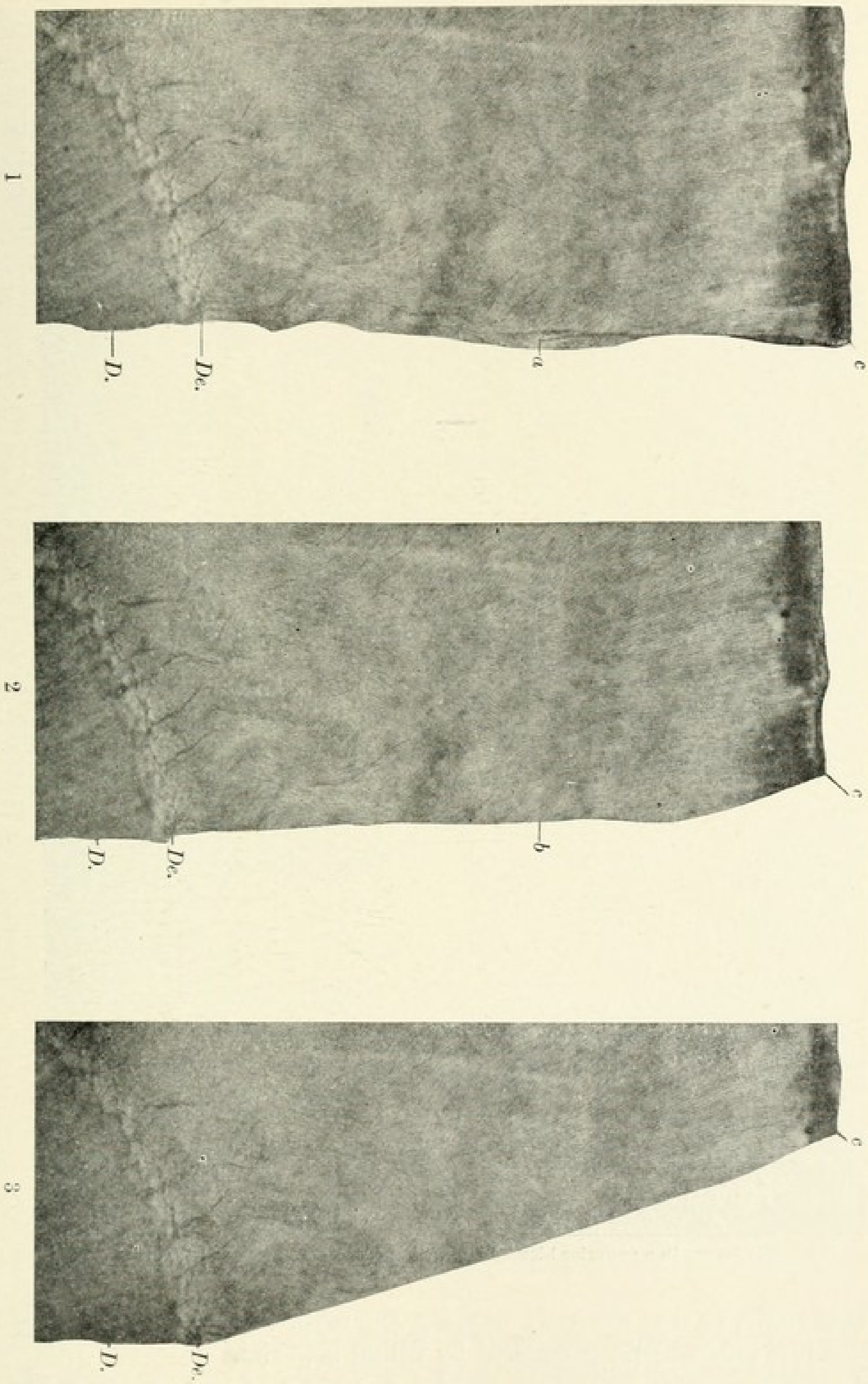
In Figs. 92 and 93, No. 1 shows an enamel wall after cleaving the enamel with a hatchet. It will be noticed that the split has not followed the direction of the rods exactly, but has broken across them, slivering the rods as wood slivers in splitting. This would cause in the cut surface a whitish, opaque appearance. The plane of the enamel wall should be extended so as to form a small angle with the plane of the dentin wall, by shaving the surface with a very sharp hand instrument. No. 2 shows the same wall after it has been extended somewhat; but it will be seen that it has not been extended enough, for the rods forming the surface at *A* do not reach the dentin, but run out at *B* on the cavity wall, and that piece would chip out in packing against it or if force came upon the surface afterward. The angle should be extended so as to produce

Fig. 92.



Preparation of enamel wall in straight enamel: 1. Enamel wall as cleaved, showing breaking across rods. 2. Wall smoothed but not extended; some rods do not reach the dentin, but their inner ends are cut off at *b*. 3. Correctly trimmed and the cavo-surface angle slightly beveled. The inclination of the enamel rods is too great to make a good enamel wall in this position. *c*, cavo-surface angle; *De*. dento-enamel junction; *D*, dentin; *b*, point at which inner ends of rods are cut off. (About 80 ×.)

FIG. 93.

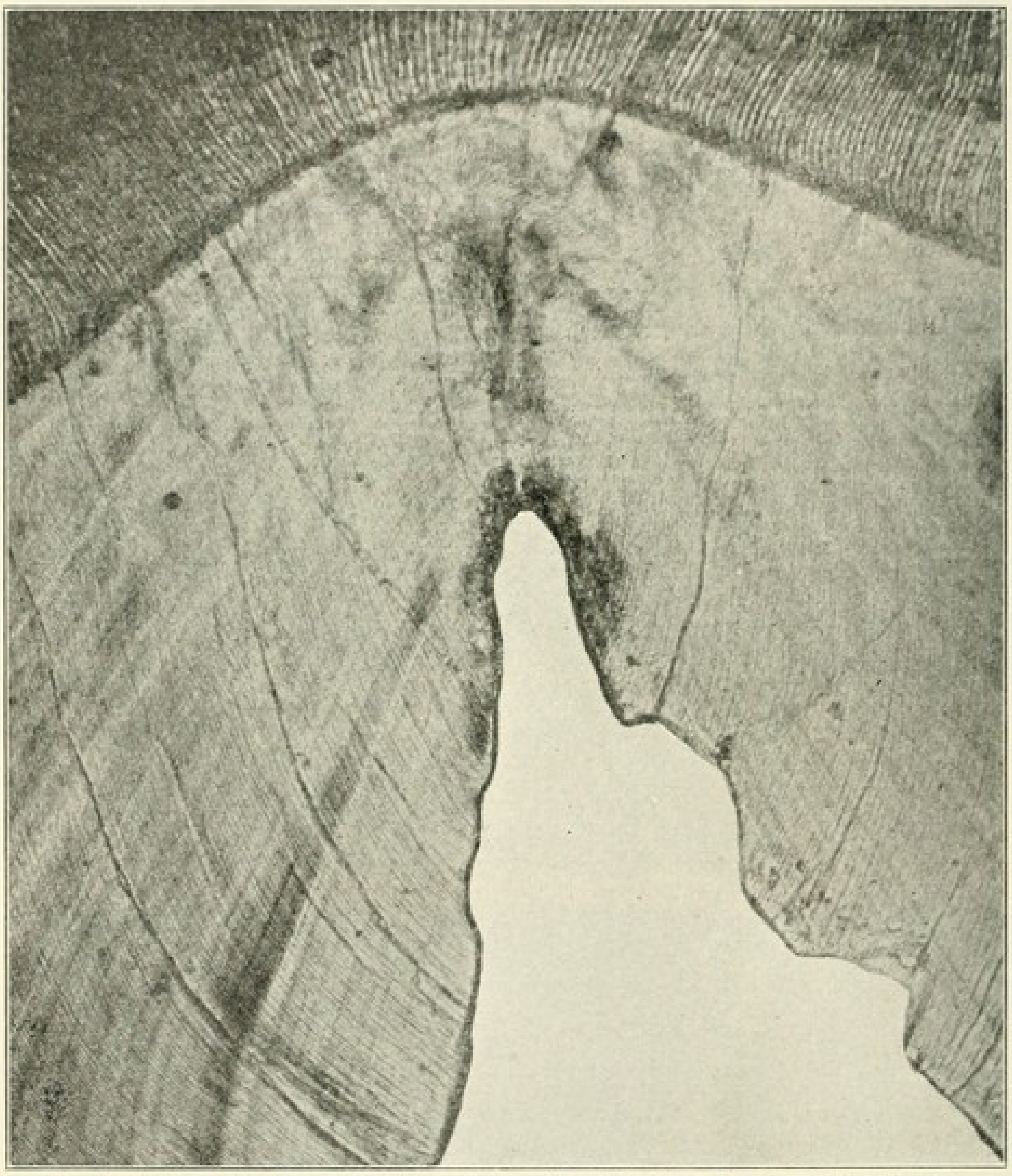


Preparation of enamel wall in gnarled enamel: 1. Enamel wall as cleaved, showing breaking across rods and slivering at *a*. 2. Wall as smoothed but not extended to remove short rods whose inner ends are cut off at *b*. 3. Wall extended and trimmed to a position of strength. *D*, dentin; *De*, dento-enamel junction; *c*, cavo-surface angle: *b*, point where inner ends of rods are cut off; *a*, slivering of the tissue. (About 80 ×.)

the plane shown in No. 3; then the cavo-surface angle may or may not be bevelled as the position demands.

In some positions, as on the axial surfaces, it is not possible to extend the plane of the entire enamel wall as described; all that can be done is to shave the cut surface, leaving the wall in the direction of the enamel rods, and then the margin is strengthened by bevelling the cavo-

Fig. 94.

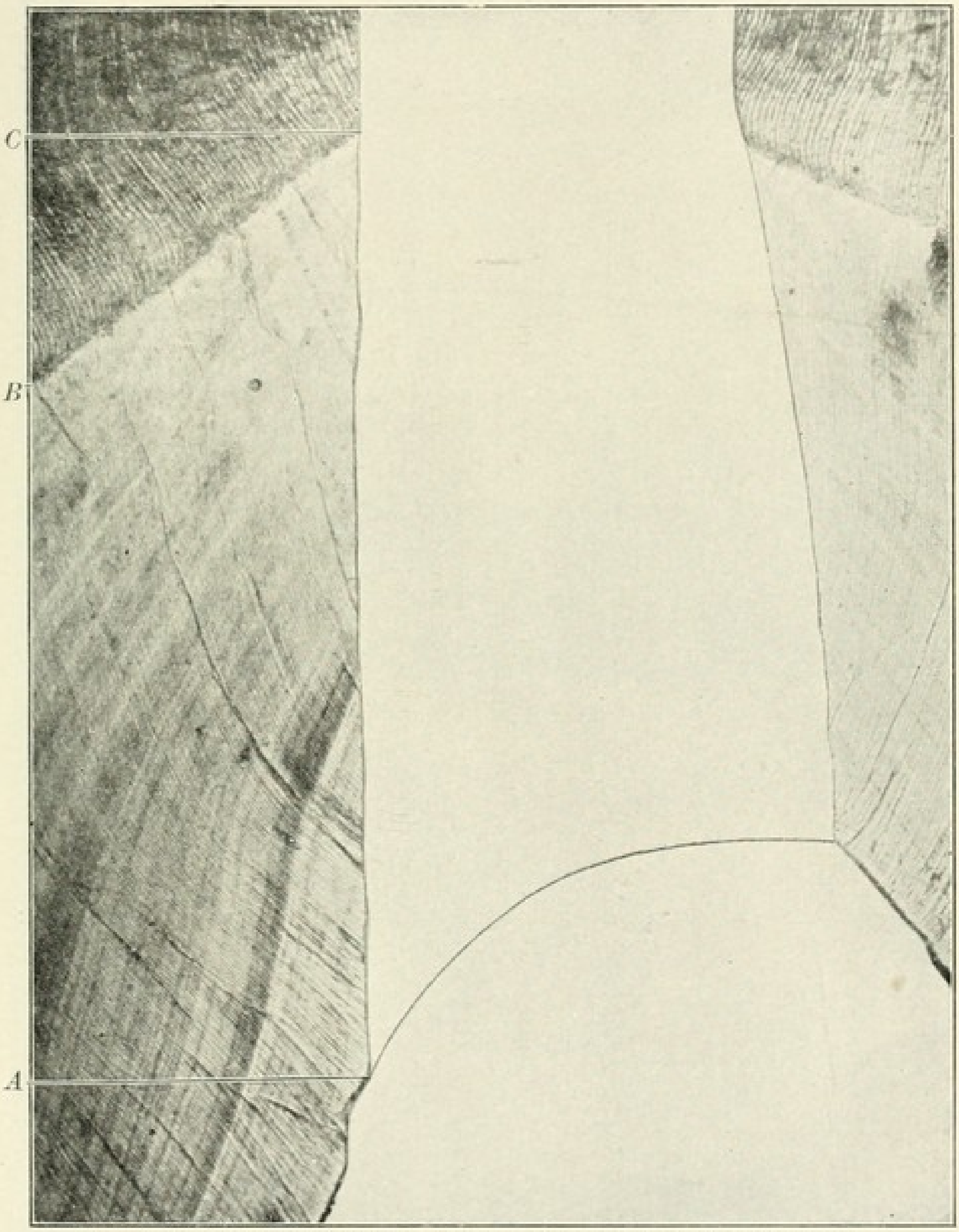


Occlusal fissure in a superior bicuspid, showing direction of rods. (About 80 ×.)

surface angle, so that the rods forming the margin are supported by at least a few rods which are covered by filling material.

In cutting out the fissures on the occlusal surfaces of molars and bicuspids, the rods are inclined centrally from the axial plane, as seen in Fig. 94. In opening a fissure the lines of cleavage will not be in the axial plane, but sloping inward toward the body of the cusp, in the direction indicated by the direction of the cracks in Fig. 94. The outer ends of the enamel rods must be shaved away, to bring the plane of the enamel wall parallel with the dentin wall or into the axial plane. When this has been done a strong margin has been formed, for the

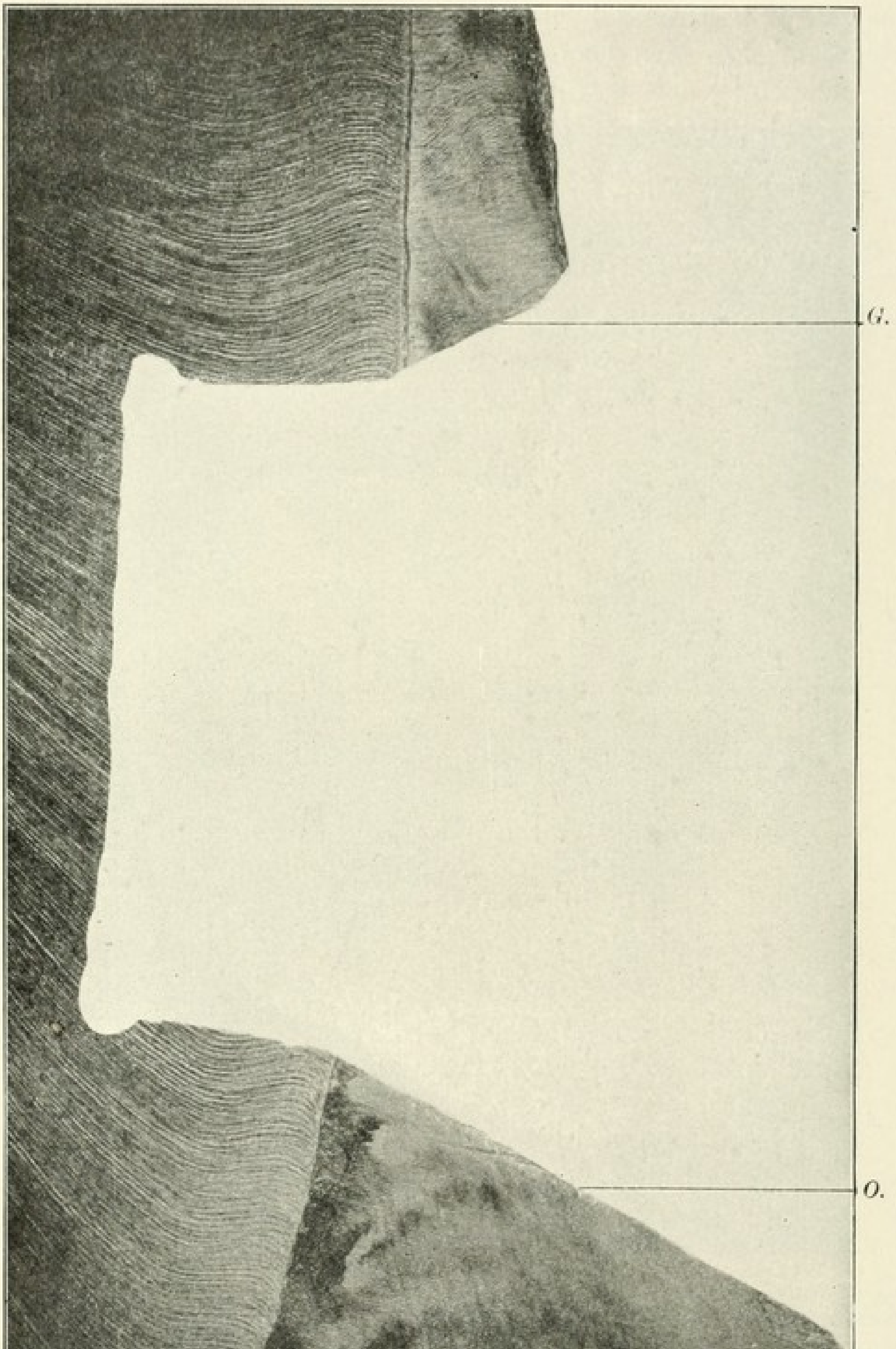
Fig. 95.



Preparation of enamel walls in occlusal fissure cavities (the same as Fig. 94).

rods which form the point of the cavo-surface angle are supported by the piece *A*, *B*, *C* (Fig. 95), made up of rods resting upon sound dentin and covered by the filling material. Often the angle will be too sharp, however, and the cavo-surface angle should usually be bevelled to protect the margin from accident. This illustration may be taken as typical of occlusal cavities.

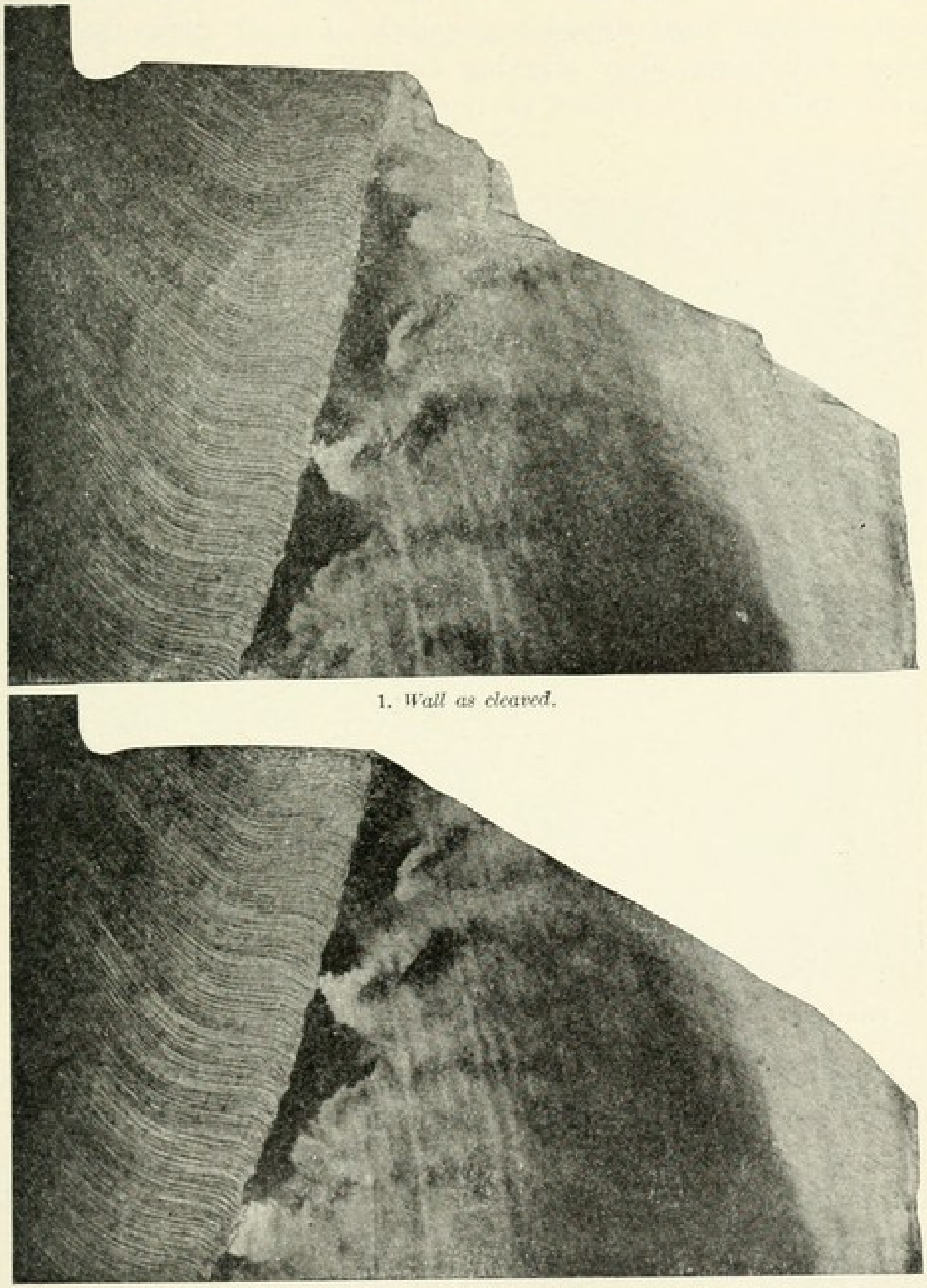
FIG. 96.



Preparation of enamel walls in a buccal cavity in a molar: *G*, gingival wall; *O*, occlusal wall. (About 70 ×.)

Fig. 96 shows a cavity prepared in the buccal surface of an upper molar. The occlusal margin is placed in the occlusal half of the middle third, and the gingival margin in the gingival half of the gingival third

Fig. 97.



1. *Wall as cleaved.*

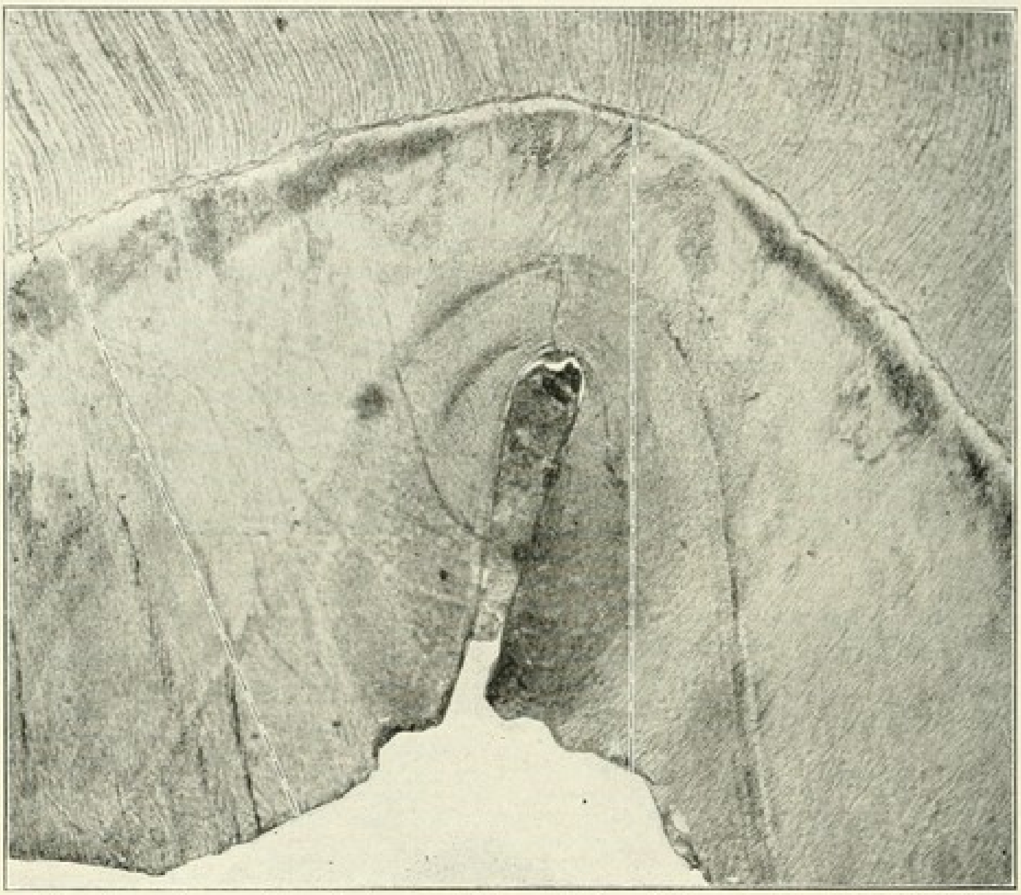
2. *Wall as trimmed.*

Preparation of occlusal wall of Fig. 96. (About 70 ×.)

of the surface. In the occlusal wall the rods are inclined occlusally about 8 centigrades (28°) from the horizontal plane. After cleaving, the broken and slivered rods should be shaved away, but the angle cannot be increased without making the margin of filling material too thin; the rods forming the margin should therefore be protected by bevelling the cavo-surface angle. At the gingival wall the rods are inclined apically from the horizontal plane about 6 centigrades (20°). The wall should be shaved in that plane, increasing the angle a little, and the cavo-surface angle should be bevelled. Fig. 97 shows the occlusal enamel wall alone, after cleaving and trimming into form. Such enamel walls may be taken as typical of axial surface cavities, the

Fig. 98.

L.



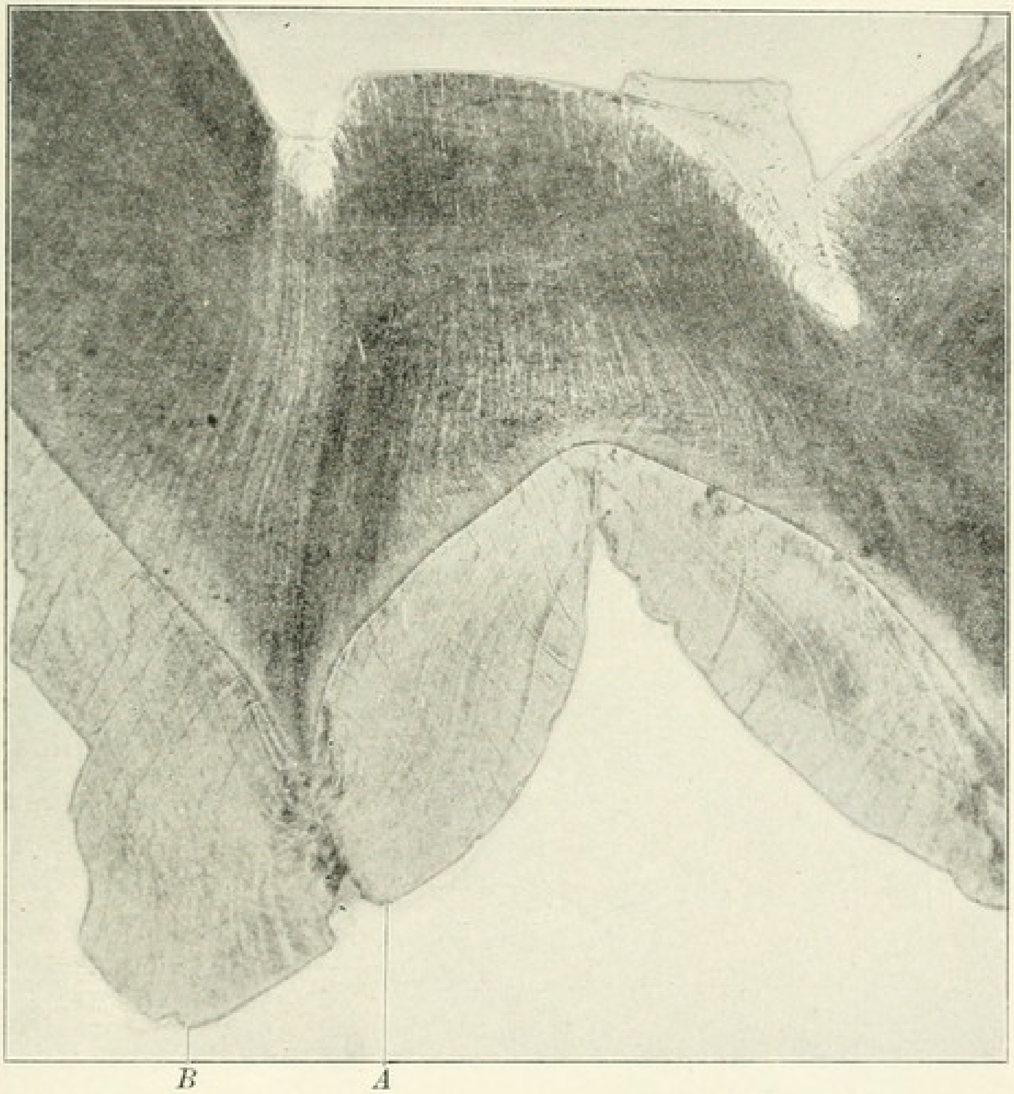
B.

Structure of enamel about a fissure: *B*, buccal side; *L*, lingual side. (About 70 ×.)

angle of the enamel with the dentin wall being determined by the direction of the enamel rods in the position where the margin is laid.

Grooves, fissures, and pits are always positions of weakness, and when a cavity approaches a groove or pit a good margin, histologically, cannot be prepared without cutting beyond it. Fig. 98 shows an occlusal fissure in a bicuspid, which illustrates the conditions of structure characteristic of these positions. The rods are inclined toward the fissure, and between the bottom of the fissure and the dentin are very irregular. If a cavity wall were made to approach this fissure from the lingual side, so as to come to the dotted line, the wall would have to be inclined 6 to 8 centigrades (20° to 28°) from the axial plane toward the fissure, and then the cavo-surface angle bevelled, when the conditions would be similar to those in the wall of an axial surface cavity, and not as strong as the location requires. Not only is this true, but it also leaves a vulnerable point next to the margin of the filling—a point of liability. Cutting just beyond the fissure, the wall may be left in the axial plane and have an ideally strong margin, and the point of liability is removed. To state the conditions in general

FIG. 99.

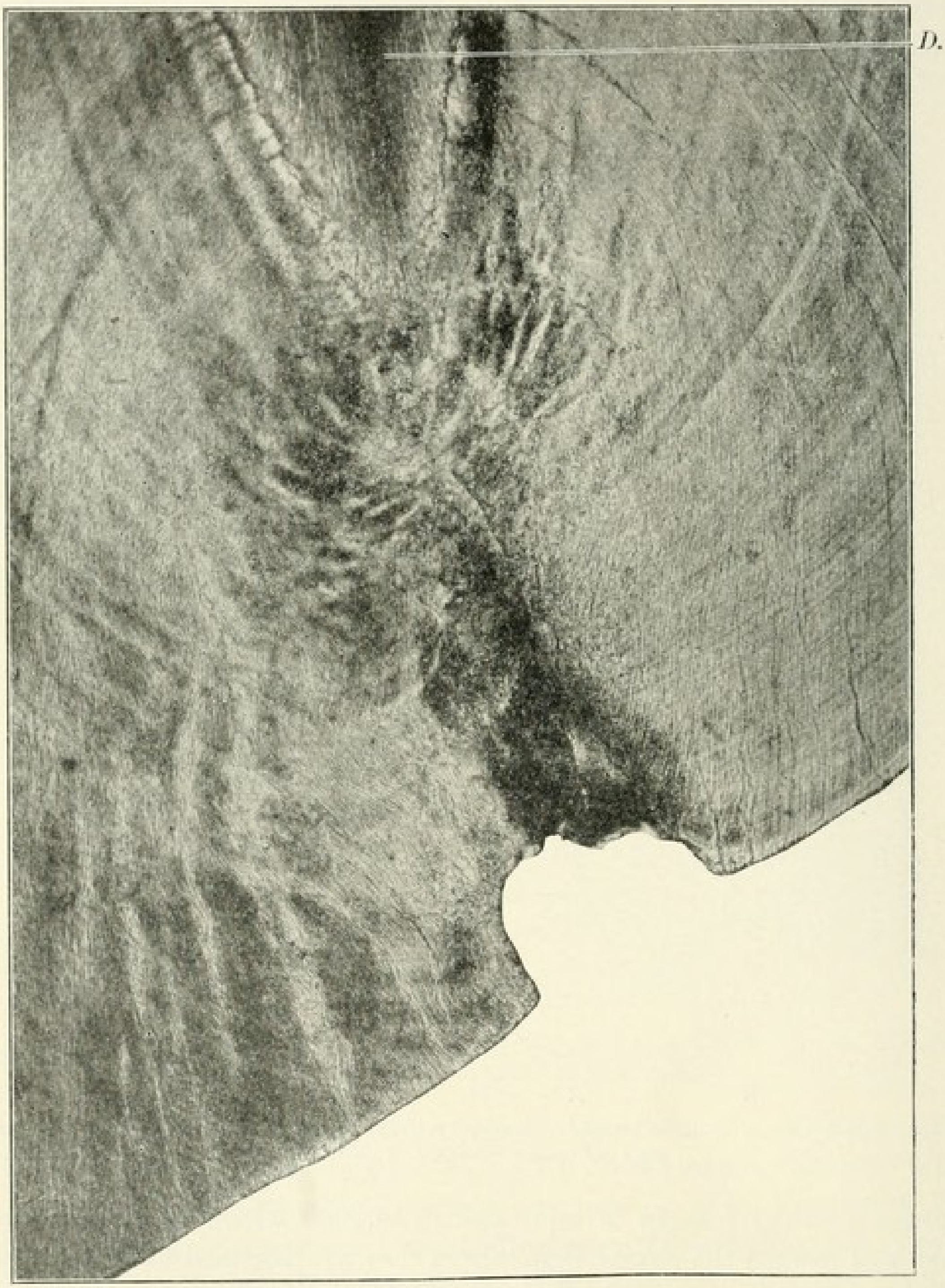


Bucco-lingual section of upper bicuspid. Enamel is broken from grinding: *A* to *B*, area of weakness for enamel margins. (About 20 ×.)

terms, a strong margin is more easily obtained where enamel rods are inclined toward the cavity than where they are inclined away from the cavity.

The points of cusps and the crests of marginal ridges are positions of strength in the perfect tissue; but when a cavity margin approaches them they become points of weakness, because it is impossible to support properly the rods which form the margin. Over the marginal ridges are many short rods which do not reach the dentin, and these are usually very much twisted about each other, so as to form the strongest possible keystone in the perfect structure. In preparing a

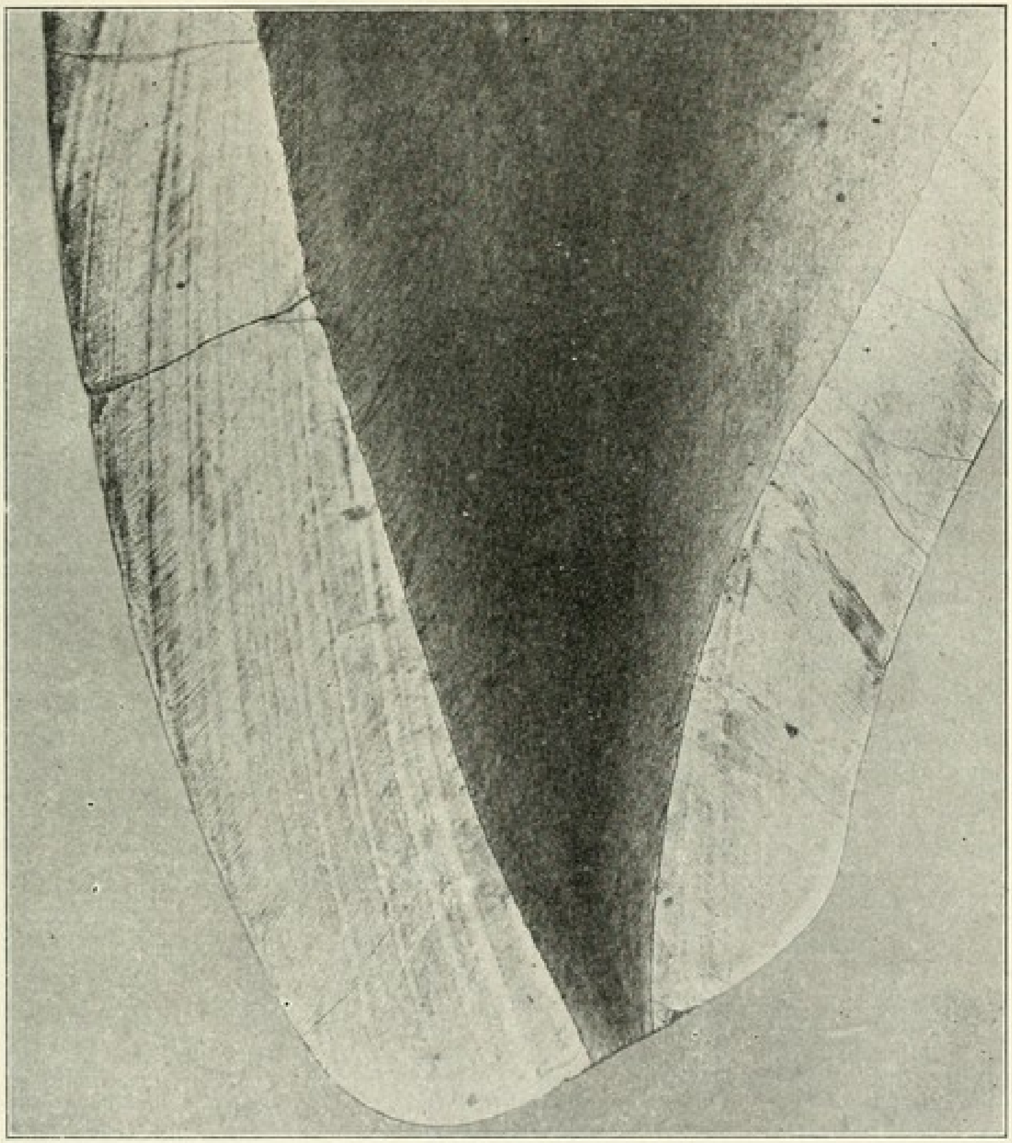
Fig. 100.



Enamel over tip of dentin cusp: *D*, dentin cusp. (About 80 ×.)

margin in such a position it is impossible to have the rods which form the margin reach the dentin with their inner ends, and these short rods are sure either to break in completing the operation or to break out later. The arrangement of enamel rods in such positions is to be borne in mind, especially when extending approximal cavities in incisors toward the lingual side and in large pit cavities in incisors. A similar condition is found over the points of the cusps. Fig. 99 shows a bucco-lingual section of an upper bicuspid. It will be noticed that the rods forming the point of the cusp are not in the axial plane, and

FIG. 101.



Tip of an incisor. (About 50 ×.)

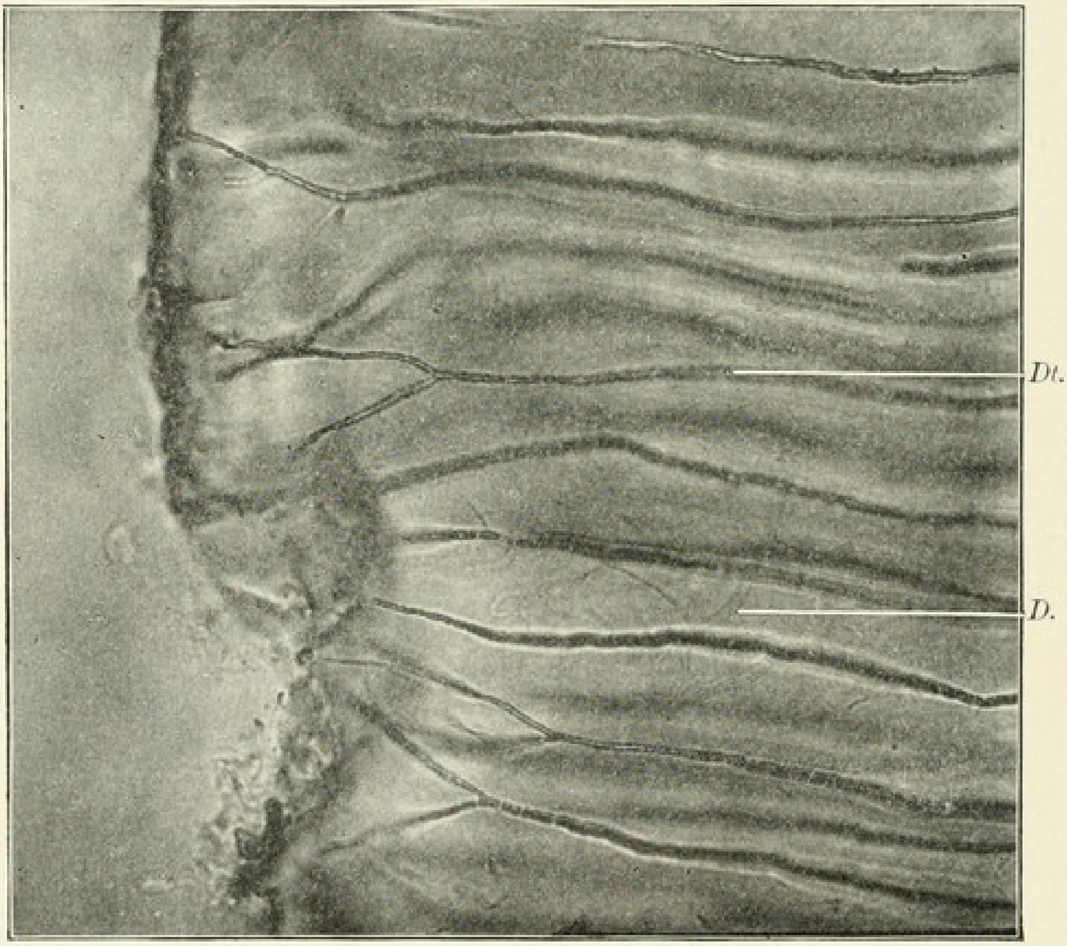
do not reach the tip of the dentin cusp, but reach the dentin a little way down on the outer slope. The enamel covering the tip of the dentin contains many short rods, and they are very much twisted about each other, so that the area from *A* and *B* to the point of the cusp is an area of weakness for the cavity margins. If the margin reaches this area, the cusp must be cut away and the enamel wall carried out in the horizontal plane. Fig. 100 shows this area more highly magnified, and illustrates the structure. It will be noticed that, in grinding, some of the short twisted rods have broken out of the section.

Fig. 101 shows the tip of an incisor in labio-lingual section, and is of interest in relation to the formation of margins in step cavities in incisors. The tip of this tooth has been worn off in use. The illustration shows that the great inclination of the rods toward the axial plane in the occlusal third of the incisors is such as to bring the wear almost at right angles to the direction of the rods.

Dentin.

The structure of dentin is of comparatively little interest in the present consideration, as its histological forms do not directly influence

Fig. 102.

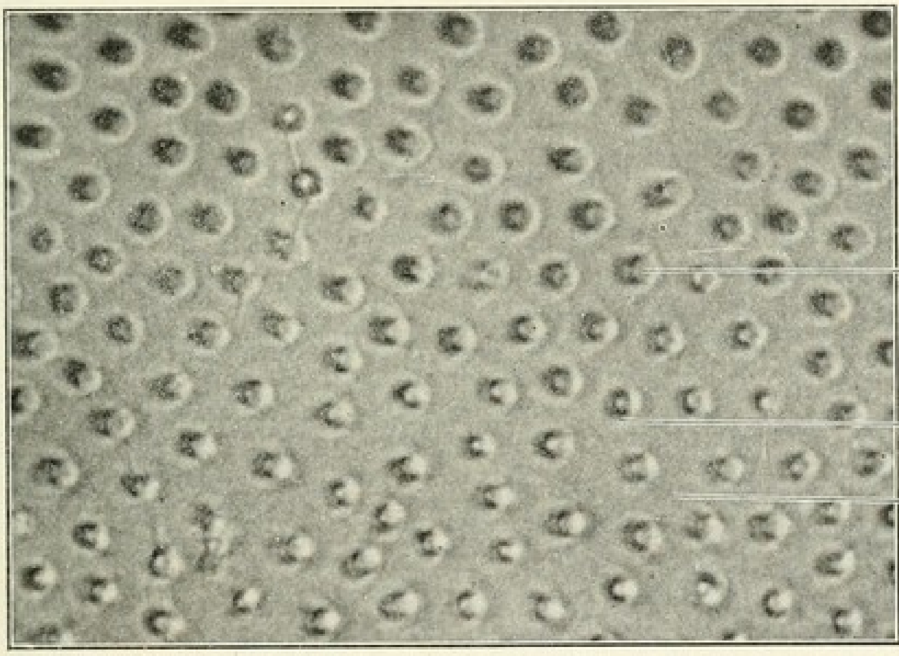


Dentin at dento-enamel junction, showing tubules cut longitudinally: *Dt*, dentinal tubules; *D*, dentin matrix. (About 760 ×.)

the cutting of the tissue in the excavation of cavities. Its histological forms have, however, much to do with the penetration of caries and with other considerations which are of importance to the intelligent practice of operative dentistry.

Dentin belongs to the connective-tissue group, and is made up of a solid organic matrix impregnated with about 72 per cent. of inorganic salts[1] and pierced by minute canals or tubules, which radiate from a central cavity which contains the remains of the formative organ, or pulp. The minute canals, or DENTINAL TUBULES, are occupied in life by protoplasmic processes from the odontoblastic cells which form the outer layer of the pulp. Dentin contains two kinds of organic matter, the contents of the tubules and the organic basis of the matrix. The dentin matrix, after the removal of the calcium salts by acids, yields gelatin on boiling and resembles the matrix of bone, reacting in a similar, though not identical, way with staining agents. The portion of the matrix immediately surrounding the tubules shows different chemical

FIG. 103.



Dentin showing tubules in cross-section: *Dt*, dentinal tubules; *D*, dentin matrix; *S*, shadow of sheaths of Neumann. (About 1150 ×.)

characteristics from the rest of the matrix, resembling elastin, and resisting the action of strong acids and alkalies after the rest of the tissue has been destroyed. This portion of the matrix surrounding the tubules and lying next to the fibrils is known as the *sheaths of Neumann*.

The dentinal tubules are from 1.1 to 2.5 microns in diameter, and are separated from each other by a thickness of about 10 microns of

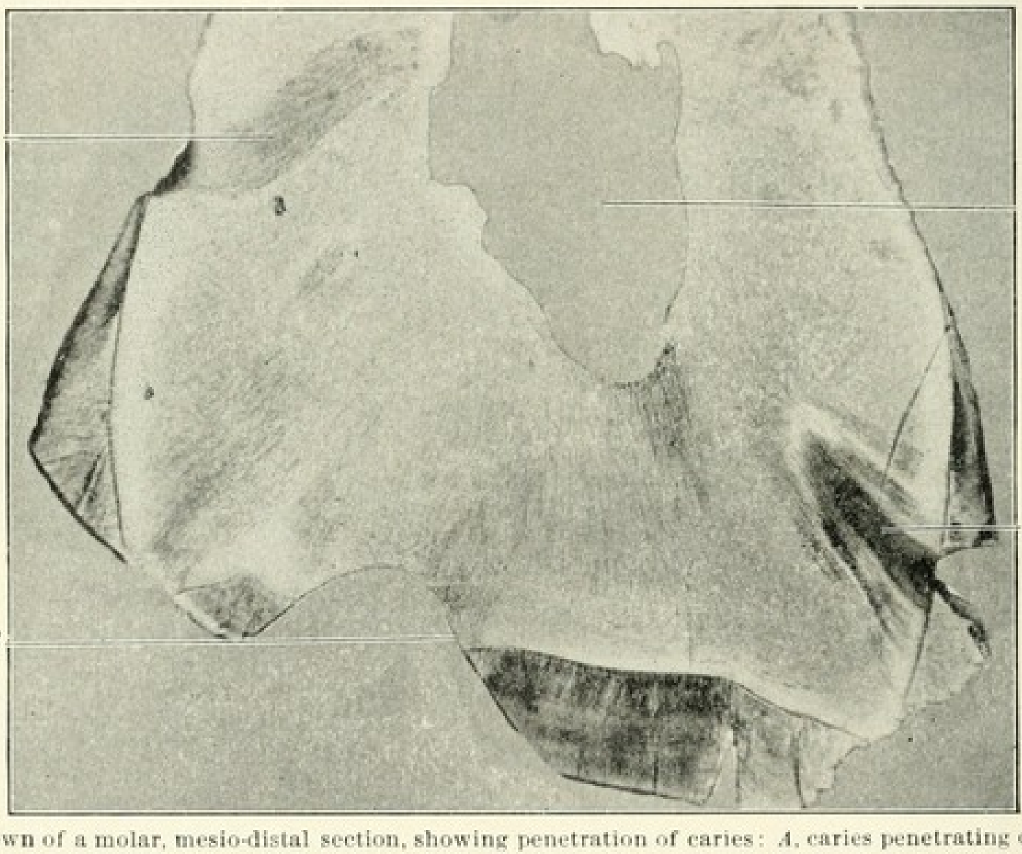
[1] Von Bibra gives the following analysis of dentin:

Organic matter	27.61
Fat	.40
Calcium phosphate and fluorid	66.72
Calcium carbonate	3.36
Magnesium phosphate	1.08
Other salts	.83

dentin matrix. This is fairly uniform throughout the dentin. The character of the tubules is different in the crown and root portions.

In the crown the tubules branch but little through most of their course; but in the outer part, close to the enamel, they branch and anastomose with each other quite freely. Fig. 102 shows a field of dentin just beneath the enamel, as seen with a high power, and shows the diameter of the tubules, their branching, and the amount of matrix between one tubule and the next. The relation of one tubule to each other is shown also in sections cut at right angles to their direction (Fig. 103). In the crown portion the tubules pass from the pulp chamber

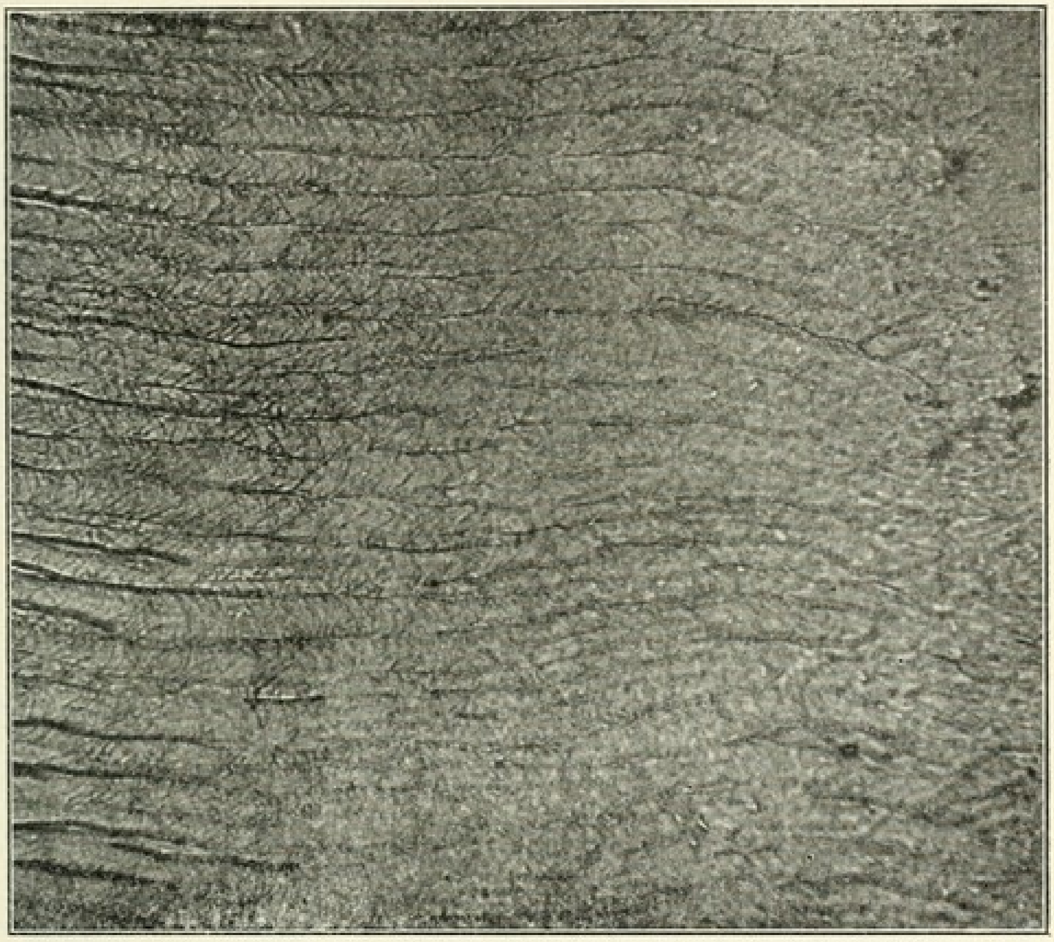
FIG. 104.



Crown of a molar, mesio-distal section, showing penetration of caries: *A*, caries penetrating dentin; *B*, line of abrasion; *P*, pulp chamber. (About 20 ×.)

to the dento-enamel junction in sweeping curves, so as to enter the pulp chamber at right angles to the surface, and end next to the enamel at right angles to that surface. This produces S- or F-shaped (∫ or ∫) curves, which are known as the primary curves of the tubules. Throughout their course the tubules are not straight, but show a great many wavy curves, known as the secondary curves. These appear as waves when seen in longitudinal sections, but are really the effect of an open spiral direction, as is seen by changing the focus of the microscope in studying sections cut at right angles to the direction of the tubules.

FIG. 105.



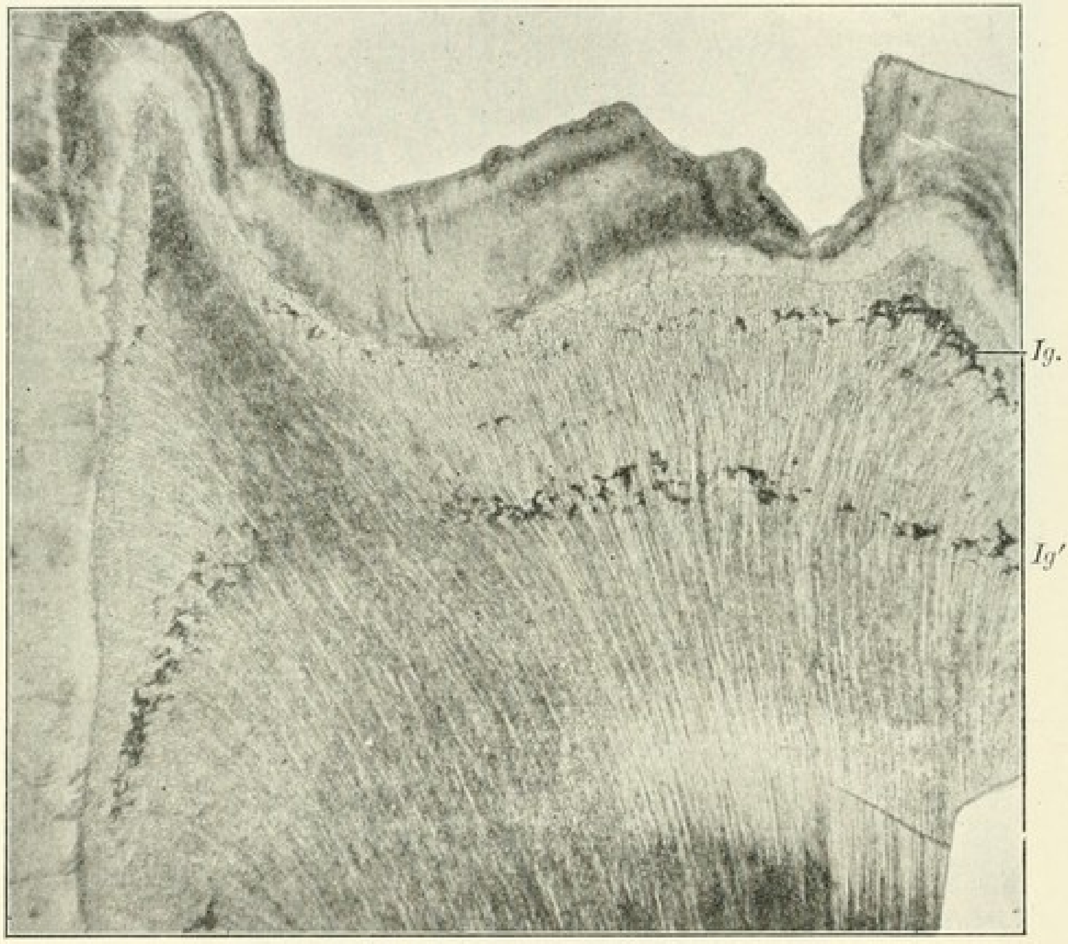
Dentin from the root, showing tubules cut longitudinally. (About 700 ×.)

FIG. 106.

Dento-enamel junction. (About 70 ×.)

The branches throughout their length are few and small, and are given off at an acute angle to the direction of the tubule; but just before the enamel is reached the tubules fork and branch, producing an appearance similar to the delta of a river. These branches are given off from the tubules for some little distance back from the enamel, and they anastomose with other tubules very freely. The branching of the tubules in their outer portion causes the spreading of caries just beneath the enamel, the micro-organisms growing through the branches from tube

FIG. 107.

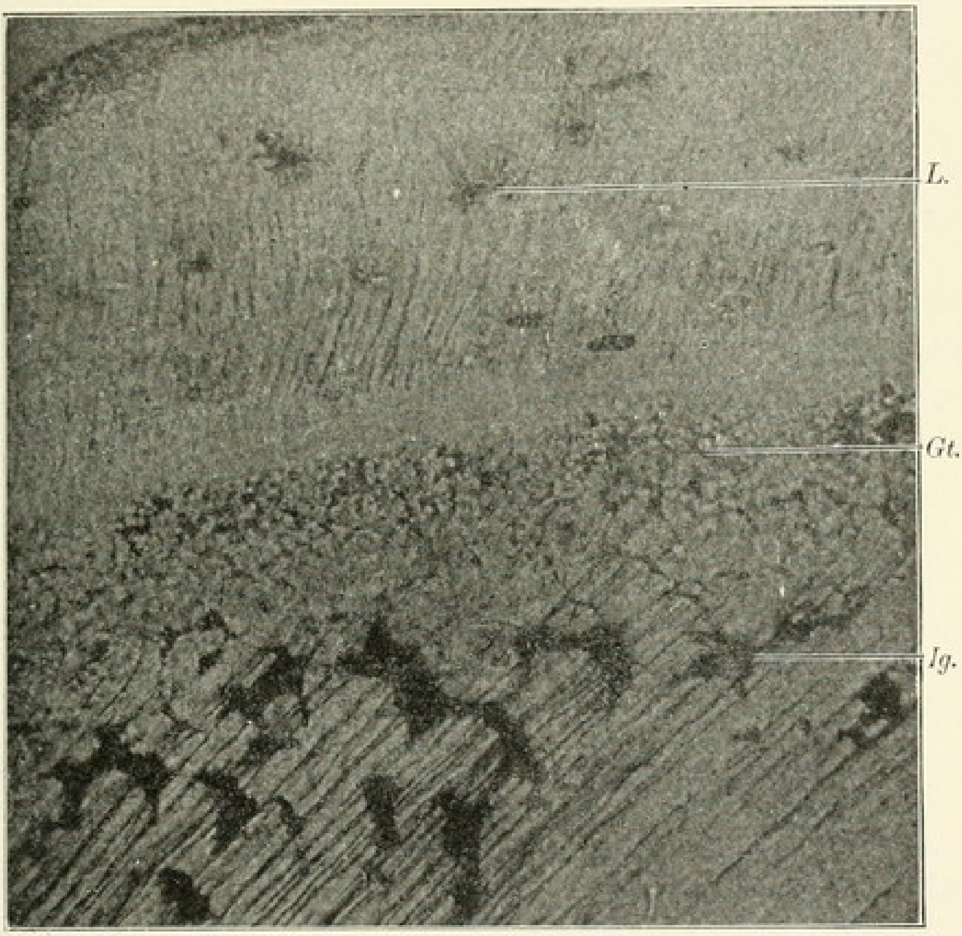


Interglobular spaces in dentin: *Ig*, first line of interglobular spaces; *Ig'*, second line of interglobular spaces. (About 30 ×.)

to tube, and so spreading sideways beneath the enamel plates, and then penetrating the dentin in the direction of the tubules. Fig. 104 shows the penetration of caries in the dentin. It will be noticed that in decay starting at the contact point there has been more spreading under the enamel than in that starting at the gingival line, but in both positions the penetration has followed the direction of the tubules.

In the root portion the tubules pass out from the pulp canals at right angles to the long axis of the tooth and pass directly out to the cementum, showing only the secondary curves. Throughout their course they give off a great many fine branches passing through the matrix in all directions from tubule to tubule. These branches are so numerous that in sections which have been mounted in such a way as to leave air in them, or if the tubules have been filled with coloring-matter, they give the impression of looking through a hazel bush; or they may be likened to the fine rootlets of a plant. These fine branches are shown in Fig. 105, and the character of the dentin in the root portion is to be compared with that in the crown portion as shown in Fig. 102. The

FIG. 108.



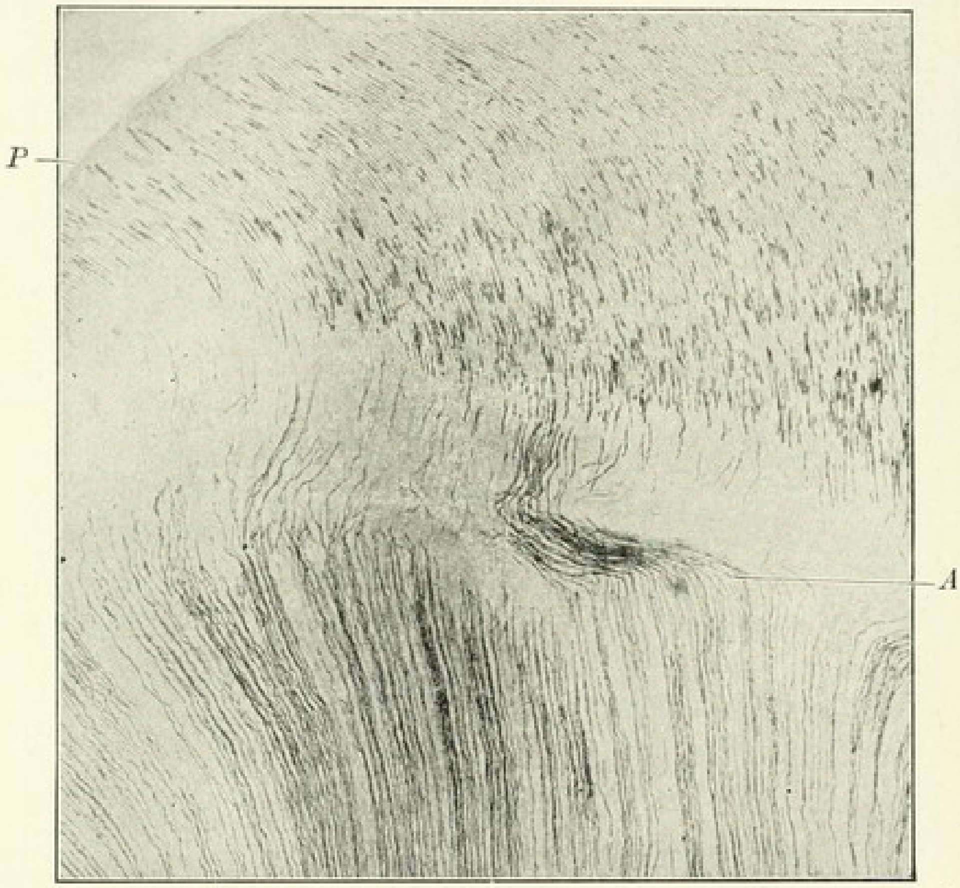
Granular layer of Tomes: *L*, lacunæ of cementum; *Gt*, granular layer of Tomes; *Ig*, interglobular spaces. (About 200 ×.)

outermost layer of the dentin next to the cementum contains many small irregular spaces, which connect with the dentinal tubules and give to the tissue when seen with low powers a granular appearance. This layer was first described by John Tomes as the granular layer, and has since been usually called the *granular layer of Tomes*. The spaces of the granular layer are probably filled by the enlarged ends of the dentinal fibrils. The same appearance is sometimes seen beneath the enamel, but is never as well marked as next to the cementum.

The dentin at the dento-enamel junction seldom presents a smooth surface, but the inner surface of the enamel plate shows rounded projections, between which the dentin extends. In sections this gives to the dento-enamel junction a scalloped appearance, as shown in Fig. 106; and often the deceptive appearance of the dentinal tubules penetrating for a short distance between the enamel rods.

In many specimens made by grinding dried teeth large irregular spaces are very conspicuous in the dentin. They usually occur in lines or zones at about uniform depth from the surface. These have been called the interglobular spaces. They are really not spaces at all, but are areas of imperfect development in which the dentin matrix has not

Fig. 109.



Secondary dentin: *A*, margin of primary dentin, showing a few of the tubules continuing into the secondary dentin; *P*, pulp chamber. (About 80 ×.)

been calcified. The dentinal tubules pass through them without interruption. In a dried specimen the organic matrix shrinks, and the resulting space becomes filled with the débris of grinding, so as to give the appearance of black spaces. Fig. 107 shows two quite distinct layers of interglobular spaces, the second much more marked than the first; and in the enamel at a position corresponding to the first is seen an imperfection of structure marked by the very dark stratification band. This is shown best in the region of the cusp (Fig. 89) from the same section. Interglobular spaces in the root portion of the dentin are shown in Fig. 108, close to the granular layer of Tomes.

The formation of dentin is not complete at the time of eruption of the tooth, but continues for an indefinite period, thickening the layer of dentin at the expense of the pulp. When the typical amount of dentin has been formed the growth ceases, and does not begin again unless excited by some irritation to the pulp or the pulp of some other tooth of the same side, which leads to the formation of secondary dentin. Secondary dentin is never as perfect in structure as primary dentin; the tubules are smaller, fewer, and much more irregular. Often in ground sections several periods of formation can be determined by differences of structure, each deposit becoming successively more and more imperfect in structure. This is shown in Fig. 109.

Pulp.

The dental pulp is the soft tissue occupying the central cavity of the dentin. It is made up of embryonal connective tissue and contains a large number of bloodvessels and nerves. Like all connective tissues, the intercellular substance is large in amount and the cells are widely scattered in this soft, jelly-like tissue, which contains but few fibers. We recognize four kinds of cells in the pulp: the odontoblasts, forming the outer surface of the pulp next to the dentin; and round, spindle-shaped, and stellate connective-tissue cells.

ARRANGEMENT OF CELLS.

The **odontoblasts** are tall columnar cells, sometimes club-shaped, and in older tissues, which have ceased to be functional, sometimes becoming almost spherical. They form a continuous layer over the entire surface of the pulp, being everywhere in contact with the dentin. The layer has been called the *membrana eboris*, or the "membrane of the ivory."

The nuclei of the odontoblasts are large and oval, containing a large amount of chromatin, and are very different from the nuclei of ordinary connective-tissue cells.

Three kinds of processes have been described in connection with the odontoblasts:

1. The dentinal fibril processes, or *fibers of Tomes*. These are long, slender protoplasmic processes projecting from the dentin end of the cell into a dentinal tubule, and running through the tubule to the outer surface of the dentin. Usually there is but one fibril extending from each odontoblast, but sometimes two can be seen, extending into two tubules. These fibrils can be demonstrated in decalcified sections or by removing the pulp from a recently extracted tooth by cracking the tooth and carefully lifting the pulp out of the pulp chamber, and then either teasing or sectioning. Fig. 110 shows the fibrils projecting from

the surface; but in this section the cut was not in the direction of the long axis of the odontoblasts, but obliquely through them. Fig. 111 (from a photograph by Röse) shows the form of the odontoblasts in a

Fig. 110.

Odontoblasts. The section cuts obliquely through the odontoblasts: *F*, fibrils: *N*, nuclei of odontoblasts; *N′*, nuclei of connective-tissue cells; *W*, layer of Weil, not well shown. (About 80×.)

young tooth in which formation of dentin is actively progressing, with the fibrils in the dentinal tubules.

2. Lateral processes projecting from the sides of the cells and uniting one with another in the formation of the layer.

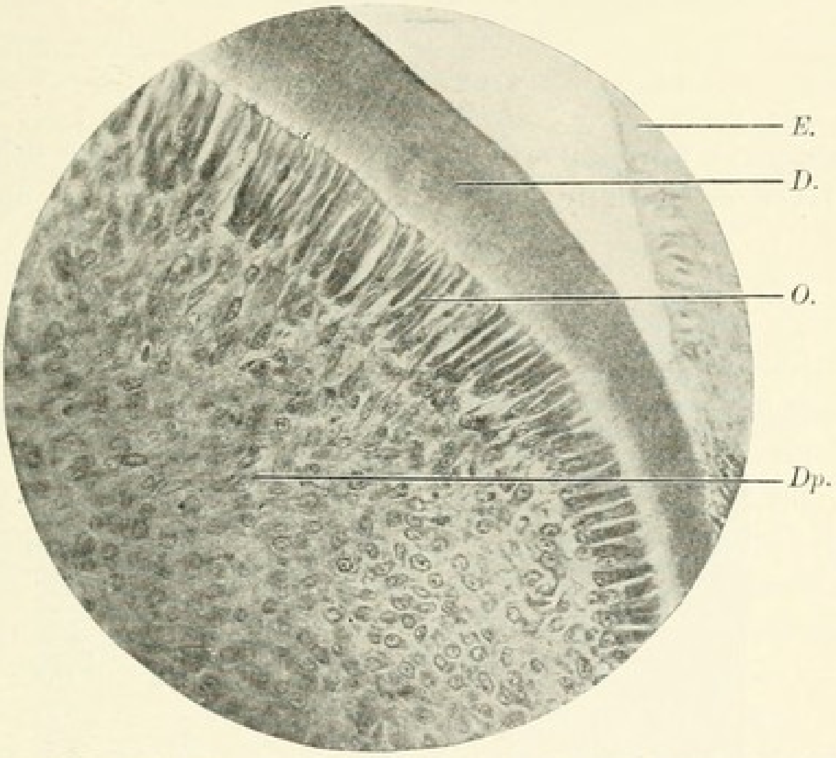
3. Pulpal processes, projecting from the pulpal ends of the odontoblasts into the layer of Weil.

The odontoblasts, as the name indicates, are the dentin-forming cells. They superintend the formation and calcification of the dentin matrix, the fibril being left behind surrounded by the formed tissue. Whether the fibrils have any share in the formation and calcification of the dentin matrix has been a matter of controversy.

The relation of the fibrils to the transmission of sensation is also a matter of dispute; but at present the weight of evidence is that they in some way transmit impressions to the sensory nerves of the pulp.

Just beneath the layer of odontoblasts is a zone which contains very few connective-tissue cells. In thin sections, especially in the body of the pulp, this appears as a clear layer about half as thick as the layer of odontoblasts. It is known as the *layer of Weil*. Just beneath the layer of Weil the connective-tissue cells are especially numerous and form a more or less distinct layer of closely placed cells. In the rest of the body of the pulp the cells are about uniformly distributed throughout the intercellular substance. These connective-tissue cells are of the characteristic forms, rather small, containing a small but deep-staining nucleus, the protoplasm stretching out into slender projections in two directions to form the spindle cells, or in more than two directions to form the stellate cells. The stellate forms are more common in the body of the pulp, the spindle form in the canal portions. The round

Fig. 111.



Odontoblasts and forming dentin: *E*, forming enamel; *D*, forming dentin; *O*, odontoblasts; *Dp*, body of dental papilla. (From photomicrograph by Röse.)

cells are comparatively few in number, and are probably young cells which have not yet acquired the adult form.

BLOODVESSELS OF THE PULP.

The blood-supply of the pulp is extremely rich, several arterial vessels entering in the region of the apex of the root, often through several foramina. These large vessels extend occlusally through the central portion of the tissue, giving off many branches which break up into a very close and fine capillary plexus (Fig. 112). From the capillaries the blood is collected into the veins, which pass apically through the central portion of the tissue. A very striking peculiarity of the bloodvessels of the pulp is the thinness of their walls. Even the large arteries show scarcely any

Fig. 112.

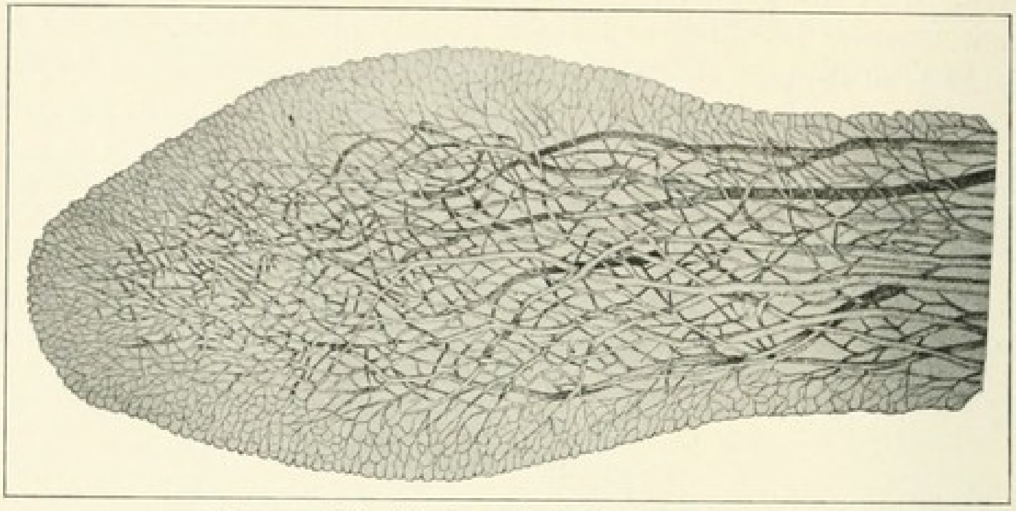


Diagram of the bloodvessels of the pulp. (Stowell.)

condensation of fibrous tissue around them to form the usual adventitious layer, and usually contain but a single involuntary muscle fiber

Fig. 113.

A pulp bloodvessel, showing the thin wall: *C*, blood corpuscles in the vessel; *Bl*, bloodvessel wall showing nuclei of endothelial cells; *N*, nuclei of connective-tissue cells in the body of the pulp; *I*, intercellular substance, showing a few fibers. (About 200 ×.)

representing the media, while the walls of even the large veins are made up of only the single layer of endothelial cells forming the intima, and are in structure like large capillaries (Fig. 113). This peculiarity of the bloodvessel walls is of great importance, as it renders the tissue specially liable to such pathologic conditions as hyperemia and inflammation.

NERVE OF THE PULP.

Several comparatively large bundles of medullated nerve fibers, containing from six or eight to fifteen or twenty fibers, enter the pulp in company with the bloodvessels and pass occlusally through the central portion of the tissue. These bundles branch and anastomose with each other very freely. Most of the fibers lose their medullary sheath before reaching the layer of Weil, in which position they form a plexus of non-medullated fibers; from these fibers free endings are given off, which penetrate between the odontoblasts. In some cases these have been followed over on to the dentinal ends of the odontoblasts, but in no instance have they been followed into the dentinal tubules.

THE FUNCTIONS OF THE PULP.

The pulp performs two functions, a vital and a sensory.

The **vital function** is the formation of dentin, and is performed by the layer of odontoblasts. This is the principal function of the pulp, and it is first manifested in the development of the tooth before the dentinal papilla is converted into the dental pulp by being inclosed in the formed dentin. After the tooth is fully formed the vital function is not manifested unless the pulp is stimulated by some excitation affecting trophic centres and which causes the formation of secondary dentin. There are some exceptions where the formation is entirely local.

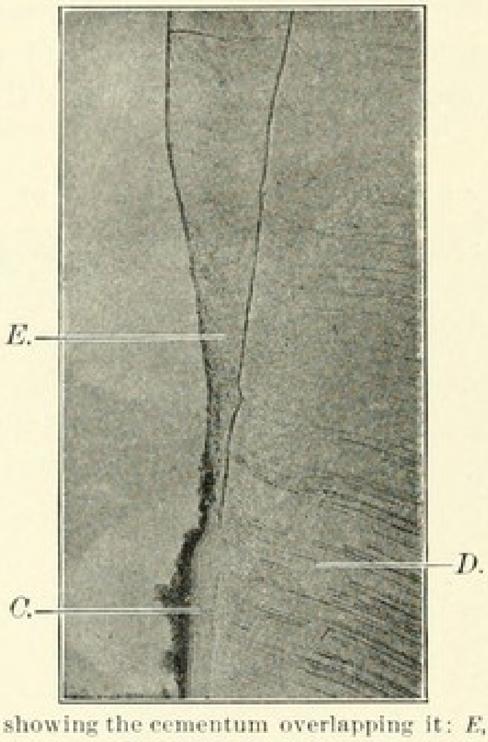
The Sensory Function.—In regard to sensation, the pulp resembles an internal organ. It has no sense of touch or localization, and responds to stimuli only by sensations of pain. The pain is usually localized correctly with reference to the median line, but, aside from that, is localized only as it is referred to some known lesion. If several pulps on the same side of the mouth and in teeth of both the upper and lower arches were exposed so that they could be irritated without impressions reaching the peridental membrane, and the patient were blindfolded, it would be impossible for him to tell which of the pulps was touched. The pain originating from a tooth pulp may be referred to the wrong tooth or to almost any point on the same side supplied by the fifth cranial nerve.

The pulp is especially sensitive to changes of temperature, but is incapable of differentiating between heat and cold; this fact is often made use of in differential diagnoses (see Chapter XVI.). The pulp is also very sensitive to traumatic and chemical irritations, even when these are conveyed to it through the agency of the dentinal fibrils. Dr. Huber has suggested[1] that this transmission may be accomplished by the traumatic or chemical action upon the fibrils setting up metabolic changes in the odontoblastic cells, which act as stimuli to the sensory nerves ending between the cells of that layer.

CEMENTUM.

The cementum covers the surface of the dentin apically from the border of the enamel, lapping slightly over the enamel at the gingival margin (Fig. 114). It forms a layer, thickest in the apical region and

FIG. 114.



Gingival border of enamel, showing the cementum overlapping it: *E*, enamel; *C*, cementum; *D*, dentin. (About 40 ×.)

between the roots of bicuspids and molars, and becoming thinner as the gingival line is approached. The cementum resembles subperiosteal bone in structure, but differs from it in the character and arrangement of the lacunæ and in the absence of Haversian systems; the layers, or lamellæ, of the cementum also are less uniform in character than those of bone.

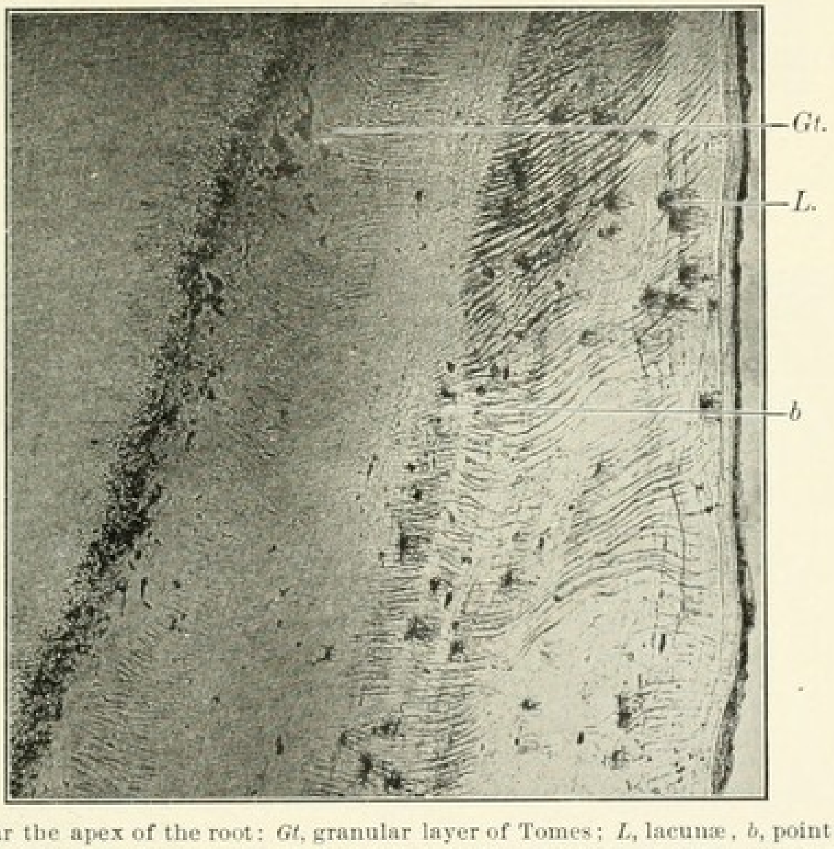
The function of the cementum is to furnish attachment for the fibers of the peridental membrane which holds the tooth in its position. The surrounding tissues are never in physiologic connection with the outer surface of the dentin, except to form cementum over it or to remove its substance by absorption; and when absorption of the dentin

[1] *Dental Cosmos*, October, 1898.

has occurred on the surface of a root it is never repaired except by the formation of cementum to fill up the cavity and reattach the membrane.

The cementum is intermittently formed during the functioning of the tooth, being added layer after layer over the entire surface of the root, the difference in thickness of the tissue in the gingival and apical portions being chiefly, though not entirely, due to the difference in thickness of each layer in the two positions (Figs. 114, 115). The cementum on the roots of newly erupted teeth is thin, and on the roots of teeth of old persons is thick. This continued formation of cementum

FIG. 115.

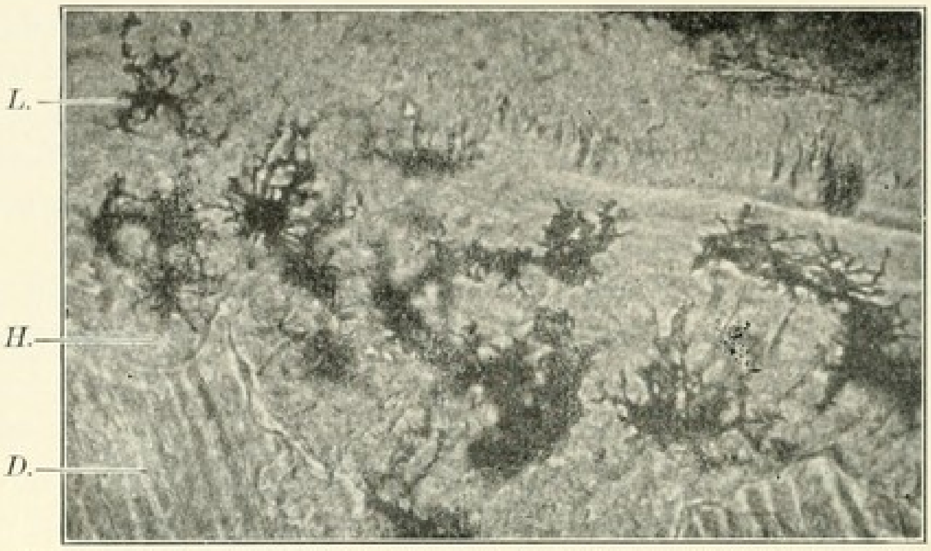


Cementum near the apex of the root: *Gt*, granular layer of Tomes; *L*, lacunæ, *b*, point at which fibers were cut off and reattached. (About 54 ×.)

is due to the necessity for change and reattachment of the fibers of the membrane.

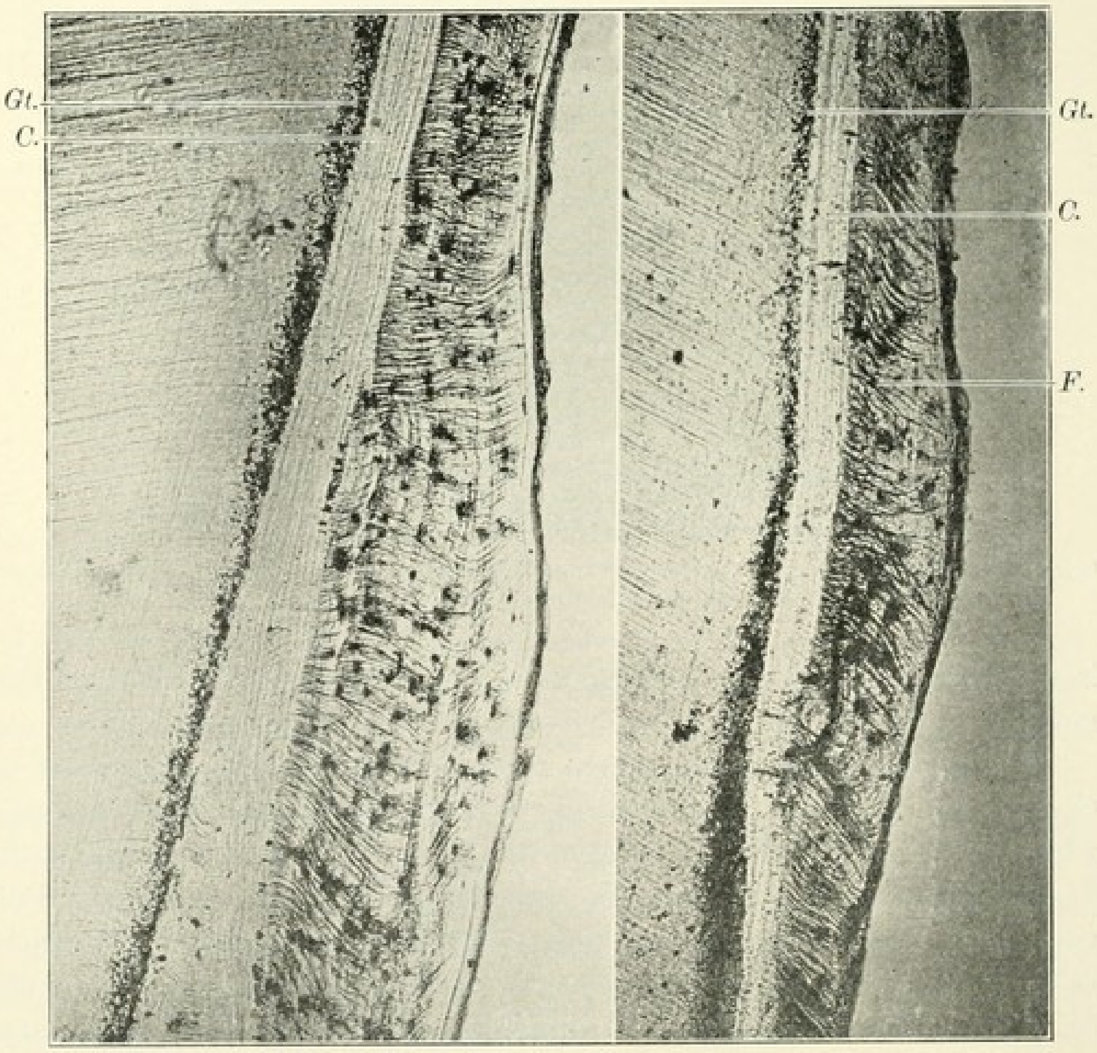
In the gingival portions, where the cementum is thin, the tissue is clear and apparently structureless, and usually contains no lacunæ; while in the apical half and between the roots the lacunæ are numerous. In general, wherever the lamellæ are thin, the lacunæ are absent; but where the lamellæ are thick they are found. The canaliculi which radiate from the lacunæ are not as regular as in the case of the lacunæ of bone. Sometimes they are numerous, sometimes few; they may extend from a lacuna in all directions, or they may be confined to one side, usually the side toward the surface of the cementum (Fig. 116).

Fig. 116.



Thick lamellæ of cementum with many lacunæ, filling an absorption in dentin: *L*, lacunæ; *H*, Howship's lacunæ filled; *D*, dentin. (About 250 ×.)

Fig. 117.



Two fields of cementum showing penetrating fibers: *Gt*, granular layer of Tomes; *C*, cementum not showing fibers; *F*, penetrating fibers. (About 54 ×.)

The cementum is penetrated through all its layers by fibers of the peridental membrane which have been imbedded in the matrix of the tissue and calcified along with it. The first layer,—that is, the one next to the dentin,—is usually structureless and shows no fibers in it, at least in its inner half. In ground sections the imbedded fibers often appear in a number of layers, while they are not apparent in the rest of the thickness. This is because just before and just after the formation of the layers in which they appear the fibers were cut off and reattached, changing their direction, so that in the other layers the fibers are cut transversely or obliquely. This is illustrated in Fig. 117. These imbedded fibers are very numerous in some places. If properly stained, the tissue seems almost a solid mass of fibers. In ground sections these have sometimes been mistaken for minute canals from the fact that they are not always as fully calcified as the cementum matrix, and shrinkage causes the appearance of little open canals.

Hypertrophies of the cementum (formerly often called exostoses, or excementoses) are very common. The increased thickness may be of one lamella or of several lamellæ in the region of the hypertrophy, or all of the layers from first to last may take part in it. Small local thickenings of a single lamella are seen in connection with the peridental membrane wherever a specially strong bundle of fibers is to be attached to the root to support the tooth against some special strain.

Peridental Membrane.

The peridental membrane may be defined as the tissue which fills the space between the root of the tooth and the bony wall of its alveolus, surrounds the root occlusally from the border of the alveolus, and supports the gingivus. It has been referred to under many names, as pericementum, dental periosteum, alveolo-dental periosteum, etc. While this tissue performs the functions of a periosteum for the bone of the alveolus, it differs in structure from the periosteum in any position, so that any name including the word periosteum or implying a double membrane should be avoided.

The peridental membrane belongs to the class of fibrous membranes, and is made up of the following structural elements:

1. Fibers. 2. Fibroblasts. 3. Cementoblasts. 4. Osteoblasts. 5. Osteoclasts. 6. Epithelial structures which have been called the glands of the peridental membrane. 7. Bloodvessels. 8. Nerves.

The peridental membrane performs three functions: a *physical* function, maintaining the tooth in relation to the adjacent hard and soft tissues; a *vital* function, the formation of bone on the alveolar wall and of cementum on the surface of the root; and a *sensory* function, the sense of touch for the tooth being exclusively in this membrane.

The fibrous tissue of the membrane is of the white variety, and may be divided into two classes, the principal fibers and the indifferent or

Fig. 118.

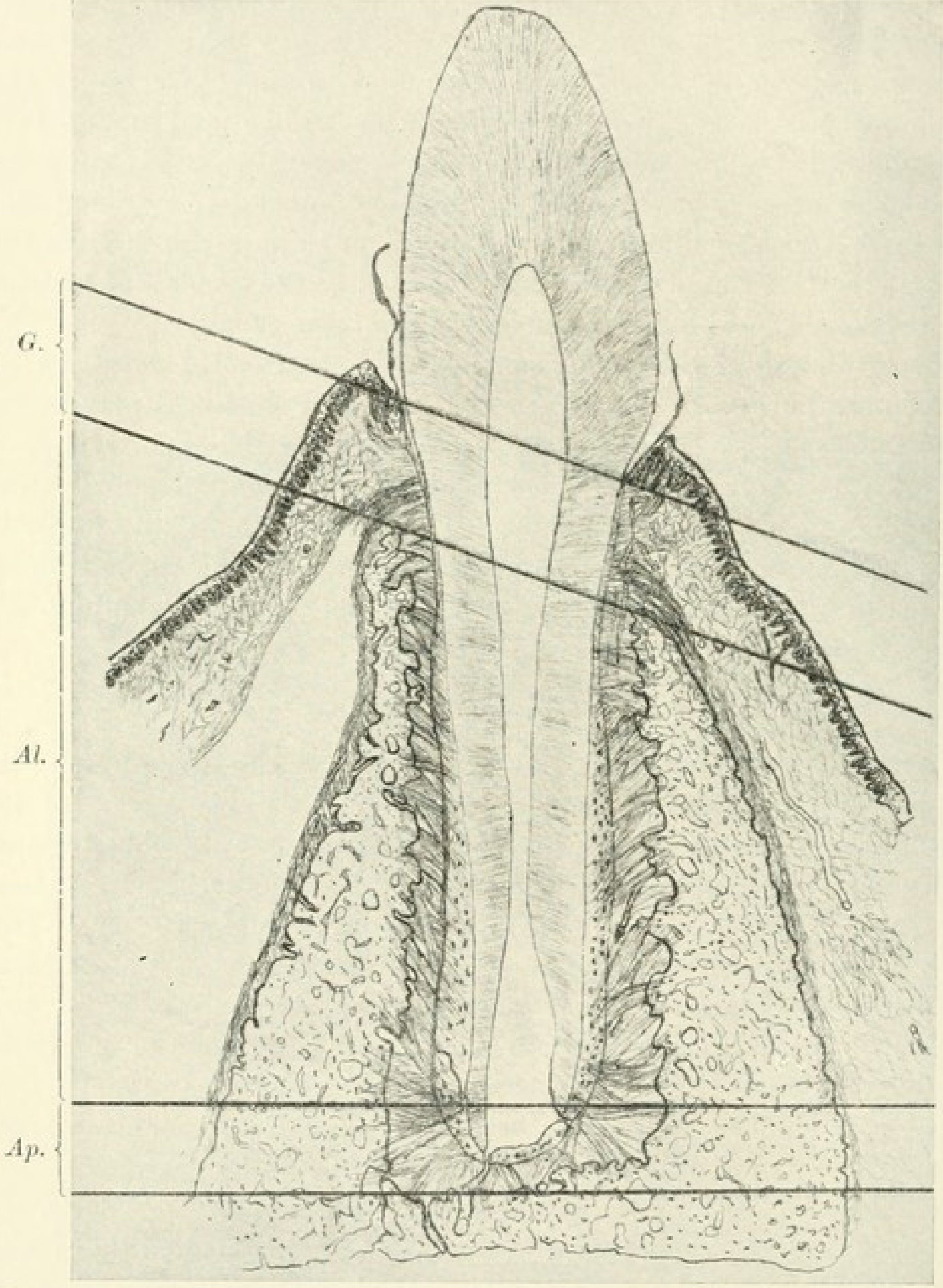
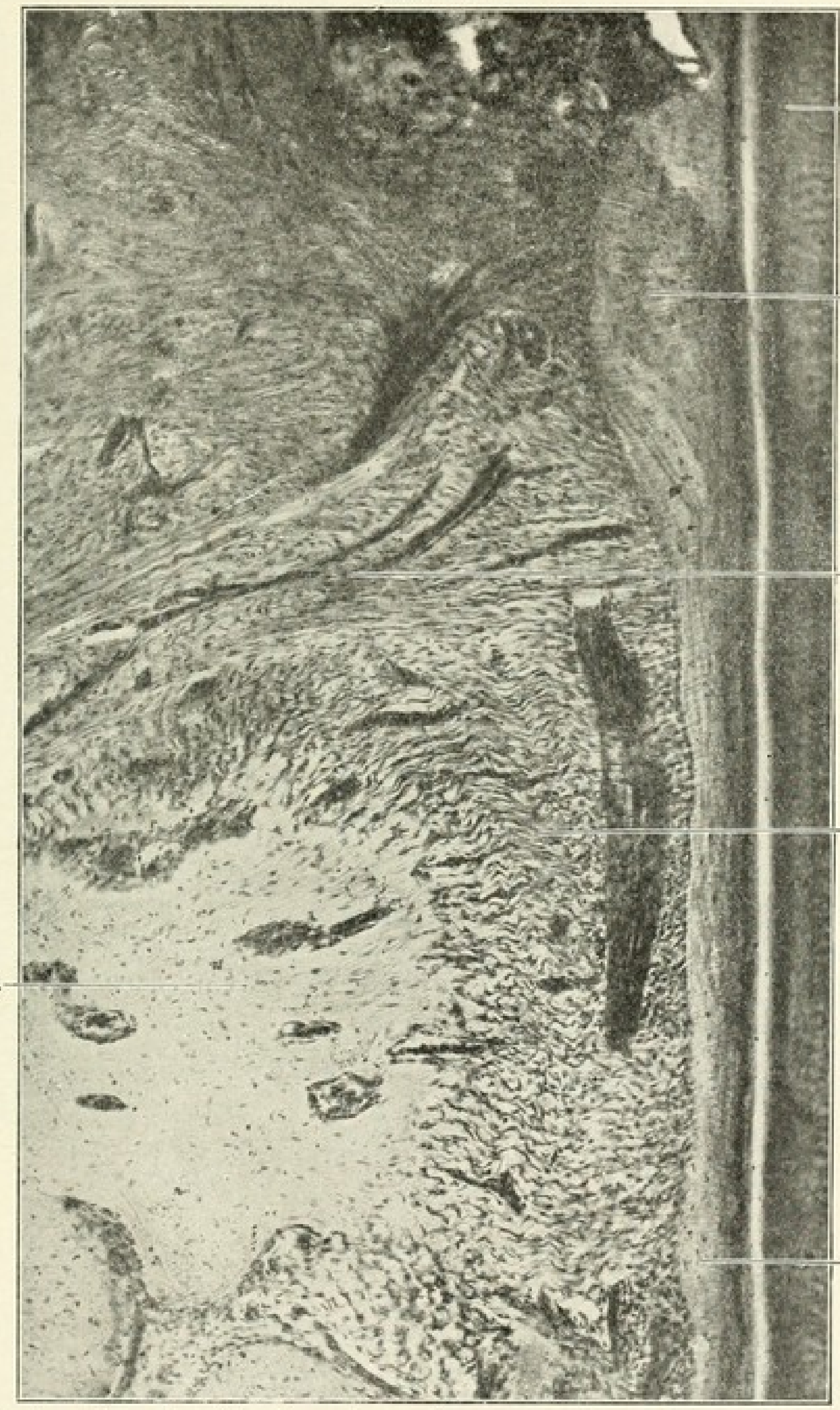


Diagram of the fibers of the peridental membrane: *G*, gingival portion; *Al*, alveolar portion; *Ap*, apical portion. (From a photograph of a section from incisor of sheep.)

interfibrous tissue. The principal fibers may be defined as those which spring from the cementum and are attached at their other end to the bone of the alveolar wall, to the outer layer of the periosteum covering the surface of the alveolar process, to the cementum of the approximating

Fig. 119.

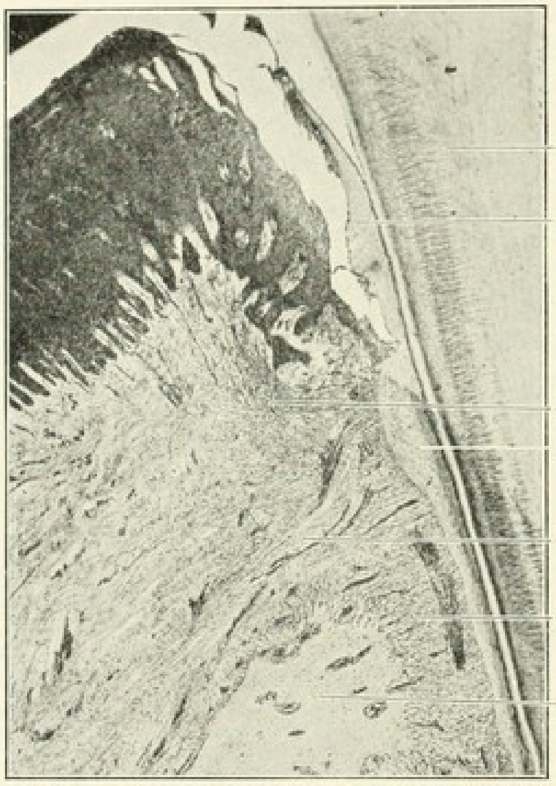


Longitudinal section of peridental membrane from young sheep, showing fibers penetrating cementum: *D*, dentin; *C*, cementum, showing imbedded fibers; *F*, fibers running to outer layer of periosteum covering the alveolar process; *F′*, fibers running to the bone at the border of the process; *B*, bone. (About 80 ×.)

tooth, or become blended with the fibrous mat of the gum supporting the epithelium. They were so called by Dr. Black, not only because they form the principal bulk of the tissue, but they also perform the principal function of the membrane, the support of the tooth and surrounding tissues. The interfibrous tissue, also of the white variety but made up of smaller and more delicate fibers, is found filling spaces between the principal fibers and surrounding and accompanying the bloodvessels and nerves.

For convenience of description and study, the peridental membrane is divided into three portions: the *gingival*, that portion which surrounds the root occlusally from the border of the alveolar process; the *alveolar*, the portion from the border of the process to the apex of the root; and

Fig. 120.



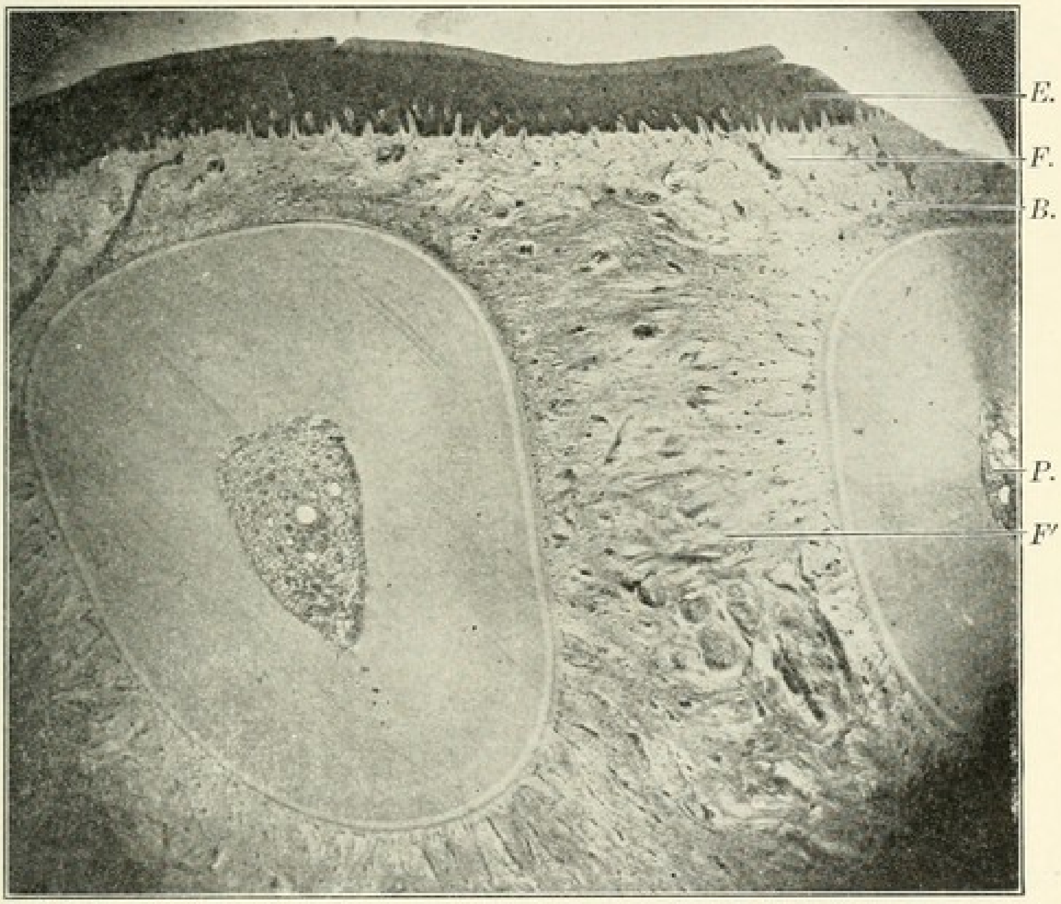
Longitudinal section of the peridental membrane in the gingival portion: *D*, dentin; *N*, Nasmyth's membrane; *C*, cementum; *F*, fibers supporting the gingivus; F^1, fibers attached to the outer layer of the periosteum over the alveolar process; F^2, fibers attached to the bone at the rim of the alveolus; *B*, bone. (About 30 ×.)

the *apical* portion, surrounding the apex of the root and filling the apical region (Fig. 118).

The principal fibers spring from the cementum, the cementoblasts building up the matrix around them and then calcifying both matrix and fibers, in this way implanting their ends into the surface of the root. In Fig. 119 the fibers are seen passing through the last-formed layer of cementum. In most positions the fibers as they spring from the cementum appear as well-marked bundles of fine fibers. A short distance from the surface of the root they break up into smaller bundles, which interlace and are reunited into larger bundles, to be attached at their other extremity to the bone, cementum, or fibrous tissue.

To arrive at an understanding of the arrangement of the fibers of the peridental membrane, they must be studied in both longitudinal and transverse sections. In longitudinal sections of the membrane, in the gingival portion (Fig. 120), the fibers springing from the cementum at the gingival line pass out for a short distance at right angles to the long axis of the tooth and then bend sharply to the occlusal,[1] passing

Fig. 121.



Transverse section of the peridental membrane in the gingival portion (from sheep): *E*, epithelium: *F*, fibrous tissue of gum; *B*, point where peridental membrane fibers are lost in fibrous mat of the gum; *P*, pulp; *F'*, fibers extending from tooth to tooth. (About 30 ×.)

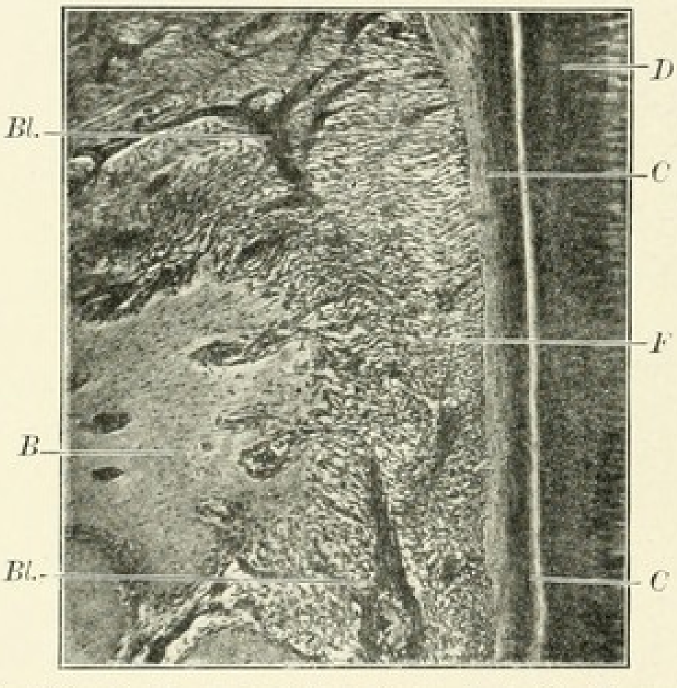
into the gingivus to support it and hold it closely against the neck of the tooth. These fibers are most numerous on the lingual side, where food is brought against the gingivus with force in mastication and tends to crush it down. In the middle of the gingival portion the fibers pass out at right angles to the axis and are blended with the fibrous mat of the gum on the labial and lingual sides, or are attached to the cementum of the adjoining teeth on the approximal sides. A little farther from the

[1] In describing the direction and inclination of peridental membrane fibers they are always traced from the cementum to the bone, the angle with the horizontal plane being formed at the surface of the cementum.

gingival line the fibers are inclined slightly apically, passing over the border of the process to be attached to the outer layer of the periosteum. These fibers are specially large and strong. Just at the rim of the alveolus the fibers are inclined slightly apically and are inserted into the bone, forming the edge of the process.

In transverse sections of the membrane in the gingival portion (Fig. 121) the fibers spring from the cementum in large bundles; at the centre of the labial surface they extend directly outward, breaking up into smaller bundles, passing around bloodvessels and bundles of fibers, and blending with the fibrous tissue supporting the epithelium. Passing mesially and distally toward the corners of the root, the fibers swing around laterally and pass to the cementum of the next tooth. On the

Fig. 122.



Fibers at the border of the alveolar process (from sheep): *D*, dentin; *C*, cementum; *F*, fibers extending from cementum to bone; *Bl*, bloodvessel; *B*, bone. (About 80 ×.)

approximal sides the fibers suddenly divide into smaller bundles, which wind in and out around bloodvessels, and bundles of fibers which pass into the gingivus and are reunited into large bundles to be inserted into the cementum of the next tooth. On the lingual side the arrangement is like that of the labial, except that the distance to which the fibers of the membrane can be followed before they are lost in the fibrous mat of the gum is usually greater than on the labial.

In the occlusal third of the alveolar portion of the membrane the fibers pass, at right angles to the axis of the tooth, directly from the cementum to the bone. In this position the fibers are large and do not break up into smaller bundles, but the original fibers can be followed

FIG. 123.

Transverse section of the peridental membrane in the occlusal third of the alveolar portion (from sheep): *M*, muscle fibers; *Per*, periosteum; *Al*, bone of the alveolar process; *Pd*, peridental membrane fibers; *P*, pulp; *D*, dentin; *Cm*, cementum.

uninterruptedly from the cementum to the bone (Figs. 119 and 122). In the middle third the fibers are inclined occlusally, and this inclination increases as the apical third is approached. In the apical third the inclination is greatest, and the fibers as they arise from the cementum are very large and break up into fan-shaped fasciculi as they pass across to the bone. In the apical portion the fibers radiate from the apex in all directions across the apical region and spread out in fan-shaped bundles like those in the apical third of the alveolar portion.

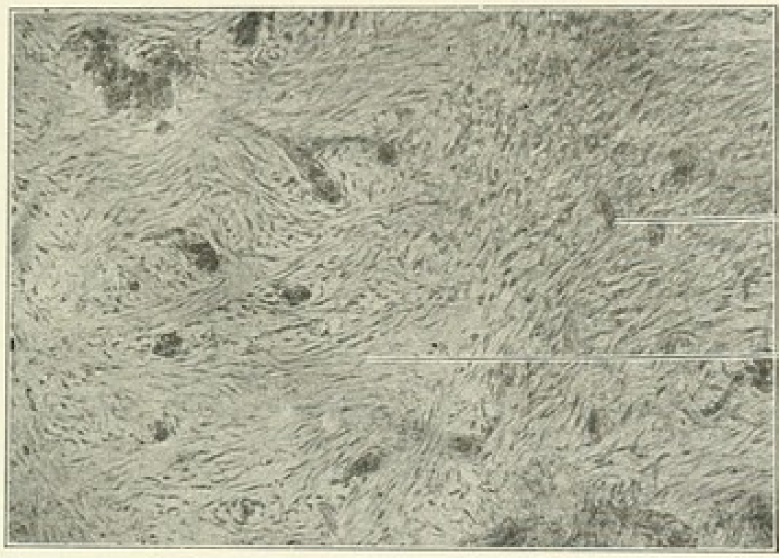
In a transverse section near the border of the alveolus (Fig. 123), at the centre of the labial surface of the root, the fibers are seen to extend directly out from the surface of the root to the bone of the process, excepting where they are diverted to pass around bloodvessels. Passing around distally at the corner of the root, the fibers swing laterally so as to be almost at a tangent to the surface of the root, and are inserted much farther to the distal on the wall of the alveolus. A similar arrangement is noticed at the other corners of the root, though these tangential fibers are usually more marked at the distal than at the mesial corners.

Studying the arrangement of the fibers with reference to the physical function of the membrane, it is seen to be the best that could be devised to support the teeth against the force of mastication and to support the tissues about them. In the gingival portion the fibers passing from tooth to tooth form the foundation for the gingivæ between the teeth filling the interproximal spaces; so that if these fibers are cut off from the cementum, by extending a crown band too far, or by the encroachment of calculary deposits beginning in the gingival space, the gingivus drops down and no longer fills the interproximal space. In the alveolar portion the fibers at the border of the process and those at the apex of the root together support the tooth against lateral strain, while those in the rest of the alveolar portion are so arranged as to swing the tooth in its socket and support it against the force of occlusion (Fig. 118). As seen from the transverse section, the fibers of the occlusal third of the alveolar portion are so arranged as to support the tooth against forces tending to rotate it in its socket.

CELLULAR ELEMENTS OF THE MEMBRANE.

The **fibroblasts** are spindle-shaped or stellate connective-tissue cells which are found between the fibers as they are arranged in bundles. In sections stained with hematoxylin they take the stain deeply, and the fibers, which are unstained, are differentiated by the cells lying in rows between them. The number of fibroblasts in the membrane decreases with age. They are large and numerous in the membrane of a newly erupted tooth, and comparatively small and few in the membrane around an old tooth. This is characteristic of fibroblasts in other positions. The fibroblasts are shown as they appear in a hematoxylin-stained section with low powers in Fig. 124, which gives part of the membrane in the gingival portion between two teeth. The cells are seen as spindle-shaped dots which mark out the fibers ; at *F* they are seen in a position

FIG. 124.

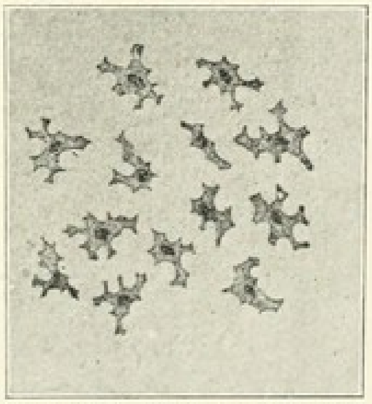


Fibers and fibroblasts from transverse section of membrane: *F*, fibers cut transversely; *F*[1], fibers cut longitudinally, showing fibroblasts. (About 80 ×.)

where the fibers are cut transversely. With higher powers these cells appear as in Figs. 126 and 135.

The **cementoblasts** are the cells which form the cementum, and are found everywhere covering the surface of the root between the fibers

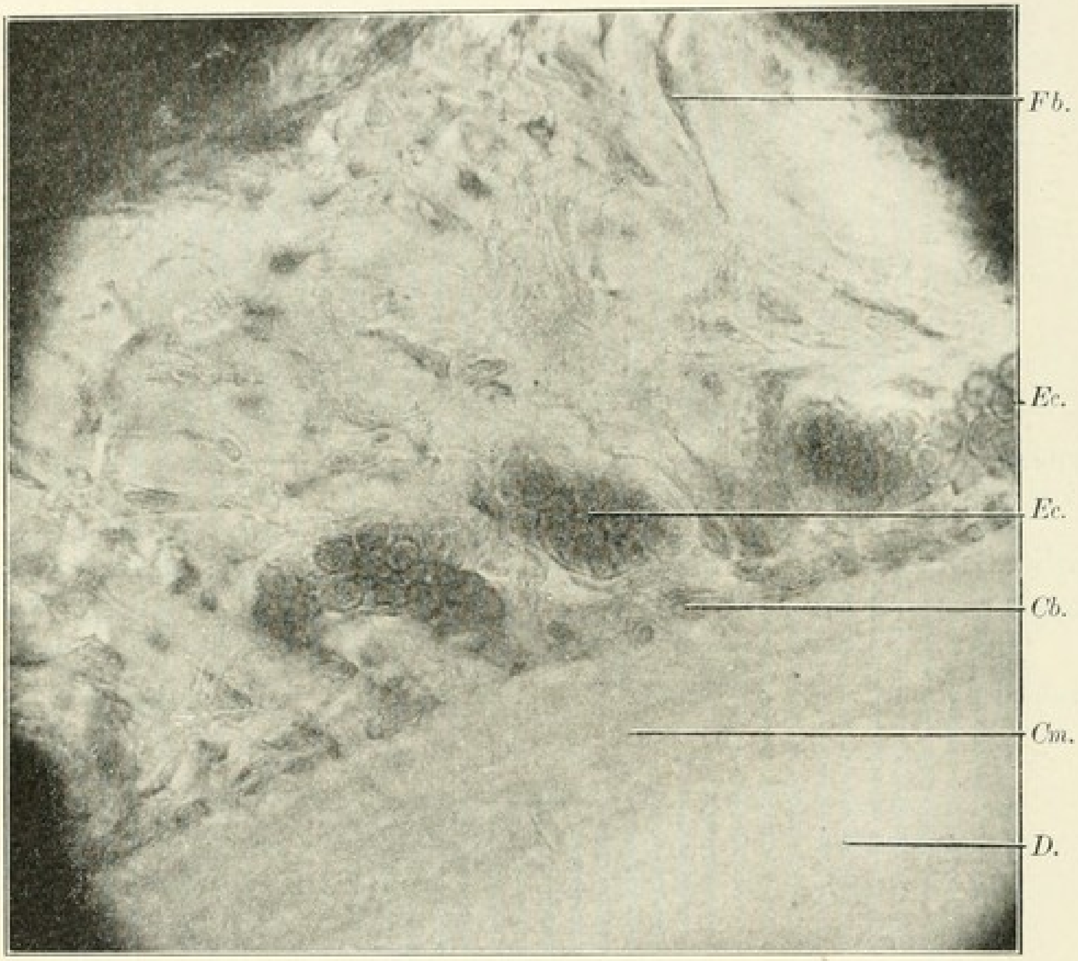
FIG. 125.



Cementoblasts. (Drawing by Dr. Black.)

which are imbedded in the tissue. While these cells perform the same function for the cementum as the osteoblasts do for bone, they are in form very different from the osteoblasts. The cementoblasts are always flattened cells, sometimes almost scale-like, and when seen from above are very irregular in outline. This irregularity of outline is caused by the cells fitting around the attached fibers of the membrane so as to cover the entire surface of the cementum between the fibers. Fig. 125, from a drawing by Dr. Black,[1] shows several cementoblasts as seen when isolated by teasing. The cementoblasts have a central mass of protoplasm containing an oval nucleus, and short irregular processes which fit around the fibers as these spring from the surface of the cementum. Fig. 126 shows them in section perpendicularly to the

Fig. 126.



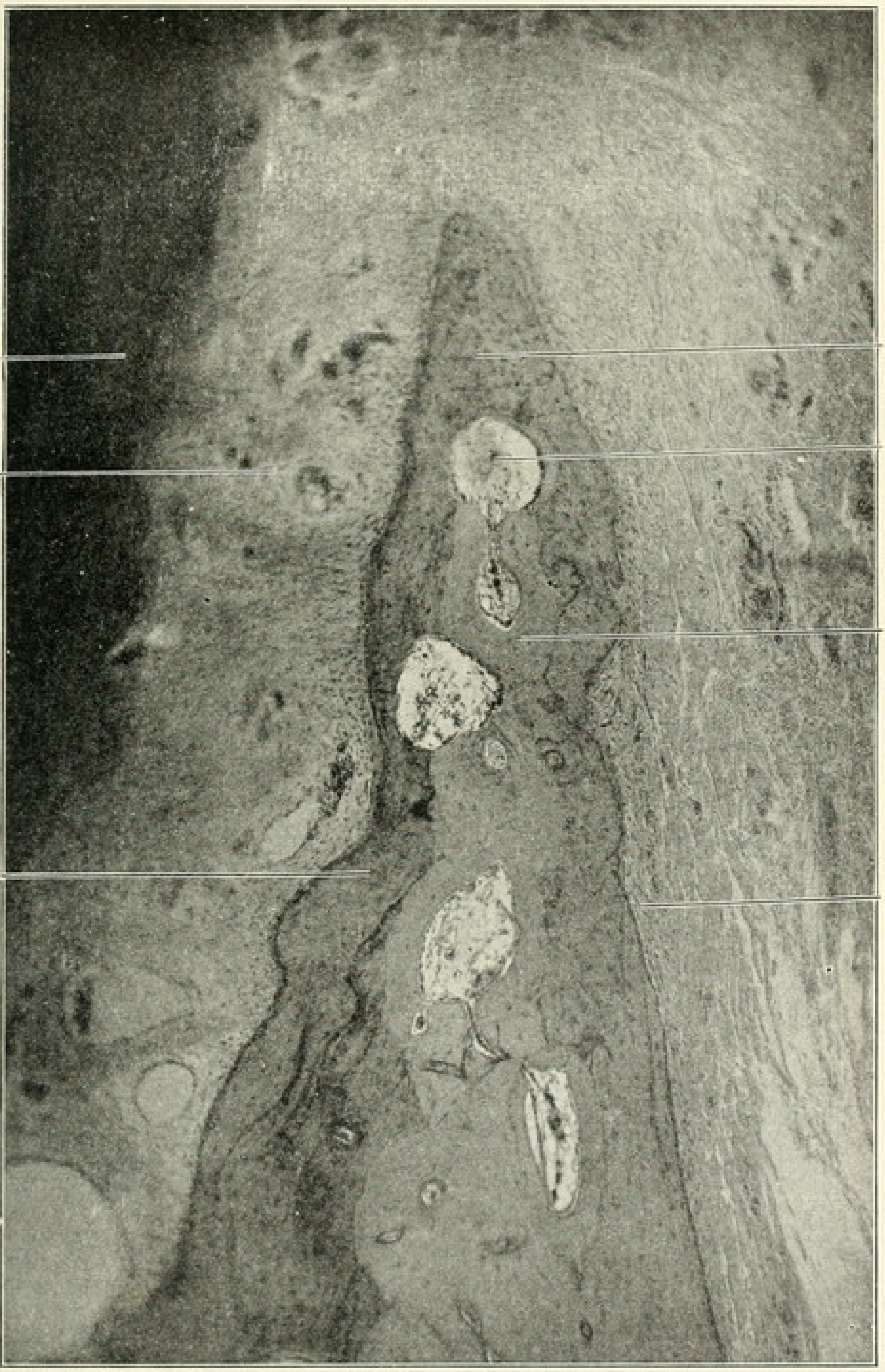
Transverse section, showing the cellular elements: *Fb*, fibroblasts; *Ec*, epithelial structures; *Cb*, cementoblasts; *Cm*, cementum; *D*, dentin. (About 900 ×.)

surface of the root, where they are crowded between the fibers. The cementoblasts often have processes projecting into the cementum like those from the osteoblast, but processes projecting into the membrane have never been demonstrated.

In the formation of the cementum occasionally a cementoblast becomes inclosed in the formed tissue filling one of the lacunæ, in which position it becomes a cement corpuscle.

[1] *Periosteum and Peridental Membrane.*

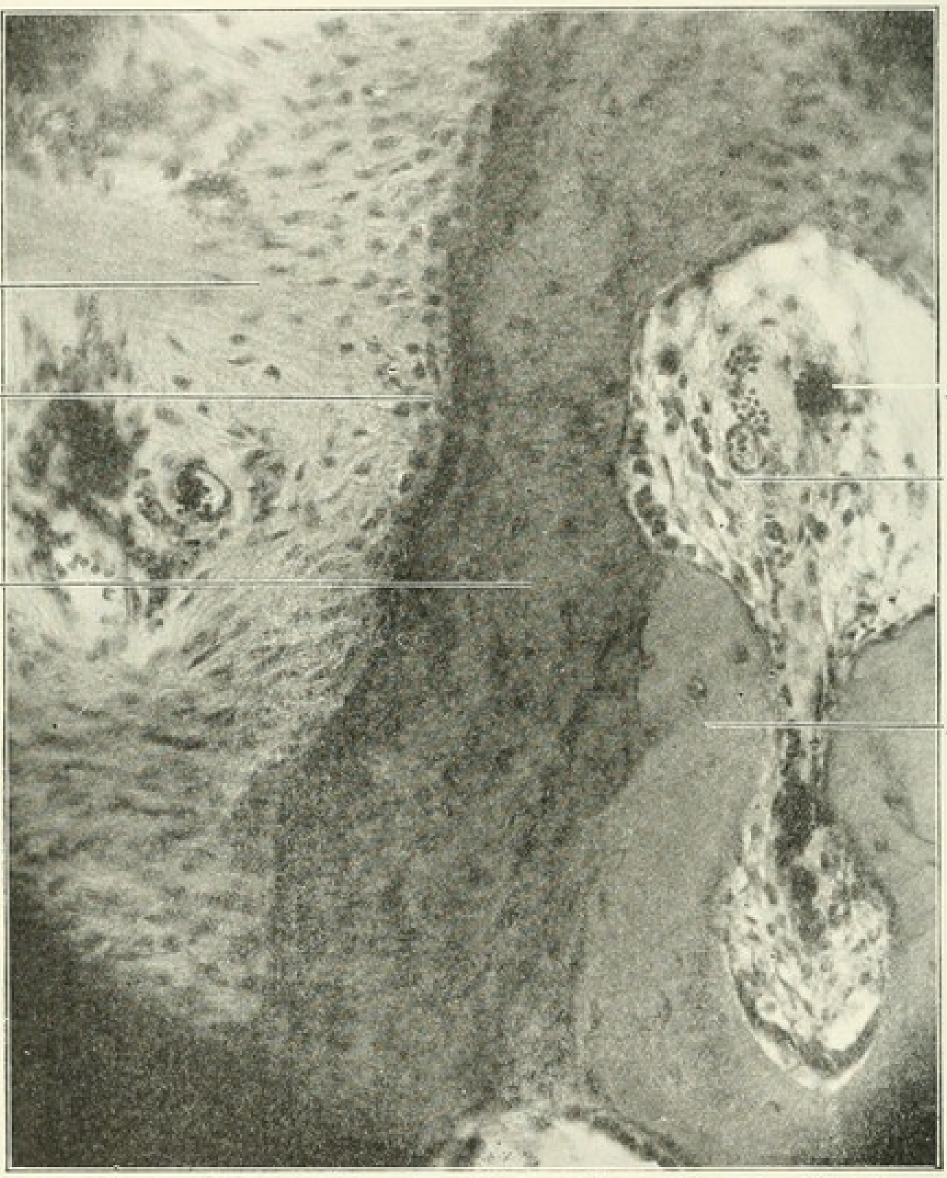
FIG. 127.



Border of growing process: *Cm*, cementum; *Pd*, peridental membrane; *Pd.B*, solid subperidental and subperiosteal bone with imbedded fibers; *Ms*, medullary space formed by absorption of the solid bone; *H.B*, Haversian-system bone without fibers; *Per*, periosteum. (About 50 ×.)

The **osteoblasts** of the membrane cover the surface of the bone, forming the wall of the alveolus, lying between the fibers which are built into the bone. In form and function they are like the osteoblasts in attached portions of the periosteum. They form bone around the ends of the peridental-membrane fibers, building them into the substance of the bone. The bone thus formed over the wall of the

Fig. 128.



Penetrating fibers in bone: *Pd.M*, peridental membrane; *Ob*[1], osteoblasts of peridental membrane; *Ob*[2], osteoblasts of medullary space; *Pd.B*, solid subperidental and subperiosteal bone with imbedded fibers; *Ms*, medullary space formed by absorption of the solid subperidental bone with imbedded fibers; *H.B*, Haversian-system bone without fibers built around the medullary space. (About 200 ×.)

alveolus is like the solid subperiosteal bone, and is penetrated throughout its thickness by the imbedded fibers; but, as with the subperiosteal bone, it is constantly being penetrated by perforating canals, the solid bone being removed by absorption and rebuilt in bone with Haversian systems. This process is shown in Fig. 127,

FIG. 129.

Osteoclast absorption of bone over permanent tooth: *Oc*, osteoclasts; *B*, bone of crypt wall; *F*, fibrous tissue of follicle wall; *A*, ameloblasts. (About 62 ×.)

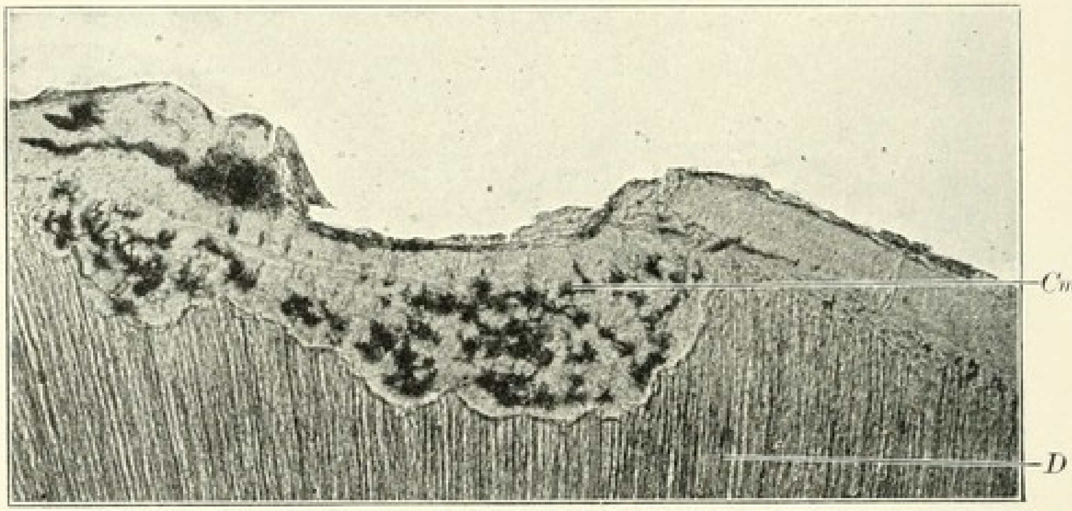
FIG. 130.

Osteoclasts: *Oc*, osteoclasts; *B*, bone. (About 66 ×.)

a section through a growing portion of the process around a permanent tooth. A higher power (Fig. 128) shows the penetrating fibers and the formation of Haversian-system bone without fibers, in the body of the process.

The **osteoclasts**, or myeloplaques, are bone-destroying cells (Fig. 129); they act not only upon bone, but also upon cementum and dentin. They are oval cells, often as much as 30 microns in diameter, and contain many nuclei,—from two or three to fifteen or twenty. They are often called giant cells. The osteoclasts are not constantly found in the membrane, but make their appearance whenever calcified tissues are to be destroyed. In order for them to act upon the tissues they must lie in contact with its surface, and therefore the first step in absorption of the peridental membrane is the cutting off of the fibers imbedded in the bone or cementum. Where the osteoclasts act upon the surface of

Fig. 131.

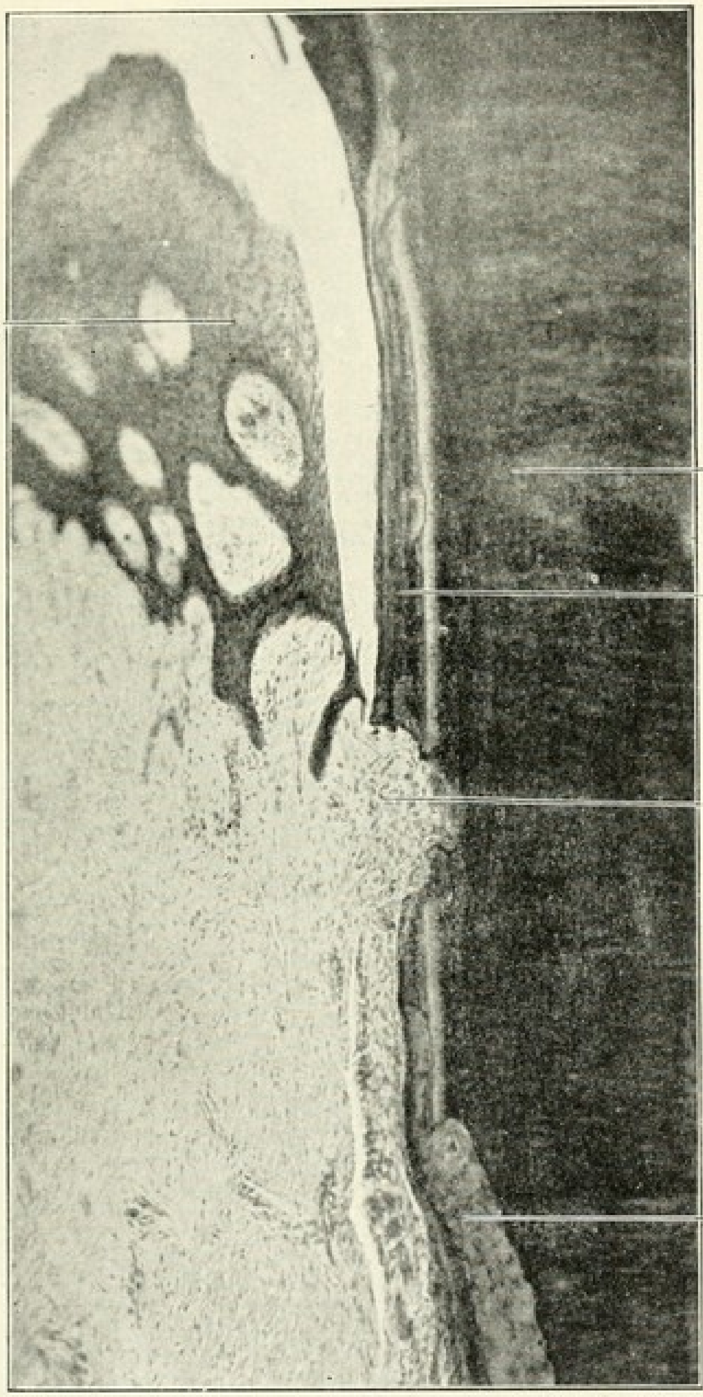


Record in the calcified tissue of an absorption repaired: *D*, dentin; *Cm*, cementum filling absorption cavity. (About 40 ×.)

the tissue they produce bay-like excavations, in which they lie, and which are known as Howship's lacunæ. These excavations are shown in Fig. 132, though the osteoclasts have disappeared. In Fig. 131, from a ground section, the basin-like excavations are shown filled with new-formed cementum, thus leaving in the tissue the record of an absorption repaired. In absorption of the roots of the temporary teeth the osteoclasts are found not only in the membrane and attacking the surface of the root, but all through the medullary spaces in the bone, removing the temporary alveolar process.

When absorption is going on at one place on the surface of a root a compensating formation of cementum is going on at another, so that not all of the fibers of the membrane are cut off. This is illustrated by sections of temporary teeth that are ready to be shed (Fig. 132).

FIG. 132.



Root of a temporary incisor, showing absorption and rebuilding of cementum (from sheep): *G*, gingivus; *D*, dentin; *Cm*, cementum; *Ab*, absorption cavity, showing Howship's lacunæ; *Cm*¹, new-formed cementum. (About 50 ×.)

EPITHELIAL STRUCTURES OF THE MEMBRANE.

The peridental membrane contains cellular structures of epithelial character which are so conspicuous that they demand consideration, though their nature and origin are not as yet fully understood.

These structures were first well illustrated and described by Dr.

Fig. 133.

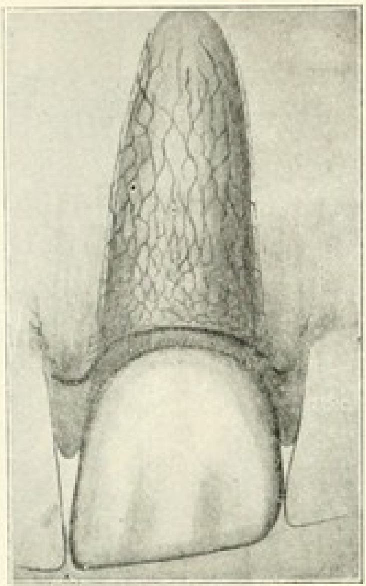
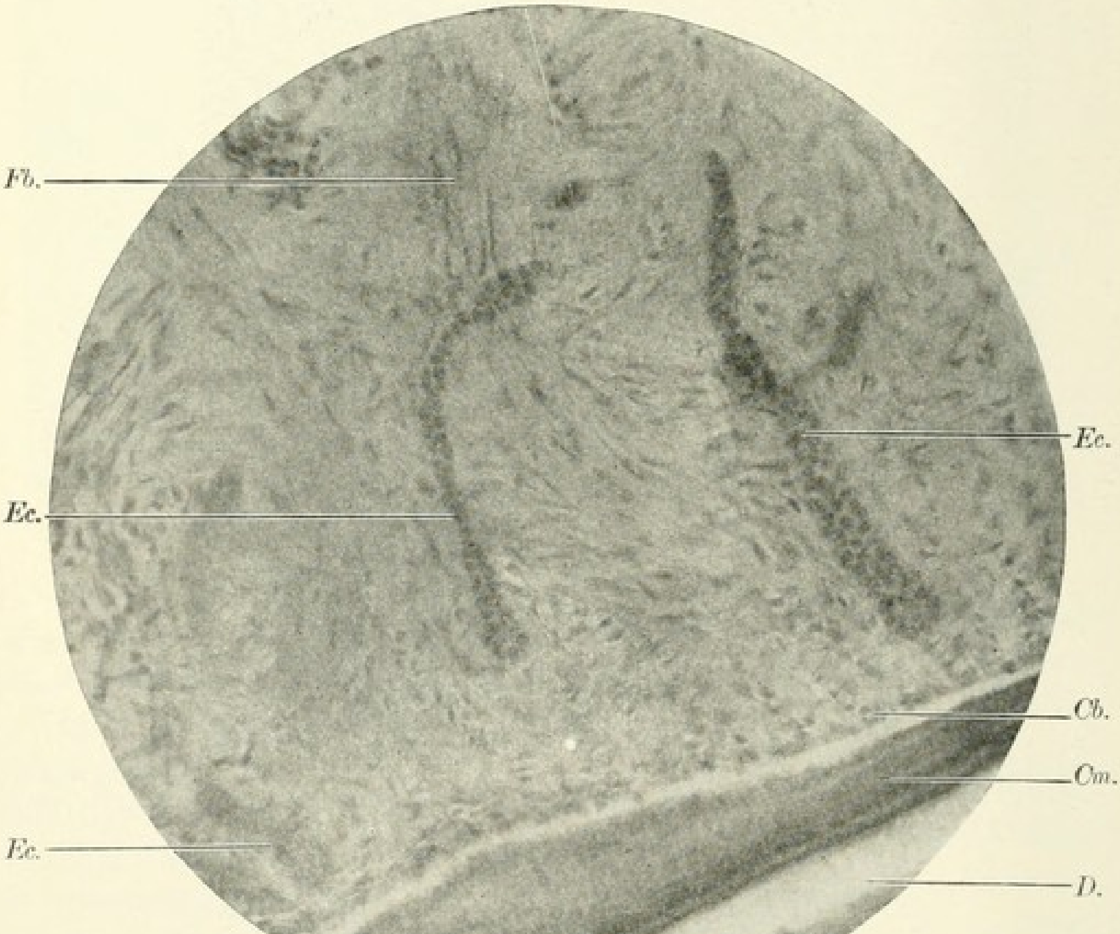


Diagram of glands of peridental membrane. (G. V. Black.)

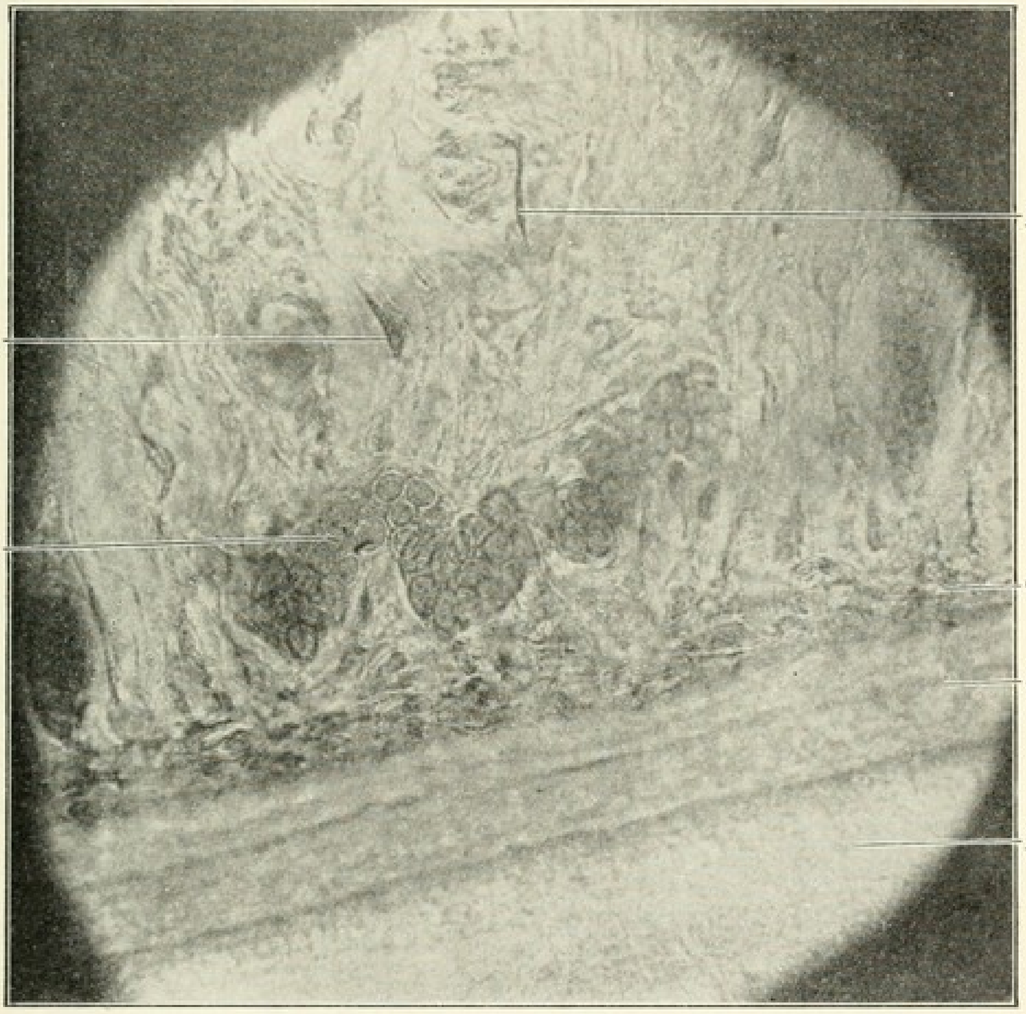
Fig. 134.



Epithelial structures of the peridental membrane (from sheep): *Fb*, fibroblasts; *Ec*, epithelial structures; *Cb*, cementoblasts; *Cm*, cementum; *D*, dentin. (About 468 ×.)

Black, in his work on the periosteum and peridental membrane, in 1887, and were called by him the glands of the peridental membrane. About the same time von Brunn[1] described what are probably the same structures, and which he regarded as embryonal remains of the inner layer of the enamel organ, which he described as growing down over the surface of the root. These structures appear as cords of epithelial cells

FIG. 135.



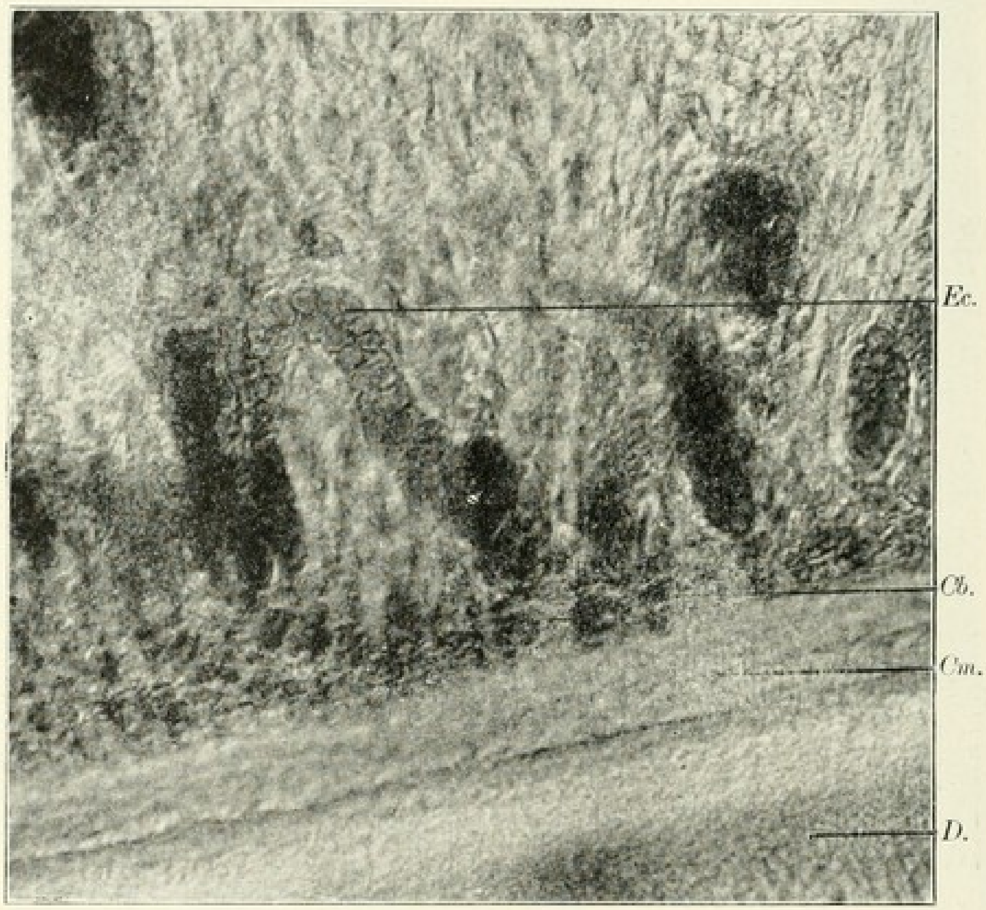
Epithelial structures (from sheep): *Fb*, fibroblasts; *Ec*, epithelial structures; *Cb*, cementoblasts; *Cm*, cementum; *D*, dentin. (About 700 ×.)

arranged in the form of a network winding between the fibers of the membrane, very close to the cementum and surrounding the root almost to the apex. Their arrangement is illustrated in Fig. 133, a diagram by Dr. Black. The meshes of the net are close in the gingival portion of the membrane, but grow more and more open in the alveolar portion. They are not confined to the membranes of young teeth or the temporary dentition, as Dr. Black has shown them in the membrane of a tooth from a man seventy years old, though, like all of the cellular elements of the

[1] *Archiv f. mikros. Anat.*, 1887.

membrane, they become less numerous as age advances. These structures are specially well shown in the membranes of the pig and sheep. Fig. 134 shows their appearance in a transverse section of the root of an incisor of a sheep; here they swing out from the surface of the cementum and back again in loops, winding in and out among the fibers. Studied with higher powers (Fig. 135), they are seen to be made up of epithelial cells, with large oval nuclei and reacting to the characteristic epithelial stains. They are arranged in cords, though sometimes what seems to be a lumen of a gland tubule can be found (Fig. 136). The

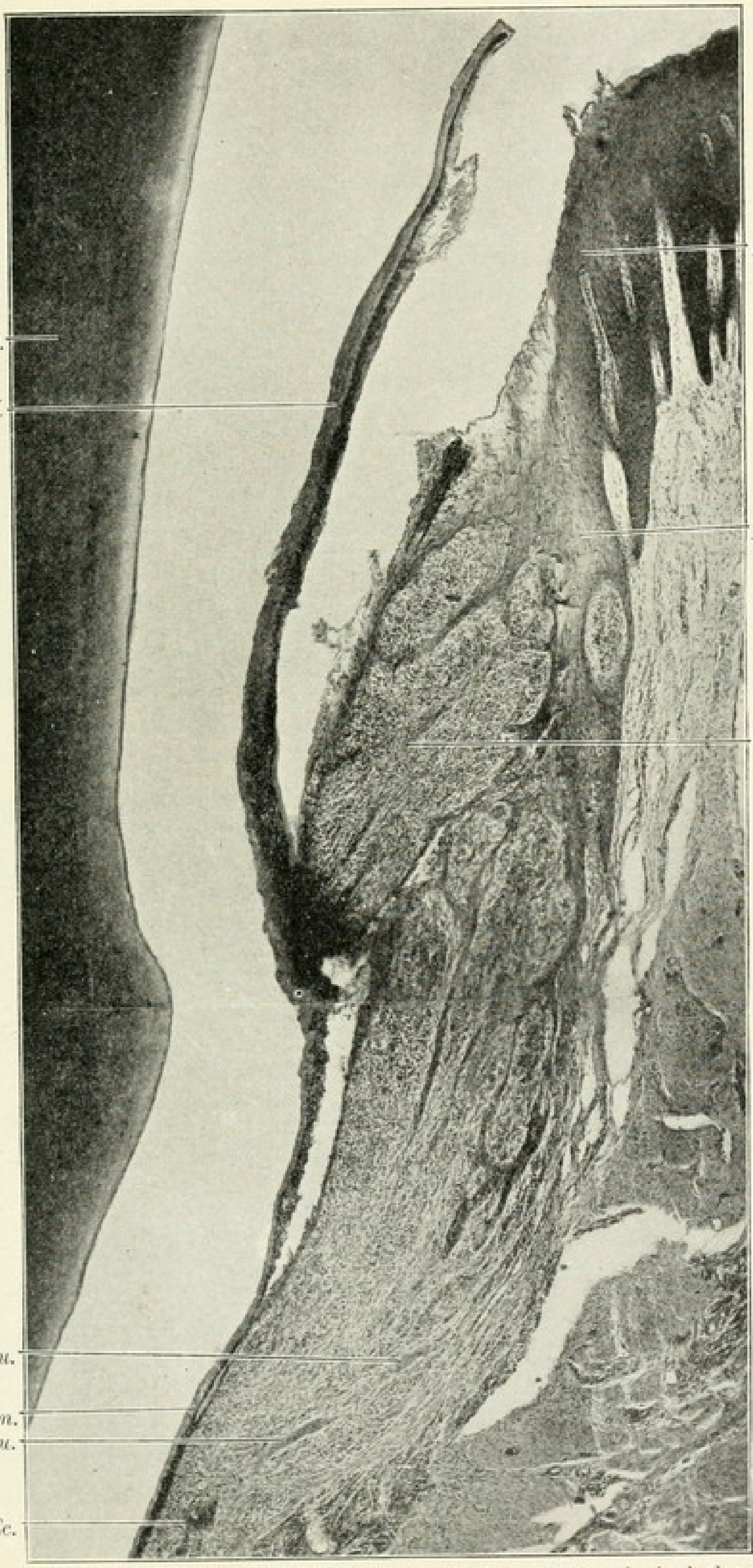
Fig. 136.



Epithelial structures: *Ec*, epithelial cord, apparently showing a lumen; *Cb*, cementoblasts; *Cm*, cementum; *D*, dentin. (About 500 ×.)

cords are invested with a delicate basement membrane, but no special relation to bloodvessels has been demonstrated. The attempt to show their connection with the surface epithelium has thus far failed. As the gingivus is approached (Fig. 137), they seem to swing out from the surface of the root and are lost between the projections of the epithelium lining the gingival space. There is evidence that these structures are, at least in some cases, of importance as the primary seat of pathological conditions of the membrane.

FIG. 137.



Longitudinal section: *Ep*, epithelium lining the gingival space; *Gg*, gingival gland, so called; *D*, dentin: *N*, Nasmyth's membrane; *Du*, duct-like structure stretching away toward the gingivus from the epithelial cord, seen at *Ec*; *Cm*, cementum, separated from the dentin by decalcification. (About 50 ×.)

Fig. 138.

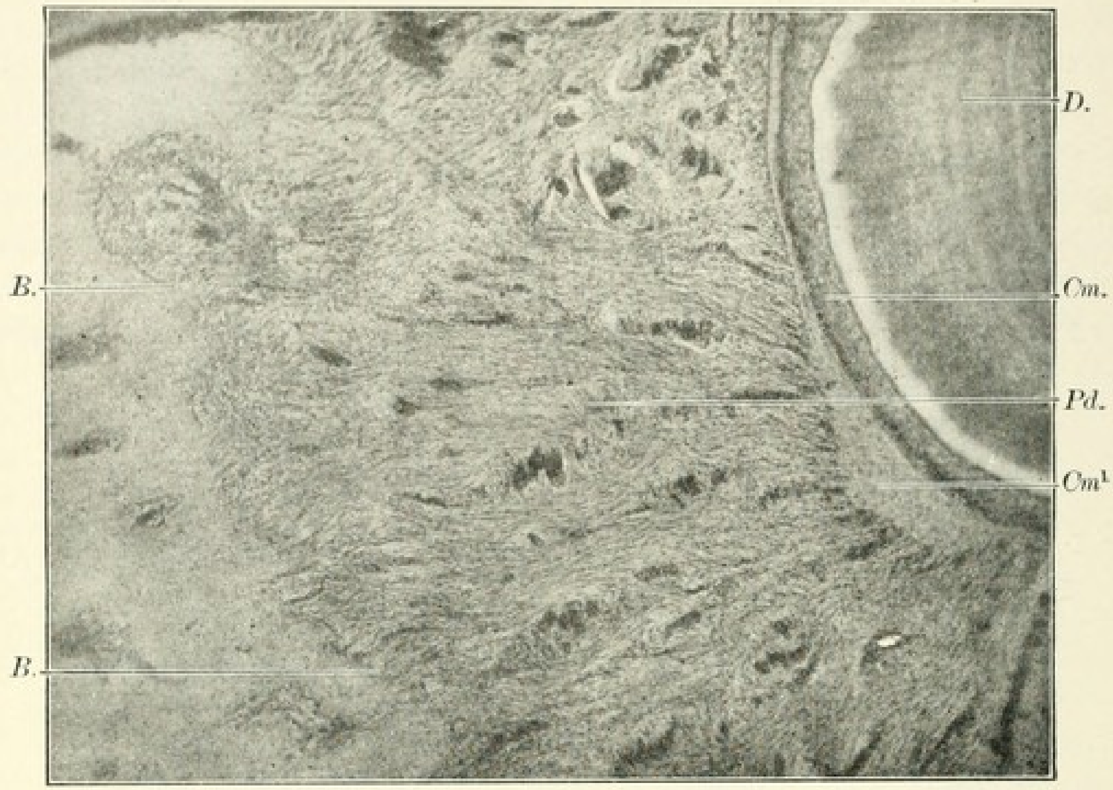


Fig. 139.

Young and old membranes (from sheep): *D*, dentin; *Cm*, cementum; *Cm*¹, thickening of cementum to attach fibers at the corner; *Pd*, peridental membrane; *B*, bone forming the wall of the alveolus; *P*, pulp. (About 80 ×.)

BLOODVESSELS AND NERVES OF THE MEMBRANE.

Bloodvessels.—The blood-supply of the peridental membrane is very abundant. Several vessels enter the membrane from the bone in the apical region. These arteries branch and divide, forming a rich network, from which the capillary vessels are given off. The arterial network is constantly receiving vessels which enter the membrane through Haversian canals opening on the wall of the alveolus, and in this way the size of the vessels passing occlusally is maintained. Arterial vessels also enter the membrane over the border of the process. This double or triple supply of the membrane is important, as it maintains the health of the membrane when the supply entering through the apical region is entirely cut off by alveolar abscess. While the arterial supply of the membrane is very rich, the capillaries in the membrane are comparatively few. This is, however, a characteristic of connective-tissue membranes.

The **nerves** of the peridental membrane have not been sufficiently studied to be described in detail. Six to eight medullated nerve trunks enter the apical region in company with the bloodvessels, and they receive other trunks through the wall of the alveolus and over the border of the process, but the manner of their distribution and the nature of their endings are not known.

THE CHANGES WHICH OCCUR IN THE MEMBRANE WITH AGE.

When a tooth is erupted the roof of the bony crypt in which it was inclosed in the body of the bone is removed by absorption and the crown advances through the opening. The diameter of the alveolus at that time is, therefore, greater than the greatest diameter of the crown, and the peridental membrane which fills the space is very thick. By the formation of bone on the wall of the alveolus and the formation of cementum on the surface of the root the thickness of the membrane is reduced. In the young membrane most of the large bloodvessels are found in its outer half, forming a rather defined vascular layer near its centre. In the old membrane most of the bloodvessels are found very close to the surface of the bone, often lying in grooves in its surface. Both young and old membranes are illustrated in Figs. 138 and 139, which are taken from the temporary teeth of a sheep, one just after eruption and the other shortly before the time of shedding.

CHAPTER IV.

ANTISEPSIS IN DENTISTRY.

By James Truman, D. D. S.

The importance of antisepsis in dental operations has not been recognized as fully as the subject would seem to warrant. This has been in part due to the fact that dentists have been accustomed to the thought that cleanliness in the use of instruments would meet all the requirements of practice. This idea has been enforced by a general immunity from unpleasant sequelæ after operations, thus leading to a skepticism in regard to the value of antiseptic measures in the oral cavity. This immunity has been in part due to the fact that the fluids of the mouth were supposed to have a direct influence in preventing infection. This has never been proved through laboratory experiments, but clinical observation and long experience have demonstrated that injuries in the mouth ordinarily heal rapidly, even though these be made by infected instruments. It seems unreasonable to suppose that a fluid peculiarly subject to fermentation should have this effect, and this has led some to ascribe it to a vital influence. Miller[1] says of this: "It is a very fortunate provision that the gums in a healthy state offer so powerful a resistance to the invasion of the germs *of most infectious diseases.* For this reason a wound in the gums may be followed by scarcely any reaction whatever, while a similar wound on the hand with the same instrument may produce most disastrous results. It has been attempted to account for this fact on the *supposition that the saliva has an antiseptic action,* in evidence of which we are often reminded that dogs lick their wounds, and that these heal rapidly. . . . . I doubt if there is anyone who would wish us to believe that the dead saliva has even the slightest antiseptic properties, in consideration of the fact that saliva, especially when it contains much organic matter, readily putrefies. If the saliva possesses any such property, it must be sought for in its living histological elements,— *i. e.*, in the living leucocytes or phagocytes."[2]

[1] *Dental Cosmos*, July, 1891.

[2] For an elaborate study of this problem see "Experimental Study of the Different Modes of Protection of the Oral Cavity Against Pathogenic Bacteria," by Arthur C. Hugenschmidt, M. D., *Dental Cosmos*, xxxviii., p. 797.

While it is true that there exists a degree of exemption from serious results, leading to indifference and careless management of cases, it is equally true that infection has resulted in the experience of almost every operator in dentistry.

Prior to the period when Lister announced that all operations in surgery should be performed antiseptically, and made modern surgery possible, this ignorance was excusable ; but at the present time, with the accumulated knowledge in bacteriology, it should be impossible for any dental operator to neglect the procedures under this head considered absolutely essential for the general surgeon.

The difficulties attending antisepsis in dentistry far exceed those in other branches of surgery. The dentist is necessarily obliged to meet conditions hourly that seem to preclude absolute freedom from sources of contamination. If he were to take the same precautionary measures now regarded as necessary for the surgeon, he would find practice almost impossible. While this is true, it does not follow that every effort should not be made to approach absolute surgical cleanliness.

The usual methods employed to accomplish this, while valuable to a limited extent, are by no means equal to what could readily be secured without consuming much time or patience. The dentist is usually satisfied that he has fulfilled all antiseptic precautions when he has dipped his instrument in some antiseptic fluid, generally carbolic acid. Little or no attention is paid to the possibility of infection from rubber-dam, towels, hands, and the variety of instruments that enter into dental operations. Some of the latter, as, for instance, the separator, are more liable to carry infection than the excavator, the one generally regarded as most important.

The appliances ordinarily in daily use are the rubber-dam, excavators, broaches, pluggers, clamps, ligatures, separators, drills, hand-pieces, napkins, and forceps. It is safe to assume that but few of these will receive any attention beyond ordinary washing. The rubber-dam is too often used as it is furnished by the manufacturer. If an attempt at cleanliness is made, it consists in washing the dam in cold or warm water, this being regarded as sufficient. When it is remembered that this is passed between teeth and usually forced up under gingival margins with ligatures, or clamps, frequently lacerating the surface, it becomes evident that the possibility of infection is always present. If infection does not occur from the rubber, it is almost certain to produce a wound in a locality extremely favorable for the growth of pathogenic germs. The result is innumerable lesions that may extend to pericemental inflammations. The great increase in the past twenty-five years of gingival inflammations subsequent to operations in mouths of more than ordinary health must be partly ascribed to this cause.

Excavators ordinarily receive the most attention, and yet, when their use is considered, they possibly require the least. It is rarely necessary to use the excavator outside of a cavity, where infection, if at all possible, would do the least harm, for the continual washing of the cavity, as the operator proceeds, reduces the danger to a minimum. Broaches, and all instruments intended to enter the pulp canals, require the most careful attention, and this applies with equal force to drills; yet it is feared that both of these, loaded though they are with septic matter, receive but indifferent care. When the dangerous possibilities which may result from this negligence are considered, it becomes a serious if not a criminal offence. The difficulty in making these instruments germ-free and in keeping them from becoming contaminated is fully appreciated; yet the effort must be made, and it is not a difficult procedure, nor does it require a large consumption of time—an important item to the dental operator.

Pluggers cannot be regarded as a source of infection. They are used solely in connection with metal, and therefore strict cleanliness is all that is absolutely required. It is fortunate that this is so, for these instruments require unusual care to protect them from rust. Hence immersion in an antiseptic fluid is deleterious and not required.

Separators—and under this head are included metal with screw attachments and wedges—require special attention, but probably receive the least. They should be made as nearly sterile as possible before their use upon a patient.

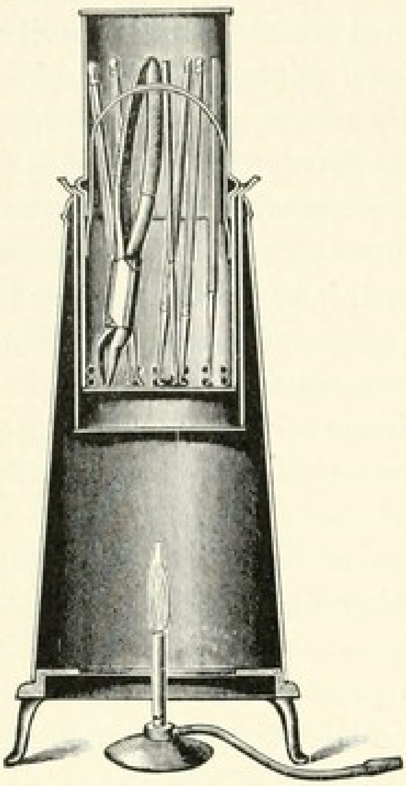
Hand-pieces, of the various kinds in use, are probably the most difficult to keep thoroughly clean. While they do not come in direct contact with the tissues of the mouth, they may indirectly, by contaminating the hands, produce unpleasant results. Frequent taking apart and boiling are essential, and should not be omitted.

Napkins from the ordinary wash have been and are used with confidence that no bad results from use can follow. If the laundry is confined to the home, this may ordinarily be true, but the indiscriminate mingling of washes indulged in by the commercial laundryman is always a menace to health. Where napkins of the latter character are to be used they should be subjected to the sterilizing process.

The chair occupied by a variety of patients may be a source of disease, and should be carefully cleansed, especial care being taken with the head-piece. The latter should be covered with a clean napkin, to be changed for every patient.

The cuspidor, where the fountain is not used, is ordinarily an abomination, for here, if anywhere, will carelessness be manifest. There can be no excuse for this, as thorough daily scalding with boiling water and the use of antiseptics will keep it measurably free from unpleasant consequences.

Fig. 140.



Downie steam sterilizer.

Glasses require to be thoroughly boiled both before and after use. Boiling should never be neglected with ejector tubes, either metal or glass, glass being generally used. Hard boiling in water for twenty minutes should be sufficient.

The lancet is an instrument demanding especial care, as it may become a dangerous source of infection. Before it is used the adjacent portions of the gum should be washed with an antiseptic.

The forceps employed in extraction should be so constructed as to render the blades readily separable at the joint, and they should be boiled in water and soda solution for an hour. The recorded cases of infection from these instruments render this care imperative in all instances.

Fig. 140 shows a convenient form of apparatus for sterilizing ordinary dental instruments by boiling soda solution.

Oral Diseases and Their Transmission.

The possibility of carrying disease from one person to another seems so self-evident that it ought not to require more than a word of caution, and yet it is clear that the attention given to this source of danger is by no means commensurate with the risks assumed constantly in practice. The peculiarly transitory character of much of dental practice precludes the possibility of any previous history of patients, and therefore every one should be regarded as a possible source of infection.

Diseases the result of pathogenic bacteria independent of possible external infection are now in the main well understood, but by no means equally appreciated by medical practitioners, nor are they properly considered by dental operators. Miller[1] states that "many facts favor the supposition that a considerable number of pathogenic micro-organisms may thrive in the juices of the mouth without showing in their vital manifestations any distinction from the common parasites of the oral cavity as long as the mucous membrane remains intact. If, however, the soft tissues have been wounded, as in extraction, or if the resistance of the mucous membrane has been impaired, these organisms may gain

[1] *The Micro-organisms of the Human Mouth*, page 275.

a point of entrance and thus become able to manifest their special actions." This fact, now well recognized, is being constantly demonstrated in the use of the various appliances that may, through careless handling, injure the mucous membrane. So much is this the case that a large proportion of gingival inflammations have undoubtedly had their origin from this cause. It has come under the observation of the writer that injuries thus received, although apparently unnoticed by dentist or patient, have resulted in the course of forty-eight hours in very disturbing pericementitis, confusing to the operator and very painful to the patient. The necessity for such antiseptic precautions here as are taken in general surgery is almost entirely overlooked. Before placing the coffer-dam, the clamp, or ligature, that portion of the mouth should be thoroughly washed with an antiseptic solution and an effort made to render the appliances equally sterile, or at least to inhibit development for a definite period. When the operation has been completed the same care should be extended to the tooth and contiguous structures. The evidence is abundant that many cases of pyorrhea alveolaris have had their origin from this careless indifference to accepted and necessary precautions.

The mouth as a source of disease to the general system does not properly belong to this article to discuss, but its importance cannot be overlooked. Dental writers have devoted much attention to this subject. It is for the dentist to understand that he is, to a large degree, responsible for the general health of his patient as far as the mouth is concerned, and he should insist on prophylactic measures that will at least reduce this source of disease to a minimum. The constant danger of what Miller aptly calls "auto-infection" from the collection and propagation of pathogenic bacteria in the fluids of the mouth should suggest to the dentist constant efforts to effect the removal of all deposits on the enamel, gingival margins, tongue, and mucous membrane. This line of study will bring about in the future an entirely different dentistry as to hygiene and prophylaxis from that practised at the present time.

The pulp of a tooth is not ordinarily regarded as a point of infection, and yet it is well known to be a serious menace to the health of an individual. Israel, quoted by Miller,[1] asserts that "the root canal furnishes a point of entrance even for the ray-fungus, actinomyces, and in one case the microscopic examination revealed the elements of this organism in the canal of a pulpless tooth." When it is considered that some individuals have decomposed pulps in a number of teeth at the same time, and frequently a score of dead and broken roots, sending out their infectious material, it is not surprising that disease of a serious nature may supervene. While there is no record of cases coming

[1] *The Micro-organisms of the Human Mouth*, p. 285.

within the observation of the writer of pulps producing pyemia directly, it is a well-known fact, supported by a long list of recorded cases, that alveolar abscess, with its concentration of putrid material, is liable to be followed by blood-poisoning.

There is no question that diseases of the digestive organs, of the lungs—in fact, of all the organs of the body—may be produced by infected material germinated in the mouth, and indeed, through sputum ejected, may affect individuals remotely situated.

Miller,[1] in considering this portion of the subject, says: "We know that under certain circumstances saccharomycetes may directly colonize in the mucous membrane of the mouth, and that in the mouths of enfeebled individuals bacteria may occasionally obtain a foothold. The mucous membrane of the mouth and pharynx is especially susceptible to the action of certain germs of infection (those of diphtheria, syphilis, etc.), and large portions of the mucous membrane and the submucous tissue may be wholly destroyed by parasitic influences."

There is a phase of this subject that requires more extended investigation. Inflammations of the mouth are not infrequent where great swelling is present. This may be observed around the lower third molars with no explainable cause in dead pulps, overlapping mucous membrane, retarded eruption, or mal-presentation. It is evidently produced by bacterial invasion, but has not always yielded to antiseptic measures, and at times has resulted in abscess entirely independent of pulp devitalization.

A recent report of three cases by Dr. John A. McClain[2] in the medical practice of Dr. M. G. Tull is interesting as indicating possibilities. The first case was an extensive swelling posterior to the lower third molar. He could not connect it with that tooth, and suspected auto-infection. He had cultures made with negative results. His theory was that it was diphtheritic; and, although laboratory evidence was wanting, he determined to inject antitoxin. This injection was followed in twenty-four hours by an entire reduction of the swelling. All other efforts had previously failed to effect any result. Two other similar cases yielded to the antitoxin treatment in the same speedy manner. If this can be regarded as something more than a coincidence in practice, it may lead to an explanation of many similar anomalous pathological cases arising posterior to the third inferior molar, yet apparently not connected with it. Similar conditions have been the cause of much uncertain diagnosis and still more empirical treatment.

The more the writer has considered this subject the more important it has appeared; and he is convinced that, when the proper prophy-

[1] *The Micro-organisms of the Human Mouth*, p. 295.

[2] *International Dental Journal*, October, 1900.

lactic measures come into use for the prevention of tuberculosis, in all its protean forms, antisepsis of the mouth will be given primary importance.

Infection from Mouth to Mouth.

Infection from mouth to mouth through instruments is a difficult matter to prove by cases, but theoretically there can be no cause for disputation. The question will always arise, Was the lesion occasioned by auto-infection or by transmission? The answer can rarely be given with the assurance desirable. In one instance, at least, in the writer's experience the origin was clearly traceable. This was in a patient of the better class, presenting for treatment in the clinic of the Dental Department of the University of Pennsylvania. Her teeth were remarkable for structure, regularity, and cleanliness; gums perfectly healthy. Necrosis of the anterior alveolar plate was threatened when first seen, and finally resulted in the entire destruction of the alveolar border and all the anterior upper teeth, but did not involve the maxilla. The history of the case as given was that a bicuspid had been extracted from the right superior region by a dentist notorious for his uncleanly habits. Not long thereafter the patient noticed a serious inflammation. These symptoms indicated a syphilitic infection, and the family physician was consulted, who insisted that no history of this disease existed and that infection must be the cause. The patient, through his treatment and that given locally, recovered, but was forced to wear an artificial substitute.

Cases of infection through extraction, either by the forceps or after-infection from the mouth, might be quoted almost indefinitely. Miller reports case upon case—in fact, the accumulation of these has become of serious moment; and yet, in the face of undisputed facts, dentists will continue to extract teeth frequently without any precautions, or, at most, relying on simple washing of the instrument. Some German writers contend that antisepsis after extraction is wholly unnecessary, as the clot formed is a sufficient protection. This is certainly not true in all cases. It is not always the fact that a clot is formed, or when formed that it serves an antiseptic purpose. One of the most serious cases that has fallen to the writer to treat was that of necrosis of the superior maxilla involving destruction of the right side, taking in all the teeth from the third molar to the lateral, the floor of the antrum, a portion of the nasal bones, and half of the hard palate. This was the result of the extraction of the third molar by a specialist before the days of antisepsis; whether it was the result of infection is difficult to determine. In the opinion of the writer, no extraction should be attempted until the instruments used have been thoroughly sterilized by boiling. Before the forceps are applied the parts surrounding the tooth should be well washed with an antiseptic solution. After the extraction the socket should be syringed with sterilized water, followed by some powerful disinfectant. In view of the serious results probable in this operation there is no longer any excuse for injuries resulting from infection, and a suit for malpractice could be well sustained against an individual who had failed to observe the well-understood methods of antisepsis, while no intelligent practitioner could conscientiously appear on behalf of the defendant.

External Infection.

The danger to the operator from external infection from instruments is a constant menace; the constant use of these with general freedom from serious results, however, leads to a degree of carelessness not warranted by the ever-present danger from wounds. There is more real danger to the operator from this source than to the patient. All the excavators, drills, and broaches are hourly in contact with infectious matter, and it requires but a slight wound to produce any of the possibilities of blood-poisoning. The operator should be on constant guard in this respect, upon the slightest abrasion immediately taking measures to destroy all possibility of infection from germs that may have been introduced into the wound. This should at once be carefully washed and an escharotic employed, burning the parts. For this purpose zinc chlorid or carbolic acid is probably the best agent to use, followed by an antiseptic. The latter should be frequently renewed. Experience has demonstrated the value of turpentine in the various mechanical shops where this agent has been for many years in common use for wounds from rusted iron, the possibility of trismus resulting from such injuries being well understood. The writer has used this agent, after burning the wound, almost to the exclusion of other antiseptics.

An illustration of the ever-present danger from wounds occurred to a friend of the writer's, one of the many young women who have graduated in dentistry in this country. She accidentally wounded her hand by a drill, and regarded it as of no moment. The result was severe blood-poisoning that for two years kept her hovering between life and death. After suffering from severe metastatic abscesses, she was finally restored to partial health, but with her constitution shattered and her practice ruined for the time being.

Implantation and Transplantation.

Previous to the recognition of the importance of antisepsis, the dentists of that period had a very natural objection to reimplanting teeth; the practice of transplantation was then practically an unknown operation. The danger of the operation was appreciated, but the reason was not then comprehended. When the study of bacteriology had advanced to a science through the labors of Pasteur, Koch, and a host of investigators, the reasons for this fear were explained, and the conditions necessary to avoid unpleasant results being understood, the danger from infection was changed to absolute security. It is, moreover, to be ever borne in mind that but for this knowledge implantation and transplantation could to-day not be practised without the probability of serious results.

A case illustrating this point occurred prior to the knowledge of antisepsis in the hands of a well-known dentist. He had removed three teeth and successfully reimplanted them for the cure of a violent case of neuralgia presumably due to calcific depositions in the pulp and about the external portions of the roots. Relief was so immediate that upon return of the pain another tooth was attempted. Trismus followed, resulting in the death of the patient. It is safe to assume that this unfortunate result could not have happened under the antiseptic care usual at the present time, even imperfect as it frequently is.

To accomplish antisepsis in this operation the greatest care is necessary. In transplantation, teeth being procured from other mouths, the danger is necessarily much increased. The method, adopted by some, of immersing these teeth in various antiseptic fluids cannot be commended. Miller says of this:[1] "It is generally accepted that the operator takes every possible precaution when he allows the tooth to lie for one-half to one hour in a 1 per cent. solution of carbolic acid, or in a 1:1000 solution of bichloride of mercury. . . . In order to reach bacteria that may have penetrated into the lacunæ or chance vascular canals a much longer action of the antiseptic is necessary, and to be perfectly certain that we have accomplished our object we should have recourse to boiling water."

Agents used for Sterilization.

The possibility of injuring instruments has deterred dentists from using many of the agents recommended for the purpose of sterilization.

Miller[2] made tests of various agents with indifferent results, with the exception of carbolic acid, trichlorphenol, and mercury bichlorid. The list tested included the following:

Carbolic acid in 5 per cent aqueous solution and in pure form.

Lysol in 5 per cent. aqueous solution.

Trichlorphenol in 5 per cent. aqueous solution.

Sublimate in 5 per cent. aqueous solution; also in the strength of 1:1000 of water.

Benzoic acid in the strength of 1:300 of water.

[1] *Dental Cosmos*, July, 1891.

[2] *Ibid.*, page 520.

Potassium permanganate in 5 per cent. aqueous solution.

Resorcin in 10 per cent. aqueous solution.

Hydrogen peroxid in 10 per cent. aqueous solution.

Saccharin in concentrated alcoholic and aqueous solution.

β-naphthol in 5 per cent. alcoholic solution.

Pyoktanin in concentrated aqueous solution.

Absolute alcohol.

Antiseptin in 5 per cent. aqueous solution.

Zinc sulfate in concentrated aqueous solution.

The essential oils in 5 per cent. emulsions and in pure form.

The three previously named, carbolic acid, trichlorphenol, and mercury bichlorid, were the only ones that gave any satisfactory results, and these only partially so. In regard to the rest, Prof. Miller says: "They all fall far short of those already mentioned. The 10 per cent. solution of the *peroxid of hydrogen* came next to carbolic acid, but is considerably inferior to it. The *essential oils*, in emulsions as well as in pure form, utterly failed to produce the desired action."

The results obtained by Miller are not wholly in accord with those of some others. Charles B. Nancrede, M. D., in an article[1] gives a list of agents which have "proved most reliable clinically, can be resorted to in any emergency, or are peculiarly applicable to meet exceptional indications:"

	Marked Inhibition.	Complete Inhibition.
Mercuric chlorid	1:1,600,000	1:300,000
Oil of mustard	1:333,000	1:33,000
Thymol	1:86,000	
Oil of turpentine	1:75,000	
Iodin	1:5,000	1:1,000
Salicylic acid	1:3,300	1:1,500
Eucalyptol	1:2,500	1:1,251
Borax	1:2,000	1:700
Potas. permanganate	1:1,400	
Boric acid	1:1,250	1:800
Carbolic acid	1:1,250	1:850
Quinin	1:830	1:625
Alcohol	1:100	1:12.5

At the time these tables were prepared one agent not mentioned was practically unknown as an antiseptic,—formaldehyd, or in solution known as formalin.

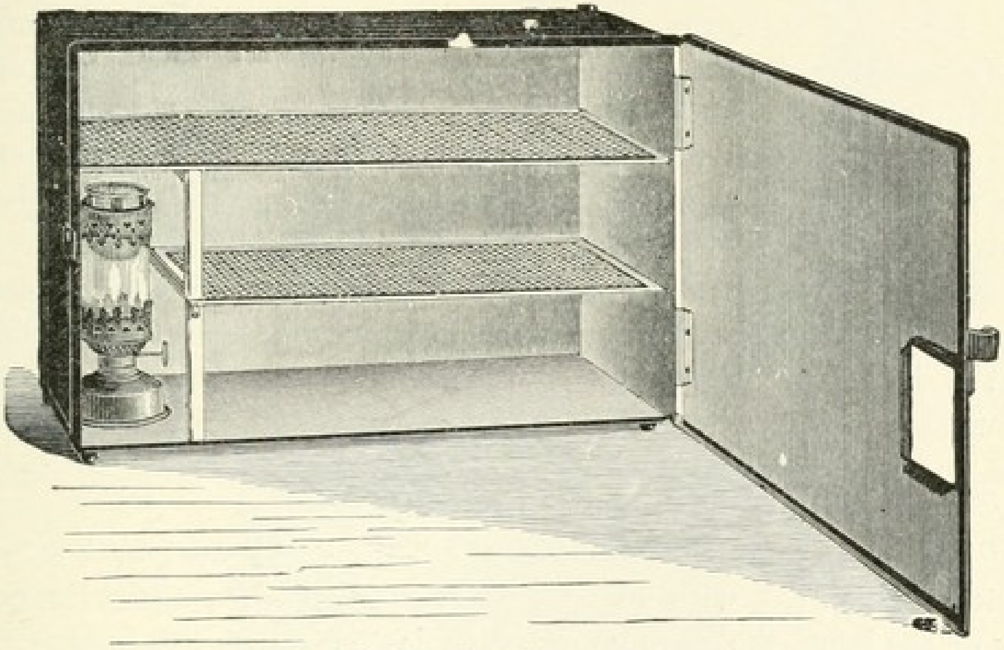
Dr. Elmer G. Horton, B. S., assistant in bacteriology, Department of Hygiene, University of Pennsylvania, undertook, at the request of Dr. Edward C. Kirk, a series of investigations with formaldehyd,[2] the results of which are given, omitting the details of experiments:

[1] "Treatment of Wounds: Antisepsis and Asepsis," *Surgery by American Authors*, Park, page 365.

[2] *Dental Cosmos*, July, 1898.

"We employed the gas generated by heating over an alcohol lamp a pastil which contained five grains of paraform. The lamp was placed in a tin box of nearly one cubic foot capacity . . . (Fig. 141). Among the instruments employed in the tests were various chisels, excavators, and burs. These were boiled, shown by cultural method to be sterile, then either dipped into bouillon cultures or infected from selected cases found in the operative clinic of the Department of Dentistry, University of Pennsylvania. After infection each instrument was placed in a sterile tube and kept at incubator temperature (37.5° C.) for three hours. . . . In a single test with moist instruments we found sterilization complete. After the infection and subsequent drying the tubes containing the infected instruments were separated into two lots, one to be subjected to

FIG. 141.



Schering's formalin sterilizer.

the method of disinfection and the others to be kept as controls, by which would be shown that no step other than the action of formaldehyd destroyed the vitality of the germs. . . . After exactly ten or fifteen minutes, according to the experiment, the door was opened and the instrument quickly removed. . . . Each instrument (controls likewise) was placed in a considerable amount of sterile bouillon and these cultures, together with the subcultures made from them, observed for at least one week. . . . In all experiments a free growth developed from the controls. . . . The disinfection of instruments purposely infected in the clinics from cases of caries, pyorrhea, and gingivitis was satisfactorily accomplished in every case. . . . We conclude that infected dental instruments can be disinfected without injury in a closed space of less than one cubic foot, by an exposure of fifteen minutes to the formaldehyd gas generated from a pastil containing five grains of paraform by heating the pastil over a proper alcohol lamp."

In an article on the "Uses and Limitations of Formaldehyd in Dentistry," by Dr. F. W. Low, Buffalo, N. Y.,[1] the effect of formaldehyd gas is further given as shown by a series of experiments conducted by Dr. Thos. B. Carpenter, assistant bacteriologist to the Health Department of the City of Buffalo. Without entering into detail, the experiments consisted of two series, one of infected instruments and the other of clothing either of school-children, of nurses, or of the doctor in the presence of contagion, to determine whether they could be thoroughly sterilized by placing them over night in a wardrobe exposed to the fumigation of the lamp used.

The conclusion of Dr. Carpenter was that "This apparatus can be relied upon, after an exposure of from ten to fifteen minutes, to destroy thin layers of the common, non-sporulating pathogenic organisms."

In regard to the second series of experiments with clothing, he says: "It is evident, therefore, that twelve hours' exposure to the action of this lamp in a closet of 15.8 cubic feet capacity is sufficient for effective surface disinfection, the most resistant pathogenic bacteria being destroyed."

A third series of experiments was undertaken with scaling instruments taken from the instrument-cases from several operators, including that of Dr. Low. The result of this elaborate experimentation is thus summed up by the author: "Every set, *except the one where the whole case was fumigated* over night, produced some cultures; but not one set developed a culture of pathogenic organisms."

"The Low lamp consists of an asbestos-lined tray, or box, supported on legs (*A*), with an opening in the bottom to admit the chimney of the lamp, the purpose of which is to conduct the fumes of the formaldehyd gas into the tray and upon the instruments it is desired to sterilize.

"The working parts of the lamp are shown in the illustration. An ordinary alcohol wick is drawn into the wick tube. To place the lamp (*B*) in operation fill it with *wood* alcohol, grain alcohol being incapable of generating formaldehyd. Adjust cone-shaped platinum coil so that it just touches the top of the wick. Light the latter; place on chimney, and after a few seconds' waiting blow out the flame. If the cone be in proper adjustment to the wick, it will be observed that the coil glows like a live coal, but there is no flame or dangerous heat.

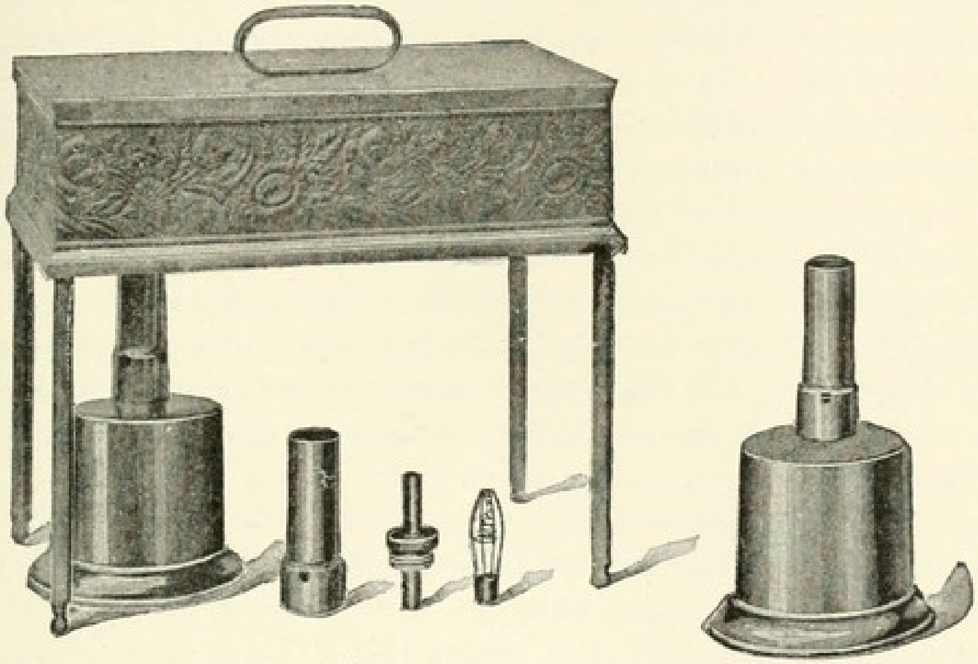
"Having the lamp in operation, as described, and the tray properly adjusted to set over it, as in illustration, instruments may be placed in the tray and allowed to remain for ten minutes, a sufficient time to

[1] *Dental Cosmos*, February, 1900.

effect sterilization. When taken out they should be wiped dry with a *surgically clean* napkin or towel.

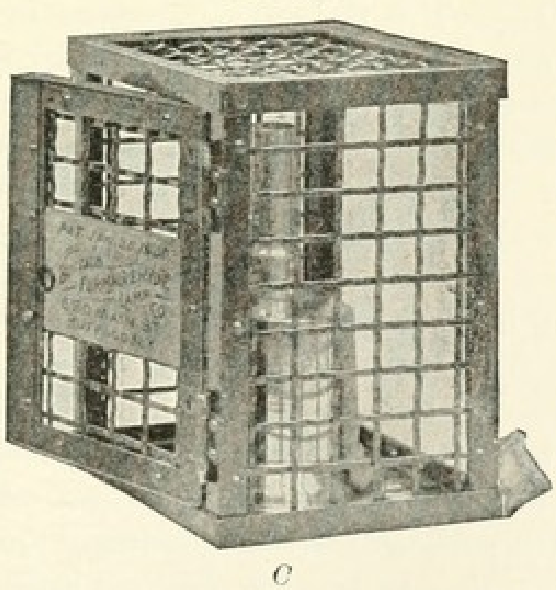
"To stop the fumigation going on in the lamp, remove the chimney and slide the cage high up on the tube, so that the platinum cone no longer touches the wick, then allow it to cool before replacing chimney."

FIG. 142.



A *B*

FIG. 143.



C

Low's formaldehyd lamp: *A*, for dental use; *B*, for household use; *C*, locked cage for public places.

While it is not difficult for the average dentist to use formaldehyd as a disinfectant, it will probably be considered a useless expenditure of time, and, therefore, boiling in water and soda for at least twenty minutes seems the more feasible and is equally certain in the results.

The dentist who aims to keep only aseptic instruments should have two sets in daily use. When through with one patient the instruments should undergo the boiling process in preparation for the next. At the close of the day all instruments used should be thoroughly boiled and dried upon aseptic napkins and placed in the case. The possibility of infection from the latter must not be overlooked. The first and second set, therefore, used the next day for the first time should be either boiled again or each instrument dipped into an antiseptic fluid. For this purpose the writer prefers a strong solution of hydronaphthol (8 grains to the ounce of alcohol) to the carbolic-acid solution ordinarily used. With this care all danger of infection can be removed and the dentist relieved of all legal responsibility.

The preparation of the hands previous to operations is most perplexing to the conscientious operator, whether this be in surgery or dental practice. In order that dental operators may be able to arrive at definite conclusions in regard to what may be required of them in their daily work, the following quotation is given from Nancrede's article[1] on the care required in hospital surgical practice:

"Sterilized water as hot as can be borne should be employed. This must, of course, be never cooled by the addition of any but cold sterilized water. . . . The nail-brush, best made of vegetable fiber, must be always carefully rinsed after use and sterilized by heat for each operation. . . . Although it is alleged that all soaps made by heat are sterile—indeed, that potash soap is an active germ-inhibitor in the proportion of 1 : 5000—yet it is the part of prudence to combine with the soft soap 5 per cent. of hydronaphthol or thymol, to insure that the soap itself is free from germs. After thoroughly rubbing into the hands and arms and under the nails abundance of soap, the nail-brush and hot water must be vigorously used, especially beneath and around the nails, for from two to five minutes. Next, carefully clean the nails and around them with a nail-cleaner. Removal of all grease can now be effected by ether or by immersion in alcohol, or best by alcohol containing 5 per cent. of dilute acetic acid, which should be rinsed off thoroughly with sterilized water, removing the last traces of soap. Finally, the hands should be immersed—not merely dipped—in a 1 : 2000 mercuric chlorid solution for not less than three—preferably five—minutes. Instead of corrosive sublimate solution, ordinary mustard flour mixed in the hands into a thin paste with sterilized water, used with gentle friction for two or three minutes and then removed with sterilized water, will prove a most successful germicide."

While the foregoing may serve as a basis for comparison, it would be wholly impracticable in dental practice. It remains, however, that the hands of the dental operator should be the subject of constant care.

[1] *Loc. cit.*

Nails should be kept short and scrupulously clean. It seems to the writer that the use of a good potash soap and nail-brush, with bathing the hands in alcohol, will be amply sufficient unless working on a syphilitic patient, when more effective methods must be resorted to, and there can be nothing better than the mode described by Dr. Nancrede.

The conclusions to which the writer has arrived from experience and study of the subject may be summed up briefly as follows :

1. Dipping instruments in an antiseptic fluid previous to operating, while beneficial, is not sterilization.

2. That boiling with soda is for the dentist the most convenient means of sterilizing instruments without injury, while the more recently introduced method of formaldehyd antisepsis is a dry process that does not rust or injure steel instruments and is also promptly effective.

3. That the ordinary methods used to effect sterilization in surgical practice are not possible in dentistry, but that every dentist is legally and morally bound to live as near to the rules of antisepsis as is possible with the demands of a daily practice.

CHAPTER V.

THE EXAMINATION OF TEETH PRELIMINARY TO OPERATION—METHODS, INSTRUMENTS, APPLIANCES—RECORDING RESULTS, ETC.

By Louis Jack, D. D. S.

The Operator.

The attitude of the body of the dental operator has considerable influence upon the ease with which the various positions required in operating may be assumed, and also has some bearing upon the freedom of his hands.

The erect position should be maintained as far as possible and the preponderance of the weight should be sustained upon the balls of the feet. This secures equilibrium and enables movements to be made with little embarrassment. The shoulders should be held well back in order that the arms may not be cramped, and to permit the respiration to be carried on deeply and with quietness. For obvious reasons the breathing should be deep, slow, and always through the nose.

The precise use of the fingers requires that in each application of the instrument a *rest*, as a fulcrum or base of action, should be used, and when force is to be applied a *guard* in addition is necessary to give security to the movement of the hand. The positions of the rest and the nature of the guard required in operating are various, depending upon the situation of the territory of operation and somewhat upon the natural tact of the individual, so that a definition of them is scarcely required. Upon a careful application of the rests and guards depends the graceful and comfortable use of the instruments, and by means of them the hand passes by quick and easy gradation from the most delicate touch to the safe exhibition of considerable force. Each student should study and practice the use of the various rests and guards until by repetition their employment becomes involuntary and appropriate to the situation.[1]

The *contact* with the patient should be at as few points as possible and should be generally made with the fingers.

Examination of the teeth and mouth in all their particulars is a

[1] To aid in this study see *American System of Dentistry*, vol. ii. p. 44 *et seq.*

necessary preliminary to the treatment of any diseased or disturbed condition which may appear. The importance of this procedure cannot be overestimated, as on it depends the formation of a correct diagnosis of departures from the normal state and it becomes a basis for the formulation of plans for the treatment required to restore the teeth and the related structures to a state of health, as well as to define the order in which the several operations shall be taken up, since an orderly *precedence* in the treatment of individual teeth is frequently necessary.

It is essential that the examination be most thorough, to prevent any failure to notice the least defect; since an unobserved slight lesion may become a deeper injury in a few months, and the consequences of an oversight may prove serious.

Appliances used in Examination.

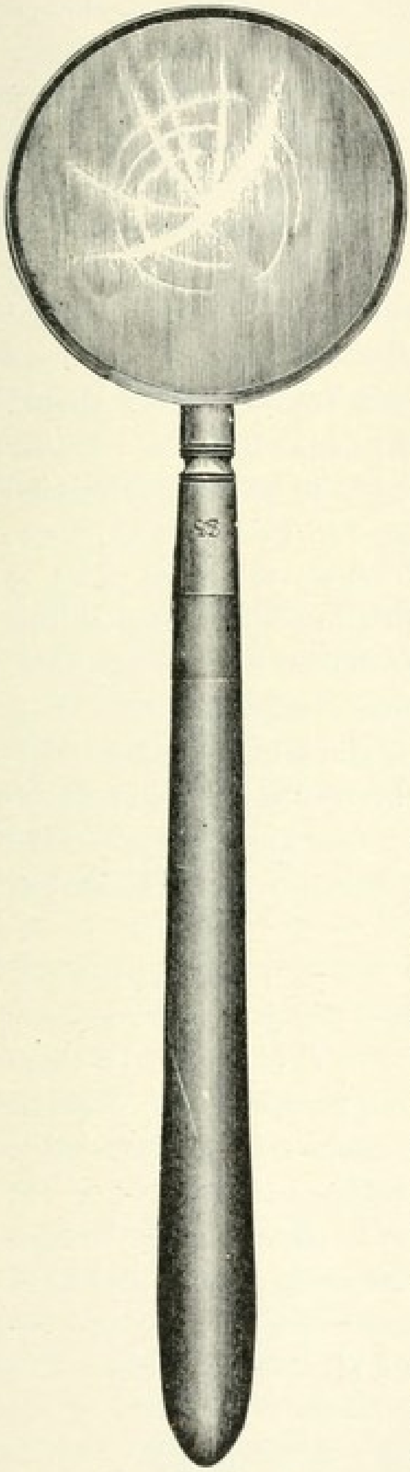
The appliances required to effect thorough observation of every portion of each tooth to ascertain the extent of any lesion are of several kinds, viz. mirrors, magnifying glasses, explorers, floss silk, and wedges.

The MIRRORS should be both plane and concave. The plane mirror is important as a means to assist by the reflected image in determining the position of defects; the concave as an adjunct to effect illumination, as it concentrates the rays of light and also may be used to produce an enlarged image. The enlarged image, however, is less sharp in definition than the image of the plane mirror.

Working to the Image.—The plane mirror is an important adjunct in all operative procedures connected with the teeth. Many situations in the mouth do not permit the direct reflection of the rays of light to the eye without assuming positions of the body and of the head of the operator which are awkward and embarrassing to free movement of the hand, as well as necessitating inconvenient and tiresome positions of the head of the patient. In addition, it frequently is impossible to secure correct observation of the progress of various procedures by direct vision. These difficulties may be overcome by the movements of the hand being directed by the image of the field of the procedure on the mirror. This method of working to the image is at first difficult to the novice, since the images are reversed; but by continued effort it becomes as easy to make correct application of movements by this method as by the direct rays of light. Further continued practice in this way renders the movements so completely under reflex control that the operator passes from a direct movement to a reverse one, and the contrary, without an apparent effort of the brain. This is equally true in all the various movements, even of those where the employment of considerable force is required.

The Quality of the Mirror.—These appliances should constantly be in good condition to insure clear definition in the image. The best kind of glasses are those in which the surface is covered by a deposit of pure silver. This furnishes a better reflecting surface and is more durable than is the so-called "silvering" with tin and mercury.

FIG. 144.

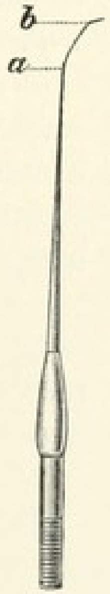


Magnifying lens.

MAGNIFYING LENSES of about four diameters are useful to detect minute defects either in the teeth or in the condition of previous operations upon the teeth. They are used either directly to magnify the parts, or else to magnify the image shown on the face of the plane mirror when direct rays of light cannot be caught. The latter method gives a clearer definition than the magnified image of the concave mirror.

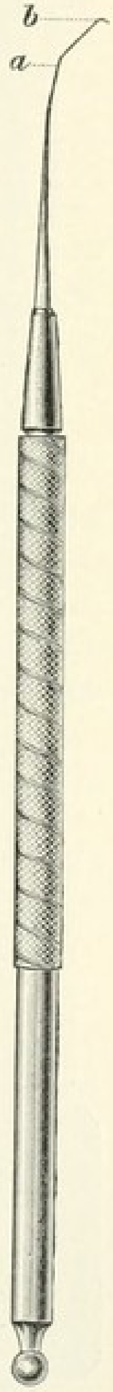
The magnifying glass may be the ordinary watchmaker's glass held before the eye by the muscles of the brow and cheek or the lens mounted as shown in Fig. 144. Such glasses are indispensable to the careful practitioner, since with their aid defects of the teeth and of operations may be detected which would escape observation by other means.

FIG. 145.



Explorer.

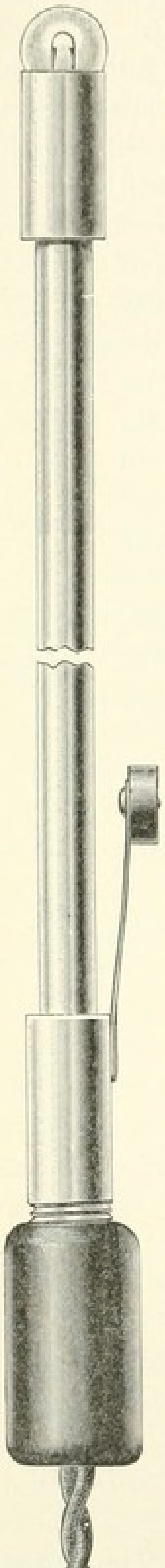
FIG. 146.



Self-contained socket.

EXPLORERS are, essentially, prolongations of the fingers; they convey impressions by their vibrations to the tactile nerves, and are principally intended to be applied to parts where direct rays of light cannot reach. The forms required are simple and few. Their points should be delicate, to enable the smaller apertures and spaces to be entered, and are best when made

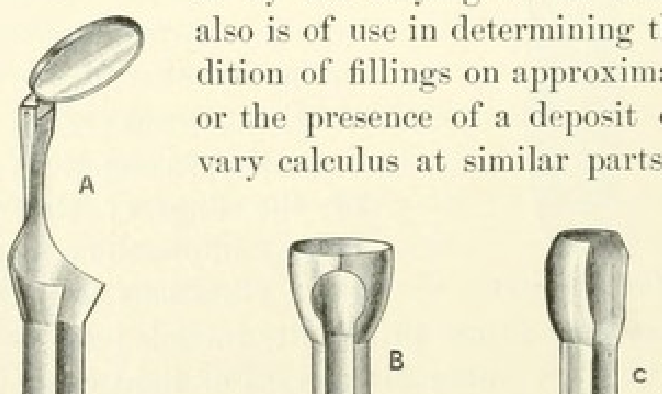
Fig. 147.



of piano-wire, No. 18 B. & S. gauge, filed to acuteness and bent to a shape similar to that shown in Fig. 145. This form may be applied to all surfaces of the teeth, and but slight modifications are needed to explore positions difficult of direct approach. At part *a* the size of the finer ones should be No. 25, and near the ultimate point, *b*, No. 30. The temper of this kind of steel gives sufficient stiffness and also permits slight bending to make modifications of the form to meet all requirements. The ultimate point may be sharpened and renewed at pleasure. The handles in which these instruments are inserted may be of wood, with metal sockets which should be of sufficient length to come into contact with the finger; or they may be fixed in metal holders, in which case the latter should be tapered to avoid weight and to give balance. Either form of handle should be round, to permit fractional rotary change of direction. Fig. 145 shows an explorer, which consists of a socket, into which the wire point is secured by means of powdered shellac or powdered sulfur. The points may be displaced and renewed when required. This socket fits into the usual cone-socket handles. Fig. 146 is a self-contained socket for the same purpose.

Explorers of this kind may be re-formed by straightening and then re-dressing between two emery-cloth disks in the dental engine, when the points can be shaped at will.

Floss silk is used to pass between the approximal surfaces of the teeth at the places which are in too close contact to permit the ingress of fine explorers. In these positions floss silk may detect the presence of superficial softening of the enamel by the character of the friction or by the fraying of its fibers. It also is of use in determining the condition of fillings on approximal faces or the presence of a deposit of salivary calculus at similar parts. The



Dow electric lamp for mouth illumination with reflectors. Reflector *A* is jointed to vary the angle of reflection. Reflector *B* is for illumination of the fauces. Reflector *C* is for lateral illumination.

silk should be slightly waxed in order to bind the fibers. Entire reliance cannot be placed upon the use of silk, since it may in some cases pass slightly carious spots without the fibers being displaced, but it frequently furnishes indications for further procedures by which to establish certainty as to the state of approximal surfaces.

WEDGES are used when neither explorers nor silk give positive indications of carious action but have raised doubts of the integrity of any part. They may be of wood where the teeth are not firmly fixed, when the space may be immediately made; otherwise, where the fixation is firm, india-rubber or linen tape may be forced in.

Transillumination of the teeth and of the adjacent parts by the electric mouth lamp (Fig. 147) is extremely useful in cases where a question has arisen as to the condition of any approximal surface. Superficial changes of the enamel may frequently be detected by this means. It is also of service in diagnosis of derangements of the antrum and to test the vitality of the pulp.

The Examination.

The **parts of the teeth most liable to carious action** are those which most easily retain deposits of sedimentary matter composed of food débris, thickened mucus, and bacterial growths. These are the *labial and buccal surfaces*, where the mechanical relations of the lips and cheeks tend to retain sediment; the *sulci*, which by the direct force of mastication have food driven into them; and the *approximal surfaces*. The latter are the most important to consider. The interproximal space is a serious predisposing cause of caries, because the counteraction of the tongue and cheek in adapting the food between the occlusal surfaces of the teeth forces the finer particles of the food into the interproximal spaces, where it is retained by capillary attraction and by the apposition of the cheeks with the buccal surfaces of the teeth. This space is usually triangular, the gum forming the base of the triangle. The point where caries usually begins is at the apex of this triangle, where there is the least movement and interchange of the contents of the space, as here the capillary force is the greatest, so that the fermentative processes of food decomposition are least interfered with.

The **technique of examination** is as follows: After a cursory inspection of the denture with the mirror, the explorer is applied to the previously indicated surfaces, particular care being used in determining the condition of *approximal surfaces*, by introducing the instrument into the triangular space, the point being directed toward the acute angle. It should be drawn back and forth with a slight rotary movement so as to impinge the point successively upon the whole approximal surface of each tooth. This movement should be made from the inner as well as from the outer aspect. In this manner the instrument will be brought into contact with every accessible portion of the interproximal surfaces.

Then the *sulci* are explored and the *buccal and lingual surfaces* examined.

The inspection is thus conducted from tooth to tooth. Next the lines of apparent contact are critically tested with the mirror for evidence of slow changes of structure as shown by discoloration or rapid alterations shown by a milk-like appearance of the tooth surface.

Finally, all approximal surfaces which could not be explored are *silked*. To do this the floss is wrapped upon the index finger of the left hand, and with the right is drawn between the contact surfaces with a sliding lateral movement. Care should be exercised that no injury be done to the gingival margin of the interproximal space by suddenly and forcibly driving the floss into contact with it. This accident may be effectually avoided by a proper guarding and supporting of the fingers by contact with the adjacent teeth. Practice gives facility in determining by means of the silk the state of the parts in contact with it.

In the inspection of previous stoppings, all margins, particularly those beneath the gum, should be critically inspected.

Lastly, doubtful situations should be noted for subsequent examination to be made after separation.

(The tests for pulp exposures are considered in Chapters VII. and VIII.)

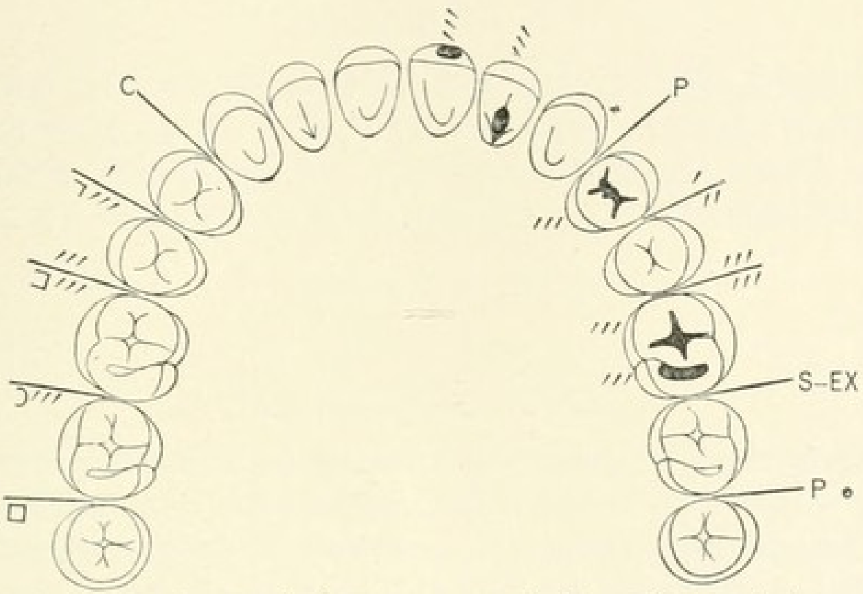
The **order of examination** is best conducted by beginning at the median line of each quarter of the denture, progressing posteriorly with one line of observation and returning to the place of beginning with another line of observation.

The Chart Record.—The chart record should at the same time be carried on by the principal, or better an assistant, with the view of securing a complete record of each derangement, for guidance and for reference. The details of the record are indicated in a simple manner by symbols which are illustrated by Fig. 148, and explained by the glossary. These symbols may be combined, where required, to give fuller expression.

From this temporary record important operations when executed may be transferred to a permanent record.

The constitutional condition and the texture and apparent resistance of the teeth to caries and attrition ; the inherited tendency to diseases of the teeth ; the chemical reaction of the mucous and salivary secretions ; the state of the general heath ; the condition of the mucous membrane of the mouth and throat; the indications presented by the tongue; the dietary habits and other hygienic relations; the tendency to catarrhal affections; the presence of the rheumatic or gouty diathesis—are all questions which

FIG. 148.



—	signifies:	In the interproximal space.	C	signifies:	Salivary calculus.
/	"	Attention—re-examine.	EX	"	To examine.
//	"	Superficial softening.	⌉	"	A pulp nearly exposed.
///	"	A carious cavity.	⊐	"	A pulp probably exposed.
•	"	At the cervix.	)	"	A pulp fully exposed.
S	"	To separate.	□	"	A devitalized pulp.
P	"	To polish.			

enter into the prognosis and frequently largely determine not only the hygienic directions to be given to the patient, but also determine, in connection with the age and habits, the important question as to whether the restorative operations shall be of a permanent character or only of a temporary nature designed to preserve the teeth until restored normal functions may make it judicious to perform more enduring operations.

The foregoing considerations with respect to the examination of the mouth and teeth sufficiently meet the requirements for beginning the rational treatment of dental disorders.

CHAPTER VI.

PRELIMINARY PREPARATION OF THE TEETH—REMOVAL OF DEPOSITS AND CLEANING OF THE TEETH—WEDGING—OTHER METHODS OF SECURING SEPARATIONS—EXPOSURE OF CERVICAL MARGINS BY SLOW PRESSURE, ETC.

By Louis Jack, D.D.S.

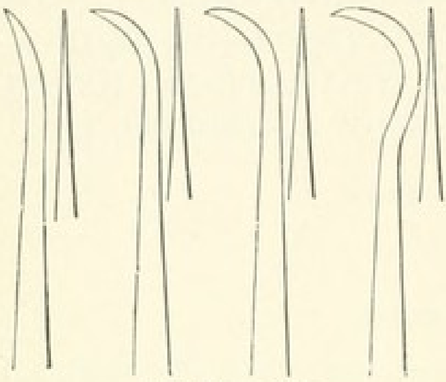
Cleansing the Teeth.

Before restorative operations are commenced upon the teeth all deposits of salivary calculus upon them should be removed and they should be cleansed of the covering of partially inspissated mucus which even in persons of more than ordinary carefulness is liable to be found upon them. This film favors the admixture with it of sedimentary matter from food substances and frequently has so much consistence as to offer considerable resistance to its removal, and it prevents to a degree the contact of the naked brush with the teeth. Its presence is in every way detrimental to the preservation of the teeth, since it not only favors the adhesion of starchy matters, but also furnishes, wherever situated in connection with these food products, a favorable habitat for the development of bacterial forms responsible for the formation of the acid products that are the active agents of enamel solution. This deposit is most frequently formed on the inner and outer surfaces of the posterior teeth, where it invades the interspaces and in some cases covers all surfaces which are not directly subject to the friction of mastication. It should be thoroughly removed and all surfaces should then be carefully polished.

The best means to effect this is to polish the parts with a mixture of *pulverized pumice with glycerin.* The glycerin binds the particles of pumice and permits its retention upon the polishing instruments. The persistence of the deposit is shown by the fact that when the pumice is applied it is a moment before the polishing implement comes into actual contact with the enamel. To be suitable for this purpose the pulverized pumice should have been elutriated or passed through a fine bolting cloth to remove the coarse and irregular particles which if permitted to remain might cause injury to the enamel surface. After the removal a vitreous surface should be given by quick friction with stannic oxid (" tutty powder"), which also is better applied when combined with glycerin or rubbed up with vaselin.

Salivary calculus is found precipitated at parts not subject to free friction, such as the buccal surfaces of the molars, the inner faces of the lower incisors, and it frequently invades the interstices. These deposits also should be displaced and the surfaces polished.

Fig. 149.



Abbott's scalers.

The better appliances for the removal of superficial calculus are sickle-shaped *scalers* of various sizes and forms, which are inserted beneath the free margin of the gum, when the direction of the movement should be obliquely toward the occlusal aspect to avoid injury to the gingival attachment with the tooth. The consideration of the removal of deeply seated salivary calculus where some serious injury has been caused by its presence is treated of in Chap. XIX.

Polishing the Triangular Portion of the Interproximal Spaces.—When this is required an efficient means is to employ gilling twine of sizes proportioned to the space. This is applied by looping one or more strands with a piece of floss silk, when the silk is drawn upward into the triangle and then is used to pull the twine into the space, which being armed with suitable powders is drawn to and fro until the absence of friction indicates that the surfaces have become smooth.

CARE BY THE PATIENT.

Coincident with the preparation above described the patient should be given such instruction as will tend to *maintain the state of cleanliness.* The importance of this should be impressed as a necessary hygienic measure to preserve the teeth. This is to be accomplished by the use of suitable brushes and properly compounded powders. The detergent effect of powder is principally due to the particles becoming mixed with the film of mucus. This action breaks up the continuity of the film, which, with the accompanying sediments, is displaced by the friction of the brush.

The *correct use of the brush* requires that it be placed with some degree of firmness upon the outer and inner faces of the teeth and then slightly rotated. The pressure drives the bristles into the valleys, and the rotary movement being away from the gum avoids injury to that structure. The application of this procedure in combination with the use of *picks* and *floss silk* should maintain a correct hygienic condition of the teeth, upon which, in the light of the present knowledge of the causes of solution of the enamel, depends the preservation of the teeth from that source of injury. It has been shown that when sound enamel becomes attacked, the potent cause is the fermentation of starchy deposits permitted to remain in contact with it.

It should be understood that the use of the pick removes deposits from the cervical triangle, and that silk is intended to sweep the more contracted portion of the interstice.

Further reason for care is found in the fact that the mouth in an unclean condition becomes a *favorable habitat for the development of germs* some of which may have pathogenic properties capable of affecting the general health. It therefore becomes the duty of the dental adviser to enforce correct hygienic conditions of the mouth.

Much importance in this connection should be attached to the use of cleansing preparations having inhibitive action toward bacterial life. Those most serviceable contain hydronaphthol, which has considerable efficiency without toxicity. Formalin as an ingredient of a wash is also applicable, but must be prescribed with considerable caution.

Treatment of the Mucous Surfaces.

When the gums, the membrane of the mouth or of the throat are *inflamed*, treatment preparatory to operations upon the teeth should be directed toward restoring these parts to a normal state. Where the inflammatory condition is not expressive of derangement of the alimentary functions and is the result of some simple local irritation, the condition will usually respond to the topical action of stimulant tonics.

It is necessary here to discriminate as to whether or not the inflamed surface has been produced by neglected care of the mouth, which frequently induces a lax condition of the gum from the absence of friction or by the presence of bacteria. These may cause a deficiency of tone or disorders in other portions of the mouth and of the throat. Should these conditions be present the employment of disinfectant gargles and mouth-washes is indicated.

The presence of salivary calculus may also induce inflammatory disturbance of the gums, and from the points of deposit this may extend by diffusion over a considerable area. In this connection deposits, either of calculus or of sedimentary accumulations, posterior to the lower third molars may induce serious diffuse inflammation of the contiguous tissues, sometimes extending to the fauces. For this condition the mechanical removal of the deposits combined with an antiseptic spray will usually be restorative.

For diffuse redness and deficient tone of the mucous surfaces a wash composed of potassium chlorate and quinin will prove sufficient in most cases, as follows:

℞. Potassii chloras,	ʒij;
Quininæ sulphas,	gr. iij;
Sp. rectificatus,	℥j;
Aquæ,	℥vj.—M.

S. For use as a gargle. A dessertspoonful to a wineglass of water, or directly upon the gum in full strength by means of a soft tooth-brush.

Concurrently with the local therapeusis the employment of massage of the gum with the finger, either naked or covered with a napkin, is of considerable value.

When the conditions are catarrhal or are expressive of gastric derangement only general treatment with concurrent attention to the diet and correct hygienic relations will meet the requirements of the case. Coincident with the general treatment above indicated, the simpler operations upon occlusal surfaces may be carried on.

In all cases of initial treatment for children or nervous patients it is important to begin with simple and, as nearly as may be, painless operations, to accustom such patients to the more or less disagreeable procedures and to elicit their interest and co-operation in what is being done for their benefit.

Cavities on Approximal Surfaces.

The preliminary treatment of this class of cases, on account of the limitation of space and the necessity for somewhat indirect application of the instruments and of the requisite force, necessitates the closest attention to every detail. Upon the care here taken depends the comfort, and furthermore, indirectly in many instances, the health of the person.

The procedure of first importance is to produce a sufficient *enlargement of the interproximal space.* In all cases, whether the teeth are in apparent contact or whether they may, from loss of substance on the approximal aspect, present sufficient room for the management of the various procedures, spacing is equally necessary. It is done in order that when the stopping procedures shall have been completed the natural relations of the teeth with each other will be restored. This relation, as before indicated, is one of apparent contact near the occlusal surface with a triangular space at the cervix. The mechanical basis of this arrangement is such that the function of comminution of food is better effected if there is no breach in the continuity of the occlusal aspect of the denture.

The consequences of breaches of continuity, especially in relation to the posterior teeth, are often of serious import. Not only may the food be driven into the space, to the discomfort of the patient, but serious injury of the gum may follow, as in many cases the tissue becomes inflamed by the impaction of food in the enlarged interspace, which induces peridental disturbances and may occasion the ultimate loss of the affected tooth. It is also not unimportant to consider that the forms of the teeth have an esthetic value, and that the harmony of the features forbids the mutilation of their natural forms.

Separation of the Teeth.

Separation of the teeth is a procedure requiring care to avoid injury and to render the process comparatively painless.

When the teeth are mobile, as in the case of children, the movement is more easily and more quickly made than when the alveolar walls are compact and when also the teeth are in close proximity. In the former case the arch easily expands and permits the teeth to yield; in the other case the resistance requires more force to be used and the application of it for a longer period. In all instances the force and the material used should be adapted to the presented conditions and the movement should be sustained until the required space is gained, it being deleterious to make repeated attempts to separate the same pair of teeth. When the proper precautions are taken there is no danger attending the process; even the firmest structures of mature age permit sufficient spacing if it be slowly and steadily done.

METHODS OF MAKING SEPARATIONS.

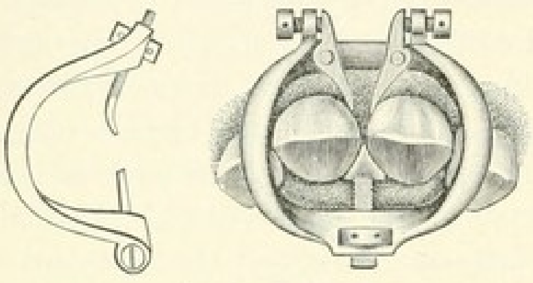
The **means** by which these are effected are various and the choice is determined by the amount of space required, the time in which it must be accomplished, and the firmness of the supporting structures. Some regard must also be had for the peculiar susceptibilities of the patient to the pain which may be caused by the effort. These methods are—by immediate wedging, which may be made when the fixation of the teeth is not firm; by the swelling of firmly impacted pellets of cotton or of tape, and by the resilience of strips of caoutchouc where the teeth are in general contact and where they are firmly fixed.

Immediate wedging is more applicable to the front teeth, where usually only a small space is required, and is a valuable method of securing a separation of the front teeth to determine their condition and to permit polishing strips to be inserted for the removal of superficial discolorations and for the treatment of superficial softening. Here the procedure is to insert a wooden wedge between the incisors near the incisive edge, when it is forced by pressure or by percussion until a sufficient opening is effected, the space then being secured by another wedge of hard close-grained wood forced between the teeth at the cervix. This process in some instances is repeated by forcing farther the first wedge and again increasing the security by driving the cervical wedge. This plan is not applicable when the interspace at the neck is quite angular, since the fixing wedge cannot be made secure, as it then is disposed to advance against the gum. In this case one of the subsequent methods should be pursued.

If the fixation of the teeth be not firm they yield by a slight enlargement of the arch and by closing the neighboring slight spaces.

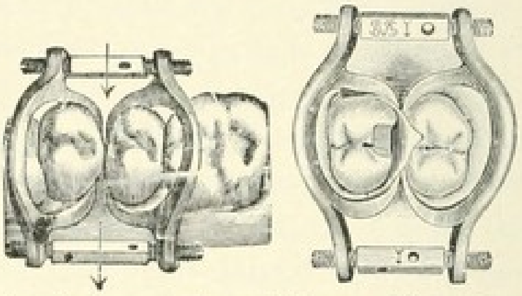
Immediate separations may be effected by *mechanical separators*, notably the William A. Woodward (see Fig. 150), for the front teeth and

FIG. 150.



Woodward's separator.

FIG. 151.



Perry's separator in conjoint use with matrix.

the Perry (see Fig. 151) for the bicuspids and molars. It should be stated that each of these is preferably to be used when some previous space has been made by other means, following which a considerable increase of space may be secured by these appliances.

Separation by the Swelling of Fibrous Materials.—These act by the capillary force of water upon the fibrous structure of the material, whether pledgets of cotton or tape. This means is also more applicable when the fixation of the teeth is not firm, and has the advantage of being painless and more readily tolerated by children and by persons who are impatient of pain or of any form of dental distress.

Pledgets of *cotton* are more applicable where a partial preliminary opening of a carious cavity has been made, and are more appropriate for the posterior teeth. Here, when there is no danger of pulp exposure, the pledgets may be packed with considerable firmness. In some instances it is advantageous to saturate the pledget with thin sandarac varnish, which attaches the fibers, but the time required is much increased, as the cotton yields to capillary attraction only as it loses the resin.

Tape is more useful for the incisors; it should be of linen and may or may not be waxed. Its entrance is facilitated by an immediate preliminary application of a wooden wedge.

Caoutchouc—India-rubber.—When a strip of india-rubber is drawn into a close interspace the middle portion is constricted to great tenuity. The action is by the resilience determining the two exposed ends toward the middle, with the result that at length the space attains the size of the thickness of the strip. It will be perceived that the physical force is that of two opposed wedges acting with constant power. The effect is such that it overcomes the greatest resistance to separation of the parts and therefore is the most effective means which we have.

Caution is required in the use of this material both as to the thickness of the rubber and as to its purity. The pronounced resilience of pure rubber is generally painful, and in most instances greatly so. The resilience can be reduced by employing adulterated specimens of the material. The white-rubber tubing of the shops cut longitudinally into various widths effects the object with less rapidity but surely, and generally without pain. The strip is drawn into position by a sliding motion, care being taken not to force the piece into contact with the gum. To prevent the rubber being conveyed to the gum as the space enlarges, a small portion should extend slightly beyond the occlusal surface. As this kind of rubber is more difficult to introduce when the contact is close and firm, a previous partial opening should be made with a piece of rubber dam. This method has the value of painlessness, and also does not usually necessitate a period of rest after the separation has been effected.

Red Base-plate Gutta-percha.—When it is desirable to gradually effect considerable spacing between teeth, where the carious cavities are deep with well-defined boundaries but not involving the pulp, the method of Dr. Bonwill, of packing the cavities and the existing space with a sufficient mass of this form of gutta-percha, produces expansion by the continued force of mastication driving the material upward. This method also has value in some instances where it is desired to force the gum beyond the cervical margins, and may be an acceptable substitute for aseptic cotton for this purpose.

Securement of the Space.—Should soreness of the teeth have been caused by the separation, a period of rest should be given the parts until the distress has passed over. It is, however, important that large spaces should not be long retained, since in some instances alveolar resorption may be induced by the continuation of the changed position. An interval of two days usually suffices for the pericementum to recover from the disturbance, when the restorative procedures may be conducted.

The retention of the space may be effected with *gutta-percha* or with the *plastic cements*,—the first being suitable when an open cavity appears; *zinc phosphate* when from the smallness of the cavity gutta-percha may not be readily retained. *Oxychlorid of zinc* should be used when the cavities are shallow but sensitive,—the reason for which will appear later. It is generally advisable to introduce a thin wedge of wood at the cervix and in contact with the gum to prevent the retaining material from impinging upon this tissue and to give a base to support the introducing force.

Exposure of Cervical Margins.—When cavities extend beneath the gum, which frequently is the case when caries has recurred above the cervical margins of fillings, it becomes necessary to force the gum somewhat above the carious border. This should be done quickly rather than slowly, otherwise in adult subjects the continued pressure may arouse diffused inflammatory disturbance of the contiguous tissues. Generally it is preferable first to cut away the gum between the teeth with a straight, narrow bistoury, and gently force red gutta-percha against the gum, gradually moulding it to the form of the depression. Cotton pellets for this purpose are not admissible unless they are antiseptically charged, for which purpose an admixture of aristol with the cotton is the most suitable, since not being soluble in water it better maintains the asepsis. Cotton may be conveniently charged with aristol by saturating it with a solution of aristol in chloroform and allowing the greater portion of the solvent to evaporate before introducing the pledget.

When hypersensitiveness of the gum tissues exists it is admissible to paralyze the sensation with a suitable solution of cocain, previous to introducing the pellet of either gutta-percha or cotton fiber. A four per cent. solution of cocain hydrochlorid applied upon cotton to the sensitive tissues will speedily relieve the condition.

CHAPTER VII.

PRELIMINARY PREPARATION OF CAVITIES—TREATMENT OF HYPERSENSITIVE DENTIN BY SEDATIVES, OBTUNDENTS, LOCAL AND GENERAL ANESTHETICS—STERILIZATION, WITH A BRIEF CONSIDERATION OF THE PHYSIOLOGICAL AND THERAPEUTIC ACTION OF THE MEDICAMENTS USED.

By Louis Jack, D. D. S.

Hypersensitive Dentin.

Dentinal hypersensitiveness frequently presents the most serious impediment to the procedures connected with the treatment of dental caries. This condition must be considered an exaltation of the normal sensitiveness of the dentin, and presents a wide range from slight pain on contact being made to so high a degree of sensitiveness as to be unendurable. In the latter instance persons of the greatest capacity for tolerating pain will shrink from the most careful instrumentation. Immediately upon the opening of a carious cavity there usually are indications of excitement of the vital elements of the dentin. This condition may be so slight as to present no obstacle to further procedures, or it may on the other hand be so excessive as to forbid all instrumentation until a reduction of the sensitiveness has been effected.

This altered state of the dentin has been considered by some as one of *inflammation* of the dentin. As the opportunity does not exist for the usual concomitants of inflammation as pathologically defined and which are induced by the alterations of the circulation of the blood, viz. heat, redness and swelling, with exaltation of nervous function caused by the additional supply of arterial blood, the term inflammation is a questionable one to apply to a hyperesthetic condition of dentin. This manifestation is more logically explainable as a disturbance caused by changed relations of a tissue which is naturally protected by the enamel from irritating influences. The relation of the enamel and the dentin is analogous to that of the epidermal coat of the skin and the rete mucosum. Pain caused by abrasion of the epidermis is immediate and acute, and occurs before the increased supply of blood increases the intensity of it. It is hence induced by the altered relation of the mucosum. The analogy is further borne out by the fact that in each instance a protective covering affords salutary relief.

The normal sensitivity of dentin is not high, as is shown by an immediate examination of a surface exposed by accident, but after a few days the denuded surface manifests impatience of mechanical contact and of applications of cold, which proves that the altered relations induce a condition of the part similar to the condition of the skin when the epidermis is broken. This appears to be the case independent of the influence of chemical agencies, as exaltation of sensitiveness occurs when the fluids of the mouth are in a normal state. The same indications are presented when a non-sensitive cavity is prepared, as here, in case the cavity be not protected by a stopping, the same phenomenon subsequently appears.

Generally also, in such cases, if a stopping is inserted without previously effecting a coagulation of the surface of the cavity, pain arises upon reduction of temperature. This condition is designated as secondary sensitivity, which is caused by the traumatism. In some cases of this kind the pain becomes so great as to require the removal of the stopping and the carbolization of the cavity. In extreme cases reflected pain in the other teeth may appear in consequence of the disturbed relations making an impression upon the nervous elements of the pulp.

When exposure of the dentin has been brought about by *caries*, the sensitivity excited is liable to be much exalted above the normal, and is only prevented from giving constant indications of this condition by the presence of the carious matter, which, being a poor conductor of heat, in a measure protects the pulp from thermal irritation. This accounts for the fact that while there may sometimes be acute pain in the early stages of decay of dentin, the irritability and reaction of the pulp appear to become less as the caries advances.

When the teeth are undergoing rapid decay the dentin is more sensitive than when the carious process is slow. As the color of the carious matter gives some indication of the rate of progress, we may from this indication form an impression of the probable degree of sensitiveness. When the carious matter is light, the action has been rapid; when it is yellow or light brown it is less active; and when it is dark brown or black, it has progressed very slowly. In some cases of the last character, when the parts are subject to friction, spontaneous cessation of decay takes place. The parts are then nearly devoid of sensitiveness. The process by which the dentinal tubuli become obliterated by calcific deposits is called *eburnation*. When the dentin becomes exposed by attrition, that tissue is not as greatly irritated as it is by the progress of caries, since by reason of the gradual loss of substance changes take place within the tubules by which their capacity to convey sensation is diminished or obliterated as the case may be.

When the gum recedes, exposing the cementum, a very high degree of sensitivity is often excited, which is prone to decline by spontaneous changes of structure. There is often here the added influence of acid conditions of the mucous secretions where they flow out upon the teeth at this point, and where, too, the parts are not easily cleansed. It is a notable fact in connection with cervical hypersensitiveness that while it persists these parts are less liable to decay than when loss of sensitiveness here takes place.

The **area of hypersensitivity** usually is not evenly distributed throughout the carious cavity, but has its chief seat near the line of union of the dentin with the enamel, thus bearing out the law that sensitivity is greatest at the terminal end-organs of the sensory nerves, with the further qualification that the more minute the fibrillæ the greater may be the acuteness of the sensitivity. This fact is illustrated by the example of cavities in the occlusal surfaces of the molars, which manifest pain only at the margins; is only less evident in the cavities of approximal surfaces, and is strongly shown in the shallow buccal and labial cavities, which present their whole surfaces near the line of juncture of enamel and dentin.

In most cases of caries, the zone of highest sensitivity is *immediately beneath the soft portion* of the decay, and when this layer of dentin is cut away the pain becomes less, in some instances approaching the normal. This statement, however, has force only in the milder manifestations of this condition.

The Effect of Acid Conditions of the Oral Fluids.—In the previous chapter some allusion was made to the fact that an *acid* state of the oral fluids is detrimental to the teeth as promoting carious action, and that alkaline or even neutral states have a retarding influence. Here it must be considered as an axiom that no cause is so active as a primary influence in inducing excessive dentinal sensitivity as a constant slightly acid state of these fluids; and, conversely, that a neutral or slightly alkaline state is non-irritating. These conditions should be kept in constant view in dealing with this subject.

The **degree of sensitivity** of dentin is modified by a variety of other general conditions. These are—relative density of the structure, rapidity of the carious action, and the constitutional peculiarities of the person which are connected most directly with nervous impressionability to disturbances of the tissues.

The *rate of progress of caries* exerts considerable modifying influence over dentinal sensitivity. When caries is of slow progress the amount of organic tissue exposed to irritation is comparatively small, for the reason that the well-known salutary and protective changes of structure go on coincidently with the slow inroad. The slight irritation of slowly advancing caries to some extent exerts a stimulating influence toward inducing tubular deposits. On the other hand, when the carious process progresses with rapidity, reparative efforts upon the part of the pulp are paralyzed, the organic elements of the tissue become denuded to a greater extent, and therefore sensitivity is increased to a proportionate degree.

As these fibrillar elements are the means of extending the irritation to the pulp of which they are the peripheral prolongations, it is evident how important a factor the active advance of caries is, and also to what extent the rapidity of the process increases the morbid concomitants of dental caries. It has been pointed out that the area of hypersensitiveness generally pertains to a narrow line at the outer limit of the dentin, but in rapid caries this line is a broader one.

The anatomical element of the dentin concerned with its sensitivity is contained within the tubuli. While the exact nature of the matter in these tubules has not yet been certainly determined, it has been shown to have sufficient consistence to permit of extension, as in separating sections under the microscope what appear to be fibers have been seen. Also the same appearance has been presented in fresh specimens when the pulp has been drawn away from the dentin. It is not difficult in reviewing these facts in connection with the various conditions and phases of dentinal sensitivity to conclude that the exaltation is inseparably connected with an irritated state of the tubular contents. The variation in the degree of sensitivity of different teeth of the same mouth—of those which are side by side and in a similar degree of progress of carious action ; the profound fact, heretofore stated, that the dentin at a short distance beneath the decay is much less sensitive ; that in some instances sedatives modify the degree of pain, and that coagulants produce a marked impression upon the capacity of the tubular contents to convey sensation, force by inference the conclusion that in diseased conditions this anatomical element is largely concerned in conveying impressions to the central organ of the tooth.

It is also undoubted that unusually high sensitivity of dentin is an inherent constitutional condition with some persons, and that it pertains to some families apparently as an inheritance, but may be explained in these instances as the transmission of acute nervous impressionability.

In connection with this subject should be considered the further observation that the temperature sense of the teeth is various ; that with some the application of ice makes no impression upon the teeth when in normal condition, while with others in the same condition the least cold induces pain. It would further appear that the degree of sensitivity when caries occurs bears some relation to the relative tolerance of the teeth to reduction of temperature.

On these premises it is not difficult to account for the manifestation of acute sensitivity, and to build thereon an hypothesis governing the various conditions presented by dentin when it is subjected to the irritation of the carious process. These views have steadily gained support with the advance of microscopic study of the tissues, and have supplanted the older view that the sensitivity of dentin is a result of mechanical vibrations extending to the dental pulp.

Treatment of Hypersensitivity of the Dentin.

Having considered the general principles governing hypersensitivity of dentin, we are prepared to enter upon a study of the TREATMENT. This is to be considered under the following general lines: namely, the *therapeutic*, the *chemical*, the *anesthetic*, and the *mechanical*.

Treatment of Slight Hypersensitivity.—The first requisites to be observed here are a calm manner and earnest sympathy, accompanied with the assurance that if severity of pain occurs, mitigating means will be resorted to. It is an important and laudable object to remove dread and secure confidence, which is attained among other means by selecting at first the simpler and less painful operations. When confidence is secured, slight pain arouses the courage of the patient. The effect of the opposite course of indifference and harsh cutting alarms the patient, arouses apprehension, and greatly increases the nervous exaltation.

In the simpler cases sharp instruments used with quick, light, and rapid movements are called for. It should in this connection be noted that cutting in this manner stimulates somewhat the nervous force of the patient, and if the movements are in very quick succession they appear to paralyze the part; the pain is thus lessened in comparison with deliberate and slow instrumentation. The movements of the excavators should be in a direction away from the pulp rather than toward it, and the cuts should be by drawing the points instead of pushing them; this is for the reason that the pressure in the latter case is greater than in the former.

When the sensitiveness is so great as to interdict immediate excavation and formation of the cavity, some method of treatment of the surface is required to overcome or to confine it within a tolerable degree.

The Therapeutic Treatment.—Under this head the available remedies are *morphin*, *veratrin*, and *cocain*,—each of them being applied with glycerin as a menstruum. It should be stated that neither have much immediate effect, and therefore they should be sealed in the cavity after the opening in the enamel has been prepared, and the softer caries has been lifted and peeled off. The closure should be effected by means of gutta-percha, or with what is probably better, a thin paste of *phosphate of zinc* laid over the dressing. After some days the pain will be found diminished in many instances. The therapeusis is effected by the absorption of these sedatives by the partially disorganized tissues. Another method of applying cocain is to secure the cavity from the entrance of moisture, and after desiccating the surface a saturated pledget of vapocain, a solution of cocain in sulfuric ether, is introduced. As evaporation of the ether takes place cocain is forced by osmosis into the tissue. In cases of subacute sensitivity this means frequently is efficacious, but is of little value in hypersensitive conditions. It is advantageous as preparatory to this line of treatment first to *neutralize the acidity of the cavity* with an alkaline solution, which may be either ammonia, sodium carbonate, or sodium dioxid, afterward removing the excess of alkali by thorough washing with warm water.

Treatment of Hypersensitivity of Dentin by Electrical Osmosis.

Within a recent period a means of treatment of this condition has become prevalent which has been designated by the terms CATAPHORESIS, ELECTRICAL DIFFUSION, and ELECTRICAL OSMOSIS. It has been demonstrated that the action of electrical currents conveys fluids, with the substances held in solution, from the positive electrode toward the negative electrode. Further, that an electrical current passing through a membrane accelerates the natural process of osmotic diffusion if the positive pole is applied on the side of a membrane or tissue from which the osmotic diffusion is taking place; in case the situation of the poles be reversed, the osmosis is retarded or prevented from occurrence or is reversed. This action bears some analogy to that which takes place in electro-metallurgy when a metal in solution is conveyed from the *anode* (positive pole), and is deposited upon the *cathode* (negative pole). If the current be reversed the deposited metal is again taken up by the solution and is conveyed back again to the other pole. This is a law connected with the passage of electrical currents through fluids which are capable of conduction.

The following will illustrate the action which takes place: "If two compartments separated by a membrane are filled with a fluid and in each an electrode is placed, there is a streaming of the fluid through the septum from the positive to the negative pole, so that in time there is an increase in the negative side. This osmotic action, as is well known, occurs naturally between two fluids of unequal density from the lighter to the denser liquid, but if the anode is placed in the denser liquid and the cathode in the lighter the natural osmotic current is not only overcome but is reversed."

If a substance containing water, as a ball of wet clay or a piece of muscular tissue, have an anode connected with a current of sufficiently high potential attached to one side, with a cathode attached to the opposite side, the watery contents of the substance are conveyed to and appear in excess on the cathodal side; at the same time the anodal side becomes less damp; also, if a capillary tube be filled with water and an anode and a cathode be similarly arranged, the water flows toward the cathode.

As a membrane or tissue may be considered to be a series of tubes in close contiguity, it is apparent that the movement of fluids must take place through them in the direction the current is passing.

These examples are an expression of electrical force. The application of this law of the passage of fluids from a higher to a lower electrical potential is the fundamental process which is employed in electrical diffusion of medicaments. The depth to which medicaments may be conveyed depends upon the conductivity of the tissue and that of the medicament which is being applied.

"The cataphoric action of electricity has often been made use of experimentally to introduce drugs into the system through the skin. In man quinin and potassium iodid have been thus introduced and subsequently been detected in the urine."

As early as 1859 Dr. B. W. Richardson used this process to produce local anesthesia, and completely demonstrated its power in this direction. It has also been clearly proven that when a solution of cocain is applied to the skin, its characteristic action upon the mucous membrane will not here take place. But when the anode is wet with the solution and a galvanic current is passed through the epidermis to the cathode, placed upon an indifferent surface, anesthesia is effected over the surface covered by the anode and to an indefinite distance inward.

This effect is not produced by the current alone, which has been abundantly proved by conclusive experiments, these having been followed by demonstrations confirming the above statement. When the medicaments so applied have anesthetic or analgesic properties their characteristic effects are produced.

When this principle is applied to the *transfer of medicaments* it is found that they pass for an indefinite distance into the contiguous tissue along with the current from the anode toward the cathode, but with some degree of diffusion; the diffusion depending upon the resistance of the tissue and upon the extent of the surface of the cathodal (negative) electrode.

GENERAL PRINCIPLES INVOLVED IN THE METHOD.

The application of electricity requires the consideration of the general principles or laws governing its transmission.

The source of this force is to be found in chemical transformation. Under the laws of the correlation of force it is capable of being converted into heat, light, magnetism, and mechanical power, and may be used to disorganize substances, when its action is called electrolysis. Its movements are constant in their direction, viz. from bodies of high to those of low potentiality.

In *perfectly conducting* substances electricity moves with entire freedom under any electro-motive force however small.

In *perfectly non-conducting* substances electricity will not move under any electro-motive force however great.

In *imperfectly conducting* substances electricity moves only on the exhibition of intense electro-motive force, the force varying according as the substance is a more or less indifferent conductor.

Electricity has two elemental properties. These are defined as current strength, designated by the term *ampèrage;* and electro-motive force, which is termed its voltage.

The active energy of electricity depends upon the first property, its distribution upon the latter. Since it must be assumed that few bodies are perfect conductors, this force or pressure is of that degree which may be required in any given case to move the active energy, the ampèrage, against the resistance it meets with.

The unit of *strength* is the AMPÈRE.

The unit of *pressure* is the VOLT.

The unit of *resistance* is the OHM.

The unit of *power* is the WATT.

A VOLT represents the electro-motive force (E. M. F.) required to impel one ampère of current through one ohm of resistance.

An AMPÈRE of current is so much as will deposit 0.00118 gram of silver per second when passing through a standard solution of nitrate of silver—or which will decompose 0.09326 milligram of water in one second. Hence the ampère is the measure of rate of flow of an electrical current, and in connection with the *voltage* measures the *energy* of the current.

The unit of resistance (OHM) is that degree of resistance which will permit the passage of one ampère of current at one volt of pressure.

The WATT is the power exerted by one ampère of current at one volt of pressure.

In the economic application of electricity its transmission is effected through metallic conductors. The resistance of these is varied by the character of the metal, the cross section, and the distance. For certain purposes other substances are employed to effect greater resistance than the metals.

The current strength flowing in a circuit is equal to the pressure divided by the resistance.

The resistance equals the pressure divided by the strength.

The pressure equals the strength multiplied by the resistance. In elementary terms:

Ampères	=	volts ÷ ohms.
Ohms	=	volts ÷ ampères.
Volts	=	ampères × ohms.
Watts	=	volts × ampères.

It follows from the formula that the amount of power and the cost of producing it is the same whether the current is of large ampèrage at low voltage or of small ampèrage at high voltage. Thus an incandescent lamp may be supplied by 100 volts at ½ ampère or by 50 volts at 1 ampère—the result in each case being 50 watts.

Comparative Illustration.—Given a current of 100 volts at fifteen ampères, and we wish to use only ½ ampère, the resistance to be put in the circuit is found thus: $100\ v \div 2\frac{1}{2}\ a = 40\ o$.

In case we have 2½ ampères under 7 ohms resistance, it requires 17½ volts to move this degree of ampèrage through the given resistance, thus: $2\frac{1}{2}\ a \times 7\ r = 17\frac{1}{2}\ v$. If one has a current of 110 volts, and desires to use a ¼-horse-power motor, the least ampèrage required is $1\frac{69}{100}$, which is found by dividing 186 watts by 110. These examples make plain the means of determining the character of current required for any given purpose.

Electrical force may be produced from its source in galvanic cells by arranging them in series or in multiple. If in series the voltage is the sum of the volts of the cells so arranged, and the ampèrage is that of each of the cells. If joined in multiple, the strength in ampères is the sum of the ampères of the cells, and the voltage is that of one cell.

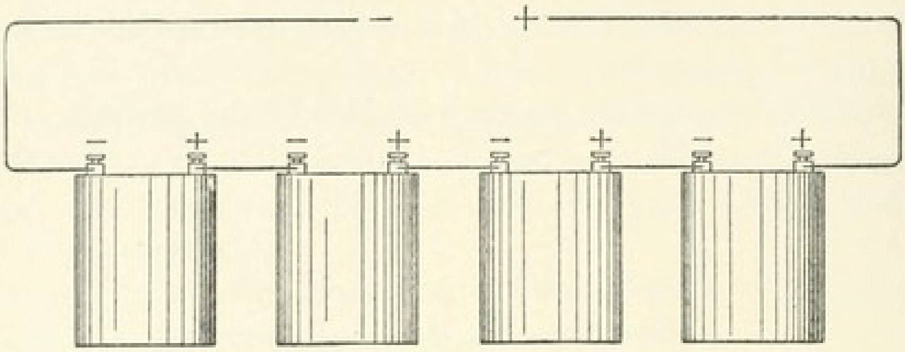
Fig. 152[1] represents the arranging of cells in series, the positive of one with the negative of the next. In case each cell has a voltage of 2 and an ampèrage of 1 the electro-motive force of 5 cells will be 10 volts at 1 ampère.

Fig. 153[2] represents the joining of cells in multiple. Here all the

[1] See *Dental Cosmos*, December 1896, p. 998. [2] *Ibid.*

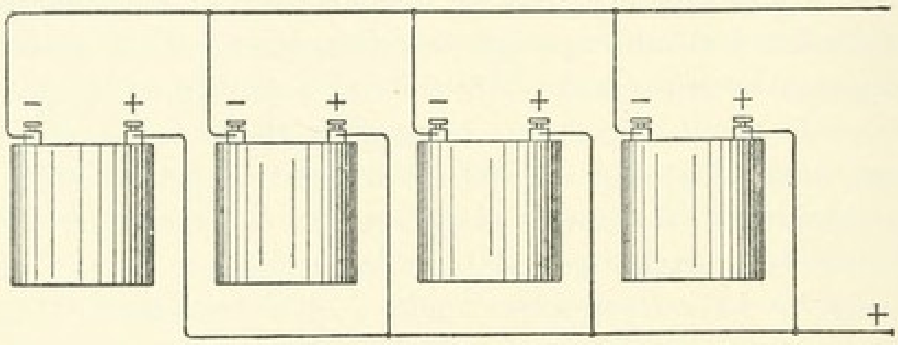
positive elements are joined together and similarly all the negative to each other. The voltage now is 2 and the ampèrage 5.

Fig. 152.



The former method of assembling the cells is designated as "high tension," the latter method as "low tension." When the source is the

Fig. 153.



dynamo, high and low tension are produced by the strength or weakness of the magnetic field.

For electrical osmosis the source should be from batteries in series, for the reason that in multiple the ampèrage would be too great when the voltage is of sufficient force to overcome the resistance.

The degree of electrical energy tolerated by living dentin is exceedingly small, on account of the peculiar and intense pain excited by the transmission of electrical currents through the teeth. This is shown by the low initial voltage of the batteries used for the purpose, varying from less than 5 to rarely more than 20. But the initial passage of a current of as high electro-motive force as these would not be tolerable, and must therefore be reduced by suitable methods of effecting resistance.

The apparatus used for this purpose is the *controller*, the purpose of which is through its resistance to diminish the energy of the current to sufficient weakness to meet the requirements of any given case. All forms are constructed on the principle of the use of materials which are highly resistant of the passage of electric currents. These substances are water, carbon, graphite, and coils of wire of known high resistance, the most effective being of German silver. In the case of the latter the degree of resistance is regulated by the length and fineness of the wire, the cross section being reduced to the size which will conduct the current without excessive heating, and to that end it is graded with reference to the initial ampèrage of the current. In comparison with silver as a unit German silver has a resistance of 13.92.

The carbon and graphite controllers usually are constructed in the form of a broken ring—one pole of the battery being connected at one end of the ring, the other pole being attached to an index which travels over this annular disk. This method of construction gives a fine gradation of current with high resistance. It may be used in connection with a German-silver wire rheostat, where currents of great strength are used for reasons which will appear later. In the use of high-voltage currents, such as the 110-volt circuit, it may be switched through the coils to a nearly definite low voltage by means of a rheostat, when the adaptation to the case may be effected through the graphite controller.

In the arrangement of the apparatus to effect electrical osmosis the battery, the controller, the instruments of observation, and the patient are in series. In the analysis of the course of the current it appears that the patient is another element of resistance, and that dentin is more highly resistant than the other tissues. In other words, there are two resistances in the circuit—the controller and the tissues of the patient. The result of the resistance of the dentin, unless the initial voltage is small and is reduced by the controller to an infinitesimal degree, is the occurrence of pain, which takes place with different persons at various degrees of ampèrage. The approach to intolerance of the current is designated the "pain limit." This condition has been assumed by some observers to be caused by the evolution of heat in the dentin consequent upon the resistance of this tissue. This view is not now considered to be conclusive, as the calculated elevation of temperature at $\frac{1}{10}$ milliampère is not sufficient to account for the degree of irritation which occurs on increasing the rate of flow. This determination leaves two other hypotheses to account for the irritation: *a*, the tendency of the current to disorganize some of the anatomical elements of the canaliculi; and *b*, the osmotic pressure of the migration of the medicaments. Here the student is not confused with consideration of the complicated forces which are in action connected with the electrolysis of the cocain solution.[1]

The pain limit is variable with different persons, and in different

[1] See "The Foundation Principles of Dental Cataphoresis," *Items of Interest,* vol. xx. p. 345 *et seq.*

teeth of the same person. With some it is reached with the first influx of the current at low voltage with a record of $\frac{1}{40}$ milliampère, this low record indicating high resistance of dentin and permitting but slow increase of the force until after cocain has diminished the sensitivity of the irritated surface. With others the pain limit may not be reached with a voltage of 20 and a recorded ampèrage of $\frac{3}{10}$ to $\frac{4}{10}$ milliampère. In respect of electrical irritation there must be taken into account also the high nervous sensitivity of some persons, as with these there usually appears greater susceptibility to electrical irritation.

The following table of calculated resistances shows the resistance in ohms, and the liability to the generation of heat in the dental tissues in view of their density, or the tendency to disorganization as previously stated, and it suggests that care be used in the application of electrical force for the purpose under consideration.

With	15	volts initial pressure	at	$\frac{4}{10}$	milliampère in circuit	the ohms	are	37,500.
"	15	"	"	$\frac{1}{10}$	"	"	"	150,000.
"	10	"	"	$\frac{4}{10}$	"	"	"	25,000.
"	10	"	"	$\frac{1}{10}$	"	"	"	100,000.
"	5	"	"	$\frac{4}{10}$	"	"	"	12,500.
"	5	"	"	$\frac{1}{10}$	"	"	"	50,000.

As the resistance of the body including the dental tissues varies from 10,000 to almost 70,000 ohms, it would appear necessary that the controller should have at the highest point a resistance of not less than 400,000 ohms. This degree of resistance is required to obviate the effect of impulse which may occur in closing the circuit. Occasionally slight shock is felt at 600,000 ohms.

The varying resistance of the current through the tissues depends upon the density of the dentin, the distance traversed, the condition of the surface of the skin, and the thickness of the adipose tissues.

The average resistance of the patient as recorded by Dr. W. A. Price is about 25,000 ohms from cavity to hand, and the difference of resistance from tooth to hand and cheek to hand is from 3000 to 5000 ohms. He reports one case where the resistance from cavity to hand with a 40 per cent. solution of cocain was 28,500 ohms, which on placing the pad on the cheek was reduced to 23,000 ohms.

Dr. Price further places the average resistance from hand to tongue at 9000 ohms, and from cheek to tongue at from 3000 to 7000. This would make the resistance of the dentin nearly 20,000 ohms. An exact determination of the resistance of the skin in any given case would enable a very close approximation for the dentin to be calculated.

The condition of the cavity as to relative moisture and the degree of saturation of the pledget of cotton containing the anesthetizing agent as well as the percentage of the medicament exert a considerable qualifying control of the resistance, as appears from the experiments of Dr. Price. When a section of dentin partially dry on the surface had a resistance of 30,000 ohms, after being dried and saturated with a 40 per cent. solution of cocain the resistance was reduced to 4500 ohms.

The principles here stated and the facts presented apparently demonstrate the importance of careful selection of the degree of voltage at the battery; of the use of a relatively low ampèrage to the voltage; of the necessity of controlling the current within the boundary of the pain limit; of the importance of avoiding impulses of current by rapid advancement or by movements of or displacements of the anode; and of attention to the maintenance of a constantly moist state of the anodal and cathodal contacts.

These principles and facts have led to the application of galvanic currents for the production of a state of anesthesia of hypersensitive dentin; and the results of experimentation in this direction have proven that the same effects have followed here as have occurred in the softer tissues.

The extreme sensitiveness of the teeth to electrical currents and their resistance to the passage of electrical force were obstacles to the earlier application of this method of treatment in dentistry. The absence of means to control the current strength (the ampèrage) and to reduce the pressure (the voltage) to the capacity of the teeth prevented experimentation in this direction until within a comparatively recent period.

The current strength that is tolerable at the commencement of the application is so small as to be scarcely measurable in many instances. To produce this small current, either the battery voltage must be low or the resistance in the controller exceedingly high.

Any form of battery which is constant when the ampèrage of the individual cell is from one-fourth to one-half of an ampère will have sufficient current strength. The E. M. F. may be from one to two volts per cell.

The *voltage* required to produce the necessary electro-motive force in an application to the teeth to produce dentinal anesthesia varies from five to thirty. For children and where the teeth are apparently not dense, ten cells sometimes are sufficient, but generally fifteen to twenty are needed. The cells should be arranged in series and connected in a manner which enables the selection of any number to produce the required E. M. F. for any given case and to permit an increase of cells during the administration.

The most important condition of the electrical force for the purpose is *that the ampèrage shall be inconsiderable*, since high ampèrage is intolerable to the teeth. As the most efficient results are produced when the recorded ampèrage is not over three-tenths of a milliampère, the use of a current of high ampèrage is unnecessary, and it is attended with distress. High voltage is equally painful, as the endeavor to force the current against the resistance of the dentin results in electrical irritation, as already described.

The **chlorid of silver cell** is probably the one best suited for the purpose, as its electro-motive force remains practically constant under various conditions. The E. M. F. of each cell is about one volt; the internal resistance eight ohms; the strength one-fifth of an ampère. This battery on account of its constancy and durability is largely used in electro-medical apparatus. It is now furnished dry, and is more acceptable as being less troublesome on this account.

The **dry Leclanché battery** is also one of the best forms, as it is an open-circuit battery. As long as the circuit is open there is no action in the cell and consequently there is no loss.

At present these two forms of galvanic battery cell appear to be the kinds best adapted for the purpose of inducing electrical osmosis.

The **storage battery** may also be used with advantage, but the plates should be small; each cell should contain but three plates to give the proper degree of current strength. When the plates are 3 x 3 inches the normal ampèrage at eight hours' discharge is five-eighths of an ampère. The voltage of each cell is two. This when discharged under the resistance required for application to sensitive dentin in cataphoric work should have a capacity for 800 applications, providing waste of current strength does not occur from accidental short-circuiting.

The life of a chlorid of silver dry cell battery is stated to be 700 hours of cataphoric work under a high resistance of tissue, but it must be remembered that the continuance of energy of all forms of battery is varied by the resistance and the conversion of electrical energy into heat by the controller which regulates the ampèrage and the voltage. This principle applies to all sources of electrical force.

The *controller* which at present appears best adapted to be interposed between the battery and the anode is the Willms controller, which, as before stated, should be constructed with a resistance at the highest point of at least 400,000 ohms. The gradations of resistance decrease from this through 112 contact points. These permit a very gradual reduction of the resistance as the switch is conveyed from point to point in the circle. This controller also has the advantage of being moderate in cost and easily procurable.

An important adjunct of any apparatus is a reliable *milliampèremeter*. This should have a scale to record divisions of fortieths of a milliampère, from the fact that the ampèrage of the current through the dentin is frequently efficient at less than two-tenths of a milliampère. The milliampèremeter also aids in detecting leakage of current, as where the indicated ampèrage exceeds five-tenths milliampère there is reason to suspect imperfection of the insulation of the tooth. In this case a longer period than usual will be required to effect the anesthetization, and the degree of this effect may be less.

The use of the direct current generated by the *dynamo* is of questionable utility as compared with the current from a battery. The current from the dynamo is subject to changes of voltage and the ampèrage is liable to fluctuations consequent upon alterations of the load in the general circuit. This instability causes a series of pulsating shocks upon sensitive dentin and the pulp, which react with the expression of pain. The possibility of the transmission of severe shock through accidental grounding or defective apparatus where such excessive voltage is used is another and sufficient reason why the steady and low-voltage current of a battery is preferable for this class of operations.

TECHNIQUE OF THE ADMINISTRATION.

At the present period *cocain* has been found to be the most effective anesthetic for obtunding dentinal sensitivity by electrical osmosis. It is used in strength varying from 12 to 24 per cent., and by some as high as 40 per cent. has been used; $1\frac{1}{5}$ grain of one of the salts of cocain added to 5 minims of water procures a solution of 24 per cent.; to $7\frac{1}{2}$ minims, 18 per cent.; to 10 minims, 12 per cent.

The salts of cocain which have been used are the *hydrochlorid* and the *citrate*. Each is efficient in the strength stated. The resistance of cocain citrate is for 12 per cent. solution 234 ohms; for 24 per cent. 153 ohms. The resistance of cocain hydrochlorid is for 12 per cent. solution 80.85; for 24 per cent. 61.25. These provings indicate that the hydrochlorid is the better salt of cocain for the purpose.[1]

The tooth to be operated upon is *isolated* by means of a rubber dam and is ligated at the cervix to prevent leakage of current. If there are metallic fillings in the tooth, these should be covered with a coat of varnish carefully laid on and dried. This precaution does not always possess the value claimed for it, as the dentin beneath a metal filling, because of its density or lack of porosity, will not convey the current as well as the carious matter and the softer dentin of the fresh cavity. In some cavities where caries has occurred at the cervix above gold fillings, and which do not permit of complete isolation of the fillings, the cataphoric influence is not interfered with.

The carious matter should not be completely removed and need only be partially dried. The cavity is loosely filled with a small pledget

[1] The writer is indebted for the determination of these resistances of cocain solutions, etc., to Mr. A. W. Schramm, of the University of Pennsylvania.

of lint saturated with the solution of cocain. The anode, the point of which is of platinum, is covered with a thin stratum of lint which is dipped in the solution and inserted in the cavity in contact with the pledget previously introduced. The cathode, which should be at least one and a half inches in diameter, is placed at a convenient place on the face or neck. The desired number of cells are placed in circuit with the controller at zero.

All being ready, the switch is placed on the first contact point. At this moment, however great the resistance of the controller, a slight sensation is sometimes experienced, but at once the switch may be passed slowly over the contacts until some sign from the patient indicates that the current is being felt. Here it is retained until subsidence of the sensation occurs, when the resistance of the controller should be very gradually lessened. This process is continued, keeping constantly within the limit of pain; at length the switch may be more rapidly advanced. When this can be done without thrill, the indication is that anesthesia is complete. The switch is then carried back to the zero point, when the excavation may be conducted.

Where it is necessary to *remove the rubber* (as the solution of cocain is strong) the preparation should be previously washed away to prevent any of it from being swallowed.

The *period of administration* varies from eight to fifteen minutes in ordinary cases where the indicated ampèrage is from $\frac{1}{10}$ to $\frac{2}{10}$ milliampère. When, however, the dentin is dense, as where denudation has taken place by attrition, a longer time is required to effect penetration by the cocain. Also where from any condition the indicated ampèrage at first is $\frac{1}{20}$ milliampère or less, time and patience are demanded. The loss of time is more apparent than real, since there usually is a direct relation between the pain limit at very low ampèrage and high sensitivity; what is apparently lost in the time of the application is gained in the after facility of instrumentation.

The sphere of the action extends throughout the cavity, but to a somewhat less degree at the extreme lateral margins, and more particularly at the occlusal margin. Here usually no more than a normal degree of sensitivity is found, which appears to be due to the fact that in making the retentive undercutting this procedure may extend beyond the sphere of the complete influence of the cocain. The effect is most pronounced when the application is made directly to the carious matter. In this case the diffusion is greater than when the caries is freely removed, for the reason that in the latter case the current seeks the line of least resistance toward the pulp. It follows from this that when all parts of the cavity are equidistant from the pulp, the action should be more effective throughout upon the surface of the dentin. This is proven to be the case from the profound effect in cavities upon buccal and labial surfaces and in shallow cavities of occlusal surfaces. Besides the less diffusion of the cocain when the carious matter is removed, a degree of electrical force which in the former case is easily tolerated becomes painful. These facts make conclusive the importance of retaining some of the carious contents of the cavity.

An explanation of the influence of the current is found in the principles and examples given on page 194. As the anode is put in connection with the lint saturated with the cocain solution the fluids of the tooth advance toward the pulp through the canaliculi, their place being taken by the solution of cocain. At the same time it is observed that loss of fluid from the lint occurs, necessitating additions to maintain the proper wetness, some loss of water taking place by evaporation.

Conditions Influencing Tolerance of the Current.—As already stated, when the electrical force is brought into connection with the carious matter the irritation caused by the current is of trifling degree and soon subsides, indicating that the anesthetic effect has been produced; but when the cavity is denuded of caries the above-stated degree of current force is not so tolerable, the irritation continues longer and does not subside in the same manner, but the effect upon the tissue is nearly if not quite as marked. The nearer the bottom of the cavity is to the pulp, the greater the irritation. Hence in this condition it becomes necessary to begin with a low degree of voltage. While in the one case fifteen cells may be selected, in the other ten cells are more satisfactory.

To avoid the removal of caries *the condition of the dentin* as regards sensitivity should be tested at the line of its connection with the enamel.

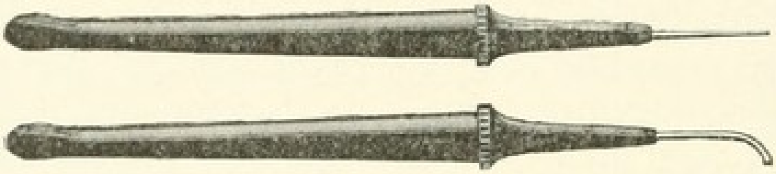
Some stress has been laid upon the necessity for rendering the solution of cocain *more highly conductive.* This claim is probably more theoretical than practical in its character, since experience with the solutions given indicates that the conductivity is sufficient, and that the resistance is more to be looked for in the dentin than in the solution, and that when the tooth has become tolerant of the current at a comparatively low voltage an increase of pressure of the current is sufficient to complete the anesthesia.

The form of the PLATINUM ANODE should be such as to permit its easy entrance into the cavity when its point is covered with a layer of absorbent lint. For all cavities in the approximal surfaces and in most occlusal positions an excellent form of anode is made by curling the end of a fine platinum wire (No. 25) into a flat knot, or forming it in a loop. On the loop a properly sized piece of lint may be gathered.

This may be packed into the cavity and secured with additional lint when required. This method is a self-sustaining one. The connection between the free end of the anode and conducting cord is made with a spring clip, as shown in Fig. 155.

For labial and buccal surfaces two or more small points to screw into a common handle are sufficient (see Fig. 154). These have to be

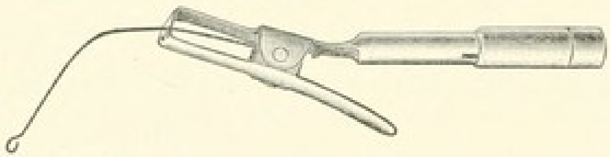
FIG. 154.



Dental anodes for cataphoresis.

held *in situ*. A form and arrangement to make these self-sustaining offers an important field for inventive skill.

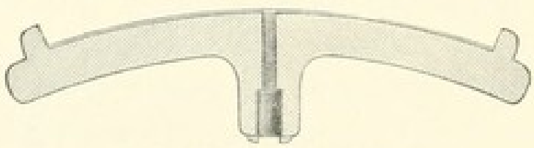
FIG. 155.



Snap and wire electrode.

A convenient CATHODE ELECTRODE is shown in Fig. 156. In this the surface is recessed to receive a disk of amadou (spunk) or cottonoid,

FIG. 156.



Cathode for cataphoresis.

one and a half to two inches in diameter, which retains an abundance of a *solution of sodium chlorid* to maintain contact. The surface is platinized to prevent corrosion. The reverse side has the usual socket to receive the conducting cord, which is placed in a projection intended to pass through an opening in the band which supports the rubber dam.

It is indifferent where this electrode is placed; the objects to be attained are to lessen the resistance as much as possible and to secure constant apposition with the surface with which it is connected. If the person be comparatively lean, the face before the ear is to be preferred.

When there is much adipose tissue on the face, the usual negative hand electrode, covered with a small wet napkin to maintain close contact, may be better than the application to the face; but in general the nearer the cathode is placed to the angle of the jaw, the quicker and surer is the result of the administration.

The action of cocain administered in this manner is profound. The effect is primarily upon the contents of the canaliculi, as is shown in the cataphoric treatment of shallow cavities. After superficial anesthesia has been established much lateral cutting will later elicit a degree of pain; in deep cavities nearing the pulp, the effect extends to that organ. The recurrence of sensitivity takes place within a few hours. No injury appears to follow.

This method of treatment is little required where the degree of hypersensitiveness is such as to yield to desiccation of the dentin or the application of carbolic acid combined with caustic potassa ("Robinson's Remedy"). But when the pain attending excavation requires active treatment, such as the employment of zinc chlorid or general anesthesia, the cataphoric method is far preferable to either, and is nearly certain of giving relief. The results of successful cataphoresis are marvellous, and it may be truly stated that no advance of recent years in the therapeutic treatment of the teeth is comparable to this.[1]

Cautious excavation is required after cataphoric treatment, as in the absence of sensitivity indiscriminate cutting may needlessly encroach upon the pulp. In case exposure really exists the action of cocain does not prejudice conservative treatment of the pulp. When devitalization is determined upon, the anesthesia facilitates this procedure. As stated in Chapter XVI. cocainization may be then continued either cataphorically or by instillation. Should arsenous acid be selected as the devitalizing agent, cocainization may be used as a preparatory measure to avoid arsenical irritation.

The Chemical Treatment.

Under this head are included the application of warmed air, the use of coagulants, notably carbolic acid or zinc chlorid, and, in combination with these, one of the essential oils, preferably oil of cloves, for reasons stated below.

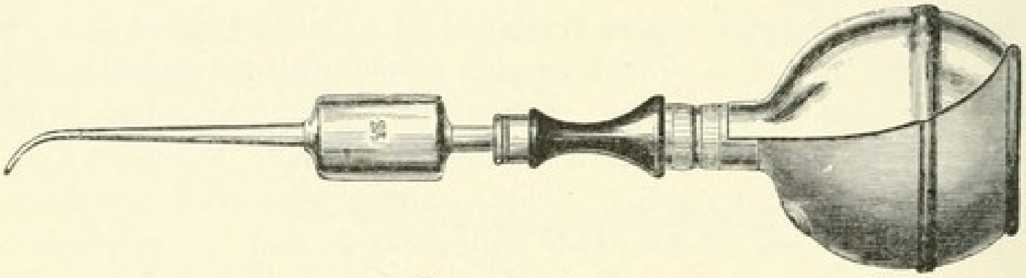
Warmed Air.—This method is of great value in subacute cases. It is especially serviceable for the cavities of incisors and bicuspids and others of easy access. The effect here produced is due to the depriva-

[1] For further study of this subject, see "International System of Electro-Therapeutics," Section C, p. 1 *et seq.*, Peterson; also, "Foundation Principles of Dental Cataphoresis," by Dr. Price, *Items of Interest*, vol. xx. p. 345.

tion of the tissue, to a greater or less degree, of one of its elements, viz. water, and it is more effective in teeth of dense structure, since the surface of these is more easily desiccated than the softer teeth. If it were possible to remove all the water of the tissue from the surface to the depth of the irritated part all sensitivity would thereby be overcome, but generally this can be only imperfectly done; nevertheless, the benefit is generally considerable. This means is easily and quickly applied, and as it presents the simplest method in the cases where it is applicable it forms therefore the easiest and most available procedure for this purpose.

The warmed air may be produced by heating the bulb of a WARM-AIR SYRINGE (Fig. 157) over a lamp or Bunsen burner, when a continu-

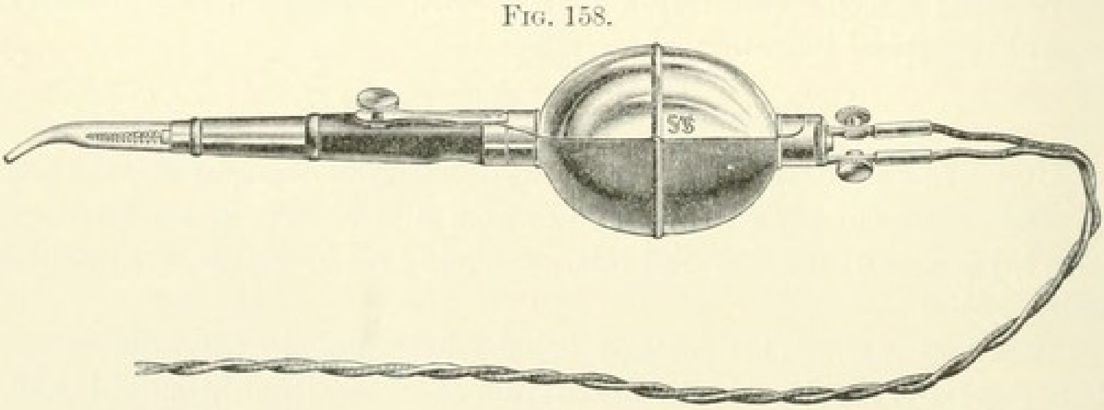
FIG. 157.



Warm-air syringe.

ous stream of air is forced through the nozzle into the cavity. Some tact is required to deliver the heated air in a manner to cause the least pain by its impingement. If the nozzle be held too far away from the tooth the stream of air in passing through the atmosphere takes along with it so much of the surrounding cool air as to cause pain, and if held too close the heat is equally painful. In all cases the abstraction of the water, even when the degree of heat is well balanced, produces some

FIG. 158.



Electric warm-air syringe.

unpleasant sensation, which soon passes away and after a few moments the case is reduced to a state of slight and simple sensitiveness. The blast should be gently applied at first at intervals of a couple of seconds; when the pain induced by the abstraction of the water somewhat diminishes, the force should be increased and made continuous, when in most cases the excavation may be continued. The air may also and preferably be heated by an electric warm-air syringe (Fig. 158), which has the advantage of maintaining an even degree of heat.

As stated before, this means is of less use with soft teeth, and frequently fails when the teeth have a high grade of sensitivity which appears to be due to constitutional conditions,—where the sensitivity is not confined to the surface of the tissues immediately beneath the caries but pertains to the whole of the dentin.

Preparatory to the use of heated air, the application to the cavity of *absolute alcohol* is serviceable, on account of its high affinity for water.

Carbolic Acid.—This substance, while of little efficiency in controlling acute sensitivity, is of benefit in moderating that condition. Its efficacy is increased by adding to it a proportion of one-third of oil of cloves, which latter has some anesthetic influence. When other more active means are not admissible and the effect is not immediately satisfactory, a better result is produced by placing this combination in the cavity and sealing it in with zinc phosphate until a subsequent visit, as before described. On account of the feeble affinity of carbolic acid for water, the obtundent effect is facilitated by the previous partial desiccation of the surface of the cavity by warm-air blasts. Carbolic acid in combination with caustic potassa, equal parts of each (Robinson's Remedy), is often of much service in subacute sensitivity. The preparation should be laid in the cavity in contact with the denuded dentin and should be allowed to remain until it deliquesces.

Carbolic acid in combination with *tannic acid* is also serviceable when sealed in the cavity by an impermeable temporary stopping.

Zinc Chlorid.—Of all substances, when not interdicted by proximity of the dental pulp, zinc chlorid is the most efficient of the topical remedies for the condition under consideration. Its action is explained by the double power of its affinity for water and its extreme coagulating effect upon albumin. It is evident that if the tissue be deprived of two of its elements the function of sensitivity must be impaired or destroyed. In the degree to which this action takes place the tissue loses its capacity for irritation.

As zinc chlorid in concentrated solution is an active escharotic to organic tissue, it must be employed with caution. After paralyzing the vital resistance of the part its action is by combining in definite proportions with the albuminous elements of the structure. It has the further property of an excessive affinity for water, which enables one to arrest its action by sufficient irrigation to remove all traces of the salt from the cavity. Its active coagulating power renders it a valuable agent in excessive dentinal sensitivity where there is not close proximity of the pulp, and its safety is ensured by the facility with which any remains of the salt may be taken up with water.

Unless employed in excess and too long continued the action of the zinc chlorid does not pass beyond the zone of the exalted tissue, which, as we are aware, generally is of limited depth. The cessation of the pain produced by it indicates the time for its removal, when usually the dentin will be found to be insensitive. There are instances, however, when no apparent effect is produced, which can only be satisfactorily explained on the ground that the vital resistance of the tissue is sufficient to overcome the coagulative power of the zinc salt.

In general, zinc chlorid must be regarded as an entirely safe agent if used with discretion. It is more applicable to shallow cavities which are so situated, or are of such form, as to require much formative cutting at the margins of the cavities, as in buccal and labial surfaces and in the very superficial cavities of incisors and bicuspids. A warning, however, should be presented that as the pulp cornua of incisors frequently project near the surface, particularly in the young subject, considerable care is here required in any but shallow cavities of decay. If it were used in excess and its action extended there would always be danger, as its energies would not cease until the affinities of the whole amount were satisfied. In deep cavities the effect, particularly in soft teeth, would eventuate in the ultimate devitalization of the pulp. It follows, therefore, that it would be improper to seal up any quantity of this substance in a cavity.

The action of zinc chlorid is terminated when the excess is removed and the cavity irrigated with water. The affinity it has for water quickly removes the excess and soon deprives the tissue of the remaining portion.

When *cavities are deep* and it is found necessary to resort to this agent the surface of the deeper parts should be protected by an insoluble coating, after which the margins, where the sensitivity is acute, may be acted upon without detriment. Here it is requisite to remove the deep caries, desiccate the surface and make a coating with a varnish. For this purpose red gutta-percha rubbed in chloroform is applicable, since it may be deftly applied to any given part and when the chloroform has escaped is protective.

To properly apply zinc chlorid it is highly important to *isolate the tooth* by means of rubber dam to protect the gum and to prevent the entrance of moisture. Its affinities for water are so great that even the vapor of the mouth dilutes it so much as to lessen its power. The form in which it is best to employ it is the saturated deliquesced salt, which is taken from a bottle containing the salt in excess. The fluid is introduced on a pledget of cotton and is permitted to remain until the pain occasioned by it has ceased. It will be found that there are two periods of pain: the first from its irritation of the fibrils in the bottom layer of the caries, and then again when it has reached the zone of exalted dentin a little beneath this ultimate layer of decay. It follows, if the caries has all been previously removed and the sensitive tissue interdicts further cutting, that but one period of pain is encountered. The cutting should therefore be deferred until after the second period of pain has passed. The disregard of this consideration has sometimes cast discredit upon the efficiency of this sovereign remedy.

It is requisite that the chlorid be *chemically pure*, and the fused form is preferable to the crystals of the shops.

The PAIN attending the application is sometimes extreme for a moment. This can be moderated by air-drying the cavity and dressing it with carbolic acid, which does not seem to prevent the action of the chlorid.

To avoid the loss of time which may be occasioned by the slow action it is advisable, after securing the dam at the neck of the tooth by a ligature, to very tightly tie the free portion of the rubber a short distance from the tooth with a strong ligature, and after cutting away the excess of rubber some other service may be rendered. When the pain has ceased the case may be proceeded with, or the excess of chlorid may be thoroughly washed out and the cavity temporarily closed until a subsequent time.

Another method of securing the action of zinc chlorid is to make a paste of *zinc oxychlorid* and fill the cavity with it. Even after crystallization of the paste takes place it contains a slight excess of the chlorid, which slowly acts upon the hypersensitive tissue. This method, however, is not adapted to deep cavities, and care must be exercised concerning its use in teeth of inferior grade.

Zinc chlorid is an extremely valuable remedy when the previously described agents prove insufficient or are not indicated.

Conditions which render Zinc Chlorid inadmissible.—It has been stated that the chief danger of its use consists in the liability of the coagulant and escharotic action reaching the pulp in deep cavities. This danger is further enhanced when the teeth are soft, as in this condition the penetration is liable to be greater than would be the case with dense dentin. The same caution must be observed when the structure is incomplete, as it is in the teeth of young subjects. Even here, as extreme sensitiveness is always found at the peripheral limits of the tubules, it is not difficult to limit the action to this part by the means above pointed out if care be taken in the required procedures.

The Acids.—Chromic and nitric acids are of service in extremely shallow cavities of very high sensitivity. The former acts by coagulation of the organic elements of the dentin and the latter by decomposition and solution. To apply these the adjacent tissues require to be protected. Each should be carried in small quantity upon a gold probe.

Nitrate of silver is applicable for reducing the sensitivity of dentin after the removal of superficial caries or when by abrasion or by erosion the exposed tissue is intolerably sensitive. It is, however, only to be used in the back of the mouth on account of the discoloration which it produces.

Chlorid of antimony is applicable only to cases of exposed cementum, where it is claimed that it is equally as efficient as silver nitrate, and has not the objection of discoloring the tissue.

General Anesthesia.

While some reluctance should exist as to the propriety of inducing general anesthesia, it sometimes becomes necessary to resort to this means of alleviation. Necessity for this election arises where the sensitivity is extreme, when the previous remedies have been inefficient, and when from the nature of the case zinc chlorid is inadmissible.

The subjects should generally be adult persons of intelligence, who possess moral force and, having confidence in their adviser, are capable of giving the requisite indications of the progress of the anesthetic influences.

Sulfuric ether is the most suitable anesthetic to be employed, and the operative procedures should be performed in the first stage, that of peripheral anesthesia. At this period, which is before the stage of excitement commences, dentin may be cut without the slightest pain being felt. This is an important consideration, since if the administration is continued into the period of excitement nothing can be done, and if it is conducted to a full degree the patient is not manageable. Also the subsequent depression is to be avoided. While general anesthesia in the first stages is available for the relief of dentinal sensitivity, it is found, on the contrary, when resorted to for the removal of the pulp, as may occasionally be required in the most severe cases of congestion, that nothing short of profound anesthesia will suffice.

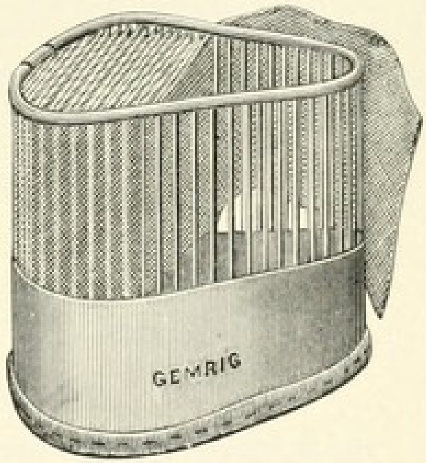
When the *first stage* is reached, the patient being conscious and able to reply to questions, the cutting is commenced; as the pain returns a few more inhalations are given, when another part of the cutting may be proceeded with. This may be repeated until the cavity is formed.

The cutting should be quickly and deftly conducted. The amount of ether administered is far less than is required to induce full anesthesia, and the patient suffers far less depression than if the operation were performed without this means. There is also no danger of shock, since the patient is, or should be, intelligently concerned in the progress of the case. If the condition were carried into the second stage, when excitement exists and alarm is aroused in addition to the operative interference, there is liability to shock, which, being due to a profound impression on the nervous system, is not liable to occur when the patient concurs in all the steps of the procedure.

The time required to bring about a sufficient degree of dentinal anesthesia frequently is less than two minutes. The ether should be pure and should be given with *a free supply of air* mixed with the vapor. The ordinary custom of using the towel to envelop the face is questionable, since this method does not permit enough air to accompany the ether vapor.

An invaluable INHALER for this purpose is the one invented by Dr. Allis (Fig. 159). This consists of an oval frame composed of a series of wires through which passes back and forth a continuous band of muslin. The layers of muslin are near each other, and still so far apart as to permit the free passage of the atmosphere. The correct manner is to continuously drop the ether in small quantity upon the muslin to maintain it at an even degree of saturation.

FIG. 159.



The Allis inhaler.

This appliance is one of value to the dental operator, as by it the anesthetic state can be more quietly brought about with less of the characteristic disturbances which attend the usual modes of applying sulfuric ether.

The use of chloroform for the purpose under discussion is wholly inadmissible.

The mechanical means consist in the use of temporary fillings, which may be either metallic or non-metallic. The metallic act by inducing, in consequence of the slight irritation of thermal conductivity, a consolidation of the subjacent dentin, which in time obliterates the tubules. The non-metallic act simply as a protective covering to the denuded dentin. Their action hence is more tardy than that which follows the use of the former.

The *metallic* stoppings for this purpose may be composed of either tin foil or amalgam. Each of these requires cavities of reasonably good retentiveness, therefore they are not applicable to shallow cavities of unsuitable form.

The *non-metallic* may be either gutta-percha, zinc phosphate, or zinc oxychlorid. The two latter are the most desirable, as they adhere to any well-dried cavity, and having some irritating influence on the tissues tend to induce structural consolidation in addition to their protective action. They have, however, the disadvantage of suffering loss by chemical solution, and unless kept under close observation are delusive and in many instances are a deceptive means of preventing the recurrence of decay. In the employment of these substances due care should be exercised concerning the proximity of the pulp, in which cases the previously indicated means of shielding the pulp walls should be pursued.

The chief disqualification of gutta-percha is its lack of resistance to attrition, and when in positions shielded from wear it may be attacked by low forms of bacterial life, which disintegrate it.

Mechanical protection of cavities is most applicable to teeth of a low grade of structure and for young children who may not have the ability to tolerate the more active means needed to reduce dentinal sensitivity. For these cases gutta-percha stoppings when carefully introduced are a great boon, since they protect the tissues during the period of completion and consolidation of the teeth.

CHAPTER VIII.

PREPARATION OF CAVITIES—OPENING THE CAVITY—REMOVING THE DECAY—SHAPING THE CAVITY—CLASSIFICATION OF CAVITIES.

By S. H. Guilford, A. M., D. D. S., Ph. D.

General Considerations.—The importance of the proper preparation of a cavity for the insertion of a filling can scarcely be overestimated. Upon its being well done the success of the completed operation largely depends. As many fillings fail from lack of thoroughness in the preparation of the cavity as from any other cause.

The operator should not be actuated by haste, but should be deliberate, careful, and painstaking. Each stage of the operation should be thoroughly performed in order that when completed the cavity may be in the best possible condition for the reception and retention of the filling.

The operation is naturally divided into three stages:

1. Opening the Cavity.
2. Removing the Decay.
3. Shaping the Cavity.

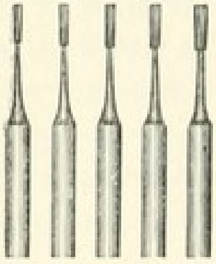
Opening the Cavity.

Every cavity to be excavated must first be *opened*, so that it may be approached and operated upon at all points. The particular manner of doing this will have to be determined by the extent of the decay and its position, but in all cases the opening must be as full and free as the conditions will permit.

The accessibility of the cavity will depend upon its location. Upon the three exposed surfaces of a tooth crown (occlusal, lingual, and labial or buccal) access to a cavity is usually easy, but upon the unexposed surfaces (approximal) access can only be had after the teeth have been pressed apart. For methods of securing temporary separation of the teeth see Chapter VI.

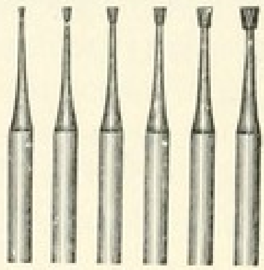
A cavity upon an exposed surface, if small, can usually best be opened by the use of some form of ENGINE BUR. A few sizes each of the forms known as "fissure," "inverted-cone," and "round" (or "rose-head") are shown in Figs. 160–162. A spear-pointed drill is sometimes used, but is less serviceable on account of its tendency to be caught or broken in the irregularities of the cavity orifice. A modified form of fissure bur has found much favor in the opening of small cavities on exposed surfaces. It is made from an ordinary bur

Fig. 160.



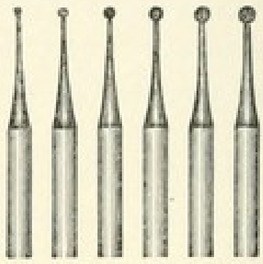
Fissure burs.

Fig. 161.



Inverted-cone burs.

Fig. 162.



Round burs.

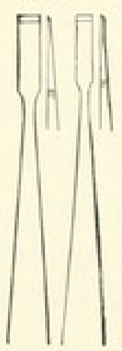
from which the head has been broken, by cutting spiral blades on the tapering neck of the shank. Being pointed, round, and tapering it easily effects an entrance into the cavity and enlarges the orifice gradually and symmetrically. It is shown in Fig. 163.

In cavities of larger size, where decay has made more progress, the overhanging walls of enamel can best be broken down by CHISELS of suitable size and form. Where a straight chisel can be employed it will be found most efficient, but in positions difficult of access one having a slight curve or angle may need to be employed. Figs. 164 and 165 represent both forms as well as the sizes usually preferred. The

Fig. 163.

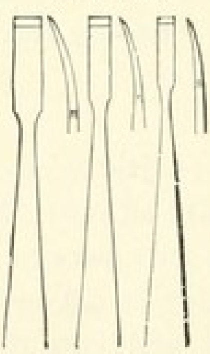
Modified fissure bur with tapering point.

Fig. 164.



Straight chisels.

Fig. 165.



Curved chisels.

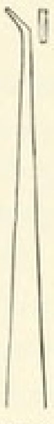
width of the blade may vary from one-sixteenth to one-eighth of an inch, but wider ones than these will seldom be required.

A chisel may be used with either hand pressure or mallet force. If the former, great care must be exercised to prevent its slipping and causing pain or possible injury. The best safeguard in its use is to place the thumb of the right hand on the tooth being operated upon or some adjoining one and use it as a fulcrum or pivot upon which the instrument may move in a curve. By this means the motion of the chisel is regulated and controlled and all danger of slipping avoided. It will sometimes be of advantage to roughly pack the interior of the cavity with cotton or spunk to receive the impact of the instrument should the chisel accidentally be forced to the bottom of the cavity.

The better plan, however, in most cases, is to employ mallet force for the cleavage of enamel unsupported by dentin. By holding the chisel between the thumb and three fingers of the left hand and resting the little finger of the same hand on an adjacent tooth for steadiness, a smart but light blow of a mallet in the right hand upon the end of the chisel will easily and painlessly cleave off portions of the enamel.

In opening cavities of small extent or limited depth upon approximal surfaces a *round* or *inverted-cone* bur will best serve the purpose, but where caries is more extensive and the surrounding enamel is unsupported by dentin the orifice of the cavity can be more advantageously enlarged by means of a delicate chisel (shown in Fig. 166) the blade of which is bent at a slight angle to the shank and all three of the edges of which are bevelled to convert them into cutting edges. This instrument will be found especially useful in opening cavities of medium or larger size on the approximal surfaces of the incisors, the point doing the cleaving and the side edges being used to smooth the enamel margins.

Fig. 166.



Delicate three-sided chisel, useful for opening cavities on approximal surfaces.

After the orifice of the cavity has been sufficiently enlarged to afford a full view of its interior the next stage of the operation is entered upon—

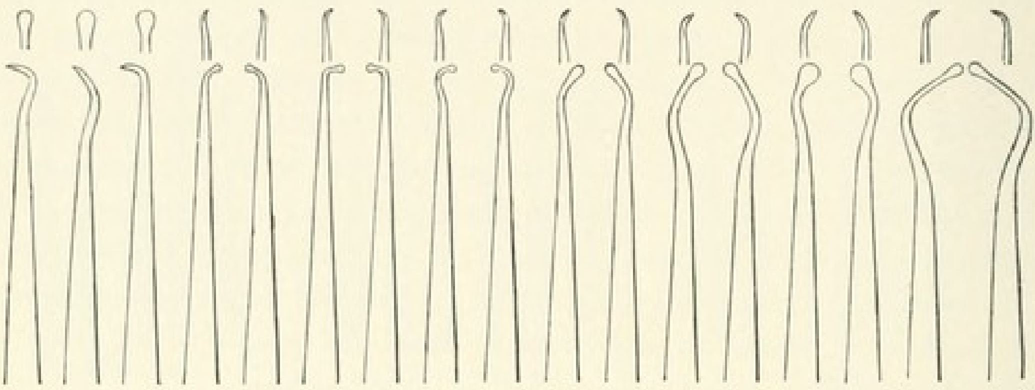
Removing the Decay.

The character or consistence of the carious structure has much to do with the method and means employed for its removal. If it be of the *semi-elastic* or *leathery* variety so often found in the teeth of young persons, it can be most easily removed by means of *spoon-shaped* or *round-bladed* excavators, which being oval or circular in edge outline and free from marginal angles, will lift and separate the layers without danger of injuring the underlying healthy dentin and with the infliction of a minimum amount of pain. Fig. 167 illustrates this kind of instrument in some of its forms, selected from the Darby-Perry set.

In the *dark*, *hard* variety of caries, as also in the *white*, *chalky* variety, the different forms of burs and excavators will be found best suited for the purpose.

In the removal of caries care should be exercised to inflict as little pain upon the patient as possible. To this end, in cavities of considerable extent, it is best, after the orifice has been sufficiently enlarged, to make a sweeping cut with an excavator around the cavity just below

Fig. 167.



Excavators.

the enamel line, thus freeing the decayed portion at that point. Following this the remaining portion of carious dentin should be removed by placing the blade of the excavator near the bottom of the cavity and making draw-cuts toward the orifice. To cut in the reverse direction would produce uncomfortable pressure upon the most tender portion of the cavity, and possibly, by inadvertence, expose and wound the pulp. When burs are employed for the removal of caries it is safest to use only such as are more or less rounded on their circumference, such as the *round* or *oval* forms, for they more nearly conform to the natural outline of the cavity, leave no angular grooves in the dentin difficult or impossible to perfectly fill, and are not so likely to injure the healthy subjacent dentin.

The varieties of bur known as the *inverted-cone* and *wheel*, while very useful for opening cavities, should not be used for the removal of caries in deep cavities, because of the irregularities of surface which their peripheral angles produce.

Rapidly revolving burs in an engine handpiece are very apt to cause pain by the development of frictional heat. This may largely be prevented by lifting the bur at short intervals and allowing it to run free for a moment, which will prevent overheating the tooth and thus avoid unnecessary pain.

Thorough excavation of the cavity and the removal of all carious dentin is absolutely essential to success. To allow any portion of it to remain and trust to the employment of germicides for its sterilization is running the risk of failure, for we can never be entirely sure of disinfection. Besides this, there is no good reason for allowing carious dentin to remain.

By carious dentin is meant the remains or débris of the action of caries,—a product resulting from this disintegrating action upon both the organic and inorganic constituents of dentin. In nearly all cavities we find *two varieties of altered tissue*. That nearest the surface is a mass of thoroughly disorganized and usually decomposed matter filled with micro-organisms. Beneath this and lying next to the healthy dentin there is a zone or layer from which the calcium salts have been removed by the acid solvent, but which still retains its original form and vitality. This layer of decalcified dentin may be allowed to remain, especially in the bottom of a cavity, as it serves to protect the subjacent tissue from thermal shock and will in the great majority of cases be again converted into normal dentin by the re-deposition of calcium salts. As a precautionary measure, however, it should be treated to an application of some germicide such as carbolic acid, mercury bichlorid, formalin (10 per cent. aqueous solution), or oil of cinnamon, before the insertion of the filling.

Occasionally caries will be found to be *self-limited*. In such cases, through some unexplained change of conditions, the progress of caries has been checked and the layer of decalcified dentin restored to its previous normal condition. Where this has taken place the restored tissue is usually of a darker color than ordinary dentin, and on this account may be mistaken for carious dentin and removed. It is, however, easily distinguished from caries by its hardness, and should in no case be removed except from the sides of a cavity, and then only when its dark color showing through the walls would prevent the cavity, after being filled, from having that clear and clean appearance which it should possess.

With some practitioners it is the custom to prepare a cavity *dry*, because in this way the operation is more rapid and usually less painful. In such case the rubber dam is applied first of all and the operations of opening, cleansing, and shaping the cavity are all performed without the presence of moisture. Repeated applications of warm air from a syringe, at intervals during the operation, desiccate the dentin and diminish its power of sensation. Others, in order to avoid the unpleasantness to the patient of having the dam in position for so long a time, prepare the cavity roughly in the presence of moisture, then apply the dam, dry the tooth thoroughly, and finish the operation.

Whichever plan is adopted it is absolutely necessary, in all cases, to finish the preparation with the dam on and the tooth dry, for it is only after a tooth has been deprived of its moisture that we are able to decide whether all the niceties of preparation have been successfully carried out. Certain marginal and structural defects that are not noticeable while the tooth is moist are plainly revealed after it has been dried.

Shaping the Cavity.

This is one of the most important of all operations associated with the stopping of a cavity, for according as it is properly or improperly performed will success or failure result. Too much stress cannot be laid upon its importance, nor too great care be exercised in its accomplishment.

Inasmuch as a filling is retained in place *mechanically* it follows that the cavity must be of such shape as to favor retention. To this end it should be larger within (at least at certain points) than at the orifice. An exception to this rule lies in such cavities as are of small diameter and of more than moderate depth. In cavities of this character, parallel walls will suffice, because lateral-surface contact is so great in proportion to the mass to be held in place that displacement could not occur. In larger cavities of moderate depth, however, the reverse is the case, and they will require the assistance of internal enlargement for the retention of the filling. To govern each of the conditions two rules may be formulated:

1. When the depth of the cavity is greater than the diameter of the orifice, parallel lateral walls will prove retentive.

2. When the diameter of the orifice is greater than the depth of the cavity, the latter will have to be somewhat enlarged internally to retain the filling.

Examples of the first class are found in the narrow but rather deep cavities which occur on the lingual surfaces of the upper incisors near the cervix; in the pit cavities on the buccal surfaces of molars; and in the small cavities found on either side of the enamel ridge on the occlusal surfaces of the lower first bicuspids.

Examples of the second class are found in numberless places on any of the crown surfaces.

In some cases cavities will be found of such form that when the decay has been removed they will have a naturally retentive shape, but in the great majority of cases more or less sound tissue will have to be removed in order to give them the required form. To give a cavity a retentive form it is not necessary that its interior be enlarged throughout its whole extent, but it must be larger at two or more points, and these points must be opposite one another. Frequently it will be easier to enlarge the cavity at all points, and to this no objection can be urged provided too much sound tissue be not removed or the pulp be not too nearly approached. Too great enlargement tends to weaken the cavity walls and therefore should be guarded against.

In shaping the cavity internally instruments should be employed that will leave the surface *free from angles*, for the filling material cannot be perfectly adapted to them. As in the removal of decay, excavators for this purpose should have curved edges, and burs should be of a round or oval form.

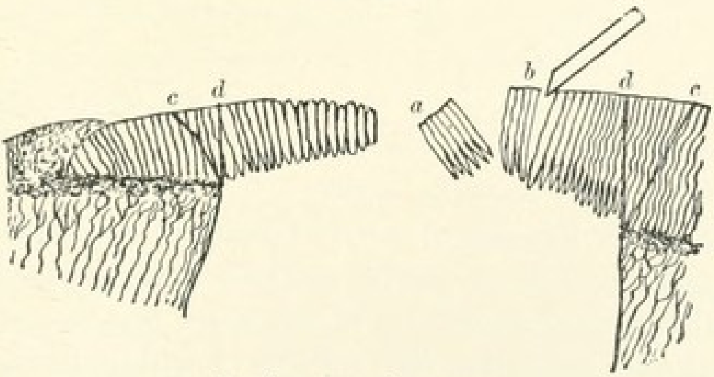
If *grooves* are required they should neither be made deep nor too near to the enamel, for fear of weakening the walls. At the cervical margins of cavities grooves and starting pits should be avoided whenever possible, for they weaken the portion of the cavity which is subjected to the greatest strain in the introduction of the filling, both mechanically and by cutting off the nutrient supply to the cervical margin, which tends to alter the resistive character of that portion of the tooth structure by devitalizing it.

For the same reasons deep grooves or undercuts should not be made near the incisal or occlusal surfaces, for the strain of mastication will be liable to result in fracture of the wall if it is thus unduly weakened.

In the process of shaping the cavity internally the enamel margins will naturally be assuming their proper form, but the final part of the preparation should consist in giving these frail portals of the cavity very careful and minute attention.

The value and permanency of a filling will largely depend upon the *strength of the enamel walls* and their proper preparation. The enamel cap of a tooth when intact is exceedingly strong and capable of resisting great strain, but when its continuity has been broken by caries and it is left unsupported by dentin it is very weak and brittle. This is readily understood when we remember that enamel is composed of an aggregation of enamel rods or prisms in close juxtaposition, slightly joined together by a cementing substance, with their greater diameters perpendicular to the plane of the surface of dentin upon which they

FIG. 168.



Showing enamel structure.

rest. When continuous, these rods mutually support one another and are thus capable of resisting great strain; but when a lesion has occurred they lose support on the adjoining side and hence are easily separated in the direction of their length. Fig. 168 (after Black[1]) shows this

[1] *Dental Cosmos*, vol. xxxiii. p. 441.

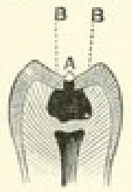
condition perfectly. A detached section of enamel prisms is represented at *a*, and at *b* is shown a portion about being separated by a chisel.

This will explain why enamel unsupported by dentin should not be allowed to form the margin of a cavity, for it will probably either be fractured while the filling is being introduced or afterward in mastication.

On all convex surfaces of a tooth the enamel rods radiate outwardly, and by forming the margins of a cavity on these lines it will have a slightly flaring or trumpet-shaped orifice, which will not only afford the greatest strength but will admit of a better finish being given to the edges of the filling. In many cases it will be necessary to give the margins of a cavity more of an outward bevel than would be obtained by simply following the cleavage lines of the enamel rods. This can be secured by cutting away the outer ends of the enamel rods in an oblique direction as shown at *c* in Fig. 168. No weakening of the border will result in such cases, inasmuch as the shorter rods will still rest upon the dentin. If, however, the rods were cut so as to leave only their outer ends in place, as shown at *d*, they would have no substantial support, and would be liable to be crushed during filling or afterward. All cavity margins should have the outward bevel to a greater or less extent in order to secure the best and most permanent results.

In cavities upon *depressed or concave surfaces* of teeth it would not do to have the enamel margins formed on the lines of enamel cleavage, for this would make the margin of the orifice the most contracted portion and result in frail marginal edges. Fig. 169, representing a cross section of a bicuspid tooth with a cavity in the sulcus, will illustrate this point: A shows the cavity orifice prepared on the lines of enamel cleavage, and B the dressing across the outer edges of enamel required to give the necessary strength.

Fig. 169.



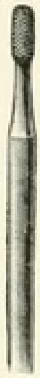
Cross section of a bicuspid showing treatment of enamel margins of cavity in the sulcus.

It may therefore be laid down as a rule that to secure the best results *the line of a cavity wall from within outward should form with the surface of the tooth at this point an obtuse angle.*

Beside the proper shaping of a cavity margin it should also be made as *smooth* as possible. In accessible cavities upon exposed surfaces of teeth the final marginal smoothing or finish can best be effected by the use of a bur shaped somewhat like a fissure bur, but having a rounded end and being simply file-cut upon its surface instead of being bladed. Such a one is shown in Fig. 170. Its sides being parallel, no rounding of the cavity margins can occur when it is used with the end inside of the cavity. Any other form of bur with a short head would unavoidably give to the cavity margin either a concave or a convex surface, both of which would be incorrect.

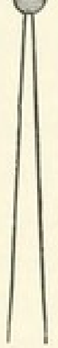
The buccal, lingual, and cervical margins of a compound approximal cavity should never be finished with a bur, even of the plug-finishing variety, but should be smoothed with suitable chisels, broad-faced excavators, or approximal trimmers, the latter being shown in Fig. 171.

FIG. 170.



File-cut enamel finishing bur.

FIG. 171.



Approximal trimmer.

The practice of finishing cavity margins with sand-paper disks, Hindostan-stone points, or wooden points charged with emery powder is very objectionable, as they are almost certain to give to the margins a rounded edge which cannot be filled and finished without leaving a feather edge of the filling overlying the enamel, which will eventually be broken off or flared up, leaving an imperfect margin.

CLASSIFICATION OF CAVITIES.[1]

I. SIMPLE CAVITIES ON EXPOSED SURFACES.

Bicuspids and Molars.

A. Occlusal.
B. Buccal.
C. Lingual.

Incisors and Canines.

D. Labial.
E. Lingual.
F. Incisal.

II. SIMPLE APPROXIMAL CAVITIES.

Incisors and Canines.

G. Mesial and distal.

Bicuspids and Molars.

H. Mesial and distal.

III. COMPOUND CAVITIES.

Incisors and Canines.

I. Mesio-labial.
J. Disto-labial.
K. Mesio-lingual.
L. Disto-lingual.
M. Mesio-incisal.
N. Disto-incisal.
O. Mesio-disto-incisal.

Bicuspids and Molars.

P. Mesio-occlusal.
Q. Disto-occlusal.
R. Occluso-buccal.
S. Occluso-lingual.
T. Mesio-disto-occlusal.

[1] Following the suggestion of Dr. Black, in the above list the word *lingual* is used for the same surfaces in both the upper and lower teeth, doing away with the word

In the foregoing classification the cavities have been arranged progressively from the simplest (*A*) to the most complicated (*T*).

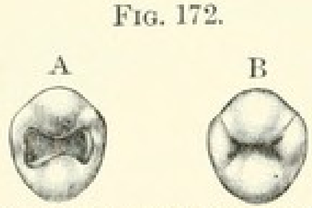
I. Simple Cavities on Exposed Surfaces.

BICUSPIDS AND MOLARS.

CLASS *A*.—Cavities upon the *occlusal* surface are very accessible and in full view, enabling the operator to see every part of the cavity and affording him plenty of room in which to operate. Naturally those nearest the front, as in the bicuspids, present the advantage of greater accessibility, but none of them are difficult to prepare and fill except under unusual conditions.

Usually the first part of a bicuspid crown to become affected by caries is the fissure between the cusps. Sometimes it presents merely as a black line into which only the point of an explorer will penetrate; at a later stage the cavity is more fully defined by the greater progress of caries and the crumbling of the walls of its orifice. In the first instance the cavity is most readily and comfortably opened by means of the tapering fissure bur shown in Fig. 163. After passing it into one of the terminal pits of the cavity it may be drawn along toward the other, opening the fissure quite freely. Once open, the decay may be removed and the cavity shaped by a suitably sized round bur (Fig. 162). As the decay has usually progressed farther in the region of the terminations of the cavity than in the space between them, the cavity when fully formed will be oblong in shape and contracted in the centre. In Fig. 172, A shows this form, while B represents the same surface before being operated upon.

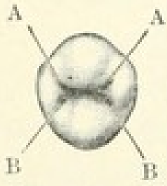
FIG. 172.



Cavity in sulcus of a bicuspid.

In preparing the cavity no more sound tooth-structure should be sacrificed than is absolutely necessary, but every portion of decay should be thoroughly removed and particular attention be given to opening up the minor fissure terminations as shown at A A, B B (Fig. 173).

FIG. 173.



The fissure terminals.

When completed, the cavity should be very slightly larger within than without, the margins should present no angles, but only a series of curves in outline, and the marginal edges should be slightly bevelled outwardly. Bicuspid cavities of this character vary in size according to the extent of decay, but the essential features in each case are very similar. The

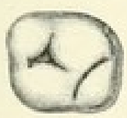
palatal. In the forming of compound terms, where the *mesial* or *distal* surfaces are included, these terms precede the others. Where they are not included and the word *occlusal* is used, it is given first place.

lower first bicuspid differs normally from all others of its kind in having no sulcus and consequently no fissure between the cusps. Instead of the two cusps being separated by a sulcus they are united by a ridge of enamel. (See Chap. I., p. 35.) The only points, therefore, that invite decay upon the occlusal surface of this tooth are the two pits that are found one on each side of the ridge. These are to be filled separately. They probably represent the very simplest form of simple cavities to be found anywhere in teeth.

The occlusal surface of an upper first or second molar presents two points liable to decay. One is a pit formed by the junction of two small fissures near the mesial margin, and the other is a fissure which runs between the disto-buccal, disto-lingual, and mesio-lingual cusps. Both are represented in Fig. 174. When limited in extent they should be opened in the same manner as a bicuspid fissure cavity, but when larger they may be opened by means of a chisel followed by a suitable bur. In these, as in all cavities in sulci, the fissures must be followed and opened up to their extremest limits in order to ensure success, while the margins and marginal edges must be so formed as to be strong, smooth, and bevelled.

The general form of these cavities when prepared is shown in Fig. 175. It will frequently be found that these two occlusal cavities

Fig. 174.

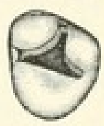


Molar fissure cavities.

Fig. 175.

Fig. 176.

Fig. 177.



Molar fissure cavities prepared for filling.

are joined underneath, while near the surface they are separated by a ridge of enamel and dentin. In such cases the ridge should be cut away and the two cavities converted into a single larger one as illustrated in Fig. 176.

If the ridge were allowed to remain it would almost certainly be fractured either in the operation of filling or subsequently by the force of mastication.

The upper third molar differs from those anterior to it in having but three cusps and consequently but one central pit with radiating fissures. A cavity occurring here when properly prepared will present a triangular outline with rounded angles, as in Fig. 177. The terminals of fissures should always be finally finished with a round bur to prevent any possible angles and opportunity for leakage at those points.

The lower first molar, as well as the third, having five cusps with intervening sulci, a cavity upon this surface will be pentagonal in outline, as represented in Fig. 178.

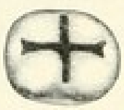
Extreme care should be exercised in preparing cavities of this character to insure that the fissures running between the buccal cusps are fully opened and cleared of every particle of decay and discoloration. Too often this is overlooked and caries supervenes.

The lower second molar with its four cusps has two sulci intersecting each other at a right angle. Decay usually begins at the intersection and extends along the radiating arms of the fissures. If the cavity were prepared by cutting out the fissures only it would yield a crucial-shaped cavity with four sharp or nearly sharp angles at the intersection, as shown in Fig. 179. Owing to these angles of dentin

Fig. 178.

Lower first molar with stellate cavity. Prepared.

Fig. 179.



Lower second molar with crucial cavity. Not properly prepared.

Fig. 180.

Prepared cavity in lower second molar.

and enamel the perfect filling of the cavity would be exceedingly difficult.

The case may be simplified and better results in every way obtained by rounding these angles and giving the cavity a form like the one shown in Fig. 180.

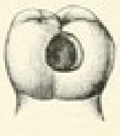
Class *B*.—*Buccal* cavities are seldom met with in the bicuspids except at the cervix. In this location they possess the same features as the similar class of cavities occurring on the labial surfaces of the incisors. Their treatment will be described under class *D*.

The upper molars also are seldom found decayed on the buccal surface except at the cervical border. Cavities occurring at this point are usually narrow and long, following the outline of the gum. They can best be prepared with an engine bur of suitable form, and if occurring on the second and third molars a right-angle attachment may have to be employed to reach them conveniently. Decay at this point is often of the white variety, and as it so nearly resembles the natural color of the tooth extreme care will have to be exercised to include all of the decalcified portion within the limits of the cavity. A retentive form is most conveniently given to these cavities by slightly undercutting them in the direction of their length. In the third molars it is sometimes advisable to make an undercut or starting-pit at the distal end for the beginning of the filling.

Sometimes a small cavity will be found at about the centre of the buccal surface of the upper molars, but far more frequently a cavity of greater extent will be found upon the same surface of the lower second molar. It originates in a pit at the termination of the fissure running over from the occlusal to the buccal surface between the two buccal cusps. Oftentimes the cavity is so large as to include the greater portion of this surface of the tooth. Its usual form and appearance are shown in Fig. 181.

Not infrequently this cavity is compounded with one on the occlusal surface. In opening and preparing it a slightly undercut form is readily given to it.

Fig. 181.



Buccal cavity in lower second molar.

Class *C*.—Decay rarely occurs upon the *lingual* surfaces of molars on account of their smoothness and convexity and because they are more or less constantly rubbed by the tongue in speech and mastication. The evenness of this surface is, however, broken in the upper first and second molars by a fissure extending over from the occlusal surface and passing between the two lingual cusps. (See Chap. I., p. 39.) This fissure is deeper and more pronounced in the first molar, but in each tooth it is generally the seat of caries early or later in life. In the majority of cases this fissure is decayed throughout its entire length, forming a compound cavity, but occasionally only the pit at its termination on the lingual surface is affected.

Another point on the lingual surface liable to decay is on or near the mesio-lingual angle of the upper first molar, about midway between the cervical and occlusal margins. At this place is often found a supplemental cusp, diminutive in size, and where it joins the main surface of the tooth a small fissure exists which invites decay. This additional cusp, when it does exist, is found only upon the first molar. It is shown at A in Fig. 182. (See Chap. I., p. 39.) Neither of these cavities presents any difficulties in preparation except such as occur from their slight difficulty of access.

Fig. 182.

Occasionally, though very rarely, the lingual surface of any of the molars may present a cavity of decay close to the gingival line and partly beneath it. Such cavities are doubtless caused by the retention of food débris beneath the free margin of the gum, and owing to their position they are difficult to treat. They should be opened and packed over-full with cotton and varnish or gutta-percha for a day or two, to press the gum away, after which they may be prepared and filled in the usual manner.

INCISORS AND CANINES.

Class *D*.—Cavities upon the *labial* surfaces of incisors and canines are usually found along the gingival margin, and are the result of the direct action of acids probably formed at this point. In the beginning, and when small, they are entirely exposed, but when of greater extent they frequently extend beneath the free margin of the gum. They are nearly always elliptical in outline and may consist of simple decalcified enamel still retaining the usual surface form, or they may possess the common characteristics of cavities in general.

The opening and preparation of this class of cavities are not attended with any marked difficulties except that when they extend beneath the gum care will have to be exercised not to wound this tissue, as the consequent bleeding would obstruct the view and interfere with the progress of the work. This may be prevented by pressing and holding the gum away with a suitable instrument held in the left hand while the cavity is being prepared. Particular attention should be paid to the careful preparation of the cervical margin of the cavity and to its terminal points. The former should be made smooth and even, and the latter should be extended far enough to include any enamel that shows the least sign of acid alteration. Slight grooves or enlargements at the base of the cavity along its upper and lower margins will give it a sufficiently retentive form.

A second locality on the labial surface where decay is frequently found is anywhere between the central portion and the incisal edge, in pits and depressions that indicate imperfect development of the enamel. These pits or grooves extend in a nearly straight line parallel to the incisal edge, and are frequently the seat of decay.

When quite shallow they may be obliterated by grinding the surface with a small corundum wheel and polishing, converting the surface at this point into a distinct concavity. When the pits are deeper and isolated they may be filled separately, the result being a lesser degree of conspicuousness ; but when they are connected by a groove, as they usually are, they will have to be converted into a single cavity and filled. A common type of this defect is shown in Fig. 183.

Fig. 183.

Pitted incisor.

When these pits occur upon the incisal edge or in close proximity to it the choice lies between an unsightly gold filling, a porcelain tip, or their removal by grinding and the resultant shortening of the crown.

Class *E*.—There is usually but one point upon the *lingual* surface of incisors and canines that is liable to decay. It is in the pit at the junction of the basilar ridge or cingulum with the adjacent tooth surface. The incipiency of caries at this point presents only as a minute cavity, the opening and shaping of which is readily accomplished with a round bur. Although the orifices of these cavities may be small, the dark spot that marks their direction is often continued quite a distance toward the pulp chamber. This black point should in all cases be followed to its termination and obliterated. It will never be found to reach the pulp or to approach dangerously near it. As the depth of these cavities is greater than the diameter of their orifices, no special retentive shape need be given them.

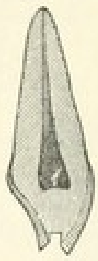
The orifice should always be bevelled and enlarged, if necessary, to include any neighboring fissures.

When these cavities are of greater extent they are prepared and filled like others of similar size and form.

Class *F*.—Cavities upon and confined to the *incisal* edge of incisors and canines are easily prepared on account of their accessibility. This particular surface should, and generally does, remain free from decay on account of the attrition to which it is constantly subjected; but when defects in the enamel exist, caries sometimes occurs in connection with it.

This surface often needs covering with gold to check abrasion in cases where, after middle life, the crowns (especially those of the upper teeth) have been shortened by excessive wear. Under these conditions the surface has to be so prepared and shaped as to retain the gold that is to cover and protect it just as though caries had originally injured the part. In forming the cavity in the exposed dentin it is only necessary to cut deeply enough to afford a lodgment for the filling, but the orifice must be so enlarged and excessively bevelled as to reach to the marginal edge of enamel all around. This is done to protect the enamel from chipping or fracture in mastication. To afford the greatest security to the filling the cavity should be undercut throughout its whole extent. When thus prepared, the cavity in cross section will resemble a double dove-tail as shown in Fig. 184.

Fig. 184.



Cross section of cavity on incisal surface.

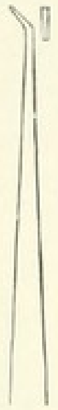
II. Simple Approximal Cavities.

INCISORS AND CANINES.

Class *G*.—Cavities upon the *mesial* and *distal* surfaces of the anterior teeth present only the difficulty arising from inaccessibility. To reach and operate upon these cavities, the teeth, if in normal contact, will usually have to be pressed apart either by gradual wedging or by immediate separation with a "separator." Even after this has been accomplished the cavity cannot be operated upon in a direct way as are cavities upon exposed surfaces, but will have to be approached from either the labial or lingual aspect of the crown. To do this, if the cavity be small, will generally necessitate an additional enlargement of the cavity toward the surface from which it is to be approached. As the lesser of two evils the enlargement is usually made toward the lingual surface, for in this way the exposure of gold when the filling is completed will not be noticeable. When the cavity is of larger size and the enamel wall on the labial surface has been weakened by caries it will have to be removed, and access will thus unavoidably be afforded from that side. Whenever possible, however, undue enlargement of the cavity and consequent exposure of gold should be avoided.

In ordinary cavities upon the *approximal* surface the frail walls bordering the orifice should be broken away with a small chisel, and after the decay has been removed by means of burs or excavators and the proper form given to the cavity, the margins should be carefully smoothed and bevelled with small plug-finishing burs or with the side-cutting edge of the small chisel shown in Fig. 166 and here reproduced (Fig. 185).

Fig. 185.



Delicate three-sided chisel, useful for opening cavities on approximal surfaces.

Anchorage is obtained in these cavities by slightly deepening the cavity at its cervical termination and making a shallow undercut in the dentin near the incisal border. Retaining grooves should never be made in the labial or lingual walls of the cavities, as they would seriously weaken them. In approximal cavities of large size where they extend from near the incisal edge to or beyond the free margins of the gum, the difficulties of producing a perfectly formed cavity are greatly increased. While affording greater ease of approach on account of their size, the cervical border of this class of cavities is apt to be less perfectly prepared owing to its obscure location. When the cervical border extends beneath the free margin of the gum the latter should be pressed and held away during excavating, so that the cervical wall may be plainly seen and operated upon throughout its whole extent.

Cutting of the wall should be sufficiently extended rootward to include any defects or checks in the enamel bordering it, and should be made entirely smooth and free from angles, for it is the most vulnerable border of the cavity after the filling has been completed. Should the cavity extend to near the enamel termination at the cervix, it will be best to still further extend it so as to pass beyond this margin; for if a small portion of enamel be left there it will be liable to be broken away in the process of filling and thus seriously impair the junction of the filling with the border.

So, also, if the cavity on account of its size should approach very near to the incisal edge, it is best to remove this frail corner and convert the cavity into a *compound* one. Where such a weak corner is allowed to remain it is very frequently broken away in subsequent mastication. Such a result is shown in Fig. 186. An accident like this is more likely to occur in thin, flat teeth where the plates of enamel meeting at the incisal edge have little or no dentin between them.

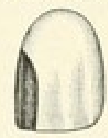


Fig. 186.

Straight fracture.

Where doubt exists as to whether the corner should be removed or allowed to remain, it is well, after the cavity has been prepared, to test the strength of the corner by strong pressure upon it in the direction of the long axis of the tooth with a piece of orange-wood. If it resists this strain it will probably resist the force of mastication, and if it break away under the test it will demonstrate that it would have been unwise to allow it to remain.

If the corner be left as a border and support for the filling it should not be weakened by a deep retaining groove. Such groove or anchorage should be shallow, and as far removed from the incisal border as the conditions will permit.

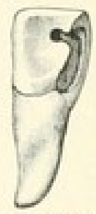


Fig. 187.

Lingual extension anchorage.

In many cases, where the incisal wall would be seriously weakened by any attempt to use it as an anchorage or support for the filling, and where it seems undesirable to remove it, an excellent anchorage for the lower border of the filling may be obtained by cutting an extension upon the lingual surface in the form of an arm, as shown in Fig. 187.[1] Such extension, if made but little deeper than the enamel, will not materially weaken the tooth and will secure the filling perfectly.

Its position should be near the incisal edge, but not so close to it as to weaken the part.

In the anterior teeth the relative difficulties between *mesial* and *distal* cavities are insignificant.

BICUSPIDS AND MOLARS.

Class *II*.—The preparation of small cavities on the *mesial* and *distal* surfaces of the bicuspids and molars, though simple in character, is usually most difficult of thorough performance. This is due entirely to their inaccessibility when the teeth are closely approximated. How to approach these cavities is often a matter of no small concern to the student or young practitioner, and the preparation and filling of them is generally more difficult than that of larger and more complicated cavities in exposed situations. To lessen the difficulty of approach it is important, whenever practicable, to create by wedging beforehand as great a separation as possible between the teeth. The greater the space gained the less the difficulty of approach.

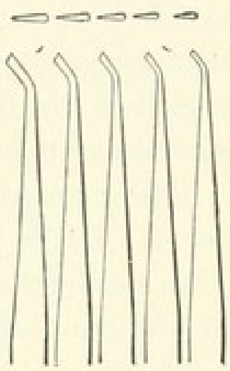
When conditions will not warrant cutting down to them from the occlusal surface, and thus converting them into compound cavities, but two ways of approach are left open: one is from the direction of

[1] *Dental Review*, vol. ix. pp. 812 and 819.

the occlusal surface, and the other from the buccal aspect. Usually the former is chosen, as it involves less sacrifice of tooth structure, although by it the difficulties are increased owing to the limited space in which we are obliged to operate.

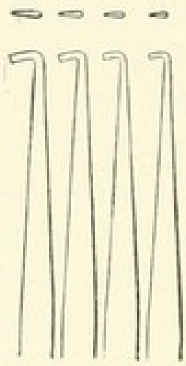
These cavities can usually be best opened and mainly prepared with a round bur. After the decay has been removed and the walls defined and prepared, the cavity may be made retentive in form by slight undercutting throughout its entire circumference, or it may be enlarged at two opposite points only. The cervical wall can be inwardly deepened by an obtuse-angle hatchet excavator as illustrated in Fig. 188, and the lower or occlusal wall be slightly undercut by an acute-angle excavator like Fig. 189.

Fig. 188.



Obtuse-angle hatchets.

Fig. 189.



Acute-angle hatchets.

The sharp angles on the cutting edges of these excavators should be rounded before being used, so as to avoid the formation of angles in the cavity.

As the enamel rods on this surface radiate outwardly at such an angle as to give the proper bevel to the orifice of the cavity, a careful following of their lines in the preparation of the cavity margins will be all that is necessary to give them the desired form and strength.

Occasionally these cavities, instead of being round or nearly so, have a decided oval or oblong form, their greater diameter being in a bucco-lingual direction, in which event the cavity may generally be best approached, for preparation and filling, from the buccal aspect.

When this seems desirable, the cavity should be extended so as to open at the approximo-buccal angle. A round bur is best suited for this purpose, and when the extension has thus been made the cervical and occlusal walls of the cavity may be slightly grooved with a hoe excavator and the inner or lingual wall be made abrupt and also slightly undercut.

In all cases where sufficient space cannot be gained to operate satisfactorily from the direction of the occlusal surface, an extension of the cavity to the buccal aspect is the only alternative.

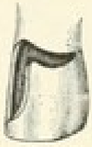
Where simple cavities upon the approximal surface are large they may extend so near to the occlusal surface as to weaken it. When this is the case the enamel wall should be cut away and the cavity converted into a compound one of the approximo-occlusal type.

III. Compound Cavities.

INCISORS AND CANINES.

Classes *I* and *J*.—*Mesio-labial* and *disto-labial* cavities occur from the near approach or union of simple cavities upon their respective surfaces. Cavities of considerable length upon the approximal and labial surfaces are very apt to join one another by extension of caries. When they do not join they are usually separated by a narrow territory of more or less impaired tooth tissue, and in such cases must be united to obtain a satisfactory result. Each cavity should be as nearly prepared as possible separately, after which the intervening tissue should be cut away and the lines of the channel connecting the two be made as strong and smooth as possible. This channel will usually be of less width than either of the cavities, but not more difficult to fill on this account. Fig. 190 shows a front view of such a compound cavity.

Fig. 190.

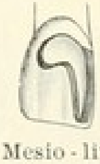


Mesio-labial cavity prepared.

Whether the cavity be a mesio-labial or a disto-labial one will not materially affect the manner or difficulty of operating.

Classes *K* and *L*.—*Mesio-lingual* and *disto-lingual* cavities are formed in the same manner as those of classes *I* and *J* except that in these cases the lingual surface is involved instead of the labial. Extensive caries in the region of the basilar pit or of the fissures connected with it often approaches so nearly to an approximal cavity in the same tooth as to demand the union of the two (see Fig. 191). The method of preparing and uniting the two is substantially the same as that followed in classes *I* and *J*, just described.

Fig. 191.



Mesio-lingual cavity.

A mesio-lingual cavity is perhaps more easily prepared and filled than a mesio-labial one, for in its preparation the free cutting away of the intervening wall is permissible, which affords increased room for operating.

Fortunately, a lingual cavity rarely extends so far as to connect with both a mesial and a distal cavity. When it does, the joining of the three cavities very seriously weakens the crown at the point where the greatest strain occurs.

Classes *M* and *N*.—These classes include cavities upon either the *mesial* or *distal* surfaces connecting with a cavity upon the *incisal edge*.

They usually occur in consequence of the wearing away of the latter surface through attrition or from the necessitated removal of the incisal corner on account of weakness. Both the approximal and incisal cavities may be prepared separately as described in classes *F* and *G*, after which they should be connected, the walls made strong and smooth and properly bevelled.

A typical cavity of this class is shown in Fig. 192. In all such cases the labial plate of enamel should be preserved intact as far as possible for appearance sake, and if any cutting has to be done to increase the size or depth of the incisal portion of the cavity, it should be done at the expense of the lingual wall. In order to protect the labial wall from possible fracture in mastication the enamel should be bevelled outwardly (as mentioned under class *F*) so that when filled the gold alone will come in contact with the opposing teeth in mastication.

Fig. 192.

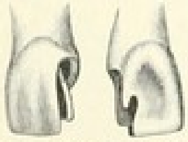
Approximo-incisal cavity.

The only anchorage needed for this class of cavities is a slight undercut along the cervical wall and a dovetailed form of the incisal portion of the cavity.

In many cases there is no cavity upon the incisal edge, but where opportunity offers for making one (as in the case of thick or worn teeth) this method of forming a compound cavity affords the greatest possible support and security for a large approximal filling involving the approximo-incisal angle.

Where the crown is thin and unworn upon the incisal surface a compound cavity of this character cannot be formed, but the same result as to anchorage may be obtained by cutting an extension upon the lingual surface of suitable size, form, and depth, as described on p. 231. One form of such extension where the corner is gone is shown in Fig. 187.[1] Another form, represented in Fig. 193,[2] consists of giving the extension a curved or hooked form. Both forms serve the same purpose, for they afford in these cases perfectly secure anchorage which could not be obtained so well in any other way.

Fig. 193.



Auxiliary dovetail anchorage.

Class *O*.—*Mesio-disto-incisal Cavities*.—Cavities of this character differ from the preceding ones principally in extent. The method of preparation in each case is similar and the operation requires the exercise of great skill and care in order to produce the best results. In both cases the following points will have to be observed:

As the operations are extensive in character, good strong walls are needed on all sides to withstand the force exerted in the introduction of the filling.

[1] *Dental Review*, vol. ix. pp. 812 and 819.

[2] I. C. St. John, D. D. S., *Dental Cosmos*, vol. xxxvi. p. 198.

All margins must be smooth and nicely bevelled.

No angles or checked enamel must exist along the borders.

All enamel should be supported by underlying dentin, although to avoid the exposure of gold the labial plate (which is thicker than the lingual) may sometimes be left thus unsupported for a short distance along the approximal and incisal margins.

No deep anchorages will be required. Only slight ones are needed to start the filling at the cervical wall, for the form of the filling, when completed, will be such as to afford the greatest possible security.

BICUSPIDS AND MOLARS.

Class *P.*—*Mesio-occlusal* cavities in bicuspids and molars represent a class not only frequently met with and difficult to fill, but one also in which a large proportion of fillings fail. This is largely due to the improper shaping of the cavity and the imperfect placing and adaptation of the filling. When these cavities are of moderate size, not extending as far as the gingival margin on the mesial surface and without any great width in a buccal or lingual direction, the preparation and filling of them is not attended with any great difficulty; but where they extend beneath the gum margin and are much spread out laterally they present complications that are difficult to overcome.

The cervical margin of such cavities as extend only to or near to the free margin of the gum has been aptly styled the "vulnerable point," because when failure occurs in these fillings it usually begins at this margin. When, however, the cavity wall extends beneath the gum margin, although the difficulties of operating are increased, recurrence of decay is seldom met with, because the conditions favorable to decay are not present there.

In the preparation of these cavities the teeth should have been previously wedged in order to afford light and room for excavating, as well as for the subsequent introduction and finishing of the filling. If the cavity extend beneath the margin of the gum the latter should be pressed away by packing the cavity over-full with gutta-percha for a day or two previously.

After opening and roughly preparing the cavity the rubber dam should be adjusted and the cavity thoroughly dried, after which the preparation can be completed more satisfactorily, as the dryness of the tooth will enable the operator to readily distinguish between sound and unsound tissue.

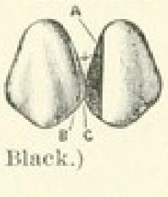
Whether the cavity be of large or moderate size, simple or difficult in character, the niceties of preparation must receive due consideration. The cervical portion of the cavity should be dressed until a strong sound wall is obtained. In it there must be no angles, and bordering it there must be no decalcified tooth structure and no checks in the enamel. Should either of the latter be found, further cutting of the wall will be necessary until these defects are entirely obliterated.

If the cavity should extend rootward to near the termination of the enamel, it will be necessary to deepen the cavity so as to include this portion, otherwise injury will be liable to result from the fracture of this frail section of enamel during filling.

The outline of the cervical wall may be either distinctly curved or more or less flattened; the latter form, shown in Fig. 194, A, being preferred by many on account of the assistance it renders in filling. The buccal and lingual walls must be dressed to a smooth outline and bevelled, and where the size of the cavity warrants it should be extended so far toward the buccal and lingual surfaces as to free them from the danger of future decay. In Fig. 195 the dark portion represents the buccal aspect of the completed filling. None of these walls should be deeply undercut to assist in either the introduction or retention of the filling, for such undercutting is a source of weakness, but shallow grooves are not objectionable when needed.

FIG. 194.

FIG. 195.

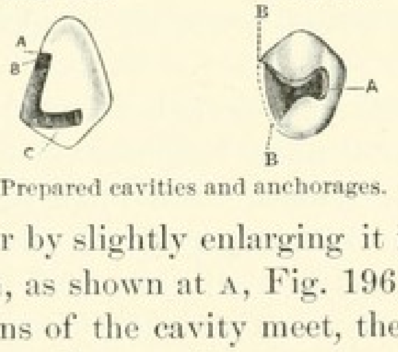


(After Black.)

Starting pits or grooves should not be made in the cervical wall except in rare cases; a slight dipping inward of the wall, as indicated at A, Fig. 196, being sufficient to furnish all the retentive form needed at this part of the cavity.

That portion of the cavity in the sulcus on the occlusal surface may

FIG. 196. FIG. 197.



Prepared cavities and anchorages.

be made retentive either by slightly enlarging it inwardly or by widening it at its termination, as shown at A, Fig. 196. Where the occlusal and approximal portions of the cavity meet, the angles should be removed and the cavity well opened so as to afford access and give strength to the filling (B, Fig. 197).

Fig. 198 represents a compound cavity of this class, incorrectly formed. In it moderately sharp angles are seen at the points where the occlusal and approximal portions of the cavity join.

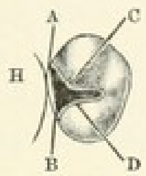
FIG. 198.

In very exceptional cases, cavities upon the approximal surfaces that involve a slight portion of the occlusal do not need to be extended along and include the sulcus or sulci on this surface, owing to the fact that no fissures and no decay exist in them.

In such instances the occlusal portion of the cavity should have a V shape as shown in Fig. 199, and anchorage for the filling at this point be obtained by slightly undercutting the approximo-occlusal walls at A and B.

Fig. 199.

Fig. 200.

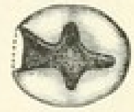


Prepared cavities and anchorages.

In the diagram Fig. 200 the black portion represents the floor of the cavity; A and B indicate the points to which the buccal and lingual walls should be cut; C and D show the curved form of cavity after the occluso-approximal angles have been removed, while the curved line outside of the cavity indicates the approximal contour of filling, with contact point at H.

Fig. 201 represents a compound cavity (mesio-occlusal) in a lower second molar. These cavities differ from similar ones in bicuspids principally in having the occlusal portion of the cavity extend in different directions along the sulci. All of the terminations should be well rounded and in no portion of the cavity should distinct angles be allowed to remain.

Fig. 201.

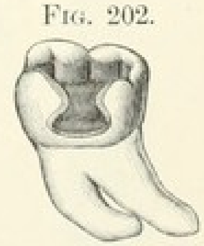


Mesio-occlusal cavity in lower second molar. Prepared.

Class *Q.—Disto-occlusal* cavities in either the bicuspids or molars are not essentially different from mesio-occlusal cavities in the same teeth. Owing to their position they are more difficult of approach, but their manner of preparation and their form are virtually the same.

Class *R.—Occluso-buccal* cavities are more frequently met with in the lower than in the upper molars. This is due to the general presence of a pit upon the buccal surface in which decay by extension reaches so near to the occlusal surface that the occluso-buccal wall is weakened and has to be removed. Coincident with this there is usually a cavity of some size upon the occlusal surface, and the union of the two cavities becomes necessary to insure a satisfactory result in filling them. A common type of such cavity is shown in Fig. 202.

Fig. 202.



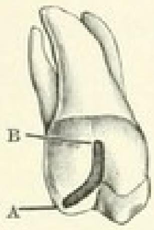
Occluso-buccal cavity in lower molar. Prepared.

The channel connecting the two cavities is usually narrower than either of the latter, and also more shallow, thus conserving the strength of the tooth. As, however, the strain upon the walls bordering this channel is very great in mastication they should be trimmed until solidity is obtained, and also be considerably bevelled for purposes of strength.

Class *S.*—*Occluso-lingual* cavities in the bicuspids and molars are of rare occurrence except in the upper first and second molars, where they follow the line of the sulcus extending between the mesio-lingual and disto-lingual lobes. Sometimes the cavity is nearly confined to the occlusal surface, running over on to the lingual surface but slightly. In such cases the cavity is easily prepared by simply cutting the occlusal cavity through to the lingual surface, giving the cavity a relatively uniform depth at all points.

At other times the fissure on the lingual surface will extend farther toward the cervical margin, and the cavity when prepared will have the form of an L, the longer arm, A, representing the occlusal, and the shorter one, B, the lingual portion of the cavity (see Fig. 203). Where the extent of decay does not demand it, it would be a mistake to make the floor level of the two portions of the cavity uniform, as the extensive removal of sound dentin would greatly weaken the disto-occluso-lingual cusp.

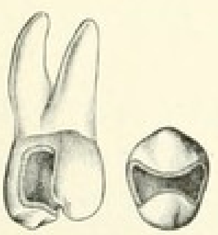
Fig. 203.



Where extensive decay has already weakened this cusp it is better to amputate it below the level of the occlusal plane and extend the filling over it.

Class *T.*—With the exception of those unusual cavities which involve the greater portion of the crown of a tooth, the *mesio-disto-occlusal* cavities in bicuspids and molars are the largest in extent of any met with. Being well exposed there is no lack of either light or room in which to operate, and the only difficulty associated with their preparation and filling lies in their size and extent.

Fig. 204.



Their preparation is accomplished in the same manner as those of classes *P* and *Q*, except that no special retentive form need be given to the occlusal portion, for with the filling once in place its general form will secure it in position. Fig. 204 represents a typical cavity of this class in a bicuspid tooth.

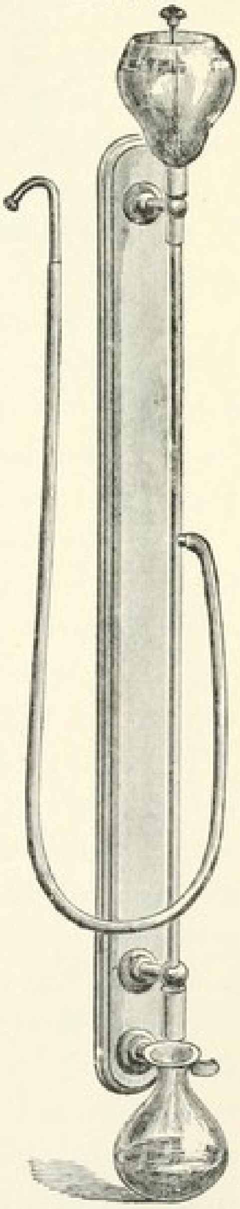
CHAPTER IX.

EXCLUSION OF MOISTURE—EJECTION OF THE SALIVA—APPLICATION OF THE DAM IN SIMPLE CASES, AND IN SPECIAL CASES PRESENTING DIFFICULT COMPLICATIONS—NAPKINS AND OTHER METHODS FOR SECURING DRYNESS.

By Louis Jack, D.D.S.

The interference of the *secretions of the mouth* offers a considerable obstacle to the treatment of the teeth. In some instances the flow is naturally excessive, and in all cases it is stimulated by the operative procedures.

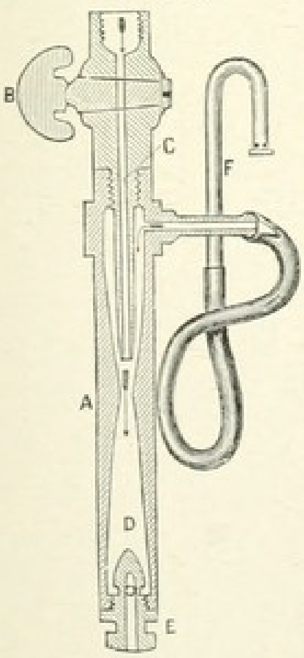
Fig. 206.



An excessive flow of saliva is uncomfortable to the patient; its accumulation also impedes the operation, and interferes with the view of parts by refracting the rays of light.

During the preparation of accessible cavities, particularly those of the upper front teeth and the occlusal surfaces, the accumulation may be carried off by the use of a saliva ejector, a simple form of which is shown in Fig. 205, which form, or some modification of it, is used where a connection can be made with the water supply, and ordinarily it is used in association with the fountain cuspidors. Another form, which is connected with a small reservoir of water, is shown in Fig. 206. Either of these forms has a further use for drawing off the saliva in connection with the employment of the rubber dam to lessen the discomfort of the patient.

Fig. 205.



Use of Rubber Dam.

During the preparation of cavities on the approximal surfaces of the bicuspids and molars where it is essential to have *unrestricted* *view* and the *exclusion of blood*, the presence of which is inseparable from thorough preparation of the cervical margins, it is necessary to make use of the RUBBER DAM. When used for this purpose the material generally becomes impaired by the action of the instruments in their free use at the cervix; but the economy of time and the essentials of thorough performance of this class of operations warrant the application during this portion of the treatment.

When the case is ready for the filling process a new piece of the dam should be prepared, and adjusted with great care to prevent the ingress of the least moisture. Without this appliance the greatest skill is powerless to secure sound results in large, difficult, or complicated cases. The introduction of this invention has made it possible to execute with gold, operations which previously were impossible; not the least advantage resulting from its use is that the operator has free use of the left hand to assist the right.

Quality of the Rubber.—The quality of the rubber greatly modifies the facility of its application. It should be of medium thickness and of light color, as it then absorbs less light. It should be freely extensible and so elastic that when the thumb is forcibly pressed into it it returns to its normal form on the removal of the force. If it responds to this test it will not tear if fairly applied.

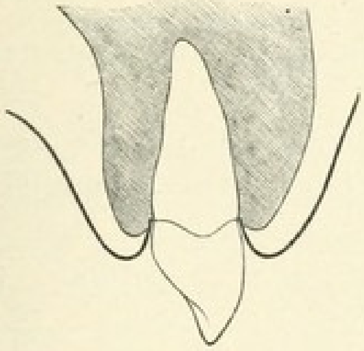
The **size and form** of the piece should be such as to avoid encumbering the face of the patient and to permit the lateral extension to be folded out of the way in such manner as to prevent obstruction of the view. The form generally best suited is a *triangle*, which form also permits of its most economical use.

For the front teeth the piece should be moderately small; for the bicuspids and molars the size should be ample and is best adapted when cut from strips about seven and a half inches in width.

The selected piece should have holes cut in it of such size as to correspond with the dimensions of the teeth over which it is to pass. When more than one hole is required the holes should be at such distances apart as will present a sufficient amount of material to allow for the take-up in the application, so that the strait which passes between the teeth shall be sufficient to allow the edge to be carried upward to form a valve at the cervices of both teeth and not be under such strain as to interfere with the valvular action of the edges of the rubber. At the same time there should be no excess to hamper the view or interfere with the placement of the filling material.

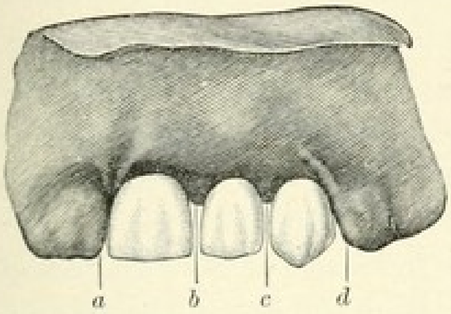
Attention to the valvular arrangement of the dam at the cervix will avoid subsequent difficulty and will prevent in many instances the infliction of pain in using ligatures except upon the tooth under treatment and the adjacent one. The appearance of this valve is shown in

Fig. 207.



perspective by Fig. 208, *a*, *b*, *c*, *d*. The holes in the rubber may

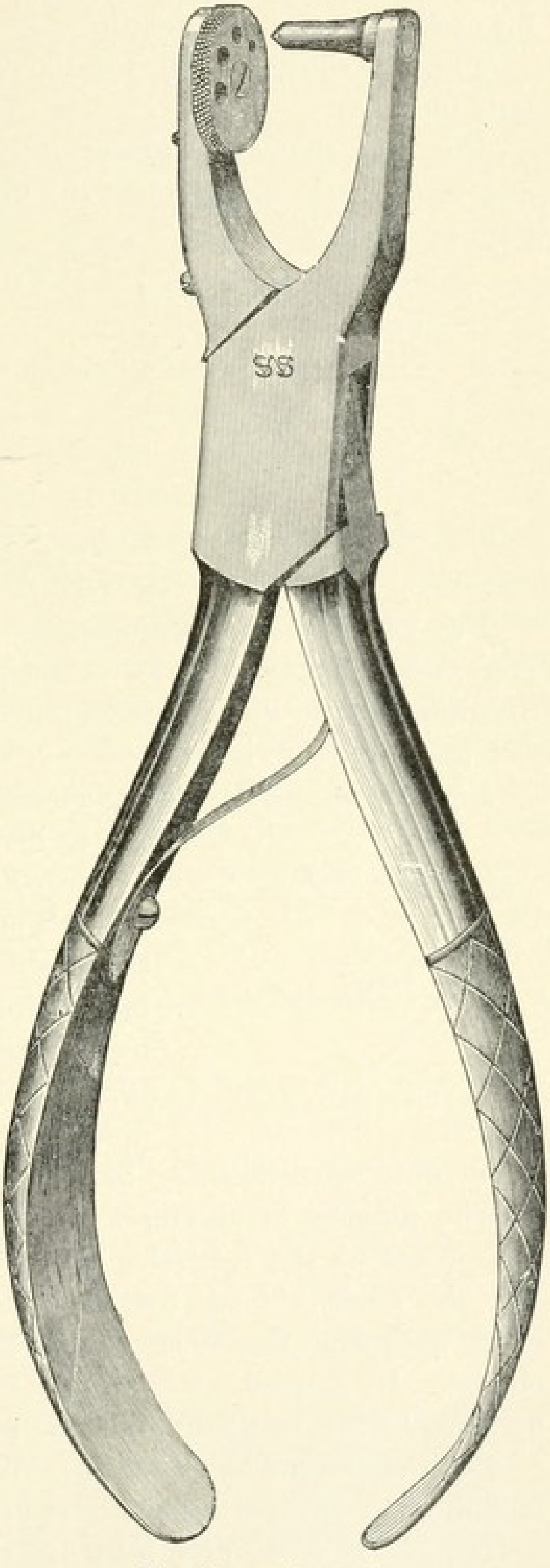
Fig. 208.



Diagrammatic drawing: form of valve.

be formed with a punch of suitable size, which should be forced upon the end of a close-grained piece of hard wood. They may be made with a little practice by drawing the rubber over a round-ended instrument with some force and pricking the rubber at a suitable point with a sharp knife, when a round section escapes. The difference in size of the holes is determined by the distance from the end of the instrument at which the puncture is made. The determination, however, of size and distance is not easily made in this manner. The best appliance for the purpose is the Ainsworth punch (see Fig. 209), with which complete control of size and distance may be easily effected.

Fig. 209.



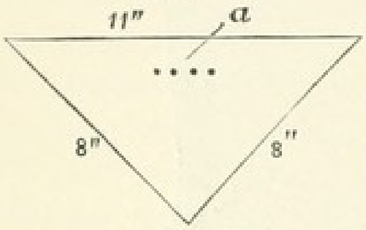
The Ainsworth punch.

The arrangement of the holes in the triangular piece should differ for each section of the mouth.

Fig. 210 shows a piece for the *central incisors.* The figures represent inches.

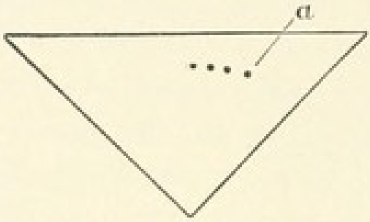
Fig. 211 shows the arrangement of holes for the *upper bicuspids and molars.* It will be observed the line of holes is not parallel with the upper edge.

Fig. 210.



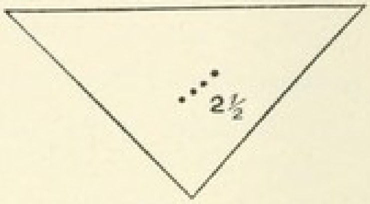
For central incisors.

Fig. 211.



For upper bicuspids and molars.

Fig. 212.

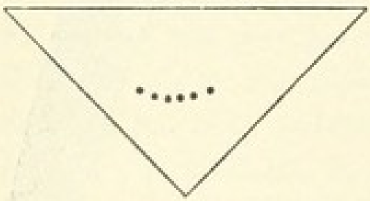


For lower bicuspids and molars.

Fig. 212 shows the arrangement for the *lower bicuspids and molars.* Here, too, the line of holes is not parallel with the edge, to allow for the difference in distance from the commissure of the lips to the anterior and posterior holes.

Fig. 213 shows the arrangement when the lower *incisors and canines* are included. Here the line of the apertures is curved.

Fig. 213.



For lower front teeth.

By conforming to these arrangements of the openings in the rubber, and by extending the line in conformity with it, as well as by increasing the size of the piece, any number of holes may be made, to include any portion or all of the teeth of one quarter of the denture when that may be required.

The number of apertures in the rubber should be such as to give easy access to the operation and to permit the free entrance of light. For the anterior teeth five to six holes are necessary, and for the posterior teeth from four to six as may be needed to secure the above-stated objects. In general, at least two teeth anterior to the one operated upon, and when admissible the one posterior, should be included.

The Placement of the Dam.—When the teeth are not in firm contact or when their attachments are flexible the adjustment of the dam is simple. But when the teeth are rigid certain preliminary conditions should be secured. It has been pointed out in speaking of the preparation of the teeth for a series of operations that they should be well cleaned of any deposits which may be upon them and be polished on their approximal surfaces. This makes easier the insertion and the application of the rubber.

Generally where the case under treatment is an approximal surface the necessary preparatory separation makes easy the immediate opening of any interstices near the operation. In cases of extreme fixation of the teeth a piece of rubber dam placed for a day or so in a couple of the neighboring spaces makes it easy to enter the margin of the interstices. The passage of a silver tape with a little benne oil or cosmolin on it often answers as an equivalent means. In the front teeth a thin wedge inserted just above a tight point permits an easy entrance.

The preliminary silking of the adjoining spaces, particularly if the silk be coated with cosmolin or its equivalent, also facilitates the passage of the rubber, and for this purpose soaping the under surface of the rubber adjacent to the holes is recommended.

At first the novice finds difficulty in making application of the dam, but practice cultivates facility. In general it is better to commence with the anterior hole and proceed posteriorly until all the intended teeth are included. Thus for the left lower teeth the rubber is taken with the index fingers applied to the upper surface, the other fingers to the under surface, and is grasped near the hole for the front bicuspid; the hole is extended; the edge of the rubber is inserted in the mesial interstice and is carried down to the gum. It is then drawn over the tooth and passed into the next interstice in the same manner. This method is pursued with each tooth until all are included. The passage of the rubber is facilitated by helping it downward by the insertion of floss silk, which is held taut, and with a firm and gently sliding movement the rubber is conveyed toward the cervix.

When the most distant tooth is the lower third molar, it is generally best when the cavity is on either side of the last interstice to pass the jaws of a dam clamp through the posterior hole; the clamp is then made to grasp the tooth, the dam is conveyed to the gum by silking, and the adjustment is then carried forward from tooth to tooth. The same procedure is sometimes applicable with short third molars in the upper denture, or in case any of the posterior teeth are so shaped as not to retain the rubber.

When the rubber is adjusted over the teeth the purpose of the dam is effected by directing the edge of the dam under the free margin of the gum. This is done by passing a silk thread around the tooth, and crossing the ends, when by a drawing movement of the thread it travels down the inclined surface of the cervix, carrying the dam with it, thus making a more secure formation of the valve.

This method avoids the needless paining of the patient caused by pushing the threads against the gum with instruments. Whenever necessary for securement the ligature should be tied. This should be done to the teeth on both sides of an approximal cavity. It is necessary here to place the cervical margin of the cavity in full view and to make certain the exclusion of moisture, which otherwise might pass the valve by capillary attraction.

The ligature should usually be passed but once around the tooth and then be tied with a surgeon's knot, the place of the knot being on the outside. When there is much strain the thread may be passed twice around the tooth, but this should be avoided as being more painful and as increasing the bulk of the ligature.

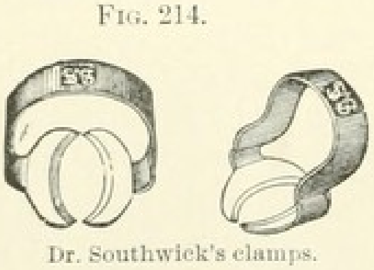
To prevent the rubber from displacement by the movement of the cheeks on the posterior teeth when they are long, if after drying the surface a little sandarac or damar varnish is applied at the last interstice, the rubber becomes fixed.

In cavities extending above the cervix where a ligature cannot be placed above the cervical border of the cavity, other means have to be adopted to obstruct the entrance of fluids. Here the strait of rubber between the holes should be much wider than usual; the abundant fold may then be forced beyond this margin with a matrix, when, by drying the parts and by the deft introduction of alcohol varnish and suitable wedges, dryness of the parts is attained. In the most extreme cases of this nature the part beneath the normal gum line may be filled with a permanent plastic substance, as described in the section on Lining Cavities (see Chapter X., p. 258).

The Securement of the Dam from Displacement.—When the teeth are short from incomplete development or when their form is tapering from the gum toward the occlusal aspect there is always tendency of the rubber to escape, and the contraction of the commissure of the lips tends to the displacement of the dam at the posterior teeth, the latter movement often being sufficient to overcome the friction of the ligatures. When these difficulties arise a clamp is required.

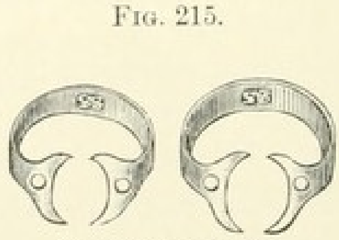
THE CLAMP.—This is an instrument of much value not only as a means of securement of the rubber, but as an adjunct to prevent the

FIG. 214.



Dr. Southwick's clamps.

FIG. 215.

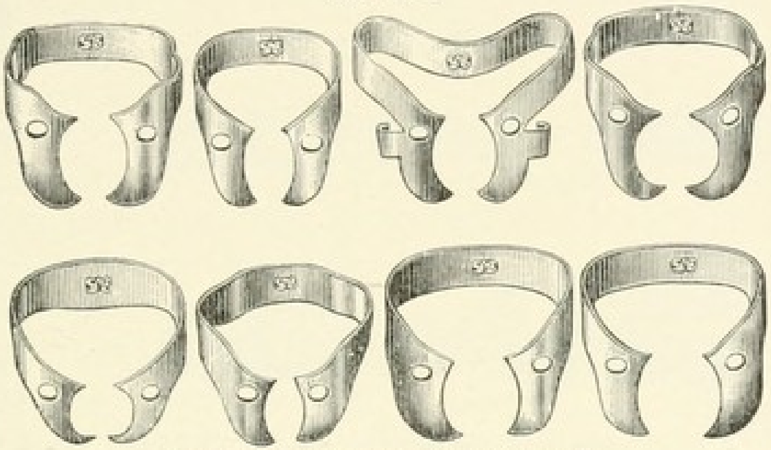


Dr. Huey's clamps.

rubber from obstructing the view. Clamps are more especially needed to detain the rubber on the molars and are rarely required for the bicuspids or the anterior teeth, since, if the foregoing directions are followed, the necessity for their use will but seldom be presented.

Forms of Clamps.—For the molars various sizes and shapes of the "Southwick" and of the "Huey wisdom-tooth clamp" are sufficient for general use. In addition to these "Palmer's set of eight," after the sharp points of the jaws are rounded, will furnish the requisite variety.

FIG. 216.



Dr. Delos Palmer's set of eight clamps.

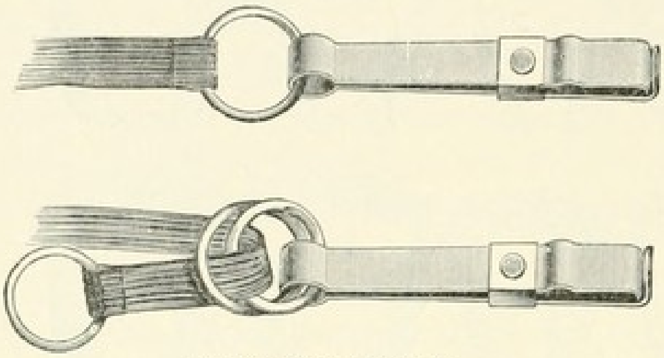
The Application of the Clamp.—The selected clamp is extended by the clamp forceps to enable it to pass over the molar. It is conveyed to the middle portion of the tooth, when the inner beak should be brought against the tooth at the gum margin; then with this point as a fulcrum the outer beak is carried to the cervix on the buccal surface. Much pain may be avoided in the employment of this appliance by deft and careful placement. Injury of the gum and needless pain has frequently been inflicted by careless use of force in the application of this appliance. Much of this may be avoided by the previous ligation of the tooth, which will prevent the tendency of the clamp to descend beneath the gum when the necks of the teeth are much inclined inward.

When it is necessary to force the clamp against the soft tissues the previous application of a solution of cocain will obtund the tissue and render the application tolerable.

The Arrangement of the Dam on the Face.—This concerns the convenience of the operator and the comfort of the patient. To give easy access and permit the entrance of light, the rubber is drawn aside at each upper corner by dam-holders. The simpler forms of these are sufficient and are more convenient than the more complicated ones when triangular pieces of rubber are employed. In addition a supporter, shown at Fig. 218, passes over the head and engages at each end with the holder. The comfort of the patient is secured by including a napkin along with the rubber in the clasps of the holder. The excess of the rubber at each side should be taken up in a fold and secured to the napkin by dressing pins. The suspended part of the rubber is kept taut by pendent weights.

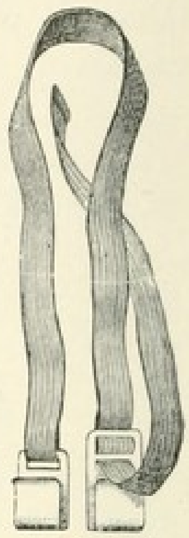
The application and arrangement of the dam becomes by practice a very simple matter, and should not be the occasion of discomfort or pain to the patient.

Fig. 217.



Design of Dr. Cogswell.

Fig. 218.



A supporter.

The Use of Napkins.—There are many instances of simple cases in accessible positions not of approximal surfaces, when the general flow of saliva can be kept under control by the saliva ejector, when it is not necessary to use a rubber dam. Also for children, when the teeth are too short to permit the correct application of the dam, it is necessary to find other means to control the moisture. Here the reliance is upon napkins, and with them much skill may be displayed by deft operators. For this purpose the napkin should not be over eight inches square. The manner of folding is to carry two adjacent edges to the diagonal of the napkin, and then fold again in like manner; by this plan the folds are held in place.

Strips of "bird's-eye" linen of various lengths and widths are also serviceable for simple cases and for children.

To apply a napkin to the *upper right side*, the point is taken between the left index-finger and the thumb, the broad end being held at the same time by the right hand. The lip near the right commissure is everted, the point is inserted here, and by the taut action of the left hand the napkin is next laid between the gum and the lip. It is then carried backward until it reaches the duct of Steno, when the left index finger is applied to maintain the compression at this latter point. The free end of the napkin lies upon the lower lip. For the left side the action is the same by the reversal of the hands.

For the *lower teeth* the application differs by commencing for each side at the upper canine of that side. When the duct of Steno is reached a fold is made to effect the compression of the orifice of the duct, then the napkin is laid between the cheek and the lower teeth and kept in position by the left index finger, a mirror, or a cheek-holder.

An important preliminary to the application of a napkin to these positions is that the saliva ejector be first placed in action and that the surfaces of the gum and cheek be wiped to dryness, to cause the napkin to cling to the surface. If the surfaces are covered with mucus and at the same time are wetted with saliva, the napkin easily becomes displaced.

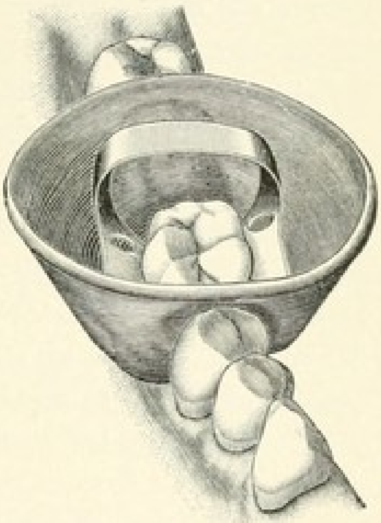
For the *inner surface* of the lower teeth a considerable fold of cottonoid or similar substance laid beneath the tongue materially prevents access of saliva here, and also, by preventing the contact of the tongue with the teeth, lessens the opportunity for the access of moisture by capillary attraction between the tongue and the teeth under treatment. In instances where the form of the parts permits, the fold of cottonoid or of linen may be retained in place by a dam clamp upon any adjacent posterior tooth.

For the medication of cavities where it is important to confine the remedy to the tooth ; in short operations, such as temporary stoppings, and particularly for the simpler

Fig. 219.

The Denham shield.

Fig. 220.



Shield in use.

cases of children, the Denham coffer-dam shields shown in Figs. 219, 220 are of much advantage, more particularly for the lower teeth. With these the ejector forms a valuable aid.

NAUSEA.

The contact of rubber dam with the tongue and the contiguous parts, the presence of napkins, and the touch of the fingers to the oral surfaces frequently excites *nausea*. With some persons this kind of distress is extreme and produces simulation of faintness and nervousness. This condition may generally be relieved by the use of *aqua camphora*, a few drachms being used as a gargle to the mouth and the throat. When indications of faintness appear a drachm may be swallowed with immediate benefit.

In case excessive nausea is occasioned by the contact of the appliances with the tongue or palate, these surfaces may be painted with tincture of camphor. Spasmodic coughing, not infrequent with nervous persons, yields to the same treatment. Camphor appears to relieve in these instances by its antispasmodic power, and it is stated to have also a specific action upon the eighth pair of nerves.

Nervousness coming on during any of the operations upon the teeth may as easily and in the same manner be avoided. It will be observed that in neither of these conditions are the first signs of approaching syncope apparent, viz. sighing respiration, pallor, and clammy perspiration of the face.

A condition somewhat simulating approaching syncope sometimes appears in connection with the use of the rubber dam, due to partially suspended respiration, which is caused not so much by the obstruction of the mouth as by the unpleasant sensations occasioned by the application and presence of the dam. This may at once be overcome by requesting the patient to breathe deeply through the nose.

CHAPTER X.

THE SELECTION OF FILLING MATERIALS WITH REFERENCE TO CHARACTER OF TOOTH STRUCTURE, VARIOUS ORAL CONDITIONS AND LOCATION, DEPTH OF CAVITY AND PROXIMITY OF THE PULP—CAVITY LINING, WITH ITS PURPOSES.

By Louis Jack, D. D. S.

The general object in view in the filling of a prepared cavity is to secure the future preservation of the tooth at that part from the recurrence of caries. This involves a consideration of the *character of the material* to be used, in relation to its adaptability to the conditions of age, the quality of the teeth, and the oral conditions which for the time are an expression of the general state of the organism. The habits of the patient as to general care of the teeth also have some bearing upon the probability of permanence of the reparative operation. A material adapted to preserve the teeth when they are of resistant quality and when the general health is sound and the care good, may be out of place when the opposite conditions exist. Methods of procedure have some bearing upon the result, and the influence of these has also to be kept in view.

The general characteristics of the material to be used as a preservative of tooth structure are of importance in the following order:

Resistance to chemical action;

Capability of adaptation to the surface of the cavity;

Sufficient hardness to withstand the force of mastication and the consequent attrition.

Capability of form and smoothness are also important in relation to cleanliness, which more than any other indirect influence has the greatest bearing upon the preservation of the margins from subsequent softening, as will further appear.

The Materials.

The various accepted materials in use are: gold, tin, amalgams, the basic oxid cements, gutta-percha.

The first three named may be designated as permanent in their character, and the others as of a temporary nature, which, after fulfilling important uses in this way, are often preparatory to later and permanent treatment.

Gold.—The properties of gold which adapt it for the restoration of carious teeth are its pliability and softness, which permit its adaptation to the form of the cavity; its tenacity, which gives facility of introduction and consolidation; and its agreeableness of color, which, when the surface is solid, smooth, and unburnished, approaches more nearly the shade of the teeth than any other metal.

Notwithstanding these appropriate qualities the packing of gold requires the employment of considerable force to overcome various resistances to its adaptation and solid condensation. To effect the requisite degree of density percussive force frequently becomes necessary. The effect of percussive force, if employed throughout, is liable to be expended on the margin toward which it is directed, and while this may not inflict any injury upon the borders of cavities when the dentin and enamel are dense, it often proves injurious to teeth when the anatomical elements of the structure are not homogeneous and resistant.

While it may be stated with the strongest assurance that gold possesses the highest preservative qualities and promises greater durability and more satisfactory results than any other material, conditions are often presented when to persist in its use would lead to unsatisfactory results; thus, in the approximal cavities of the teeth of children, when the calcifying process has not become complete and when by the use of the required force some impairment of the incomplete tissues is almost certain to ensue. The same maladaptability occurs later in life when senile conditions have set in, when the teeth not only have lost their density from the peculiar molecular changes which take place in the dentin and enamel, but when usually also their resistance to chemical influences is greatly impaired. These conditions, coupled with the usual inability to properly care for the teeth, render the use of gold very questionable.

Similar states of the dental tissues take place in middle life in both sexes, but more particularly in women during the pregnant state, when the teeth lose their resistant power, which may later be restored. While this condition lasts, materials requiring less force should be selected until restoration of resistance has occurred.

The mode of effecting percussion should be taken into account in estimating the influences which bear against the use of gold. When percussion is effected by the electro-magnetic instruments with proper precautions with respect to the placement of the first portions of gold, there is less danger of marginal injury than when percussion is made with the hand or the automatic mallet.

Finally, the fact must also be recognized that in cases in which the character of the structure of the teeth raises a question as to the adaptability of gold, the physical and nervous resistance of the patient is generally below that which would enable him to endure the ordeal connected with the thorough completion of the work in harmony with the high standard impressed by the continued advancement which has taken place in dentistry.

The *tendency to caries* of the teeth is a general consideration to be held in view in determining the propriety of employing gold. When the enamel is hard, the dentin solid, and the general tone of the health excellent, there can be no doubt that the inherent qualities of gold constitute it the most nearly permanent material. When, on the contrary, the opposite conditions exist, gold becomes, in proportion to the prominence of the unfavorable states present, the most questionable material.

No correct conclusion, however, can be reached without consideration of the state of the oral secretions and of the habits of the patient as to the care taken of the mouth. The first stage of decay of the teeth is the softening of the enamel, which is brought about as the consequence of the presence of carbohydrates undergoing fermentation in secluded positions, which effects the solution of the enamel at these places and prepares the way for the occurrence of caries of the dentin. Hence a correct hygienic condition of the mouth is the most important requirement for the protection of the margins of the tooth adjacent to fillings intended to restore them.

The *reaction of the oral secretions* in their bearing upon the permanence of dental operations has also much weight, since, when these secretions have an acid reaction, as the consequence of the presence of fermenting material, this condition favors the continuance of the process. A continual acid state of the oral fluids, as a consequence of derangements of health such as occur in impaired digestion or attend the rheumatic diathesis, should be taken into account. Only an appreciable degree of *alkalinity* can inhibit enamel solution unless the general and local hygienic conditions are favorable.

Tin.—This metal, in the form of foil, shavings, and rolled into thin strips, while not in much use, should have a wider field than is accorded it. It possesses great softness, when chemically pure, and is readily adapted to the walls of cavities for the reason that it presents less resistance since it does not harden under the mechanical force employed. For the same reason, when the cavity is overfilled, the condensing appliances effect by the lateral movement of the mass a better and more easily procured adaptation with the cavity walls. For these reasons it possesses excellent preservative qualities.

Tin is also a poorer thermal conductor than gold, and this is an important consideration when thermal irritation is to be avoided, and is of great value in deep cavities approaching dangerously near to the pulp.

The objections to this metal are its color when exposed to view and its softness, which greatly lessens its value in positions where it may be subject to severe attrition.

Its most important use is for the temporary teeth of children, where it may be easily inserted and readily condensed, and rapid progress in its introduction may be made, producing good results.

Except when freshly prepared, tin is not cohesive, a quality which cannot be restored by heat, as may be done with gold.

AMALGAMS.

Their Composition.—The essential metals which enter into the composition of the dental amalgams are **silver, tin,** and **mercury.** To these are added various metals in varying proportions to modify the "setting," the color, and the affinity for sulfur compounds. For these purposes gold is used to influence the rate of chemical combination, and it also affects the color. Zinc and copper are added in order to modify the shade and also to lessen the affinity for sulfur.

The effect of various proportions of the metals entering into the formulas upon the working qualities of an amalgam is extremely puzzling; slight differences in proportions causing widely varying results.

The order in which the metals are introduced into the crucible and the degree of heat to which the mass is subjected in the fusing process also affect the working qualities.

The Proportion of the Ingredients.—Valuable tables have been given by Dr. Black which indicate that a nearly definite ratio between the silver and tin should be maintained. This ratio is found to be approximately as follows—Silver 65, Tin 35—when only these two metals are used to make the alloy. Whatever addition of a modifying metal is introduced should be of small quantity and at an equivalent reduction of the percentage of the tin.

The ingot of the alloy should be finely divided either by filing or by thin shavings made by turning them off in a lathe. When the comminution of the alloy is made immediately before using, amalgamation is more easily effected than when the filings are kept for any considerable time, unless in the latter case there is a disproportion of tin or gold. This has been attributed to oxidation of the particles taking place, which would retard the amalgamation. Silver not being an oxidizable metal under ordinary conditions, the cause of the tardy combination with mercury is to be found in the attachment of sulfids to the surface, and also to the influences of occluded gases, which also tend to retard amalgamation. It is a notable fact that while freshly comminuted alloy will more readily amalgamate, it requires more mercury than aged alloy.

More recent investigations by Dr. Black tend to the conclusion that the difference in capacity for mercury observed in freshly cut alloy and that which has been cut for some time is due to the difference in molecular arrangement of the alloy, brought about by the comminuting process, which has the effect of hardening the grains and condensing their texture in the same manner that hammering the ingot would harden the entire mass. By the application of sufficient heat the particles of alloy may be "aged" artificially, and this aging is presumed to be simply an annealing process. The capacity of the aged alloy for mercury is markedly different from that of the freshly cut alloy, as are also the working qualities of the resulting amalgam mass, the aged alloy forming a slower setting and much smoother working amalgam than that made from freshly cut alloy. For the further details of this subject see Chapter XIII., on Plastic Fillings.

It is held by many that the proportion of mercury should be in some excess, to give decided plasticity to the mass for the purpose of securing complete amalgamation of the particles of the alloy. When the amalgamation is complete the redundance is forced out through chamois skin, or the mass is kneaded in a napkin or piece of China silk, which forces through the meshes most of the excess. It is claimed that this method of conducting the amalgamation effects an approximately correct atomic relation of the metals with each other; it being held that the freer proportion of mercury during the mixing process tends to this result, as the redundant metal is carried out with the excess of mercury as it is expressed. On the other hand, it is maintained that the proportions of any given alloy and mercury which will produce an amalgam fulfilling every requirement should be established by experimentation, and thereafter be weighed out in those proportions.

The Distinguishing Features of a Good Amalgam.—An amalgam (1) Should be non-shrinking; (2) Should have edge strength; (3) Should maintain lightness of color under the varying oral conditions; (4) Should tend to assume a spheroidal surface. A further qualification is that the surfaces of the material may not undergo electrolysis.

Indisposition to shrinkage is secured by a close conformity of the alloy with the proportions above given.

Edge strength is a term which has not as yet had a clear definition in respect to the causes which determine the deficiency of this quality. The maintenance of unchangeability of the surface is directly related to this important desideratum, as roughening and erosion of the margins is the result of molecular waste, which causes a ragged and unclean appearance of the edges and an apparent separation of the filling from the borders of the cavity. The causes which produce this condition are slowly progressive and are continuous.

This kind of erosion is most marked when contraction takes place, from incorrect preparation or improper ratio of the metals entering into the formula, or careless manipulation, when capillary defects are liable to occur at the margins.

The most probable hypothesis to account for these observed changes is that the presence of moisture having acid reaction, by inducing electrolytic action between the metals, brings about the erosion of the material immediately within the margins. In these cases the exposed surfaces generally suffer little waste, for the reason that they are subject to the continued movement of the oral fluids, but it is often observed that entire fillings undergo a similar gradual loss and disappear. This result is common where there is an excess of gold or mercury. In some instances the above described action takes place to a limited degree upon the whole surface in proximity with the dentin, when a residue is found upon the filling as well as on the surface of the dentin.

The conclusion from these observed facts is that the securement of edge strength depends upon an approximation to the chemical ratio of the elements of the alloy. This would appear to be most nearly secured when the material is subject neither to shrinkage nor expansion. Expansion under some circumstances might produce marginal space and therefore lead to the same result; for instance, if in approximal or buccal cavities the depth were greater at one division than another the expansion of the thicker part of the filling would tend to raise the edge surrounding the shallow part of the cavity, and would then subject the edge of the filling to electrolytic changes.

A related condition sometimes appears when an amalgam filling, quite hard at completion, after some years becomes comparatively soft, which apparently is due to molecular changes.

The close conformity of the alloy to the proportions recently established by Black, and foreshadowed by the much earlier experimentation of Flagg, furnishes a result that is directly conducive to fixity of form and edge strength when the margins of the cavity are overlapped.

This formula is approximately—silver, 68; tin, 26; copper, 5; zinc, 1.

The maintenance of size, form, and strength depends largely, if not entirely, upon the influence of silver. When the proportion of this element becomes less than 60 per cent. of the formula, the tendency to shrinkage appears and holds a nearly direct relation with the diminution. When the ratio of silver advances above 70 per cent. the expansion becomes marked, and at 80 per cent. is excessive.

Lightness of Color.—The means by which this property may be secured have not as yet been well determined and should be the subject of extended experimentation. Some of the so-called white alloys approximate stability in this respect, but the ratios of the modifying metal have not been accurately determined.

Amalgam as a filling material is adapted to *large cavities in the posterior teeth* when the margins are too frail to permit gold to be condensed; for positions where mechanical force cannot be exerted with efficiency, notably the cavities of the third molar; distal cavities of the second molar when of large size; and the lingual cavities of the lower molars. When the teeth are of deficient resistance and when the condition of the oral secretions favors the rapid progress of caries these limitations may be extended to cavities where otherwise gold would appear to be a more suitable material.

As a material for the filling of the *deciduous teeth* amalgam possesses superiority over any other substance, for the reasons that it can be introduced with less effort than tin and has greater durability than either the mineral cements or gutta-percha preparations; the exception to its use here being when the conditions prevent retentive formation of the cavity.

Concerning the *form of the cavity* adapted to amalgam, it is necessary that the retentive formation be equally exact as for gold, since many of the formulas in use undergo slight movement for some time after their introduction, during which there is liability of marginal displacement which may lead to the defects treated of under the section concerning "edge strength." Amalgam, while presenting in its appearance an unfavorable comparison with gold, is capable of rendering important service when every consideration is given to the requirements governing its successful employment.

To attain the best results in the use of the amalgams requires extreme exactness as to the ratios of the ingredients and great care in all the procedures connected with the formation of the cavity, the form of the filling, and the subsequent finishing process.

The *disqualifications* of amalgam are its unsatisfactory color and the unknown character of the composition of the formulas as furnished by the depots of supply.

THE MINERAL CEMENTS.

Oxychlorid of Zinc.—This material, because of its lacking the quality of indestructibility, is contraindicated in all exposed situations. It possesses, however, a considerable degree of antiseptic power, and for this reason renders valuable service in deep cavities not nearly approaching the pulp, or even here when the pulp wall of the cavity has been previously protected by a layer of gutta-percha or a disk of asbestos paper. In such cases, particularly on occlusal aspects, the cavity may be nearly filled, leaving a remainder the thickness of enamel to be completed with gold.

For the filling of root canals and pulp chambers it offers the best solution of the problem of preventing septic changes in the devitalized dentin. After many years, fillings of root canals and pulp chambers of this material remain unchanged and are found clean and without odor on removal—a result that is not presented by any other filling material which may be introduced in these situations. Here it is important that the material be not mixed very thin, especially on account of the danger of forcing it through the apical foramen.

A further use of this substance is to influence the shade of devitalized teeth by the color tone it imparts to the crown of the tooth on account of its whiteness. This is enhanced by the fact that it comes into exact contact and remains without change, a quality which cannot be given to gutta-percha or other cements.

As a temporary filling to correct extreme sensitivity of dentin in situations or under conditions which forbid ordinary therapeutic treatment, oxychlorid of zinc has considerable value. Here when the pulp is not closely approached it may be retained for several months with considerable advantage. To secure the best results the proportion of zinc chlorid should be slightly greater than in the formulas used for ordinary fillings.

Zinc Phosphate.—This material, because of its greater power to withstand the influence of the oral secretions, has a wider use than the previously described cement. It cannot, however, be depended upon for permanent uses. While in some instances it may remain for several years when the oral fluids are neutral and when every attention is given toward the attainment of cleanliness, it is nevertheless a deceptive substance, since it is liable under temporary changes of the secretions to undergo solution, more particularly in situations near the gum. When placed in approximal cavities it is extremely liable to become fissured at the cervical margin and then permit carious action insidiously to take place.

Unlike oxychlorid of zinc, the phosphate has no antiseptic influence, hence it does not inhibit decay of the dentin in its proximity. Its chief use is as a temporary expedient for filling cavities on labial and buccal surfaces, where, being under easy observation, it may be used with benefit. On account of its chemical solution by the oral secretions, however slow this may be, it requires frequent renewal.

Zinc phosphate is also of value for filling the principal portion of large compound cavities where the teeth would be injured by the force employed in the condensation of gold, and as a desideratum to avoid the great amount of time required to fill large cavities with this metal. It also here imparts in some instances much strength to frail margins.

In the cavities which early form upon the occlusal surfaces of the permanent molar teeth of children it is of great value, as here it is kept clean by the friction of mastication, and being under easy observation can be renewed when this is required. When the child reaches the age to have permanent operations the margins may be shaped for the retention of gold, and in this case the principal part of the cement should be allowed to remain.

Zinc phosphate is of questionable use in pulp chambers as not having antiseptic properties, and being porous it becomes after several years quite offensive. For the same reason it is inadmissible for canal fillings. Furthermore, for this purpose it is questionable, on account of its adhesiveness, whether it is capable of being thoroughly introduced into root canals. All things considered, it is for these purposes greatly inferior to oxychlorid of zinc.

Gutta-percha.—Compounds of gutta-percha with oxid of zinc form a useful substance for temporary fillings, acceptable for teeth of low grade at points not subject to attrition. Its preservative properties are very considerable, and were it not subject to surface degeneration would in the situations noted be a nearly permanent material.

The requirements for its successful use are that it be not heated higher than 212° F., that the cavity be quite dry, that it be introduced in small pieces, and be *kept under continual condensation until cooled* to prevent shrinkage. (See Chapter XIII.)

Cavity Lining in Respect to Proximity of the Pulp.

As caries approaches the pulp it reaches a period when the proximity of this organ is so close as to require much care to avoid irritation and probable congestion. Under these circumstances it is necessary to avoid thermal conduction and to exclude chemical influences. After disinfection of the dentin some substance the ingrediency of which is non-irritating and non-conducting should be selected to overlay the pulp wall of the cavity. Here choice must be made between gutta-percha and either of the classes of mineral cements.

When the use of gold is preferable for the external portion of the filling, it is required that the foundation be sufficiently solid to withstand the force to be applied to the gold. Hence one of the cements is here necessary. Previous to the placement of the cement, should the pulp be near, the surface should be covered with a thin solution of one of the resins to prevent the influence of the fluid element of the cement from producing irritation. Copal ether varnish, a solution of hard

Canada balsam in chloroform, or the solution of nitro-cellulose in amyl acetate sold as "kristaline" or "cavitine" are effective materials for this purpose. When the cavity is deep the layer of cement should be brought to the inner line of the retentive grooves. As soon as hardening takes place the metallic covering may be given.

When the shallowness of the cavity will not permit a considerable layer of the cement, a metal cap covering the pulp wall of the cavity filled with the cement may be laid in place, the metal of the cap thus sustaining the force.

These forms of cavity lining are of great utility, and should be regarded as of importance.

Marginal Cavity Lining.—When cavities are situated on approximal surfaces of the teeth and extend high up on the cervical aspect so as to place them beyond the probability of efficient service with metal foils, and when the lateral walls of cavities are weak either by their thinness or by instability from defects of structure, some form of "lining" is necessary. In the one case, to ensure certainty of performance at the cervix; in the other, to prevent injury.

For the cervical part the choice is between (1) *tin*, (2) a combination of *tin and gold*, and (3) *amalgam.*

Tin has the objection when superimposed above gold that it suffers waste, in most instances by electrolysis, to which the mixture of tin and gold is not liable. This latter combination—made by folding a layer of the tin within the gold foil—appears to give the tin protection. This combination is more plastic and more yielding than gold alone, and permits adaptation and consolidation in places difficult of approach. When used in connection with a matrix thorough consolidation may be effected without injury to the cervical margin when the tissues are not dense.

When the color of a lining at the cervix will not be objectionable, a quick-setting amalgam answers extremely well, and may at the same sitting be followed by the completion of the operation with gold. In this situation, whatever the lining material, close conformity with the lines of the cervical form of the tooth must be assured. In many instances the lining and the completion of this portion of the filling should be effected before the rubber dam is placed, when the lining portion is for the time being considered in its relations as a part of the tooth.

When it is necessary to use the mineral cements on approximal surfaces of the posterior teeth for temporary purposes, the cervical border should be covered with a line of gutta-percha stopping, to protect this vulnerable part of such fillings from the exposure of this border by the solution to which they are there liable.

Lining Lateral Walls.—For this purpose choice should be made of *zinc phosphate,* since it has the required strength and enters into the necessary adhesive union with the margins to give the required security. The layer should be kept within the extreme outer border of the cavity, to permit the metal filling to overlay the margin of the enamel. When the cavity is deep the retaining groove may be formed in the cement.

A general summary of cavity lining is, that this procedure is required in proportion to the difficulty of effective approach, and for the safe treatment of teeth below the average of structural quality.

CHAPTER XI.

TREATMENT OF FILLINGS WITH RESPECT TO CONTOUR, AND THE RELATION OF CONTOUR TO PRESERVATION OF THE INTEGRITY OF APPROXIMAL SURFACES.

By S. H. Guilford, D. D. S., Ph. D.

The treatment of a cavity of decay by filling must have a twofold object in order to subserve its best purposes: first, the restoration of the affected part to a healthy condition; and second, the prevention as far as possible of a recurrence of the lesion.

The first is accomplished by the removal of all disintegrated tissue and the perfect filling of the cavity with a suitable and durable material. The second demands for its success a proper understanding of the character of the surfaces operated upon and their mechanical and physiological relations. While the simple filling of a cavity, if properly done, will generally prevent the extension of decay on exposed surfaces, the same operation on surfaces less favorably situated may utterly fail to subserve the desired end.

The contiguity of the approximal surfaces of teeth greatly favors the retention of food and the harboring of micro-organisms, while at the same time it prevents the free cleansing movement of saliva between them. For these reasons such surfaces, though originally perfect in their continuity, are attacked by caries more frequently than any others, except the occlusal surfaces where continuity is broken by fissures and pits. When once affected by caries, their restoration by filling is difficult owing to their inaccessibility, and while the operations on this account often lack the perfection that would otherwise be secured and the fillings consequently fail, the recurrence of decay is more largely due to the same influences that brought about the initial lesion.

This being the case it is obvious that the original conditions must be changed if immunity from future decay is to be expected. This principle was early recognized and the first attempt to alter the conditions was by filing or cutting the approximal surfaces so as to free them from contact, on the principle of "no contact, no decay." Where all of the teeth were thus separated immunity from decay was generally secured, although at the cost of great loss of masticating surface, much disfigurement, and subsequent serious injury to the gum and pericementum.

Where only an occasional space of this character was made, the operation proved a failure because in a short time, through the pressure of adjoining teeth and altered occlusion, the mutilated teeth would again be brought into contact and the opportunity for decay be increased a hundredfold. With the recurrence of decay, cutting or filing would again have to be resorted to until but little of the teeth remained, and they were eventually lost. On account of its unfortunate results the method was for a time abandoned, but in 1870 it was revived in a modified form through the teachings and writings of Dr. Robert Arthur. His method consisted in altering the form of the approximal surfaces of teeth by filing or grinding so as to change the point of approximal contact from near the occlusal surface to near the cervical margin. This not only changed the normally convex approximal surface into a flat or plane one, but was also supposed to free it from further liability to decay by preventing the retention of food débris and rendering the surfaces and spaces "self-cleansing." The method was measurably adopted by numbers of conscientious practitioners as a means of obviating a difficulty hitherto unsuccessfully combated. In a short time, however, it was discovered that its promise of success was not being realized, and it was also gradually abandoned. Its failure was due to its being wrong in principle, for, while it seemed to offer temporary relief, its after results were most disastrous.

By leaving a shoulder near the cervical margin the point of contact was simply transferred from one point to another with the result that the latter point was far more liable to caries than the former one, owing to its position. More than this, the exposed dentin on the cut surfaces, lacking the natural protection of the enamel covering, was apt to be sensitive, and the food crowding into the space and pressing upon the gum rendered it hypersensitive and eventually caused its recession. The discomfort following this unnatural operation, together with the increased liability to decay resulting from it, were sufficient to condemn the method and cause its abandonment.

These failures to secure freedom from decay by an unnatural alteration of the forms of approximal surfaces led to a more careful investigation of the causes responsible for its recurrence on these surfaces, and the gradual adoption of more rational and scientific methods for its prevention. It was apparent to even the most casual student of comparative dental anatomy that the number and kinds of teeth found in the jaws of man, their arrangement in the arches, and their general form were all such as to best subserve the wants and needs of the individual, but the more minute points of their external anatomy, their interdependence and relation to one another, and the part played by the fluids of the mouth in the causation of caries under both original and changed conditions, had not previously been carefully inquired into. Under the old belief that contact caused decay it was thought that decay upon approximal surfaces always began at the point of contact and that this was due to the fermentative changes occurring in food débris retained at this point. Investigation proved, however, that the points of contact between teeth were not only free from decay, but more or less polished from slight motion of the teeth in their sockets, and that approximal decay always began just above the contact point, that is, slightly nearer the gum; also that it could occur nearly as readily without the presence of food as with it.

It was further noted that the normal contact of teeth on their approximal surfaces, which was formerly supposed to be essential only for mutual support, was equally necessary for the protection of the tender gum tissue from injurious pressure of food in mastication.

Finally it was observed that those portions of the crown of a tooth that were beneath the gum margin or those above it that were constantly covered by saliva (as on the approximal surfaces near the gum) were always free from the beginnings of decay, and that the approximal and buccal or lingual surfaces, when faultless in structure, were first attacked by caries on a line corresponding with the point to which the fluids of the mouth usually rose. An explanation of this peculiarity was soon found in the fact that the saliva is usually alkaline and consequently protective of the parts covered by it, but at its surface, in a state of rest (as in sleep), this condition of alkalinity is changed to one of acidity—the calcium salts are dissolved and decay is begun.

As a result of the foregoing observations and investigations it became apparent to the mass of conscientious workers in the field of operative dentistry: 1st. That the natural form or outline of each tooth was the best for its particular function, and that to materially alter it was to lessen its usefulness and hasten its loss. 2d. That contact of adjoining teeth was essential both to the comfort of the individual and the durability of the organs. 3d. That inasmuch as the teeth originally decay in spite of their natural form and contact, some plan would have to be devised by which, in their repair after decay, liability to a recurrence of caries would be greatly lessened if not entirely prevented.

To fulfill these requirements there was but one course left to pursue, namely, to fill approximal cavities in such a way as to restore the original contour of the surface, and, in all cases where the extent of decay was sufficient to warrant it, to extend the cavities so far over upon the buccal and lingual surfaces as to bring the enamel margins within the range of protective influences.

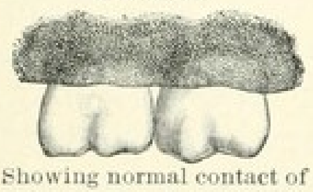
The rationale of original and recurring decay upon approximal surfaces is readily made apparent by considering certain facts and principles of physics.

When a tube is inserted in a liquid capable of wetting its surface the liquid will rise to a higher level within the tube than the surface level of the surrounding liquid. This phenomenon is known as *capillary attraction*, and is explained upon the principle of "surface tension of liquids." If, instead of a tube, two rounded or flat plates are immersed in the liquid, the same rising of the fluid between them will be noticed. The smaller the tube, or the nearer the two plates are together, the higher will the liquid rise.

Applying the principles governing these facts to the teeth and considering them as bodies immersed in a liquid (saliva), it will readily be seen that if the approximal surfaces of the teeth were parallel and close together the saliva would rise to a higher level between them and cover more tooth surface than if they stood farther apart, and being retained in this narrow space with little opportunity for motion the saliva would soon assume an acid character and destruction of the tooth tissue begin. This is exactly what takes place upon approximal surfaces made flat by filing, and will occur whether fillings have been placed in such surfaces or not.

Normally, however, the crowns of the human teeth are more or less convex upon their approximal surfaces and touch each other only at the point of their greatest transverse diameters, which is near to and just above the occlusal surface. From this point their diameters gradually become less until they reach the cervical border, where they are smallest. This leaves a triangular interdental space with the base of the triangle at the gum, as shown in Fig. 221, in which the saliva will rise but a short distance owing to the separation near the gum and the consequent lessening of the capillary attraction. For this reason teeth preserving their normal forms are less liable to approximal decay than they could possibly be under any other conditions.

Fig. 221.



Showing normal contact of teeth.

The earliest treatment of approximal surfaces with a view to the prevention of caries consists in gaining access to them by wedging, and if found to be superficially affected by caries the removal of the injured structure and the perfect polishing of the surfaces.

When cavities of moderate size are discovered they should be carefully prepared and filled, preserving the original contour as far as possible. Decay may recur, but it is less likely to do so with advancing age, increased density of tissue, and proper prophylactic treatment.

Where the decay is of larger extent, however, we have it in our power to make such physical change in the parts affected as to render future immunity from decay reasonably certain.

First, it is necessary to separate the teeth well by wedging, to so enlarge the cavities as to bring their lateral margins well out upon the lingual and buccal surfaces, and to extend the cervical margins of the cavities down to or beneath the free margin of the gum.

Next, the fillings must be carefully inserted, built out to fully restore the original contour, and most perfectly finished. When this has been done and the teeth have returned to their former positions the approximal surfaces will be in a better condition to resist the influences of decay than they originally were, for any changes in the character of the saliva cannot affect the gold, and while the cervical border of the filling is protected by being constantly covered by saliva the lateral borders are so far out upon their respective surfaces as to be subject to the cleansing influences of the lips and tongue.

In addition to this, and scarcely less important, the restoration of contour on the approximal surfaces affords normal protection to the tender gingivæ by preventing the lodgment and pressure of food upon them.

The contour method of filling, based as it is upon physiological, anatomical, and mechanical principles, has become the accepted method of operating. Experience has proved it to be the only rational method of treatment of approximal surfaces, for by it we secure all the desirable conditions of preservation of the natural outline of the teeth, necessary contact, immunity from future decay, and protection of the gum margins. Its practice involves some sacrifice of healthy tooth structure along the buccal and lingual aspects, as well as greater expenditure of time in filling and finishing, but the results compensate for both of these.

To properly perform the operation of filling and restoration of approximal contour requires not only manipulative skill of a high order, but also an artistically trained eye in order that the restoration may in all respects correspond both in extent and form to the original outline of the tooth; both of these requisites will be acquired through frequent repetition. In certain cases, as where the teeth originally were not quite in contact, the contour may be advantageously exaggerated in order to close the space, but it should never be less than normal or the result will not be satisfactory.

In the filling of an approximal surface next to a space, as where a tooth has been lost, the necessity for full restoration of contour does not exist and is not absolutely demanded, although a more artistic result is secured by its performance in all cases.

CHAPTER XII.

THE OPERATION OF FILLING CAVITIES WITH METALLIC FOILS AND THEIR SEVERAL MODIFICATIONS.

By Edwin T. Darby, D. D. S., M. D.

In the selection of a filling material the operator should consider the character of the secretions of the oral cavity, the position of the tooth to be filled, the extent of the diseased area, the physical structure of the tooth, and the strength of the cavity walls. A filling material must possess certain inherent qualifications, the most important of which are adaptability, indestructibility, non-conductivity, hardness, absence of shrinkage, harmony of color, and ease of manipulation. All of these are not to be realized in any one material, and yet some of the more important are to be found in a single metal or in a combination of metals.

Lead possesses the quality of softness and is easy of adaptation but is readily oxidized when exposed to the air or the secretions of the mouth. Likewise *tin* possesses characteristics, such for instance as ductility and softness, low conducting power, and the ease with which it may be manipulated, which place it in the front rank as a preservative of carious teeth, but it is inharmonious in color, and its very softness, which is so desirable in manipulation, is an obstacle to its use upon surfaces where there is much attrition. The *zinc phosphates*, which are composed of zinc oxid and phosphoric acid in solution, form a combination which at first attracted the favorable attention of the dental surgeon as possible substitutes for metallic foil fillings. They possess, owing to their plasticity, ease of manipulation, harmony of color, comparative non-conductivity, and absence of shrinkage, many desirable qualities, but are lacking in one essential qualification, namely, indestructibility.

Gold.

Gold, which has been used for about a century, has fulfilled in a more marked degree than any other material or combination of materials the requirements sought for in a filling for carious teeth. It has one or two objectionable features, such as high conductivity of heat and inharmonious color.

Too much stress cannot be laid upon the question of its purity if the best results are to be obtained from its use. While it is claimed by manufacturers of dental gold foil that their products are absolutely free from alloy, it is nevertheless true that but few specimens of dental foil show a fineness above 999. If this standard were always attained the operator would have little cause for complaint. So small a percentage of alloy as 1 in 1000 would not materially affect the working qualities of the product, but when this is increased to 4 or 6 parts per 1000 it manifests itself by harshness and intractability under the instrument.

Great care should be exercised in the preparation of the foil, since so much depends upon its purity and cleanliness. For a detailed description of the process of manufacture, from the ingot to the beaten and annealed foil, the reader is referred to an article by a practical foil-maker.[1]

In former times the dental surgeon was restricted to one form of gold for filling. This was foil ranging in thickness from 4 to 10 grains to the leaf, but as the requirements of the operator broadened the art of manufacture increased, and new preparations were offered, until to-day the most fastidious can find such as will please his fancy: foils ranging in weight from 4 to 120 grains to the leaf; cylinders of various sizes and composed of non-cohesive and semi-cohesive foil; cohesive blocks prepared for use; rolled gold, varying in thickness from No. 30 to 120, and crystal gold possessing great cohesive properties. These are the more important forms in which gold is offered the operator at the present time.

Before entering upon a description of the classes of cases where each of these seems best adapted, it may be well to describe somewhat in detail the peculiar qualities which each form of gold presents when subjected to clinical use.

Soft or Non-cohesive Foil.—Prior to 1854, when Dr. Robert Arthur discovered and promulgated the desirability of cohesive foil in certain cases, the operator used gold which possessed very low cohesive properties. Used as it then was, in the form of large rope, tape, or as cylinders, the property of cohesion would have been a serious objection, since there would be constant danger of the mass clogging and bridging in the cavity, and the cause of many unfilled places along the cavity walls.

The terms *soft* and *hard*, when used to designate the kind of gold, are misleading, since all gold foil prepared from pure gold or gold that is nearly pure possesses great softness under the instrument. The distinguishing characteristics between the two kinds of gold are the inability to make a certain kind of foil cohesive when exposed to a reasonable

[1] *American System of Dentistry*, vol. iii. p. 839.

degree of heat, and the ability to render another make of equal purity cohesive by the application of a similar degree of heat. It has been claimed by some manufacturers of dental gold foils that they are able to procure from the same ingot samples of non-cohesive, semi-cohesive, and extra-cohesive gold, attaining these physical properties of the material without alloying with other metals. This has led to the belief that, since absolutely pure gold possesses inherent cohesive properties, some metallic salt or other foreign substance has been deposited upon the surface of the leaf of non-cohesive foil which has the power of preventing the union of the surfaces of the foil when contact is sought. It has been surmised that a thin film of iron has been deposited upon the surfaces of the leaf of non-cohesive foil, for the reason that if a leaf of such foil be melted into a globule, it presents a reddish brown appearance, which is not true of the leaf of cohesive foil when melted as above.

Much of the so-called non-cohesive foil offered for sale is not, strictly speaking, of this variety, as the application of moderate heat will render it quite cohesive. It possesses the softness peculiar to pure gold foil, but it should not be classed with the variety which does not weld with other particles of the same metal except when subjected to great heat.

It has been claimed by some that non-cohesive foil has no place in dental practice—that any tooth which can be filled with gold may be filled with cohesive foil. This statement may be true in the main, but it is also true that many teeth having strong cavity walls can be just as well filled where a large portion of the filling is made with non-cohesive foil, and with a great saving of time. Adaptation, not hardness, constitutes the saving quality in cavity filling.

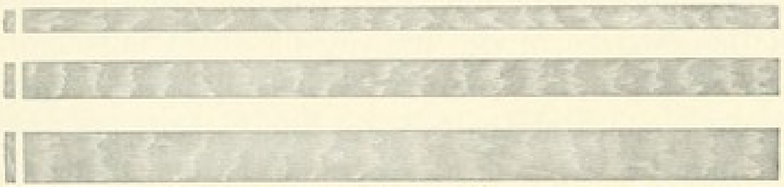
As most non-cohesive foil is prepared in the form of sheets and is placed in books containing one-eighth of an ounce, the operator is compelled to prepare it in some form suitable for introduction to the cavity. The size and shape of the cavity will be some guide as to the best method of preparing the gold. The narrow tape, the mat, the tightly rolled cylinder, and the roll or rope are the forms best adapted for the use of non-cohesive gold foil.

The *tape* is best made by taking one-half or one-third of a leaf of No. 4 or No. 5 foil, laying it upon a table napkin of medium size folded square as it comes from the laundry; the napkin is then taken in the palm of the left hand, and the foil spatula is placed in the middle of the piece of foil; the hand is then closed tightly, thus folding the napkin, likewise the foil, upon the sides of the spatula. This process is repeated until the tape is one-eighth or one-sixteenth inch in width (Fig. 222).

If *mats* are required, the foil may be folded twice or three times and then folded lengthwise upon itself until mats of any thickness are produced, as shown in Fig. 223.

When non-cohesive *cylinders* are desired, it is better for the operator to make them rather than depend upon the ready-made ones as prepared by the manufacturer, since these are usually loosely rolled and more or less cohesive. The tape is quickly made into the cylinder by rolling it

Fig. 222.



Tapes of gold foil.

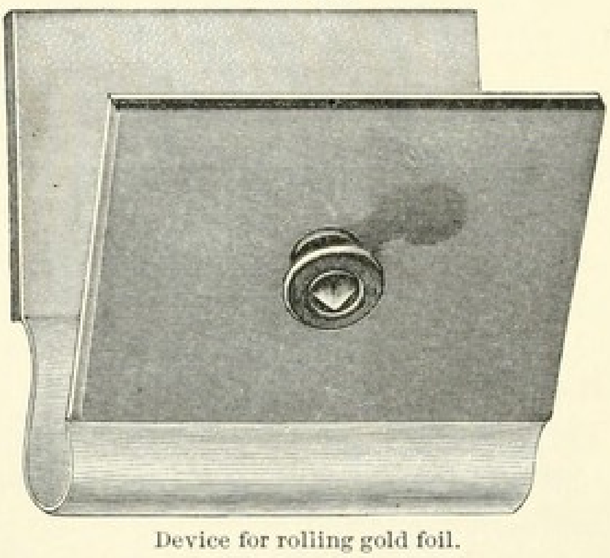
Fig. 223.

Mats of gold foil.

upon a five-sided broach to the desired size. The depth of the cavity is a guide to the width of the tape, and the width of the tape determines the length of the cylinder. These should be somewhat longer than the depth of the cavity. The manner of introducing and condensing will be described later when special cases are under consideration.

The *roll*, or "rope" as it was formerly called, is made in the following way: A leaf or half leaf or a third of a leaf of foil is rolled between the

Fig. 224.



Device for rolling gold foil.

thumb and finger until a roll of moderate density is obtained. As foil is contaminated by contact with the moisture and surface impurities of the hands, it is better to avoid such contact as much as possible. This can be completely attained by rolling it upon the little device shown in Fig. 224. Any operator can make one of these by taking two pieces of thin board, such for instance as the lid of a cigar box, and fastening to the two pieces with glue a piece of white kid about eight inches in length, and in width equal to the sheet of foil. Two little drawer-knobs of ebony should be inserted into the centre of each of the pieces of board. These act the part of handles for holding the appliance. The gold is then placed upon the kid strip between the two pieces of board, and by bringing the two surfaces of the kid in contact the foil is rolled between them. The undressed surface of the kid should be the one upon which the gold is rolled. Ropes thus made may be cut in lengths to suit the size of the cavity to be filled, and, as gold thus prepared has great softness and ease of adaptation, it may be inserted in quite large pieces if plenty of condensing force be applied to it.

Cohesive Gold Foil.—All gold which has been refined by any of the ordinary methods and is in a pure state may be said to be cohesive. Nor is absolute freedom from alloy an absolute necessity. It has been shown that softness is dependent upon purity, but a foil may contain quite a percentage of silver, copper, palladium, or zinc, and yet its cohesion may not be impaired. It may also be alloyed or combined with platinum and not lose its cohesive properties. It is, however, desirable that cohesive gold be pure, since the smallest percentage of alloy destroys its softness.

When two sheets or laminæ of freshly annealed foil are brought into contact and slight pressure is applied, they form a permanent union and are practically inseparable. It is this property in gold to which the term cohesive has been applied. But this property is soon lost by the occlusion of gases or impurities of any kind which may be deposited upon the surface of the gold.[1]

Experiments have demonstrated the fact that if the gold be subjected to the fumes of ammonia, hydrogen, hydrogen carbid, hydrogen phosphid, or sulfurous acid gas its cohesive property is quickly destroyed, but this property may be restored by heat except in the case of sulfur or phosphorus fumes. Hence the importance of excluding the gold as much as possible from the atmosphere, especially during the winter months when gases arising from the combustion of coal are most liable to be present in the operating room.

Dr. Black has shown that ammoniacal gas has the power to prevent the deleterious influence of other gases, and recommends that the foil be subjected to the influence of carbonate of ammonia by keeping it in a drawer with a bottle of that salt.

The *advantages* of cohesive foil cannot be overestimated. With its introduction in 1855 began a new era in the possibilities of saving carious teeth. Operations which were deemed impossible by the use of non-cohesive foil were made comparatively easy by the intelligent use of cohesive foil. The restoration of broken-down or badly decayed

[1] G. V. Black, *Dental Cosmos*, vol. xvii. p. 138.

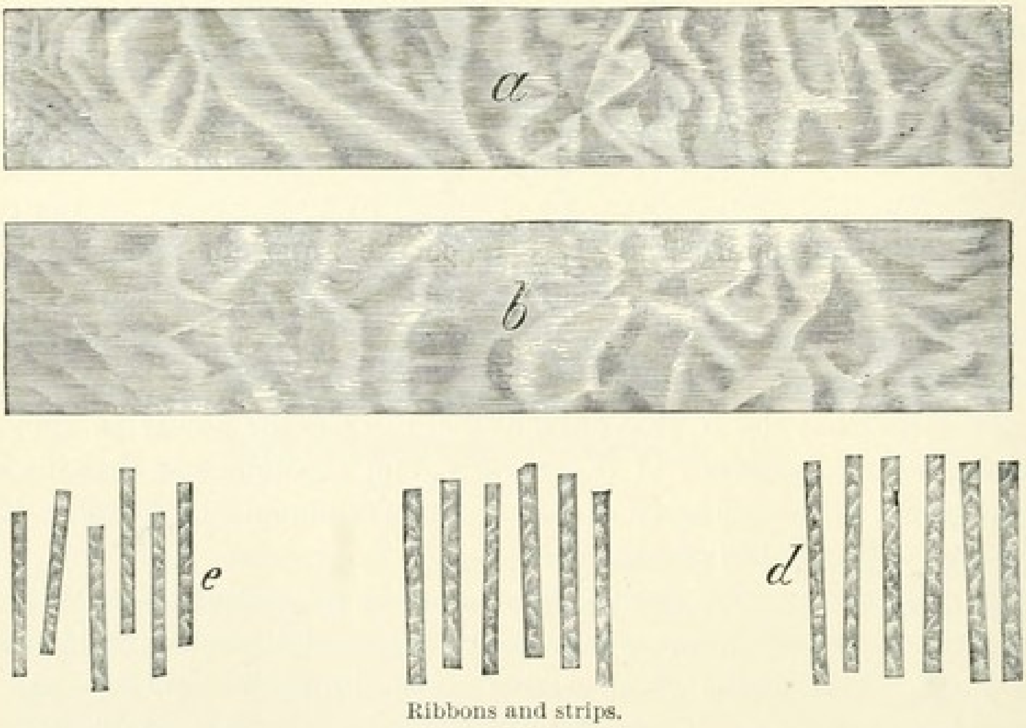
teeth became the common practice in the hands of the skillful, and modern methods of practice coupled with intelligent use of this form of gold have made it possible for the operator of modern times to do that which the earlier practitioner deemed impossible.

The beginner, however, must not lose sight of the fact that cohesive foil cannot be worked after the same methods as non-cohesive foil. To use cohesive foil in the form of mats or cylinders or in tightly rolled ropes would mean inevitable failure in adaptation. The very property which renders it valuable in the restoration of broken-down teeth and in surfacing is the one which would condemn it if used carelessly in the interior of inaccessible cavities. Non-cohesive gold may be introduced into a well-shaped cavity in large masses, and because of its softness and ease of adaptation may be made to touch all points of the cavity walls if persistent pressure be applied. On the contrary, cohesive foil should be introduced in small pieces, the first of which should be well anchored in a retaining pit or groove and each subsequent piece welded thereto.

There are several modes of preparing the beaten cohesive gold foil for the cavity, and good results are obtained by either of the following methods.

A loosely rolled rope made of a quarter sheet of No. 4 or 5 foil may be cut into lengths varying from one-eighth to one-quarter of

FIG. 225.



Ribbons and strips.

an inch, and after annealing carried to the cavity upon the point of the plugging instrument. Or a leaf may be folded with a spatula four times, making a broad ribbon, which may be cut either lengthwise or crosswise of the ribbon in pieces one-sixteenth or one-eighth of an inch in width (see Fig. 225). This is a very convenient manner of working cohesive gold. Or the heavier foil up to No. 20 or No. 30 in thickness may be cut in strips of a single thickness and of the widths above indicated, and after annealing may be packed into the cavity—the essential idea being ever in mind, that but a small quantity of the gold shall be under the instrument at a given time. Cohesive gold which has been rolled instead of beaten to the desired thickness is much prized by some. It has been asserted that greater softness is obtained when gold has been thus prepared. Such gold should not be more than No. 20 or No. 30 in thickness to insure the best results. It should be cut in narrow strips and after annealing be folded back and forth as rapidly only as each previous fold has been well condensed. Good results are only attainable if each lamina be thoroughly welded.

The loosely rolled cylinders and blocks which are prepared by some dealers and offered as cohesive gold are usually but slightly cohesive, and if used in this form, without re-annealing, may be packed in the interior of cavities without danger of clogging, but if freshly annealed they are contraindicated, since there is more or less danger of imperfect union of all particles of the gold. It is questionable whether the larger sizes are admissible when the filling extends beyond the cavity walls and great solidity is an essential factor.

Crystal Gold.—This form of gold was introduced by Mr. A. J. Watts in 1853, and as prepared at the present time is one of the best preparations of cohesive gold. When first brought out the method of manufacture was faulty, since it was difficult or impossible to rid the spongy mass of nitric acid which was used in its preparation, but since Mr. Watts adopted electrolysis instead of chemical precipitation the objectionable features no longer exist. Gold thus prepared manifests great cohesive properties, and when used with care as beautiful operations can be made with this gold as with any form of cohesive foil. The operator should not lose sight of the fact that the gold is to be introduced into the cavity in small quantities. Should failure attend its use, it would doubtless be from the attempt to introduce it too rapidly. Gold of this variety comes in bricks containing one-eighth of an ounce each, and is either torn apart in irregular-shaped pieces or cut by means of a razor into small cubes. This gold should be excluded as much as possible from the atmosphere and when used should be well annealed, although when recently made it is quite cohesive. There is no preparation of gold better adapted for starting fillings in shallow or irregular cavities, or for surfacing fillings. Many operators make use of it always for starting and for finishing fillings.

Crystal Mat Gold.—This is another form of crystal gold, and differs from that previously described in that it presents a more compact form, the crystals appearing smaller and matted together. It breaks and crumbles under the instrument to a greater degree than the other, and possesses no desirable qualities which the other has not. If it has any merit it is for finishing the fillings upon occlusal surfaces, or such surfaces as are easy of access, or it may be used in conjunction with amalgam.

Gold and Platinum.—This form of gold has found much favor with many practitioners for the restoration of incisal edges, or where for any reason great hardness of surface is desired.

An ingot or bar of pure gold and one of platinum are "sweated" together and then rolled to the desired thinness, usually about that of No. 20 or No. 30 foil. It is then cut into narrow strips, freshly annealed and used after the same manner as heavy foil. The commingling of the platinum with the gold gives the filling a tint more nearly the shade of the tooth, and for this reason it is much used upon labial surfaces and in mouths where the teeth are much exposed.

Gold thus combined with platinum is much more rigid than gold alone,and is contraindicated for making the bulk of most fillings. The best results are obtained from it when the mallet is used for its condensation throughout.

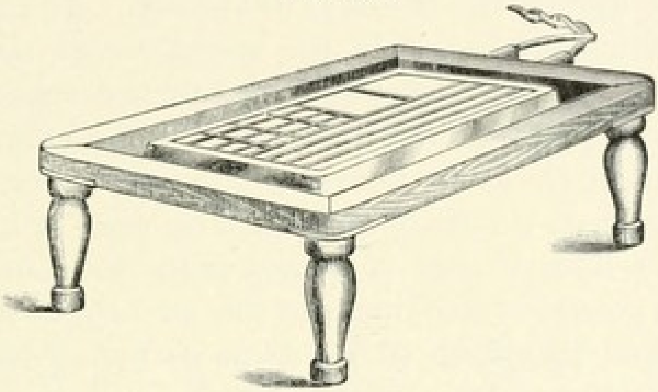
Annealing Gold.

After the manufacturer has reduced the gold to the desired thinness by beating, his last act before booking it is to heat it; this is termed *annealing*. The object of this is to remove any harshness which has been given to it by the process of beating. All metals become more or less stiff or rigid by hammering, but become soft again by the application of considerable heat. Gold foil which has been recently made and excluded from the atmosphere or certain gases, as previously mentioned, may present sufficient cohesive properties to weld satisfactorily, but this property is soon lost, and reheating becomes necessary if it is desirable to get union of the various layers.

Most operators make use of an alcohol flame for annealing gold; others a small Bunsen gas burner. Some hold the piece of gold to be annealed in the direct flame or a little above it; others place the gold upon a tray of Russia iron, mica, or platinum and hold this in the flame of the lamp or gas jet. This latter method is safest, since there are apt to be impurities in the flame dependent upon a charred wick, a particle of phosphorus dropping into the wick from the burning match, or, in the case of the gas jet, imperfect combustion which might give either carbon or sulfur deposits upon the surface of the gold. All or any of these accidents would impair the working qualities of the gold.

The most satisfactory method of annealing gold is by the use of the Electric Annealing Tray. Such a device has been invented by Dr. L. E. Custer, and is shown in Fig. 226. By this method the gold can be

FIG. 226.



Custer's electric annealing tray.

heated to any desired degree and with a uniformity not easily attained by the methods generally used. The working qualities of foil whether non-cohesive or cohesive are greatly enhanced by the application of heat at the time of using. Gold that is absolutely non-cohesive is made tougher by annealing and yet its softness is not impaired, while cohesive gold may be made either slightly or decidedly cohesive according as much or little heat may be applied to it. It is the practice of many operators to use the gold but slightly cohesive when filling cavities surrounded by strong walls, and the gold known as semi-cohesive, in the form of loosely rolled cylinders, is much used. As the filling approaches completion the cylinders are heated and additional cohesive property imparted to them. But when the object is the restoration of contour or building up of teeth which have been broken, the gold should be heated but little short of redness in order that the greatest cohesive property may be realized.

Introduction of the Gold, and Manner of Adapting It to the Walls of the Cavity.

It has been shown in Chapter VIII. that few cavities are of proper shape for retaining the filling when the decay alone has been removed. Most cavities require to be given a retentive shape so that the filling shall not be dislodged during its introduction or by mastication or otherwise after its completion. In former times, when the operator was restricted to one form of gold and that the non-cohesive variety, he was compelled to prepare his cavities accordingly; but at the present time, when the variety is almost endless, he can shape his cavity with a view to conserving tooth structure, and when he has given it a shape to please him he can select, from the many, a special form of gold that will meet his requirements.

There are certain principles involved in the packing of gold which must be borne in mind, and the operator should study these before introducing his filling. The first of these is *force*, and the direction and relation of that force to the object to be attained. If a given cavity is to be filled with non-cohesive gold the operator must take into consideration the strength of the cavity walls, and must determine whether by the wedging process which he will exercise in the effort to adapt the gold to the walls of the cavity he will run the risk of breaking them.

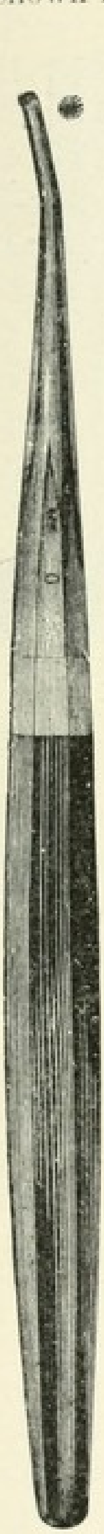
Non-cohesive gold is usually introduced by what is known as hand pressure. Each layer of gold is carried to the floor and the walls of the cavity by a process of wedging, and the mechanical arrangement of each piece of gold should be such that no portion of the gold can escape when the filling is completed. It will be shown later on, when considering the various types of cavities to be filled, that in small cavities of simple shape the gold prepared in the form of tape is best suited, whereas in compound cavities or those of greater size the gold may be introduced in the form of compact cylinders or blocks.

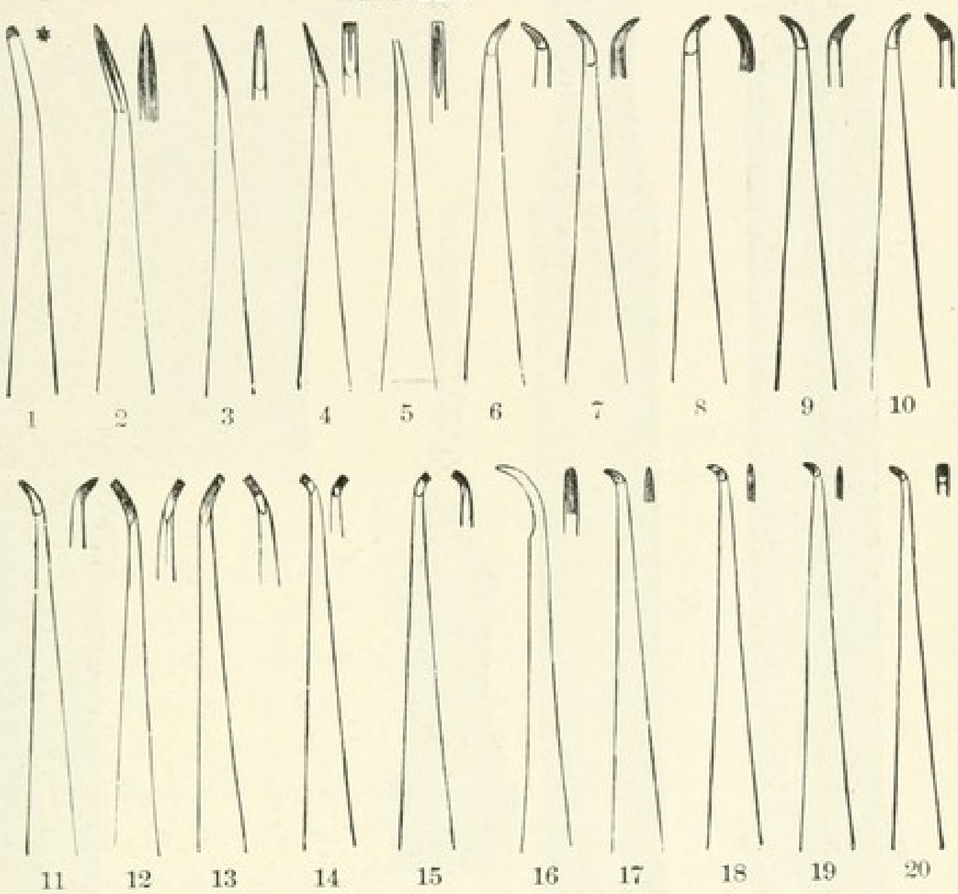
When it is desirable to use a combination of non-cohesive and cohesive gold, the former is generally introduced first and the cohesive is incorporated with it by driving or forcing layers of cohesive into the non-cohesive. This is best effected by using single layers of heavy foil or rolled gold of a thickness equal to 20, 30, or 40 grains to the leaf. If the filling is to be made of but one kind of gold and that the cohesive variety, both hand pressure and percussion by means of the mallet may advantageously be employed. The operator who has learned to combine the two forms of gold and is not restricted to either method of packing is best qualified for the requirements which are presented in general practice. Perfect adaptation to the walls may be effected by either method, but greater celerity and the attainment of equal excellence may be reached by combining the two.

Plugging Instruments.—In the selection of instruments for packing gold the operator should have a sufficient number to meet his every need. They should be of such a variety of patterns that every part of every cavity, however remote, can be reached with ease. It is a mistaken notion that a large number of instruments (if well selected) is confusing. The operator should study his instruments and know their uses as thoroughly as he knows the letters of the alphabet, and if this be done and they be arranged in an orderly manner in his case, the confusion will be manifest in their absence, not in the possession of them.

For packing non-cohesive foil none are better adapted than the set shown in Fig. 227, made from patterns furnished by Dr. B. J. Bing.

Fig. 227.

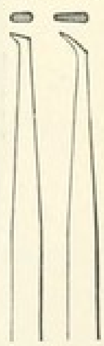




Dr. Bing's set of pluggers.

This set should be supplemented by a small and a medium sized foot-shaped condenser (Fig. 228), for packing cylinders, mats, or blocks against the cervical wall.

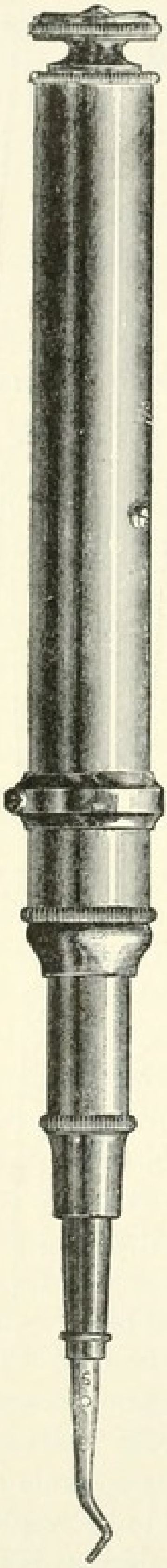
Fig. 228.



Foot-shaped condensers.

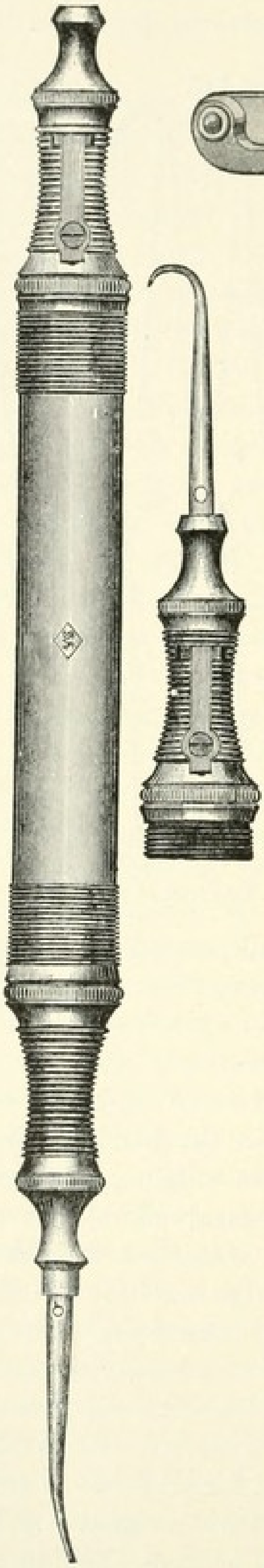
The handles of instruments used for packing non-cohesive foil should be of such size that they can be grasped firmly in the hand. When made of wood they are light in weight and agreeable to touch. Plugging instruments should have as few curves and angles as is consistent with the ability to reach all points in the cavity. As these are multiplied, direct force is sacrificed. The point of the instrument should be as nearly as possible in a line with the shaft. Deviations from this rule are sometimes necessary in order to reach all points in the cavity. Most plugging instruments have serrated points and are used for all forms of gold. As a rule these serrations should be shallow, and when cohesive gold is to be employed they should be only sufficient to prevent slipping, as gold that is quite cohesive packs as readily with smooth points as with rough ones.

Fig. 229.



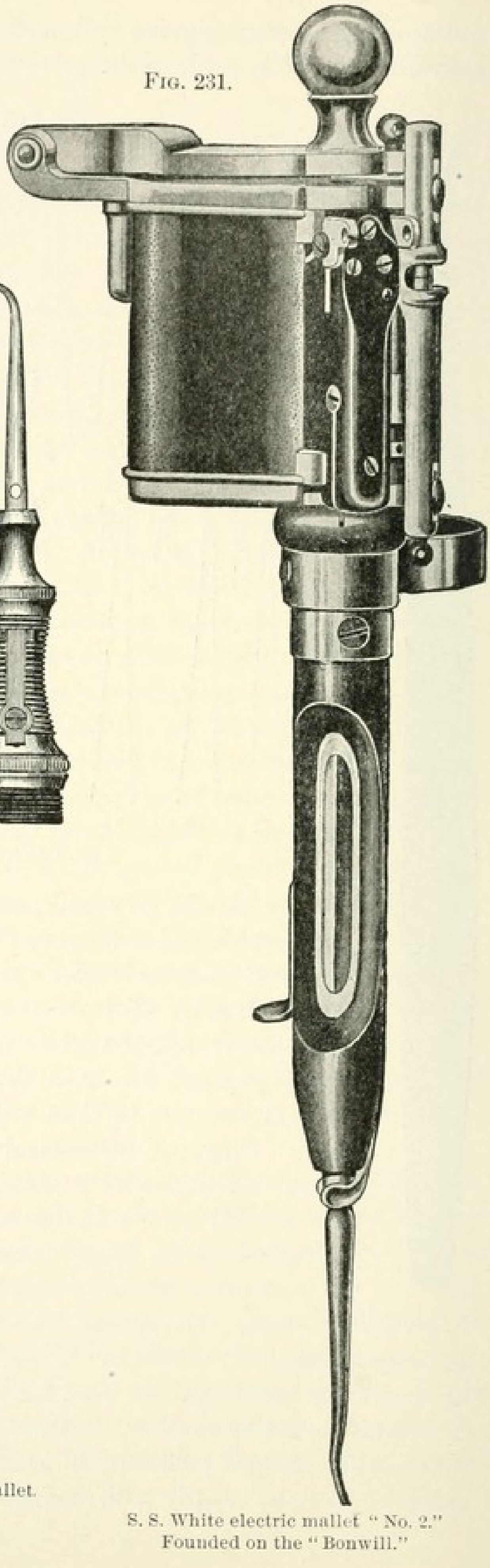
Snow and Lewis automatic mallet.

Fig. 230.



The Abbott mallet.

Fig. 231.



S. S. White electric mallet "No. 2." Founded on the "Bonwill."

It is not definitely known when packing gold by percussion was first suggested, but the idea is quite generally accorded to Dr. E. Merrit of Pittsburg, who as early as 1838 used the hand mallet for condensing the surface of fillings which had been introduced by hand pressure. The first mallets used were of light weight and were made of wood or ivory. As the method became more general, heavier mallets were employed, and those made of lead, tin, various alloys, and steel found much favor. Before the introduction of rubber dam for excluding moisture one hand of the operator was employed in holding the napkin, and it became necessary to have an assistant at hand to do the malleting. This led ingenious minds to discover some means of percussion besides the hand mallet, and several spring instruments known as automatic pluggers were introduced. The Snow and Lewis, the Foote, and the Salmon found greatest favor, and all of them were good of their kind. The accompanying cut (Fig. 229) shows the Snow and Lewis Automatic Mallet as made at the present time. When pressure is applied to the point of the instrument a spring is liberated which throws a plunger forward with great force, which is expended upon the gold beneath the point. The impacting quality of this blow is not excelled by any of the mechanical devices in use. It is so constructed that a light or a heavy blow can be given at will. The operator will do well to adjust the instrument for light blows when using it in close proximity to frail or delicate walls, as there is more or less danger of fracturing them.

Instruments of this class are not well adapted to packing gold in the posterior teeth of the lower jaw, as the blow is delivered at a more or less acute angle, and unless care be exercised when the operation is nearing completion the plugger point will slip from the surface of the filling and wound the soft tissues.

Another instrument of this type devised by Dr. Frank Abbott (see Fig. 230) has a socket at either end of the hand-piece, the one giving a pushing and the other a pulling blow. The latter is serviceable for condensing gold upon distal surfaces.

The ELECTRIC MALLET is one of the most ingenious devices employed in dentistry. The first practical application of electro-magnetic force for dental malleting was made by the late Dr. W. G. A. Bonwill. Its latest development is shown in Fig. 231. This instrument has found great favor among dentists for packing cohesive gold. Its blows are delivered with great rapidity and with such force that great solidity is attainable. A pair of electro-magnets transforms the electric current into electro-magnetic force, which is transmitted to the hammer. The electric current is furnished by a Bunsen or Partz battery, or the controlled current from a dynamo or storage battery can be used as the motive power. In the hands of a skilful operator there could be nothing better for packing cohesive gold. The best results are obtained by its use when the gold is prepared in thin laminæ or where a single thickness of heavy foil or rolled gold is employed.

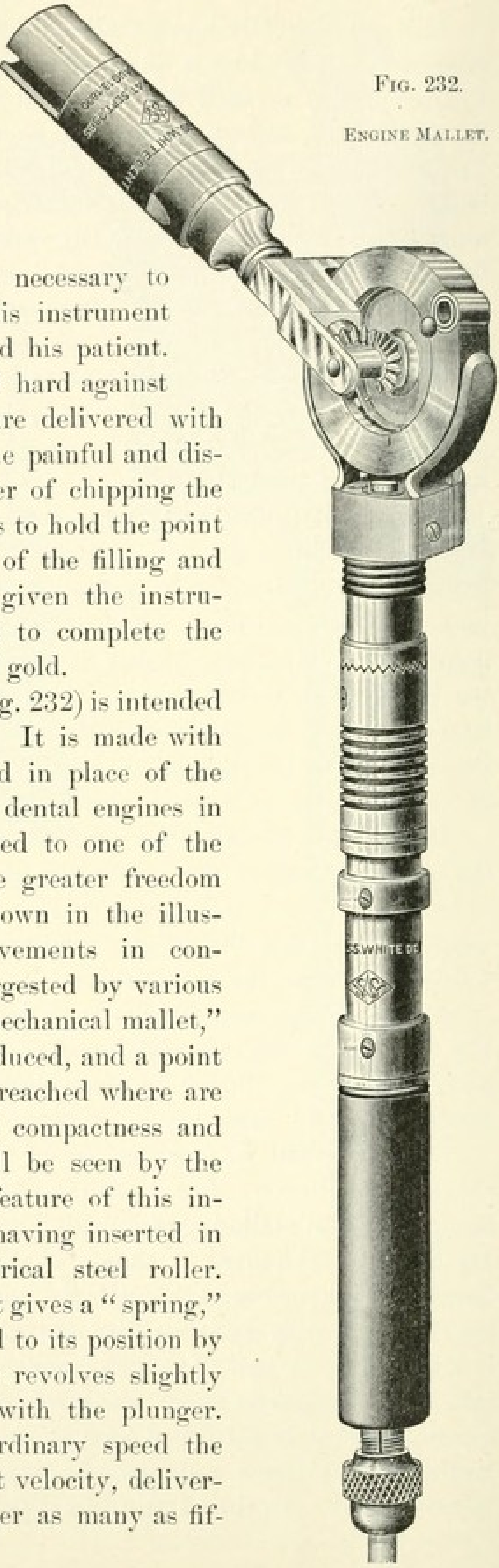


Fig. 232.

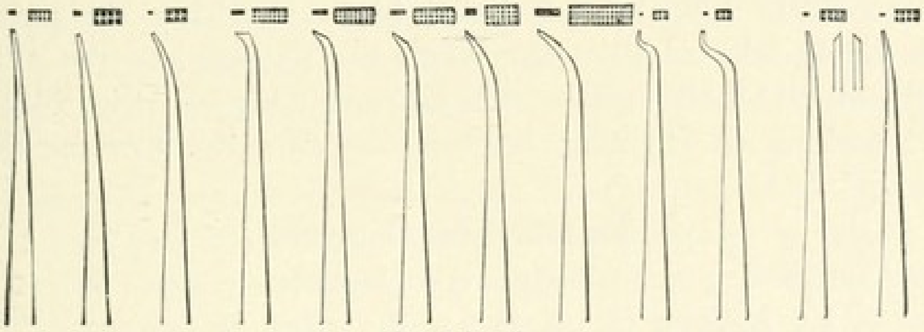
Engine Mallet.

Considerable experience is necessary to enable the operator to use this instrument with satisfaction to himself and his patient. If the plugger point be pressed hard against the filling, the blows, which are delivered with great rapidity and force, become painful and distressing and there is also danger of chipping the cavity walls. The better plan is to hold the point slightly away from the surface of the filling and allow the momentum which is given the instrument by the falling armature to complete the union of the various pieces of gold.

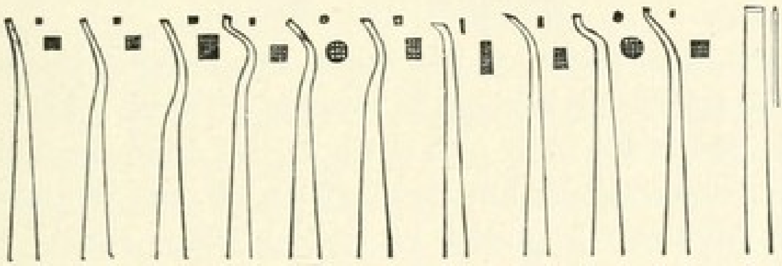
The ENGINE MALLET (see Fig. 232) is intended for use upon the dental engine. It is made with a slip joint and can be applied in place of the hand-piece to nearly all of the dental engines in use, although it is best adapted to one of the "cord" engines because of the greater freedom of action. The instrument shown in the illustration embodies many improvements in construction which have been suggested by various operators since the "Bonwill mechanical mallet," on which it is based, was introduced, and a point of relative perfection has been reached where are combined great efficiency with compactness and lightness in handling. It will be seen by the illustration that the essential feature of this instrument is a revolving wheel having inserted in its periphery a hollow cylindrical steel roller. This constitutes the hammer. It gives a "spring," not a "dead" blow, as it is held to its position by a stiff steel spring. The roller revolves slightly in its socket at each contact with the plunger. When the engine is run at ordinary speed the small wheel revolves with great velocity, delivering upon the head of the plunger as many as fifteen blows per second. The force of the blow can be modified at will by an extremely simple contrivance, as follows: The interdigitations seen around the upper end of the sleeve are held together by means of a spring attached to the sleeve. Pulling the sleeve away from the head against the spring, and revolving it to the right or left, raises or lowers the head of the plunger. Upon releasing the sleeve the spring at once throws it back to engage with the head, and the blow is heavier or lighter, according to the direction in which the sleeve has been revolved.

The impacting power of the blow from this is great, and in the hands of an experienced operator a large quantity of gold can be con-

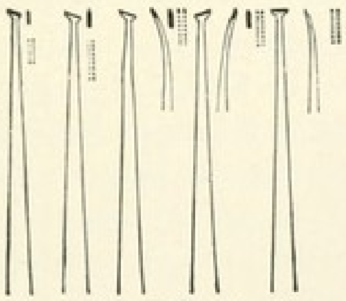
Fig. 233.



Varney's set.



Webb's set.



Chappell's set.

densed in a short space of time. When cohesive gold foil is employed smooth oval points may be used with most satisfactory results. The point should not be pressed hard against the filling, but a skimming or smoothing motion given to the instrument. The surface of the filling when thus packed has a polished or planished appearance as if done with a hand burnisher. Such fillings are usually of great density.

There are other mechanical mallets intended for use on the engine which have what is known as a "cam" movement. They are not, strictly speaking, mallets, for the instrument is pushed rather than driven forward by an eccentric. The Buckingham and the Holmes mallets belong to this class. They have not the same steadiness of motion as the ones previously described, and for this reason, among others, have not been in general use.

In the *selection of plugger points* for power mallets the operator will do well to confine himself to those having more than one row of serrations and those which are smooth-faced. The serrations, if any, should be extremely shallow, and the corners of the instrument slightly rounded. Those of the foot-shaped variety are admirably adapted to power mallets, and as there is a great variety of patterns and sizes he will have little difficulty in meeting his every wish in this particular. A few points selected from the Webb, the Varney, and the Chappell sets will fill all requirements. The accompanying cut (Fig. 233) shows a good working set which has been selected from the three mentioned.

Filling—by Classes.

(As arranged in Chapter VIII.)

I. Simple Cavities on Exposed Surfaces.

Bicuspids and Molars.

Class *A*.—The small cavities upon the *occlusal surfaces* of the *bicuspids and molars* are among the simplest in form. They are shown in Chapter VIII., Fig. 173. Cavities of this kind are quickly filled by means of non-cohesive foil in the form of tape as shown in Fig. 222. Such cavities are usually of regular shape and of a form requiring little if any additional shaping to make them retentive. A length of tape varying from an inch to two inches should be taken upon a wedge-shaped plugger point and carried to the bottom of the cavity, where it may be held for an instant with a point in the left hand; the instrument in the right hand makes a fold of the gold and carries it into and against the walls of the cavity by a lateral motion; fold after fold is then carried into the cavity and pressed firmly in every direction. As it is always best to finish such fillings with cohesive gold, a strip of No. 20 cohesive foil should be wedged into the mass already in the cavity, and then all subsequent pieces malleted, to give the occlusal surface as great hardness as possible. A completed filling of this class is shown in Fig. 234. Perfect adaptation to the walls of the cavity is obtained by the use of the non-cohesive foil, and great solidity is only essential upon the surface.

Fig. 234.

Bicuspid fissure cavity.

Cavities of this character, though of greater size, are found in the *molars*, as shown in Figs. 235–237, and may be filled in the same general way. Mats of foil may be substituted for tape, and where the decay has progressed to such an extent as to involve a large portion of the occlusal surface, making, as is frequently found, large round and quite deep cavities, the gold may be introduced in the form of cylinders. In former times, when the dentist's only means of excluding moisture

Fig. 235.

Fig. 236.

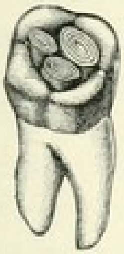
Fig. 237.

Fillings in molar fissure cavities.

was the napkin, and when his ability to keep cavities free from saliva was for a limited time only, the use of cylinders was much more common than at the present time when the rubber dam is generally employed.

Cylinders for such cavities should be hand-made and of No. 4 non-cohesive foil (Fig. 238). They should be long enough to extend above the margins of the cavity as shown in Fig. 238 and arranged around its walls. The first one is usually carried to that point in the cavity farthest away, and should be pressed with a foot-shaped instrument against the wall. Others are then put in place and wedged laterally until room is made in the centre of the mass for another cylinder, this in turn being wedged toward the outer walls, and the operation continued until no more cylinders can be introduced. The cylinders should then be condensed with great force upon their protruding ends, and finished with cohesive foil in the same manner as previously described. This mode of filling is best suited to deep cavities in which the walls are nearly parallel and yet sufficiently strong to endure great lateral pressure.

Fig. 238.



Occlusal cavity with cylinders.

In a cavity of unequal depth, where the central portion is quite deep and the sulci radiating from it quite shallow (see Fig. 239), it is well to use semi-cohesive foil in the central portion and cohesive foil in the radiating sulci. Such fillings require to be well anchored at the extremities of the fissures lest they be dislodged by sticky candy, which often adheres with great tenacity to the surface of the gold. The operator will do well in filling such cavities to confine himself to gold that is quite cohesive, except in the central portion as above indicated.

Fig. 239.

Filled stellate cavity in lower first molar.

Class *B.*—Cavities situated upon the *buccal surfaces* of the *bicuspids and molars* are rather more difficult to fill because of the difficulty in getting the rubber dam beyond the cervical border of the cavity.

When this has been done and perfect dryness effected these cavities may be classed as simple ones.

In small or non-elastic mouths it is often difficult to reach the second or third molars, hence the view of the cavity is somewhat impaired. In selecting the gold for such cavities the operator must take into consideration the depth of the cavity. If it be shallow he will do better to start his filling in a retaining pit and fill throughout with cohesive foil. If, on the contrary, the cavity be of considerable depth, he may fill the bulk of the cavity with mats or tape made of non-cohesive foil, and, as he approaches the surface of the filling, incorporate with it cohesive gold and finish his operation with the last-named variety. Such cavities are often advantageously filled throughout with Watts' crystal gold. This form of gold is easily seated and it has no tendency to rock or move in the cavity. A slight undercut along the upper and lower border of the cavity is sufficient to hold the filling in place (Fig. 240).

Fig. 240.

Buccal cavity in lower second molar.

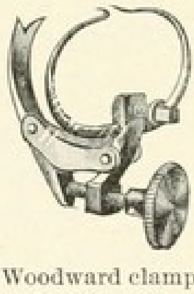
When these cavities assume larger proportions, as they frequently do in the lower molars, and become confluent with cavities on the occlusal surface, they should be filled after the following method: A mat or block of non-cohesive foil should be placed at the border nearest the gum; this may be held for a moment with an instrument in the left hand. One or two other blocks may be laid against this, and, when they have been well fixed in the undercut, should be malleted thoroughly against the cervical border; the remainder of the cavity may then be filled with semi-cohesive or cohesive gold. The surfacing of all fillings should be done with gold which has been made cohesive by recent annealing.

Class *C.*—Cavities do not often occur on the *lingual surfaces* of the *bicuspids or molars* except in teeth of very poor structure and in teeth from which the gum has receded to a point below the enamel border. Such cavities because of their inaccessible position are difficult to fill with gold, and, as a rule, some of the plastics are indicated. When the fissures on the upper molars become the seat of caries they may be filled with gold in the same manner as those in class *B.* It is usually necessary to pack the gold in these cases almost entirely by hand pressure because of the inaccessible situation of the cavity.

Incisors and Canines.

Class *D.*—Cavities upon the *labial surfaces* of the *incisors and canines* situated at or near the gingival border of the gum were formerly the source of much annoyance to the dentist when gold was the material selected for filling. The principal difficulty was occasioned by moisture, either in the form of blood or serum from the wounded gum or mucus from the follicles situated along the mucous surface. Since the introduction of the rubber dam this difficulty has been greatly modified. But when the cavity extends somewhat above the normal gum line there is more or less difficulty in keeping the rubber above the gingival border of the cavity. This is best done by taking a straight instrument the point of which has been made very sharp by rubbing it upon an Arkansas hone. The dam is then raised well above the cavity border and the point pressed firmly into the dentin and held with the left hand throughout the operation of filling the cavity. A very neat and valuable device in the form of a clamp has been introduced by Dr. W. A. Woodward for this purpose. It is shown in Fig. 241.

Fig. 241.



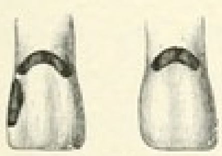
Woodward clamp.

The dam should include not only the tooth to be filled, but several on each side of it. With the left hand it is stretched above the margin of the cavity, while with the right hand the two little points on the bow of the clamp are pressed firmly into the cementum above the cavity. The clamp is then made secure by turning the set-screw. This clamp when well seated rarely fails, and the operator feels that this difficult operation has become a simple one.

There are cases, however, where the decay has followed the receding gum or extended beneath it to such an extent that the clamp cannot be used. To overcome this difficulty the gum should be slit and a "Mack" screw inserted to the depth of two or three threads into the dentin. The rubber dam is then drawn above this and held securely above the cavity. When the operation is completed the screw should be cut off with the wedge-cutters and nicely smoothed. When the slit in the gum has healed, the portion of the screw remaining will be concealed.

Most cavities upon the labial surfaces are shallow and are best filled with cohesive foil or Watts' crystal gold. It is well to fix the first piece securely in a small retaining pit and build each piece upon a sure foundation. As fillings upon the labial surfaces of teeth are usually conspicuous (Fig. 242), it is often desirable to fill such cavities with platinous gold, because the tint of the two metals in combination is more nearly the shade of the tooth. Especially is this true in teeth of yellowish hue.

Fig. 242.



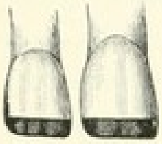
Labial fillings.

Class *E*.—As cavities upon the *lingual surface* of the *incisors* are usually confined to the laterals and most frequently are the result of imperfect development of the enamel in relation to the cingulum (see Chapter I., p. 25); they are small in size and easily filled. A tape of non-cohesive foil, or a small mat of the same material, may be inserted into the cavity first, and the filling completed with cohesive gold as in other cavities surrounded by strong walls.

CLASS *F*.—As caries rarely attacks the *incisal edge* of the *anterior teeth* the operation of filling with gold is usually confined to artificially made cavities, with the view of arresting waste of tooth substance caused by attrition, or where for any reason it is deemed best to "open the bite." Great strain is often brought to bear upon fillings in this position, and too great care cannot be exercised in the shaping of the cavity and the subsequent packing of the gold.

Cohesive gold is best suited to cavities of this description, and each piece should be freshly annealed, that there may be no doubt about the perfect union of each piece. It is well to start the first piece in a small retaining or starting pit and then fill all of the undercut before attempting to build the gold above the walls. As fillings in this position are subjected to great wear, the greatest hardness of surface attainable should be sought for, otherwise there will be battering of the edges and possibly flaking of the gold. Platinous gold is well adapted for this kind of fillings. Narrow strips of No. 20 or No. 30, well annealed and condensed with mallet force, will answer a better purpose than lighter foil (Fig. 243).

FIG. 243.



Edge restoration.

II. SIMPLE APPROXIMAL CAVITIES.

Incisors and Canines.

CLASS *G*.—In selecting the kind of gold and the form in which it should be prepared for fillings upon the *approximal surfaces* of the *incisors and canines*, the operator must consider the size of the cavity to be filled and the retaining hold which he is able to secure without sacrificing too much of the tooth structure.

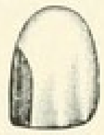
If the cavity be a small one, situated midway between the labial and palatal walls, and the surrounding borders be strong, a rapid and easy way of filling such cavities is to prepare the non-cohesive foil in the form of narrow tape. A leaf of foil cut into four pieces and folded with a spatula upon a napkin to the width of one-sixteenth of an inch, and then cut into lengths of three-quarters or one inch, is a good way of preparing it.

An excavator of an angle of forty-five degrees, with the extreme point broken off, makes a very good instrument for packing such fillings. Space should previously be obtained, either by the slow process of wedging with rubber or linen tape or by means of the Perry separator.

When the cavity is two-thirds filled it is well to use a few pieces of No. 20 cohesive foil, so that a dense surface may be given to the filling.

Such cavities may be classed among the simple ones, and present no difficulties except their inaccessibility (Fig. 244).

FIG. 244.



Mesio-approximal incisor filling.

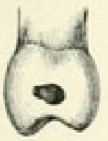
The operator should ever strive to conceal as much as possible the gold in the anterior part of the mouth, and when it is possible he should preserve the labial wall intact. This can often be done by cutting away a portion of the palatal wall and by packing the filling almost entirely from the under side of the tooth. Where a large portion of the approximal surface is involved, the retaining hold for the filling must be had at the cervical border and at the cutting edge. The first pieces of gold should be anchored in a groove or retaining pit near the cervix and the cervical border made secure before any other portion of the cavity is filled. The beginner will ordinarily do better to start such fillings with cohesive foil or Watts' crystal gold. If the latter, he may then complete his filling with cohesive foil. Non-cohesive gold is rarely indicated in cavities of this description.

The electro-magnetic mallet or the Bonwill mechanical mallet is well adapted for packing such fillings.

Bicuspids and Molars.

CLASS *H.*—Cavities of medium size situated upon the *mesial* or *distal surfaces* of the *bicuspids and molars* and not involving the occlusal surface may be filled after the same manner as small cavities in the incisors or canines. Operators who are not in the habit of using non-cohesive foil prefer starting such fillings in a small undercut or retaining pit and filling throughout with cohesive gold prepared either in narrow ribbons or loosely rolled cylinders (Fig. 245).

FIG. 245.



Approximal bicuspid filling.

Such fillings, because of their position, must be packed largely by hand pressure, although the mallet may be used as the filling approaches completion.

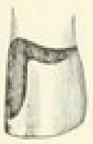
III. COMPOUND CAVITIES.

Incisors and Canines.

CLASSES *I* and *J.*—*Mesio-labial* and *disto-labial* cavities in the *incisors and canines* are usually best filled throughout with cohesive gold. Each cavity independent of the others should have retentive shape, so that in the event of one filling being displaced the other will remain intact.

As a rule it is better to fill the cavity on the labial surface first, because the first pieces of gold are more easily anchored in an accessible cavity, and because also of the danger of displacing the gold in the approximal cavity when filling the channel connecting the two fillings.

Fig. 246.

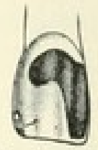


Mesio-labial filling.

Every possible care should be exercised in packing the gold in cavities of this description. The gold should be made thoroughly cohesive by recent annealing, and be used in pieces sufficiently small to prevent clogging. Such operations are more or less exposed to view, and the greatest degree of artistic skill should be bestowed upon them to render them as pleasing as possible to the eye. The original outline of the tooth should be restored with the gold, because it presents a better appearance than a space between it and the adjoining tooth (Fig. 246).

Classes *K* and *L*.—Cavities upon the *mesio-lingual* or *disto-lingual surfaces* of the teeth are filled in precisely the same way as those described under classes *I* and *J*. If the cavity be of considerable depth, non-cohesive gold may be used as part of the filling, but in any event the bulk of the filling should be made of cohesive foil (Fig. 247).

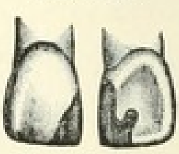
Fig. 247.



Mesio-lingual filling.

Classes *M* and *N*.—*Mesio-incisal; Disto-incisal.*—Cavities situated upon the approximal surfaces of the incisors and becoming confluent with one on the incisal edge require great care in the matter of packing gold. It is often an advantage to have the cavity on the approximal surface unite with a natural or an artificially made one upon the incisal edge, because much better anchorage can be obtained in such cavities. Cohesive gold prepared in the form of ribbon or in pellets or cohesive cylinders, if loosely rolled, may be used. The better method is to fill the undercut at the cervical border of the cavity first, and then bring the gold toward the incisal edge as squarely as possible, keeping the mass on a line with the labial and palatal walls. The operator feels a sense of security when he is able to anchor such fillings in an undercut or retaining pit on the incisal edge. In teeth with broad incisal edges there is ample opportunity to make a strong retaining hold, but where the edge is narrow a lateral cut into the palatal wall one-third back from the incisal edge affords a strong and secure hold for that portion of the filling. Operations of this class require great thoroughness in the packing of the gold. It should be very cohesive and when possible condensed with some form of mallet (Fig. 248).

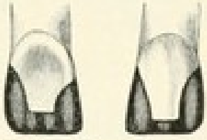
Fig. 248.



Mesio-incisal filling.

Class *O*.—*Mesio-disto-incisal.*—Where both approximal surfaces and the incisal edge are united in one cavity, the better plan is to begin the filling at the undercut near the cervical border of the distal cavity, and build the gold squarely down as in classes *M* and *N* until the incisal edge is reached, thence across the incisal edge, then fill the mesial cavity after the same manner, uniting the three fillings at the mesio-incisal corner. It is better to insert such fillings with an electric or a mechanical mallet, as there is always danger, when packing across the incisal edge by hand pressure, of pushing one or the other of the fillings out of the approximal surfaces.

Fig. 249.



Mesio-disto-incisal fillings.

If no accident occurs in the packing of the gold a filling thus made is very secure, for its form is like a staple and each portion helps to bind the others securely in the triple cavity. Non-cohesive gold should form no part of such fillings (Fig. 249).

Bicuspids and Molars.

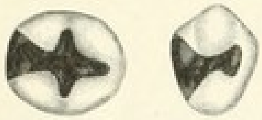
Class *P.*—*Mesio-occlusal.*—The filling of this class of cavities offers no serious difficulties provided sufficient space has previously been obtained. As it is desirable to restore with gold the original outline of the tooth, sufficient space to do this in is a necessity, and the operator will soon learn that he can only accomplish good results in proportion as he recognizes the importance of this preliminary.

The cervical border is the vulnerable point for recurrence of decay, and imperfection here in the matter of packing the gold means speedy failure of the filling, hence the importance of a perfect joint between gold and tooth. This may be obtained by either non-cohesive or cohesive gold if due care be exercised in its use. Where the cavity has not great depth and the retaining grooves are also shallow, no better method of laying the cervical foundation can be adopted than by the use of Watts' crystal gold or the "Velvet" cylinders, which possess great softness and some slight cohesive properties. If the operator has had some experience in working non-cohesive foil he will do well to use a mat of non-cohesive foil at this point, allowing the mat to extend somewhat beyond the cervical border of the cavity. This may be followed by another mat or two, after which they should be malleted to place, a foot-shaped plugger point being used. The upper third or even one-half of the cavity may be filled after this method. He should then begin the use of cohesive gold. The two kinds can be incorporated as previously described and the filling completed with gold which has been freshly annealed.

It is always better to insert too much rather than too little gold, as the operator can shape the contour according to his fancy or to the necessities of the case.

The occlusal portion of the filling should be thoroughly condensed, as much depends upon this for holding the filling in place. Great hardness is also essential to prevent battering in the act of mastication (Fig. 250).

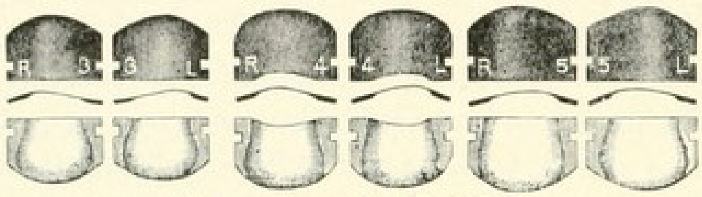
Fig. 250.



Approximo-occlusal cavities.

Class Q.—*Disto-occlusal* cavities may be filled in precisely the same manner as those situated upon the mesio-occlusal surface. The difficulties are slightly greater because these cavities are not so accessible. Cavities of this description can be greatly simplified by the use of the matrix. This little device converts compound cavities into simple ones, and when used with care and judgment facilitates the operation of filling to a wonderful degree. It will be observed in the Jack matrices (as shown in Fig. 251) that provision

Fig. 251.

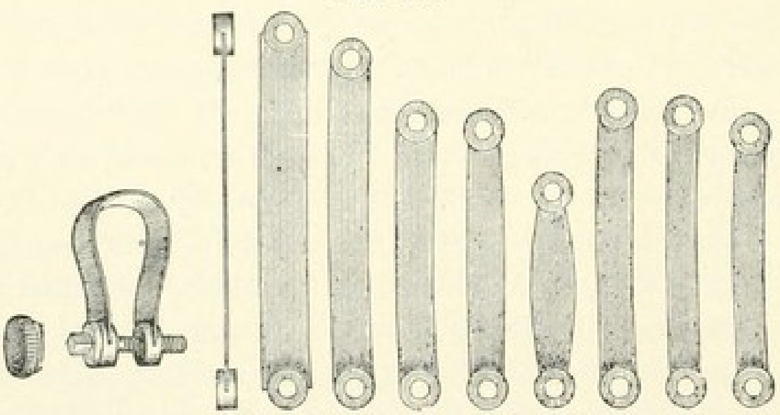


The matrices of Dr. Louis Jack.

has been made for contouring the filling. If this style be employed the operator must study the outline which he desires his filling to assume and select his matrix accordingly. He must have previously obtained ample space between the teeth for the placement of the matrix.

When put in place the matrix should be thoroughly fixed against the tooth to be filled, with wedges of orange wood previously dipped in

Fig 252.



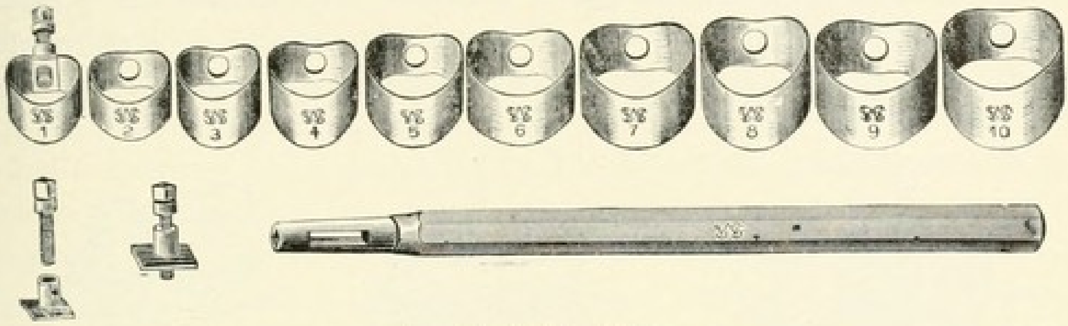
Loop matrices.

moderately thick sandarac varnish. This will keep the wedges from slipping. A very good way of fixing the matrix is to pack between it and the adjoining tooth some quick-setting oxyphosphate of zinc. If the part be thoroughly dry the cement will become adherent to the matrix and the adjoining tooth and the matrix will thus be made secure.

Whenever the matrix is to be employed it must be understood that an important feature is absolute fixation of the device, otherwise the operator will suffer continual annoyance throughout the operation.

Where there is sufficient space between the adjoining teeth for a band matrix the operator will find great satisfaction in their use (they

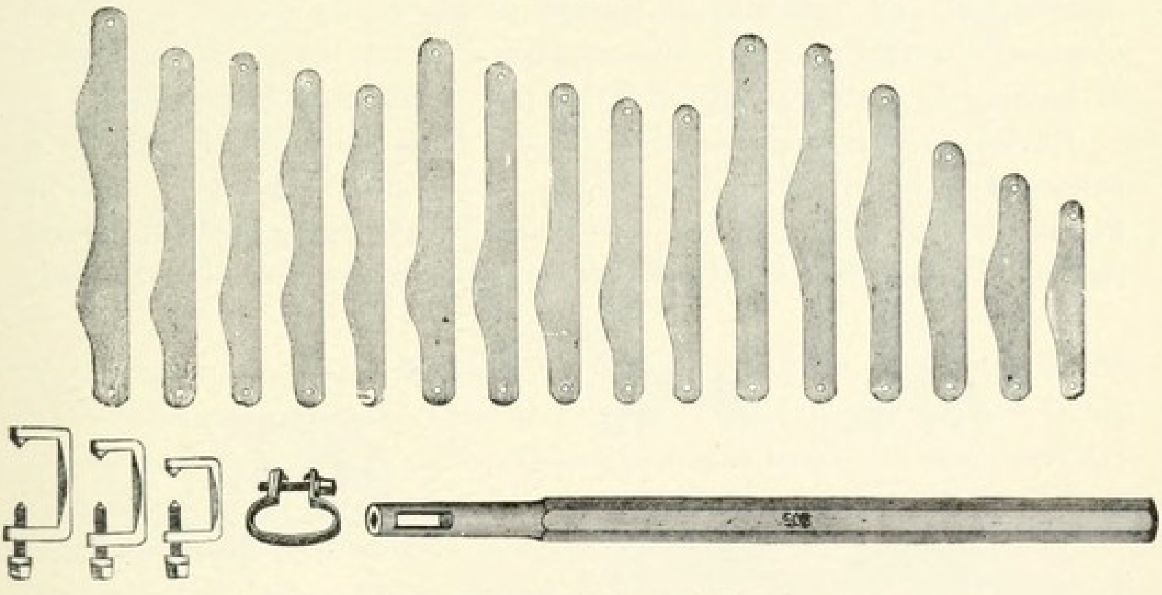
Fig. 253.



Brophy's band matrices.

are shown in Figs. 253, 254), but as most teeth are smaller at the neck than at the occlusal surface, there is often difficulty in adjusting the

Fig. 254.



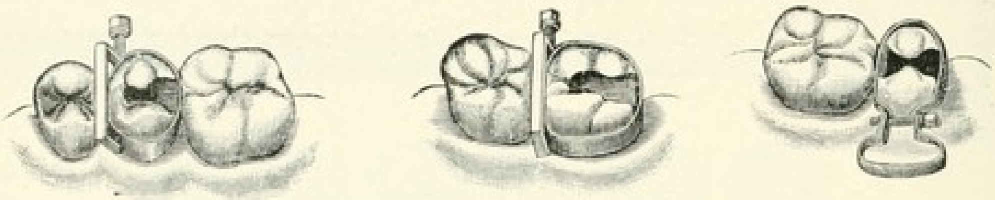
Guilford's band matrices and clamps.

matrix to that portion of the tooth: a wedge used as previously described will often overcome this difficulty.

A modification of the band matrix has been devised by Dr. Guilford, and is shown in Figs. 254, 255. It will be seen that space upon both sides of the tooth to be filled is unnecessary, as the little clamp binds the matrix to the tooth. Another style of matrix, and one admirably adapted to many cavities in the bicuspids and molars, has been introduced by Dr. W. A. Woodward, and is shown in Fig. 256. It will be seen that this matrix has two screws which are driven against the adjoining tooth and keep the matrix firmly in place and at the same time act as a separator. If the operator feels that he has insufficient space, as his filling progresses he can occasionally tighten the screws and gradually gain space between the teeth, which is of value when he is ready to dress down and polish his filling. Several sizes of these should be at hand to meet the exigencies of individual cases.

It has been said that the matrix converts a compound cavity into a simple one. This is accomplished by making of metal a temporary fourth wall to the cavity. It must be borne in mind, however, that

FIG. 255.

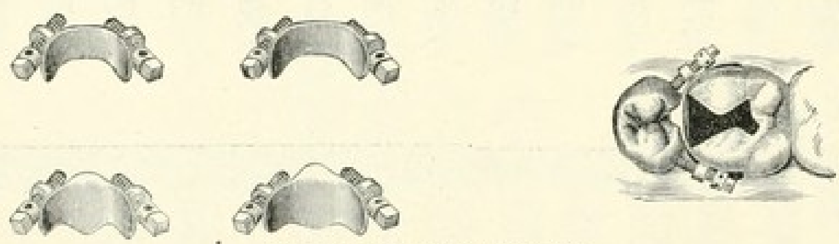


Examples showing uses of matrices.

the use of the matrix does not lessen the care which should at all times be exercised in the packing of the filling. Direct pressure against the disto-buccal and disto-lingual borders of the cavity cannot be as well obtained when the matrix is used as when it is not, hence the importance of having the matrix so adjusted that these walls may be accessible.

Cavities of this variety seldom require retaining pits. The cavity is supposed to be of a retentive form. If the matrix has been made to fit the cervical border of the cavity and is thoroughly wedged against it, the filling may be started with mats of non-cohesive foil or with loosely

FIG. 256.

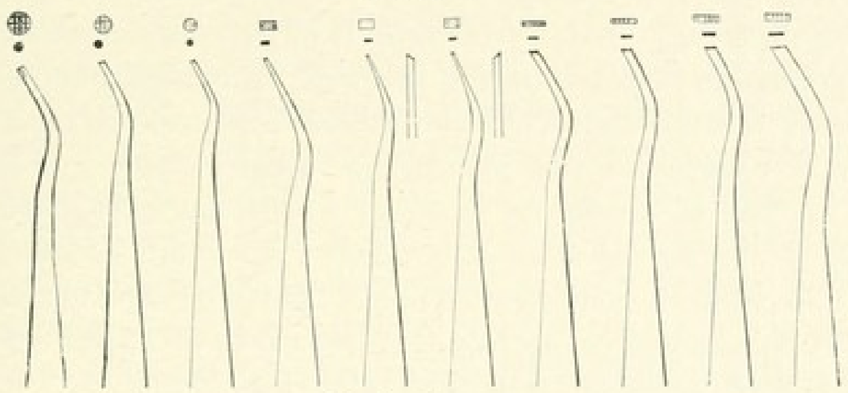


Woodward's screw matrices.

rolled cylinders. Two, three, or even more may be pressed thoroughly against the cervical wall and condensed with a hand mallet or with the automatic mallet. Similar pieces are then inserted and malleted to place until the upper third of the cavity has been filled. Cohesive gold may then be substituted for the non-cohesive and each piece packed with hand pressure or mallet force as preferred. The instruments shown in Fig. 257 are well adapted to fillings of this description.

As there is sometimes difficulty in adjusting the matrix to the cervical border of the cavity, it is well at times to insert a cylinder or two before putting the matrix in position, letting the ends of the cylinder extend beyond the walls and into the space between the teeth. The matrix is then put in place and rests upon the protruding ends of the cylinders. These are condensed against the cervical border and the operation is completed as previously described. The introduction of the cylinders as stated, previous to the adjustment of the matrix, contributes largely to the successful formation of a tight joint of the gold and the cervical border. Or the same object may be accomplished with perhaps greater certainty by adjusting a band matrix and screwing it tightly into close contact with the tooth surfaces. When this is done there will usually be found a slight space between the matrix and the tooth at the cervical border, caused by the band standing away from the tooth at that margin. In filling this cavity the first pieces of gold, preferably loosely rolled cylinders or mats, are grasped singly by the foil tweezers near the end and passed endwise into the space between the matrix and

FIG. 257.



Matrix pluggers.

the cervical margin of the cavity. The end projecting into the cavity is then bent inward and over the cervical margin and pressed firmly down upon the cervical wall. Other pieces of gold are then similarly introduced and condensed. This forms the foundation of the filling, after which the operation is completed with cohesive foil as before described. The advantages of this method are that the first pieces of gold by being wedged between the matrix and the neck of the tooth are immovably held, thus rendering the usual starting anchorages unnecessary. This method also gives positive assurance that the cervical border is perfectly filled. The same perfection of joint at the lateral margins of the filling may be attained where a band matrix of the Guilford type is employed by slightly loosening the set-screw of the matrix clamp as the operation proceeds, so that the band may be moved from contact with the lateral margins of the cavity and the gold carried over them as was done at the cervical margin. Moreover, when excessive contour is desired it is easily accomplished by a gradual loosening of the clamp screw as the operation proceeds and the additional space is needed.

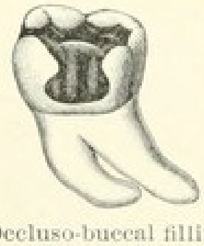
The matrix is best suited to disto-occlusal cavities. It is sometimes employed upon mesio-occlusal cavities, but as a rule obstructs the light and adds little to the convenience of the operator.

Experience has demonstrated that the only satisfactory method of filling cavities upon the approximal surfaces of the bicuspids and molars is to restore, by means of filling material, the original outline of the tooth. This is termed "restoration of contour." To do this successfully requires artistic sense and mechanical skill of a high order, and an accurate knowledge of the topographical anatomy of the teeth. To the man who has these the operation is easy, but otherwise persistent effort alone will enable him to acquire the ability. The inexperienced operator will often do better if he confine himself in the beginning to but one kind of gold, and that of the cohesive variety. If this be done he should start the filling in a well-defined groove at the cervical border of the cavity, and then add, piece by piece, well-annealed foil until the filling is completed. Such a procedure is of necessity slow, but excellent operations can be made by this method. The beautiful and lasting operations of Varney and Webb and others were made in this way.

Class *R*.—*Occluso-buccal* cavities are usually confined to the *lower molars*. If they be shallow it is better to fill throughout with cohesive gold. If, on the other hand, the cavity upon the occlusal surface be deep, non-cohesive gold may be used in part and then cohesive gold used to fill the channel connecting the two cavities. Such fillings are subjected to great wear and should be solid (Fig. 258).

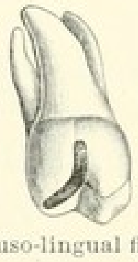
Class *S*.—*Occluso-lingual*.—These cavities are nearly always confined to the *first and second upper molars*, and as a rule are best filled

Fig. 258.



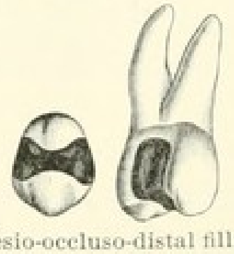
Occluso-buccal filling.

Fig. 259.



Occluso-lingual filling.

Fig. 260.



Mesio-occluso-distal filling.

with cohesive gold. The channel running into the lingual aspect of the tooth is not often deep, and non-cohesive gold is contra-indicated (Fig. 259).

Class *T*.—Cavities upon the *mesial* and *distal* surfaces of the *bicuspids* often become confluent with those upon the occlusal surface, and it becomes necessary to fill them as one cavity. Such operations are simplified by the use of a matrix upon the distal surface. A band matrix could be employed, but it obstructs the light somewhat and the operator will more frequently confine himself to a matrix upon but one side of the tooth. The filling should be commenced at the disto-cervical border, and after inserting a few mats or cylinders of non-cohesive foil proceed as in cavities described under class *Q* (Fig. 250).

If these cavities be of considerable size the buccal and lingual walls are weakened and there is danger of their being broken away in the act of mastication. It is often well to truncate the cusps somewhat and build the gold well across the occlusal surface, allowing the strain to come directly upon the gold instead of upon the tooth structure.

Filling with Tin.

It is not definitely known when tin was first employed for filling carious teeth, but it has been used for at least a century and has found great favor with many. Prior to the improvement in the formulas of dental amalgams, tin was used more generally than at the present time.

Tin possesses certain inherent characteristics which make it valuable as a filling material. Among these are great malleability, non-conductivity, and it is thought by many to possess antiseptic properties. But while it has desirable qualities it has also some undesirable ones, such as softness, and when exposed to the secretions of the mouth it discolors, —which facts render it unfit for surfaces exposed to great wear in the act of mastication and upon surfaces exposed to view. The discoloration, however, is confined to the surface, and teeth filled with tin are not discolored in consequence of its presence.

There are various methods of preparing tin for dental purposes. That which has found greatest favor in the past is in the form of foil. The tin used should be chemically pure. An ingot of the metal is rolled into ribbon and then beaten, after the same manner as gold foil, into sheets of the desired thickness. As a rule it is not beaten as thin as the former. The foil best suited for most fillings is No. 10.

Pure tin, like pure gold, is cohesive, and fillings of great solidity can be made if the operator will exercise care in packing it. The best results are obtained by taking a third of a leaf of No. 10 foil and rolling it into a loose rope, then cutting it into lengths of half an inch or less and packing each piece with a view of making each part of the filling solid. Some prefer folding the sheet with a spatula after the same manner as gold foil, and then cutting into narrow tape. Equally good results are obtainable by either method.

A more rapid but less satisfactory manner of introducing the fillings is to use the tin in the form of cylinders, not relying so much upon the cohesive properties of the metal. The directions for using gold in the form of cylinders will apply equally well for inserting tin foil.

Felt Tin.—This form of tin was introduced by Dr. Slayton some years ago, and at one time found favor with many operators. Tin thus prepared resembles coarse felt, and comes in sheets of various thicknesses, usually about that of billiard cloth. This is cut into squares or strips of various widths and packed into the cavity after the same manner as tin foil. It appears to possess no advantages over ordinary foil prepared as above.

Shredded Tin.—This form of tin, as its name implies, presents a shredded appearance, and it is said to contain a small percentage of platinum. It is quite cohesive, and works with a degree of softness that is pleasing to the operator. It is claimed for it that cohesive gold foil will adhere to it much more readily than to pure tin in the form of foil. If this claim be valid the advantages are apparent when the operator desires for any reason to use the two metals in combination.

Shavings of Tin.—The cohesive property of tin is best illustrated when it is used in the form of freshly cut shavings from a revolving ingot of the metal. Any operator can prepare his own shavings and have them fresh daily or hourly, if necessary, after the following method: Take an ordinary corundum wheel two inches in diameter and one-half inch in thickness, such as is used in the laboratory. Make a mould of this in sand or marble dust, then melt in a crucible or ladle enough *pure* tin to fill the mould. When it has cooled mount accurately upon the mandrel of the laboratory lathe, and from it, with a sharp carpenter's chisel, turn shavings of great tenuity. When freshly cut, and before oxidation of the surface has taken place by exposure to the atmosphere, it will be found that the tin coheres with the same readiness that pure gold does. Broken-down teeth can be built up by this method, or by means of it surfaces may be contoured as with gold.

The plugging instruments best adapted for tin filling are those having shallow but well-defined serrations and points not too broad. As the marginal surface is approached broader points and condensers may be used, and the surface should be well burnished. The operator must not lose sight of the fact that while tin possesses many desirable qualities and is easily manipulated, it lacks hardness and is not adapted to surfaces where great attrition occurs. Its chief value is found in its use upon surfaces concealed from view and shielded from wear, and in the temporary teeth, where its greatest value is manifest.

Tin fillings should be finished with the same care as gold ones, and the same directions will apply in all particulars.

FINISHING FILLINGS.

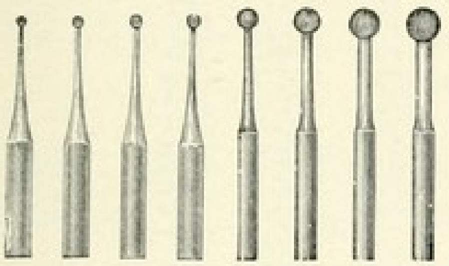
Much of the beauty and utility of a filling is imparted to it in the finishing. It is not enough that it be well made, it must also be well finished if the best results are to be attained.

All fillings should contain rather more gold than it is intended shall remain, and this for the purpose of dressing down to such lines as will be artistic and practical.

Fillings that are not well condensed cannot be given a fine finish. Solidity of the surface is an essential quality. After the last piece of gold has been well condensed it is well to give the surface a thorough burnishing for the purpose of getting a compact surface as well as to insure perfect contact with the margins of the cavity.

The simple fillings upon the occlusal surface of the bicuspids and molars are best dressed down with small finishing burs, as shown in Fig. 261. These are fine cut and leave the gold with a better surface than when cavity burs are used for this purpose.

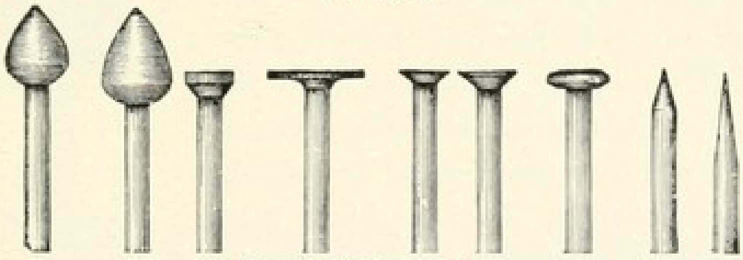
FIG. 261.



Plug finishing burs.

The gold should be cut away until the margin of the cavity has been reached and until all overlapping of gold has been removed. The occlusion of the tooth of the opposite jaw should be noted, and, if it occludes unduly with the filling, enough should be taken from the surface of the gold to prevent it. When a uniform surface has been given to the gold, a suitable wood point as shown in Fig. 262 should be mounted in an engine mandrel and dipped first in water and then in fine pumice powder and the surface nicely smoothed. A round-end burnisher may be used if the operator desires a polished surface, although it adds nothing to either the beauty or the utility of the filling.

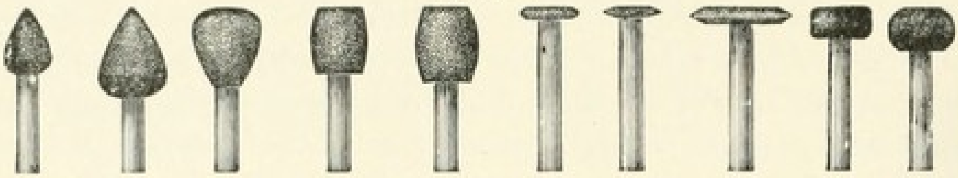
FIG. 262.



Wood polishing points.

When fillings cover a larger portion of the occlusal surface the dressing down may be done with corundum points, which if kept wet will cut more rapidly than burs and cause less heating. These are shown in Fig. 263, and are of many patterns and admirably adapted to all parts of the filling. Those made of fine corundum and shellac, or corundum and vulcanized rubber, are more desirable than the coarse ones, which

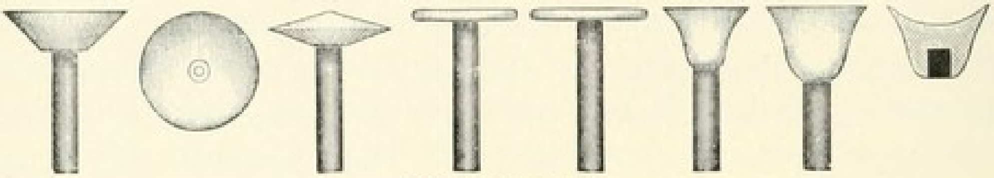
FIG. 263.



Corundum points.

are liable to grind away the cavity margins because of the rapidity with which they cut.

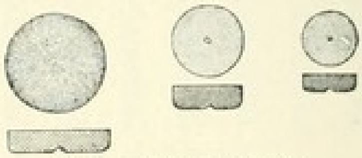
FIG. 264.



Hindostan points.

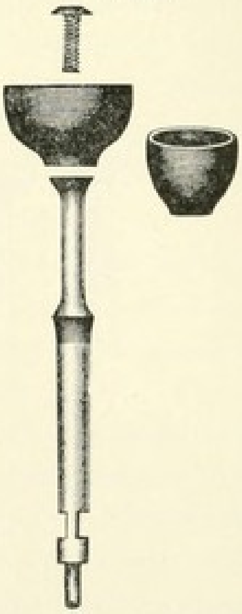
Fillings upon labial and buccal surfaces should be dressed down with fine corundum points or the Hindostan stones shown in Fig. 264 until the outline of the cavity has been reached. Any overlapping of the gold upon these surfaces gives a ragged appearance to the filling and detracts much from its beauty. Care should also be exercised in giving the filling the same degree of convexity that the tooth formerly had; in other words, the filling should accurately restore the lost anatomical contour of the tooth.

FIG. 265.



Felt polishing wheels.

FIG. 266.



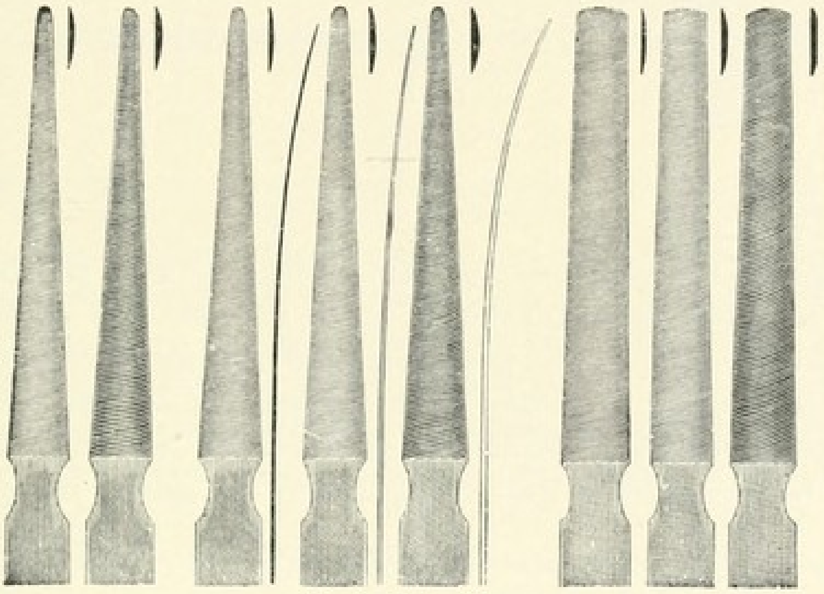
Dr. Wood's polishing cup.

When sufficient gold has been removed the surface should be nicely smoothed with revolving wood points charged with pumice powder and water, or a paste made of pumice and glycerin, after which the final finish may be made with flour of pumice, chalk, or oxid of tin, used by means of a revolving disk or wheel of felt or soft rubber (Fig. 265). The soft rubber polishing cup of Dr. John B. Wood is a valuable aid in polishing the convex surfaces of approximal fillings or those upon the cervical portion of labial cavities. It is shown in Fig. 266. As fillings upon the labial surface are more or less conspicuous at best, it is better not to give them a burnished surface. The dead or satin-like finish which is left by the flour of pumice is usually preferred.

Fillings upon *approximal surfaces* are more difficult to finish, and too great care cannot be bestowed upon them. An operator is often judged by the finish which he gives his approximal fillings, and justly so, as no class of fillings requires a higher degree of skill in the finishing.

There is of necessity more or less overlapping of the gold in the insertion of a filling, and the removal of all excess is as important as any other part of the operation. For this purpose a great variety of instruments is supplied. Files and gold trimmers, as shown in Figs.

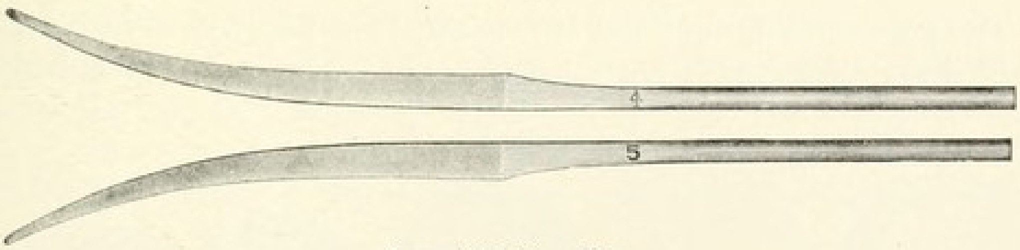
Fig. 267.



Plug finishing files.

267 and 268, are best adapted. The cervical border is one which should receive most careful attention. The gold should be filed and dressed down until the finest excavator or probe will not catch when drawn from the cervix toward the cutting edge. In addition to the

Fig. 268.

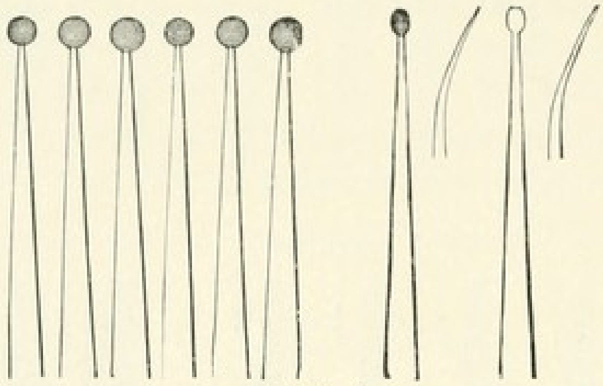


Curved finishing files.

file and gold trimmer, strips of emery tape or sandpaper should be used until all margins are well defined. The operator should have at hand a great variety of these strips, some of extreme thinness and of various grits, of emery, of silex, and of buckhorn.

When the filling has assumed the desired shape and all overlapping gold has been removed, the final finish should be given with linen or cotton tape charged with pumice of exceeding fineness. If there are places where the tape cannot be made to reach, a soft-rubber wheel in

FIG. 269.

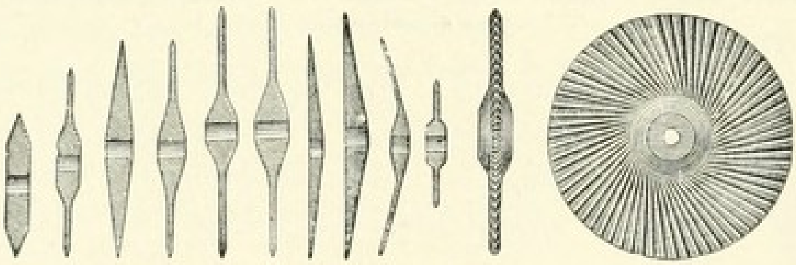


Approximal trimmers.

the handpiece of the engine and charged with the same powder may be used (Fig. 270).

Fillings in the bicuspids and molars because of their inaccessible position are often most difficult to finish, and for this reason should receive unusual care. If a matrix has been used at the cervical border, and has been made to fit the tooth perfectly at or near the gum, it will be found that the finishing process has been simplified in a great measure, because there is less overlapping of the gold at this point.

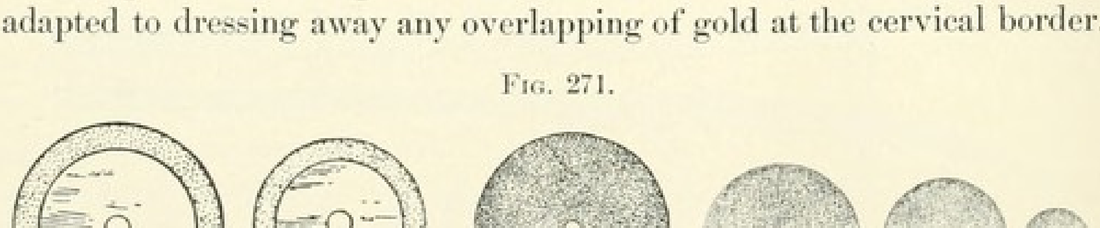
FIG. 270.



Soft-rubber disks.

The pointed files, right and left, as shown in Fig. 268, are admirably adapted to dressing away any overlapping of gold at the cervical border.

FIG. 271.

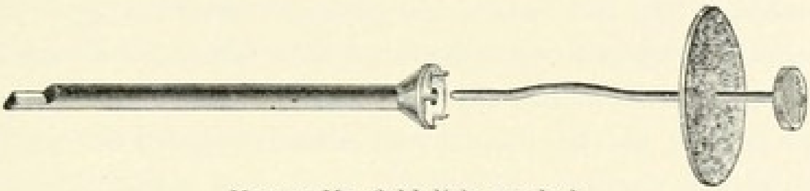


Sandpaper disks.

With these and the trimmers shown in Fig. 269 the general outline of the filling may be obtained, after which the emery and corundum tape may be used and the filling polished after the same manner as described above. Disks of sandpaper and emery cloth and finer ones charged with cuttlefish powder (Fig. 271) are exceedingly useful in shaping and polishing the filling. Fig. 272 shows two forms of disk mandrels which may be satisfactorily used in carrying disks.

Fig. 272.

Huey disk mandrel.



Morgan-Maxfield disk mandrel.

Many approximal fillings in the bicuspids and molars extend to the occlusal surface. When this is the case the operator should pay special heed to the occlusion of the opposing teeth. If left too full the constant touching of an opposing cusp may batter the filling, or, if not securely anchored, dislodge it. Overlapping gold is the rock of offence, and is the cause of many failures. A filling is not well finished until a delicate instrument can be passed from enamel surface to filling without catching. When this can be done, and dental floss is not frayed at the cervical margin, the inference is justified that no gold has been left overlapping.

Repairing Fillings.

Fillings somewhat defective are often susceptible of repair. The defect may sometimes be apparent in the finishing; at other times it is the result of subsequent caries, and at still other times the result of a fracture of the tooth enamel along the border of the filling.

The nature of the defect and the condition of the remaining filling must be taken into consideration before an effort to repair is undertaken.

When the defect is due to insufficient gold at any point in the filling more gold may be added. It is well to first cut out a portion of the filling, making a distinct cavity of retentive shape. Cohesive gold is usually best suited to the purpose; crystal gold often serves well in the repair of such defects.

If the filling has been thoroughly condensed and the mass is solid there is little difficulty in adding more gold to it, provided the surface be clean. If it has been wetted with saliva, the surface of the gold must be made not only dry but clean. It is well to wipe it with a pellet of cotton or paper saturated with alcohol or ether, after which the filling should be scraped with a suitable instrument. If the filling be of considerable size and well anchored, shallow retaining pits may be drilled into it, which will make an additional hold for the gold which is to be added. Defects which arise from subsequent caries are perhaps more frequent in approximal surfaces at or near the cervical margin. These borders are vulnerable points for the recurrence of caries, and imperfect adaptation is not infrequently the determining cause of the beginning of such decay.

To effect a successful repair in such localities ample space should be obtained, especially so if the repair is to be made with gold.

If the decay has not extended beneath the filling, and sufficient space has been obtained, there is no greater difficulty in making a successful repair than in filling a simple cavity similarly located. If the operator is skilled in the use of non-cohesive gold, he will do well to prepare his foil in the form of narrow tape, and work it into the cavity fold after fold, allowing the loops to extend somewhat above the walls of the cavity. When the cavity has been completely filled the protruding folds may be well condensed and the filling finished in the usual way; or the repair may be made with cohesive gold, the first piece having been made fast in a groove or retaining pit.

Such repairs are often required in the bicuspids and molars, and large fillings otherwise good are saved by a successful repair at the cervix. The plastics are sometimes indicated in this class of cases, provided they be not so near the anterior part of the mouth as to be unsightly. Gutta-percha often serves a good purpose here, but in some mouths undergoes decomposition and is less reliable than gold. The oxyphosphates are contraindicated because of their liability to wash away after a few months. Amalgams are more frequently used, and nearly always serve well when thus employed; but unfortunately the contact with gold insures discoloration, and an unsightly filling is the result. Whenever gold and amalgam are brought in contact in the same tooth, if the surface of each is exposed to the fluids of the mouth, the amalgam is almost sure to turn quite black. The discoloration of the surface of the alloy does not lessen its value as a preserver of the tooth, but its unsightliness is often too great to be tolerated; nevertheless, utility enters so largely into the equation that the operator feels justified in using the alloy, because with it he feels sure of making a better repair. After the alloy has hardened it should be nicely dressed down and all overlapping of the material at the gum margin removed, when it should be smoothed and polished with the same care that other fillings receive.

Fracture of one or more of the cavity walls is a common accident, and one which may be repaired if the filling has been securely anchored in portions of the tooth not involved in the fracture. Such accidents sometimes befall bicuspids and molars, especially the bicuspids, where fillings have been inserted in each approximal surface, the two meeting in the fissure upon the occlusal surface. The buccal wall is sometimes the one broken away, sometimes the lingual. In either case the ability to successfully repair depends upon the stability of the approximal fillings and the anchorage which can be obtained at the cervical wall and in the exposed fillings. To restore with gold a buccal cusp or the entire buccal surface of a bicuspid might necessitate a show of gold which would be objectionable; and a better plan would be to engraft a porcelain facing or an entire porcelain crown; whereas such a restoration on the lingual surface would not be open to the same objections. Cohesive gold alone is indicated for repairs of this kind. Watts' crystal gold when used in cases of this description has been most satisfactory.

If the fracture extends above the margin of the gum the operation is much more difficult because of the danger from a flow of blood, and the additional difficulty of getting the rubber dam above the border of the fractured surface. This may be accomplished by filling for a few weeks with gutta-percha, when there will be recession of the gum caused by the pressure of the gutta-percha upon it. When a similar fracture occurs in a molar, if the fractured surface does not encroach upon the pulp, and will admit of drilling retaining pits without danger to the pulp, there is no difficulty in restoring the broken portion with cohesive gold. Mack's screws are sometimes indicated in cases of this kind, since strong anchorage can be secured in this way without much loss of tooth substance.

Fracture of the incisal edge of the anterior teeth is often a serious accident, because of the difficulty of repair and the unsightly display of gold when it has been accomplished.

Large fillings situated upon the approximal surfaces of the incisors but not extending to the cutting edge, yet near enough to weaken the enamel overhanging, are especially liable to need repairs. The corner of the tooth breaks away, leaving the surface of the gold exposed, and the only hold the filling has is at the cervical border and the slight undercut along the labial and lingual walls of the cavity. In order to secure retaining hold for additional gold the operator must be careful not to displace the original filling. Sometimes a retaining pit can be made laterally into the sound dentin, or, by cutting a little channel through to the lingual surface and then deepening the channel at its extremity with a round bur, a secure anchorage may be had for the fresh gold.

Great care should be exercised in packing the gold lest by inadvertence the instrument should slip and push the original filling from its position. Fractured surfaces should receive prompt attention, for if left for a period of time disintegration of the dentin will set in and the caries may extend beneath the filling and thus jeopardize or ruin the most thorough work.

Eroded Areas.

There is a class of cavities which has not been specifically treated in the foregoing chapter, partly because the lesions under consideration cannot, strictly speaking, be classed under the head of carious cavities, and they are of such a peculiar formation that no definite rule can be laid down as to the best mode of treatment. If the eroded area be narrow and confined to the cervical border of the labial surface, and in a mouth in which the teeth are not conspicuous, a filling of gold may be employed; but not infrequently the eroded area extends over a considerable portion of the labial surface, and in such cases a filling of gold would be so inharmonious that it should be avoided if possible. Hitherto the operator has had little choice of filling materials, and has often been compelled, against his better judgment, to employ gold in these cases.

The zinc phosphates have been almost as inharmonious in color as the gold, and their durability has been so variable that they could not be regarded as permanent in character. The same may be said of gutta-percha.

Happily, the progress which is being made in *porcelain inlay work* promises something both artistic and durable. It is quite possible, with the great variety of shades of porcelain now being furnished, to match the tint of the natural tooth, and if care be exercised in the selection of shades and the contour given to the inlay these eroded areas may be covered and the tooth made to assume almost as natural an appearance as before the disease had attacked the surface. (For a detailed description of porcelain inlays the reader is referred to Chapter XV.)

CHAPTER XIII.

PLASTIC FILLING MATERIALS—THEIR PROPERTIES, USES, AND MANIPULATION.

By Henry H. Burchard, M. D., D. D. S.

The materials included in the heading of this chapter are—(1) Amalgam; (2) Gutta-percha and its preparations; (3) The basic zinc cements.

History.—The introduction of the first member of the group was not prompted by any specific merit that it had been demonstrated to possess, but was due solely to its properties of easy introduction, comparatively perfect sealing and prompt hardening, qualities which apparently recommended its wide and general use to those not possessing the requisite degree of skill for the successful manipulation of gold foil.

Applied upon a basis of glaring empiricism, with an absence of technical skill, the material received the prompt and sustained condemnation which its abuse had warranted. The steps and phases of this opposition of the trained and skilled against untrained and unskilled operators may be read in the dental journals of from 1846 to 1878 and even after. It was commonly known as the "amalgam war."

The first dental amalgam was that of Taveau, called "Silver Paste." It was made of filings of coin silver (silver 9, copper 1), combined with sufficient mercury to make a plastic mass. It was presumably this alloy which was introduced into America by two charlatans named Crawcour, under the glittering title of "Royal Mineral Succedaneum." The discovery of the nature of the paste followed soon after its introduction, which was clearly prompted by the motives above stated. Thereupon followed a persistent and virulent attack upon the material and all who used it. Upon less than the merest shreds of evidence alleged cases of salivation and mercurial necrosis were recorded as due to the use of amalgam.

That amalgam was still employed by the practitioners of France is evidenced by the presentation in 1849 of a formula for an amalgam alloy of pure tin and cadmium by Dr. Thomas Evans, an American dentist practising in Paris. An amalgam made from this alloy was found to shrink, and also to stain the dentin of teeth into which it had been introduced, owing to the formation of cadmium sulfid. It is noteworthy that Dr. Evans himself was the first to discover and make public the deficiencies of his amalgam.

In America amalgam remained under a ban until Dr. Elisha Townsend of Philadelphia, a practitioner of such great skill as to be safe from any imputation of lack of manipulative ability, introduced in 1855 an alloy of $44\frac{1}{2}$ silver, $55\frac{1}{2}$ tin. The amalgam of this alloy received an endorsement and application based more upon the eminence of its author than upon the results of actual clinical tests, and a reaction occurred which brought amalgam again under general condemnation.

What was known as the "new-departure corps" had its birth shortly after this time. This was composed of a limited number of practitioners and metallurgists, who were impressed by the fact that gold as a filling material was not the panacea of dental caries, and that by investigation alone could the proper place of amalgam be found in the dental armamentarium. It is due to this group of investigators to state that the history of the rational employment of plastics is the history of the "new-departure corps." It was undoubtedly due to it that plastics have come to be regarded as substances having definite physical and chemical properties which fit them for application as restorative and therapeutic agents for the relief of clearly defined physical and pathological states. As the properties of these agents become better understood, their employment more closely follows what is known as rational therapeutics.

The use of any or of all of these several materials is founded so entirely upon their individual properties that a discussion of these properties must precede and govern that of their methods of manipulation.

Nature and Properties of Amalgam.

An amalgam is a *combination of one or more metals with mercury*; it is therefore any alloy into which mercury enters as a constituent. The word amalgam (Fr. *amalgame*) is derived from Gr. *ἅμα*, together, *γαμέω*, I marry; or from *ἅμα* and *μάλαγμα*, from *μαλάσσω*, I soften—because of the softness and fusibility which mercury confers upon alloys.

It is to be understood that amalgams are classified as alloys, and may be therefore members of any of Matthiessen's groups as follows: A chemical compound in which the affinities are exactly satisfied; one in which there is unstable chemical equilibrium; a sub-chemical compound, or a mechanical mixture—although this latter is rare, as mercury exhibits some degree of affinity for all metals.

There are two possible ways in which mercury brings about the solution of other metals: First, by a chemical affinity for the metals; second, by lowering the melting-point of the solid metal, forming an alloy whose melting-point is higher than that of a mean of its constituents. The former is the explanation more in accord with the observed phenomena relative to the combination.

Physical Properties of Amalgams.—As a class amalgams have definite physical properties. First, that of *hardening* from a previous plastic condition; and nearly all of them for some time subsequent to apparent hardening undergo change of volume and of form. The change of volume may be either contraction or expansion.

Contraction and Expansion.—In contraction the mass tends to assume the form shown in Fig. 273. It has been shown by Dr. Black[1] that the extent of this contraction is due to several factors:

Fig. 273.

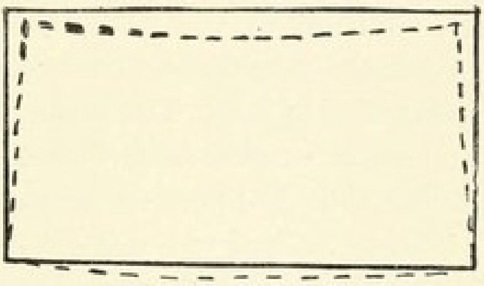


Diagram of amalgam shrinkage.

1. *To the composition of the primary alloy.* All other things being equal, an alloy of 65 per cent. silver, 35 per cent. tin, represents about the fixed point where there is a minimum of shrinkage. As a class, alloys containing less than 65 per cent. silver make amalgams which contract; those containing more than 65 per cent. silver make expanding amalgams.

2. *To the amount of mercury* used in amalgamation. There appears to be a definite percentage of mercury which produces the greatest strength of an amalgam mass; moreover, the percentage which produces the maximum strength increases the shrinkage of the shrinking alloys and increases the expansion of the expanding alloys. Surplus mercury in the amalgam mass can reduce neither the expansion nor contraction of the amalgam mass. While an excess or deficiency of mercury increases the shrinkage or expansion of an amalgam (according as the percentage of silver is 65 – or 65 +), these volume changes cannot be overcome by the percentage of mercury. An excess or deficiency of mercury weakens an amalgam. It would appear that the conditions which bring about the most perfect union of the metals produce the greatest changes of bulk in those alloys in which changes of bulk occur. An alloy the amalgam of which neither shrinks nor expands cannot be made to do so by changes in the amount of mercury employed.

3. A strong controlling factor has been found to be *the evenness of distribution* of mercury and alloy throughout the amalgam mass. An increase of the ratio of silver above 70 per cent. is followed by an enormous expansion of the hardening mass. It had always been noted that the amalgam made of a coin-silver alloy bulged from the walls of

[1] *Dental Cosmos*, 1895, vol. xxvii. p. 637.

a cavity inclosing it. This alloy contains, as stated, 90 per cent. of silver. The appearance of an expanded amalgam is similar to that of ice at the mouth of an iron tube in which the water has been frozen.

Copper amalgam is the only alloy tested by Dr. Black which underwent no change of form in hardening.

"Flow" of Amalgam.—A property attributed to certain amalgams, that of spheroiding, has been shown by Dr. Black to be without existence. The bulging of amalgams from the orifices of cavities was held to be due to the tendency of the mass to assume a spheroidal form, hence the term spheroiding. Tests showed the appearance to be delusive, the phenomenon being due to expansion and not to a spheroidal tendency. In addition to the properties of contraction and expansion the same investigator has discovered the property, hitherto unsuspected in amalgams, that of *flow*. The property of flow—*i. e.* change of mass form, from molecular motion under stress—had been observed in the majority of metals, but as found in amalgams it has a unique expression. Instead of being limited to a definite degree, proportioned by the stress applied, it has been found that amalgams yield repeatedly to the same amount of stress when applied at intervals, as in mastication, or yield continuously when the stress is constant. The process appears to be without limitations. It is at zero in copper amalgams ; next less in amount with alloys containing 55–60 per cent. of silver with 5 per cent. copper and the remainder tin. It will be readily seen that this property exercises a great influence upon the integrity and adaptation of an amalgam filling.

The notes quoted from Dr. Black were compiled from studies made of amalgams whose exact chemical composition had not been actually tested by the investigator. Later experiments[1] made with alloys prepared with the utmost care and exactitude by the investigator himself, gave widely different results (particularly as to the effect of adding a third or fourth metal to the basal alloy) in the direction of both flow and shrinkage. The first series of experiments which appeared to show an enormous increase of shrinkage and flow together with a lessening of edge strength, by the addition of a third or fourth metal (except copper, which the latest experiments still show to lessen flow and increase rigidity) were not confirmed when Dr. Black experimented with alloys made by himself, and an additional and unsuspected factor was taken into consideration, viz. the influence of heat upon the alloy.

It has been noted by Dr. J. Foster Flagg[2] that alloys which were freshly cut possessed working properties different from the same alloys when "old cut," or when aged. Dr. Black's observations appeared to confirm this, and his later experiments were directed toward determining the cause underlying the change. Motion, which was said to

[1] *Dental Cosmos*, December, 1896. [2] *Plastics and Plastic Fillings.*

bring about the change, was found to have no influence. After exhaustive and conclusive experiments it was ascertained that the change was due to a molecular alteration of the cut alloy, through a process of annealing or "tempering"—*i. e.* heat was the agent producing the change. The degrees of heat applied ranged from 130° to 212° F.

It was found that the amount of time during which an alloy was subjected to the action of heat governed the extent of tempering; for example, alloy subjected to a temperature of 130° for a given period, had the amount of amalgam expansion reduced a given amount; if the heat were maintained for a longer period the expansion was correspondingly decreased. Each formula has its zero point beyond which tempering has no effect.

In general terms, it was found that alloys in amalgams which expanded in hardening had the extent of expansion reduced by annealing; those which contracted had the contraction increased.

Alloys which were without alteration of volume unannealed, shrank when annealed.

The following tables will show the extent of change produced by annealing. It will be noted that the alloy of 72.5 silver, 27.5 tin, exhibits the minimum contraction after annealing. It will also be observed that less mercury is required to effect amalgamation in the annealed alloy.[1] Amalgams made from annealed alloys have both their flow and crushing stress slightly increased.

I. *Exhibit of Unmodified Silver-Tin Alloys.*[2]

Formulæ.		How prepared.	Per cent. of mercury.	Shrinkage.	Expansion.	Flow.	Crushing stress.
Silver.	Tin.						
40	60	Fresh-cut.	45.78	6	7	40.15	178
40	60	Annealed.	34.14	9	3	44.60	186
45	55	Fresh-cut.	49.52	4	8	25.46	188
45	55	Annealed.	32.13	11	1	28.57	222
50	50	Fresh-cut.	51.18	2	2	22.16	232
50	50	Annealed.	37.58	17	1	21.03	245
55	45	Fresh-cut.	51.62	2	2	19.66	245
55	45	Annealed.	40.11	18	0	17.53	276
60	40	Fresh-cut.	52.00	1	0	9.06	239
60	40	Annealed.	39.80	17	0	14.10	297
65	35	Fresh-cut.	52.00	0	1	3.67	290
65	35	Annealed.	33.00	10	0	5.00	335
70	30	Fresh-cut.	55.00	0	14	3.45	316
70	30	Annealed.	40.00	7	0	4.67	375
72.5	27.5	Fresh-cut.	55.00	0	42	3.92	275
72.5	27.5	Annealed.	45.00	3	0	3.76	362
75	25	Fresh-cut.	55.00	0	60	5.64	258
75	25	Annealed.	50.00	0	6	5.40	300

[1] For a full exhibit of this stupendous work of Dr. Black's, the reader is referred to his contributions in the *Dental Cosmos* for 1895 and 1896.

[2] Black, *Dental Cosmos*, 1896, p. 982.

II. *Exhibit of Modified Silver-Tin Alloys.*[1]

Formulæ.			How prepared.	Per cent. of mercury.	Shrinkage.	Expansion.	Flow.	Crushing stress.
Modifying metal.	Silver.	Tin.						
	65	35	Fresh-cut.	52.33	0	1	3.67	290
	65	35	Annealed.	33.00	10	0	5.00	335
	66.75	33.25	Fresh-cut.	51.52	0	4	3.35	329
	66.75	33.25	Annealed.	33.53	7	0	5.06	380
Gold 5.	61.75	33.25	Fresh-cut.	47.56	0	1	4.62	330
Gold 5.	61.75	33.25	Annealed.	30.35	7	0	6.07	395
Platinum 5.	61.75	33.25	Fresh-cut.	51.87	0	9	9.68	273
Platinum 5.	61.75	33.25	Annealed.	37.33	7	0	8.20	352
Copper 5.	61.75	33.25	Fresh-cut.	53.65	0	23	2.38	343
Copper 5.	61.75	33.25	Annealed.	35.60	5	0	3.50	416
Zinc 5.	61.75	33.25	Fresh-cut.	56.65	0	68	1.83	290
Zinc 5.	61.75	33.25	Annealed.	40.65	0	9	2.07	345
Bismuth 5.	61.75	33.25	Fresh-cut.	46.26	0	0	4.78	288
Bismuth 5.	61.75	33.25	Annealed.	23.67	6	0	5.58	308
Cadmium 5.	61.75	33.25	Fresh-cut.	57.57	0	100	6.40	225
Cadmium 5.	61.75	33.25	Annealed.	47.25	0	5	3.54	290
Lead 5.	61.75	33.25	Fresh-cut.	44.17	0	1	4.88	290
Lead 5.	61.75	33.25	Annealed.	32.76	10	0	7.18	276
Aluminum 5.	61.75	33.25	Fresh-cut.	65.00	0	445		
Aluminum 1.	64.5	34.5	Fresh-cut.	46.98	0	166	12.60	198
Aluminum 1.	64.5	34.5	Annealed.	38.26	0	48	17.90	213

Edge Strength.—What is termed the edge strength of an amalgam is the degree of resistance an edge or angle of an amalgam mass offers to force which tends to fracture it.

Amalgams have heretofore been regarded as rigid crystalline masses, utterly devoid of malleability. The discovery of the existence of flow at once modifies all previous conceptions and data regarding edge strength, for it is evident that a corner or angle might not fracture and yet might flow under the stress of the impact of mastication, whereupon edge strength might be said to be great, and in reality be but slight. In view of the existence of the property of flow, edge strength must be measured as *rigidity*, the antithesis of flow, and a high crushing stress.

It has been shown that contraction or expansion, and flow, are the influences which would disturb the maintenance of size and form of an amalgam filling ; therefore, a minimum of shrinkage and flow are the primary considerations in a satisfactory dental amalgam.

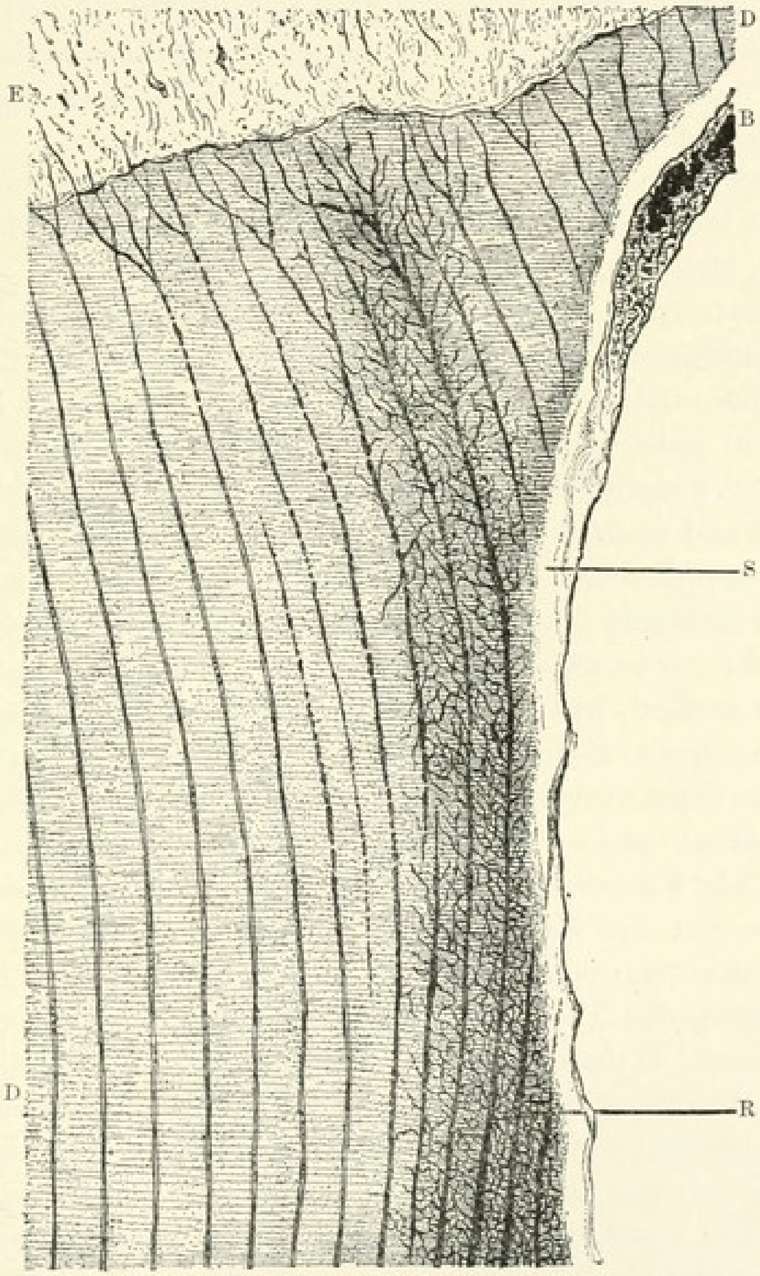
Color.—One of the serious drawbacks to the wide employment of amalgam has been its objectionable color, both in its original state and furthermore when it has suffered discoloration through the formation of oxids or sulfids upon its surface. The silvery white of amalgam in its most acceptable condition is not so harmonious a color as the yellow of gold, which fact has led first to the restriction of the use of amalgams to such spaces as are not readily visible, where its original and subsequently its altered color could not be a strong objection ; and, next,

[1] Black, *Dental Cosmos*, 1896, p. 987.

has prompted a modification of the silver-tin formulæ with the object of maintaining their original color.

The discolorations are not alone upon the external surfaces of fillings, but frequently (and most frequently in improperly prepared and filled cavities) the discoloration affects the dentinal walls bounding the cavity (see Fig. 274).

FIG. 274.



Staining of tooth structure with amalgam (Bödecker): E, enamel; D, D, dentin; B, border of cavity; S, solidified dentin along the border of the cavity; R, reticulum brought forth by the amalgam. (× 500.)

As shown in the illustration the discoloration may be deep. This danger is increased by leakage, when putrefaction of the protoplasmic contents of the dentinal tubuli or decomposing albuminous substances generate H_2S, and metallic sulfids are formed in marked quantities.

This danger of dentinal discoloration is guarded against by interposing a barrier between the cavity walls and the amalgam prior to the insertion of the latter. The influence of individual metals upon color will be discussed later.

Thermal and Chemical Relations.—As a conductor of thermal influence, amalgam is midway between gold and the basic zinc cements.

As to the actual effects upon the vital tissues of dentin, it has never been demonstrated that amalgam exercises any specific influence, except that cadmium appears to cause, through the cadmium sulfid formed, a degenerative influence (Flagg), and copper has antiseptic properties (Miller, Fletcher).

Chemically the dental amalgams are, to all intents and purposes, insoluble in the fluids of the mouth, the common solvent found in the oral cavity, lactic acid, affecting them but little.

Classification of Amalgams.—Amalgams are divided into binary, ternary, quaternary, and so on, according to the number of constituent metals. The only binary amalgams employed in dentistry are those of copper and of palladium.

BINARY AMALGAMS.—Copper amalgam is made by adding freshly precipitated and washed metallic copper to an excess of mercury ; when solution is complete the surplus mercury is expressed through chamois. The plastic residuum is then packed into moulds to make small tablets of the usual form in which it is dispensed.

A better method, which yields a product of greater purity, is to precipitate the copper directly into the mercury by electrolytic process. This may be done conveniently by pouring a quantity of mercury into a suitable glass vessel—a small battery jar, for example—and suspending a thick plate of copper, by means of a wooden support, some distance above the surface of the mercury. A saturated solution of cupric sulfate is then poured into the jar until the copper plate is completely submerged. The cathode pole of a battery or other source of electrical current is then connected with the layer of mercury, and the anode with the copper plate. All that portion of the cathode electrode in contact with the cupric sulfate solution should be insulated with gutta-percha, and only the point which is in contact with the mercury left exposed. The passage of the current causes solution of the copper from the anode and deposits it in the mercury continuously as long as the foregoing conditions are maintained. The precipitation should be continued until the mercury is saturated, which will be evidenced by the appearance of the characteristic red color of the excess of copper at the cathode pole. When the saturation point has been fully reached the mass should be washed, first in dilute hydrochloric acid and then in water, dried and compressed as is usual with this amalgam when prepared by the ordinary processes. This method was suggested to the writer by Dr. E. C. Kirk.

In its typical form and condition, copper amalgam, when made plastic by heat, may be packed into matrices, such as cavities in teeth, where it sets quickly, undergoes no change of volume or form, and is devoid of flow. Therefore a cavity which has been sealed by it remains sealed. Upon its outer surface a coating of black sulfid quickly forms, which remains but does not penetrate the tooth structure. The dentinal walls are commonly stained green through the absorption of the metallic salts.

In improperly prepared specimens there is not a perfect chemical union between the metallic mercury and the copper. The presence in a filling mass of oxids of either of these metals establishes local electrolytic conditions which prevent the formation of the black sulfid coating and bring about the gradual dissolution of the amalgam mass. To recapitulate: Copper amalgam is physically unchangeable as a filling material; it brings about very offensive discoloration both of the dentin and of its own surface; it is antiseptic.

The second binary amalgam is that of palladium. Palladium is precipitated from a solution of its chlorid by iron or zinc, washed in nitric acid, and dried. To the precipitated metal, mercury is added, the combination being attended by the evolution of much heat (*i. e.* is an active chemical union). If an excess of mercury has not been used the amalgam sets quickly, does not alter in form,[1] and becomes black upon the surface,[2] but does not discolor the dentin. The addition of an excess of mercury retards the setting, and produces an inferior filling.

Ternary Amalgams.—The base of all ternary amalgams is the alloy of silver and tin. The first of these was the alloy of Townsend, $44\frac{1}{2}$ per cent. silver, $55\frac{1}{2}$ per cent. tin. From this point the investigations and experiments radiated—it being found after many years of clinical testing that those alloys containing more than 50 per cent. of silver gave the best results.

The formula given by Dr. J. Foster Flagg as affording the most stable alloy for amalgam—60 silver, 35 tin, and 5 copper—was found by Dr. Black to be that giving the highest degrees of resistance to change of form, to flow, and to crushing. In view of Dr. Black's researches into the effects of annealing alloys it is evident that the ternary amalgam of the future will have a composition closely approximating 72.5 per cent. silver, 27.5 per cent. tin.

The binary alloys of tin and silver form the basis of all of the quaternary amalgams used in dentistry.

[1] Tomes, *Trans. Odontological Society of Great Britain*, 1872.

[2] Bogue, *Dental Cosmos*, 1884.

Quaternary Amalgams.—The metal additional to the basal alloy is added for the purpose of modifying the color or increasing the edge strength of the amalgam. The addition of copper 5 per cent. to an alloy containing over 60 per cent. silver increases the crushing stress and lessens both flow and contraction. The alloy is white when fresh, but in the presence of sulfur compounds discolors.

The addition of gold (5 per cent.), as clinical records testify, aids in maintaining the color of the filling. It lessens shrinkage slightly (compare this and following statements with table No. II.), and appears to have little or no influence upon flow and crushing stress. The addition of platinum causes dark fillings and notably increases the flow; the setting is slowed.

The addition of zinc increases rigidity; the amalgams expand for long periods after apparent hardening; the crushing stress is moderately high—a direct contradiction of statements of several previous observers.[1]

Additions of bismuth, cadmium, lead and aluminum were made to the basal alloy, but all of them exhibited properties which exclude them from introduction into dental amalgam.

Dr. Black[2] states that "alloys containing 5 per cent. of aluminum have their setting attended by the evolution of much heat; an enormous expansion of the mass occurs; the instruments used in packing are oxidized, and a distinct crackling of gas-disengagement is heard." "The formation of aluminum amalgam is characterized by an exhibition of the affinity of aluminum for oxygen. Aluminum oxid is doubtless formed, which increases the volume of the amalgam mass."

Washing of Amalgams.—Alloys which have been cut for some time, and mercury the purity of which is questionable, are found to be coated with oxids of the metals—in the case of mercury, with the oxids of contaminating metals. The advisability of washing the amalgam mass in some solvent which will remove the oxids is a mooted question. It has been stated that the washing of an amalgam mass increases its shrinkage (Flagg). On the other hand it has been observed that washed amalgams retain their color better. It is difficult to see how the washing could affect the integrity of the set mass unless oxidizing substances were left in it; and this is clearly contraindicated by the maintenance of color in washed amalgam. The writer prefers washing the plastic mass in chloroform prior to expressing the surplus of mercury.

[1] It is to be recalled in this connection that Dr. Black's measurements are made with instruments of unequalled accuracy, those of previous observers with comparatively crude instruments.

[2] Private communication.

Use of Amalgam.

It is to be understood that amalgam is to be employed only in those conditions and situations which clearly indicate it as the proper material. As a general rule, it is excluded from the ten anterior teeth of each jaw, although this rule is open to exceptions. Its anterior limit of application is usually regarded as the distal surface of the first bicuspid. Its more general employment has been greatly reduced in many places since the introduction of what are known as combination fillings (see Chapter XIV.), and by improvement in the forms and character of artificial crowns.

The first class of cavities to which amalgam is applied are those which extend beneath the gum margin; the second, buccal cavities; the third, compound cavities; the fourth, approximal cavities; the fifth, cavities upon the masticating faces of the teeth. These are the classes in which gold is most difficult of introduction and of proper shaping and finishing, in the order named. Amalgam should rarely or never be packed against dentinal or enamel walls without the interposition of a layer which will prevent either the discoloration of the dentin or the bluish appearance noted when amalgam underlies enamel.

The shaping of cavities for the reception of amalgam fillings (see Chapter VIII.) should be done with such care as will give assurance of the permanent retention of the filling and the perfect sterilization of the dentin before and during its introduction.

The separation of the teeth, removal of gum overhanging cavity margins, and breaking down of frail enamel walls by means of chisels, precede the filling.

The rubber dam is to be adjusted where and when possible, with such care that an exclusion of the fluids of the mouth is assured during the shaping, sterilizing, and filling of the cavity. As Dr. Black has shown,[1] much of the permanency of form of an amalgam mass depends upon the even distribution of the constituents; it is evident that every aid to this end should be utilized, an important one being that the mass should be packed into a cavity having but one orifice, that for the introduction of the filling.

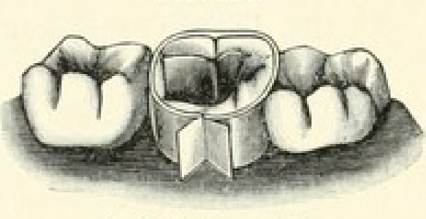
With the data relative to dental amalgams which have been given, it is evident that a dental amalgam mass is by no means simple, but is a very complex body. If sufficient mercury has been used to effect solution of the alloy particles the mass will consist, first, of a quantity of a chemical amalgam—*i. e.* one in which the metals are united in atomic ratios—this being surrounded by one or more other distinct

[1] *Dental Cosmos*, 1895, vol. xxxvii. p. 553.

amalgams, each having its own time of setting and rate of contraction. If only enough mercury has been used to make a creaky mass the surfaces of each alloy particle are covered by an amalgam of indefinite composition which acts as a cement binding the particles together. In this line the same experimenter has shown that mixing the alloy and mercury in a mortar by means of a pestle, wringing the surplus mercurial solvent from the mass by means of heavy pliers, and packing the filling with steel burnishers are all influences which lessen the strength of the completed filling.

The conditions are now a prepared and sterilized cavity; any missing wall required to give four sides has been replaced by a properly adjusted matrix (see Figs. 255, 256, Chapter XII.).

Fig. 275.



Dr. Herbst's matrix.

Matrices.—Matrices may be readily and quickly formed by cutting strips from a sheet of very thin steel which has been annealed

Fig. 276.

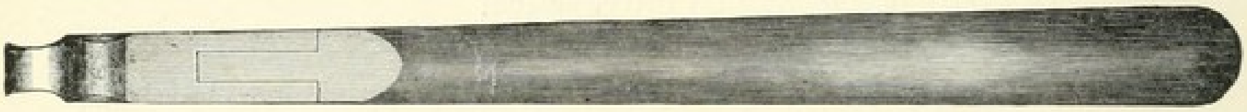
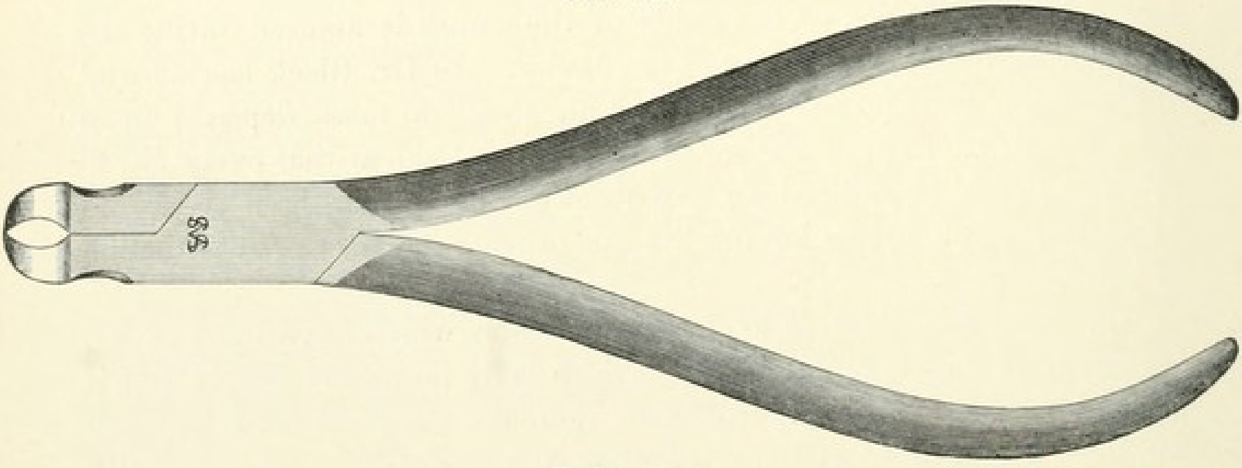


Fig. 277.



Herbst pliers.

and polished. By means of contouring pliers the matrix is given the correct contour, then wedged or tied into place. They must be so adjusted that they are immovably held during the filling operation.

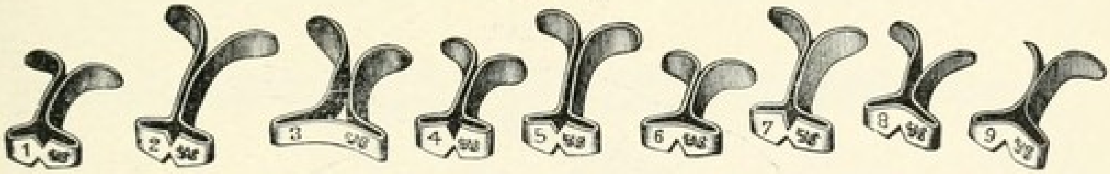
A rapid method of forming a matrix is that of Dr. Wilhelm Herbst: A strip of German silver No. 33, wide enough to extend from the cervical margin of a cavity to its mouth, and long enough to more than embrace the tooth, is passed around the tooth (see Fig. 275); the strip is caught near its extremities by a pair of Herbst pliers (Figs. 276, 277) and drawn taut; the pliers pinch the metal into close adaptation to the tooth walls. Held by the pliers the matrix is withdrawn, the line of junction touched with zinc chlorid solution, and soldered over an alcohol or Bunsen flame with soft solder. The matrix is replaced upon the tooth, the rubber dam applied, and the matrix pressed against the cervical margin of the cavity by means of a wooden wedge.

The matrices of Guilford and those of Brophy (Figs. 253, 254, Chapter XII.) are operated upon a common principle; the band which most nearly fits the periphery of the tooth is adapted, then drawn into close apposition with the tooth by means of the screw appliances.

The matrix of Woodward is one of the most convenient. Its mode of application is shown in Fig. 256, Chapter XII.

The Miller matrix (Fig. 278) is useful and adapted for the class of cavities shown in Fig. 279, as held in contact with cervical mar-

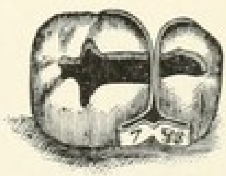
Fig. 278.



The Miller matrices.

gins through the action of the duplex spring leaflets. When necessary a wooden wedge is forced between the leaflets.

Fig. 279.

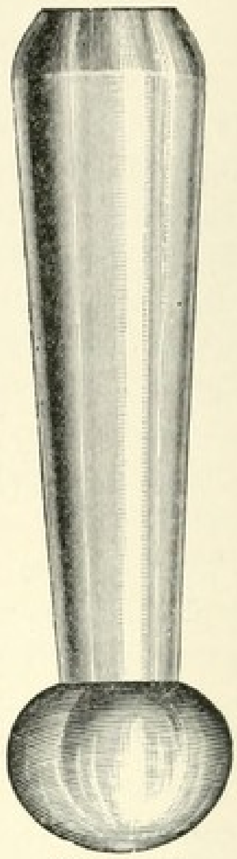


Miller matrix adjusted.

(For other forms and applications of matrices see Chapter XII.)

Mixing the Amalgam.—It is usually recommended that the proportion of mercury and alloy be determined by weight. An amount of alloy is first weighed, then weighed additions of mercury are added to it sufficient to make a plastic mass, when the two are to be mixed together; the relative amounts of mercury and alloy are to be gauged and recorded for each formula of alloy. With the "submarine" alloy of Flagg—60 silver, 35 tin, and 5 copper—the ratio is equal parts by weight of filings and mercury. When a mortar is used for making the amalgam, one of glass and having a glass pestle (see Figs. 280, 281) is to be preferred. Mixing in the palm of the hand is a dirty process, the hand and fingers becoming much discolored by the metallic oxids.

Fig. 281.



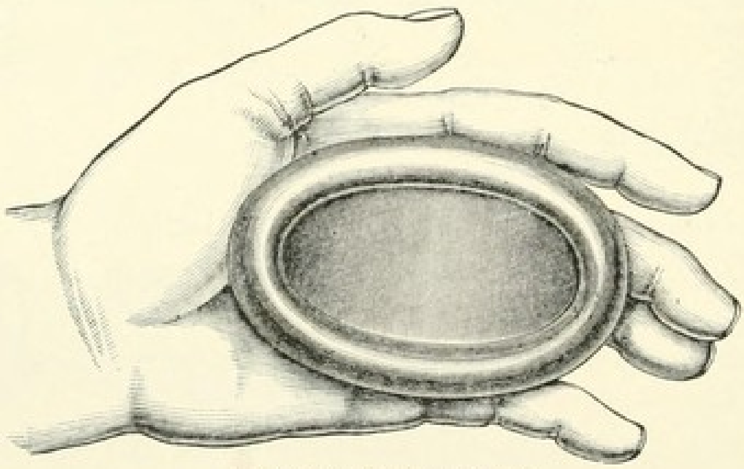
Glass pestle.

Fig. 280.

Glass mortar.

A rubber mortar (Fig. 282) to be received in the palm of the hand has been devised by Dr. Genese. In view of deductions from Dr.

Fig. 282.



Dr. Genese's rubber mortar.

Black's experiments this latter method of mixing is regarded as usually the preferable one.

The filings are placed in the receptacle, the mercury is added, and the mass is triturated—if in a mortar, by the pestle, if in the rubber basin, by the forefinger guarded by a rubber finger-stall. When the amalgamation appears to be complete the mass is transferred to the hand and kneaded, then pressed into a ball. It is next enclosed in stout muslin, or China silk as recommended by Dr. C. E. Kells, Jr., and the surplus mercury expressed by wringing; when no more mercury appears through the muslin, the button is removed: it should break with a clean, white fracture surface.

Another method of mixing the filings and mercury is that of Fletcher. Filings and mercury are placed in a long glass tube which is shaken violently until amalgamation is complete.

The Packing Operation.—Several devices have been invented for the purpose of carrying the amalgam to the tooth cavity, one of the

Fig. 283.

most simple being shown in Fig. 283, and another in Fig. 284. Another excellent instrument is shown in Fig. 285, one end having ser-

Fig. 284.

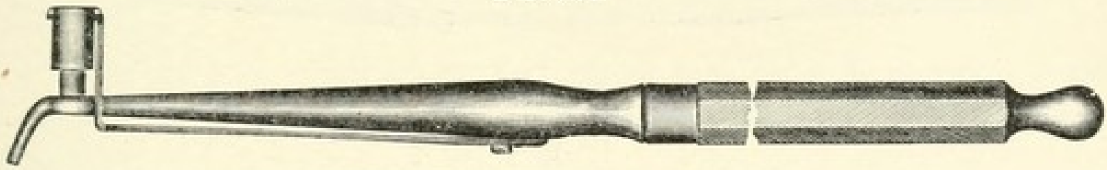
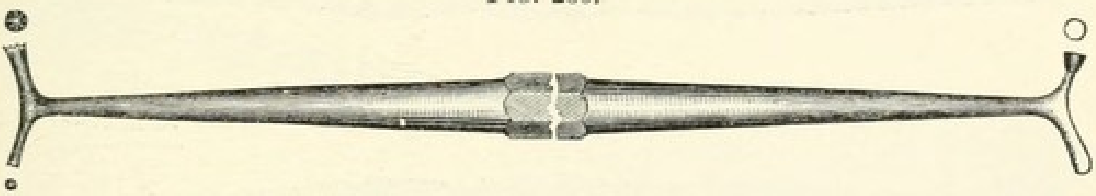


Fig. 285.

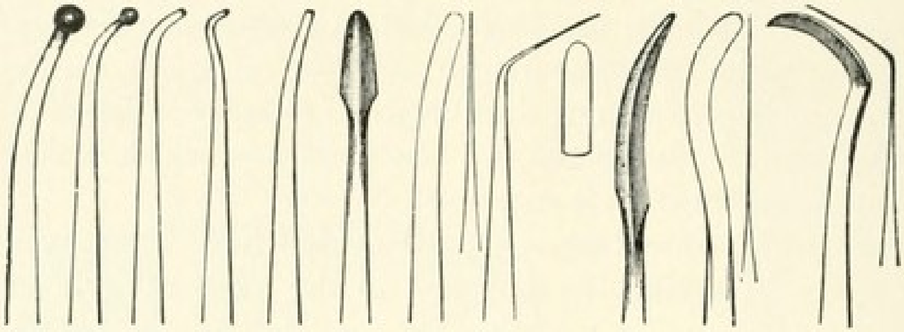


rated points which engage the soft amalgam, the other a plugger head.

Numerous methods have been advanced and advocated for the packing operation. The one commonly followed is that of burnishing the amalgam. This has been shown by Dr. Black to weaken the mass. A small piece, rarely more than a cube of $\frac{1}{8}$ in. side, is carried to the deepest and most inaccessible recess of the cavity and pressed against its walls by tapping, burnishing, or uniform pressure. Dr. Flagg's method is by tapping. Each successive piece of amalgam is tapped upon by the packing instruments until it combines with its predecessor and is perfectly adapted to the cavity walls. The set of instruments shown in Fig. 286 are those by which this process is accomplished—Nos. 30–34 being packing instruments, while the others are shapers.

A convenient and effective set of instruments for accomplishing the packing are shown in Figs. 287–289.

Fig. 286.



Dr. J. Foster Flagg's amalgam and zinc filling instruments.

Dr. W. G. A. Bonwill has advised a method which accomplishes the removal of surplus mercury and the even distribution of the mass,

Fig. 287.

Fig. 288.

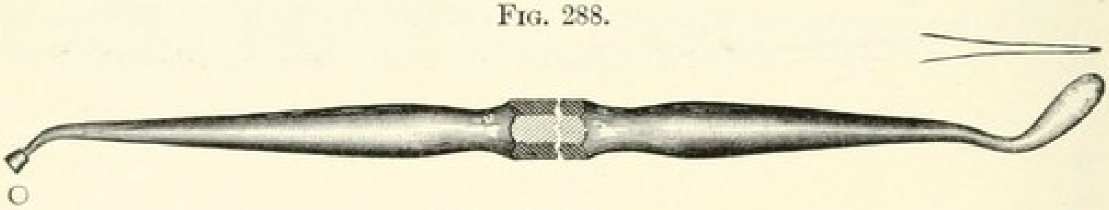
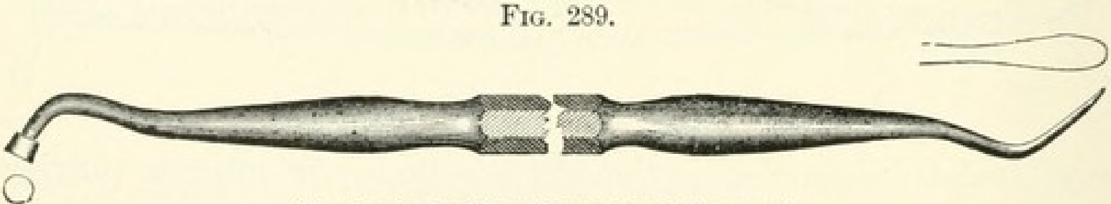


Fig. 289.



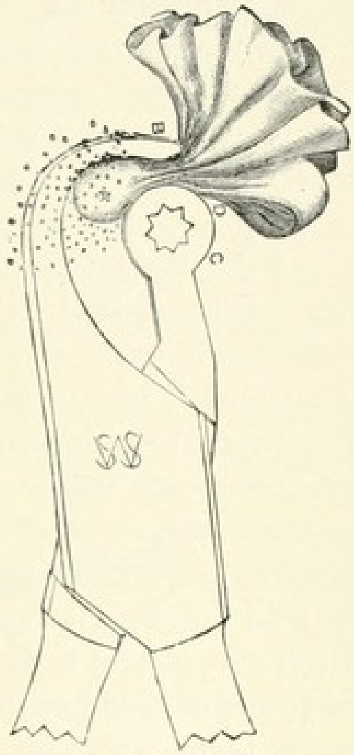
Woodson's double-end amalgam instruments.

during the progress of the filling. Small squares of folded bibulous paper are caught in the jaws of pliers and laid upon the amalgam, when the exertion of pressure by means of amalgam pluggers or pliers forces out the surplus solvent and it is wiped away with the paper. The same end is also accomplished by the use of bulbous points of soft rubber.

When through either method the cavity is more than half full, the remainder of the amalgam mass is wrung out to express more mercury, and the packing is resumed until the cavity is more than full.

At the later stages of the filling the process of wafering is usually followed. By means of chamois and heavy pliers (Figs. 290, 291) the amalgam mass remaining is compressed into a wafer, driving the surplus mercury through the pores of the chamois. The amalgam is put in a piece of chamois, and the chamois sack A is entered between the beaks B and C (the latter a roller); closing the handles of the instrument progressively squeezes out the mercury till any desired degree of dryness is attained. When the amalgam is squeezed to the requirements of the operator, the handles are released, and the spring opens the appliance. The action is analogous to the finger and thumb movement in common use, but is much more powerful, and therefore more certain and more uniform. Small sections of the wafer are laid upon the half-completed filling and tapped into a union with it. The cavity is more than filled, and at the completion of the packing the amalgam should cut as though nearly set.

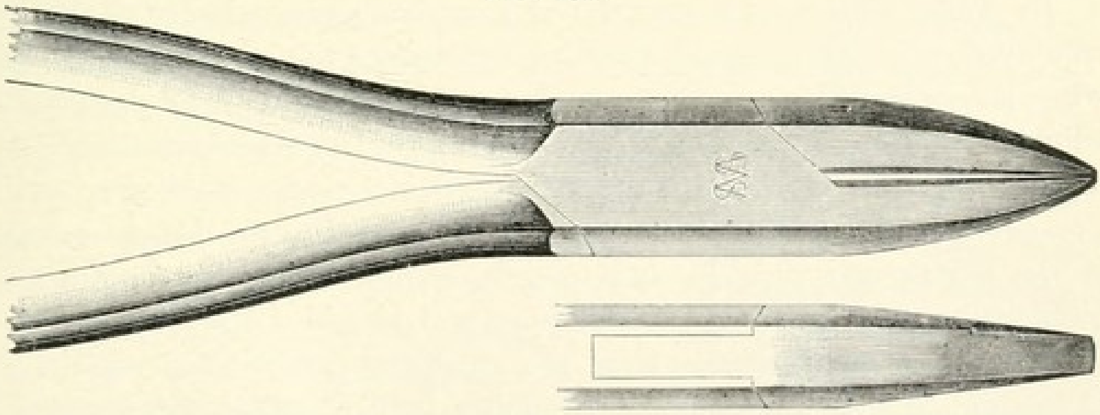
FIG. 290.



Mercury expresser.

Another and excellent method where applicable is to shape small pieces of half-vulcanized rubber and cement them upon broken excava-

FIG. 291.



Flagg's wafering pliers.

tors, and use them as pluggers during the later stages of the filling. The fluid cementing amalgam will have its surplus mercury expressed about the sides of the plugger.

Still another method is to fill the cavity more than half full, then cut away the softened portion, and complete the filling with drier amalgam. Fillings the initial portions of which have been introduced comparatively dry are more homogeneous and are less likely to discolor and crevice than when more fluid amalgam has been used to begin the filling. An examination of an amalgam filling immediately after completion will show the marginal portions to contain the softer amalgam, the harder being in the more central parts.

The too common practice of placing in the prepared cavity sufficient amalgam in one mass to nearly or quite half fill it, is faulty. By no means can this method secure the accuracy of adaptation of filling material to cavity walls which is demanded of a correct filling.

At the completion of the packing operation, unless the filling has been finished by wafering, the surface will be found still soft. It has been recommended[1] that small pieces of annealed No. 1 gold foil be burnished over the surface of the amalgam, until no more gold can be amalgamated by this means, when the filling will be found quite hard. The indefinite cementing amalgam has combined with the gold, for which mercury has a strong affinity, and formed a distinct amalgam upon the surface of the filling proper. As amalgams of gold are comparatively soft, it is advisable to first fill the cavity more than full, apply the gold foil, then scrape the filling down to the cavity margins. Dr. Rhein's procedure is to fill the cavity with plastic amalgam and rub on the pieces of gold until no more gold is amalgamated. This gold amalgam is permitted to remain. The surplus of mercury may also be conveniently removed by absorbing it from the surface of the filling by pieces of sponge or crystal mat gold.

An amalgam filling should be hard enough to resist cutting before the rubber dam is removed.

In those situations where the rubber dam cannot be successfully employed, it is the accepted practice to prepare the cavity, sterilize it, when access is difficult sealing a germicide in the cavity for a day; next adjust a napkin, and having mixed a submarine amalgam (one containing copper and a high percentage of silver), the cavity is dried as well as possible; a piece of the amalgam is then carried to the deepest recess of the cavity and quickly and forcibly compressed with a mass of bibulous paper. Another piece of amalgam is added and compressed, driving the surplus mercury from the amalgam. While the napkin is in position, a mass of temporary stopping (which see) is softened and placed in the remainder of the cavity. A knife blade passed over the edges of the amalgam will remove overhanging portions. At a subsequent visit, the rubber dam is adjusted, the temporary stopping is removed, and the filling completed with amalgam.

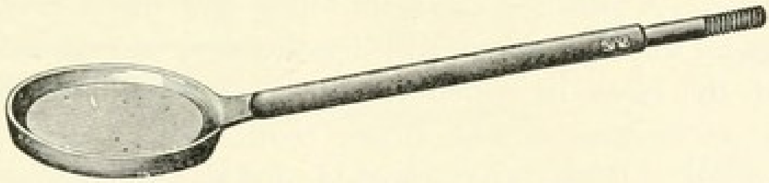
If the operator prefer, the rubber dam may be adjusted at once and the filling completed at one sitting; the former method is, however, preferable, as the cervical portion of the filling may be perfectly finished, and not be in danger of displacement, while the second section is packed.

[1] Ottolengui's *Methods of Filling Teeth*, "Method of M. L. Rhein."

In cavities extending beneath the gum, and opening broadly upon a surface of a tooth where discoloration would be highly objectionable, the cervical half of the filling is made of a submarine amalgam and is completed with an amalgam containing gold, which will retain a better color. Should the external face of the filling be readily visible and not subjected to the stress of mastication, its outer surface is made of a wafer of an amalgam containing zinc, known as a facing amalgam. Copper amalgam is used, when used at all (and that is but seldom), upon the distal and buccal walls of third molars, in cavities extending under the gum line, which are difficult of access and to sterilize, and which cannot be properly dried.

A cavity is prepared which need be but slightly undercut. A pellet of the copper amalgam is placed in an *iron* spoon (Fig. 292) held above

Fig. 292.



Heating spoon for copper amalgam.

a Bunsen flame until globules of mercury appear upon its surface, when it is quickly crushed in a mortar and pounded until made into a paste. There can be no objection to washing the soft mass in aqua ammonia to dissolve and remove oxids which later form discoloring salts, and thus permit a chemical union of the metals which would be prevented by their presence. A napkin, or always when possible the rubber dam, is adjusted, and the filling inserted in sections. At the end of the operation the filling should be firmly compressed with a broad-bladed spatula.

In by far the greater number of cases in which amalgam was at one time used alone, it is now the accepted practice to place a lining of a zinc cement, and add the amalgam as a resistant and insoluble covering.

In cavities which approach the pulp the same precautions are taken for the prevention of thermal shock as with gold.

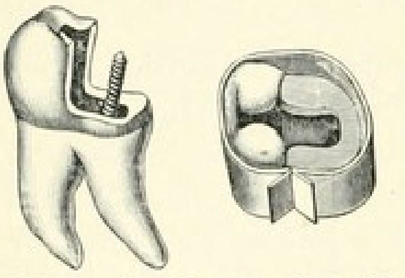
The *most difficult class of cases* in which to obtain satisfactory results with amalgam are those opening alone upon the approximal surfaces of bicuspids and molars. While it is true that amalgam may be manipulated in spaces impossible with gold foil even in soft cylinders, it is essential that sufficient room be obtained for the perfect introduction of the material and its subsequent trimming and polishing; for polishing is quite as necessary an operation with amalgam as with gold. This space is obtained either through wedging or by cutting through the occlusal face of the tooth into the cavity.

Space is to be obtained and amalgam packed in such a manner that the amalgam at the completion of the operation shall exhibit no evidence of pastiness. To insure the removal of the excess of the solvent, gold foil may be burnished over it as already described until it requires some effort to cut the mass with a lancet blade. Amalgam when set is more difficult to cut and polish than gold; the greater portion of the carving is therefore done at the same sitting as the filling, but should never be undertaken while the filling is soft. It should be in such a condition that it is necessary to carve, not smear, it into shape.

A suitable cutting instrument of the form of Nos. 37 to 40 of Flagg's set (see Fig. 286) is passed first across the cervical border of the filling, removing any excess due to imperfect contact of the matrix with the cervical margin of the cavity; next the lateral borders are carved, and then the masticating surface. The body of the filling is left full, so that after two days, when the filling receives its final dressing and polishing with cuttlefish disks, strips, pumice, etc., the filling will be reduced to correct contour. A polished amalgam filling will retain an untarnished surface when an unpolished one will discolor very objectionably.

Many of the cases in which it was at one time the usual practice to fill or restore almost entire tooth crowns with amalgam, are trimmed down, shaped, and artificial crowns applied. One class of cases is frequently seen in which the indication is for an enormous amalgam filling rather than an artificial crown; this is, the loss of the distal half of the crown of a molar. As a rule the teeth are pulpless, or it is necessary to devitalize the pulp. The appearance of the crown after the removal of carious dentin and cutting away frail enamel walls is seen in Fig. 293.

Fig. 293.



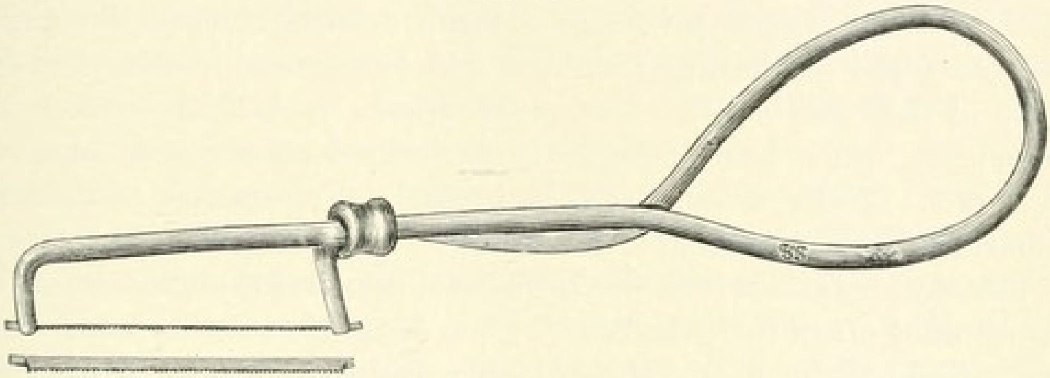
Restoration of lower molar with amalgam.

A Herbst matrix is fitted, closely embracing all the margins of the cavity. The rubber dam is adjusted. It is of course understood that the root canals have been properly sterilized and filled. The posterior canal is drilled out for about $\frac{1}{4}$ in. and screw-tapped. A thin solution of zinc phosphate is mixed and the tip of a screw to fit the tapped root has its point dipped into the cement, and then quickly screwed into place. The amalgam is packed in larger masses than usual, using bibulous paper to compress it about the screw and into such scant undercuts as may be secured in the anterior portion of the tooth. The filling is completed with amalgam wafers.

Such a filling should be well set before the rubber dam is removed. The upper surface is carved into cusps and sulci to occlude properly with the antagonizing teeth. The matrix should remain for twenty-four hours, when it may be split and removed. If the matrix has been exactly adjusted there should be no trimming of the margins required, no carving of contour, and no smoothing, the amalgam being ready for polishing strips. The occlusal surface is smoothed and polished with moosehide points and pumice, using a stiff brush to polish the sulci.

Finishing.—The process of finishing hard amalgam fillings is similar to that of finishing gold. For example: a compound cavity occupying the approximal and occlusal faces of a molar. A fine saw is placed in a frame as in Fig. 294, but set to draw-cut with its teeth

Fig. 294.



The Kaeber saw frame.

pointing toward the frame. The blade is passed above the cervical margin of the filling, engaging any projecting amalgam, which is then sawn off. It is just as essential with an amalgam as with a gold filling that the cervical edge should be exactly flush.

The lateral margins of the filling are next carved smooth; strips of emery cloth are passed into the interdental space and the filling smoothed and rounded, completing this portion of the operation with emery strips of the finest grit.

Linen tapes or metal polishing strips are next charged with pumice and passed over the surfaces until they are smooth and the margins are perfect. The occlusal portion is polished by means of rubber or moosehide points and pumice.

Should it be a plain approximal filling, not a "contour," the saw is used to cut away surplus amalgam, and the polishing accomplished by means of disks and powders.

Fillings upon the buccal surfaces of teeth are smoothed by means of disks and polished with rubber cups or disks and pumice.

Gutta-percha.

Origin.—The gutta-percha of commerce is the coagulated juice of the *Isonandra gutta*, a tree of the order of *Sapotaceæ*. The juice is found in all trees of this order, but some specimens are of much higher value than others. That from Borneo is regarded by manufacturers as being inferior; it is the variety from which the name is derived—Malay, *gatah* or *gittah*, gum, and *pertja*, a tree. The gutta Tuban from Singapore is regarded as a superior variety.

The mode of securing the juice is by tapping the cambium layer of the tree and catching the juice as it exudes. From this stage to its formation into sheets it undergoes several processes (see works on gutta-percha); it is possible that in some of these operations it may have its texture injured by overheating.

"The purified gutta-percha probably consists of a hydrocarbon (pure gutta) having the formula $C_{10}H_{16}$; albane, $C_{10}H_{16}O$; fluavile, $C_{40}H_{64}O_3$; and a variable compound named guttane. Pure gutta possesses all the good qualities of gutta-percha in a much enhanced degree, becoming soft and plastic on heating and hard and tenacious on cooling without being in the least brittle. The resins appear to be simply accessory components which have a decidedly detrimental effect when they preponderate. Water, wood, fibers, bark, sand, etc., occur as mechanical impurities of gutta-percha." (Obach.)

History.—Gutta-percha was introduced into dental practice as a filling material about the year 1847. Soon after this a secret preparation was introduced by a Dr. Hill, which received his name. Numerous alleged analyses of Hill's stopping have been given, all of which are untrustworthy. It was found to subserve so useful a purpose that it received the tribute of wide imitation; in fact, the white gutta-percha preparations of the present day had their foundation in this imitation. There is no entirely trustworthy evidence that the original was superior to the best of contemporary preparations.

As at present employed as a filling material gutta-percha is in two forms, the first the well-known pink gutta-percha base plate, which is colored by the insoluble sulfid of mercury, the second the white preparations, made firmer in texture by additions of the soluble zinc oxid. The specimens of crude gum differ as to the amount of heat required to soften them to an equal degree. Dr. Flagg[1] states that the specimens requiring the greatest degrees of heat for softening, prior to the addition of the zinc oxid, afford the best dental gutta-perchas. The method of making the gutta-percha of dentistry is by softening a mass of the brownish-yellow gum on a slab which has been heated over boiling water, and driving zinc oxid into the softened mass by a process of kneading, using a wedge-shaped steel instrument as the kneader. It requires infinite patience and much time to distribute the powder evenly throughout the mass. Overheating the material at any stage of its manufacture or manipulation is ruinous to its texture.

Classes.—Gutta-perchas are divided into three classes according to the temperature of softening: *Low heat*, softening below 200° F. *Medium heat*, becomes plastic at 200° to 210° F. *High heat*, 210° to 218° F. The low-heat specimens contain 1 part by weight of gutta-percha to 4

[1] *Plastics and Plastic Filling.*

of zinc oxid; in medium-heat the ratio is 1 to 6 or 7; and in the high-heat specimens the gutta-percha is almost saturated with zinc oxid.

Physical Properties.—Gutta-percha is an almost perfect non-conductor both of heat and electricity. It is less hard and rigid than any other filling material. It contracts in hardening, *i. e.* cooling. Softened masses of it are coherent when dry, but not when wet. Its color may be made to resemble that of the teeth. To vital tissues it is the most bland, unirritating filling material known.

After it has served as a filling for a greater or less period it is found to have increased in hardness and difficulty of softening, and its surface, and perhaps its substance, has become porous in variable degree. The increased hardness is observed in such situations as those in which putrefactive decomposition occurs; that is, in places where there is an evolution of hydrogen sulfid; the gutta-percha apparently undergoes a species of vulcanization. It becomes somewhat porous in those situations where the formation of a solvent is active (lactic acid), which abstracts the soluble zinc oxid from the mass. The pink variety containing the insoluble mercury sulfid does not become porous, but wears with a comparatively smooth surface when subjected to attrition.

Examining in detail these several physical properties it will be noted that gutta-percha has but one property in common with gold—its insolubility. Its rational employment is therefore in such situations and conditions as those in which the use of gold is contraindicated.

Indications for its Employment.—First, in its several forms it is employed as a temporary filling material for both the temporary and permanent teeth. Owing to its non-conductivity it is employed near the pulp; its insolubility recommends its use at the cervical margins of cavities, particularly in the buccal cavities of molars which do not extend to the masticating surface, where the non-resistance of the material would cause its rapid wasting.

This is the most common of the situations in which gutta-percha is applied: very deep cavities upon the buccal surfaces of molars, extending beneath the gum, and having ragged enamel margins, the orifice of the cavity being much smaller than its body. Owing to its non-irritating quality, the condition of the gum in contact with a gutta-percha filling remains normal.

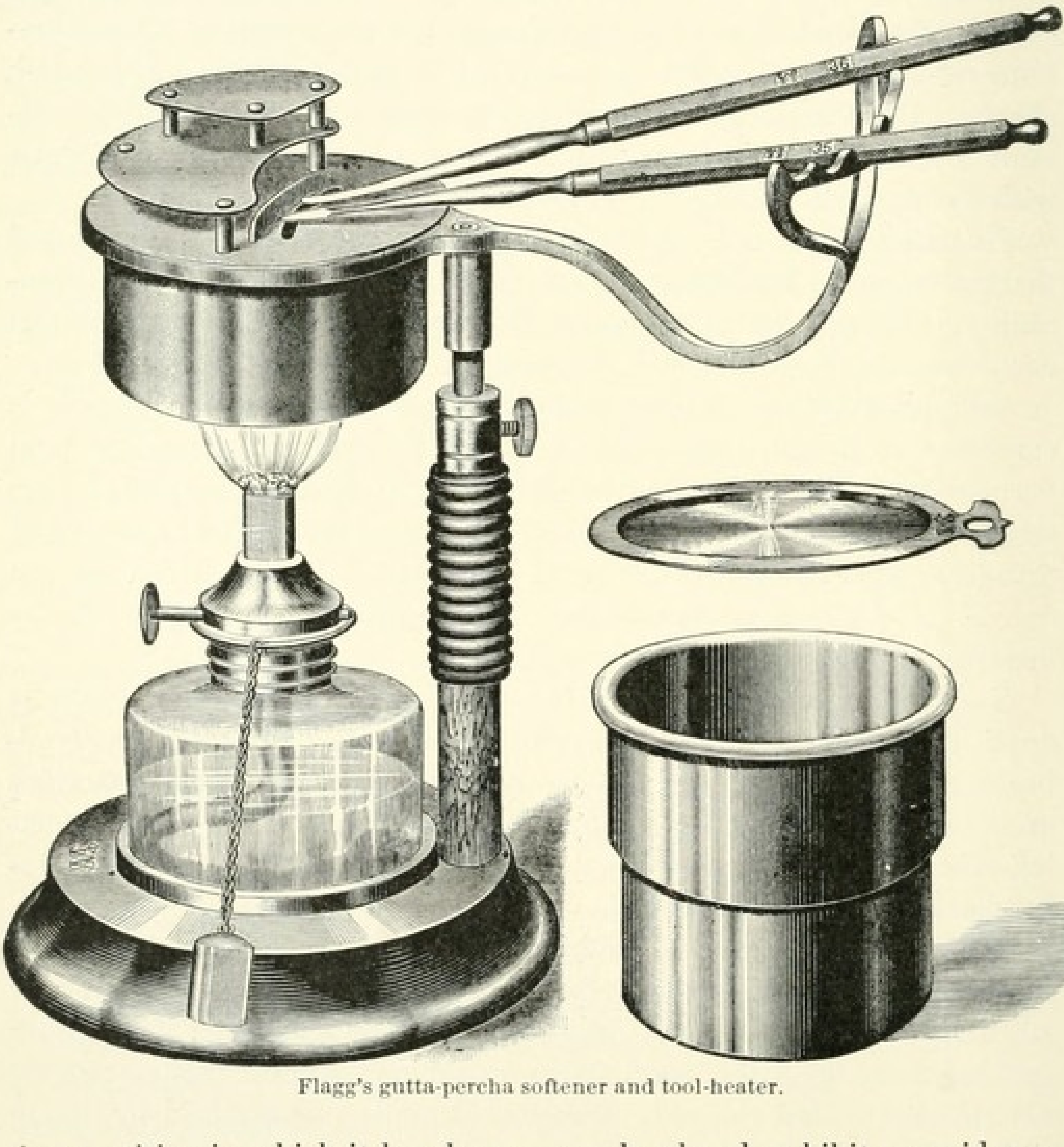
It is used in approximal cavities of the anterior teeth which have a similar form to those just described; also in labial cavities, particularly when these teeth are in any degree loose. For example: in a cavity opening alone upon the distal wall of a canine tooth the carious process has almost invaded the pulp, the enamel walls unsupported by dentin still retain their form and have a good texture.

Pink base plate is invaluable for the temporary filling of spaces after wedging and also the cavities to be subsequently filled with metal. A mass of the material may be packed into such spaces and be permitted to remain for months if desired, the gum in contact with it after its prolonged presence exhibiting no indications of irritation. Masses of gutta-percha may be packed in interdental spaces where there is not sufficient space for the introduction of contour fillings, with the purpose of having the teeth gradually separated by the impact of mastication; the gutta-percha acts as a persistent and very gradual wedge.

When it has been determined that an excavated cavity is unfit for the reception of a permanent filling, gutta-percha is the filling material *par excellence*.

Although it is stated that gutta-percha shrinks markedly in harden-

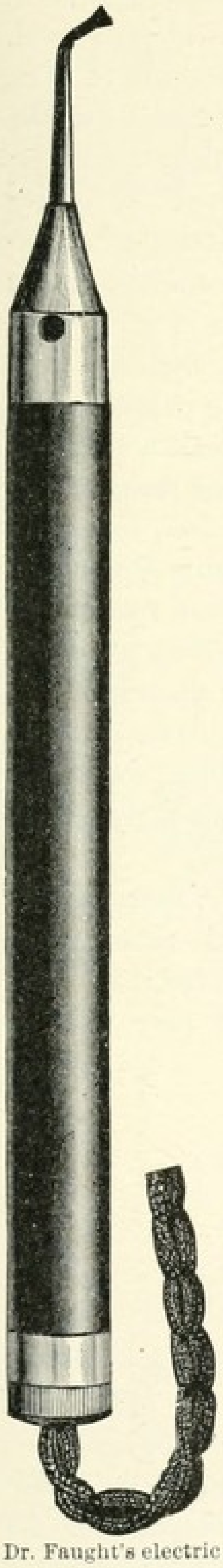
FIG. 295.



Flagg's gutta-percha softener and tool-heater.

ing, cavities in which it has been properly placed exhibit no evidences of softening after the material has been worn for months, or it may be for years. Particularly is this true when the pink variety has been employed and the method of introduction is correct.

FIG. 296.



Dr. Faught's electric heater.

Mode of Softening.—Gutta-percha should never be heated beyond a point which permits of accurate adaptation to undercuts and frail walls. The softening should be gradual. Any heat in excess of this is not only harmful but ruinous.

For its proper softening some device is necessary which shall permit of this type and degree of heating (see Figs. 295–297, 306).

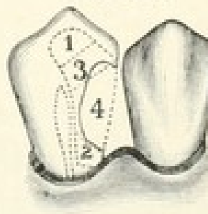
Fig. 295 illustrates the heater of Dr. Flagg. There are three metallic shelves, the highest of which receives the least amount of heat, and is designed for softening low-heat gutta-percha. The second shelf is for the softening of high-heat specimens. The lowest shelf and rack support the packing instruments, which are kept at a higher temperature than the filling material.

Fig. 296 illustrates a device of Dr. L. A. Faught for the packing of gutta-percha. The heating wires connect at the bases of the instrument points, which are of aluminum, and sufficient heat is conveyed to the gutta-percha to maintain it in a plastic state during the packing operation.

Instruments.—As a rule the instruments used in packing gutta-percha are too large and the material itself is used in too large pieces. If the cavity is of considerable extent, and usually it is, the filling should be introduced in four or more pieces. It is preferable to warm all the packing instruments so that the gutta-percha will remain plastic until perfectly adapted.

Manipulation.—The rubber dam having been adjusted, the cavity excavated and sterilized, the frail enamel edges broken away, without any particular object of margin forming, but to gain space, the cavity is dried for the reception of the gutta-percha. The field of operation should be dry, in order that each additional piece of gutta-percha shall adhere to its predecessor, which it would not do if wet. A softened pellet is taken upon the point of a probe and placed in the most inaccessible portion of the cavity and tapped into accurate contact with the tooth walls (by

FIG. 297.



Order of placing gutta-percha pellets.

means of the corkscrew plugger No. 32 or No. 33), as shown in No. 1 of Fig. 297. A second pellet is added (No. 2) and similarly manipulated. The Nos. 3, 4 pellets are packed in the order shown in the figure. In adding the last piece broad-faced instruments are used, adapting the gutta-percha accurately to the margins of the cavity. The softened gutta-percha may be made to adhere better to the walls of the cavity if these be first coated with one of the lining varnishes.

Another method of manipulation is to line the walls of the cavity with pellets until a cylindrical cavity remains. A cylinder of gutta-percha of that size is nearly softened and pressed firmly into the cavity by means of a broad spatula.

Should the cavity be very deep, the pulp almost exposed, the portion of dentin overlying the pulp is to be covered by a thin pellet of low-heat gutta-percha softened sufficiently to permit of adaptation. A disk of pink gutta-percha base plate answers admirably for this purpose.

The use of one of the lining varnishes, noted at page 257, especially the cellulose solution known as kristaline, previous to placing the pellets, will insure their adhesion to the cavity walls and prevent rocking or tipping of the mass of gutta-percha during the operation of its insertion. In order to secure the best results the kristaline solution should be thin when applied, and the solvent completely evaporated by blasts of warm air before any attempt is made to introduce the gutta-percha, for unless the varnish lining is fully hardened the pellets will not strongly adhere to the surface so treated.

Dr. How's Improved Gutta-percha Fillings.—Dr. W. Storer How[1] has published a method of packing gutta-percha which is as excellent as rational, when the directions given are closely followed:

"Many approximal cavities like *C*, Figs. 298, 299, may well be

Fig. 298.

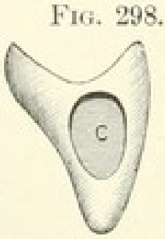


Fig. 299.

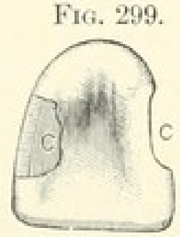
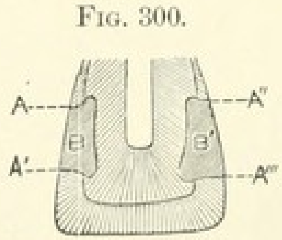


Fig. 300.



Approximal cavities.

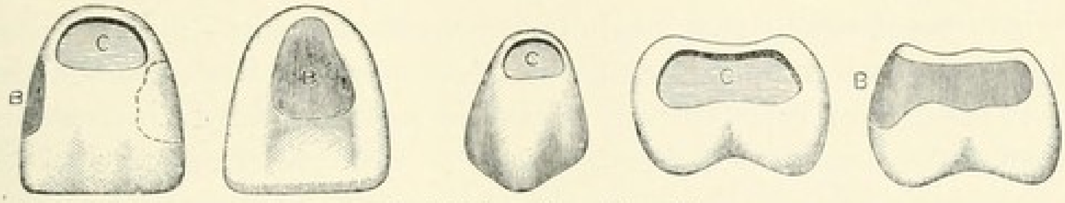
filled with gutta-percha, and such as *C*, Fig. 299, where a gold filling would show through the thin enamel front, can better be filled with suitable gutta-percha. The section, Fig. 300, shows the angles *A*, *A'*, which should be given the enamel-edges when practicable, and in any case the enamel-margin should have a squarely defined angle at its surface border.

"Cervico-labial or buccal cavities, as shown in Figs. 301–305,

[1] *Dental Cosmos*, 1892, vol. xxxiv. p. 281.

admit of permanent gutta-percha fillings. Of course due attention

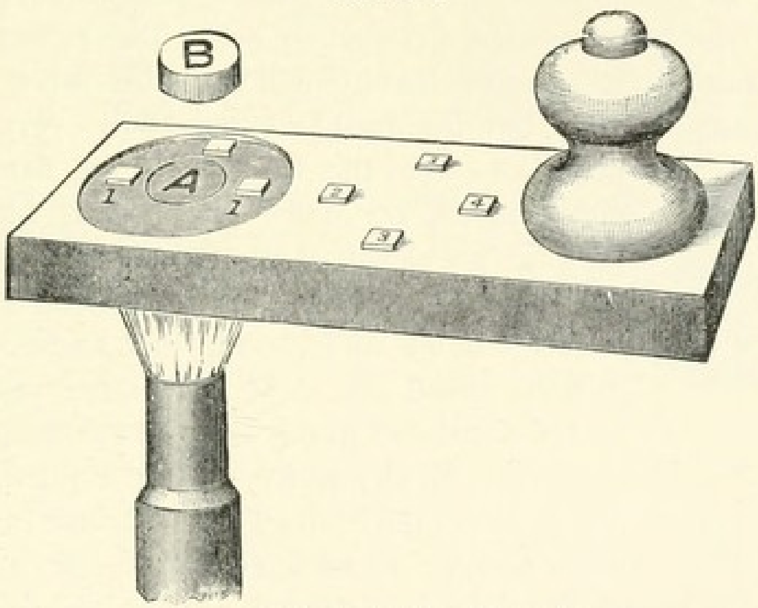
Fig. 301. Fig. 302. Fig. 303. Fig. 304. Fig. 305.



Cervico-labial and buccal cavities.

must be given to the retention of the fillings by enlarging the interior walls of the cavities when they have not already such expansions. After suitably preparing the cavity, it should be made as dry as possible and so kept. The problem of conveniently and properly softening pellets of gutta-percha has been solved by the production of the thermoscopic heater shown in Fig. 306, which approximates the exact size

Fig. 306.

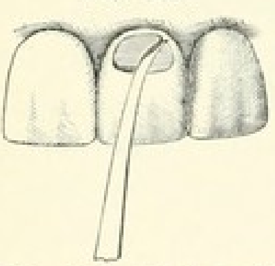


Thermoscopic heater for gutta-percha.

of the device. The heater is in this instance made of steatite, because of its heat-retaining property and the desirable physical qualities of its surface. The handle is of wood, at the opposite end from which, in the centre of the circular recess, is a small disk (*A*) of metal, fusible at about 212° F. On the heater near the metal a suitable number of gutta-percha pellets, as 1, 1, are placed, and the heater held over the flame of the annealing lamp or burner (as in the illustration) until the fusible metal melts, when the heater is placed on a piece of cardboard (or an empty foil-book), and the gutta-percha will be found to be properly softened. The steatite plaque retains the heat long enough for an ordinary operation, but if the metal meantime loses its fluidity and so indicates a lowering of the standard heat, it may be quickly restored by a moment's holding of the heater over the flame, which will again fuse the metal.

"When the flame is applied directly under the metal, as in the illustration, the material placed at 1 will, when the metal is seen to be fused, be at the heat of near 208° F., while the pellets at 2 will be heated to about 200°, those at 3 and 4 to near 194° and 180° respectively. Of course the location of the heat-source will produce corresponding variations in the relative temperatures of the materials as severally situated; but with a visibly definite standard such as the metal *A*, having a known fusing-point, the desired degree of heat may repeatedly be produced at any place on the receiving surface of the heater. A few seconds' continuance of the heater over the flame, after the metal has melted, will raise the surface heat to 212° or 215°, as the case may be; but as a suitable indicator for a high-heat stopping, a button (*B*) of metal fusing at 230° is provided as a substitute for *A*, which is first melted and poured out on a piece of clean paper, the heater cavity being undercut so that when cold the metal cannot be shaken out. The boiling of a few drops of water in the heater cavity will likewise serve to indicate the proper temperature, but the fusible metal is in every way preferable. The best plan is to hold the heater over the flame until the metal melts, set down the heater, blow hot air into the previously prepared and dry cavity until the tooth is sensibly warm, hold the heater again over the flame to melt the metal, and then with a suitable broad and cold instrument pick from the heater a pellet or group of pellets sufficient to a little more than fill the cavity, and by a quick, firm, rocking pressure force the mass into the cavity as if it were sought to take an impression of the same.

FIG. 307.



Trimming margins of gutta-percha filling.

Then dip the instrument into ice-water, wipe dry, and hold it firmly against the filling for one or more minutes, after which with a keen-edged thin blade pare off the surplus, cutting from the centre obliquely toward the margin, as in Fig. 307, taking great care that the filling *B* shall be flush with the cavity margin at every point, as at *A*, *A'*, Figs. 308 and 309.

"Access to approximal cavities, as *C*, *C*, Figs. 298 and 299, will seldom permit the instantaneous mass-method just described, but in many such cases a warm, broad, flat blade, as stiff as the space will admit, can by repeated quick pressures be made to squeeze the soft mass into the cavity of the warmed tooth, and be instantly followed by a very thin strip of metal held tightly in both hands and wrapped with hard pressure over the filling around that side of the tooth, to both condense and contour the plastic and produce the closest adaptation of the material to all parts of the cavity walls.

"There is good reason for the belief that the common mode of successively introducing small pieces of imperfectly softened gutta-percha into a comparatively cold cavity, and employing instrument points more or less heated for packing the cooled plastic against one side of the cavity after the other, must in the nature of the case result in a leaky filling, such as gutta-percha is commonly said to make, whereas the defect is due not to the material, but to its inconsiderate manipulator.

"In order to definitely determine whether or not suitably softened gutta-percha inserted by the mass-method will make a moisture-tight filling, some porcelain teeth of natural sizes and forms were made, hav-

FIG. 308.

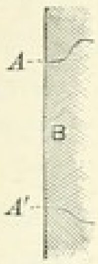


FIG. 309.

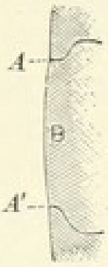


FIG. 310.

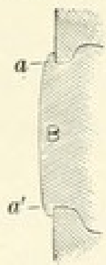


FIG. 311.

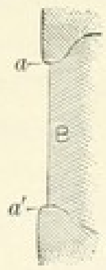


FIG. 312.

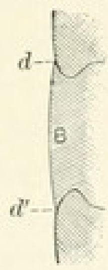
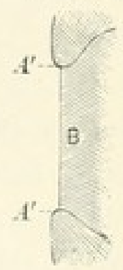


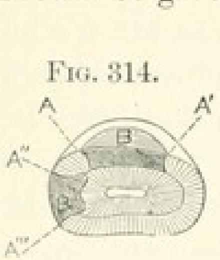
FIG. 313.



ing cut in them, prior to baking, cavities of the class shown in Figs. 298–305. These cavities have been filled with gutta-percha, leaving a surplus over the margins as at *a*, *a′*, Fig. 310, and when quite cool paring them flush as at *A*, *A′*, Figs. 308 and 309, and after several days' immersion in dilute aniline ink, the fillings have been removed without a trace of color showing on the walls of either the fillings or the cavities. The only exceptions have been where the margins were rounded, as at *a*, *a′*, Fig. 310, and the fillings not cut below them as shown, but left feather-edged as at *d*, *d′*, Fig. 312. In these few instances discolorations were found under the laps, but in no case extending farther than to *A′*, *A′*, Fig. 313. The tests prove that under conditions as nearly practically parallel as extra-oral tests can well be, gutta-percha fillings properly made will exclude external moisture. Obviously, it is better to pare the filling below the enamel-slopes, as in Figs. 311 and 313, than to leave it overlapping, as in Figs. 310 and 312. For a final finish use a rapidly revolved, lightly touching cuttlefish-paper disk, followed by a wisp of bibulous paper or piece of tape wet with chloro-percha, applied for but an instant, to glaze the surface of the filling.

"In the case of a very thin enamel front like that of Fig. 299, that part of the cavity *C* may be varnished with thin chloro-percha and dried with hot air just prior to filling it as before said. It might first be thinly coated with a tinted oxyphosphate or oxychlorid of zinc, which should be given ample time to harden before placing the gutta-percha. Indeed, it is a fundamental feature of good gutta-percha work that while one cannot operate too rapidly when the plastic is at its proper temperature, the preparatory and completing processes should be given as much time, care, and close scrutiny as more elaborate and often less enduring gold operations. There is furthermore room for the exercise of the artistic faculty in having at hand chloro-percha, or cellulose varnish of varied colors, with which, by means of a small brush, a gutta-percha filling as *B*, Fig. 301, and one in the like cavity *C*, may be given an inconspicuous shade, and the painting be renewed from time to time, if that be necessary by reason of wear. Fig. 314 is a sectional view of fillings like *B*, *C*, Fig. 301."

FIG. 314.



Finishing Gutta-percha Fillings.—If a gutta-percha filling has been packed with the proper amount of care and skill, it should require but little trimming. It should be undisturbed until cold. Its hardening may be hastened and intensified by holding ice-water in contact with it for a few moments.

The portions overlying the margins are to be trimmed with extremely sharp lancets or by warm blades. Every cut should remove a little of the surplus material, never a mass of it, and should be made toward the cavity margins, never away from them. The filling should have been made so that no fulness is present to require reducing.

It is a general practice to give a smooth face to a gutta-percha filling by wiping it with a tape slightly moistened, not wet, with chloroform. The surface produced by this means, although smooth, does not retain its integrity so well as when the surface is formed by cutting.

The use of gutta-percha as a canal filling is discussed in Chap. XVII.

BASIC ZINC CEMENTS.

Zinc Oxychlorid.—The basic zinc cements employed in dentistry are the oxychlorid and the phosphate; the oxysulfate should also be included.

The oxychlorid is formed by the combination of calcined and pulverized zinc oxid with a solution of zinc chlorid:

$$ZnO + ZnCl_2 + H_2O = 2ZnClHO.$$

This compound was introduced as a dental filling material about 1850, its hardness, whiteness, and apparent insolubility recommending it for that purpose. It required no lengthy period of time to demonstrate that as a filling material *per se* it was unfit for use. It disintegrated rapidly and was not free from shrinkage.

PROPERTIES.—Freshly mixed, this material is irritating to vital tissues with which it is brought in contact; applied close to or upon an exposed pulp it may be productive of a transient or a persistent irritation, or even inflammation. The extent of the irritation is largely governed by the fluidity of the cement paste, *i. e.* the amount of zinc chlorid present.

It sets in fifteen minutes sufficiently to permit the packing upon it of an amalgam, and in half an hour a gold filling. After setting it is whiter though less hard than the zinc phosphate; it shrinks, particularly when used in large masses. It is a poor thermal conductor, and, like all bodies containing zinc oxid, is soluble in lactic acid—the usual solvent in the oral cavity. These several features are at present regarded as limiting the application of oxychlorid to—first, a lining material for carious cavities over which the insoluble filling proper is to be placed; second, as a root-filling material (its use in this connection is discussed in Chapter XVII.). It is to be noted that the cement retains after setting an antiseptic power for a greater or less period.

USE.—Zinc oxychlorid is usually employed as a lining material in teeth having what is known as poor structure—those in which caries proceeds to great depths without external evidence of the extent of invasion. After these cavities have been partially excavated it is found that further excavation and the removal of the deepest layers of the leathery dentin which appear to have retained sensitivity would probably uncover the pulp; it may be that the pulp has given subjective evidence of a mild attack of active hyperemia.

In such cases the deepest layer of the partially disorganized dentin is permitted to remain and is subjected to the prolonged—fifteen minutes or longer—contact of hydrogen peroxid in the 25 per cent. ethereal solution (caustic pyrozone), 5 per cent. aqueous solution of formalin, or preferably a saturated solution of thymol in alcohol. The cavity walls are well dried with bibulous paper and the warm-air blast. Upon a mixing slab (see Fig. 315), a drop or two of the zinc chlorid is placed, and beside it a quantity of the zinc oxid powder. The powder is gradually incorporated with the fluid by means of a spatula until a creamy paste is made. A number of balls of bibulous paper are to be at hand. A portion of the paste is taken upon the end of an instrument and placed in the cavity, where it is quickly pressed into a layer against the cavity walls by means of the balls of bibulous paper. The walls are to be covered to a uniform depth of about one-sixteenth of an inch. The prompt application of the bibulous paper usually prevents any irritation due to the contact of the oxychlorid with the dentin overlying the pulp. Should the cavity be very deep it is advisable to protect the pulp by interposing a film of ethereal varnish between the oxychlorid and the dentin over the pulp.

At the completion of the lining operation, the margins of the cavities are to be cleansed of the oxychlorid and the filling completed with the material indicated.

Zinc oxychlorid as an obtunding agent in the treatment of hypersensitive dentin is of considerable value, and its use for that purpose is described in Chapter VII.

The use of zinc oxychlorid as a canal filling, and the mode of using it, are discussed in Chapter XVII.

The *powder* of this cement is made of zinc oxid calcined and powdered, to which have been added substances (borax, silica, etc.) which affect its properties but little if at all.

The *fluid* is made by dissolving pure zinc or its oxid in hydrochloric acid to the point of saturation ; or, by making a solution of zinc chlorid 4 parts, water 3 parts, and filtering the solution.

The use and effects of zinc oxychlorid as a *pulp capping* are discussed in Chapter XVI.

Zinc Phosphate.—These cements are nominally a combination of calcined zinc oxid with a syrupy solution of orthophosphoric acid :

$$3ZnO + 2H_3PO_4 = Zn_3(PO_4)_2 + 3H_2O,$$

although their actual composition is more variable than that of any other filling material. Both base and solvent commonly contain impurities—those of the base owing to lack of discrimination, or worse, in the source of the oxid. Many of the impurities of the phosphoric acid are due primarily to the well-known inconstancy of the acid itself, and others to the mode of its manufacture.

Many of the specimens of powder are prepared from commercial metallic zinc, and therefore contain the impurities of that metal. Among the latter is arsenic, so that the presence of arsenic compounds in inferior cement powders is by no means impossible, which may possibly explain in some cases the death of non-exposed pulps in teeth which have been filled with zinc phosphate ; but as recent chemical investigation has shown that the arsenic when present in cement powders is in the form of an insoluble zinc arsenite, the danger of arsenical irritation of the pulp from that source would seem to be a remote one.

A common source of the glacial phosphoric (metaphosphoric) acid of commerce is from sodium phosphate, variable quantities of which are retained in the acid solution as acid sodium phosphate (dihydrogen sodium phosphate). This substance is soluble in water, and must therefore greatly increase the solubility of any cement containing it.

To properly make pure specimens of zinc oxid and phosphoric acid is a comparatively expensive operation—which will serve to explain the seemingly high cost of fine specimens of cement, and incidentally serve as a warning against the indiscriminate use of cheap cements.

Making the Powder.—A quantity of pure zinc oxid is luted in a sand crucible and kept at the highest forge-heat for hours. When cool the crucible is broken away and the vitreous mass of yellowish zinc oxid is reduced to a powder which will pass through a fine bolting cloth. This powder is placed in tightly stoppered bottles, for if exposed to the air it absorbs carbon dioxid and a portion of it is converted into the hydrated carbonate of zinc. This change may be noted in old powders by the effervescence due to the disengagement of carbonic oxid when phosphoric acid is added to them. Numerous substances have been added to the basal powder with the object of lessening the disintegration, *i. e.* chemical solution, when used as a dental cement. Usually these additions are the oxids of other metals. The oxid of magnesium added to the powders causes the cement to set more rapidly ; the oxid of aluminum increases the rapidity of setting and makes a finer-grained cement, the central texture of which is, however, inferior. Cements of zinc oxid and phosphoric acid alone are apparently less soluble in lactic acid than when the oxids of aluminum and magnesium are added.

Various other substances have been added which do not enter into chemical combination with the phosphoric acid, in the hope of conferring greater durability on the cement, but as yet but few of them have been shown to possess any value.

The Fluid.—Phosphoric acid in its pure state is formed by hydrating phosphorus pentoxid :

$$P_2O_5 + 3H_2O = 2H_3PO_4.$$

Much of the phosphoric acid used for cements is made by hydrating the glacial (metaphosphoric) acid, HPO_3. The acid dissolves readily in water, being deliquescent when pure. Difficulty of solution is therefore an indication of impurity of the glacial acid. It requires a definite degree of heat to bring about the chemical hydration of the acid. At a temperature of 210° F. the union occurs, which is attended by the evolution of heat, the glacial acid being transformed into orthophosphoric acid. These acids are all hygroscopic. They will even abstract water from sulfuric acid.

Impurities.—The commercial glacial acid is commonly, or as a rule, impure, containing variable amounts of sodium and magnesium phosphates. These salts, particularly the dihydrogen (acid) sodium phosphate, are permanently soluble in the phosphoric acid, and therefore give no evidence of their presence by the formation of precipitates. They are also soluble in water, which fact has a direct bearing upon the durability of cements made with the impure acid.

It has been stated by writers that the acids of cement were occasionally the meta- and pyrophosphoric. A test of some of them said to be of these varieties showed none of them to give the reaction of the pyro-acid; a few giving traces of the meta- acid.

Precipitates which form in cement fluids are probably metallic phosphates. The instability of cement fluids is notorious. Aside from the known or probable contaminations which they may contain this instability is to be regarded as a distinctive feature of phosphoric acid.

THE CEMENT.—To *make the cement,* successive portions of the oxid are mechanically incorporated with the fluid until a stiff paste results. In five minutes a ball made of the paste glazes, and rebounds when dropped upon a hard surface. It breaks with a granular surface; in fifteen minutes it is cut with some difficulty. If the cement fluid contain the acid sodium phosphate, an acid reaction may remain for hours or days. The atmospheric conditions markedly modify the properties. In warm, or hot and moist weather, the setting is more rapid and it may be sudden. In cold weather it is delayed. The greater the dilution (the thinner the fluid), the more rapid the setting.

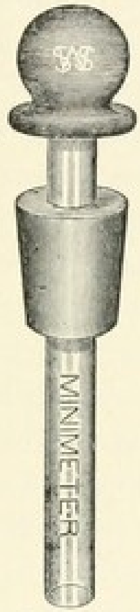
In its freshly mixed state zinc phosphate is adhesive, losing this property in a great degree when set, if surrounded by moisture. It has a higher rate of heat conductivity than zinc oxychlorid.

USES.—Its legitimate field of usefulness is in situations and under conditions where its advantageous properties may be utilized and its disadvantages minimized. One of the principal facts to be borne in mind is the solubility of the cement in lactic acid, which is present almost always about the necks of the teeth, in approximal spaces, and along gingival margins. Its clinical use is therefore attended by the greatest measure of success when placed at a distance from such situations—as, for example, in cavities opening upon the masticating surfaces of teeth, where its great hardness is an element of advantage. Good specimens have been known to last for periods varying from three to eight years. Dr. Henry Weston has cited cases where an unusually good zinc phosphate filling has lasted for ten years.

As a filling material *per se,* zinc phosphate has but limited employment except for the teeth of children, and as a temporary filling in the teeth of adults. Times and occasions will suggest themselves to every operator where gold, amalgam, and gutta-percha are contraindicated as filling materials; in such cases zinc phosphate performs a useful service. Its great field of usefulness—where, indeed, there is no substitute for it—is in the filling of the greater portion of extensive cavities, which are then filled and sealed with gold or amalgam, by an inlay, or it may be by a partial crown. It is invaluable, and in most cases indispensable, as the retaining medium of fixed bridge work and of many forms of artificial crowns.

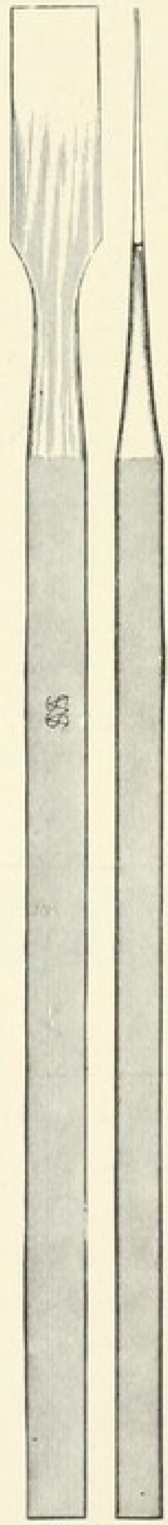
Prior to placing the zinc phosphate filling in a cavity, it is a wise precaution to line the latter with one of the quick-drying ethereal varnishes, to protect the dentinal walls from contact with acid sodium phosphate which may be present in the cement. In some cases the placing of the cement in proximity to a non-exposed pulp is productive of marked suffering. Should the cavity be very deep it is the usual practice to place a softened disk of gutta-percha over the wall nearest the pulp. The rubber dam should always be adjusted before the insertion of a phosphate filling, to insure dryness not only during the insertion, but during the period of hardening, at least fifteen minutes.

FIG. 316.



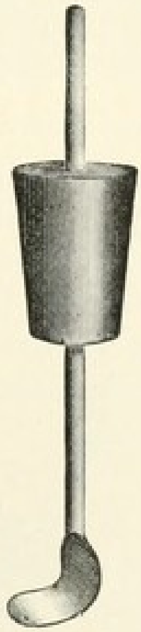
Dropper.

FIG. 318.



Spatula.

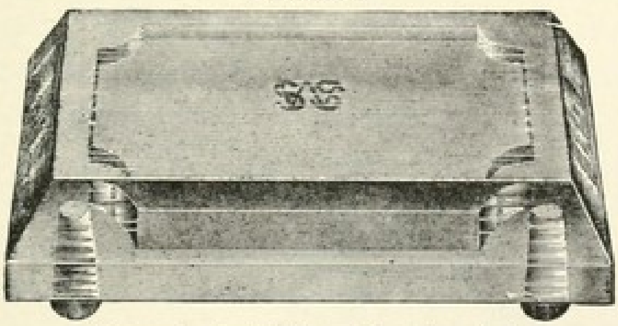
FIG. 317.



Scoop.

MIXING OF CEMENT.—This is an operation of equal, if not greater, importance than any other in the manipulation of zinc phosphate. Dr. Henry Weston has demonstrated how, almost entirely, the mixing of cement governs its stability. Specimens of the same powder and fluid mixed after different methods gave entirely different results, not only in the appearance but also in the hardness, texture, and solubility. The method of mixing set forth is that of the same experimenter. Assuming for illustration that an approximal cavity is to receive a contour filling, or a large occlusal cavity is to be filled,

FIG. 315.



Glass mixing tablet, with rubber feet.

or an extensive cavity is to be three-fourths filled with cement:

A drop, or, where a large mass of cement is required, two drops of fluid are placed upon a scrupulously clean glass (Fig. 315) by means of the dropper shown in Fig. 316, and a mass of powder, in great apparent excess of that required, is heaped at a distance from it, taken from the bottle by the scoop (Fig. 317). A portion of the powder is drawn into the fluid by means of a stout spatula (Fig. 318), and stirred with a rotary movement until a thin paste is made; another portion of powder is then added and is slowly and thoroughly incorporated; more powder is added until the mass is as thick as putty and difficult to smear with the heavy spatula; the mass is scraped together, taken from the spatula, and rolled between the forefinger and thumb, which have been well scrubbed. The mass is now kneaded, then rolled into an oblong pellet.

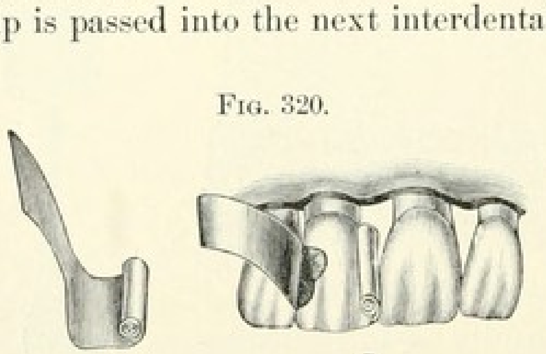
If for an occlusal cavity a piece about one-fourth the size of the cavity is set in the deepest portion and tapped into perfect apposition with the cavity walls by means of a burnisher. Other pellets are added, and the process is repeated until the cavity is exactly full, the burnisher forming the surface of the filling and outlining clearly every margin of the cavity. The filling should remain under rubber dam for at least fifteen minutes—longer when possible. A coating of ethereal varnish, a solution of gutta-percha in chloroform, or melted paraffin as suggested by Dr. Bonwill, is applied to the surface and the grinding of the filling deferred for a day or two. Should the cavity be upon an approximal side of a tooth, a matrix is to be employed; the most satisfactory and quickly adapted instrument for this purpose is one of the composition silver strips used for carrying polishing powders (Fig. 319). A strip

Fig. 319.

Polishing strip.

as wide as the length of the tooth is to have one end rolled upon itself until it forms a cylinder more than one-sixteenth of an inch thick (Fig. 320, *A*). The strip is passed into the next interdental space and drawn

Fig. 320.



A *B*

through until the cylinder (*A*) rests firmly upon the teeth; the free end is now passed through the space into which the cavity opens; where it rests upon the lingual surface of the tooth it is burnished into contact with the edges of the cavity, forming walls to the latter (320, *B*). The cement is introduced as in the preceding case, and when the cavity is full the free end of the strip is drawn upon, compressing and rounding the filling. Should the cement be an adhesive specimen or mixed thinner than described, the surface of the flexible matrix is to be faintly oiled by means of olive oil.

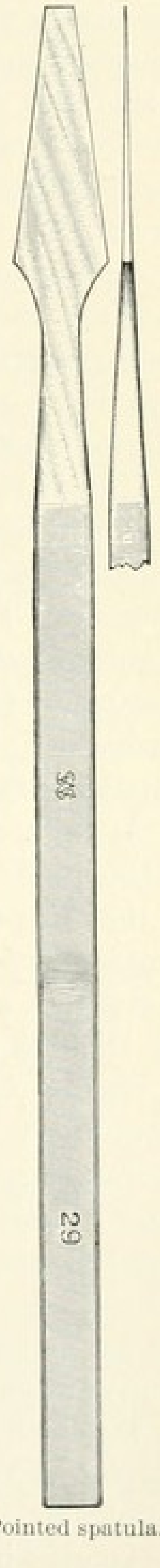
At the completion of the operation the cement should be exactly flush with the margins except at the labial aspect, and the surface of the cement should have such smoothness that polishing is not necessary. Cement fillings are polished dry with the finest of cuttlefish disks.

The process of filling the body of any cavity is the same, except when the enamel walls are thin and frail. In the latter case, where space permits, it is preferable to line the walls with the oxychlorid of zinc, over which the phosphate is placed. Before inserting a veneer filling of gold or amalgam, each cavity margin must be scraped free from cement.

When orthodontia appliances such as rings or caps, or prosthetic appliances, crowns and bridges, are to be set it is preferable to use a cement prepared for that purpose, although it is the general practice to use the cement to which the operator is accustomed, mixing it thinner than for filling purposes. Wherever possible, it is advisable to operate under rubber dam, even while setting orthodontia appliances.

The tooth is cleansed with chloroform—as, for example, when a ring or cap is set—to remove fatty matters, and a layer of shellac varnish applied, which is then dried by the air blast (chip blower). Cement paste is formed, of such consistence that it will flow readily and yet not be watery; the inside of the band or cap is filled with cement by means of an appropriate spatula (Fig. 321); a layer of cement is placed on the tooth where it is to be embraced by the band, which is then pressed into position and is to remain without disturbance until it is hard. The application of bands or ligatures should be deferred until the following day. As soon as the cement is hard the surplus is cut away and the dam removed.

Fig. 321.



Pointed spatula.

Temporary Stopping.

Preparations of this name are compounds of gutta-percha with various substances added to lessen the temperature of softening.

As procured from the manufacturer they are of two varieties, the adhesive and the non-adhesive—or, to be more precise, the less adhesive. The former preparations, the adhesive, are usually made of gutta-percha (generally the pink base plate), Burgundy pitch, white wax, and chalk or zinc oxid. In the non-adhesive varieties the Burgundy pitch is omitted. The latter varieties are usually made of a pink color, to furnish a safeguard against mistaking a filling of temporary stopping for one of gutta-percha.

As the name implies, they are designed for temporary use, retaining dressings in teeth, to maintain space between teeth which have been wedged apart, until the attendant pericementitis subsides ; to press away gum tissue overhanging the margins of a cavity ; to fill excavated cavities for a few days.

Unlike gutta-percha, most of these preparations cannot be permitted to remain for a prolonged period ; they usually become offensive, particularly so when the hygiene of the mouth does not receive proper attention. To maintain space and press away gum tissue they are used as gutta-percha ; their lower heat of softening permits their application close to the pulp of a tooth without the painful response associated with placing hot gutta-percha in the same position. A prominent use of the material is the sealing of arsenical applications in teeth.

As with any other material, it is necessary, in order to have the minimum of pain, to make the application and manipulate the stopping so that no pressure shall be exerted upon the pulp. Temporary stopping is inferior to zinc phosphate for this purpose, as the latter may be flowed into a cavity and over an arsenical application without causing the slightest pressure.

Should the cavity of decay extend to or beyond the gum, a small conical piece of the temporary stopping should be softened and packed carefully against the cervical margin and gum, to act as a guard to the latter against contact with the virulent irritant arsenic trioxid. The arsenical paste on a minute pledget of cotton is laid upon the exposed pulp—if the latter be hypersensitive, beside it—and the remainder of the cavity and interdental space are filled with one very soft piece of temporary stopping.

Temporary stopping, in cones, has been used as a canal filling (see Chapter XVII.) and as a filling for the bulbous portion of pulp chambers.

Another important use of the material is the sealing of the occlusal cavities of teeth which are under treatment for septic pericementitis.

Plugs of softened temporary stopping have been used for the arrest of alveolar hemorrhage; also for the temporary setting of artificial crowns.

Lining Varnishes.

These are solutions of various gums and resins in alcohol, chloroform, and ether, which are employed to furnish a non-conducting and impermeable film to cover the dentinal walls of excavated cavities.

The first, *sandarac varnish*, is a thin solution of sandarac in alcohol.

The second, a solution of *virgin rubber* in chloroform.

The third a solution of *hard Canada balsam*, *copal*, or *damar* in ether.

Another is the preparation known as *kristaline*, a solution of trinitrocellulose in anhydrous amyl acetate.

Before lining a cavity with zinc oxychlorid, a film of one of these varnishes, the quick-drying ones preferred, is applied, and when this is dry the cement may be inserted without causing pain. Varnishes have been used to furnish an adhesive surface upon which to pack gutta-percha fillings. It is always advisable to varnish the walls of a cavity which is to receive a filling of zinc phosphate, to prevent the action of any free acid or acid salt upon the dentinal walls.

Some of these varnishes are admirable non-conductors, and serve in that capacity under gold or amalgam fillings in a most satisfactory manner.

They may be used to prevent the tooth discoloration due to the presence of amalgam, particularly of copper amalgam.

Oxysulfate of Zinc.

What is known as the oxysulfate of zinc in dental parlance is merely a thin zinc oxychlorid containing zinc sulfate. A true zinc oxysulfate is made by mixing a saturated solution of zinc sulfate with uncalcined zinc oxid. It forms a white paste which sets quickly and attains about the hardness of an inferior plaster-of-Paris.

It is bland and unirritating to exposed pulps; is a non-conductor; is faintly and persistently astringent.[1]

Its principal use is as a pulp capping or protective. A thin paste is made, in which a disk of paper is dipped, then quickly and accurately laid upon the area of exposure. When hard (in a few seconds) a drop of fresh thin paste is flowed over the capping. The cavity may then be lined with zinc phosphate.

As a pulp protector from thermal shock it is applied in a thin layer, and over it a lining of zinc phosphate is packed.

[1] J. Foster Flagg.

CHAPTER XIV.

COMBINATION[1] FILLINGS.

By Dwight M. Clapp, D. M. D.

The use of more than one material for filling a single cavity was suggested by the observation of the condition of fillings composed of but one material and noting the effects of time and use thereon.

If a large number of amalgam fillings in crown cavities are examined, many will be found to have imperfect edges. One cause of this imperfection is, undoubtedly, the *brittle* character of amalgam, in consequence of which the edges have become broken. In other words, amalgam as a filling material lacks edge strength. Its dark, sometimes almost black, color also renders it very objectionable, especially if used in conspicuous positions.

If the same number of gold fillings in occlusal cavities are examined, the edges will be found in better condition than was the case with the amalgam. One reason for this is, undoubtedly, because gold is not brittle, but possesses sufficient edge strength to withstand the force of mastication. Its color is also less unsightly than that of amalgam. For occlusal cavities, therefore, gold is regarded as the better filling material.

If a series of occluso-approximal cavities filled with gold be studied, it will be found that the teeth are in much better condition on the occlusal surface than at the cervical borders of the fillings. Compare gold fillings with a series of amalgam fillings in the same class of cavities, and the condition of the teeth will be reversed: at least a much larger percentage of the teeth will be found in good condition around the approximal portion of the fillings than was the case with the gold. Hence, the deduction is inevitable that, of these two materials, amalgam is the better to fill the *cervical portion* of approximal cavities.

[1] The term "combination" is adopted for the various fillings here described, in which more than one material is used, because it seems to be the most comprehensive. The putting together of different materials in filling teeth makes in no sense a chemical combination, in which "any part of the compound is the same as any other part of it." Strictly speaking, the fillings are more "mixtures" than "combinations." According to the best authorities, however, the meaning given to combination makes its use here quite admissible.

Zinc phosphate cement has many admirable qualities and is one of the most valuable filling materials known. It is easily worked, its color is good, its adhesiveness serves to bind tooth and filling together as the stonemason's cement unites the blocks of granite that he piles one on the other into one solid piece of masonry. As a tooth-saver it has no equal; but its one great defect, its solubility in the fluids of the mouth, restricts, in a great degree, its usefulness when exposed to these fluids.

From this it will be easily understood why it is often desirable to combine in one filling two or more different materials; and it may be said with truth that the operator who selects his filling materials with the best judgment, and combines and uses them with the most skill, will save the greatest number of teeth. There would be just as much common sense and scientific reason for an electrician to make a dynamo entirely of copper, or a watchmaker to use nothing but gold in making a watch, as for a dentist to fill many of the cavities that come to him with but one material.

It is an error to think that combination fillings are resorted to because more easily made than fillings of but one material, or that it indicates a lack of skill on the part of the operator who makes and recommends them. On the contrary, it is often much more difficult to make a suitable combination filling than one of any single material; and the student will find that combination work will give ample opportunity for the employment of all the skill and ingenuity he may possess.

Every operation must be made with the greatest amount of care and attention to minute details, or the object sought will be unattained, and the result be an inferior piece of work which will sooner or later cause grief to the patient and chagrin to the operator.

It is impossible to describe all the combination fillings that have been found advantageous and useful, therefore only some of the most important will be considered in detail. The list is limited only by the perverse manner in which teeth decay, and by the ingenuity of the operator to devise scientific and practical combinations to meet the cases presenting.

It is to be understood in every instance in this chapter that the teeth are in proper condition to be filled without further treatment. If pulpless, the roots are supposed to have been put in a healthy condition and filled. In cases of exposed, or nearly exposed, pulps, they are supposed to have been properly protected, and the teeth ready in every respect for the mechanical operation of inserting the fillings.

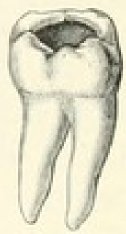
Cement (Zinc Phosphate) and Amalgam.

In Simple Cavities.—This combination is of the greatest service in saving badly decayed teeth that otherwise might have to be cut off and crowned, or perhaps lost altogether. The simplest cases where it may judiciously be employed are occlusal cavities. Many such cases are seen where there is little left but the enamel, which, however, is thick around the orifice of the cavity, and, if properly supported, will have sufficient strength to withstand the ordinary strain of mastication. Great care should be taken to remove the decay from every part of the cavity, being sure that none is left under the cusps or any part of the overhanging enamel.

The edges of the cavity must be carefully trimmed, so that the filling can be finished flush with the external surface, in order not to leave any overhanging portion of amalgam to be broken off, as it certainly will be if so left, to the great injury of the filling.

There are but few cases, even in occlusal cavities, where the rubber dam should not be used, at least for the final excavation and for putting in the filling; for it is almost impossible to be sure that all decay has been removed from a cavity unless it is dry. No filling should be allowed to get wet before it is all in place if it can possibly be avoided. It is much better to err by using the rubber dam too often than not often enough. Fig. 322 shows a cavity such as described.

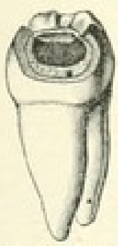
Fig. 322.



Large occlusal cavity.

The cavity being ready, sufficient amalgam to fill one-third of it is prepared. Before introducing the amalgam, however, the cavity is filled two-thirds or three-fourths with rather soft cement, into which pieces of the prepared amalgam are crowded, forcing the cement into every portion of the cavity. The cement which has oozed out around the edges is then removed with an excavator, and the operation will have the appearance shown in Fig. 323. The filling is then completed in the same manner as an ordinary filling of amalgam in an occlusal cavity.

Fig. 323.

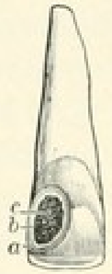


Section showing amalgam and cement. (Surplus cement must now be removed; then finish with amalgam.)

The advantages of this kind of filling are many: The bulk of it is of cement, which does not change its shape perceptibly and is the best of materials when not exposed to the fluids of the mouth. The cement firmly unites the tooth to the filling, thus making a support to the frail walls as well as a stopping to the cavity. The amount of metal is reduced to just enough for a covering of sufficient strength to guard the cement, and the tooth will not be discolored by the amalgam, as is often the case in teeth of not very dense structure, and especially in the mouths of young patients, when not thus protected.

The combination of cement and amalgam, as described above for occlusal cavities, may be used in the same manner in simple approximal cavities in the molars and bicuspids, and even in the six front teeth, when the cavities are so situated that the amalgam does not show. When used in the front teeth the cement should be allowed to remain very near to the edges of the cavity. The amalgam need not be more in amount at this point than the thickness of an ordinary

FIG. 324.



Cement and amalgam filling in an incisor. The surplus cement has been removed and the filling is now ready for the finishing portions of amalgam: *a*, enamel; *b*, cement; *c*, amalgam.

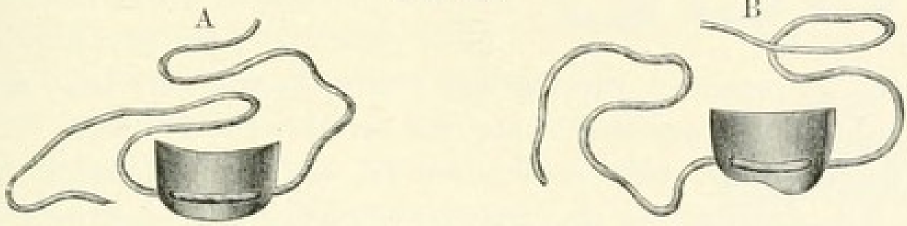
visiting card (see Fig. 324). For the front teeth very light colored amalgam should be selected, as color is of more importance than strength.

In the temporary molars this combination can be used, frequently, with the greatest satisfaction, especially in those shallow approximal cavities where but little undercut can be obtained without exposing the pulp. The cement should be used quite thin, and the amalgam worked into it with a burnisher, or rounded instrument, forcing the cement to a feather edge at the margins of the cavity. In cases of this kind restoration of contour should not be attempted, as the force of mastication might serve to fracture the cement and dislodge the filling. In this manner many troublesome and difficult cavities can be successfully treated, and teeth made to last their allotted time that would otherwise be prematurely lost.

In Compound Cavities.—A more extended description will be necessary for the treatment of compound cavities in the bicuspids and molars, especially where it is desirable to restore contour. In these cases a matrix is often a necessity. There are many matrices that may be used successfully, but, as they are described in other parts of this work, only one need be mentioned here. This is selected on account of being almost universal in its application. It can be made from any metal not acted on by the mercury contained in amalgam. German silver is inexpensive and seems to meet every requirement, and is, therefore, recommended. For ordinary use it should be from No. 35 to No. 38 gauge. If stiff it should be annealed, so as to be readily bent to the form of the tooth. It can be easily polished so as to reflect light into the cavity, by drawing a narrow strip of it between two pieces of stationer's rubber (ink erasers). Place one piece of the rubber on a table, then the strip of metal held with pliers in one hand is placed on the cake of rubber, while with the other hand another piece of rubber is held firmly down on the metal, which is drawn between the two until sufficiently bright.

For ordinary cases, a piece is cut from the German silver, as shown in Fig. 325, A, wide enough to extend from the top of the tooth to a little beyond the cervical wall of the cavity, and long enough to a little more than cover the cavity laterally when tied in place. Sometimes it is necessary to make the matrix with a lip to extend under the gum, as shown in Fig. 325, B, or in some other irregular form, so that it can be

Fig. 325.

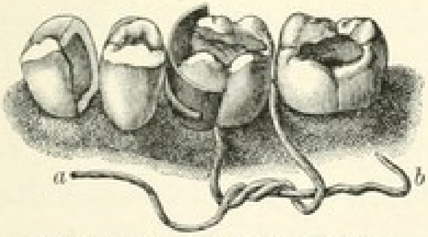


A, Matrix and ligature; B, lipped matrix.

made to properly fit the cavity. Special cases may require a very wide or a very narrow one. The operator's ingenuity must devise the right shape.

For tying the matrix to the tooth, coarse, well-waxed floss silk is the best. It is passed through the holes punched in the metal, as shown in Fig. 325, A and B. When these holes are made, the edges must be finished smooth, or the silk will be cut when drawn tightly around the tooth. The operator must use tact as to how and where to make his knots in tying on the matrix. Usually, a good way is to place one end of the ligature, *a*, between the teeth, then to make a surgeon's knot, as shown in Fig. 326. The other end of the ligature, *b*, is then forced between the teeth, and the knot tightened. This will bring the knot between the teeth and opposite the matrix and will hold the latter until it can be shaped and bent into place with a burnisher or other suitable instrument. The knot is again tightened, and the two ends of the ligature carried to the back of the matrix and a similar knot tied there. The second knot, when drawn tightly against the back of the matrix, forces it closely up to the cervical border of the cavity, and makes a firm resistance when the filling is being condensed. The silk is then wound

Fig. 326.

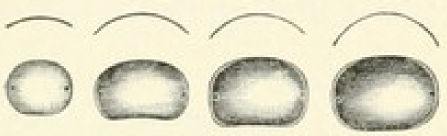


Manner of ligating the matrix.

round and round the tooth and matrix until it nearly covers both, or at least sufficiently to insure its remaining in place during the operation. A knot may be tied each time the silk is wound around the tooth, or not, as appears to be necessary. Sometimes, when the sides of the tooth are sloping, the ligature has a tendency to slip off. This can usually be overcome by turning back, with tweezers, the two upper corners, as shown in Fig. 331. To saturate the ligature with sandarac or other sticky varnish will sometimes be sufficient to prevent the same tendency.

Fig. 327 illustrates a simple and delicate, but very powerful, little slip matrix which is of great efficiency in the treatment of occluso-approximal cavities. They were conceived originally for the plastics, in which case they are *left in place over night* (the plastics thus setting under pressure), slipping out easily the next day away from the then hardened and perfectly contoured surface of the filling.

Fig. 327.



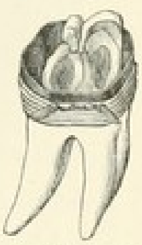
"They are most easily made, even for each case (though in practice this is not necessary, as they may be employed over and over again), as follows: Suitable-shaped pieces, of a size to a little more than overlap the cavity margins, are cut from thin . . . steel, . . . all corners and burred edges smoothly finished; a tiny hole is punched close to the middle of both the buccal and lingual edges, and it is then laid upon a piece of lead and *swaged* (not merely bent, be it remarked) into perfect concavity, greater or less as the individual case shall require, by tapping with a hammer a convex rod of hardened steel laid upon it; my own instrument being a round-headed picture nail, case-hardened, polished, and with twisted wire attached at right angles to a handle. Any amount or shape of concavity required for each case can thus be produced in a moment, either newly from blanks kept ready or changes made in those used for other cases to fit the one in hand, about a dozen of different sizes and degrees of convexity being sufficient to select from, with little or no changes for all ordinary cases. The tapping having re-stiffened the steel somewhat, taken in connection with the impingement of the convex face against the approximal surface of the adjoining tooth, gives firmness and strength to these delicate little strips and a perfect hugging fit to the surfaces of the tooth being filled, especially at its cervical margin, that is most satisfactory."[1]

When the cavity involves a large portion of the crown, or the mesial and distal surfaces, the matrix should be long enough to almost encircle

[1] *Dental Cosmos*, June 1898, vol. xl. No. 6, p. 452.

the tooth, the ends nearly joining against the sound remaining wall (see Fig. 328). In such cases it may be desirable to slit it one or more times, in order that it may be made to take the form of the tooth more easily (Fig. 329).

FIG. 328.



Continuous matrix.

After the tying is completed, a suitably shaped burnisher is used to form the matrix, by pressing it outward, to a proper contour.

One of the desirable features of the matrix here described is the ease with which it is made to give just the right shape and contour to the filling. When used for gold fillings it yields enough so that with a little care in packing the gold can be forced beyond the margin of the cavity sufficiently to insure a flush filling when burnished, after removing the matrix.

A matrix put on as described will have sufficient resistance for a gold filling; for amalgam, cement, or gutta-percha it may not be necessary to tie it quite so securely.

FIG. 329.

Matrix with marginal slits.

For compound fillings of cement and amalgam two methods, *A* and *B*, are here given.

A. Those cavities which, although large and involving much of the tooth, may have but small or comparatively small openings, especially if a matrix be used—and there are but few cases where the matrix is not advisable. If, after putting on the matrix, in this class of cavities, cement is introduced, and pieces of amalgam thrust into it, the cement will most likely be carried to the margin of the cavity at the cervical wall, and it will be found, after removing the matrix and finishing the filling, that a part of the external portion is of cement, and not being protected by the amalgam, would be washed out. To avoid this, a portion of the filling is made *before the matrix is put on*. Cement is put in, followed immediately by the amalgam as described for "occlusal cavities" with the added complication of the missing approximal wall. After sufficient amalgam has been put into the cement the portion of the latter which may have oozed out must be carefully cut away, so as to expose the entire outer edge of the cavity, including the *cervical wall* (see Fig. 330).

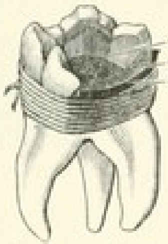
FIG. 330.

Cement lining and amalgam.

After this has been done, the matrix may be tied on and the filling completed as though it were but a simple cavity. Sometimes it is well to leave the matrix in place until the amalgam is fully set. If this be done, care must be taken that no sharp edge or corner of it be left to wound the tongue or cheek.

B. Cavities with *large openings.* The rubber dam and matrix having been adjusted, enough amalgam is packed *against the matrix* to form a shell of sufficient strength to make the approximal wall of the filling (see Fig. 331).

Fig. 331.

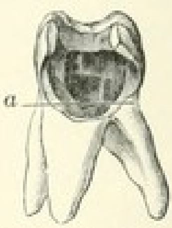


a, Matrix; *b*, amalgam packed against the matrix; *c*, portion of cavity to be nearly filled with cement and finished with amalgam.

This will leave a large portion of the cavity unfilled as shown in the figure; in this space is placed cement, which is gently worked into the soft amalgam, but with care not to carry it through to the matrix. Before the cement becomes hard more amalgam is put in, the surplus cement is removed, and the whole finished to look like an entire amalgam filling, while in reality it is only a shell of amalgam, perfectly fitting the outside of the cavity, cemented into place. If the walls of the tooth are frail, the cement will serve to greatly strengthen them. If, as some claim, large metal fillings alter sufficiently under changes of temperature to fracture frail walls, the danger is by this method reduced to a minimum, as the amount of metal is only just sufficient to give requisite strength.

There is another class of cavities which may be described in this connection, presenting great difficulties in themselves, yet, with this simple matrix, they are often easily filled. It is those cases where decay has reached the alveolar border approximally, and extended on either the buccal or lingual portion of the tooth, or both, in such a manner that the dam cannot be made to stay beyond the cervical border of the cavity. If a ligature is used, it will draw into the lateral grooves of decay and be of no use (Fig. 332).

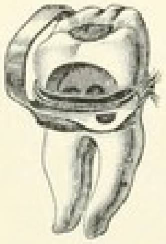
Fig. 332.



a, Alveolar line beyond which the ligature cannot be made to stay.

The mode of treatment is as already described, with the exception that the matrix is adjusted *before the rubber is put on.* After the matrix is in place, it is but the work of a moment to put a Palmer clamp on to the tooth, and slip the rubber dam over clamp, matrix, and tooth. If the matrix has been carefully fitted there will be no trouble in keeping the cavity dry long enough for any ordinary operation.

Fig. 333.



Matrix and clamp adjusted, ready for application of the dam.

There are certain buccal cavities, also, below which it is difficult to retain the rubber dam. A very narrow matrix, adjusted with ligature and clamp (Fig. 333), over which the rubber is placed, will often greatly simplify the operation. Modifications of this method may also be applied to the bicuspids, and sometimes even to marginal cavities in the incisors and canines, with good results.

Cement and Gold.

This combination may be used, with but slight modification, in the same manner and in the same class of cases that have been mentioned for the use of amalgam and cement, cases under *B* excepted. The cement is placed in the cavity, and, while soft, pieces of some of the so-called "plastic" golds are put into it, in the same manner as has been described for cement and amalgam ; the surplus cement is carefully cut away, and, after waiting for that in the cavity to become *so hard as not to break or crumble under pressure*, the pieces of gold placed in the soft cement are thoroughly condensed. For this purpose, de Trey's "Solila" Gold, Steurer's Plastic Gold, White's Crystal Mat Gold, and Watts' Crystal Gold are recommended. The filling can then be completed with the same or any kind of cohesive gold. Care must be taken to place a sufficient amount of the plastic gold into the cement to make, when condensed, a solid foundation upon which to build the rest of the filling. If too little gold has been used, it will "chop up" and not make a secure union with the cement.

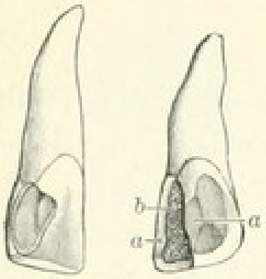
In some large cavities it may be found more convenient, after having filled the approximal portion with the cement and gold, to make a second mix of cement for the rest of the cavity, into which the gold is put as before.

In some special cases it may be well to use foil in this manner, but, as a rule, the plastic golds will be found preferable.

Too much stress cannot be laid on the desirability of this method for frail teeth, remembering always that the cement is the strengthening and supporting medium. The mason would not build a bridge pier of granite alone, or a house of bricks without mortar. However nicely the blocks of granite or the bricks might fit each other, it is the cement and the mortar that hold them together as in one piece.

Especial attention is called to this combination of gold and cement for the six front teeth. In the teeth of young patients and teeth of low-grade structure there are often found large cavities which, if filled with gold alone, will in a few years, sometimes months, show discoloration around the fillings. Filled as above described, every vestige of decay having first been removed, a combination results which is the ideal preservative filling as far as present knowledge and facilities go. Pulpless front teeth that are much decayed can be improved in appearance and greatly strengthened by this method. Fig. 334 shows a cavity in a central incisor that can be filled to advantage with cement and gold. Fig. 335 shows a cavity in a central incisor with the pulp removed and but little of the crown remaining but the enamel. The greater part of the cavity has been filled with cement into which plastic gold has been put and condensed. The filling can be completed with any cohesive gold.

FIG. 334. FIG. 335.



a, a, Frail enamel walls; *b,* gold surface made by plastic gold condensed into cement.

In compound cavities in molars and bicuspids, after the cement and gold have been put in, as described for cement and amalgam *A*, and the matrix adjusted, *soft foil* can be used to great advantage at the cervical portion of the cavities, as elsewhere described for using soft and cohesive golds.

AMALGAM AND GOLD.

Gold may be used in combination with amalgam—*A*, by allowing the amalgam to become hard before adding the gold; *B*, by adding the gold while the amalgam is soft and finishing the filling at one sitting.

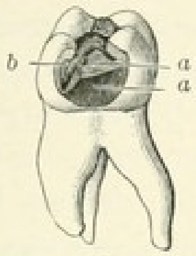
A. **Allowing the amalgam to harden and then adding gold at a subsequent sitting** will usually be done in compound cavities in bicuspids and molars, for the purpose, principally, of overcoming the dark appearance of the amalgam. For instance, a filling involving the occlusal and mesial surfaces of an upper first molar will, in many mouths, show more or less, and, if of amalgam, be dark and unsightly. To avoid this, the cavity may be nearly filled with amalgam, leaving a portion of the occlusal surface and along the buccal wall (this being the part of the filling most likely to show) for completion with gold later.

The matrix should be used as described for cement and amalgam fillings. It is a good plan to leave it in place, when convenient, until the amalgam is hard. Before adding the gold, it should be ascertained what part of the filling will show, and the amalgam trimmed and shaped so that the gold may form that portion of the filling that will be in sight. Fig. 336 shows a compound cavity in a molar partially filled with amalgam. The amalgam has been left until hard and the filling is now ready to be finished with gold. The figure also shows the cement lining under the amalgam.

Suitable retaining places must be made in the amalgam to hold the gold in position, as there is no union between the two in this case, as there is when gold is added to unset amalgam. The gold being added makes a filling much superior in appearance to one entirely of amalgam. The gold will also make a better wearing material for the masticating surface, having better edge strength than the amalgam, and therefore being less liable to be broken away from the walls of the cavity by the force of mastication, as spoken of elsewhere.

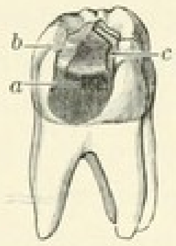
Large amalgam fillings, when it is not necessary to have gold added on account of color, will be greatly improved if a channel is made with a small fissure bur between the amalgam and the enamel, and this carefully filled with gold (Fig. 337).

Fig. 336.



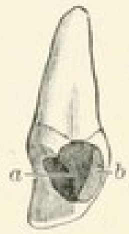
Occluso-approximal cavity partly filled with amalgam ready for completion with gold: *a*, *a*, amalgam; *b*, cement lining.

Fig. 337.



Amalgam and cement combination with channel cut in occlusal margin for reception of gold: *a*, amalgam; *b*, gold; *c*, channel burred out ready for gold, shows also cement lining.

Fig. 338.



Gold and amalgam combination in incisor: *a*, amalgam; *b*, gold.

All amalgam fillings when gold is intended to be added, should be put in with soft cement, whenever possible, as described for "Cement and Amalgam" fillings. This will prevent much of the discoloration from the amalgam, as well as strengthen the teeth. Many front teeth can be saved and made to look well by filling with cement and amalgam, as before described, and, after the amalgam becomes hard, cutting away that portion which is in sight, and filling with gold (Fig. 338).

B. **Amalgam and gold fillings, the gold being added while the amalgam is soft.** These fillings will be indicated, usually, in compound cavities of the molars, and in the occluso-distal and sometimes even the mesial surfaces of the bicuspids. The amalgam will occupy not more than one-quarter or one-third of the approximal portion of the cavity, but sometimes in distal cavities of molars it may be good judgment to have as much as three-fourths of that portion of the filling, amalgam.

No operation requires greater attention to detail, or more neatness of execution, than where gold is used in conjunction with soft amalgam. If chips of the unset amalgam are left around the matrix, or in the folds of the rubber, or in any place where they may be caught up on the disk or finishing strip and rubbed over the surface of the gold while the filling is being finished, they will give it a coating of mercury and injure the appearance of the work. On the other hand, if the method given is followed carefully, no detail left out of account, no slovenly manipulation allowed to pass for neatness and tact in handling the materials, the fillings can be finished as soon as the last piece of gold is consolidated, without the least danger of mercury coating.

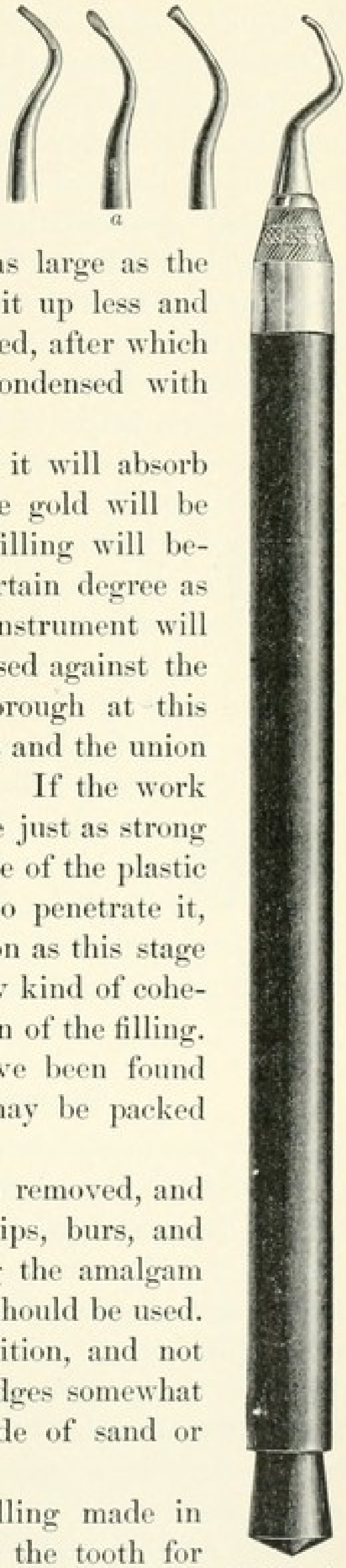
In preparing the cavity for a filling of this kind, almost no tooth substance has to be cut away *simply to get access* to the cavity, to properly start and pack the filling, as is often necessary if an entire gold filling is to be made. As a consequence, much valuable tooth substance is saved, for, so long as the decay is removed and frail edge walls are cut away, the amalgam can be perfectly packed, no matter how irregular the surface to which it is to be adapted. Of course, the excavation must be planned so that a filling of proper contour can be made, and walls cut back when by so doing future decay can be better guarded against. There will be many cases encountered, however, where, by this method, much of a tooth structure can be left, whereas if gold were to be used it would be necessary to cut, often causing severe pain, in order that the part might be properly filled.

For the purpose of describing a simple combination filling of this kind, a cavity involving the occlusal and distal surface of an upper second bicuspid is selected as an example. In the first place, sufficient space must be secured for a filling of the right contour, and to allow for passing in a very thin strip for finishing the filling. It is best to secure this room by previous wedging. Space having been secured, the cavity is prepared with proper undercuts, and the walls of the approximal part, to be filled with gold, made at as nearly a *right angle* to the matrix as possible. This is in order to facilitate packing the gold, it being very difficult to obtain a satisfactory margin if the walls form a very acute angle with the matrix.

A matrix so adjusted that it will stand the pressure of putting in the filling without moving is an absolute necessity for this combination. It having been put on as described under the head of "Cement and Amalgam" fillings (page 349), enough amalgam is carefully packed at the cervical wall to fill one-fourth or one-third of that portion of the cavity. It should be thoroughly consolidated by using properly shaped instruments and sufficient force to drive it into every part of the cavity. It is a good plan to use small pellets of bibulous paper, forcing them against the amalgam with medium-sized instruments. The free mercury which rises to the surface should be carefully removed. It is well to put in considerably more amalgam than is to be left, cutting out the surplus, which method leaves a good surface upon which to begin with the gold. Before the gold is added, however, care should be taken to remove every chip of soft amalgam from the folds of the dam, or any that may be clinging to the matrix, or in any position where it might be brought in contact with the gold when finishing the filling. These chips will remain for a long time soft enough to coat the gold with mercury if rubbed against it, therefore they must be disposed of or an unsatisfactory filling will be the result.

The proper amount of amalgam having been packed in the cavity, medium-sized pieces of some of the plastic golds before referred to are immediately added. The instruments used first on the gold should be as large as the cavity will accommodate, as they will break it up less and more readily carry the piece where it is wanted, after which each piece of gold should be thoroughly condensed with smaller instruments.

FIG. 339.



Gold-packing instruments.

As soon as the gold touches the amalgam it will absorb mercury, and sometimes several pieces of the gold will be entirely amalgamated. The surface of the filling will become very granular, and "chop up" to a certain degree as the first pieces of gold are used, and the instrument will cause a peculiar squeaky sound as it is pressed against the filling. The condensation must be very thorough at this point of the work, or the filling will be porous and the union between the amalgam and gold unsatisfactory. If the work is thoroughly done, however, the filling will be just as strong at this point as any other. As piece after piece of the plastic gold is added, the mercury will soon cease to penetrate it, and the surface become entirely gold. As soon as this stage is reached, and no more mercury is visible, any kind of cohesive gold can be used for the remaining portion of the filling. Fig. 339 presents some instruments that have been found especially useful in this work. The gold may be packed with hand or mallet pressure, or both.

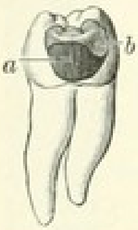
After the gold is all packed the matrix is removed, and the filling finished with sandpaper disks, strips, burs, and stones, in the ordinary manner. For finishing the amalgam portion of the filling only fine disks or strips should be used. The amalgam being yet in a granular condition, and not thoroughly hard, will be dragged from the edges somewhat and made slightly imperfect if a coarse grade of sand or emery paper be used.

The gold will not break away from a filling made in this manner, even if there be no undercut in the tooth for holding it; the union with the amalgam will be quite sufficient to retain it. The cavity must have the proper shape, however, for holding in the filling as a whole, the same as if it were entirely of gold or amalgam.

Cases may occur where it does not matter whether the amalgam and gold are firmly united or not; then, instead of putting the plastic gold into the amalgam, soft foil may be used against it in the manner described for the combination of "soft" and "cohesive" golds (page 361).

Having become familiar with the simplest form of fillings of amalgam and gold, it will be well now to go a step farther, and take up some of the complications that constantly occur. Even the small amount of amalgam that is used will sometimes discolor a tooth slightly, especially if the buccal wall is thin or if the tooth is not of very dense structure. When there is danger of this discoloration taking place, it can be largely prevented by placing a medium-sized pellet or fold of foil, known as "gilded platinum," against the buccal wall of the cavity before putting in the amalgam. This foil being faced with platinum, which has but very slight affinity for mercury, the amalgam can be consolidated against it with little danger of discoloration following.

FIG. 340.



a, Amalgam; *b*, gold extending on the buccal side nearly to the gum margin.

On the mesial surface of bicuspids and molars it will not be enough, always, to put the gold and platinum foil against the buccal wall; more or less of the proximo-buccal surface of the filling being exposed to view—*i. e.* not hidden by the tooth anterior to it—it would look badly if made of amalgam; consequently, in these cases the gold must be carried to the cervical wall, as shown in Fig. 340, the amalgam occupying a triangular space.

CEMENT, AMALGAM, AND GOLD.

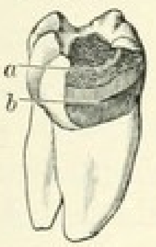
There are many teeth with very large cavities and frail walls, that can be rendered serviceable for years and made to look surprisingly well by the use of this triple combination. For instance, a molar or bicuspid having lost its pulp and a large portion of its crown, and occupying a conspicuous position, presents to the conscientious dentist a serious problem. He knows that if filled with amalgam it will be an eyesore to every one by its unsightliness. If filled with gold it would take hours, and exhaust both patient and operator, and there would be every probability of the walls soon breaking away and the filling coming out, testifying to the poor judgment of the operator in recommending such a filling under such circumstances. If filled with cement it will have to be refilled often, and with each refilling would more than likely be somewhat weakened. The loss of contour by the wasting away of the cement will allow the tooth to change position, and its usefulness will gradually be lost, and the tooth sacrificed because the dentist did not bring the requisite amount of knowledge and skill to his aid to meet the opportunity offered. It is in saving such teeth as these that the reputation of the dental profession for skill and usefulness is increased, and honor and gratitude are accorded to the men who can accomplish it.

The method of procedure will vary according to the size, shape, and position of the cavity. If small, a little amalgam can be put into the soft cement before putting on the matrix, as described for "Cement and Amalgam" *A*, the surplus cement removed from the entire edge of the cavity, the matrix adjusted, more amalgam put in, and gold added, as described for "Amalgam and Gold."

In larger cavities, involving more of the crown, after having filled the approximal portion of the cavity with the cement, amalgam, and gold, cement should be put in a second time, into which plastic gold is carried, and the filling completed by building gold on to that which was added to the amalgam, and joining it to that which was put into the second mix of cement.

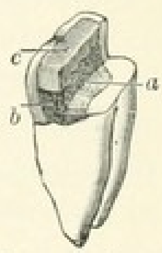
In still larger cavities, the matrix can be put on first, amalgam packed against it to form the outer shell of the approximal side, as described for "Cement and Amalgam" *B;* cement is then put into the body of the tooth, and into this gold is pressed (*not* amalgam) and afterward added to until it joins the amalgam, thus completing the metallic shell. From the specimen shown in Fig. 341 the matrix has been removed to better show the partially completed filling.

FIG. 341.



a, Amalgam and gold to form approximal shell of filling; *b*, cement and gold to which is to be added gold to complete the filling.

FIG. 342.



a, Cement; *b*, amalgam; *c*, gold.

It will be seen that the cement plays a very important part in this operation. It will preserve the color of the tooth though it may have been necessary to use a little of the gilded platinum, or to have the gold extend to the cervical border of the buccal corner of the cavity to support and bind firmly together the tooth and filling, yet it is protected from external influences which would destroy it. Fig. 342 shows section of a filling of cement, amalgam, and gold.

GUTTA-PERCHA AND CEMENT.

This combination is extensively used for what may be termed temporary work, in the teeth of young patients, in teeth of poor quality, and in badly decayed and frail teeth.

It is generally believed that zinc phosphate will not last as well at, or just under, the gum margin in approximal cavities as will gutta-percha; although exceptions might be taken to such a general rule. It is the common custom to combine these materials, placing the gutta-percha at cervical margins, using the cement for the occlusal and contour portions of the filling.

There is no doubt that fillings of these materials last much better when inserted with considerable pressure, thereby condensing well and making them solid. In accomplishing this, the matrix is of great assistance. It not only allows force to be used on the material while in a plastic state, but prevents its being crowded out of the cavity and up into the gum, and leaves the filling in such condition that but little shaping and finishing are necessary.

Any suitable matrix—the one previously described in this chapter is recommended—having been adjusted, gutta-percha sufficient to fill the cavity a little below the gum margin is carefully packed into place with warm instruments. Sufficient heat must be used to make it thoroughly plastic, but great care must be taken not to burn or overheat the material. If the gutta-percha is overheated its physical properties and durability are very much impaired.

All cavities where gutta-percha is used should be varnished with a thin coating of white resin or Canada balsam dissolved in chloroform. This will prevent the dragging away of the gutta-percha from the walls of the cavity in finishing, and will make the filling water-tight.

Sufficient gutta-percha having been put in, the rest of the cavity is filled with cement. The matrix being in place and properly shaped, the operation is reduced, practically, to that of filling an occlusal cavity.

It is of great importance that the cavities be kept dry, consequently the rubber dam should be used wherever it is possible to do so. The cement should be kept dry for at least fifteen minutes after it is put in, and then covered with varnish or vaselin to prevent the disagreeable taste due to its acid reaction, also to keep the filling for a still longer time from the saliva after the dam is removed.

Cement will wear better if smooth and well polished. A fine glossy surface can be obtained with an oiled burnisher when the cement is at just the right degree of hardness, *i. e.* when but slightly plastic.

A convenient method of oiling burnishers and other instruments for plastic fillings is to place on the back of the third joint of the forefinger of the left hand a bit of vaselin, half the size of a drop of water, just before beginning to put in the filling. The instrument can be readily touched to this, and it quite does away with the necessity for an "oil pad."

An excellent lubricant for instruments used to manipulate gutta-percha or cement is cocoa butter. A small porcelain druggist's jar into which it has been melted is convenient to have on the operating table. Plastic fillings will rarely stick to instruments that have been rubbed on cocoa butter. If a shaving of it is placed on a completed cement filling it will instantly melt and flow over the entire surface, preventing the disagreeable taste when the dam is removed, and will keep it from contact with the saliva for some time.

Gutta-percha and Gold.

For many years it has been the habit of some good operators to fill the interior of large cavities with gutta-percha, covering it with gold. Although this may not be objectionable practice in some cases, it certainly cannot be recommended for general use. The principal objection to it is the danger of frail walls being fractured by the subsequent expansion of the gutta-percha. So many instances have been noticed where fracture has followed this combination that the fact seems well demonstrated that this danger exists. Again, there is no need of combining these two materials when zinc phosphate, which is so much better than gutta-percha for this purpose, is available and does not possess the dangerous quality of expansion attributed to gutta-percha.

Gutta-percha and Amalgam.

What has been said in regard to gutta-percha and gold will apply equally well to gutta-percha and amalgam. Rarely, if ever, can this combination be used to so good advantage as can zinc phosphate and amalgam.

Various Kinds of Gold in Combination.

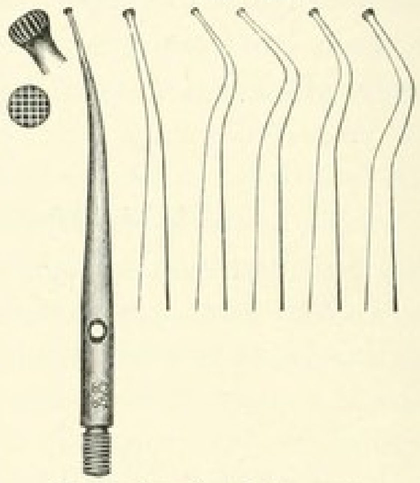
(A) The So-called Plastic or Crystal Mat Gold, with Other Forms of Gold.—Within a few years, preparations of gold other than that known as foil, or foil made into cylinders, ropes, and so forth, have been introduced and have become of great value in the filling of teeth.

These golds are commonly known as "plastic gold." The term is, however, misapplied. The granular quality of these gold preparations, *i. e.* lack of fiber, is what gives them their peculiar and, for certain purposes, very valuable working qualities. To understand this characteristic, take a piece of White's "crystal mat gold" and place it upon a piece of blotting paper, then press the point of a medium-sized gold packer upon the centre. It will be observed that when the pressure is applied the gold is not inclined to curl up, but rests in its flat position, and the instrument has cut a clean track in the gold, condensing only that which is directly under the point. The gold being without "fiber," so to speak, the particles not directly under the point are not drawn down as the pressure is applied. This is why this preparation of gold is so useful for starting fillings.

Now take a cylinder made of gold foil, place it on blotting paper as before, and with the same instrument press on the centre of it. It will be noticed that the instrument does not make a clean cut through the cylinder, as was the case with the piece of mat gold, and, instead of remaining flat on the blotting paper, it is inclined to curl up. The fibrous quality of the foil is an advantage when a corner is to be built on to a tooth, or in any place where toughness of the material assists in its manipulation.

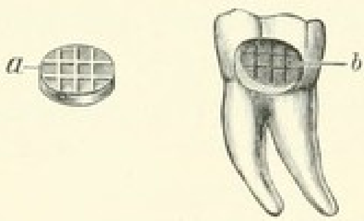
By using these golds for starting cavities, the peculiar qualities just referred to will be exhibited. For illustration, we will take an extreme case—that of a shallow circular cavity in the buccal surface of a lower molar. This cavity is entirely without angles or undercuts, its walls flaring outward, the bottom being flat, or as nearly so as it can be made with a large bur (see Fig. 343). A piece of plastic gold a little larger than the cavity is placed in position, then with a flat, very slightly serrated instrument (a, Fig. 339) it is carefully and gently worked into place. When it is condensed about even with the outer edge of the cavity, a smaller instrument is used to condense around the edge. As only the portion of gold under the point is disturbed, this can be done quite readily without dislodging the whole piece. Soon sufficient force can be used to thoroughly condense the whole. Care must be used in selecting a first piece that it be not too large, but *large enough*, so that it will not chop up as it is being manipulated. After getting the first piece in place, the filling can be finished with the same or any other preparation of gold. If of the same, it is well to use oval points (Fig. 344) and work the gold toward the sides of the cavity with a sort of rotary motion, keeping the edges of the filling higher than the centre.

Fig. 344.



Royce plugging instruments.

Fig. 343.



This gold is very soft and takes a very sharp impression of the surface on which it is packed, as shown by the cross lines on the filling, *a*, Fig. 343, which are reproduced from those made in the cavity shown at *b* in Fig. 343. The lines across the bottom of the cavity were made with the sharp point of a hatchet excavator.

This form of gold can be used to advantage, sometimes, at the cervical wall of compound cavities, provided a matrix has been tightly adjusted. For starting fillings in approximal cavities in the front teeth it is sometimes invaluable, and it can be used in conjunction with any other form of gold, or interchangeably. If at any point in a filling the operator sees a place where he thinks he can put a piece of plastic gold better than any other, there is no reason why he should not use it. Sometimes it is particularly useful to thrust into soft foil to make a surface upon which to build cohesive foil. It can be packed with either hand or mallet force, and with smooth or serrated instruments.

(B) **Non-cohesive and Cohesive Gold.**—Strictly speaking, non-cohesive gold cannot be made cohesive by annealing, and can be used only on what is known as the "wedge" principle. "Soft gold," as the term is generally understood, is non-cohesive when used without annealing, but when annealed it becomes cohesive.

Softness and toughness are the qualities necessary to make tight joints between fillings and cavity walls, and good preparations of non-cohesive and soft golds have these qualities. Consequently, a method that will admit the use of these golds against cavity walls with a sufficient amount of cohesive gold added to insure strength and hardness, when strength and hardness are necessary, is desirable.

An exaggerated illustration of stopping a cavity watertight with soft or cohesive gold is that of stopping a bottle tightly by using a velvet cork or a piece of hickory. It *can* be done with the hickory, but the time required to do it perfectly, as compared with doing it with the velvet cork, is not unlike the difference between making a filling of soft and one of cohesive gold.

Simple cavities, whether in occlusal or approximal surfaces, can often be half or two-thirds filled with soft gold in a very few minutes, and the rest of the cavity filled with cohesive gold. A filling made in this manner is as good as, or even better than, one made entirely of cohesive foil, and the time required to do it is much less, as the soft gold can, on account of its softness, be used much faster than can the cohesive. In cavities of easy access the soft gold can be so manipulated as to be against the walls of the cavity at every point. Small cylinders, or any other form of soft gold, can be set around the edges, and the central portion of the cavity filled with cohesive gold. Care must be taken to carry the cohesive gold into the soft with instruments not too large, so that a *mechanical union* between the two golds is effected, as but little cohesion can be had between soft and cohesive gold. In large cavities, after the first pieces of soft gold have been put in place and cohesive gold worked in, the two kinds of gold can be used interchangeably. A piece of soft gold can be placed against a portion of the wall of the cavity, followed by a piece of cohesive, which is first attached to the cohesive portion of the filling and then used to force the piece of soft gold to its place. Dexterity and tact in using these two golds together can only be obtained by experience, and carefully noting the characteristics exhibited under manipulation.

In compound cavities soft gold plays a most important part. Fillings in these cavities fail, usually, at the cervical wall, and too much care cannot be taken in making them at this place as nearly perfect as possible. For this purpose it is now generally conceded that soft gold is much better than cohesive.

A suitable matrix will greatly facilitate the operation and assist in obtaining the proper contour. The thorough packing of the gold will also be much simplified if the cavity is so prepared that the walls form no acute angles with the matrix, therefore attention to this point is important.

A matrix having been properly adjusted—the one described under "Amalgam and Gold" fillings is recommended—one-half or two-thirds of the approximal portion of the cavity is filled with soft gold. For this purpose soft cylinders, ropes, pellets, or mats can be used. Great care must be taken in condensing the gold that it does not tilt under the instrument. The pressure should force the matrix away from the tooth enough to allow the gold to be condensed just a little over the edge of the cavity, so that when the burnisher is applied there will be sufficient gold to make a flush filling.

When all the soft gold has been put in that the case will allow, the cohesive gold should first be added in very small pieces in order to facilitate the driving of it into the soft gold, so as to make a strong union between the two. For this purpose very small cohesive cylinders or No. 3 or No. 4 foil will generally be used, but sometimes No. 30 or No. 60 foil or some of the plastic or crystal gold can be used. The filling can be finished with any cohesive gold, that kind being selected which the operator has found by experience he can best manipulate under the existing conditions. He will also remember, as the work goes on, that a piece of soft gold laid against an exposed wall, and backed up with cohesive, as before described, will do much toward securing a good filling.

(C) **Soft, or Cohesive Gold, and Heavy Gold.**—Fillings of soft or cohesive gold, or a combination of the two, should sometimes be finished with *heavy gold*. Nos. 30, 40, 60, and sometimes No. 120, can be used to advantage. These heavy golds—which are usually rolled, not beaten—make a very dense filling, and, when great strength and hardness are required, they are preferable to lighter grades.

When a filling that is to be finished with heavy gold has been brought to the point where the thick gold is to be added, the surface should be as nearly level as possible, as it is difficult to adapt the heavy gold to indentations and irregularities. The instruments used should have the very finest serrations, if any at all. The gold can be put on by hand or mallet pressure, or by burnishing with oval points having very slight serrations, or with an ordinary burnisher. When done in this way the burnisher is apt to become gold plated, and the instrument will stick to and drag away the gold. When this happens the gold plating can be removed from the steel by rubbing on a piece of ink eraser, or on flour-of-emery paper.

In using heavy gold great care is necessary that no portion of the piece added be left uncondensed. Hard pressure must be applied to every part of the gold, or it will flake off and destroy the good appearance, if not the utility, of the filling.

Gold and Tin.

Compound cavities are sometimes partially filled with tin and then finished with gold.

At the present time it is a disputed question whether tin, if used as above suggested, will not be dissolved out, after a time, by the action upon it of the fluids of the mouth, leaving a cavity.

It can be used exactly as described for soft and cohesive golds, substituting the tin for the soft gold, or for a portion of it—for, as a rule, much less tin would be used than soft gold.

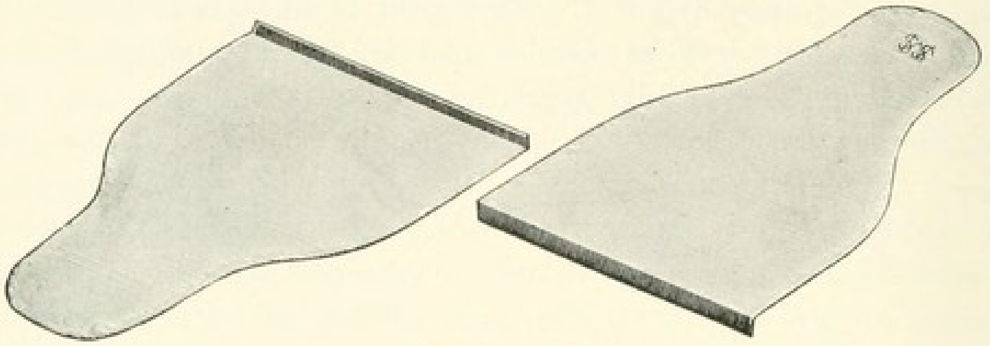
If desired enough tin can be used to cover the cervical wall, followed by sufficient soft gold to complete one-half or two-thirds of the filling, the final finish being of cohesive gold.

The matrix will be found of the same service as in the case of soft and cohesive gold.

Tin-Gold.

The term "tin-gold" has been applied to the combination of tin and gold when a sheet of tin and a sheet of gold have been laid one upon the other, and rolled, folded, or crimped together, being then used in the same manner as non-cohesive foil, depending on the "wedge" principle for holding in the filling. Various authorities recommend different proportions of the tin and gold to be used in this manner. All the way from one-quarter of tin to three-quarters of gold, *i. e.* the proportion of one-quarter of a sheet of tin and three-quarters of a sheet of gold to be folded or crimped together, to three-quarters of tin and one-quarter of gold. A convenient way of preparing "tin-gold" for use

Fig. 345.



Foil crimpers.

in medium-sized cavities is to take one-third of a sheet of No. 4 tin foil, upon which one-third of a sheet of No. 4 non-cohesive foil is laid. It is then placed upon crimpers (Fig. 345) and drawn into an evenly folded mass (Fig. 346).

Fig. 346.

Crimped tin-gold.

This is to be cut into lengths suitable to be used for the cavity in hand. These pieces can be doubled to make blocks, or rolled around a broach into cylinders, if desired. For larger cavities one-half, two-thirds, or even a whole sheet each of the tin and gold foils can be used. For very small cavities, one-quarter sheet of each may be sufficient.

If it be a fact, as often claimed, that tin has peculiar preservative qualities as a filling material, it will be best to so crimp or fold the "tin-gold" that the tin will be on the outside, in order that it may be placed against the cavity walls.

To obtain good results with this combination, it must be used with the same care and accuracy that are required for working gold. It is very tough and soft, and can be worked with great rapidity by an expert. For method of using see chapter on Non-cohesive Gold, and work "tin-gold" as there described for non-cohesive gold.

After a filling of "tin-gold" has been in for some time it will often be found to have changed in character, and instead of being a mass of malleable metal, as it was when put in, to have become hard and brittle, closely resembling amalgam, but, unlike it, will not stain or discolor the teeth.

"Tin-gold" is recommended for use in the temporary teeth, in occlusal and buccal cavities of molars, especially in teeth of poor quality, and in the mouths of young patients. Small approximal cavities in all the teeth may be filled with it to good advantage, when located where its dark color will not be objectionable.

"Tin-gold" and Gold.—"Tin-gold" can be used in connection with gold in the same manner as has been described for the use of tin and gold, or soft and cohesive golds.

Amalgams of Different Quality in Combination.

For certain amalgams is claimed a greater preservative character than is possessed by others. But on account of very dark color or little edge strength[1] they may be undesirable for the surface of fillings, especially when contour is necessary, or when prominently exposed to view.

In simple cavities it is very easy to fill nearly full with the amalgam deemed best for its preservative qualities, and to finish with that having superior color or edge strength as the case may require.

For compound cavities fill about two-thirds with the first-mentioned amalgam, cutting away the surfaces and exposing the entire outer rim of the cavity, as shown in Fig. 336. The matrix is then adjusted and the remaining portion of the cavity filled with amalgam having the requisite edge strength for contour work.

Cement and Alloy.

Mixing alloys (such as used for amalgam) with cement has been recommended to a certain extent. This can be done by adding from 25 to 50 per cent. of the alloy filings to the cement powder and then mixing with the liquid, or the alloy may be worked into a thin mix of cement.

The object of the alloy is to protect the cement, in a measure, from the fluids of the mouth, thereby making the filling more lasting.

Another combination of *cement* and *alloy* which has proved of considerable worth, especially where it is impossible to secure proper retention for an ordinary amalgam filling, the combination having a very strong adhesive quality, is thus described by a well-known writer:

"Ordinary alloy should be used, and not the recently introduced quick-setting varieties. On the mixing slab should be placed a quantity of zinc oxid powder and a sufficient quantity of the liquid. Now mix the alloy in the usual way, but do not express the mercury, unless in considerable excess, as a very dry mix is difficult to incorporate with the cement. Mix the cement as usual for use as a filling, and immediately mix in about an equal quantity of amalgam, using a stiff steel spatula. The white metal or bronze spatula should not be used, as it is acted upon by the mercury. Now you have a stiff plastic mass, which

[1] See Chapter XIII.; also writings of Dr. J. Foster Flagg.

may be rolled between the thumb and finger into a convenient pellet and placed entire in the cavity, pressing carefully to place with smooth burnishers. A perfect contour may be built up without the aid of a matrix.

"The mixture is extremely adhesive to the dry cavity walls, and no definite retaining shape is needed. Some of the amalgam may be saved unmixed with the cement, and can now be burnished over the surface of the combination filling, to which it adheres almost greedily, and thus a pure metallic surface, like a veneer, is given it which is as durable as an amalgam filling. Or a quick-setting amalgam may be employed for the veneering.

"In color this combination is like amalgam, but is more granular in appearance, and in its working properties resembles stiff cement. When hard it takes on a metallic luster under the burnisher; if sawed through it shows a metallic surface. It is less soluble in the oral fluids than oxyphosphate cement, but less durable than amalgam alone, except when veneered with amalgam as described.

"Its advantages over amalgam are, first, its adhesiveness, which property makes it applicable to cavities in which, for any reason, a retentive form cannot be obtained; secondly, the rapidity with which a large cavity can be filled, a valuable item where dryness cannot be long maintained, and making it unnecessary to employ the rubber dam in many cases; thirdly, the ease with which large contours may be made without using a matrix.

"Its advantages over cement are its greater hardness and durability, but it is less agreeable in color, hence should be employed only in the posterior teeth."

CHAPTER XV.

RESTORATION OF TEETH BY CEMENTED INLAYS.

By Joseph Head, D. D. S., M. D.

Strictly speaking, the term inlay may be applied to any substance placed in a tooth cavity, but custom has restricted this term to fillings inserted as one piece.

In primitive times teeth were filled by driving a solid piece of lead into the cavity; gum mastic was also used in the same way; and the green stone inlays in the central incisors of a human skull discovered at Copan, Honduras, probably antedate all historical record.

Before describing the construction of inlays it may be well to consider their advantages and disadvantages; for if they have no superiority over other fillings to counterbalance their inherent defects, inlays are without excuse for existence.

Let us, therefore, first consider the main characteristics of the perfect filling; and then by a comparative table of other filling materials the good and bad points of each may be justly examined.

The *characteristics of an ideal filling* may be stated as follows:

1. Resistance to wear of mastication.
2. Resistance to action of oral fluids.
3. Harmony of color.
4. Exclusion of bacteria, and preclusion from growth of those that enter the margin.
5. Non-conductivity of heat.
6. Manipulation easy to patient.
7. Manipulation easy to operator.
8. Manipulation not destructive of healthy tooth structure.

By a study of the table on page 370 cohesive gold will be seen to possess over all other materials the sole, though important, superiority of greatest edge strength and resistance to the crushing force of mastication. True, it excludes bacteria from the cavity; but experience proves that if the edges of a cohesive gold filling begin to leak and admit micro-organisms, the gold seems to be almost entirely lacking in the antiseptic power possessed by tin, amalgam, gutta-percha, and the cements. And

TABLE SHOWING CHARACTERISTICS OF VARIOUS FILLING MATERIALS.

ATTRIBUTES OF IDEAL FILLING.	*Cohesive Gold.*	*Soft Gold.*	*Tin.*	*Amalgam.*	*Oxyphosphate of Zinc.*	*Oxychlorid of Zinc.*	*Gutta-percha.*	*Porcelain Inlays.*
1. Resistance to wear of mastication.	Best of all materials for edge strength.	Almost as good as cohesive gold.	Almost as good as non-cohesive gold.	Bulges and chips at edges.	Edge strength good through adhesion; wears from abrasion.		Lacks resistance to pressure and wear.	Chips at edges; crushing resistance excellent.
2. Resistance to the action of oral fluids.	Best of all materials.		Corrode slightly.		Very poor.		Poor.	Excellent.
3. Harmony of color.	Poor.	Poor.	Unsightly.	Unsightly.	Possibly good for a short time.			Best of all materials.
4. Prevents decay. (a) Excludes bacteria.	(a) Yes.	(a) Moderately.	(a) Moderately.	(a) Leaks badly.	(a) Partly excludes bacteria.		(a) Leaks at margins.	(a) Excludes bacteria.
4. Prevents decay. (b) Precludes growth of bacteria that enter margins.	(b) Very little.	(b) Fairly well.	(b) Fairly well.	(b) Very considerably.	(b) Partly precludes growth of bacteria.		(b) Precludes growth.	(b) Precludes growth.
5. Non-conductivity of heat.	Bad in its great conductivity.	Less of a conductor than cohesive gold.	Less of a conductor than soft gold.		Excellent as to non-conductivity of heat.			
6. Manipulation easy to patient.	Most exhausting of all materials.	Less exhausting than cohesive gold.		Easy to patient.	Easiest of all materials.	Painful to sensitive dentin.	Easy.	Easy.
7. Manipulation easy to operator.	Very difficult to body and mind.	Difficult.	Difficult.	Easy.	Easiest of all materials.		Easy.	Taxes mind, not body.
8. Manipulation not destructive of healthy tooth structure. (a) Adhesion to cavity walls.	No adhesion.	No adhesion.	No adhesion.	No adhesion.	Great adhesion.		Moderate adhesion.	Great adhesion.
8. (b) Undercuts unnecessary.	Deep undercuts necessary.	Undercuts necessary.	Deep undercuts necessary.	Undercuts necessary.	No undercuts necessary.		Often unnecessary.	Undercuts not always necessary.
8. (c) Free access, and slicing of edges unnecessary.	Necessary.	Necessary.	Necessary.	Unnecessary.	Unnecessary.		Unnecessary.	Absolutely necessary.

while it resists perfectly the action of the oral fluids, it so utterly lacks the other ideal attributes, as already enumerated, that with front teeth, soft teeth, and teeth of nervous patients its manifest disadvantages more than counterbalance its advantages.

Soft gold is open to the same objections, but it has the advantages of resistance to wear, resistance to oral fluids, and, to a less degree, exclusion of bacteria.

Tin has to a marked degree the good and bad attributes of soft gold, but it turns black.

Amalgam bulges under mastication, chips on the edges, rusts, and leaks; it prevents decay, however, through antiseptic action. When rusty it is a moderately poor conductor of heat, it is easy of adaptation both for operator and patient, and calls for a manner of manipulation that is conservative of healthy tooth structure. It is therefore often available where gold is not.

Oxyphosphate of zinc has all the advantages lacking in cohesive gold with the exception of color, and lacks all the advantages that cohesive gold possesses. Its edge strength is solely due to its great adhesion. It wears under mastication, dissolves in the fluids of the mouth, and usually absorbs bacteria; but, on the other hand, it prevents the growth of germs, is a non-conductor of heat, has better color than gold, is easy of insertion for patient and operator, preserves weak walls, and does not require undercuts.

The same may be said of oxychlorid of zinc, except that it causes pain to sensitive dentin and exposed gums.

Gutta-percha, in a similar way, with the exception of color, possesses the good points lacking in cohesive gold, and lacks the good points possessed by cohesive gold. It loses shape and wears under mastication, has feeble resistance to fluids of the mouth, has poor color, and leaks micro-organisms; but, on the other hand, it inhibits from further growth the germs that enter, is a non-conductor of heat, is easy of insertion for both patient and dentist, and has a manipulation that tends to conserve frail though healthy walls.

When we come to inlays we have a filling in which the good points of the cement are combined with those of amalgam, gold, or porcelain in such a way as to insure the advantages of both in the largest degree, and to reduce to a minimum the disadvantages of each.

When a cavity is lined with a thin zinc cement squeezed out by the insertion of soft amalgam, this amalgam afterward having as much as possible of its mercury removed and the edges of the metal burnished to the cavity margins, an inlay of amalgam is to all intents and purposes made. This treatment takes away from the amalgam three of its objectionable features, conductivity of heat, lack of adhesion to the cavity, and discoloration of adjacent tooth structure, while the adaptation of the plastic metal to the tooth margins can be quite as perfect as though no cement were used. So in using the principle of the inlay with amalgam three distinct advantages are gained without any counteracting disadvantages, all of which would seem to indicate that whenever possible zinc cement should be used under amalgam.

When an inlay of gold is cemented into a cavity with oxyphosphate of zinc all the advantages of cohesive gold and oxyphosphate of zinc are obtained, excepting that a fine line of cement remaining at the margins may in time prove a source of weakness. Except in the fine line above mentioned, such a filling compared with the ideal filling possesses excellent resistance to mastication and to the action of oral fluids, it has power to restrain the growth of bacteria that may enter, it is a non-conductor of heat, and is easy for the patient, while the manipulation involves no greater labor or loss of tooth structure than is entailed in the use of cohesive gold. The two objections that can be raised against the filling are bad color and an edge protected by a soluble cement. Hence—given a firm tooth structure that can bear the mallet without danger of being crushed, a dentin not sensitive to thermal changes, and a patient not too severely prostrated by the necessary malleting—a cohesive gold filling is superior to a gold inlay, inasmuch as the cohesive filling may have edges that perfectly exclude bacteria, even though it has no antiseptic action. Though the inlay largely inhibits from growth the germs that enter its margins, it nevertheless does allow them to enter; and the filling that keeps out the germs entirely must be held superior to the filling that admits germs and then inhibits or destroys them. Unfortunately, in the soft, sensitive teeth of nervous patients the manipulation of cohesive gold does not result in the exclusion of decay germs. The tooth margins are powdered or weakened in some way by the manipulation or apposition of the gold, and the entering germs cause rapid decay, the cohesive gold not having the antiseptic power of restraining them. The thermal shocks, and the overwrought condition of the patient that sometimes lasts longer than can be avoided, both tend to produce unhealthy conditions of the mouth and consequent tooth dissolution. In such a mouth the inlay is indicated, as the patient should not be made to undergo the malleting; and since the germs of decay will probably enter under any circumstances, it is necessary to use a filling the action of which will inhibit or prevent their growth.

In approximal cavities where the filling does not show, and where great resistance to the percussive force of mastication is necessary, the gold inlay is usually to be preferred. Its sole objection is the fine line of cement that connects it with the cavity walls; but if the gold inlay be properly prepared, burnished, and finished as hereafter described, this line of cement may be rendered so microscopic as to become practically no longer a source of danger. In other respects the gold inlay, when not visible, approaches very nearly the requirements of the ideal filling, having the advantages of perfect resistance to mastication, preclusion from growth of bacteria, non-conductivity of variations in temperature, easy manipulation, firm adherence to cavity walls, and an adaptation not usually so expensive to tooth structure as is the ordinary insertion of a gold filling.

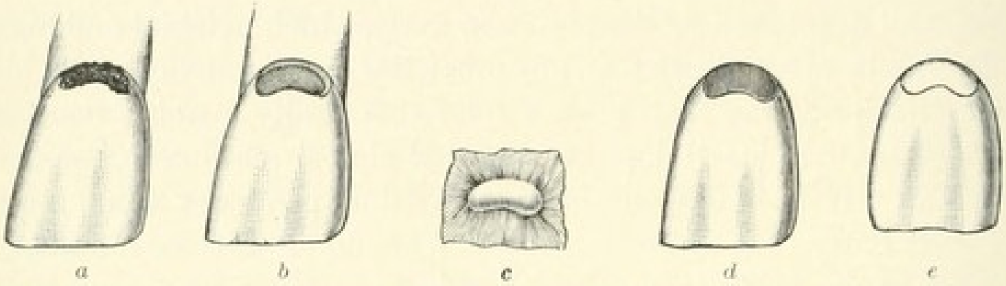
We shall now speak of the *porcelain inlay,* which in labial and buccal cavities fulfills more nearly than any other the characteristics of the ideal filling. Such a filling may possess color that really matches the tooth. It may be set with a cellulose cement that almost absolutely resists the oral fluids. It excludes germs of decay and precludes from growth those that enter. A porcelain inlay is a non-conductor of heat, it adheres to cavity walls, its manipulation is easy to the patient, and is conservative of tooth structure. The only real objection to labial porcelain fillings is in the fact that great skill and patience are required in their insertion. Where, however, porcelain inlays have to withstand heavy strain in mastication, as in Figs. 370, 375, and 376, they are liable to chip on the edges, and thus to demand the use of oxyphosphate of zinc as a cement. This objection, therefore, renders them somewhat less serviceable than gold inlays for non-visible approximal cavities in molars and bicuspids. For while the porcelain is sufficiently strong to withstand the crushing force of mastication, the chipping of the margin tends to accentuate the weakness already found in the solubility of the cement, which is its sole defence against bacteria. If such chipping occurs on the masticating surface of the molars or bicuspids, the fractured margins can be readily filled with gold in such a way that edge strength equal to gold is obtained. Also, if the edges of the inlays are painted with insoluble cellulose[1] before the filling is cemented into place, all the strength and adhesibility of oxyphosphate of zinc can be combined. Thus with care and patience the porcelain inlay acquires the advantages of gold, cement, and porcelain, while it has none of the usual disadvantages. The porcelain filling properly guarded may have the natural color possessed by no other filling material, strength to withstand mastication, resistance to the fluids of the mouth, power to exclude bacteria and to inhibit the growth of those that enter, non-conductivity of heat, adaptation, and conservatism of tooth structure. And if at times the manipulation for the dentist is of necessity so deft and artistic that the highest skill and judgment are required, it is but further evidence that the finest work is usually the most difficult.

[1] The Doyle cement, a cellulose cement, is claimed to be permanent, and seems promising, but only years of experience can prove its value.

The Porcelain Inlay.—The work of manufacturing and manipulating porcelain inlays remains to be considered.

Pieces of porcelain matching the natural tooth have, in times past, been ground to fit the cavities and then held in position with cement. This class of work, however, is hardly feasible except in labial cavities on the surfaces of the front teeth. An excellent method for obtaining

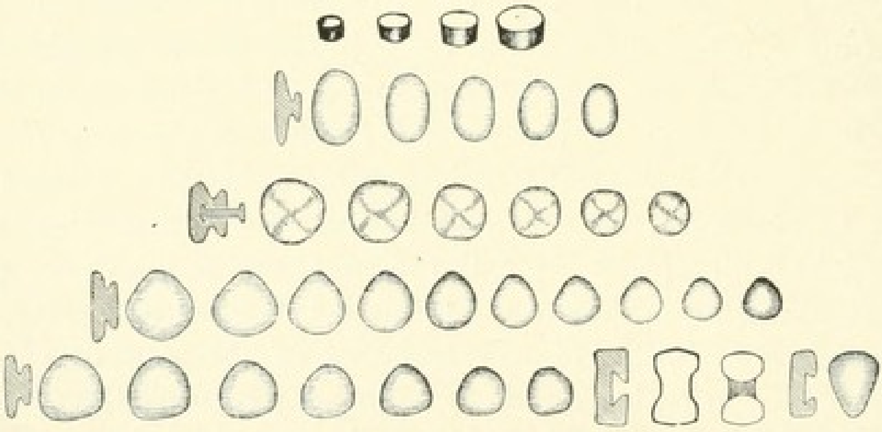
Fig. 347.



a, Defect at gingival margin; *b*, cavity prepared; *c*, mark of edge on tin foil; *d*, tin foil cut out and glued to artificial tooth; *e*, piece of porcelain ground and cemented into the cavity.

good adaptation is to proceed as follows: A piece of tin-foil should be lightly burnished over the prepared cavity, as in Fig. 347, *b*, and the edges thoroughly outlined either with a burnisher or a plug of cotton lightly pressed into the cavity, making the foil appear as in Fig. 347, *c*.

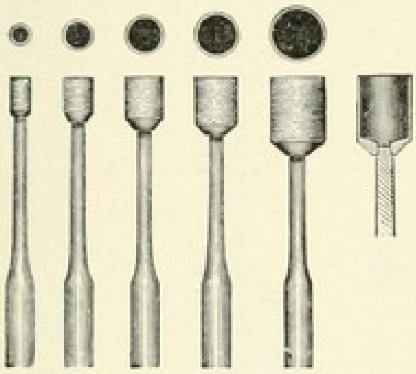
Fig. 348.



Porcelain cavity stoppers.

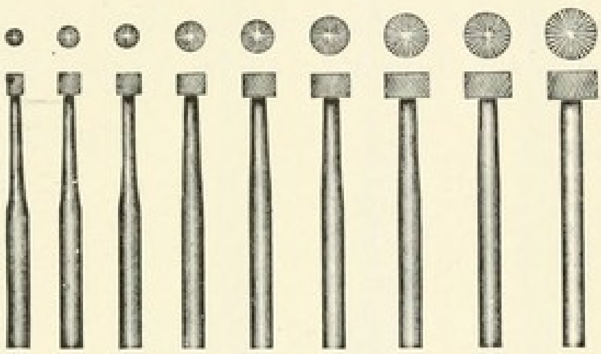
The foil within the line of demarkation is then cut out and glued to the surface of a piece of porcelain that matches the tooth, as in Fig. 347, *d*, the porcelain is ground away up to the edges of the tin on all sides, and a moderately good fit is thus secured (Fig. 347, *e*). This method, however, is superseded by recent discoveries; but for those who are interested historically Fig. 347, illustrating the steps of the operation, may prove of value. Ready-made porcelain inlays have been kept in stock for years at the dental depots. These stoppings are of different shapes and sizes, and are intended to be ground to fit the cavities and finally to be cemented in place (Fig. 348). Some, however, instead of being ground to fit the cavity, require the cavity to be ground to fit them. Dr. George H. Weagant has devised a set of instruments suitable for this purpose (Fig. 349), consisting of five trephines of consecutive sizes made of copper charged with diamond dust. These instruments are intended to cut pieces of porcelain out of an artificial tooth that matches the color of the natural tooth, and the cavity in the natural tooth is prepared with one of Dr. How's inlay

Fig. 349.



Dr. Weagant's diamond trephines.

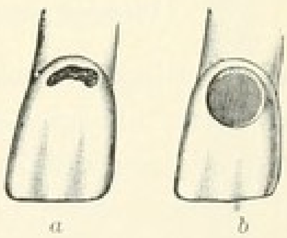
Fig. 350.



Dr. How's inlay burs.

burs (Fig. 350) corresponding in size to the trephine. This method has several serious objections, one of the principal being that in order to give the cavity a circular shape much sound tooth structure is usually sacrificed. Take for example the decayed spot shown in Fig. 351, *a*. This would have to be enlarged as in Fig. 351, *b*, —a very serious objection.

Fig. 351.



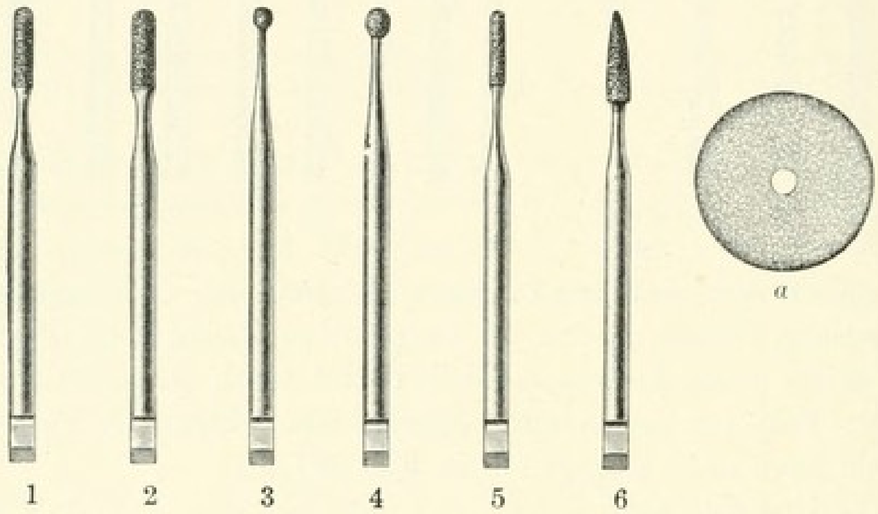
a *b*

As early as 1882 Dr. Herbst advocated glass fillings. These were made by taking impressions of the cavity in wax and making two moulds in some such material as plaster or asbestos. The ground glass was then flowed into the first mould, in which most of the shrinkage occurred. The partly formed filling was then removed and placed in the second mould, when more glass was added until the filling was complete. Even with this crude method the results were fairly satisfactory, although the margins were far from perfect and the glass was permeable to such an extent as to blacken; nevertheless, fillings were made that preserved the teeth for years.

In 1887 Dr. C. H. Land made mechanically perfect edges possible by devising the metal matrix. He used both gold and platinum, but found the latter preferable, as platinum could be adapted with a facility equal to gold, and allowed the use of a high-fusing tooth body much stronger and less likely to deteriorate than bodies capable of being fused on gold, these of necessity requiring so large a percentage of glass that they, like the fillings of Herbst, lacked permanence of gloss and color. From this discovery of Land dates all effective porcelain filling. Before this, pieces of porcelain had been ground to fit labial cavities, with fairly good results, and pieces of enamel from extracted teeth had been inserted in a similar fashion, but the accurate adaptation of porcelain to approximal cavities as far back as the molars was impossible until the metal matrix was evolved.

At present the advocates of porcelain fillings are represented by two distinct parties: those who advocate a low-fusing porcelain that can be melted in a gold matrix, and those who advocate a porcelain of a fusing-point and resistance at least equal to Close's continuous-gum body,

FIG. 352.



Diamond points, Nos. 1 to 6; *a*, copper disk charged with diamond dust.

necessitating the use of platinum for the matrix. It is claimed by the advocates of low-fusing porcelains that gold can be more perfectly adapted as a matrix than platinum. This, if true, is a very important advantage. But, on the other hand, those advocating high-fusing porcelains believe that they can get as perfect an adaptation with platinum as with gold, and that their porcelains have a better color, are stronger, more durable, and more easily manipulated, thus giving to the work a far wider range than seems possible with any low-fusing bodies yet devised, for porcelains seem to have strength and durability in direct proportion to their fusing-points. In this connection we should remember that when brilliant men of the past, through long series of experiments, were perfecting the process of continuous-gum work, they would undoubtedly have adopted the low-fusing bodies had they found any that would melt on gold and remain permanent. That they finally resorted to platinum and made durable porcelain bodies at their present fusing-points would seem to indicate that low-fusing porcelains are unable to withstand the solvent action of saliva and the force of mastication.

The preparation of the cavity for either high-fusing or low-fusing porcelains is identical. The cavities should be free from undercuts. If

FIG. 353.

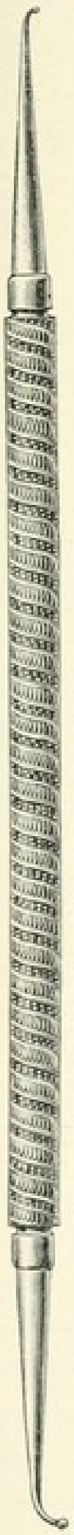


FIG. 354.

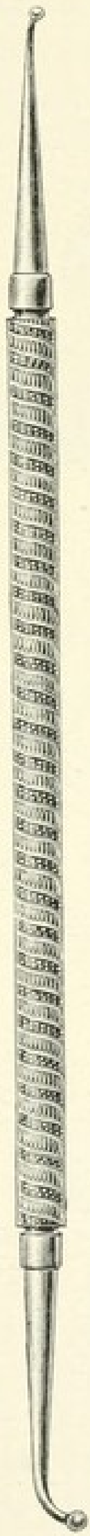


FIG. 355.

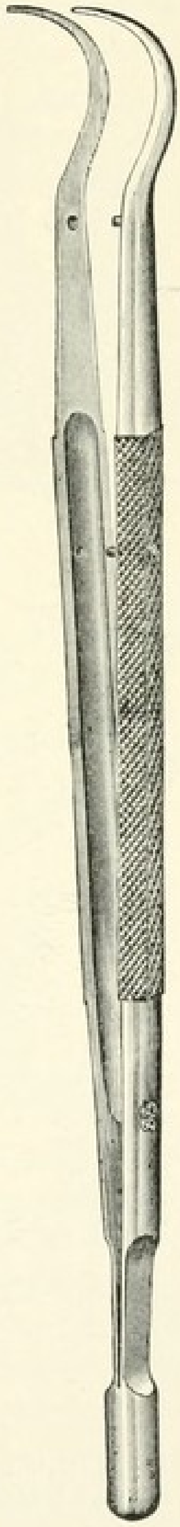


FIG. 356.

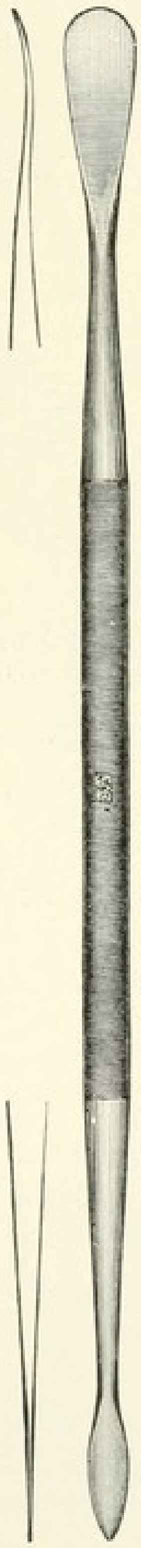


FIG. 357.

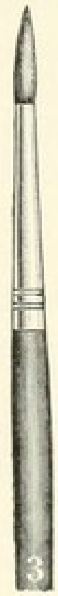
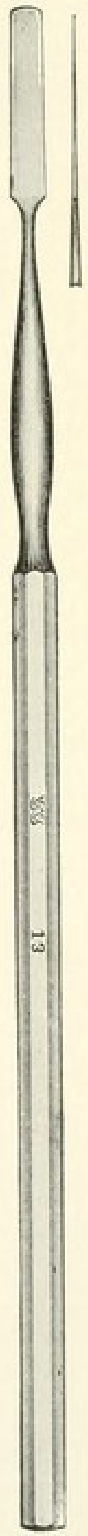
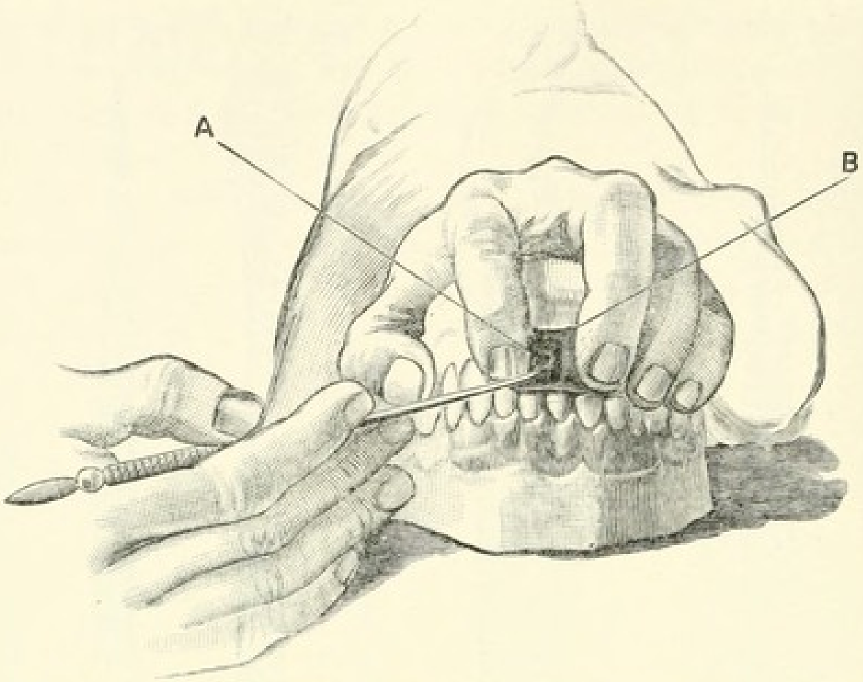


FIG. 358.



these are unavoidable through extensive decay, the cavity should first be filled with oxyphosphate of zinc. The edges should be sharp and smooth, and where they are approximal there must be sufficient separation to allow the metallic matrix, or mould, to be withdrawn without

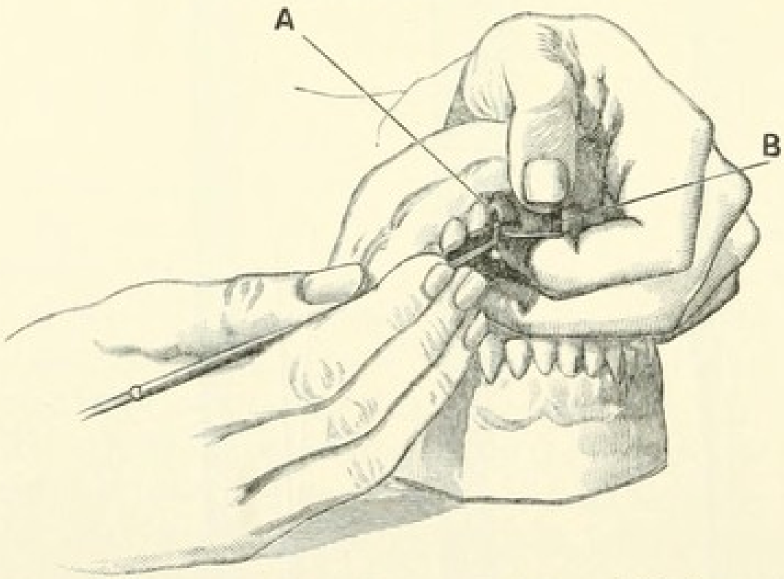
Fig. 359.



A, Outline of labial cavity; *B*, platinum foil large enough to be readily held immovable by the first and second fingers during the formation of the matrix.

distortion, as success is impossible with a distorted matrix. The final polishing can be best accomplished with a set of diamond points (Fig. 352).

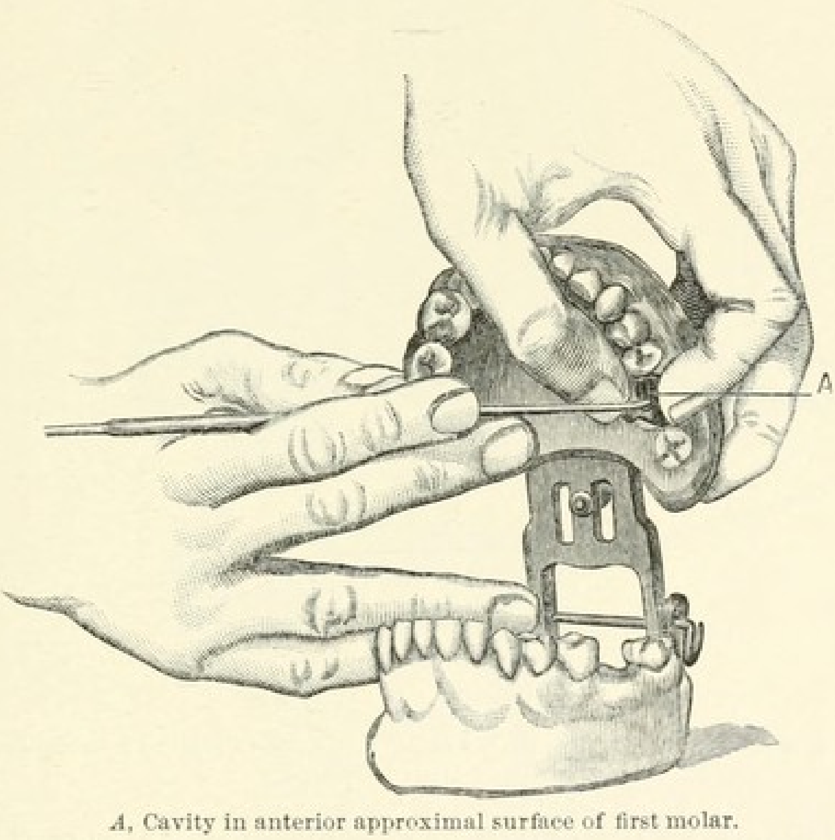
Fig. 360.



A, Outline of cavity in distal aspect of lateral incisor: *B*, platinum folded over cutting edge to insure immobility and to give outlines of tooth so that a perfect contour of porcelain may be obtained.

The separation may be obtained with rubber, cotton, or tape. Approximal cavities between front teeth may be sometimes advantageously cut freely away from the back, as in Fig. 374, *a*, *b*, *c*, *d*. When the fillings are between bicuspids the palatal or lingual walls should be cut unsparingly whenever it is necessary. Where the filling is to stand the force of mastication the edges of the cavity should be at least at right angles to the grinding surface, as in Figs. 370 and 375. The preparation of the cavity being completed, if high-fusing porcelain is to be used the matrix must be made with rolled platinum one one-thousandth of an inch in thickness. If found desirable, thinner platinum may be used for small cavities; but the firm burnishing required usually reduces the foil of one one-thousandth of an inch to one three-thousandth

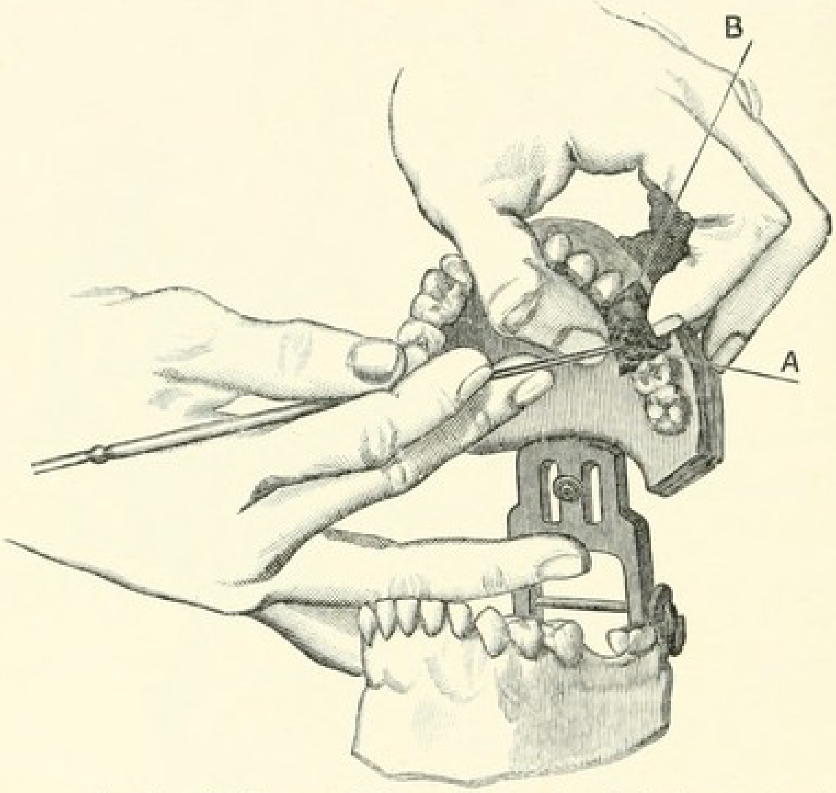
Fig. 361.



A, Cavity in anterior approximal surface of first molar.

or one four-thousandth of an inch on the margins, where excessive thickness of the metal is objectionable. Foil thinner than one one-thousandth of an inch seems to lack sufficient body to stretch properly without tearing. This platinum, if annealed in a Bunsen burner or blowpipe, will be harsh and unfit for use, but when annealed in a muffle or electric furnace it becomes soft and tough. The platinum is placed immovably over the cavity and spun into all parts with a ball burnisher (Figs. 353 and 354), great care being taken to define the edges sharply and smoothly. The edges that wrinkle may be flattened and smoothed with the broad surfaces of the spatula shown in Fig. 356. Should the bottom tear, it is of little moment as long as the edges are smooth and intact. Sometimes it is useful to form the matrix by driving the metal into all the recesses with cotton; but while this is undoubtedly of advantage in some instances, the careful spinning of a piece of foil from the edges to the cavity floor will generally give the best results. The soft, unburnished platinum takes a beautiful impression, but when the metal has been burnished it becomes elastic; if therefore the matrix be moved during its formation, an accurate impression is impossible, for the elastic platinum when distorted cannot be forced back accurately into position until it has been reannealed. When complaint is made

FIG. 362.



A, Posterior approximal cavity in second bicuspid; *B*, edge of platinum extending over first bicuspid to insure mobility.

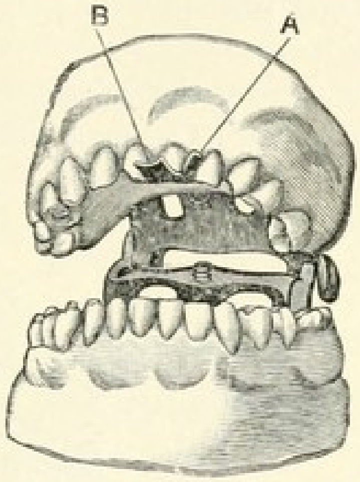
against platinum by the advocates of gold matrices it probably arises from the fact that they try to work the platinum in the same manner as gold.

The matrix when finished should be carefully removed and heated to redness in order to destroy all organic material, as such material will tend to destroy the true shade of the porcelain.

In labial cavities the piece of platinum should be cut sufficiently large to extend beyond the two adjacent teeth, and the metal should be moulded to the three teeth by pressure with cotton and bibulous paper. The metal is then held firmly upon the two adjacent teeth by the first and second fingers, as in Fig. 359, when the general directions for adjusting the matrix to the cavity may be readily carried out. The large piece of platinum has two great advantages: it conduces to immobility of the metal during the formation of the matrix, and it gives the entire labial form of the tooth, so that an accurate idea may be obtained of the desired contour of the filling.

In corners of centrals, as in Fig. 360, the platinum should be folded well over the labial and palatal surfaces of the tooth; then it should

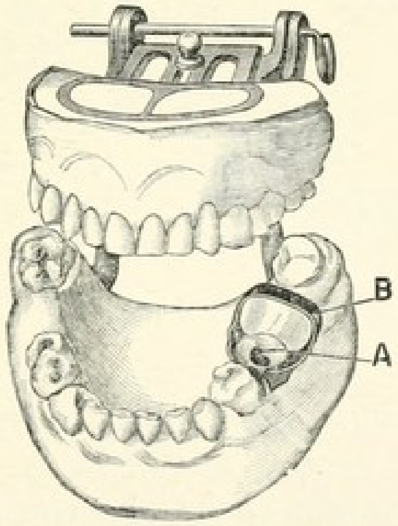
Fig. 363.



A, Outline of approximal cavity; *B*, flap of platinum that had been cut away and turned back to facilitate the removal of the matrix.

also be bent over the cutting edge, forming a sort of cap, beneath which shows the entire contour of the tooth, and by means of which entire

Fig. 364.



A, Outline of cavity as formed in platinum matrix; *B*, clamp holding platinum immovable while the matrix is being burnished into place.

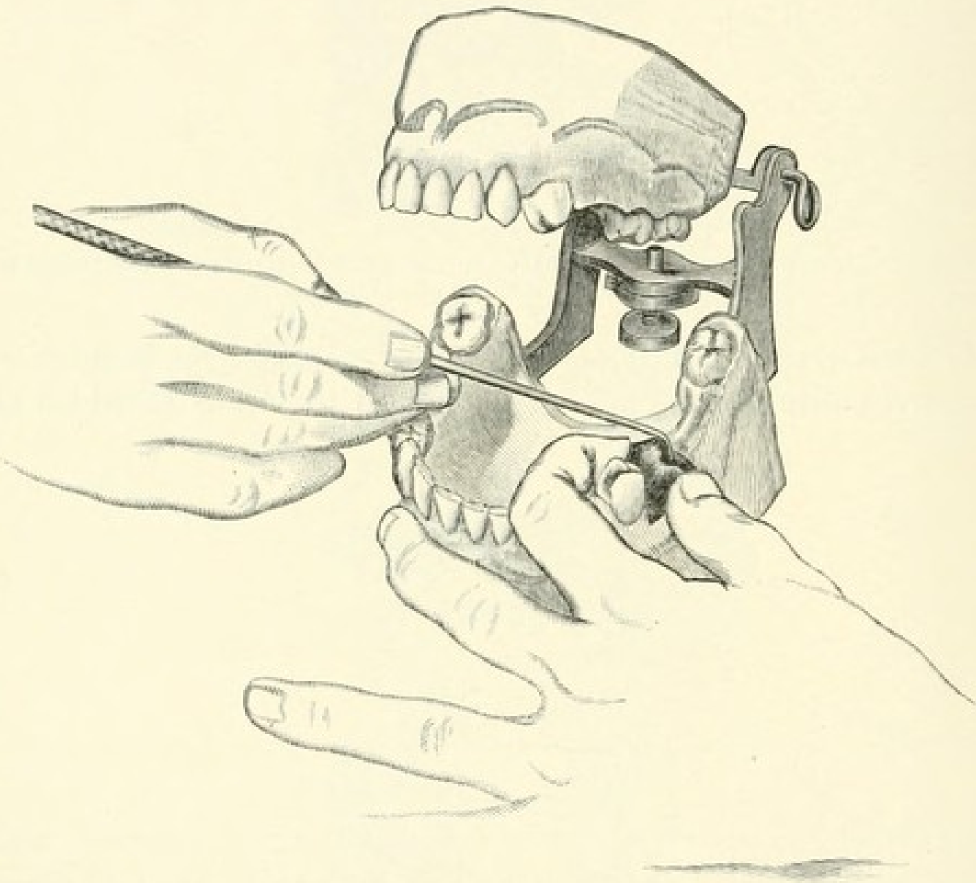
immobility may be obtained while the cavity margins are being defined and the matrix formed.

The same principle applies in forming a half cap from a large piece of platinum for the approximal cavities of bicuspids and molars. The platinum should extend, as in Figs. 361 and 362, from grinding edge to cervical margin, and along the sides of the adjacent tooth. This can be firmly held with the index and middle fingers of the left hand, while the right hand presses the metal with cotton partly into the cavity. The margins and floor of the matrix may then be defined with a burnisher.

In mesial cavities the metal must be pushed away from the operator and the work accomplished by means of the index and middle fingers, as in Fig. 361. In distal cavities the metal is pulled toward the operator, who works around and beyond the hand, holding the platinum as in Fig. 362.

When, as sometimes occurs, the adapted platinum is dovetailed around the teeth, so as to render its removal difficult or impossible with-

Fig. 365.

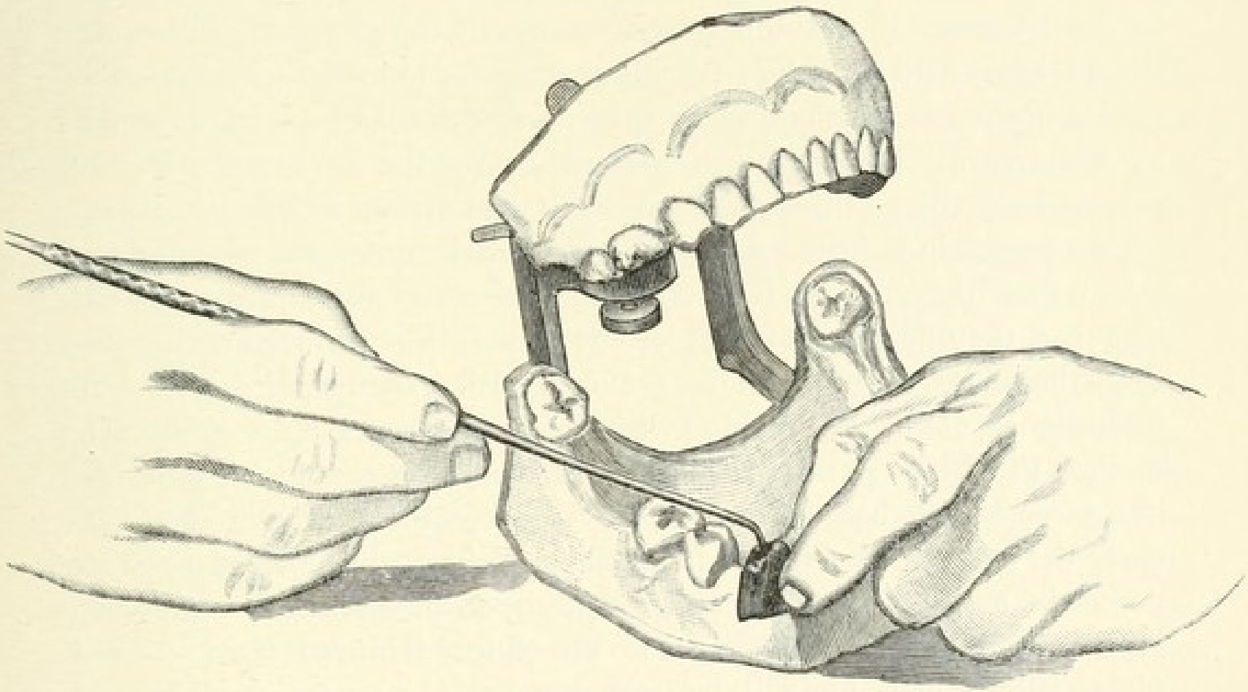


Position of fingers: left lower bicuspid.

out distortion, the outer edge of the platinum cap may be split with a sharp knife from the gum line, just beyond the cavity margins, as is shown in Fig. 363. Fig. 364 shows a method of obtaining immobility of the matrix by a clamp that sometimes proves useful. Figs. 365 and 366 show the position of the fingers when manipulating the matrix on the lower teeth. This, of course, should be done while the matrix is held motionless in the cavity. It is sometimes advisable, in order that perfect immobility may be obtained, first to pack the matrix full of bibulous paper or cotton. When this is done and the packing removed there will be no difficulty in teasing out an undistorted matrix from the cavity.

The color of the filling must next be decided by means of a shade ring. The basal color of nine-tenths of all porcelain fillings is light yellow, and white added according to necessity will in a large number of cases be all that is required to obtain a perfect match. Whatever tint is desired, the basal color should be first ascertained, when the correct toning material may be added with comparative ease. The thoroughly mixed body, being wet with distilled water and dried with blotting-paper to the consistence of dough, is placed in the matrix on the point of the brush or spatula (Figs. 357 and 358), and settled to the bottom with a few taps on the pliers that hold the platinum. The porcelain should not

Fig. 366.



Position of fingers: right lower bicuspid.

be allowed to come quite to the edge. After it has been carefully dried by turning it face downward on a piece of soft muslin, the filling is placed in an electric or gas furnace, as the case may be, and baked until a gloss appears. It is then removed, cooled, and placed again accurately in the cavity, and the edges once more burnished down.

This second burnishing is the most important part of the operation, for however perfect the first adaptation may have been, the edges must of necessity be warped in the furnace by the unequal expansion and contraction of the porcelain and platinum. This contraction having for the most part occurred, a second burnishing makes an adaptation that may be practically perfect. The partially filled matrix must then be removed, filled up to the edges with porcelain paste, and finally baked.

A third addition of porcelain may be needed, but this is usually unnecessary. After baking, the filling may be taken from the furnace almost immediately, as practically only very large pieces need to be cooled slowly, although theoretically a gradual cooling will make the porcelain tougher. The platinum should now be stripped off, care being taken to pull it away from the edge. Should it be pulled off toward the edge, chipping is likely to occur. If small portions of platinum stick to the porcelain, they can be peeled off with a sharp, tempered, pointed instrument.

The filling is now ready for insertion. Undercuts may be carefully made in the cavity and grooves made in the porcelain, by using a thin copper disk (Fig. 352, *a*) charged with diamond dust, so as not to mar the edges. This is usually, if the proper method is employed, a safe and easy procedure with the smallest fillings. The disk and porcelain must be kept thoroughly wet during the cutting of the grooves. The inlay should be so held that the edge adjacent to the intended groove may be buried in the skin of the finger; the groove can then be fearlessly made by the swiftly revolving disk that cuts only the hard porcelain and pushes back the yielding tissue of the finger without inflicting injury. If the porcelain is blackened by the powdered copper, the discoloration may be readily removed by a strong jet of water thrown upon it. If, however, the undercuts are not deemed feasible or sufficient, the gloss from the under side should be removed with a sandpaper disk or with hydrofluoric acid. For etching with the hydrofluoric acid the following method should be pursued: The face of the filling should be imbedded in a piece of soft base-plate wax, leaving free the porcelain that is to enter the cavity. A drop of hydrofluoric acid is then placed upon the porcelain and left there for about five minutes, when wax and porcelain may be washed in water and the filling removed from the base plate. The under side will be frosted and the cement will adhere to it fairly well, but not so well as though efficient grooves had been obtained.

The filling and the cavity should next be washed in alcohol and thoroughly dried. The rubber dam may often be put on with advantage just before the filling is inserted, although the thorough dryness of the tooth thus obtained will at first tend to make the filling appear too dark.

In a buccal or labial cavity, where no force of mastication is to be withstood, the transparent cellulose cement may be advantageously used. If this cement proves to be durable and sufficiently adhesive it will be a great desideratum, for a translucent insoluble cement is the one thing lacking to make porcelain fillings practically perfect; but great care should be observed in its use. The dried cavity, well undercut, should be filled with the cement. The cement should then be painted all over the under side of the porcelain filling, so that the undercuts may be well filled. These coatings should then be allowed to dry to the consistence of a thick jelly, when the filling is put into the cavity and ironed into place with a hot instrument. The cement sets hard only through evaporation of the solvent, and if the filling is too soon inserted it will act as a stopper, preventing the hardening of the cement.

Where great strain is brought to bear upon the filling, or where the cavity is not deep enough to warrant the use of any but the most adhesive cement, oxyphosphate of zinc should be used. The rubber dam should be applied wherever practicable. The filling and cavity should be carefully undercut and dried in alcohol. Creamy, slow-setting oxyphosphate of zinc, corresponding in color as nearly as possible to the tooth, should then be placed in the cavity, and the filling, picked up by means of a little cement on the spatula, be pressed home. The porcelain should be held in position for a minute or two until the oxyphosphate has lost its elasticity; for, however perfectly the porcelain filling may have been fitted, if it does not go accurately into place the edges will be as imperfect as though an ill-adapted matrix had been used. As before mentioned, a creamy, slow-setting cement is essential, and up to the present time the Harvard cement seems best to satisfy these requirements. When the filling is finally in position the setting of the cement may be hastened by a blast of hot air or a hot instrument applied to the porcelain. When the cement is wiped away and the tooth cleaned, paraffin or varnish should be flowed over the filling, in order that the cement may set for six hours before it is exposed to the action of the saliva. On the following day the edges may be ground with an Arkansas stone or polished with sandpaper. It is better for finishing that the edges should be a little too low than too high. If, however, the porcelain is too high it can be ground down and still give good results; but the original gloss is in most cases to be preferred. Having described the general operation of putting in a porcelain filling, a few cautions may not be out of place before describing the special operations.

A filling smaller than a pinhead should not be attempted, as good edges can hardly be obtained. Simple circular cavities without compound curves in the margin frequently require only one burnish, especially if they be small, as the contraction of the fused porcelain is often less than the probable personal error of the operator.

Labial cavities should be made deep if good color and adhesion are desired. A bar of porcelain running into the tooth makes a much stronger anchorage than a platinum pin, as the platinum may stretch and it always tends to weaken the substance of the body.

In large contours excessive contraction may be avoided by adding one part in four of a colorless high-fusing powder to that part of the mixed enamel which is to be used for the first baking. The unfused particles extend across the matrix in every direction, making what is practically an internal investment. The slight lightening thus occasioned is entirely overcome by the second coat, and the proper contour is obtained in fewer bakings. When handling small fillings, the pliers and cavity may be advantageously kept wet up to the time of insertion, as capillary attraction will prevent the filling being dropped and lost. To place a tiny filling on the operating-case in the same relative position that it will take in the tooth prevents mistakes as to which side should go in first.

In addition to the classification—labial, buccal, approximal, contour, etc.—porcelain fillings are to be considered in regard to their position in the mouth, viz. fillings that keep their color when cemented into place, and those that will be darkened by the consequent shadow. Unless these classifications are understood, many a well-matched porcelain inlay will end by appearing dark and unsightly in the mouth. Color variations are met similar to those that are seen upon examining a piece of window-glass. The surface may be nearly colorless while the edge is dark green. The color of porcelain fillings is dependent upon the perfection with which the light is reflected to the eye of the observer. For instance, in a perfect light, yellow porcelain is yellow, because all of the other rays that make up light are absorbed and only the yellow are reflected to the eye. If the light be gradually decreased, fewer yellow rays will be reflected, and the color will become darker; when there is no light reflected the porcelain will appear black. The more perfect the front and side lights in porcelain fillings the less will be the shadow variations in color. Take, for example, a simple labial cavity, as illustrated in Fig. 367. If this extend into the dentin sufficiently deep to prevent the color of the oxyphosphate of zinc or of any other cement shining through it, the correct color of the porcelain will be given. If, however, we place this well-matched material on the approximal surface of the tooth, as in Fig. 368, with an adjacent tooth shutting off direct reflection, and thus allowing only indirect rays to meet the eye of the observer, the color will be lost in shadow, and from having been a perfect match, or nearly so, the shade will assume a dull lead color. Also, if in Fig. 367 the labial cavity should penetrate entirely through the tooth, through the palatal enamel, the inlay would present a problem of almost insurmountable difficulty; for nearly all of the direct rays would pass through it and would be lost in the shadows of the mouth, while the side lights would be shut off by the non-transparent but necessary zinc cement. This difficulty may be overcome by placing two fillings, one on the palatal and one on the labial surface. The oval inlay running through the entire tooth substance is mentioned only as an illustration of the greatest amount of color variation to be met with; and the nearer that a porcelain inlay approximates to this condition the greater will become the tendency of the color to be lost in shadow.

Take, for further example, the two fillings shown in Fig. 369. In each illustration the fillings go evenly through the labial and palatal walls of the enamel, and yet if both fillings are made of material that matches the tooth substance the corner inlay will look well, while the halfmoon-shaped filling will be dark. If, however, *b* does not go through the palatal wall and the cement extends entirely behind it, its color will be nearly, if not quite, as good as that of the corner, it having almost assumed the classification of the simple labial cavity before mentioned. The difference in the shades of these two fillings may be explained as follows: The corner (*a*) is illuminated by side light from the cutting edge, while the halfmoon-shaped filling (*b*) is shut in on four sides, on three by cement and on the fourth by the adjacent tooth. It must be further noted with reference to the corner (*a*),

Fig. 367.

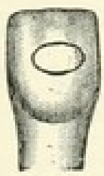
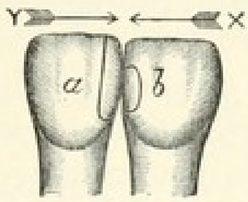


Fig. 368

Fig. 369.



that if it is looked at from directly in front, or from the direction of the arrow X toward the cement, the color will be good; if, however, it is looked at away from the cement, as indicated by the arrow Y, the color will be lighter or darker according to the intensity of the light; but the true color will not be seen. This, however, is not a serious objection, as the filling is usually seen from directly in front, and the occasional side views are equally divided between good and bad lights.

We may, therefore, feel that a corner inlay which does not include more than a third of the tooth's cutting edge is an inlay favorable to the obtaining of a good match. Buccal fillings in bicuspids and molars are as easily matched as the simple labial cavities, for they come under the same conditions of light reflection; but all approximal inlays, from the posterior surface of the canines back to the molars, show the same falling off in color, and unless allowance be made for this falling off disheartening results will be the outcome of otherwise careful work. The greater the slope of the cavity floor into the mouth the greater will be the shadow variations, as in Fig. 374; the greater the slope outward the less will be the shadow variations.

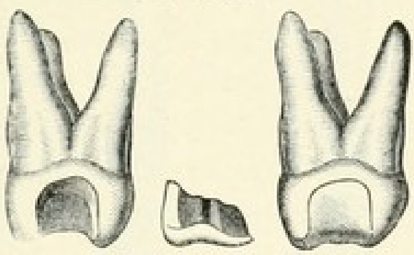
Those not affected are simple labial cavities, corners of centrals and laterals, cusps of canines, bicuspids, and molars.

Those most affected are tips of centrals and of lateral incisors, and approximal and halfmoon-shaped cavities running through the palatal enamel. The broader the adjacent teeth the greater will be the shutting out of light and the consequent darkening of color. Tips of central and lateral incisors running entirely across the tooth are so subject to the shadow variations from cross light, side light, top light, and bottom light, that the restoration of more than a third is not advisable. When half of a tooth has been carefully matched and cemented into place, the tip may look very well in good daylight, but at night it may turn dark; also in an artificial light shining from above the tooth and cement line show very dark while the porcelain seems snow-white. In all such cases, whenever possible, a portion of the tooth should be allowed to run down to the cutting edge.

And now let us consider how we may partly conquer these shadow variations. Halfmoon-shaped cavities, as in Figs. 368 and 369, may be filled on the palatal wall with gold, an absolute match thus being made possible. A porcelain tip may be built up as two corners, to avoid the side lights; but generally all attempts to antagonize shadow variations will result in an effort to lighten the fillings, so that the shadows will be overcome. This lightening is now quite possible, for experiments indicate that an addition of from one-tenth to one-fifth of oxid of tin to the ordinary white enamel gives a white so dense as to be practically the reverse of shadow. If, therefore, we have a filling halfmoon-shaped or approximal, we should first match the porcelain tooth as though it were a simple labial cavity; then by adding to this paste one-fourth to one-third of the dense white powder mentioned above we shall find that, if the colors have been properly mixed, the filling when cemented into place will darken to the original color of the tooth.

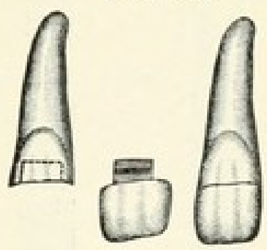
And now having described the process of using high-fusing porcelain for inlays, the next consideration will be the modifications necessary when the low-fusing porcelain is melted in a gold matrix. The best of the low-fusing bodies are said to keep their color and texture in the mouth indefinitely, to be strong enough for all necessary wear, and to retain their color in fusing,—which would indicate that the low-fusing materials have greatly improved during the last eight or ten years. Porcelains capable of being melted in a gold matrix are of two classes: those that are sufficiently low fusing to be melted in a bare matrix, and those that melt so near the fusing-point of gold as to render necessary the investment of the gold matrix in order to prevent its being warped by the fire. In porcelains of the first class the method of procedure is very similar to that in which the high-fusing porcelains are fused in a platinum matrix. The No. 30 gold foil is placed over the cavity margins in a manner similar to that prescribed for the use of platinum; and then, instead of burnishing or spinning it in place, it is pressed into all parts of the cavity by means of spunk or cotton. The metal is so soft and ductile that this can be accomplished in a manner impossible with platinum; and it is this easy manipulation of the gold that makes the sole advantage of the low-fusing over the high-fusing porcelain bodies. The gold matrix is then teased out of the cavity. This must be carefully done, as, being more easily adapted, it is also more easily distorted than the platinum. The proper mixture of porcelain is placed in it, and the baking is performed exactly as with the high-fusing materials, the only marked difference in the working of the low-fusing

Fig. 370.



Large cavity in molar tooth involving approximal and grinding surfaces. Restored by porcelain inlay.

Fig. 371.



Showing restoration of broken lateral incisor by porcelain tip.

and the high-fusing materials being that low-fusing bodies tend to spheroid and lose contour. This can be remedied by mixing with the paste a small quantity of similarly colored high-fusing porcelain.

When such porcelains are used as require the gold matrix to be invested, the following additional points should be carefully observed: The matrix must not be torn on the bottom at all, as in such event the porcelain will tend to run through into the investment instead of drawing away from the crack, as it does from a platinum matrix where no investment is used. The gold matrix must be dropped bottom side down into a paste of asbestos and alcohol, which is allowed to evaporate. Then the porcelain may be flowed into the matrix little by little, to minimize warping.

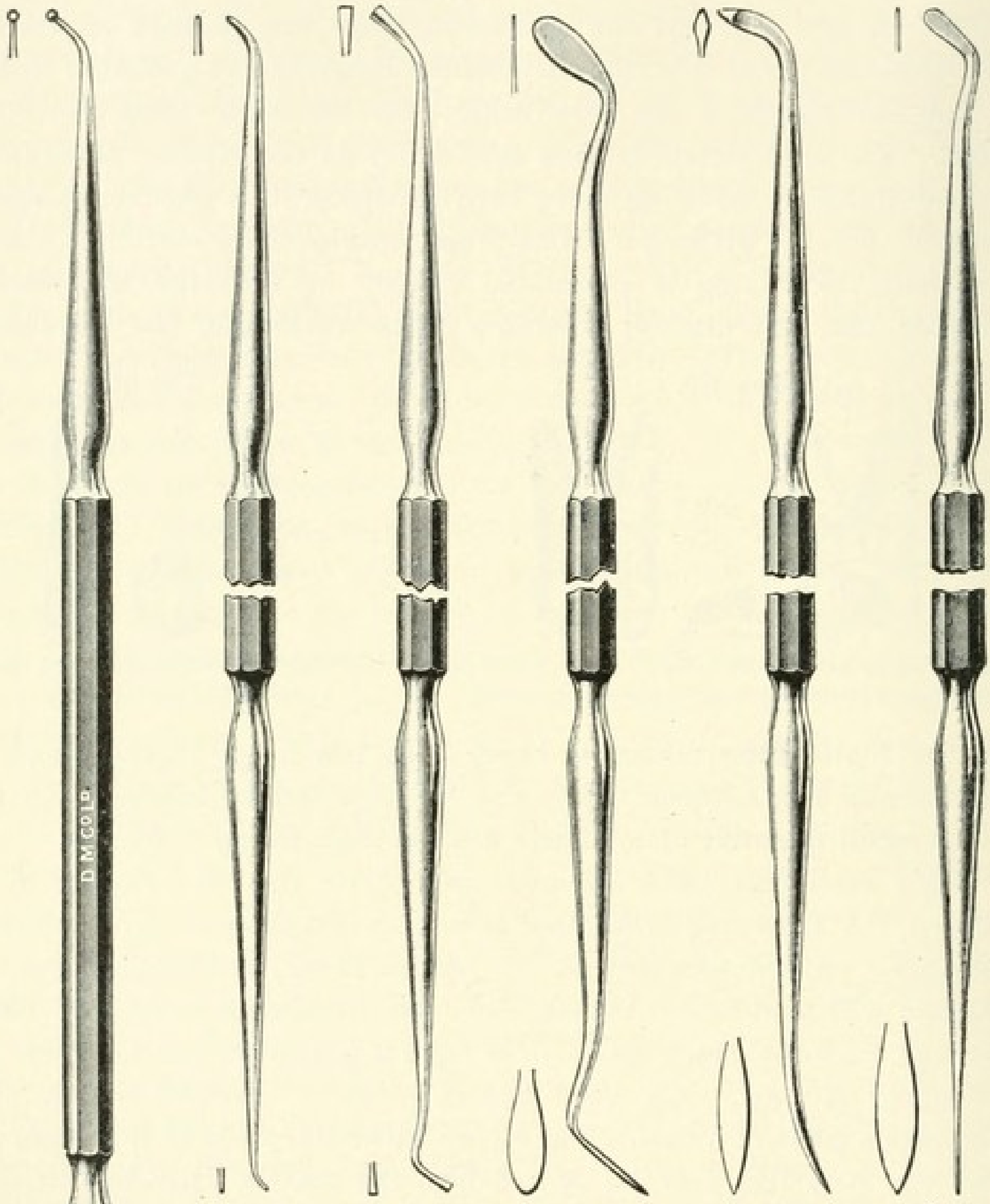
The method described by Dr. J. Leon Williams[1] is as follows:

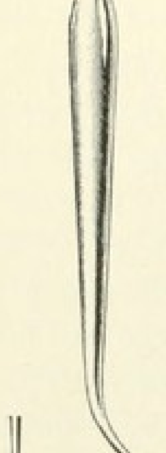
"The thinner the gold can be used, the more perfect the fit of the finished inlay. A proper set of instruments for shaping the gold form and for manipulating the porcelain paste is an important matter. I have devised for these purposes the set of instruments shown in Fig. 372. They are all double-end instruments. Nos. 1, 2, 3, and 4 are designed for fitting the gold form to the cavity, while Nos. 5 and 6 are for manipulating the porcelain paste. The gold should be cut out to represent roughly the shape of the orifice of the cavity, but consider-

[1] *Dental Cosmos*, November 1899, vol. xli. p. 1087.

ably larger. Fig. 373 shows the proper shape for such a cavity as is shown in Fig. 374 at *a*. It will greatly facilitate the shaping of the gold

Fig. 372.

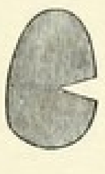




form if a notch be cut out of the gold as shown in Fig. 373, and at the same time decrease the chances of breaking through the gold in forcing it into the shape of the cavity. It should first be introduced into the cavity without annealing. The cut edges will then slide over each other as the centre of the gold is forced to the bottom of the cavity. . . . Then, with the cotton or spunk tightly packed in the cavity, take instrument No. 2 and most carefully burnish the gold around the entire edge of the cavity. This instrument will be found well adapted to reach every part of the margin. It will generally be found best to hold the cotton-wool back a little from the margin of the cavity when one is burnishing, with an instrument held in the left hand, and with this instrument (preferably a ball burnisher) also press the cotton-wool well into the cavity. This holds the gold form well in place and prevents rocking while the edges are being burnished.

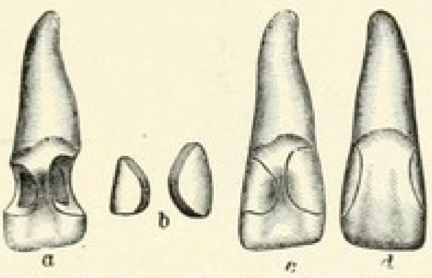
"Most operators have found the removal and imbedding of the gold form to require the most delicate manipulation, and by the methods heretofore described one is never quite certain whether or not this part of the operation has been successfully performed until the inlay has been completed and tried in place. All of this uncertainty may be avoided by the following procedure: Slightly warm and roll up in the fingers a small ball or pledget of hard white wax, such as is supplied for crown- and bridge-work. The ball of wax should be just a little larger than is necessary to fill the cavity completely; that is to say, it should *slightly* project over the margin of the cavity all round. The wax should be quite stiff when introduced into the gold form as it lies in the cavity of the tooth. Now take the broad, thin burnisher, shown

FIG. 373.



Sheet of gold or platinum, notched and ready for adaptation to cavity.

FIG. 374.

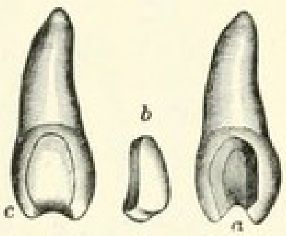


Right superior central, showing two large approximal cavities to which access is obtained by cutting freely from the lingual walls: *a*, tooth with cavities prepared; *b*, porcelain inlays for same; *c*, tooth showing lingual surface; and *d*, labial surface after cementing of inlays.

in No. 4, Fig. 372, and press the ball of wax firmly into place. To prevent the burnisher from sticking to the wax, it should first be dipped into French chalk or pulverized soapstone. In such cavities as are shown in Fig. 374, at *a*, broad polishing tape, dusted with French chalk, may be used for pressing the wax ball into place; but great care should be exercised not to pull the tape the least in one direction or the other, as one would do in polishing a filling. This would rock the gold form and mar the fit. The pull should be steadily and equably from both ends of the tape, the object being to press the wax everywhere firmly over the edges of the cavity. A stream of cold water should now be thrown on the wax, and then the wax and gold form should be quickly removed. If this part of the operation is done with ordinary care, the finished inlay will always be found to fit perfectly. To facilitate the quick removal of the form, care should be taken to prevent the wax overlapping the gold much at any point outside the margin of the cavity. To prevent this and also to assist in securing proper imbedding of the gold matrix it is well to let the margin of the gold project as much as possible beyond the edges of the cavity.

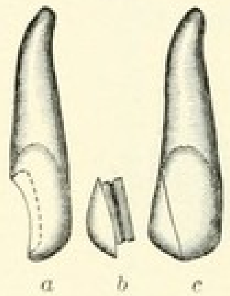
"The matrix may now be imbedded without the slightest fear that its shape will be changed. For imbedding material I use plaster and marble-dust. When the investment is sufficiently hard the wax is thoroughly melted out with a stream of boiling water. The investment is then dried and brought to a full red heat with the blowpipe. It is then allowed to cool, and is ready for packing. Now, the first step in the packing of the porcelain paste is the all-important one to prevent the porcelain shrinking away from the walls of the matrix. This may always be accomplished easily with porcelain of any make if the following instructions are carefully observed: Mix the porcelain paste to the consistence of soft putty, and with the upper point shown in No. 6, Fig. 372, *place a ring of this putty around the entire circumference of the cavity,*

FIG. 375.



Showing bicuspid with cavity involving approximal and grinding surfaces: *a*, tooth with cavity prepared; *b*, porcelain inlay; *c*, inlay cemented in place.

FIG. 376.



Canine tooth showing at *a*, large cavity, and at *b* and *c*, large porcelain inlay restoring contour of tooth.

leaving the centre quite free or empty. In melting a porcelain paste it naturally shrinks toward the largest mass of its own body, or toward the centre of the mass. If, then, this centre be removed we should naturally expect the mass to shrink *toward the circumference,* and this is precisely what happens when manipulated as directed. The matrix always comes out from the first baking with the porcelain everywhere firmly melted to the walls of the matrix. Nor will it start from this position at any subsequent baking unless it is very much overheated.

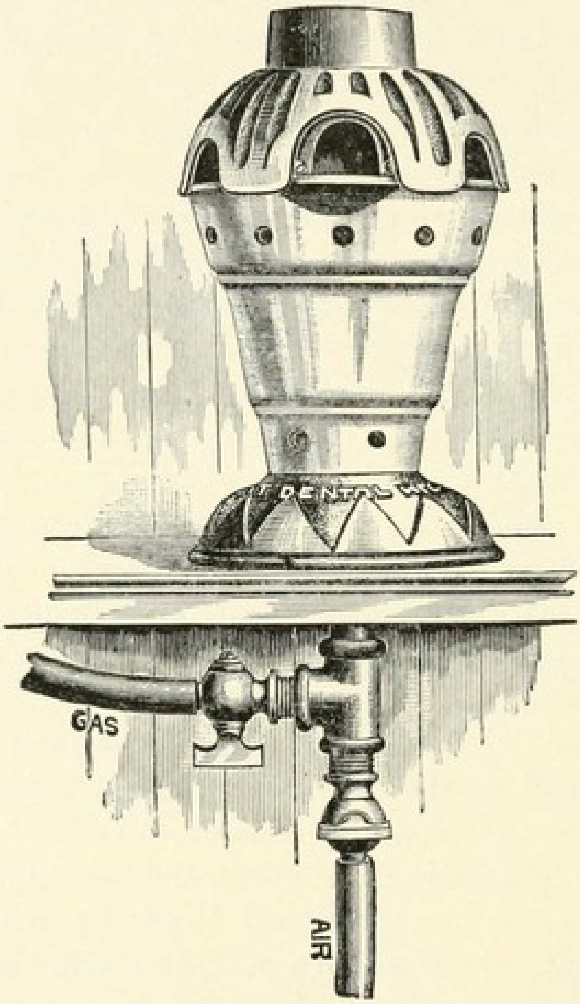
"After each packing of the porcelain paste, a small camel's-hair brush with a fine point should be moistened (this is best done by drawing it between the lips after the manner of water-color artists) and drawn around the margin of the matrix to remove all overhanging particles of the paste. If this be not done, the margins of the inlay will often be found ragged, and a perfect margin is the most essential feature of a porcelain inlay. If gum-water be used for mixing the paste, it will be found necessary to remove these overhanging particles with great care, as the tendency naturally is for the gum-water to cause the particles of powdered porcelain to stick to the gold or platinum margin of the matrix. In building up the inlay for restoring lost corners of teeth and for general contours the work will be much facilitated if, after the first baking has been carried through as above described, to secure perfect union with the walls of the matrix, a small piece of solid porcelain be placed at the point representing the highest point of the contour of the inlay. These pieces of porcelain may be made by crushing old porcelain teeth in an iron mortar. Care should be taken to use a piece small enough so that the outer edge will not show through when the inlay is completed. Corners like the one shown in Fig. 376 may be produced in this manner without much difficulty."

Dr. Williams's method of separating the gold matrix from the porcelain, and grooving the inlay and cementing it into the cavity, need not be dwelt upon, the subject having already been fully discussed.

In summing up the advantages and disadvantages of the high-fusing and low-fusing bodies it will be seen that the advocates of the low-fusing materials claim the sole point that gold is more easily adapted as a matrix than platinum; while the others claim that porcelains of high-fusing bodies are known to be permanent, to keep their color under firing, to contour without spheroidal tendency, to dispense with the use and consequent restrictions of an investment, and to furnish a process so simple and reliable that fillings may be constructed with greater certainty of good results and with more rapidity.

Furnaces suitable for fusing the porcelains used in inlays are of two classes—gas and electric. The gas furnace is usually noisy, odorous, and dirty; but it seldom, if ever, gets out of order. On the other hand, the electric furnace is clean, silent, and beautiful; but it has only a limited life. Even in experienced hands its wires will burn out and need mending once or twice a year, and with the inexperienced it may easily be rendered useless in a few seconds. Nevertheless, in spite of these drawbacks, the electric furnace is to be preferred to the gas, as with a little practice it can be easily mended, while the gas furnace is suitable only for the laboratory. The only feasible gas furnaces for high-fusing bodies are those which have a platinum muffle, in which the fusing porcelain can be thoroughly protected from the gas, for no fusing porcelain can keep its color if subjected to the products of combustion of carbon. The two most practicable gas furnaces are the Downie (Fig. 377) and the Midget Land. Either of these properly manipulated will fuse continuous-gum body within three minutes. They work on the blowpipe principle, and necessitate either a pressure-reservoir or labor with the foot-bellows. The electric furnaces are based on the principle that platinum wire submerged in fire-clay will become red-hot when a current is passed through it. The fire-clay stores up this heat indefinitely, so that any degree of temperature below the fusing-point of platinum may be obtained. This fusing-point is said to be about 4500° Fahrenheit. The best of these furnaces for the high-fusing bodies that require a temperature of from 2500° to 3000° F. are the Timme (Fig. 379), the Custer crown (Fig. 378), and the McBriar crown.

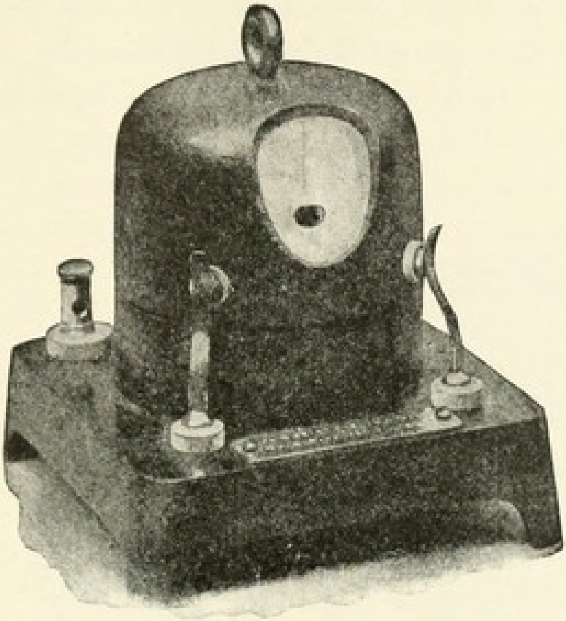
Fig. 377.



Downie gas crown furnace.

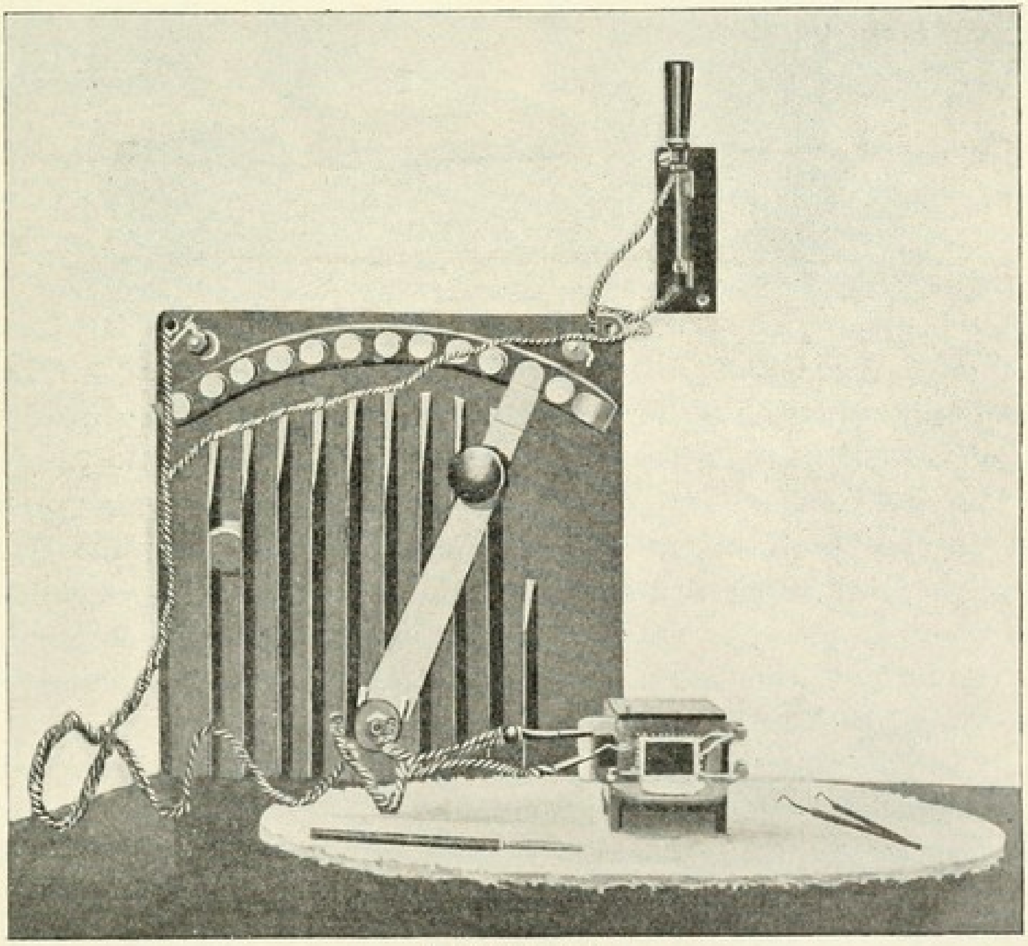
Any one of these will give satisfactory results, but the Timme furnace has the important advantage of being made in sections which can be readily taken apart, thus rendering a burn-out easy to locate and mend. With the other furnaces it is difficult at times to find and twist together the fused or broken wires; and when the break is located, it has to be reached by cutting down through fused fire-clay that is sometimes so dense as to require the use of a hammer. Should electric furnaces be used, it is well to have two, so that if a burn-out occur the operation need not be delayed while the defect is being located and repaired.

Fig. 378.



Custer electric oven No. 1.

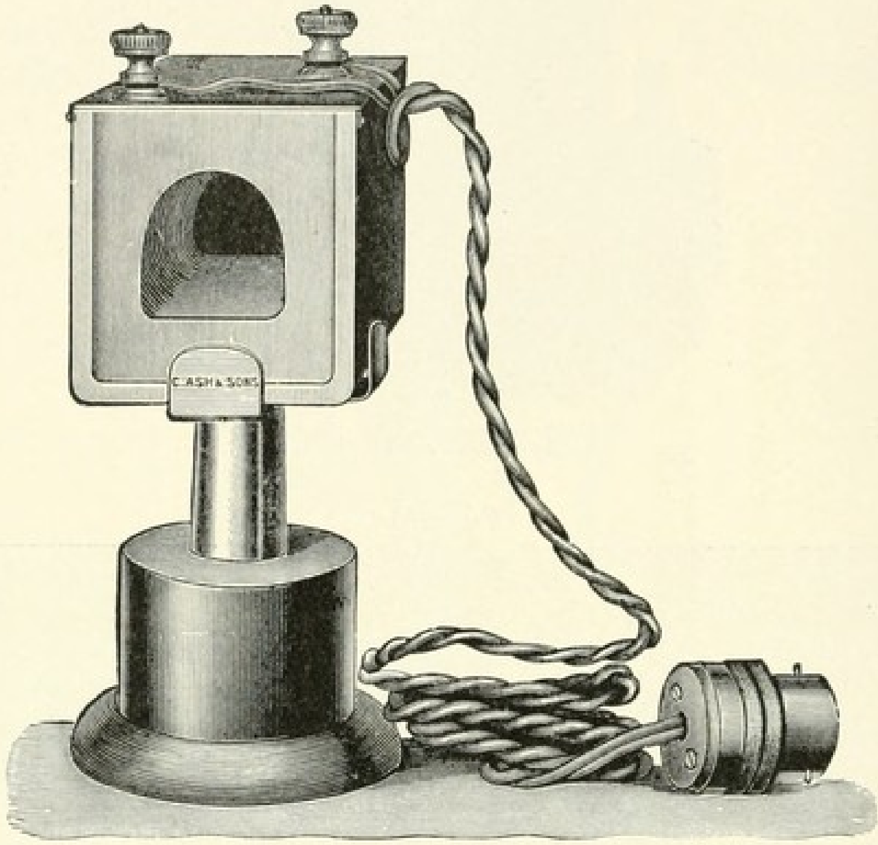
Fig. 379.



Timme furnace.

For baking the low-fusing bodies the gas outfit of Dr. Jenkins is neat and effective; in fact, as a gas outfit it is almost ideal. The little electric oven made by Ash (Fig. 380) is perfect for low-fusing bodies, and wherever a current can be secured and low-fusing bodies are used this little furnace is to be strongly recommended. Its only drawback is that it cannot be mended, and that if a burn-out occur it must be

FIG. 380.



Ash electric oven.

sent to the manufacturer for a new coil of wire. It has not sufficient power to melt the high-fusing bodies quickly and well.

The Gold Inlay.—As previously said, the gold inlay has practically perfect edge strength, and therefore is to be preferred to the porcelain inlay in the back of the mouth, where its color is no objection and where its power of resisting mastication is of prime importance.

The following method of making gold inlays is the one advocated by Dr. W. V. B. Ames, of Chicago:

"The gold inlay is especially useful in compound approximal cavities of bicuspids and molars. There must be ample separation. As in the case of porcelain, there should be excavation, both to prevent decay and to permit the easy removal of the matrix.

"Taking, for example, an occluso-approximal cavity of a soft molar or bicuspid where a gold or amalgam filling has failed: in such a case decay has usually extended laterally, one side or both, necessitating the cutting away of the side walls to such an extent as to leave very little support for the filling at the cervical margin. The fissure of the occlusal surface must then be opened thoroughly to the end for anchorage, and the entire margins of the cavity be excavated until they are strong, smooth, and sharp. When practicable, an impression of the cavity may be taken in modeling compound and run out in plaster or oxyphosphate of zinc. To this the matrix, made of pure gold No. 36 B. & S. gauge, can be approximately fitted and trimmed, avoiding much laceration to the gum. The matrix should be, however, finally burnished to fit the tooth cavity. Then 22-carat gold solder should

FIG. 381.

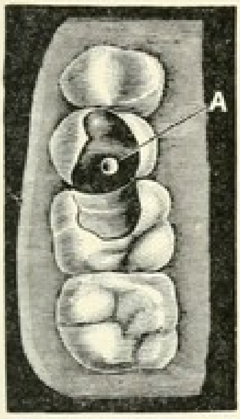


FIG. 382.

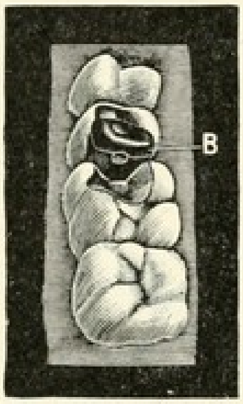


FIG. 383.

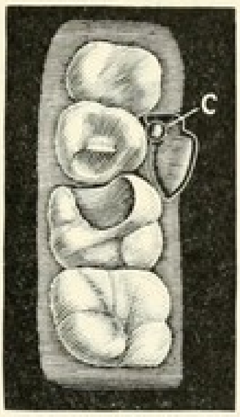
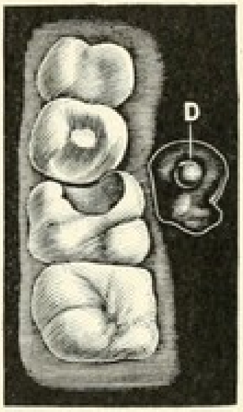


FIG. 384.



be flowed into the hollows of the occlusal surface, running off into the fissure. A coating of whiting placed on the outside of the matrix will prevent the solder from running over the edge and destroying the fit. Then it must be cooled, washed, and replaced in the cavity for further burnishing. When the occlusal groove is nearly full of solder, a small globule of pure gold should be placed, as in Fig. 381, A, to serve as a guide for the contour, which must be shaped up about the pellet with crystal gold or foil, into the interstices of which 22-carat solder is to be again flowed.

"In the efforts to obtain anchorage on the occlusal surface punctures or tears frequently occur. Gold foil can be inserted into these, which when filled with solder afford excellent retaining pins (see C, Figs. 383 and 385).

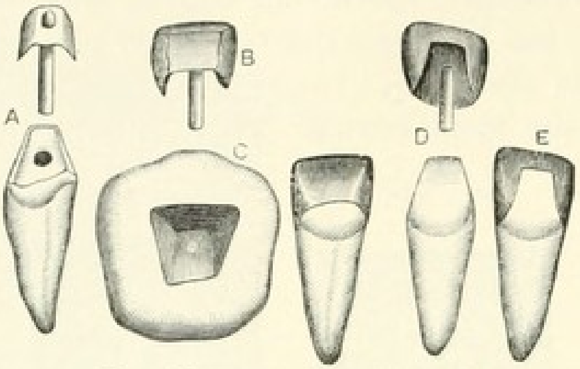
FIG. 385.

"Where sufficient anchorage is easily obtained, as in pulpless bicuspids and molars, a dowel or small gold bead may be soldered to the gold foil, and adjusted to the pulp cavity, when the first start in the formation of the matrix is made, as in D, Figs. 384 and 385."

Some dentists restore the tips of abraded front teeth by burnishing pure gold over the surface, running little dowels up on each side, so as to avoid the pulp chamber, and finally moulding the contour with 22-carat solder, gold foil, and spongy platinum.

Dr. C. L. Alexander's method[1] is described by its author as follows: "My method consists in detail of burnishing platinum over the surface to be restored; the holes for retaining posts having already been made, can easily be located and the posts adjusted therein. Then by

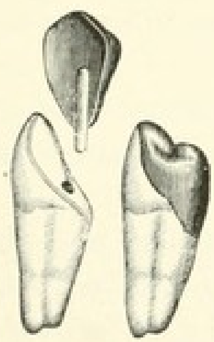
FIG. 386.



Showing details of the process for making cast filling for incisor: A, post with plate adapted; B, restored contour in wax; C, the contour invested; D, cast contour detached; E, E, the finished restoration.

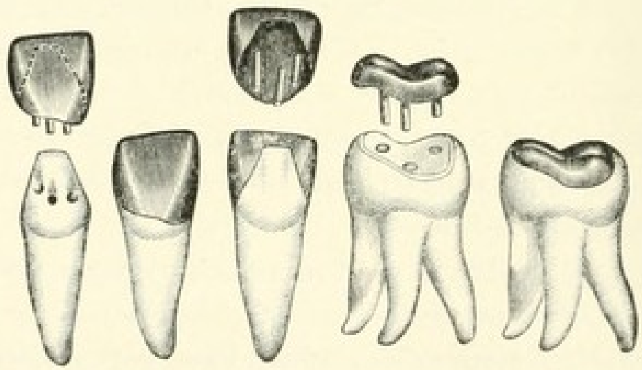
heating a little modeling compound over a spirit lamp, and pressing it firmly down over the surface and allowing it to cool, we can remove the platinum sheet and posts in correct relation to each other. We now invest and solder the posts with pure gold. The piece is again placed upon the tooth in the mouth, and after carefully trimming and reburnishing an impression is taken, and when an occlusion is needed it

FIG. 387.



Restoration of bicuspid by cast filling.

FIG. 388.



Front and back view of an incisor restoration, and cast filling for molar.

is made at the same time by the patient closing the teeth together before the impression material has become hard. The metal foundation will be drawn out by the impression compound when it is removed from the mouth. Each side of the impression thus secured is filled with any good investing material and placed in an articulator. After heating and removing the impression material, the contour of the tooth may be restored by building up with wax. Over the wax surface thus

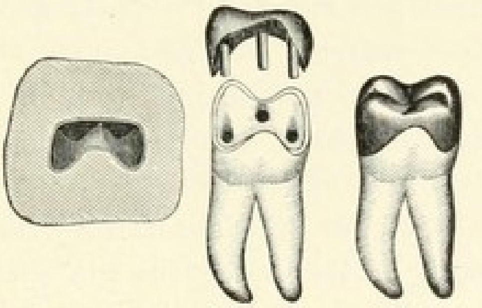
[1] *Dental Cosmos*, October 1896, vol. xxxviii. p. 850.

formed gold or platinum foil is burnished; if the former, it should be very heavy, say No. 60. A suitable portion of the wax being left uncovered, the work is cut away from the model and invested, with the exception of that part of the wax left uncovered by the metal. Through this opening the wax is boiled out, leaving a matrix lined with metal, which acts as a carrier for the fused gold; 20- or 22-carat gold solder should be used for this purpose. When pure gold is used, of course the matrix must be lined with platinum throughout. When removed from the investment, the casting is finished and cemented to its position in the tooth.

"In bicuspids and molars it will frequently be found more convenient to stamp up the cusps, using pure gold, 35 gauge."

The pieces made as described by Dr. Alexander may be used as abutments for bridge-work. The gold inlays are, of course, to be

FIG. 389.



Foil matrix invested. Cast filling for molar.

cemented into place with great care as regards asepsis, dryness, and apposition. They have a great advantage over the porcelain inlays in that their edges may be burnished into place while the cement is soft; and therefore when they are being given their final polish with the sandpaper disk the disk should always be run toward the margins, so that a feather edge may be formed, which, with the burnishing mentioned, may make an almost absolute joint possible.

A Hard-Rubber Inlay.—Some dentists advocate making cemented inlays of hard rubber approximating the tooth in color. These inlays are feasible only where a perfect impression can be readily taken of the cavity, the filling being then made by the method usually followed in vulcanite work. The rubber inlay is noted only as a curious fact, and is not enlarged upon or recommended, as its color is not equal to porcelain, nor is its edge strength equal to that of gold. As we have not only other materials that will produce better results, but also materials that can be manipulated in the time required merely for the vulcanizing of the rubber, it does not seem advisable to enlarge upon a process that appears to have no practical value.

MAKING MATRICES UPON MODELS FOR PORCELAIN INLAYS.

There are many who take impressions of the cavities intended for porcelain inlays, which impressions are run out in plaster or oxyphosphate of zinc. On the models thus obtained the matrices are formed, and the porcelain fillings finished according to shades selected when the impression was taken. This has the advantage of saving much time for the operator, as the work of construction may be done by an assistant in the laboratory. As good results are claimed, the process should be given a fair trial; but on theoretical grounds the expansion of the plaster, or the contraction of the oxyphosphate of zinc[1] used for the mould would tend to cause inaccuracy in adaptation of the edge. Most inlay workers find it sufficiently difficult to get perfect adaptation when the matrix is burnished to sharp enamel edges, and, except in labial cavities, to get the exact contour. Also, the colors often require such nice calculation that an assistant, not having seen the mouth, could hardly mix them satisfactorily. While good results have been obtained by giving the matrices for filling to an assistant especially trained in the art of fusing and mixing the porcelains, thus proving that such time-saving methods are practicable, the average dentist should not attempt the art of inlays with the idea of saving time; probably there will always be sufficient factors for failure if he works directly from the tooth cavity and gives his entire personal skill to the completion of the filling. With porcelain inlays the question of artistic color effect is paramount, and only through the most subtle discrimination can the best results be obtained.

[1] Wet oxyphosphate of zinc usually expands; dry oxyphosphate usually contracts.

CHAPTER XVI.

THE CONSERVATIVE TREATMENT OF THE DENTAL PULP—DEVITALIZATION AND EXTIRPATION OF THE PULP.

BY LOUIS JACK, D. D. S.

As the dental pulp by its supply of nutritive pabulum maintains the vitality of the dentin and increases the resisting power of the tooth, it is important when this organ becomes exposed to agencies which threaten its destruction, to attempt its preservation when the conditions are favorable to that object. A further reason for maintaining the vitality of the dentin is that when the pulp becomes devitalized the loss of cohesive force which occurs as a consequence leads sooner or later to the fracture and early loss of the tooth—this final result being delayed in proportion to the inherent strength of the tooth and the period of life at which devitalization takes place.

The treatment of teeth when the pulp has been approximately reached by the invasion of dental caries has been previously considered (Chapter VII.). Here will be set forth a rational line of treatment when the carious action has encroached upon that organ.

NORMAL CHARACTERISTICS AND PATHOLOGICAL TENDENCIES OF THE DENTAL PULP.

The minute anatomical elements of the dental pulp are given in Chapters II. and III. The salient features of these elements which have to be kept in view in connection with treatment are—

(1) The minuteness of the apical foramina, which restricts the efferent circulation when the vascular phenomenon known as "determination" occurs.

(2) The ultimate nervous distribution immediately beneath the odontoblastic layer, forming a plexus which renders the whole surface of the organ highly sensitive when the blood supply is increased as the effect of irritation.

(3) The arrangement of the capillary circulation in loops which arise from the vertical vessels. This relation of the vessels lessens the tendency to inflammatory diffusion.

(4) The absence of lymphatics, which deprives the pulp of the power to remove inflammatory effusions or to convey insoluble medicaments.

It should be noted that the pulp in a normal state is not a highly sensitive organ, but is rendered exquisitely so by the irritation from external chemical and infectious influences incident to its exposure. And it is under all conditions so extremely impatient of compression that a severe shock of that kind renders recuperation nearly impossible. This is probably due to the liability of disconnection of the pulp with its walls at some point on account of its feeble attachment to them.

The pathological tendencies of the pulp under irritation are—

(1) To hyperesthesia.

(2) To circumscribed hyperemia under slight irritation.

(3) To congestion or mechanical hyperemia under increased irritation which terminates at length in stasis by the restriction of the circulation.

(4) To proliferation of the deeper tissues as the result of latent congestion attended by fatty degeneration of cells and the development of dentinal nodules—pulp stones.

An important consideration connected with the treatment of the pulp is the indication presented by a state of the teeth designated as the "temperature sense." This is a variable condition with different individuals, some being able to apply the coldest water in the mouth and to crunch ice without pain, whilst others whose teeth are sound are disturbed if cool water is brought into direct contact with these organs. When irritation of the pulp occurs the temperature sense is exaggerated in the individual tooth. This variation from the normal, as determined by a comparative test of the sound teeth, becomes an important diagnostic indication, as will appear later.

A further pertinent consideration bearing upon the various conditions of the exposed pulp, as shown by the symptomatology, is here in place. It has already been indicated that when the exposure of the pulp to irritation has been slight—that is, where this organ has been measurably protected from exterior influences by the covering layer of incompletely decalcified dentin—the pulp is ordinarily but slightly affected. When the denudation has become complete and the amount of pulp surface in contact with the carious matter has become considerable, and further, when by the solution and displacement of the carious matter the influence of the contents of the mouth is direct, the disturbances of the pulp become progressively increased. In the light of present knowledge of these injurious influences the causes of their operation must be attributed to infection of the pulp by the various minute organisms which have their habitat in the mouth. The pulp tissue becomes infected in the degree to which it is exposed and in proportion to its power of resistance to the pathogenic character of these forms of life. It is axiomatic that the activity of inflammatory processes is usually in proportion to the degree and the kind of infection. Therefore it must be held here as elsewhere in surgical procedures that the existence of infective influences and their control have to be kept clearly in view.

This consideration enables us to understand the causes which render conservative treatment inoperative, in cases in which there has existed for a considerable period the opportunity for active invasion of the pulp by micro-organisms. When these deleterious influences have long continued, the deeper tissues of the pulp, as before stated, become involved; the chief factors producing the disturbed state eventuate in a suppurative condition. This state of the organ clearly indicates invasion by pyogenic germs, the inflammatory processes attending this condition being superinduced by the peculiar irritation caused by the infection. This results in some instances in stasis followed by gangrene; in other cases, where the arterial tension has not been great, in suppuration. The character of the suppurative process, rarely, is a circumscribed abscess of the pulp, the more common form being by progressive and destructive ulceration of the organ.

FIG. 390.

Invasion of pulp by micrococci.

Fig. 390 (after Arkövy) shows the phenomenon of invasion of the pulp by micrococci.[1]

In the treatment of an organ which cannot be brought under ocular inspection, the chief guides to determine its state are the apparent conditions—viewed in connection with the symptomatology of the case under treatment.

The above-stated anatomical relations, physiological qualities, and pathological tendencies have an interesting bearing upon conservative treatment of the pulp.

Exposure of the Pulp.—As an indication of the tolerance of the pulp to the approach of caries it is a common experience that after solution of the enamel has taken place, caries of the dentin proceeds until the pulp is nearly reached by the destructive process with little or no signs of irritation, as evinced by pain, appearing. It is the exception that even persons of high nervous sensibility are cognizant of the influence of the carious process upon the pulp previous to actual encroachment.

In the earlier stages of exposure the elements of the organ involved

[1] In this connection see *Micro-organisms of the Human Mouth*, by W. D. Miller, pp. 293–295.

are its peripheral nerve filaments, which are hyperesthetic from the hyperemic state of the organ immediately adjacent to the point of encroachment. At this stage the pulp becomes impatient of cold, and may indicate the nature of the lesion by reflex pain in other branches of the trigeminus. Later on, unless these conditions are subdued by treatment congestion of the organ takes place, when objective symptoms in the organ itself may be elicited. This is shown by some soreness upon percussion, accompanied by much pain on the application of heat.

These indications point to a greatly increased blood supply. Dilatation of the arterial vessels of the apical region occurs, and the blood being unable to enter at the foramen is distributed to the peridental membrane. These manifestations indicate that the point of danger has approached. Soon thereafter congestion becomes so far established that prospect of successful conservative treatment vanishes.

When patients are under frequent observation and have regular and periodical care taken of the teeth the pulp exposures which occur should be found in the hyperemic state, and if placed under treatment early after the carious action has approached the pulp, the prognosis should be favorable. But when neglected cases appear the history of which is obscure, and where the patient is forced to seek relief by the occurrence of objective symptoms as narrated above, accompanied by local pain and pulsation, the indications point to devitalization and extirpation as the suitable recourse.

The exposure of the pulp is often discovered in the treatment of ordinary cavities in a somewhat unexpected manner, no indications appearing until the part is uncovered; or a variety of subjective or possibly objective indications may be elicited which plainly point to this condition.

At the commencement of the treatment to restore the lost tissue in any given carious tooth, except in very small cavities, the probability of encroachment upon the pulp should be a supposition, and each step should be made with reference to this probability. The destruction of the dentin is frequently surprisingly deep, or the cornua of the pulp may be acutely pointed and liable to be unexpectedly encountered. Therefore, in what may seem simple cases, cautious approach should be made toward the bottom of the cavity.

Method of Opening the Cavity.

The opening of the cavity should be effected by instruments which will not easily enter it, and the softer caries removed in a manner which will not induce pressure of the carious matter upon the pulp. For this reason, in the removal of the caries the excavation should be first carried on at the sides of the cavity, and also along the margin of the cervical wall in approximal cases. Then the carious matter nearest the pulp should be carefully peeled off without pressure and without irritation. In this manner a pulp may be uncovered and the cavity cleansed of carious matter without contact being made with the pulp. To do this is the acme of skilful preparation.

The instruments for removing caries should be of thin edge, very sharp, and always having cutting surfaces which are rounded, since angular or square-ended excavators are liable to make exposures unnecessarily. It is important that the direction of movement of the excavators should be from the cervix toward the occlusal part—in other words, by drawing cuts instead of pushing ones. The difference in the excitement of pain between these two methods of cutting is surprising, and can only be appreciated by those who have experienced the comparison upon their own teeth. The probable reason for this is that the force of the pushing cut is necessarily greater, and this may induce compression of the caries or of fluids against the pulp. It causes more pain at the moment, and cleansing in this manner is followed by greater after-irritation. Patients will at the time complain of reflected pain being caused by incorrect manipulation.

It is obvious that every mode of procedure which increases the local irritation in the preliminary procedures of a pulp treatment must be deleterious in its results. The danger of making accidental exposures and of forcing the instruments upon the pulp are increased under push cutting. It is also clear that the use of burring instruments upon the pulp wall of cavities is questionable, since the infliction of some compression by excavating in this manner is nearly unavoidable.

Here an interesting question appears: A cavity may be sufficiently deep to cause an exposure; it has been carefully cleansed of caries, and the cornua are not apparent. It is then necessary to determine whether there is a real but minute exposure or whether there is a safe amount of healthy dentin to protect the pulp beneath the stopping material.

One method is to *cross-hatch the cavity by a very fine explorer.* This is effected by holding the instrument very lightly and passing it gently over the surface in parallel lines in two directions. If the pulp has been reached, the instrument at the point of encroachment will lose its resistance or will drag the point of the cornu, as the case may be.

While there may be no visual evidence of exposure, the certainty of it is frequently shown during the preparation of the cavity or the testing by a peculiar expression of the face of the patient, different from that manifested by the cutting of the most exquisitely sensitive dentin. This change of the countenance, accompanied by a slight start of the features, may occur without the recognition of pain. This indication sometimes appears previous to the removal of all the caries; it is then probably caused by some tension of the apex of the cornu produced by the disturbance of the carious dentin.

The Diagnostic Value of the Reaction of the Pulp to Thermal Tests.

Allusion has been made to the effects caused by reducing the temperature of the teeth. To make this subject clear it is necessary to consider the reaction of the dental pulp to thermal changes in its states of health and of disease.

The normal rate at which the pulp of sound teeth reacts to cold applications varies with different persons from 22 to 66 degrees F. below the blood heat, the reaction to heat varying from 20 to over 55 degrees F. above the blood temperature, these tests being the extremes of the writer's observations.

The degree of heat reaction may be designated by the + sign and the cold rate by the − symbol. These ascertained extremes may be taken as representing the *range of tolerance* in any individual case.

The significance of ascertaining the *normal rate* of thermal irritation of the teeth is important in connection with the treatment of any case. When a healthy rate of + 144° − 32° F. is compared with one of + 124° − 76° F. this at once is apparent. In the one case, the range of tolerance is 112 degrees; in the other, 48 degrees. Hence it is obvious that the determination of the normal rate is essential as a basis from which to consider the value of the thermal reaction of any given disturbed pulp. It is also evident that where the range of tolerance is considerable the probability of favorable treatment is greater than when this is small. Where the normal range is found to be below 50 degrees F., unless the other conditions are very favorable, conservative treatment of the pulp becomes questionable.

The normal rate is easiest found by exposing the lower incisors to a continued discharge of water from a small-aperture syringe. The most suitable kind of syringe is that having a large aperture for charging and a small one for discharging.[1]

The tests are begun at a temperature of 80° F., reduced successively by diminutions of ten degrees until slight pain follows the tests. The continuation of the stream of cold water is necessary to enable the effect to reach the pulp through the dentin. With some persons the response is so quickly shown as to indicate that the dentin is responsive.

[1] The best for the purpose is a modified form of the Laskey syringe.

A large proportion of persons manifest distress between 40° and 60° F.

Intolerance of heat is determined in the same manner, except that it is frequently necessary to isolate the tooth by applying rubber dam, since the gum usually begins to be pained at 130° F. In all cases in which the cementum is exposed isolation is required, since the cementum may react at slight variations from blood heat. To secure exactness in any case isolation is better than an open test.

When disturbance of the pulp occurs from the extended progress of caries the reaction of the pulp to changes of temperature is usually marked, and the variation from the normal rate is indicative of the degree of disorder of this organ. The response occurs to temperatures both below and above the normal rate. When the irritation of the pulp consequent upon its exposure is slight, the reaction is principally to cold, the degree apparently depending upon the extent of the hyperemia. When the reaction to heat is marked, congestion of the organ is threatening.

Disorders of the pulp appear to excite other anatomical elements of the teeth, as is indicated by reaction to cold and heat being more immediate than is the case with the sound teeth. A more exact degree of temperature reaction may also be secured when this condition exists.

It is essential in making tests that a carious cavity be closed by a pledget of wet cotton. This is sufficient to exclude the disturbing effect of the hypersensitive dentin, since water is a nearly absolute non-conductor.

Examples from practice to illustrate: 1. Cavity rate, + 110° – 80°, when protected as above + 130° – 60°. Here the normal rate was + 131° – 58°. 2. Cavity rate, + 108° – 90°; normal rate, + 134° – 65°. 3. Cavity, + 120° – 50°; normal, 128° – 48°.

The following table of normal rates shows the relation between the point of heat reaction of the pulp and the degree of its reaction upon the abstraction of heat:

+ 152° — 41°	+ 133° — 66°
+ 150° — 40°	+ 131° — 63°
+ 144° — 48°	+ 130° — 55°
+ 144° — 32°	+ 130° — 72°
+ 140° — 48°	+ 128° — 48°
+ 140° — 46°	+ 126° — 64°
+ 140° — 46°	+ 124° — 76°
+ 140° — 32°	+ 124° — 60°
+ 140° — 56°	+ 122° — 75°
+ 134° — 58°	+ 120° — 72°
+ 134° — 65°	+ 118° — 74°
+ 134° — 60°	

The normal averages of table—

9 cases from + 152° to + 140°
average + 143.3° — 43.2° = 100° range of tolerance;
7 cases from + 140° to + 130°
average + 132.3° — 62.7° = 69.6° range of tolerance;
7 cases from + 130° to + 118°
average + 123° — 67° = 56° range of tolerance.

Occult Cases of Reflected Pain.

Cases difficult of diagnosis sometimes appear in which the question arises whether the pain is caused by a hyperesthetic pulp, by the influence of malarial poisoning, or by a gouty condition. When the origin depends upon the two causes last named the teeth are not subject to thermal irritation; also from these causes the occurrences of pain are not confined to the evening, as usually is the case with teeth in the early stages of disturbance.

The stages of pulp exposure are divisible into three periods—(1) of *quiescence;* (2) of *subjective symptoms,* and (3) of *objective manifestations.*

(1) *Quiescence* may continue in many instances for a considerable period after caries has reached the pulp where the situation is such that the force of mastication cannot cause compression of the contents of the cavity. Notwithstanding constant saturation of the gelatinous covering, and the presence of the micrococci concerned in producing the caries of the dentin, excitement of the pulp may not occur. The fact should not be overlooked that some persons escape odontalgic symptoms notwithstanding such progressive alteration of the pulp tissue takes place as to result in gangrene of the organ.

(2) Usually, however, after a period of quiescence of a longer or shorter duration there arises a train of subjective disturbances brought on by the continuance of chemical irritation and by the presence of fluids in the cavity, these influences becoming accelerated as the area of exposure becomes increased. The pain which occurs in this stage is reflected to one or more branches of the fifth pair of nerves. Flashes of pain occur to the teeth of the other maxilla, to the eye, or the supraorbital region, the most common region affected being the nerves of the ear, pain in this organ being probably the most general form of reflection which occurs. The exacerbations take place usually in the evening and at first entirely remit in the daytime. The pain in this stage will frequently pass away as the pulp is relieved from pressure and chemical irritation.

In this stage the surface of the pulp does not present indications of being inflamed. From the lack of continuity of the symptoms it is a reasonable inference that the hyperesthesia observed in this condition is due to impressions made upon the point of encroachment and is confined to the nerve fibrils distributed about the capillary loops involved, and thereby induces the reflected manifestations, the nerve fibrils being in this stage the anatomical element chiefly implicated.

(3) Objective symptoms comprise those manifestations which, after the subjective ones have continued for some time, become localized in and about the affected tooth. These are: some soreness of the peridental membrane; extreme sensitiveness to heat, accompanied throughout with dull, heavy pain in the tooth, and at length pulsative throbs.

This order of statement is the usual sequence in which these indications appear. They are the result of the extension of the disturbance to the deeper circulatory elements of the tissue. When this condition appears on the presentation of a case, or when in the course of the treatment it becomes apparent, the prognosis usually is rendered unfavorable to recuperation.

The Technical Treatment of the Uncovered Pulp.

Accidental Exposures.—These, which happen in the preparation of cavities, if produced by clean (aseptic) instruments where compression has been avoided, require but simple treatment. The pain is relieved by the application of tincture of calendula one part, to four of water. When the bleeding ceases, the point of exposure should be antiseptically dressed and capped in the manner to be described.

If the injury has been slight, the cavity may be at once filled with a metal, having regard to the strength, the placement, and the fixation of the cap used to defend the part from compression. Here the fixation may be made by covering the cap with a broad block of gold foil; after adapting this to the margins of the pulp wall of the cavity the filling may be proceeded with. In case of doubt a metal of less conductivity may be used, such as tin or amalgam. A metal filling is better in these cases, since the slight thermal irritation tends to the ultimate recovery. (See Chapter VII.)

Treatment of Recent Exposures.—When the pulp has been fully uncovered, as previously described, the cavity should be washed clean with tepid water, be securely protected from the fluids of the mouth with rubber dam, dried, and lightly filled with a pledget of lint saturated with a mild disinfectant. On account of the invasion of the zone of dentin immediately beneath the caries by bacteria and micrococci, it is recognized that some means of sterilization must be adopted. This being necessary in the treatment of ordinary cavities, it is evidently here more demanded. On account of the impatience of the pulp to medication it is important to be careful in the selection of the sterilizing agent. The choice should be between hydronaphthol, acetanilid, and formalin : the first in the strength of 1 to 300 parts water ; the second, 1 to 200 parts ; the third, not stronger than 3 per cent.

The saturated pledget of cotton may remain in the cavity during the procedures of the preparation of the dressing paste, the selection of the cap, etc.

When these preparations are complete the cavity should be again dried, the drying being finished by a few puffs of warmed air. The point of exposure and the adjacent dentin are now touched with lint, filled with carbolic acid and oil of cloves, equal parts. The effect of this is to coagulate to a superficial degree the point of exposure. This practice is largely empirical. It may be avoided in cases where no disturbance has previously existed ; but where there are evidences of irritation it seems indispensable.

The application of carbolic acid in this manner should be for a moment only. As carbolic acid has a very feeble affinity for water and as the topical touch is but momentary, it probably does not invade the tissue to an appreciable degree. It will also be observed that the combination possesses anesthetic properties.

The student will not fail to hold in view that the treatment is applicable to cases in which it is evident the pulp tissue is not under much irritation. The condition should be one of hyperemia of the organ and gives indications of this by the existing hyperesthesia. Congestion should not have taken place, neither should inflammatory indications exist. Therefore the inference is that after the carious matter is removed the surface of the dentin and the point of exposure may be sterilized and the vital force of the pulp be given the opportunity to overcome whatever slight bacterial invasion may have reached that organ. Here the case must rest upon the well-established fact that the tissues have considerable power of mastering the influence of non-pathogenic germs as a factor in the process of recuperation.

Treatment of Old Exposures.—In the conditions which exist where denudation has taken place to a considerable degree and where irritation has long continued, the disturbances which have arisen in consequence of the extension of the disorder to the larger bloodvessels and the attendant alteration of most of the anatomical elements of the pulp, the chances of establishing quiescence are slight.

In the earliest stages of objective disturbances when the constitutional conditions are favorable an attempt may be made at conservative treatment after the inflammatory conditions are subdued by antiseptic treatment, accompanied by the use of resorbents and counter-irritation upon the gum.

Capping the Pulp.

A prominent feature in the conservative treatment of the pulp is the means to protect it from pressure, in agreement with the established fact that there is no irritation so fatal to the normal functions of the pulp as compression, and no condition from which it recovers with so much difficulty as this. Therefore all means directed toward its conservation must conform to the necessity of preventing the least degree of compression. The means employed to prevent this form of disturbance have given this method of treatment the common appellation of "capping the pulp."

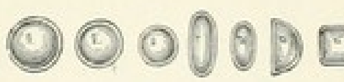
Another principle of equal importance connected with the foregoing is that the capping material should be brought into immediate apposition with the pulp. This is for the reason that if the least space be permitted to exist between the capping and the exposed point this space will fill with effused fluids, and the putrefactive changes which take place in these fluids induce the formation of gases with consequent compression.

METHOD OF CAPPING.

Various methods of capping are practised, such as laying on the part disks of paper or asbestos rendered antiseptic in various ways; using disks of paper coated on the side to be placed next the pulp with "chloro-percha" or other plastic matter; flowing over the exposed point a coating of oxysulfate or oxychlorid of zinc, being careful with the latter to use a formula of the fluid element in which the zinc chlorid is only in sufficient proportion in relation with the water that the union with the zinc oxid is not active. In connection with this method it has been common to mistakenly employ the strength of the fluid which is used when the formula is adapted for temporary fillings. When this method is used the coating is flowed over or laid in a cap on the pulp, and when somewhat "set" the cavity is temporarily filled with a more resistant material laid upon it with great care.

With all the precautions which may be taken these dressings are somewhat complicated and are not applicable to small cavities or those difficult of access. In these cases the writer has generally depended upon the use of a dressing composed of carbolic acid and oil of cloves equal parts combined with zinc oxid to form a plastic paste of such consistence that when it is laid upon the pulp it will yield as it is adapted to the part, without producing pressure, and will flow out around the margins of the metal cap when this is used to convey the dressing.

Fig. 391.



Weston's dental cavity caps.

The composition of the dressing is based upon the considerations that the menstruum is antiseptic, and possesses some anesthetic value. It also remains unchanged within the space and in time becomes, from the dissipation of the menstruum, somewhat firm in its character. The therapeutic action of the menstruum when combined with the zinc oxid is mild, and is employed for the reason that it is slowly given up by the oxid, and therefore makes an acceptable dressing.

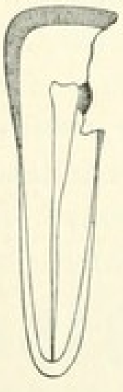
The Cap.—In all cases where metal fillings are selected it is essential to use a metal cap. The methods where this is used are simpler and better under control than when dressings are made without this appliance. The reason for this is that the avoidance of compression is more certain.

The caps are best when made of platinum, for the reasons that this metal is a resistant material and the caps are easily formed.

When the outer filling is to be of gutta-percha or of the mineral cements, caps may be formed of concave disks of pure tin. The tin and platinum caps are stamped from the plate by the hollow punches of the hardware shops, by which means various sizes of round and elliptical ones may be made. The effect of punching them upon the end of a block of wood gives the suitable concavity to meet the requirements. For ordinary purposes they should be quite thin, but when gold fillings are made over them the thickness and the concavity should be such as to enable them to sustain the force applied. In cases where there are indications of approaching congestion, or where it is probable that the exposure is not recent, the dressing should have added to it a portion of guaiacocain.

Placing the Cap in Position.—Placing the cap in position is a step in the treatment requiring care. It should be assured that it is of sufficient size to pass well beyond the borders of the exposed organ, and in the approximal cavities it should cover the pulp wall of the cavity without intruding upon the marginal walls. If there is a single exposure it should be round; if two cornua are exposed, either two caps should be laid or one oval one employed, as may best suit the case. In molars, usually, where two points are exposed, two caps are generally best; in the bicuspid, one oval one under the same circumstances. The cap should be inserted edgewise in such manner that as it is laid in place the excess of dressing may flow out at the margin toward the operator. This is to prevent undue pressure, and to avoid air being included beneath the dressing, which would prevent complete apposition of the dressing with the pulp.

Fig. 392.

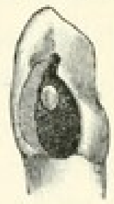


In cases of easy access the cap may be laid in place with fine-pointed pliers—notably the Bogue pliers; but in the majority of instances it is preferable to previously coat the convex side of the metal with wax, when, with an instrument adapted to the case, it may be carried into position and then placed in the manner described. It should next be pressed into position with sufficient force to bring the margins in contact with the dentin. Any excess of dressing should be taken away by light touches of an excavator, and when the cavity is to be filled temporarily it is better to fix the cap in place by flowing over it a little chloro-percha, which, when dried, prevents disturbance of its position in the filling procedure.

Care should be taken that when the pulp is found exposed in a depression, as occurs sometimes in the molars, this depression should be filled nearly or quite to a level with the floor of the cavity by taking a little of the dressing upon a suitable instrument and carefully filling this point; otherwise, when the cap is placed, the paste may not find its way into contact with the pulp.

At the moment of placing the cap, as the paste is yielding under the gentle pressure of forcing the edges of the cap into contact with the dentin, a little pain will sometimes be observed; but unless the paste is too stiff no compression of the pulp should be caused.

Fig. 393.



Cap in position.

Filling the Cavity.—Whether the cavity shall be filled temporarily or permanently depends upon the prognosis. This, as will be perceived, is based upon the constitutional conditions and the state of the pulp at the time of treatment.

For those of small experience in this line of treatment it would not be safe to attempt the permanent stopping of the cavity, except in accidental exposures and in cases where the history of no previous disturbance can be elicited and where the thermal reaction is slight. Even in the latter class it is generally best to delay permanent closure by a conductor of heat until after an experience of a year or more with a non-conducting stopping. At the end of this time the filling may be nearly all removed, care being taken not to disturb the cap, when with suitable precaution a metallic filling may be inserted.

In the majority of instances it is safest to fill the cervical part with gutta-percha stopping, carrying the material over the cap, and then to complete the filling with zinc phosphate. In this way, with an occasional renewal of this temporary work, cases may be carried forward from ten to fifteen years.

They may, however, be closed permanently and safely after an experimental trial of five years where no irritation has appeared.

In many instances recovery takes place by secondary deposits of dentinal tissue the exact character of which has not been made out. The writer has observed a multitude of cases in practice when the opening at the point of exposure has become occluded by bony tissue. In some instances this has occurred in two years, in others after longer periods. In one instance a lateral incisor became protected by this formation, but in consequence of mistaken diagnosis of another condition causing pericementitis, a drill was passed through the new tissue to the living pulp. This new opening healed again. In the same mouth another incisor also recuperated in the same manner.

In some cases when entire quiescence has been maintained for many years the pulp will be found not to have undergone any protective changes.

It is not remarkable, however, that pulps may remain in a state of quiescence for a long period, when it is considered that in slowly-advancing caries the pulp will often be exposed for a long time without the occurrence of any signs of irritation, unless, by the position of the mouth of the cavity, the pulp has been subjected to the pressure of food.

It may be concluded that, whether the pulp becomes protected by secondary deposits or acquires complete quiescence, conservative treatment in these cases has considerable advantage over immediate devitalization. Still, in this connection in order to avoid embarrassments the necessity exists for careful selection of subjects to be treated in this manner, and also for proper analysis of the apparent condition of the pulp itself. To aid in this discrimination the following summary of conditions should be held in mind:

(*a*) Where no previous observable disturbances can be elicited.

(*b*) Where the tooth has been impressed only by the application of low temperature.

(*c*) Where, in addition, reflected pain in related parts has been observed.

(*d*) Where the tooth has become much subject to impressions by heat.

(*e*) Where continued objective disturbances appear, such as soreness to touch, or local pain of spontaneous character accompanied by pulsation.

Classes *a*, *b*, and *c* may be considered as amenable to treatment, and also, problematically, class *d* if taken early. Class *e* must, in view of the principles stated in this section, be eliminated from the field of conservative treatment; and where cases in the other divisions apparently amenable subsequently take on disorders coming within this classification they usually have passed beyond the reach of palliative treatment.

It is important here to consider the influence of the physical endowments of the patient upon the conservative treatment of the pulp. For some persons this treatment is followed by the happiest results; no intolerance of the operation appearing, and even cases somewhat unpromising doing well. Again, with others, any case, however simple, goes down the scale to class *e* in spite of every care.

The first constitutional condition favorable to success is that of soundness. As to what are called temperamental indications, when the subject is of good health, the lymphatic should alone be excluded and more particularly the bilio-lymphatic. These latter do not respond to pulp treatment in any conditions which occur to them; and in reference to their exposed pulps the probabilities are that in the sluggish condition of the parts involved the organ is early invaded by bacteria, and such changes have quickly taken place in the anatomical elements of the pulp as to render all chances of successful treatment valueless. The most promising cases are those for persons of active temperaments, with good circulation, thin skins, healthy gums, and limpid oral secretions.

After-treatment.—It is not unusual for classes *a*, *b*, and *c* to require after-treatment. For this reason close observation for some time should be maintained. It is presumed that the judicious operator has made careful selection of the cases to be conservatively treated and that he will early decide from an analysis of the evident conditions whether the prognosis is promising or not. As previously indicated, some of the apparently favorable cases will not yield to treatment for the reason that the actual condition of the pulp may not be made out. Part of the difficulty here is occasioned by the indefinite character of the statements of the patient, who should in all cases be instructed to return for consultation if painful response to cold appears or if reflected pain should occur. If these conditions supervene, it is a sign of needed care to avert increasing disturbance.

A most marked form of reflected pain is felt in the ear, and this frequently occurs previous to the aggravation of the temperature reactions. So much importance should be attached to this symptom of pulp disturbance that the first question asked a patient appearing with pain, or on approaching a suspected pulp, is, Have you had any pain in the ear of that side? As reflection to the ear often occurs in advance of similar pain in other branches of the fifth pair, it becomes important to maintain close observation of this indication. In this state, sedation combined with counter-irritation is required.

In any case where the tooth has been impressed by cold, either before the treatment or afterward, an application should be made to the gum over the tooth, of tincture of aconite root two parts, chloroform one part. The mode of application is important. A pledget of cotton or muslin to cover an area of one-half by three-fourths of an inch should be filled with the prescription, then squeezed out nearly to dryness between folds of a napkin to prevent an excess flowing over the mouth and with the saliva entering the fauces, to which it is extremely irritating as well as unnecessarily medicating the patient. Before the pledget is applied the surface of the gum should be cleansed of the coat of mucus covering it, otherwise the remedy will fail to come in contact with the membrane. It is equally important that dryness of the surface be secured. This application should be maintained for from twelve to fifteen seconds. If allowed to remain too long upon the part, vesication takes place. The general after-treatment consists in the repeated application of aconitum as above directed, the repetitions not being made at the same point more frequently than at intervals of forty-eight hours. When it is desired to increase the counter-irritation, the gum may be scarified very superficially by quick, light movements of a small scalpel. The patient should be instructed to avoid subjecting the tooth to extremes of temperature in either direction. The control period of conservatively treated cases is usually within the first fortnight after the capping.

It is important that treatment be given at the beginning of the disturbance, when a few applications may suffice. Neglected cases, from the tendency to pulp disorders, are liable to pass beyond the curative stage.

The interesting phenomenon is frequently observed that when the heat rate rises the pulp at first becomes more intolerant of cold. In case the pulp continues to respond to the remedy the range of toleration should increase in both directions.

Examples: No. 1, W. H. J., + 108°–73°; 112°– 76°; + 120° – 74°; 124° – 74°; 128° – 67°; + 130° – 66°. No. 2, I. A. W., + 120° – 84°; + 120° – 86°; 128° – 86°; + 124°–76°; + 134°–70°; + 140° – 67°; + 142° – 66°; + 142° – 64°.

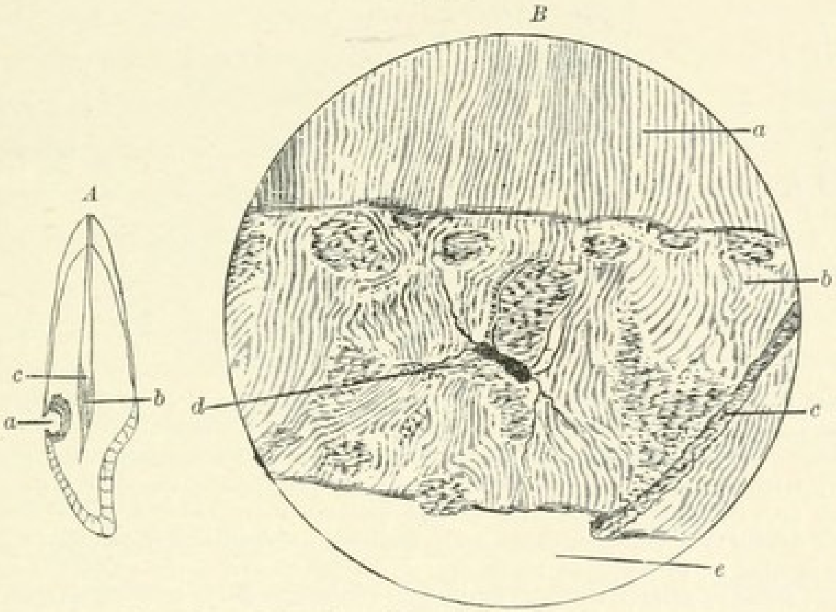
It sometimes becomes necessary to open the cases and recap. This usually occurs when in reviewing the case it is considered that some oversight has befallen. There may have been two exposures. The cap may not have completely covered the exposed part. There may have been some compression from forcing the cap, or it may have been displaced during the after-procedures.

Most careful records of all cases should be kept, with a relation of the condition and of the controlling symptoms. These records should be methodically preserved in a book kept for this purpose. Should subsequent irritation occur, a new diagnosis may be formed from the recorded facts and the new conditions. The record of conservatively treated pulps should be carried forward to the examination chart at each recurring periodic examination of the teeth. It is better that they be marked in symbol with red ink, to prevent the unnecessary removal of temporary fillings and to explain the reason for their presence and thus avoid the accident of unnecessarily uncovering the pulp in such cases.

Calcific Changes in the Pulp as related to the Operation of Pulp Capping.

When loss of substance takes place slowly, either by carious action or by attrition, a notable calcific growth takes place in the pulp chamber opposite to the point of waste in the direction of the radiant course

Fig. 394.



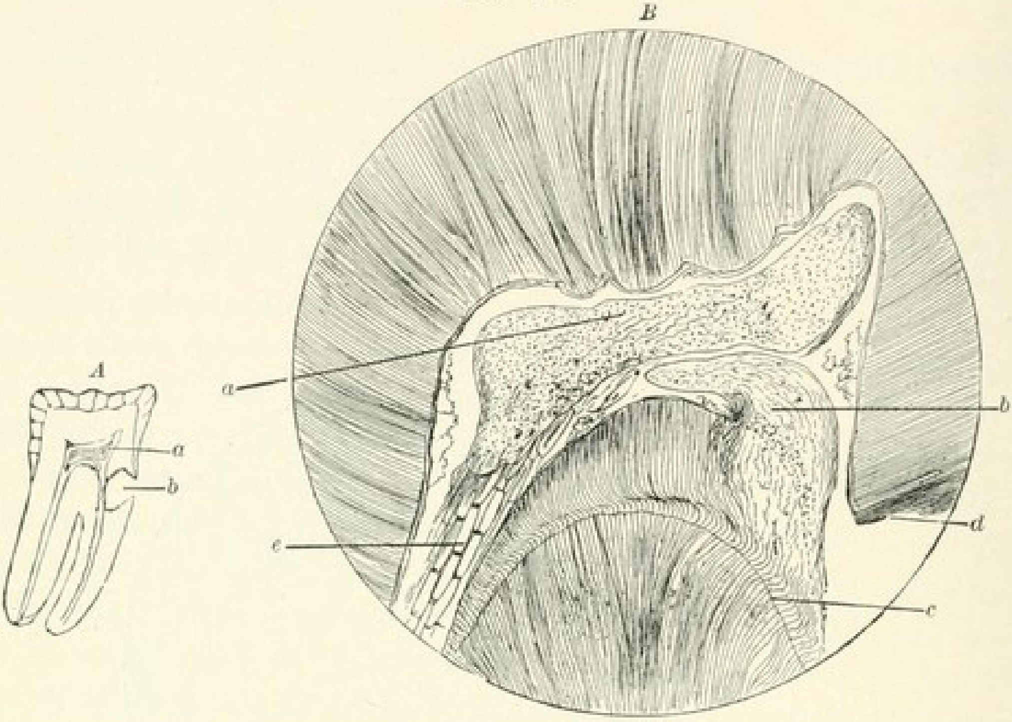
Secondary dentin, resulting from irritation of the dentinal fibrils by caries (Black). *A*, Diagram of an incisor having a decay in the labial surface, *a*, and a deposit of secondary dentin at *b*. The point from which the illustration *B* is taken is shown by *c*. *B*, Illustration of the tissue of the secondary deposit in *A*: *a*, primary dentin; *b*, secondary dentin; *c*, seems to be a blood-vessel that has become calcified; *d*, an irregular fault having some resemblance to the lacunæ of bone; *e*, pulp chamber. It will be noted that there are irregular deposits of granular matter in the substance of the secondary dentin, and that the tubules wind about them.

of the tubules (see Fig. 394). If the loss of substance from the exterior progresses with sufficient slowness encroachment upon the pulp does not take place. The pulp chamber may become obliterated by the progressive deposition of calcific matter, which has the designation of secondary dentin.

The morphological character of the secondary deposit is histologically irregular, being frequently of mixed character, presenting some of the characteristics of dentin and also containing cemental cells with radiant and anastomosing canaliculi. For this reason deposits have been designated as osteo-dentin.

In the earlier years of life opportunity does not offer to study these changes of structure, as the usual progress of caries is too rapid, but in advanced life they are common, it being not infrequent to find complete obliteration of the pulp cavity as well as of the canal of the root (see Fig. 395). In some instances nodules of calcific material appear un-

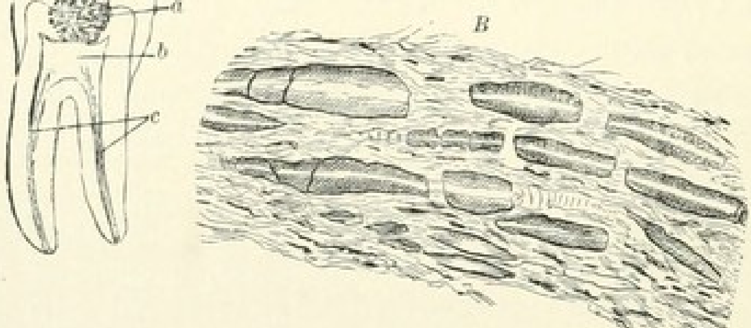
Fig. 395.



Calcification of the dental pulp (Black). At *A* is shown the outline of a lower molar with a cavity at *b*. The pulp chamber is much reduced in size and filled with calcific material, as shown in *B*. *a*, *a* large granular mass of calcific material, which is very transparent but finely granular. A very few irregular lines are seen in the centre, which slightly resemble dentinal tubes; *b*, an erratic growth of irregularly formed and unusually transparent dentin; *c*, line of the growth of dentin from the floor of the pulp chamber: the growth from other directions is so perfectly regular as to leave no markings; *d*, margin of the cavity of decay; *e*, a bundle of cylindrical forms of calcific material extending down into the root canal. These extended to the apex of the root.

attached to the walls of the pulp cavity (Fig. 396). These increase sometimes by external development and in other cases by the coalescence

Fig. 396.



A, Outline of a lower molar, with a large carious cavity at *a*; *b*, pulp chamber. The shaded portion, *c*, was occupied by cylindrical calcifications. *B*, Illustration of the cylindrical calcifications. × 100. (Black.)

of several contiguous nodules. Again, several nodules inhabiting the pulp chamber may increase in size without becoming fused, and, accommodating themselves to each other as development progresses, they at length completely fill the cavity, from which they are severally removed with great difficulty.

It is remarkable that while in some instances pulp nodules become the cause of producing violent pain by their pressure upon the nerves of the pulp, in the majority of cases substitution of the normal tissue takes place until nearly complete occlusion of the pulp cavity is affected without the occurrence of pain.

Small pulp nodules are not infrequently found in pulps otherwise perfectly normal, but generally they are evidence of continued irritation of a mild form usually attending the progressive slow advancement of caries of the tooth. But this is not necessarily the case, since some of the most violent attacks of dental neuralgia have arisen from the presence of nodules in perfectly sound teeth.

The diagnosis of the existence of pulp nodules as the cause of pulp irritation is not easily made out. The determination of the condition usually can be reached only by the process of exclusion. As they do not occur early in life while the teeth are undergoing ordinary development, they may be looked for only after middle life. The pain is dull and reflected, and the paroxysms are frequent. There is sensibility to cold, and rarely pain appears on percussion. When the teeth are sound, the disturbing one will usually be determined by the temperature tests.

An important differentiation from the usual irritation of ordinary pulp disturbance from exposure or the thermal irritation caused by the approximation to the pulp of large metal fillings, is that the disturbance from nodular irritation is not rapidly progressive and that the irritation may continue without marked exacerbations or subsidence for considerable periods.

Treatment is useless which does not include drilling to the pulp and devitalizing it. The difficulties involved in treatment by devitalization are liable to be attended by great pain, since when the pulp chamber is much occupied by nodules the action of the devitalizing agent has not free course. In these cases the remains of the pulp between the nodules and the walls of the chamber are attenuated, and when irritated by the arsenous acid give expression to an excessive degree of pain.[1]

The Influence of Pulp Exposure, and the Effect of Conservative Treatment of the Pulp upon Calcific Depositions.—Allusion has been made to calcific deposits occurring on the walls of the pulp chamber as the result of peripheral irritation. Here, as stated, these accretions only occur when the degree of irritation is slight and of long continuance. The examples of this which have been given in dental literature are

[1] For the form and extent of nodular calcification see *American System of Dentistry.*

conclusive as to the ability of the pulp at all stages of its existence to take on this action when the conditions are as stated. On the contrary, when the disturbances are active the formation of calcific deposits on the walls of the pulp chamber do not take place, or if in the earlier progress of decay they have commenced, as the progress of the destructive action approaches the pulp this change is suspended, and in some instances resorption of the secondary deposit takes place.

It is apparently in this manner that the pulp becomes denuded under the influence of thermal or traumatic irritation in cases in which there was no evidence of exposure at the time of the preparation and filling of the cavity. This result would appear to be related to the principle that secondary structures and tissue of repair are liable to resorption as the result of irritation or disturbances of nutrition.

The frequent occurrence of secondary dentin following the conservative treatment of the pulp and in some instances occurring spontaneously over exposed pulps, raises important considerations connected with the subject. The writer has had many instances come under his observation in which secondary dentin has obliterated exposures, both in his own cases and in those of others.

The influence of the tendency to nodular deposits upon the results of conservative treatment does not appear to be detrimental unless the pulp chamber becomes largely filled with them. The pulp at the period of life when calcific deposits usually take place is not so sensitive as it is at an earlier age, and therefore, unless senile conditions appear to be present or imminent, the existence of such deposits should not be inimical to the preservation of the pulp. The writer, who has had frequent cases of pulp devitalization after conservative treatment, has rarely observed "pulp stones" in these cases.

It is an important consideration that when calcific deposits take place beneath fillings where the pulp has been nearly exposed, or where they have followed conservative treatment of the pulp, they are liable to resorption on the occurrence of irritation of the pulp from any cause which brings on an increased blood supply. This is more remarkable since there are no lymphatic vessels in the pulp. This change can occur only by the development of osteoclasts on the surface of the pulp. Of this development there have been several recorded instances where the dentin has suffered resorption until the enamel has been encroached upon by the process of denudation, and when favorable conditions were established a deposition or formation of secondary dentin has occurred.

Devitalization and Extirpation of the Dental Pulp.

When the existing conditions are such as to require the devitalization of the pulp there are several requirements essential to secure a satisfactory result:

(1) That little pain be inflicted.

(2) That the destruction be quickly effected.

(3) That precaution be taken to prevent discoloration of the dentin.

The first requirement is the most important, since, if the means used to effect the devitalization are painless or nearly so, the pulp promptly yields to the devitalizing agent and there is little danger of discoloration of the dentin.

At present there are three general methods of procedure: by chemical means, by extirpation with suitable instruments, and by narcotization of the tissue.

Reliance has usually been placed upon chemical agents, these being —1. Zinc chlorid; 2. Caustic potassa; 3. Chromic acid; 4. Arsenous acid; 5. Arsenical ore (cobalt).

The agents 1, 2, 3 are usually painful, of slow progress, difficult of application, and uncertain. Hence arsenous acid has usually been depended on. This substance, notwithstanding certain objections, is the most available and most reliable of the substances above named. It has generally been combined with acetate of morphin in variable proportions, to which has been added in the formation of this paste a sufficient quantity of creosote, carbolic acid, or one of the essential oils, to give the combination the consistence of cream.[1]

In making this formula it is important that the ingredients be thoroughly ground together to effect the comminution of the arsenic and the morphin as well as to intimately mix the components. The morphin is used as a sedative to counteract the excessive irritation frequently caused by the action of the arsenous acid, which is also modified by the anesthetic influence of the creosote. Carbolic acid has been frequently substituted for creosote as being of less disagreeable odor, and as, from its coagulative action upon the surface of the pulp, it prepares the tissue to absorb the arsenic and markedly lessens the time of absorption. It is a well-known fact that with great frequency the application of arsenous acid to the pulp is so greatly irritating to it that much pain

[1] Of late cocain has largely superseded the morphin salt as an ingredient of these prescriptions. As—

℞ Acid. arsenosi,
Cocainæ hydrochl., āā. pars æq.
Ol. caryophylli, q. s.
M. et ft. pasta.

is excited, which brings about congestion of the surface of the pulp to such a degree as to delay absorption of this agent.

When the above-stated combination is applied to a living pulp which has not been in a state of disturbance, and therefore is in the condition of quiescence considered in the section on conservative treatment of the pulp, little or no excitement of the organ takes place. If the paste be carefully applied in such a manner as to avoid pressure the pulp does not usually become excited and promptly succumbs to the *chemical force* of the arsenic. When on the contrary the pulp is in a condition of active congestion, such as is presented by cases of prolonged exposure, and where congestion has supervened as the consequence of futile attempts at conservation, violent further excitement of the pulp is nearly certain. In this condition the pulp resists the absorption of the arsenic and repeated applications are likely to produce no better results. The failure to discriminate between the different conditions of the pulp accounts largely for the variation in the action of the same formula upon the exposed pulp.

It becomes important, therefore, to reduce the state of hyperesthesia of the pulp and to relieve the congestion in many instances before commencing the devitalization.

The *relief of congestion* requires, first, the disinfection of the surface of the pulp and of the dentin contiguous to it. The most efficient agent for this purpose, generally, is formalin, which after the first slight pain produced by it is almost immediately soothing. Formalin owes its value as a disinfectant to its extreme diffusibility,and in the strength applicable does not appear to be coagulative in its action. The strength should for this purpose not be greater than 2½ per cent. As formalin is composed of 40 volumes of formaldehyd with 60 of water, the above-stated percentage of formaldehyd is produced by adding 1 volume of formalin to 14 volumes of water.

When violent congestion is manifest and when the pain attending the removal of the carious matter forbids the complete baring of the pulp, a paste composed of tannic acid and oil of cloves sealed in the cavity will so far subdue the conditions as to permit complete removal of the caries. This application should be allowed to remain for several days. This paste should be contained in a large concave cap and secured with one of the plastic cements.

For the relief of ordinary congestion of the pulp cocain offers the best means, since it has direct and positive action over the capillaries, which has generally been adduced to account in part for its anesthetic influence, as by lessening the supply of blood in the capillaries it thereby reduces the stimulation of the nerve fibrils. In cases of known congestion as determined by the symptomatology when there is no effusion of lymph or pus from the exposed surface, the pulp is bathed with a strong solution of cocain and is then covered with a deep cap filled with a paste of cocain and oil of cloves hermetically sealed in for several days, when usually the arsenical paste may be used with much-lessened danger of irritation.

In these cases, and indeed in all cases, an excellent formula for devitalization will be found in the combination of 10 grams of arsenous acid ground well with 20 grams of cocain. This is taken upon a minute pledget of cotton previously charged with oil of cloves or carbolic acid, which is laid upon the exposed point and then sealed in hermetically, care being taken to avoid compression by arching over the dressing a suitable cap, or by flowing over the dressing a soft paste of one of the mineral cements. Too much care cannot be taken concerning the protection of the gum from escape of the arsenical preparation, since serious destruction of the gum and alveolus may be produced by the exuding of the arsenic.

When there is evidence of the exudation of pus, this is checked by the application of deliquescent zinc chlorid or by washing with pyrozone. Usually in such cases the surface of the pulp has become necrotic by the suppurative process and will not be so repellant of the arsenic as in ordinary cases.

The time usually required for the action of the arsenic to reach well toward the apex of the roots is from four to six days. This, however, depends upon the quantity of the preparation applied and the resistance of the pulp tissue. As the aim should be to procure the nearly complete death of the pulp by one application, the longer period is preferable as entailing less difficulty and the expenditure of less time than when shorter intervals are allowed.

When the application is made to an entirely quiescent pulp it will often be found that at the end of one or two days a broach may be passed to the end of single-rooted teeth, when the pulp may sometimes be removed. In these cases, if the pulp be not then extracted, it will be found in some instances that at a subsequent period the organ has apparently recovered its sensitivity. The explanation of this is that the arsenic apparently paralyzes the nerves of the pulp without having acted deeper than the surface. In this case the application should be repeated for a lengthened period without disturbing the tissue. On removing the dressings if the broach cannot be passed to the end of the canal either of two courses may be pursued ; the application may be repeated without removing the devitalized portion, or a strong solution of cocain may be carefully instillated until it is conveyed to the apex of the canal by means of a broach. This procedure is best effected by isolating the tooth with rubber dam and then filling the pulp chamber with the solution of cocain, which may be conveniently conveyed forward by gentle advancements and withdrawals of this instrument. The best form of instrument for this purpose is the Swiss broach tempered a little beyond a spring temper.

A matter of considerable importance in connection with the instruments used in these manipulations is that they be either such as have not been previously used or that they be thoroughly disinfected previous to use. If an instrument of this kind is indiscriminately used, having probably been infected by some purulent case, septic disturbance of the tissues at the apex is brought about. The safest course is to use a new broach suited in size and stiffness to the case in hand.

Since cataphoresis has been employed in dentistry it has been frequently used to effect the anesthetization of the pulp by cocain. This method has certain advantages. The time expended in the procedure is from ten to thirty minutes. The requirements are that insulation be perfectly secured; that the selected voltage be low at the commencement—in most instances from 5 to 10 volts—and be gradually increased as the pain limit will permit.

The impediments are the usual small size of the foramina and the density of the pulp walls. When the foramen is large the resistance is less and the action prompt.

Cocain may be employed in this manner to obtund the parietes of the cavity and the surface of the pulp, when after the removal of the carious matter the pulp may be uncovered. The application can then be renewed to complete the anesthetization of the pulp.

This procedure saves much time and discomfort and also avoids pain as compared with devitalization by chemical means. It is indicated in cases of severe congestion of the pulp, in which arsenic usually produces great pain and often is without satisfactory result.

In some instances complete obtundation is not effected throughout the extent of the pulp. Here, after removal of the part anesthetized the remainder may be devitalized easily by "White's fiber," which is the safest arsenical preparation to use under these conditions.

Instillation of cocain by means of a broach may also be efficacious.

A further advantage in this method of treatment is that when the anesthesia is completed the pulp may be entirely removed and the canal be filled at the same sitting.

It is sometimes observed, as the result of forcing the current beyond reasonable limits, that soreness of the peridental membrane follows. What effect has been produced in this instance is not clearly apparent. Whether it is a result of undue pressure of the current upon the apical tissues or is caused by the interference of cocain with the nutrition of the parts has not been determined. This effect is mentioned to induce the degree of caution which is the accompaniment of an intelligent use of a force of signal service when carefully applied, but which recklessly pushed may do injury.[1]

The Pressure Method of Obtunding the Pulp.

A method of applying cocain to the pulp under pressure has recently come into use. It consists of laying over the exposed surface, after the pulp is carefully and broadly uncovered, a small piece of amadou (punk) filled with a saturated solution of cocain in absolute alcohol or chloroform. The cavity is then filled with a piece of unvulcanized caoutchouc. Pressure is effected directly upon the rubber with a broad rounded instrument, so adapted in size that it will not meet with impediment and yet not small enough to exert force directly upon the point of exposure. The degree of pressure should at first be slight, and be gradually increased as the cocain exerts its effect upon the pulp. The force is exerted by successive steps, terminating when pain follows, but maintained until the sensation ceases. At length when no pain is produced by excessive pressure the rubber and punk are removed, when the pulp is immediately removed by the usual means. This operation is done quickly, to avoid the return of sensitivity.

Those who pursue this plan state that it produces nearly uniform results and enables the canal and pulp chamber to be filled immediately.

The indications are that the cocain overcomes the sensitivity of the surface of the pulp, and that pressure paralyzes the tissue by the compression to which it is subjected. Were the cocain conveyed to the apex, as when it is instillated, pain would not so soon return.

Precautions required to Prevent Discoloration of the Dentin.

It sometimes occurs where arsenous acid produces much irritation of the pulp that the violent congestion occasions disorganization of the blood corpuscles, resulting in the distribution of the hematin throughout the dentin. This most unfortunate result is liable to follow the application to an already congested pulp when the application is made without first subduing this condition. It is also more liable to happen when under these circumstances the pulp has not been completely denuded of the carious matter.

The removal of the ultimate layers of carious matter is important to permit the pulp to bleed and thus to deplete the engorged vessels. It is also necessary to avoid making an arsenical application until the

[1] The student will find much instruction in Price's "Foundation Principles of Dental Cataphoresis," *Items of Interest*, vol. xx. p. 345 *et seq.*

assurance is reached that the bleeding has completely ceased, else subsequent bleeding may induce discoloration. In addition the bleeding or any other kind of effusion prevents direct contact between the pulp and the arsenical paste.

These general directions apply also to the employment of powdered cobalt as a devitalizer. The difference between the action of cobalt and arsenous acid is due to the variations in their respective solubility in the fluids of the pulp—cobalt having a low rate of solubility. For this reason this substance requires a longer interval, at least a week being necessary for its action to extend into the canals. In anterior teeth a shorter period should be chosen. With this substance it is of extreme importance that the application be made directly to the pulp. The method is as follows :

A pellet of cotton the size of a pinhead is saturated with any of the essential oils ; it is then dipped in the powder and laid upon the pulp. The previously stated precautions are taken to prevent pressure of the pellet of cotton upon the pulp and to protect the cavity from the ingress of moisture.

In these procedures connected with the removal of the pulp the use of alcohol is an important aid, since on account of its affinity for water it much aids, in addition to its cleansing properties, in the procurement of dryness of the parts. Desiccation of the pulp chamber materially assists in all the delicate procedures connected with the treatment of this class of cases. It lessens the pain of the remaining living portion of the pulp, and by giving firmness to the devitalized part makes more easy the removal of the dead tissue. It also facilitates the action of the disinfectants which may be employed to prevent rapid changes in the organic contents of the canal. The process of desiccation may be much facilitated by the concurrent injection of warmed air.

It should be emphasized that in all procedures connected with the treatment of pulps undergoing devitalization the teeth should be isolated by the use of rubber dam. This is necessary not only to facilitate observation and secure dryness but to protect from mouth infection.

The removal of the dead pulp tissue is effected by small barbed broaches which are passed between the pulp and the walls of the canal. When these reach the apex the pulp may in most instances be wound upon the instruments by a gentle rotation. When this does not take place because of the loss of consistence of the tissue, it is broken up by constant rotation of the instrument and removed piecemeal. The displacement of the shreds is best effected by wrapping the broach with a few fibers of cotton dipped in alcohol.

Previously to this, free communication must be established between the cavity and the pulp chamber, as well as such a formation of the lines of approach to the canals of the root as will give free access, not only for the removal of the dead tissue, but as well to facilitate the complete closure of the root canals to the apices to prevent the ingress of organic matter from the adjacent tissues.

Minute directions for the form of approach to the various canals and the related procedures will be found in the next chapter.

CHAPTER XVII.

THE TREATMENT AND FILLING OF ROOT CANALS.

By Henry H. Burchard, M. D., D. D. S.

Pathological Conditions.

The modes of treatment of the pulp chambers and canals of teeth containing non-vital pulps, or those in which the pulp is absent, are determined and governed by the pathological conditions present. These conditions may be broadly divided into aseptic and septic; *i. e.* those which have not been invaded by micro-organisms, the others those in which the pulp or its remnants furnish the soil in which the development of micro-organisms has taken place.

The first class includes those cases in which the pulp has been intentionally devitalized *en masse*, and also those in which the organ has undergone a process known as mummification, or dry gangrene. This latter condition is occasionally found as a consequence of traumatic death of the pulp without exposure, and sometimes as a sequel of attempts at conservation of exposed pulps by capping them with zinc oxychlorid.

The septic cases may be divided into classes according to the depth of invasion of septic organisms; they range from superficial ulceration of the pulp, to its disorganization through the agency of putrefaction, and the infection of the tissues beyond the apex of the root.

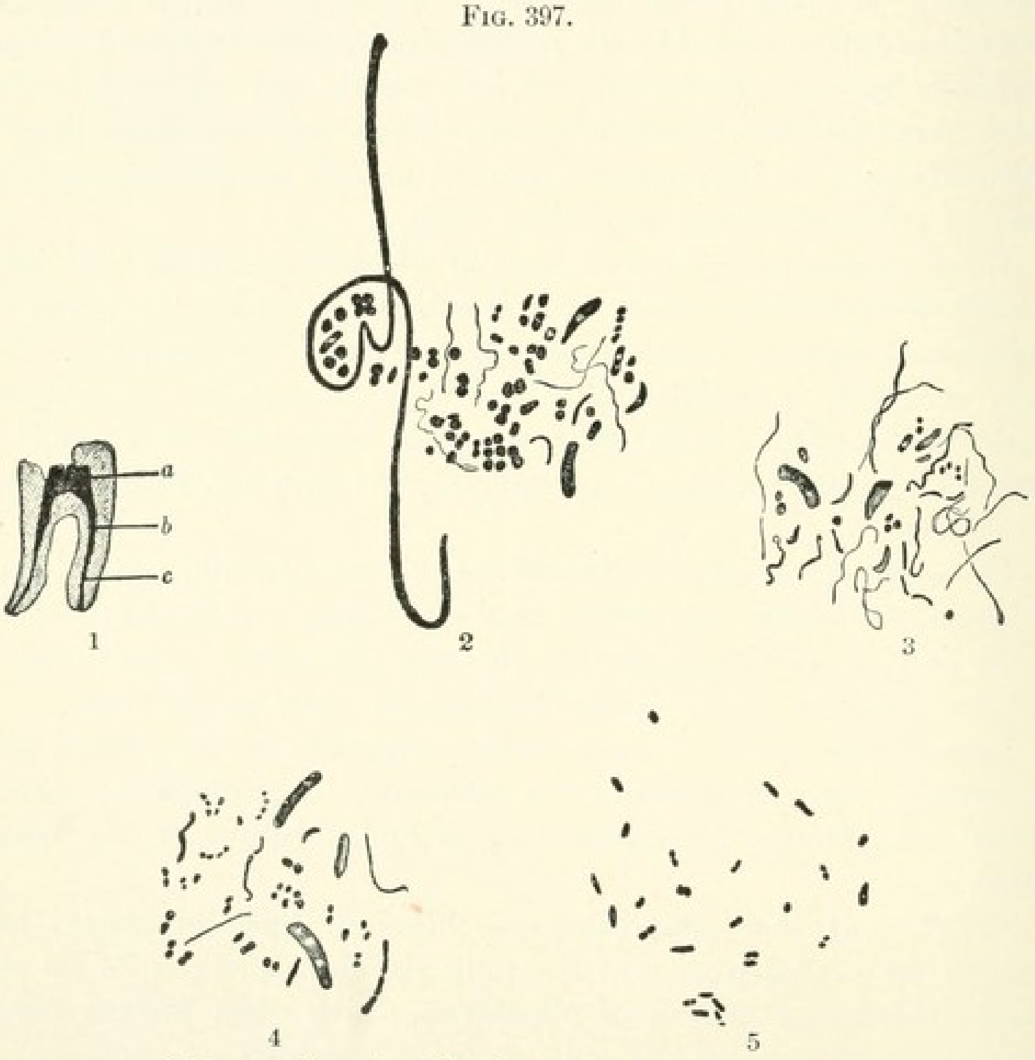
Immediately upon or even before exposure of the dental pulp, its surface, and subsequently its substance, is invaded by several of the many forms of organisms which find a habitat in the human mouth.

The first of the septic cases are those in which organisms have invaded the coronal portion of the pulp and destroyed part of its substance—through a process of ulceration. Such cases become aseptic through the removal of the pulp *en masse*, provided no organisms be carried into the canal during or subsequent to the removal of the pulp.

The second class of cases comprises those in which septic organisms have invaded the pulp along the direction of its veins and destroyed the mass of the organ through a process of suppuration. In these cases it is not uncommon to find the tissues of the apical region affected in some degree presumably by infection with the waste products of the organisms, a transitory pericementitis occurring which ceases when the dead pulp sloughs from its vital connection at the apex. The succeeding stages of the infection are those of moist gangrene and putrefactive decomposition of the pulp tissues, and later of the contents of the tubules. Following upon these conditions are affections of the cementum and the pericementum in the apical region, resulting in an inflammatory process in these parts.

All of these stages of infection and decomposition may be found in the pulp at one time, the suppurative process preceding that of putrefaction. Cultures made from a gangrenous pulp (see Fig. 397)[1] showed

Fig. 397.



Micro-organisms found in cultures from a gangrenous pulp.

the smaller cocci and diplococci (5) nearest the apex of the root (*c*, Fig. 397, 1) where suppuration was in progress; the larger forms and more varieties were found in the necrosed and decomposing portions of the

[1] Miller, *Dental Cosmos*, July, 1894.

pulp (4, 3, 2). The cases of gangrenous pulps exhibit a mixed infection, several varieties of cocci, bacilli, and spirochætes being found.[1]

Cases are occasionally seen in which the pulp of a non-carious tooth has been devitalized in consequence of a blow, injuring the vessels as they enter the apex of the root; the same effect is not rare as a consequence of too rapid or extensive movement of teeth in regulating. The pulps in such cases are probably destroyed by thrombosis of the vessels at the root apex. The death of the pulp may not be detected for years; when evidences of albuminous decomposition are discovered, a growing opacity and changing color of the tooth may be detected. In other cases alveolar abscesses may form and discharge at some point near the tooth, or it may be at some distance from it. It is presumed that the organisms which have effected this decomposition of the pulp resulting in the suppurative process have found their way to it *via* the blood current.

It is within the experience of every dentist that the products of decomposition occurring under these conditions afford a suitable soil for the development of virulent micro-organisms as soon as the tooth is opened to the air.

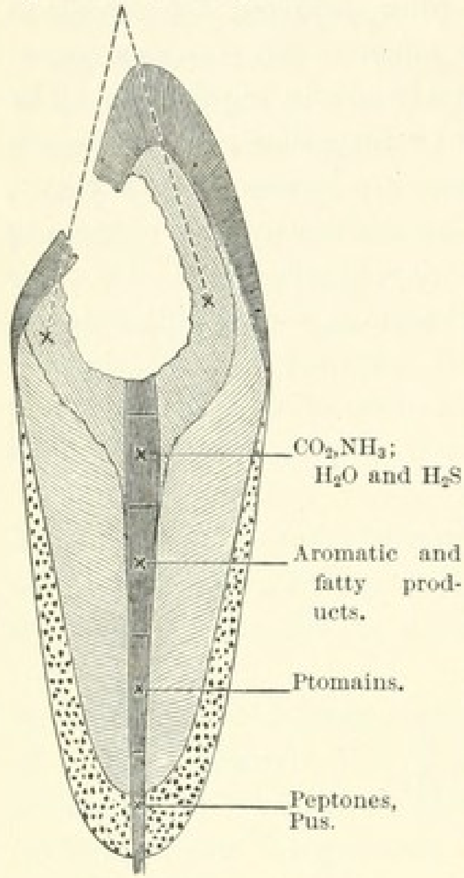
The several conditions described are to be regarded, for purposes of treatment, as definite pathological states. The treatment is to be directed to the attaining of such conditions as shall insure the retention of the tooth with an entire absence of pathological manifestations. Rational therapeutics should govern each procedure.

Cases in which the Pulp has been Intentionally Destroyed and Removed en masse.—As this procedure usually has been determined upon in consequence of suppuration or inflammation of the pulp, the septic organisms, the staphylococci, streptococci, and bacilli, have followed the course of the inflammation, *i. e.* along the veins. The organisms of putrefaction, if present, have affected but in very limited degree the most external portions of the pulp, so that the color of the dentin is unaltered except to a very slight depth. After the removal of the pulp the contents of the tubules are chemically unchanged, and the canals contain no organic matter, except the blood which may have escaped in consequence of tearing away the pulp. There may also remain odontoblasts which have become mechanically detached during the operation. Provided no organisms have been introduced during or subsequent to the operation of extirpation, the canals are aseptic. If proper antiseptic precautions have been taken, sterilizing and isolating the tooth to be operated on and also the instruments employed, no infection occurs. These are the cases in which immediate root filling has been recommended and practised with success.

[1] See Fig. 397.

If the septic process has invaded the pulp extensively the pulp tissue, as its destruction progresses, becomes the seat and soil of putrefactive decomposition involving also to a variable extent the contents of the dentinal tubules, and the color of the dentin undergoes a series of changes.[1] The appended figure (Fig. 398) gives a graphic diagrammatic representation of the serial decomposition of an infected pulp. The albuminous constituents of the pulp undergo fatty transformation; next putrefactive decomposition attended by the evolution of hydrogen sulfid, ammonia, and other end products. According to the extent of invasion and its variety, waste products are formed (ptomains and allied substances) by the organisms which act as irritants to the vital tissues, until, when the apical but still vital portions of the pulp become the soil for the development of pyogenic organisms, the tissues of the apical region are affected. Usually in the later stages of pulp suppuration the tooth becomes sensitive upon percussion. Succeeding this state of affairs is a period of delusive quiet, during which the apical tissues, although doubtless affected by the toxic substances present, exhibit but slight subjective symptoms. The remnants of the pulp are undergoing progressive decomposition, as are also the contents of the dentinal tubules. After a variable period, governed by the virulence of the organisms present and the inherent resistance of the vital tissues of the apical region, these latter succumb, poisoned by the toxic substances formed in contact with them, and an inflammatory action arises; this may be subacute, evidenced by sensitiveness upon percussion and a deepening of the gum color overlying the apex of the root, constituting a condition known as subacute pericementitis; or, if the attack be more severe, or the resistance lessened, the symptoms are more violent; there is a pronounced hyperemia, quickly succeeded by the evidences of marked inflammatory action. The tooth, owing to the effusions in the pericementum, becomes elevated and exquisitely sensitive to touch; the color of the gum deepens, and heavy throbbing pain is complained of; acute pericementitis is in progress. In more severe cases marked

Fig. 398.



[1] See Chapter XX. on Bleaching.

œdema of the gum and it may be of the face arises; the pulse increases in volume, tension and frequency; febrile action, with a temperature as high as 103° or 104° may occur; in other cases distinct evidences of septic intoxication may appear, and indeed even septicemia or pyemia[1] may result at a later stage.

The severity of the inflammatory action is no doubt governed in part by the variety of the infecting organisms, and again by the physical condition of the individual attacked. Judging from the mode of progress and attack, the staphylococci are the offenders where the inflammatory action is circumscribed, and the streptococci in cases which exhibit a tendency to spread along the course of the fascia and produce phlegmonous inflammation.[2] Schreier has found the almost invariable presence of a diplococcus in this condition, probably the *diplococcus pneumoniæ*.

Individuals presenting any of the several manifestations of struma, inherited or acquired, suffer from a debility of general vital processes, and may have the inflammatory action run a riotous course (see Alveolar Abscess, Chapter XVIII.). As a rule, when a tooth has been the seat of subacute pericementitis for a lengthened period, or of acute septic pericementitis for from twenty-four to forty-eight hours, there is more or less death of cellular elements in the inflammatory effusion, pus forms, and alveolar abscess is established (see Chapter XVIII.).

In cases of subacute pericementitis, even those in which pus formation is not evident, the tissues of the apical region are assailed by the products of putrefactive decomposition, which latter process may prove difficult to overcome, the tissues rebelling at each attempt to close the outlet to the escape of gases which irritate them.

Each phenomenon mentioned as accompanying the stages of septic infection and albuminous decomposition forms an item for consideration in the therapeutic measures to be applied.

Therapeutic Agents.

The natural and true inference from what has been stated is that the class of therapeutic agents to be locally employed in any of these conditions are all included under the general order of *germicides*, *antiseptics*, and *disinfectants*.

The one distinguishing feature that all of these substances have in common is the power—differing in degree in each—of destroying pathogenic organisms or rendering innocuous their waste products; their other properties differ widely, so that the agent for application to spe-

[1] See case of Dr. E. T. Darby, *Proc. Odontological Society of Pennsylvania*, 1892.

[2] See case reported by Dr. E. C. Kirk, *Proc. Odontological Society of Pennsylvania*, 1892.

cific disease conditions is selected with a regard to which shall best and most completely attain a definite end. According to the effects produced upon albumin the agents under consideration may be placed in two classes, coagulants and non-coagulants. In the former class are included salts of the metals and alcohols; in the latter, many of the essential oils.

Mineral acids and the alkalies act by chemically destroying the albumin. The metallic salts which have been employed or tested as germicides in pulp canals are the chlorids of zinc and of aluminum, the bichlorid of mercury, the bichlorid of gold and sodium, the sulfate of copper, and the nitrate of silver. The salts of copper, silver, and gold are not adapted on account of the discolorations produced by them. Mercuric chlorid is open to the same objection; thus the only metallic salt having general application is zinc chlorid.

The alcohols employed are the ethylic (commercial) alcohol; phenylic alcohol, *i. e.* carbolic acid, and creosote, with the coal-tar derivatives, the cresols. In this connection formalin—a 40 per cent. solution of the gas formaldehyd in water should be mentioned very favorably; in dental practice it is reduced to a strength of 3 to 5 per cent.

Preparations of iodin, bromin, and chlorin are all powerful antiseptics and disinfectants. Bromin is inapplicable owing to its irritating effects and offensive odor; chlorin is employed in the form of hypochlorites; usually in the solutions called electrozone and meditrina, electrolytic products of sea-water. Labarraque's solution of sodium hypochlorite appears to have fallen into general disuse, as have also the hyposulfites. The usual form in which iodin is applied is as the tincture. Iodin trichlorid is said[1] to be five times as strong as mercuric chlorid as an antiseptic.

The essential oils recommended as antiseptics for employment in canal and dentin sterilization are those of thyme, cinnamon, cassia, myrtle, and eucalyptus.

The alkalies employed as sterilizing agents are Schreier's alloy of potassium and sodium, called Kalium-natrium; sodium carbonate and sodium dioxid. The mineral acids which have been recommended are hydrochloric and sulfuric, the latter by the method described by Dr. Callahan.[2]

The gases oxygen and chlorin, *in statu nascendi*, are employed as sterilizing agents, the former extensively. When these are applied as bleaching agents, the sterilization is coincidently accomplished, as pointed out in the chapter on Bleaching.

Oxygen is liberated from aqueous and ethereal solutions of hydrogen dioxid and solutions of sodium dioxid.

[1] Langenbach, quoted by Miller, *Dental Cosmos*, vol. xxxiii. p. 342.

[2] *Proc. Ohio State Dental Society*, 1894.

Iodol, iodoform, and kindred substances are not employed as germicides *per se*, but for other therapeutic properties possessed by them, *e. g.* their supposed capability of maintaining sterilization after the more powerful antiseptics have been employed as germicides.

Aristol, dithymol biniodid, is another member of this group, which owing to its chemical composition is theoretically preferable to the others. It contains twice the quantity of iodin in loose combination, and in addition has as its base a powerful antiseptic, thymol.

These agents are supposed to act as antiseptics in consequence of setting free iodin when brought in contact with albuminous substances.

It has been demonstrated that iodoform is not a germicide (organisms growing about it), but it appears to lessen or destroy the effects of toxic substances generated about it as the result of albuminous decomposition.

The final antiseptic to be mentioned is the mechanical removal of infected tissues.

Zinc chlorid forms, when brought in contact with albumin, a dense and almost colorless coagulum of zinc albuminate. Placed at one end of a capillary tube containing albumin, it diffuses rapidly through the solution, coagulating it throughout.[1]

Carbolic acid forms less dense coagula, and creosote still less. Mercuric chlorid and silver nitrate form complete coagula also. It may be well in this connection to call attention to an observation made by Dr. Kirk, in an essay read before the First District Dental Society of New York, that coagulation is a chemical process, as illustrated in the union of mercuric chlorid with albumin. The metallic salt does not act by catalysis, but there is a distinct quantitative relation between the coagulant and the coagulable material, the process ceasing when the quantitative relation of these bodies is chemically satisfied; if an excess of $HgCl_2$ be employed, a definite amount of the salt combines with albumin to form an albuminate of mercury suspended in a solution of the chemical excess of $HgCl_2$. If an excess of the albumin be employed, an albuminate of mercury is formed suspended in a solution of albumin. The albuminate of mercury when brought in contact with an easily decomposable sulfur compound may be reduced by the formation of mercury sulfid and the albumin be restored to its primary condition,[2] which would seem to indicate that $HgCl_2$ is an unreliable germicide where putrefactive decomposition is in progress giving rise to H_2S.

Formalin readily and quickly affects both albumin and gelatin, converting them into a tough coagulum which maintains its form and

[1] Prof. James Truman, *Proc. Academy of Stomatology of Philadelphia*, Dec. 1894.

[2] Abbott, *Principles of Bacteriology*, 3d ed., 1896.

appears to be persistently antiseptic for certain varieties of micro-organisms.

The essential oils act as antiseptics without coagulation, having markedly less germicidal action than the agents above mentioned. Placed in root canals they diffuse through the dentin, maintaining a prolonged antiseptic influence; their absorption into the dentin produces some degree of discoloration in that tissue. These oils differ in antiseptic power. Oil of thyme and oil of cinnamon stand at the head of the list, oil of cloves and eucalyptus being far below them in the antiseptic scale.

The alkalies employed as antiseptics saponify the fatty matters formed in the course of albuminous decomposition, and dissolve albuminous substances with which they are brought in contact. The first of these, the alloy of potassium and sodium, when placed in contact with decomposing pulp tissue, abstracts the elements of water from it, and sodium and potassium hydroxids are formed, which have the power of saponifying fats and dissolving albumins. Sodium carbonate has similar properties, but acts less energetically. Sodium dioxid under the same conditions forms sodium hydroxid, nascent oxygen being set free, which acts as a germicide and also decomposes the coloring substances in the dentinal tubules, acting as a bleaching agent to the dentin. Solutions of hydrogen dioxid are decomposed into water and nascent oxygen in contact with the putrescent canal contents; the liberated oxygen acting as an oxidizer.

The mineral acids when employed subserve a double office. Sulfuric acid placed at the mouth of fine canals unites with and decomposes the calcium salts of the dentin, forming calcium sulfate, easily removable with the fine canal scrapers; its second office is that of an effective germicide, destroying all organisms with which it is brought in contact.

Materials for Filling the Root Canal.

The materials employed to hermetically seal the apical foramina of sterilized canals are in the condition of solids inserted *en masse* or in successive portions; or they are pastes applied alone, or upon some medium which acts as a vehicle. Another class are ordinarily solid, but are brought to a condition of fluidity before inserting them.

The properties which should be possessed by a satisfactory canal filling are as follows: Impermeability—it should hermetically seal the apical foramen, effectually preventing the egress of pathogenic organisms or their waste products from the canals to the tissues of the apical region and *vice versa*, and it should prevent transudations from the apical tissues into the pulp canals. It should be unchanged by the influences about it; be unirritating to the soft tissues; and possess sufficient plasticity to permit of its ready adaptation to the walls of the space it is designed to fill. It should be at least aseptic when applied, and preferably antiseptic: it is to be esteemed in the degree that it maintains this latter quality in combination with the other desiderata stated.

The solid materials which have been employed for this purpose are gold foil, shredded tin foil, gold, copper and lead points; wood points dipped in creosote have been used for this purpose. The readily oxidizable metals have not found favor owing to the possibility of dentinal staining following their employment. The plastic materials employed are softened gutta-percha cones and the zinc oxychlorid cement. The latter and also other pastes are frequently employed to fill the meshes of a wisp of crude cotton wool or asbestos fiber, these latter being the vehicle for carrying the paste into position. It is to be remembered that when cotton fiber is kept in prolonged contact with zinc chlorid, the cellulose undergoes a chemical change: it is converted into a pectous substance called amyloid, which is a colorless colloid, unchangeable in the conditions existing at the apex of a pulp canal.

Cotton itself may be included among the plastic root fillings.

The fluid substances employed are solutions of red gutta-percha base plate in chloroform, the solution called chloro-percha, which contains in this case vermilion; if made of white gutta-percha it contains zinc oxid and a variable amount of other mineral substances. The other members of this class are salol and paraffin, made fluid by heat before insertion and becoming hard when cool.

Gold was the first material adopted for the purpose of canal filling, being introduced in this connection by Dr. Maynard over fifty years ago. Properly adapted it may be made to hermetically seal the apical foramen. It is difficult to manipulate, and its removal after the type of adaptation required is wellnigh impossible. Tin has the same virtues and is open to the same objection, which in fact obtains when any metal is forcibly driven into the apical portion of the canal. It is held, however, and with a measure of good reason, by those who advocate the employment of metal for this purpose, that when a pulp canal has been thoroughly sterilized and filled, the necessity for the removal of the root filling will never arise. The degree of confidence expressed in this opinion has not yet served to override the caution of the conservative operator, so that metals have an extremely limited employment in this connection.

The plastic materials most frequently recommended and which statistics and general experience demonstrate to serve most acceptably as canal fillings, are the oxychlorid of zinc and gutta-percha.

The zinc cement when in paste form may be readily adapted to any accessible canals, and it maintains during and for some time after setting an antiseptic action. The peculiar and specific influence exerted by this material upon the albuminous constituents of the tooth may be seen as a not infrequent sequel to its employment as a pulp capping. Many of such teeth whose pulp chambers have been opened some years after the capping operation are found to have had their pulps changed to a dry tough mass which has not been the seat of septic invasion; moreover, the normal color of the dentin of such teeth has been maintained, showing that no extensive chemical decomposition has occurred in the contents of the tubules. As a canal filling it becomes very hard, remains white, and when freshly mixed is markedly irritating to vital tissue with which it is brought in contact. Its removal when indicated may be accomplished by repeated applications of sulfuric acid after the Callahan method of opening canals.

When the meshes of cotton are filled with the paste made thin, the zinc chlorid acts upon the cotton, converting it into amyloid; so that if a pellet of cotton moistened with a sedative antiseptic be placed in the apical portion of a root canal and the thin paste placed over it, the filling of the apex after the chemical action noted consists of the unchangeable impervious amyloid and not of cotton.

Long thin gutta-percha cones are readily made plastic, but the adaptation of the material to the walls of the canal is less intimate than is that of the oxychlorid of zinc. It is unchangeable in the conditions under which it is placed, and is the most bland and unirritating of filling materials. Its removal after proper placement is difficult but by no means impossible. The gutta-percha compound known as temporary stopping has similar properties, but is less tough in texture.

The last of the plastics introduced is a resinous substance called the *balsamo del deserto*. It is probably an exudation from one of the varieties of pine or fir. Its virtues and employment were first described by Dr. W. H. White of Silver City, N. M. His experiments indicate that the resin has a pronounced antiseptic action; it adheres to wet surfaces, and is perfectly non-irritating to soft tissues with which it is brought in contact. It remains unchanged when employed as a canal dressing. He finds that the roots of temporary teeth which have been filled with the material suffer no interference with the resorption process because of its presence.

Thin solutions of gutta-percha in chloroform (chloro-percha) have wide employment as fillings for fine and tortuous root canals. These solutions may be carried into any canal which will admit the finest broach. They shrink in hardening, so that a canal filling of such a solution does not hermetically seal the cavity when the material is hardened.

The solution is usually employed in combination with the gutta-percha cones. Dr. R. Ottolengui[1] recommends a method which may be followed with advantage: A number of pieces of floss silk about an inch long are saturated with chloro-percha and dried; these are then thrust in a chloro-percha canal filling while it is fluid. Should it ever become necessary to remove the filling, the projecting end of one of the pieces of silk is caught, and the entire filling may be withdrawn.

The use of salol in this connection was first described and advocated by Dr. Mascort of Paris.[2] Salol, the salicylate of phenol, is mildly antiseptic. When brought into contact with alkalies it is decomposed into carbolic and salicylic acids, two powerful antiseptics. It melts at 40°C. (104°F.), and if fused at or but little above this heat it crystallizes in a few minutes; if the heat be raised to a higher point crystallization is delayed for some time after the mass has cooled far below its normal melting-point. The melted salol may be readily carried into any canal which will admit the finest broach. Portions of the material which may be carried beyond the apical foramen appear to be unirritating.

Reports as to the permanence and value of this material vary from enthusiastic endorsement to unqualified condemnation. Many of those who have used salol have found, upon reopening canals which have been filled with it, an absence of the salol; however, where the practice has been to employ a central canal filling of gutta-percha, a cone of which material is thrust into the melted salol, in such cases its absence has not been observed. Salol has been found to suffer rapid decomposition in canals which have been treated with one of the fixed alkalies just before the salol was inserted.

Paraffin has been employed for a canal filling, made fluid by heat and carried into the canals; it is bland, unirritating, unchangeable, and easily removable.[3] It may be used, mixed with aristol, in sterilized canals.[4]

Before discussing the cleansing of pulp canals, certain means and methods suggested for avoiding the necessity for the toil and care necessary to mechanically cleanse the more inaccessible canals require consideration. These agents are preservative pastes.

Mummification of the Pulp.—As early as the introduction of arsenous oxid as a devitalizing agent it was noted that a certain percentage—or rather, an uncertain percentage—of cases gave evidence of little or no disease after the application of arsenic and its sealing in a cavity by a filling. Later, it was found that applications of powerful antiseptics to exposed pulps not infrequently were followed by a long-continued quiet of that organ; still later, when more definite knowledge was possessed of the pathological results which might follow the leaving of portions of pulp substance in the canals of teeth after devitalization

[1] *Methods of Filling Teeth.*
[2] *Dental Cosmos*, 1894, p. 352.
[3] *Ibid.*
[4] *Ibid.*, June 1897.

by arsenic, it was observed that after saturating the canals with creosote or zinc chlorid solutions, many cases gave little or no evidence of pericemental disturbance thereafter.

While it is unquestionably preferable to always thoroughly remove the last vestige of devitalized pulps, the time, care, skill, and expense involved in perfect cleansing are detriments to its universal practice. The only other possible solution of the difficulty is to so alter the tissue not removed that it shall remain permanently aseptic, and, if possible to make it so, antiseptic.

Observations derived from clinical experience, although undoubtedly of great and permanent value, are indeterminate, and our truly scientific knowledge of this matter dates from Dr. W. D. Miller's experiments.[1] He credits Dr. Witzel with the first systematic observations in this direction. Dr. Witzel in 1874, "devitalized the crown portion of pulps by means of arsenic, extirpated that portion leaving the pulp in the canals undisturbed, their exposed ends being treated as freshly exposed pulps." This is the method followed by Herbst, who employs cobalt (which is native arsenic sulfid or metallic arsenic) instead of arsenic trioxid.

Dr. Miller's experiments have shown that none but the most powerful and penetrating antiseptics have value as permanent sterilizers. These are: The cyanid, bichlorid, and salicylate of mercury, sulfate of copper, and oil of cinnamon. Orthocresol, carbolic acid, trichlorphenol, and zinc chlorid penetrate the pulp tissue rapidly, but are too diffusible, disappearing in a few weeks.

He classifies salicylic acid, eugenol, campho-phénique, hydronaphthol, α- and β-naphthol, acetico-tartrate of aluminum, and some essential oils, resorcin, thallin, sulpho-carbolate of zinc, etc., as being of doubtful value.

Those nearly or quite worthless are iodoform, basic anilin coloring matters, borax, boric acid, dermatol, europhen, calcium chlorid, hydrogen dioxid, sozoiodol salts, tincture of iodin, spirit of camphor, and naphthalin.

The preparation giving the best results consisted of—Mercuric chlorid, 0.0075 gram; thymol, 0.0075 gram, in tablet form.

The pulp is devitalized; the crown portion and all the root portion readily accessible is removed; one of the tablets is placed in the pulp chamber, crushed by means of an amalgam plugger, and covered with gold foil. The mercury salt tends to discolor the crown of the tooth, so that its employment should be restricted to the posterior teeth; indeed, the necessity for its use would be, as a rule, found with these teeth, being those from which it is most difficult to extract pulp rem-

[1] *Proc. Columbian Dental Congress*, 1893.

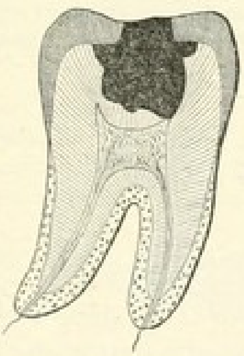
nants. Dr. Miller expresses faith in the power of oil of cinnamon to permanently sterilize pulp fragments. He suggests the experimental application of the sterilizing tablets to such teeth as are readily salvable yet which are for various reasons "consigned to the forceps."

Dr. Theodore Söderberg of Sydney, N. S. W., reports excellent results from a continuous practice of this variety of pulp sterilization. He employs a paste composed of—

℞. Alum exsic.,
Thymol,
Glycerol, *āā.* ℨj;
Zinc oxid, q. s. to make stiff paste.—M.

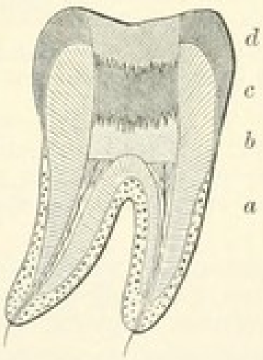
It will be noted that he substitutes dried alum for tannin, originally used by him as the hardening agent: his experiments showed the tannin to be productive of discoloration. Mercuric chlorid is set aside for the same reason. Oil of cassia employed in the paste also caused discoloration. At present Dr. Söderberg adds a small quantity of cocain to the paste to prevent the pain arising from the action of the dried alum. He states (Nov. 1895) that he has in a year applied the paste in 97 cases and has had no untoward results. The method of placing the material is shown in Figs. 399, 400.

Fig. 399.



a, Caries exposing a horn of the pulp.

Fig. 400.



a, Root portion of pulp; *b*, mummifying paste; *c*, zinc phosphate; *d*, gold or amalgam.

C. A. Firth of Queenleyan, N. S. W.,[1] advises the omission of zinc oxid from the paste, to avoid the formation of the brown tannate of zinc. He suggests the use of a mixture of tannic acid and thymol equal parts, made into a paste with glycerol and applied with *ivory* instruments, to avoid discolorations. He expresses himself as gratified at the results obtained. Another formula suggested by the same gentleman is—

[1] *Dental Cosmos,* May, 1896.

DESCRIPTION OF FIGS. 401, 402, AND 403.[1]

FIG. 401.—Fig. 3 gives in contrast a sectional view of deciduous and permanent upper teeth divided through their lateral diameters.

Fig. 4, a sectional view of the corresponding lower teeth divided through their antero-posterior diameters. *a, b, c* represent, respectively, the deciduous and permanent front incisors in contrast: *d, e, f,* the lateral incisors; *g, h, i,* the canines; *k,* deciduous molars, upper and lower; and *l, m,* the successors to the deciduous molars, the bicuspids; *n, o* represent permanent molars. *c, f, i, m, o* have dotted lines indicating the thickness of enamel removed by wear, atrophy of the cementum, and reduction in the size of the pulp due to progressive calcification, these changes being incident to old age.

FIG. 402 represents in Fig. 1, letters *a* to *h* and *a* to *h,* the longitudinal or vertical sections of the sixteen upper teeth, showing the labio-palatal diameter of the pulp chamber and canal in crown and roots, the section of the molars being through the anterior buccal and palatal roots, while the bicuspids *d e* and *d e* illustrate the result of such a compression of the root as to divide the pulp chamber into two canals—a condition which so frequently exists in these flattened roots. The double-lettered series, *d d* to *h h* and *d d* to *h h,* represent in the molars a section through the posterior buccal and the palatal roots, from which is quite readily recognized the slightly greater lateral diameter of the pulp chamber in the crown and the larger canal in the posterior buccal root over that in the anterior buccal root, while the bicuspids lettered *e e d d* and *d d e e* illustrate a modified pulp chamber and canal, with bifurcation of the root in one, these being cut through a different axis or plane from the single-lettered series.

Fig. 2, letters *a* to *h* and *a* to *h,* represent the sixteen lower teeth with the section through their long diameters, as in the upper series. These incisors illustrate the compressed or flattened condition of their roots in contrast with the cylindrical character of the roots of the upper incisors, while the bicuspids *d e* and *d e* illustrate the singleness of their pulp chamber and the cylindrical condition of their roots as in contrast with the flattened or compressed condition of the roots of the upper bicuspids. The molars *f, g, h* and *f, g, h* represent sections through the anterior root, illustrating its compressed condition and divided pulp chamber in the first and second molar, and a somewhat flattened one in the anterior root of the third molar: *f f, g g, h h* and *f f, g g, h h* represent the single and cylindrical pulp chamber in the posterior root of the lower molars, while *b b, c c* and *a a, b b* represent the incisors and canines of the same series, with modified pulp chambers arising from modified development.

FIG. 403.—Fig. 1, from *a* to *h* and *a* to *h,* represents the upper teeth, with transverse or horizontal section through the base of the pulp chamber in the crown, viewing the entrance to the canals of the several roots, while the same letters in Fig. 2 represent the lower series in the same manner.

Fig. 3 represents the upper teeth, with the transverse or horizontal section made below the largest diameter of the pulp chamber and through the canals after they have diverged from the central chamber, but before the roots into which they run have in the molars bifurcated.

Fig. 4 in like manner represents the lower series, well illustrating the flattened or compressed condition of the canal in anterior roots of the molars and the division of the chamber, as is frequently found in the roots of the lower incisors.

The letters *a a, b b, c c, d d, f f, d d* and *e e* (Fig. 3) represent the relative shapes, whether circular, oval, or flattened, of the pulp canal in the roots of the upper central and lateral incisors, the canines, the first and second bicuspids, and the first, second, and third molars, while the same letters in Fig. 4 represent the relative shapes of the pulp canal in similar teeth in the lower series.

[1] These figures are taken from v. Carabelli's *Anatomie des Mundes.*

Fig. 401.
(For description, see page 442.)

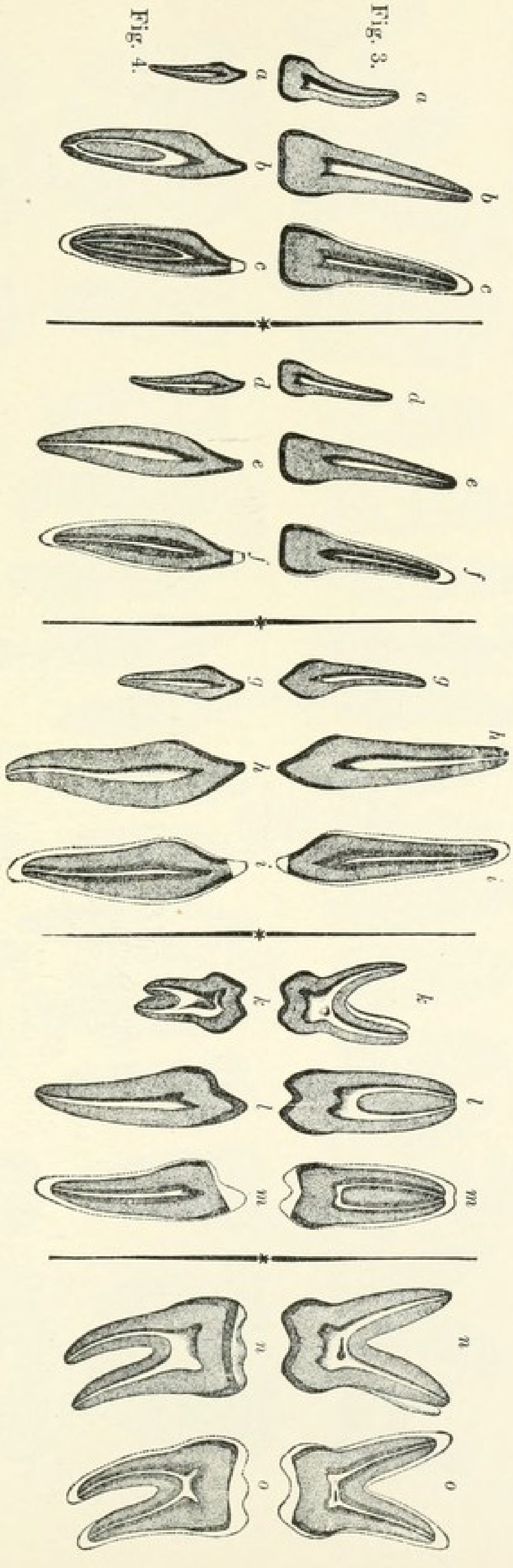


Fig. 402.

(For description, see page 442.)

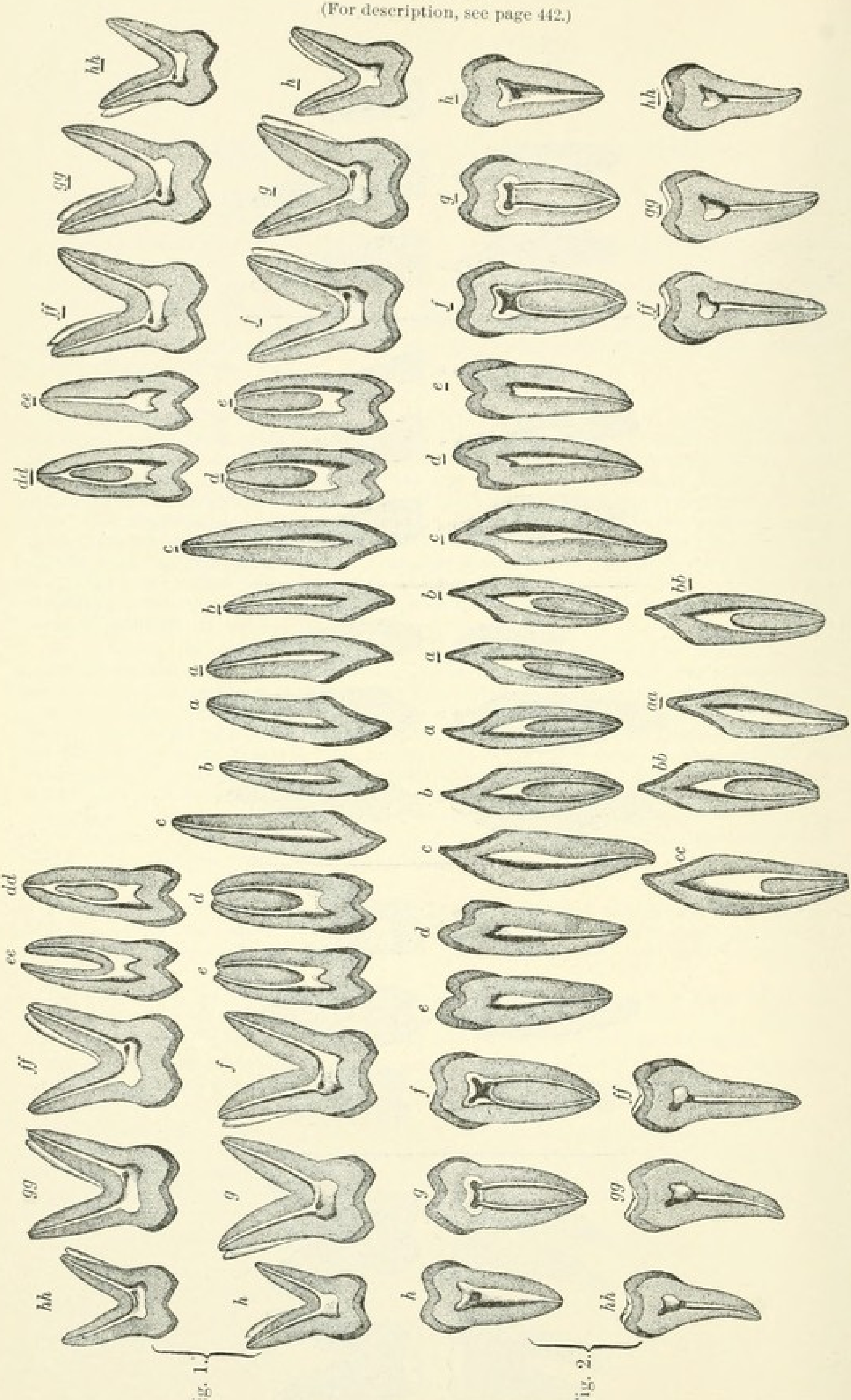
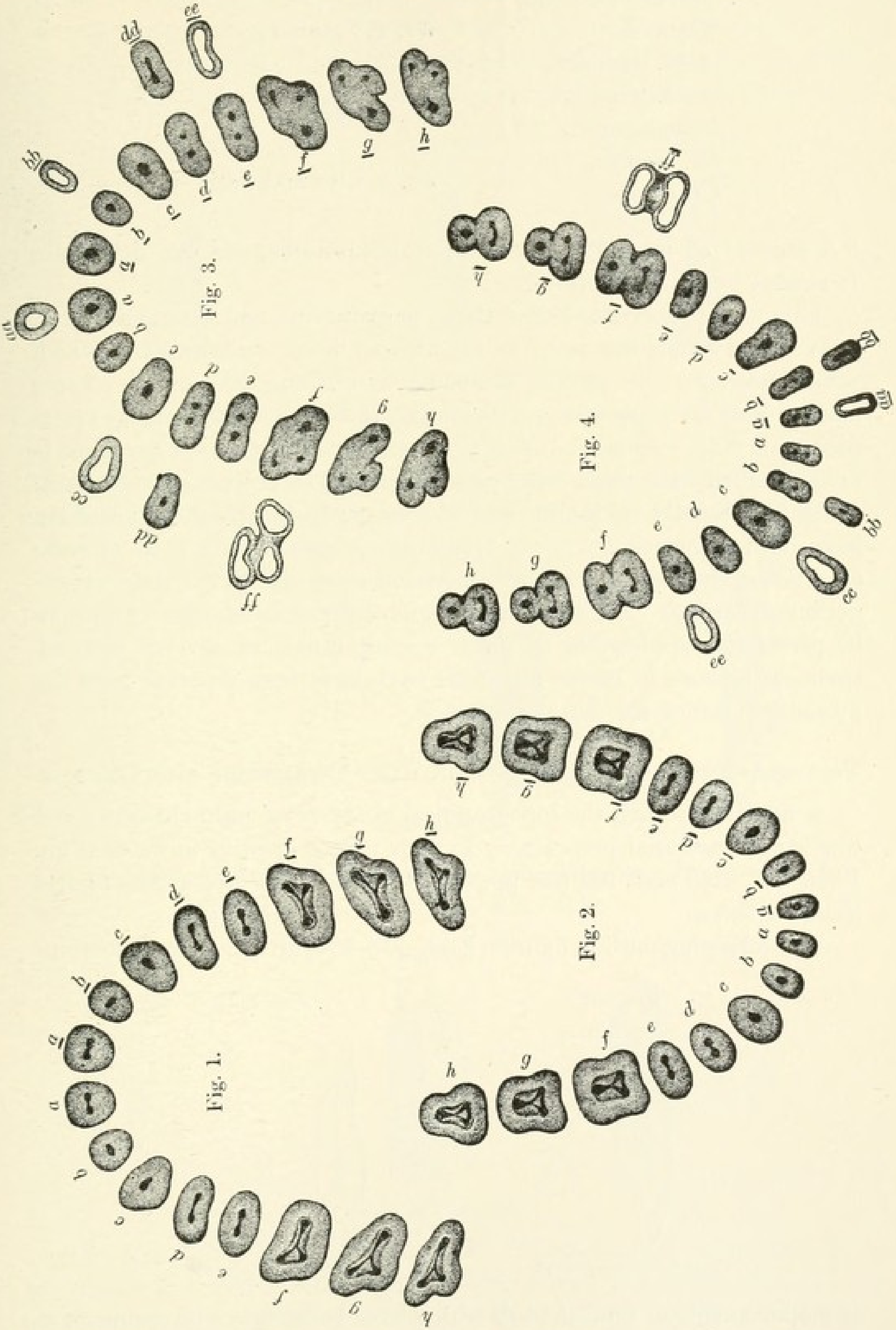


Fig. 403.

(For description, see page 442.)



℞. Mercuric chlorid, Thymol, Acid. carbolic.,	*āā*. 2.0 grams ;
Acid. tannic., Morph. mur.,	*āā*. 1.5 gram ;
Ol. menth., Ol. cassiæ,	*āā*. q. s. to make stiff paste.—M.

"A tannate of mercury is formed ; it is insoluble, and but little pain is caused by its absorption."

It is to be understood that these preparations and this method of pulp preservation are only to be utilized when reasons exist which would preclude the perfect cleansing and filling of canals. These reasons may be economic or the impracticability of thoroughly extirpating all pulp remnants. Failing in perfect extirpation, the paste is to be packed into parts where the irremovable pulp remnants exist.

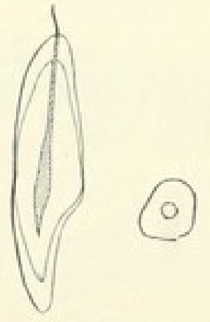
Quite recently formalin and its isomeric modification paraform have been suggested for use as mummifying agents, with some promise of satisfactory results, but these substances are still in the stage of experimental study. The irritating nature of formalin suggests caution in its permanent application to pulps or pulp canals, as several cases of chemical necrosis of tissues about the teeth have been reported from the injudicious use of the drug in question.

Topographical Anatomy of the Pulp Chambers and Canals.

A familiarity with the topographical anatomy of pulp chambers and canals is an essential preliminary to their proper opening and cleansing. Figs. 401, 402, and 403 (see pp. 443–445) illustrate the average pulp-chamber forms.

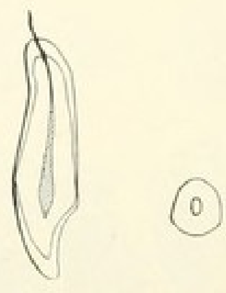
The following outline figures (Figs. 404–439) are exact reproductions

Fig. 404.



Upper central incisor.

Fig. 405.



Upper lateral incisor.

of sections made of typical teeth which have been shown by comparison with numerous other sections to be about the average anatomical forms.

The Upper Central Incisor.—The pulp chamber (Fig. 404) approximates in form that of the tooth itself. The opening of the canal is seen to be almost circular, and in the central axis of the tooth.

Upper Lateral Incisor.—The chamber of the lateral incisor (Fig. 405) has a similar form; the canal exhibits a tendency to diverge from the

FIG. 406.

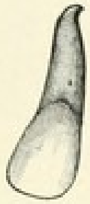


FIG. 407.

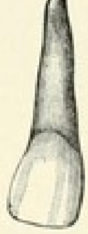
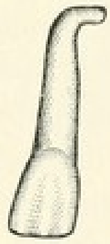


FIG. 408.



Upper lateral incisors (Ottolengui).

straight line toward the apical end (see Figs. 406–408). The entrance to the canal is nearly oval.

Upper Canine.—The chamber of the upper canine is large and open and has an elliptical canal entrance (Fig. 409). The root of this tooth

FIG. 409.

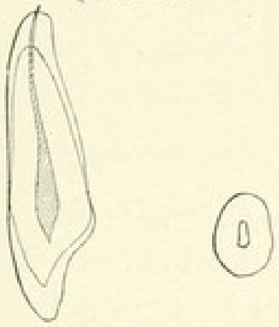


FIG. 410.

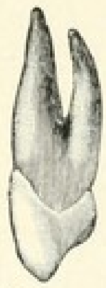
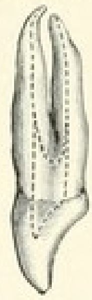


FIG. 411.



Upper canines.

may also deflect from the line of the general axis. In rare cases a bifurcation of the root is seen (Figs. 410, 411).

FIG. 412.

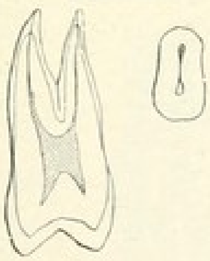


FIG. 413.

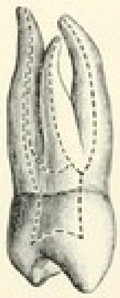
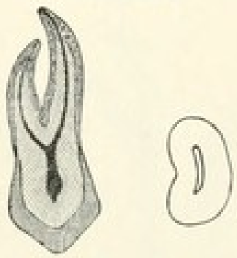


FIG. 414.



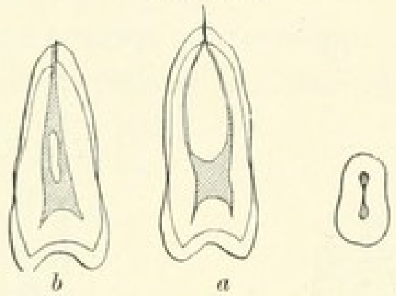
Upper first bicuspids.

The upper first bicuspid very commonly exhibits a bifurcation of the roots which may extend to any distance toward the crown (Fig. 412). At its entrance the pulp canal has a dumb-bell form, the handle of the dumb-bell being much attenuated. The distinct canals may begin almost at the base of the chamber, or be evident only near the apices of the roots. Two distinct canals may be present even in the absence of bifurcation of the root. The roots of this tooth may be much curved. Fig. 413 presents a condition occasionally seen: a trifurcation of the root of a bicuspid. Fig. 414 represents a section through the buccal roots; Fig. 414 also shows the neck section of the tooth. In the same mouth were found three bicuspids exhibiting the same condition. The bifurcated cuspid, Fig. 411, was from the same denture.

Upper Second Bicuspid.—Sections of two typical forms of upper second bicuspid are shown in Fig. 415, *a* and *b*. In such a case as *b*—far from uncommon—it will readily be seen what dangers exist as to the difficulty of perfectly filling the flat general canal beyond the elliptical obstruction. The neck section in both types is almost alike.

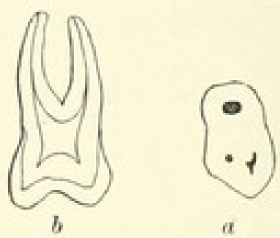
Upper First Molar.—The neck section of the upper first molar

FIG. 415.



Upper second bicuspid.

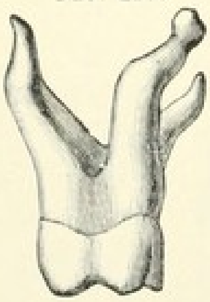
FIG. 416.



Upper first molar.

(Fig. 416, *a*) shows a free entrance to the palatal root; the anterior buccal root has a triangular entrance, near the mesio-buccal angle of the tooth. The entrance to the disto-buccal root is very small; *b*, Fig. 416, shows a section through the buccal roots of the tooth. Cases are occasionally seen where a short crown is associated with very long and divergent roots (Fig. 417).

FIG. 417.



Upper molar.

FIG. 418.

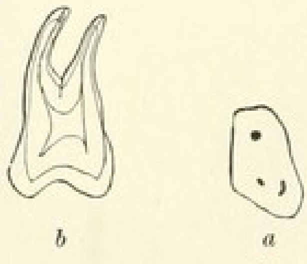
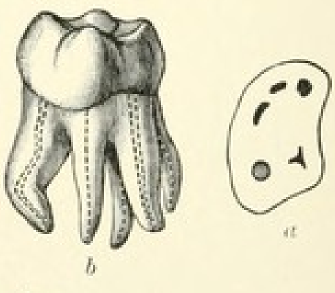


FIG. 419.



Upper second molars.

Upper Second Molar.—The arrangement of canals in the second upper molar (Fig. 418, *a*) is much like that in the first; except that the tooth has a compressed form which brings the canal entrances closer together. A section through the buccal roots is seen in Fig. 418, *b*. This tooth occasionally presents marked aberrations in the location and distribution of pulp canals. Fig. 419 illustrates a case in which there was a trifurcation of the palatal root. Other abnormalities of the canals of upper molars are shown in Figs. 420–425 (Ottolengui[1]).

Fig. 420.

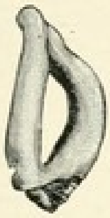


Fig. 421.

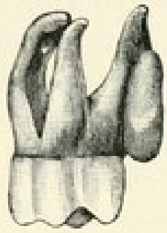


Fig. 422.

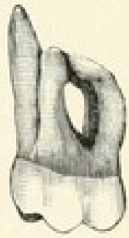


Fig. 423.

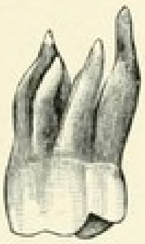
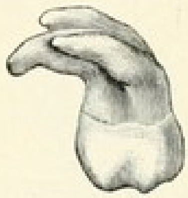


Fig. 424.

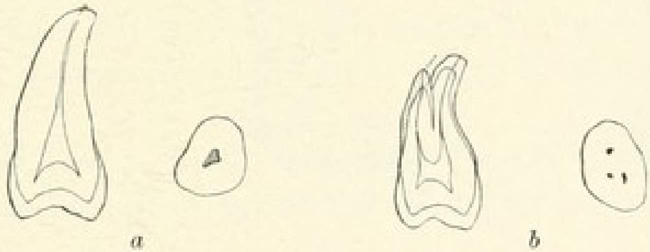
Fig. 425.



Upper molars (Ottolengui).

Upper Third Molar.—The three roots of the upper third molar are frequently compressed together, giving the external appearance of a

Fig. 426.



Upper third molars.

single round conical root. In many instances there will be found but a single large canal, as in Fig. 426, *a*. The rule is three canals, as

Fig. 427.

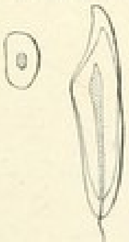


Fig. 428.

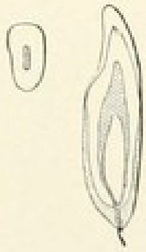
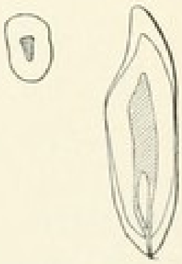


Fig. 429.



Lower incisors and canine.

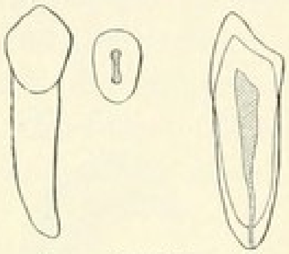
shown in Fig. 426, *b*, which shows also a section through the buccal roots. The root is generally curved backward more or less.

[1] *Methods of Filling Teeth.*

Lower Anterior Teeth.—The forms of the canals and canal entrances to the lower anterior teeth are shown in Figs. 427–429. The form of partial canal bifurcation shown in Figs. 428 and 429 is noted frequently in longitudinal sections of typical teeth.

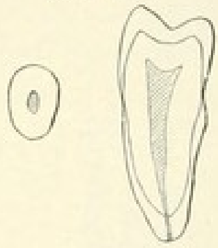
Lower Bicuspids.—The forms of the canals in the lower bicuspids are much alike; the canal of the first, however, exhibits a tendency to the dumb-bell form of entrance (Figs. 430, 431). Tortuosities of the

Fig. 430.



Lower first bicuspid.

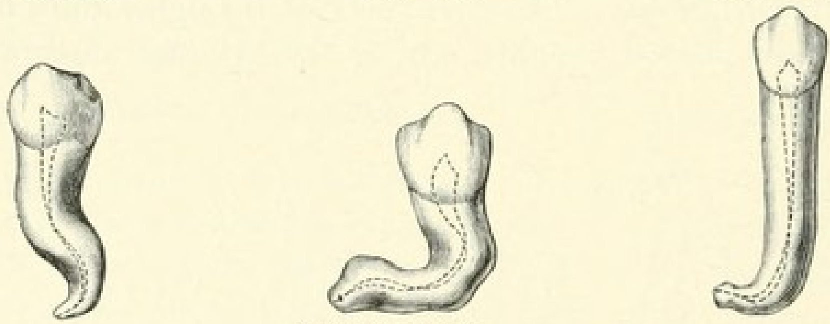
Fig. 431.



Lower second bicuspid.

canal are far from uncommon, many of them of such nature as to render full and complete entrance to their ends next to impossible; in

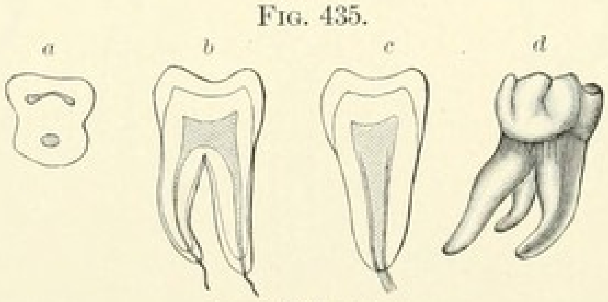
Fig. 432. Fig. 433. Fig. 434.



Lower bicuspids.

Fig. 432 the root was of corkscrew form, in Fig. 433 bent at right angles, and in Fig. 434 a short crown is associated with an extremely long and bent root.

Fig. 435.



Lower first molars.

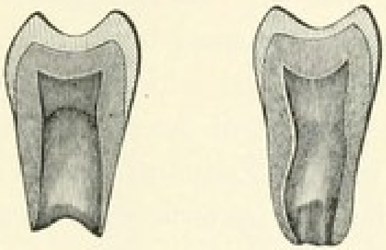
Lower First Molar.—The lower first molar usually presents two canals: a large open canal for the posterior root, as seen in Fig. 435, *a* and *b*, while the anterior root presents a flat ribbon-like canal very difficult of entrance. A transverse longitudinal section of the anterior root is shown in Fig. 435, *c*. In order to effect an entrance to the majority of these canals it is absolutely essential that the rubber dam be applied and the tooth well dried. A section through both roots is shown in Fig. 435, *b*. Not uncommonly two distinct anterior canals are found, and in rare instances two distal roots may be present, as shown in Fig. 435, *d*. The roots of this tooth, as those of the other lower molars, as a rule, bend backward. Fig. 436 (from Ottolengui) shows an exaggeration of this bending.

This tooth not infrequently requires canal treatment before the roots are fully formed. A section through the anterior half of an immature

Fig. 436.

Lower first molar.

Fig. 437.



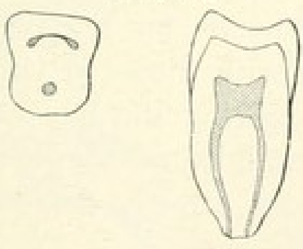
a *b*
Lower first molar, immature.

tooth is shown in Fig. 437, *a*; through the posterior half, Fig. 437, *b*.

Lower Second Molar.—A section of the lower second molar resembles that of the first, but distinct double canals in the anterior root are more frequently seen, as shown in the section of the anterior half in Fig. 438, *b*.

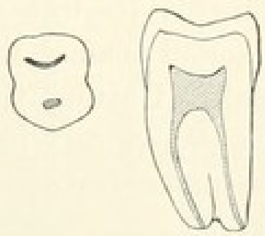
Lower Third Molar.—In the lower third molar the roots are frequently compressed together, exhibiting bifurcation toward their apices (Fig. 439).

Fig. 438.



a *b*
Lower second molar.

Fig. 439.



Lower third molar.

The canals of any tooth may exhibit constrictions or flexions at any points of their lengths. Although there is no absolute indication as to the presence of flexions or abnormal lengths, an examination of the overlying gum should always be made, when lengths and irregularities may possibly be determined if the gum tissue and alveolar wall be very thin. If any of these irregularities be present it is important that they be discovered and additional care be taken to effect a complete entrance to the canals.

Instruments for Canal Treatment.

The description thus far has included the territory to be operated upon and its condition as regards sepsis, the agents commonly employed to produce asepsis and antisepsis, and those applied to maintain these conditions. The first, the condition of the root canals and dentin; the second, the various antiseptics employed therein; the third, the several materials used as canal fillings. The next study includes the instruments employed and their specific applications.

The first are *enamel chisels*. These are employed to cut down weak unsupported enamel walls and those portions of enamel removable by such instruments, which interfere with direct access to the pulp canals. The next, *burs*, of several forms; the first, that known as the "dentate fissure bur," for cutting enamel; next rose, inverted cone, and oval forms for enlarging cavities and removing infected dentin. Next, several forms of *broaches*, *canal cleansers*, and *probes*, Gates-Glidden *reamers* for enlarging canals; *syringes*, *pluggers*, and finally *rubber dam* and the appropriate selection of *clamps*.

In relation with this latter device, it is to be recalled that demonstrations have shown the saliva to be a highly infective fluid, for the reason that it contains a variety of pathogenic organisms which must be excluded from pulp canals if asepsis of these passages is hoped for. No other single means serves so effectively as isolation by the rubber dam.

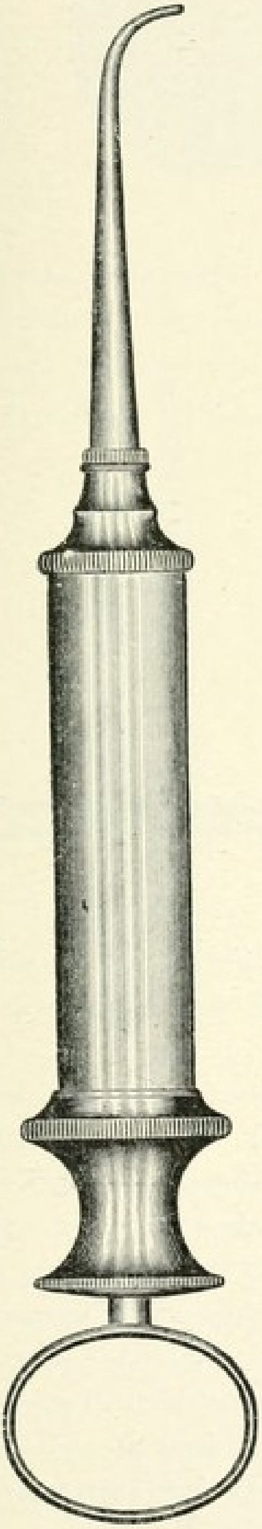
A variety of syringes will be required, a large instrument for irrigation (Fig. 440), to wash away loose débris which may be present in the cavities; smaller syringes will be required to accurately place definite quantities of medicaments in canals (Figs. 441, 442, and 443).

Dentate fissure burs are invaluable instruments for removing portions of sound enamel walls which interfere with direct access to the root canals. Cutting from within outward, giving the bur a sawing motion, a groove may in a few minutes be extended across the occlusal face of a molar from a distal cavity to a point directly over the anterior root.

Large rose, inverted cone, and oval burs are employed to remove the dentin which may obstruct direct entrance to the canals; these are as a rule to be used with a draw-cut, placed first in the deepest portion of the cavity, and while revolving drawn toward the operator. Care is to be exercised that no more than necessary of the walls, particularly the floor of the pulp chamber, is to be burred away, to avoid mechanically weakening the tooth.

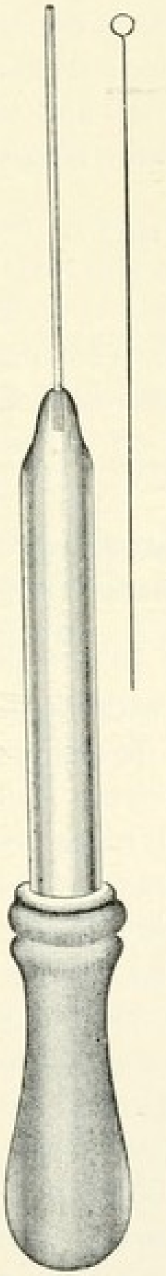
The broaches employed are of several forms. A broach is, accurately speaking, an instrument designed to enlarge openings; so that the

Fig. 440.



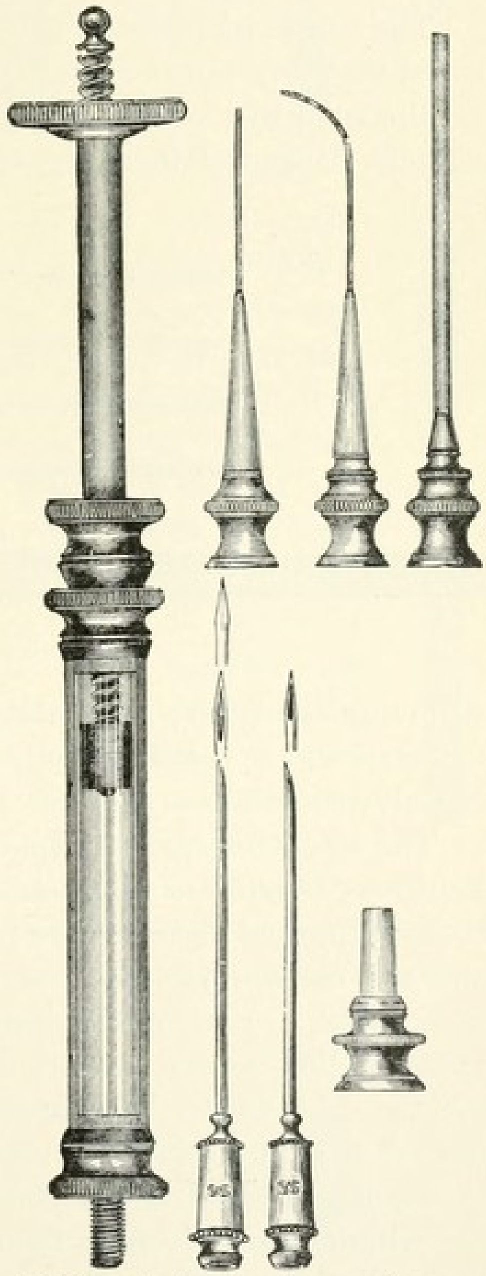
Dental syringe.

Fig. 441.



Minim syringe.

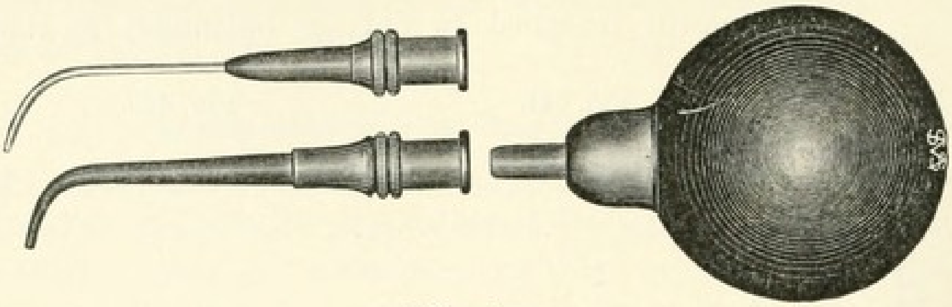
Fig. 442.



J. N. Farrar's alveolar abscess syringe.

barbed nerve broach is not employed as a broach but as a pulp-extractor (Fig. 444). They and other forms of extractors (Fig. 445) are used to loosen and remove débris from canals.

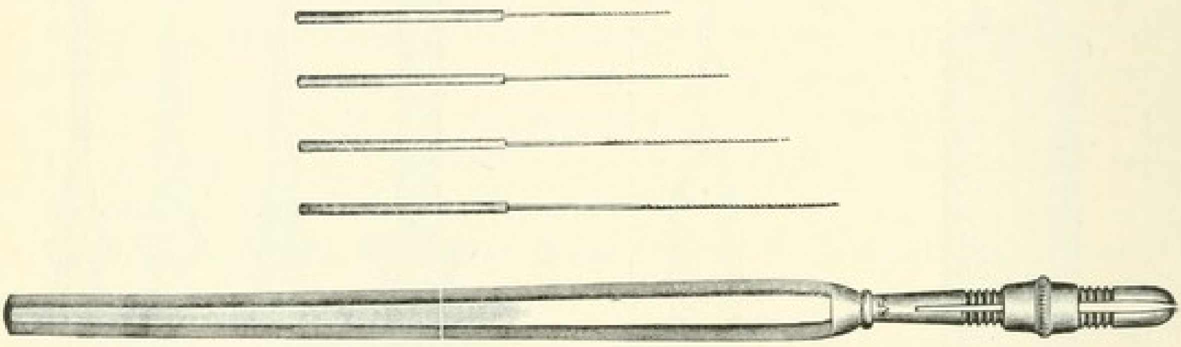
FIG. 443.



Bulb syringe.

The toughness of these instruments is remarkable. They are so tempered that they can be bent in any desired direction and when properly manipulated will readily follow a small and crooked canal to the apex without danger of breaking off. Two forms: with sharp hooks, for

FIG. 444.



Barbed pulp-extractors and holder.

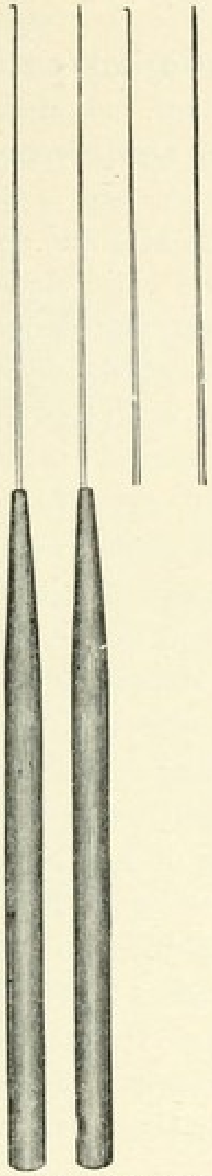
removing the pulp; and straight, with the ends slightly roughened, for carrying a shred of cotton in cleansing out the canal or treating alveolar abscess.

The next instruments employed in this connection are what are known as Donaldson's pulp-canal cleansers (Fig. 446). The points of these pulp-canal cleansers are reduced so as to enter the canal readily, and the barbs, which are cut of just sufficient depth to accomplish their work, are arranged spirally around the shaft, in effect forming a screw, so that no two cuts are exactly opposite each other (see enlarged view, *a*, Fig. 446). With ordinarily careful usage these cleansers will remove the pulp substance perfectly, without liability to be broken or to become fastened in the canal. If at any time the instrument does not withdraw readily from the root, a turn or two to the left (unscrewing) will at once release it.

Made of tough steel piano-wire, with polished rubber handles; also without handles, to be used in broach-holder.

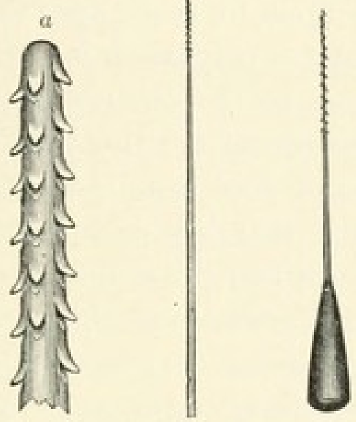
The enlarged view of the Gates-Glidden nerve-canal drill (Fig. 447) shows the peculiarity of the safety Glidden point, which will not

Fig. 445.



Dr. Donaldson's spring-tempered nerve-bristles.

Fig. 446.

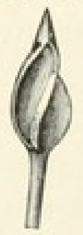


Dr. Donaldson's pulp-canal cleansers.

enlarge the canal, but will merely guide the drill into a canal no wider than itself, until it reaches the root-apex, through which only the sharp point will pass, and produce a sensation of pain that gives notice of its protrusion; yet, unless the foramen is wider than the base of the guide, the Gates drill will *not cut through* the end of the root—a danger that the improved drill is specially designed to avoid. The reamers are made with their thinnest part near the junction of shaft and stem, so that should fracture of the *tool* occur, a long piece will be left protruding from the tooth and may be readily withdrawn.

Using the series, one after the other, with care and judgment, even a tortuous canal may be suitably enlarged; but it should be kept in mind that many roots are thin at their apical portions, and their canals, if much enlarged, may be cut through laterally; hence the advisability of employing usually the smaller sizes of drills, and always the smallest first when the canal is narrow.

Fig. 447.



Improved Gates-Glidden nerve-canal drill for engine work.

There is a diversity of opinion as to the wisdom and propriety of using reamers of any kind in pulp canals. They are condemned *in toto* by some operators; others advise their employment in all cases.

The Cleansing of Canals.

The student has been made familiar with the pathological conditions he is called upon to treat, and with his armamentarium, including the medicinal agents employed in their correction, and is now prepared to apply the one to the other.

It is most *apropos* at this juncture that the arguments for and against the reaming of root canals should be reviewed. The valid objections urged against reaming as a routine practice are, first, the danger of encroachment upon the cementum by the reamer; second, the breaking of the delicate reamers in the canal and the difficulty and often impossibility of removing the fragment when such accident occurs; third, the liability of forming false canals by inability to confine the drill to the anatomical canal. The argument advanced in support of the practice is the direct and ready access attained by it to the length of the canal. Owing to the fineness and tortuosity of many canals it is impossible for the operator to assure himself that he has thoroughly cleansed and filled them; by accurately and properly reaming the canals directly accessible to fine reamers they are given such form that a filling may be placed with a reasonable assurance that the apex is hermetically sealed. It is urged that as many roots—notably the anterior roots of lower molars, the anterior buccal roots of upper molars, the roots of upper bicuspids and of lower incisors—have a flattened form, their pulp canals have a ribbon form. In reaming such canals there is danger of the reamer impinging upon the cementum at the thin portion of the root. The advocate of root reaming, therefore, advises in such cases the employment of Donaldson's canal cleansers to scrape away the canal walls, enlarging them uniformly.

The danger of breaking reamers is always an imminent one, although such accidents are commonly due either to poorly made or imperfectly tempered instruments, or to carelessness upon the part of the operator. Even the most skilful must be ever on the alert to detect any unusual resistance offered to the advance of the reamer. This danger increases if the direction of the canal diverges from a straight line. It is obvious that with any instrument which is being rotated, its point must be kept in line with its shaft to minimize the strain on the part immediately above the cutting portion.

The employment of reamers is therefore advised only in nearly straight and rounded roots; the central idea to keep in mind is that reamers are employed merely to uniformly enlarge canals which already exist, never to form new ones. Root canals which have a flattened form are enlarged by means of the cleansers, using progressively increasing sizes, and supplementing their action where and when necessary with sulfuric acid, as advised by Dr. J. R. Callahan.[1] This method is of great value; it furnishes a means for entering and thoroughly cleansing and enlarging canals which before its introduction were regarded as impossible of entry.

It has no doubt been observed by every operator, how seldom roots which have been well prepared for artificial crowns of the post variety become the seat of pericementitis. This fact suggests that the mechanical removal of the existing boundary walls of the root canals, by removing those portions of dentin invaded by septic organisms may lessen the opportunity of sepsis. Miller has shown[2] that this infection of dentin about canals is, as a rule, superficial (Fig. 448). The observations made in the essay of Dr. Miller show also that any danger to the lateral pericementum by invasion of the dentinal tubules leading from the root canal is remote in the extreme. Infection to some depth does occur, however (Fig. 449). It is undisputed that the source of septic infection of the pericementum is from the canals by way of the apical foramen,

Fig. 448.

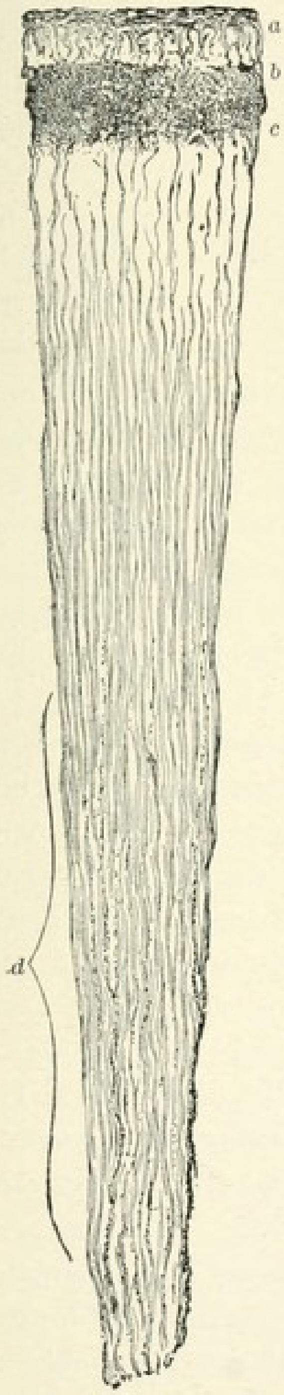


Fig. 449.

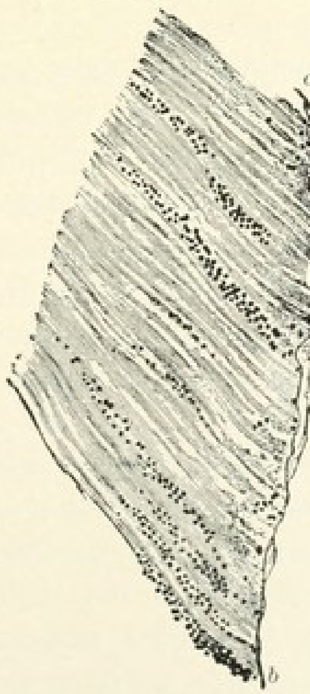


Fig. 448.—Sector of a cross section from a diseased root: *a*, cement; *b*, stratum granulosum; *c*, very narrow and finely branched tubules; *d*, infected district. ($\times$ 150.)

Fig. 449.—Dentin from the root of an abscessed tooth, showing the penetration of cocci to a depth of about $\frac{1}{10}$ mm. ($\frac{1}{250}$ in.). The side *a–b* bordered upon the canal. ($\times$ 1000.)

[1] *Proc. Ohio State Dental Society*, 1894.

[2] *Dental Cosmos*, 1890, p. 353.

and if the tract there represented be made aseptic no trouble need be feared.

As the object in all succeeding operations is to remove and not to institute a septic condition, care must be exercised that no septic organisms be introduced by the operator into the field of operation. The first step is therefore the rendering aseptic of this field. The teeth should be cleansed first with a brush and soap, then the mouth be rinsed with an antiseptic, as 3 per cent. pyrozone, 10 per cent. solution of meditrina, or a lilac-colored solution of potassium permanganate. The instruments are to be sterilized, and to effect this object an excellent means is by dipping the mechanically cleansed instruments in strong ammonia water.[1] If any food or pulp débris occupy the pulp chamber it is to be washed away with the antiseptic employed to sterilize the mouth. The rubber dam is adjusted, and direct sterilization of the canals, and, when indicated, of the tissues at the apex of the root, is to be attained.

Method of Entrance to Canals.—The first step or stage of the operation is the gaining of direct and free access to every canal of the tooth. This may at times appear to involve the removal of an undue amount of the crown of the tooth. Unfortunately this is true, but efforts at the conservation of too much of the crown structures and form are frequently followed by incomplete cleansing and filling of the canals. This latter is the greater evil of the two, so the cutting away of the crown is always to be done when necessary to accomplish the end in view.

In the vast majority of cases in which it is necessary to remove a putrescent or septic pulp the carious process has invaded the crown of the tooth extensively; the cavity of decay is therefore excavated until perfectly free from carious dentin; weak enamel walls are dressed away by means of enamel chisels, and usually direct access to the pulp chamber is gained. This is still insufficient; the cavity must be opened so that the finest size of canal bristle can be carried directly to the apex of the root without danger of fracturing the instrument.

In central incisors, as the carious cavities usually open upon the approximal surfaces, entrance is gained to the pulp chamber by extending at the palatal aspect of the cavity a groove from the cavity to over the entrance of the pulp chamber (A, Fig. 450).

The same rule is observed with the lateral incisors and canines. Should the pulp have died subsequently to the insertion of fillings which are mechanically faultless, entrance to the pulp canal is made in the basilar pit (B, Fig. 451). For canines the opening is made at a higher point, about one-third the way toward the cutting edge. These openings, while they should be large enough to afford free access to the

[1] See also Chapter IV.

canals, should not be made so large as to weaken the crown, or there is danger of fracturing it when in physiological use.

Cavities in bicuspids invading the pulp are usually upon the approximal surfaces; they are to be extended over the occlusal face of the tooth until access to the canals may be had (see Fig. 452).

Fig. 450.

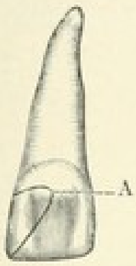


Fig. 451.

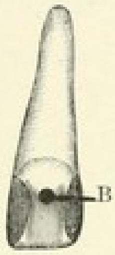
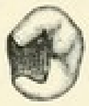
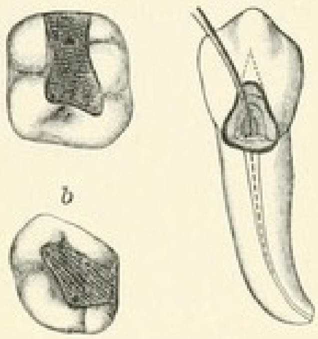


Fig. 452.



Cavity in bicuspid.

Fig. 453.



The same procedures are to be followed in molar teeth. In lower molars if the carious cavity be upon the distal wall, it is to be artificially lengthened across the occlusal face until the probe may be carried directly into each canal (Fig. 453, *a*); the same method is pursued if for a mesial cavity. In upper molars, especial care is required to gain primary access to the anterior buccal root, and tooth structure must be cut away until this access is secured (Fig. 453, *b*). Should the carious cavities open upon the buccal faces of the posterior or lingual faces of the anterior teeth, the upper cavity edge, that farthest from the gum, must be extended toward the cutting edge of the tooth until a bent probe may be readily passed to the apex of each root (Fig. 453, *c*). In operating upon many, or most, of the canals of the posterior teeth it is necessary to bend the pulp extractor or canal cleanser until it is almost or quite at a right angle with the instrument carrier.

In the six anterior lower teeth where openings are to be made in them in the absence of large cavities of decay, entrance is effected through the lingual wall.

The advice of Dr. J. Foster Flagg is appended, as to the position of tap openings to be made in the several teeth, when the teeth if carious have not the carious cavity in such position as to afford access to the pulp chamber:

"By means of a diamond drill or an inverted cone bur, a rough spot is made in the centre of the face to be perforated; this prevents slipping of the spear-pointed drill which is then employed to enter the pulp chamber. The outlines of the chamber are to be obliterated with burs." The dentate bur is a most effective means of enlarging such openings. "The opening is to be enlarged until a fine probe may be passed into each canal; the teeth are tapped in the following situations:

Upper Teeth.—Centrals and laterals: On the lingual face.

Canines: On the tuberosity, or disto-labially.

First or second bicuspids: On occlusal or buccal face.

First molars: On occlusal, or, as a second choice, on buccal face.

Second molars: On occlusal, mesio-occlusal, or buccal face.

Third molars: On mesio-occlusal face.

Lower Teeth.—Centrals and laterals: On lingual face just posterior to cutting edge.

Canines: On disto-labial portion near the gum.

Bicuspids: On mesio-buccal face.

First, second, and third molars: On mesial, buccal, or mesio-occlusal face."

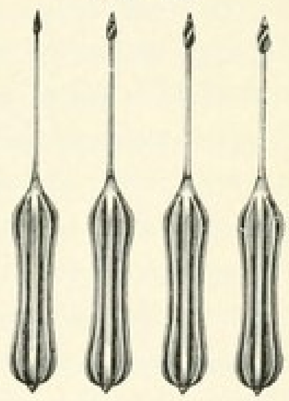
Treatment of Canals.

The tooth and adjacent teeth being isolated by the rubber dam, direct access to each canal having been gained, the tooth having its walls sterilized and each instrument which has been or is to be used being sterilized, the subsequent procedures depend entirely upon the condition of the pulp chamber, canals, and dentin (and perhaps the pericementum), as regards sepsis. One of the several conditions described in the opening of the chapter is present; which of these it is, governs the therapeusis.

First: *A case in which the pulp has been intentionally devitalized and extirpated.* The pulp having been removed *en masse* it has carried with it, provided of course no organisms have been introduced during or subsequent to its extirpation, all of the sources of infection. The remote danger is now the existence of small fragments of pulp tissue which if unremoved might form a soil for the development of organisms obtaining entrance to them; or blood may have escaped into the canals where the dead pulp was torn from its connection at the apex. These must both be removed.

Hydrogen dioxid, being the agent which will most quickly and effectively disorganize the blood corpuscles, is carried into the canals and permitted to act for a few minutes, when it is absorbed by means of cotton, or taper twists of bibulous paper; then canal cleansers, beginning with the smaller sizes, are employed to scrape the walls of the canals free of any adherent pulp shreds or odontoblasts which may have been torn off when the pulp was removed. Larger sizes are to succeed these until the caliber of the canal is made larger and smooth. If it be a round root and there be any interference with the passage of these instruments to the apex of the root, it is evident that the same difficulty would be found in carrying filling material to its apex. A judicious reaming of the root removes this difficulty and is therefore done. That size of the Gates-Glidden reamer which will enter the canal readily is revolved by hand, or, if in the engine, is revolved very slowly, stopping the moment any resistance is felt. The reamer is frequently withdrawn to remove the débris which collects behind it. As soon as resistance is felt, a fine canal cleanser is passed beyond the point and the walls scraped, when the reamer is reapplied; this alternation of instruments is continued until sensitivity shows that the point of the reamer has reached the pericementum. The next size of reamer is then employed to enlarge the canal uniformly. As soon as a canal is reamed a temporary dressing of alcohol on cotton is placed in it to prevent the ingress of débris from other canals—that is, if it be a tooth having two or more roots. In upper molars, the palatal, and in lower molars the distal, root is to be first cleansed and dressed. If the subject of operation be a single-rooted tooth, preparation is now made for hermetically sealing the apex and filling the canal; if a multi-rooted tooth, the canal next in size is entered if the root be round as evidenced by the general shape of the canal. For example, the anterior roots of lower molars, the buccal roots of upper molars or of bicuspids, which exhibit a round opening, have usually but not always a rounded body; those showing a ribbon-like outline are likely to have a corresponding outward form. Any efforts at reaming such canals should be confined to that portion showing a rounded opening; thus, if a lower molar, the finest reamer, rotated by hand, the device of Dr. W. W. Walker (Fig. 454), is employed to enter and enlarge the buccal and lingual extremities of the ribbon-like canals. Any further enlarging should be done with the canal cleansers. The same rule applies to the buccal roots of upper molars and to bicuspids. When any doubt exists, the enlarging should always be done with the cleansers instead of the reamers.

FIG. 454.



Walker pulp-canal reamers.

Not infrequently cases are found in which the root canals, or one of them, may have such contracted caliber as to refuse entrance to the finest canal cleansers. As a rule, such canals will be found in the buccal roots of upper molars and the anterior root or roots of lower molars; occasionally the bicuspids, particularly the upper first bicuspids, will exhibit this condition. It is in such cases that the method of cleansing and enlarging introduced by Dr. Callahan will be found effective. A rose bur is employed to form a small pit of which the entrance of the pulp canal is the centre. In this pit a drop of sulfuric acid, 50 per cent. solution, is placed; immediately upon the contact of the acid the finest size of Donaldson canal cleanser is passed as far as it will go into the canal, the cleanser is inserted and partially withdrawn, scraping away the calcium sulfate formed by the action of the acid upon the calcium salts of the tooth. The acid is quickly neutralized and fresh applications are made drop by drop, the scraping and pumping with the cleanser being continued until the point of the instrument is felt to reach or pass the apical foramen. Any organic matter, such as filaments or minute fragments of pulp tissue, which may have been present in the canal is destroyed. This applies also to organic matter undergoing decomposition or to organisms which may be present. As there is no marked degree of force required in the operation it may be pursued even in cases of pericementitis or acute abscess, to gain direct and free entrance to the seat of morbid action, the focus of germ development.

In the event of the operator being unable to detect through instrumental means the openings of minute canals, Dr. Callahan advises that a pellet of cotton containing a minute portion of acid be placed over the probable situation of each canal and sealed in over night. The following day, when the rubber dam is applied and the cavity dried, the spot of application of acid will be represented by a small white area, in which, if a canal entrance exist, it will be represented by a black dot. A pit is made at this point and acid is applied, when entrance by cleansers is attempted; should failure to gain entrance result, it is most probable that the canal is almost or quite obliterated with secondary deposits formed by a receding pulp, hence no future sepsis is probable. As soon as the cleanser is felt to touch or pass the apical foramen the canals are syringed out with a saturated solution of sodium bicarbonate. Carbon dioxid is disengaged, which drives the débris left in the canals into the pulp chamber, and the acid is neutralized.

Thus far has been described the entrance to and thorough cleansing and uniform enlarging of canals of a tooth from which the intentionally devitalized pulp has been extracted; the immediate question is, What treatment shall now be pursued? Owing to the method of pulp withdrawal, the contents of the dentinal tubules are as yet chemically unchanged; and it scarcely requires argument to demonstrate that, can they be kept in a stable condition, they constitute the best material for occupancy of the tubules. Examining the list of medicaments applicable as preservatives zinc chlorid is the agent fixed upon as the one which will best procure an unchangeable condition of the contents of the tubules. The experiments of Prof. Jas. Truman[1] have shown that this agent quickly diffuses through a capillary tube containing albumin, converting it into a whitish coagulum, an albuminate of zinc, which every anatomist knows to be one of the most efficient of all preserva-

[1] *Proc. Academy of Stomatology, Philadelphia*, 1894.

tives. Anatomical specimens of parts injected with a zinc chlorid solution, and which have been subjected to all the conditions known to favor the development of putrefaction, remained unchanged after the lapse of years. It is advised, therefore—advice endorsed by a majority percentage of operators—that a solution of zinc chlorid be now placed in each canal. A twist of absorbent cotton is dipped in a solution of the salt. Should the apical foramen be large, a weak solution, about 10 per cent., is employed; if fine, the strength of the solution may be 40 per cent. Unless carelessly manipulated or too great an excess of the coagulant be employed there is but little danger of forcing the solution beyond the apex of the root. After about ten or fifteen minutes the application is withdrawn and cotton or paper cones passed in the canal to absorb any excess of the chlorid which may be present, and the canals are now ready for filling.

The Root-canal Filling.

When oxychlorid of zinc has been determined upon as the permanent canal filling, the preliminary treatment of the canal with zinc chlorid solution is superfluous, as the coagulating and antiseptic action of the zinc chlorid used in making the oxychlorid cement fully answers the purpose in the short period of time elapsing before chemical combination of the fluid and powder results in a hardened body.

Examining the available statistics regarding the several materials which have been employed for canal filling in such cases, there is found a greater percentage of success—that is, a fewer number of cases present subsequent evidences of sepsis—when *zinc oxychlorid* has been used. This is quite in accord with rational therapeusis; the material is capable of hermetically sealing the apex and is unchangeable in the conditions surrounding it. Its antiseptic action probably plays little or no continued part, disappearing shortly after the material sets; it is, however, indisputable that when this material has been employed as a pulp capping it has not infrequently converted the entire pulp into a hyaline coagulum which has remained permanently aseptic.

This material is mentioned first on account of the ease, readiness, and certainty with which it may be placed.

Gutta-percha ranks second in point of favor as a canal filling; this not on account of any deficiency of specific properties contraindicating its use, but there is not the same certainty of accurate placement and hermetic sealing as with the oxychlorid. Gold and tin, the remaining materials which have found any extensive employment in such cases, are open to the same common objection, viz. difficulty of manipulation.

These are the practically irremovable materials. The removable materials which have been recommended are, first—

Cotton.—It is due to Prof. J. Foster Flagg that this substance has been extensively employed, not as a filling material *per se*, but as a medium holding an antiseptic. The variety of cotton employed is the crude uncarded cotton wool. Dr. Flagg cites as a proof of the impermeability of this material when properly packed, that bales of cotton which have floated in sea-water for long periods, when opened show no evidences of moisture in their interior.

Evidence regarding the value and danger of this material is conflicting. It is asserted by the advocates of cotton canal fillings that, properly inserted, they remain unchanged for long periods, are readily packed into position, and if necessity demand may be readily removed. Those who oppose the use of cotton assert that it soon becomes filled with products of decomposition, and that after some years the texture of the material is destroyed, rendering its removal very difficult. In consequence of these conflicting opinions, the weight of evidence being with those who oppose its use, cotton has found but limited endorsement.

The other removable materials, salol and paraffin, are innovations too recent to determine their value and position as canal fillings. The reports regarding salol are sufficiently conflicting to warrant advising its use only in conjunction with a central mass of gutta-percha or tin points; the salol filling the space between the gutta-percha or metal point and the walls of the canal.

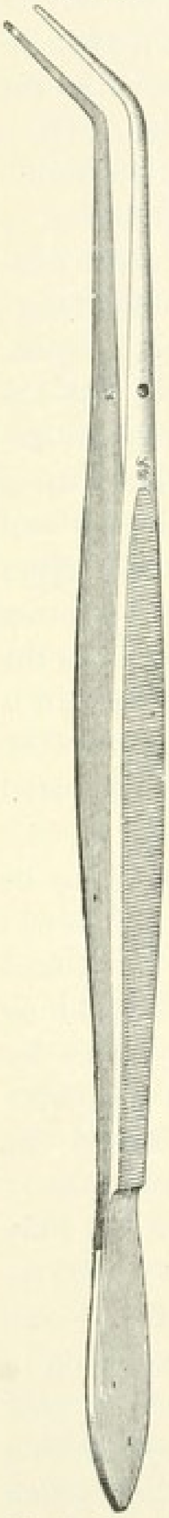
These are the arguments for and against the several materials; the weight of evidence being largely in favor of, first, the oxychlorid of zinc; and second, gutta-percha.

The question is, now, When shall the canals be filled? Shall it be done immediately, or shall a period be permitted to elapse for assurance that no inflammatory action shall arise and the filling be a bar to its prompt reduction? There are two causes which might be productive of inflammatory action: First, the dental manipulations of removing the pulp and cleansing the canals might be productive of sufficient irritation to give rise to inflammatory reaction; in that event the open canal would afford an escape for inflammatory effusions. The second danger would depend upon whether septic organisms had been introduced or had not been thoroughly destroyed; their sealing in the canals might be productive of septic inflammation. If the foregoing measures of cleansing have been followed it is scarcely possible that any organisms could survive. General experience demonstrates that in but a small percentage of cases does the pericementum suffer markedly from traumatism during the cleansing and sterilizing of canals, so that the weight of evidence clearly teaches that such canals may be filled at once, and little or no reaction occur.

Freshly mixed zinc oxychlorid being markedly irritating to vital tissues, it is usual to place between the paste and the tissues of the apical region a barrier to the former. This may be of gutta-percha. A very fine cone of gutta-percha about one-quarter inch long is dipped in oil of eucalyptus or oil of cajuput to soften it; it is then carried to the apex of the root upon a fine probe and pressed into position. Or, a small pellet of cotton is dipped in a strong solution of thymol or aristol. It is extremely probable that when the freshly mixed oxychlorid is placed over it, the cotton becomes converted into amyloid which hermetically and permanently seals the apical foramen; the same change occurs in the cotton upon which the oxychlorid is carried into position. Slender wisps of cotton are rolled thin enough to pass readily into the canals. A thin paste of oxychlorid is mixed, the cotton wisps are rolled in it until the meshes are full, when the extremity of a wisp is caught upon the end of a long, smooth, and slender canal plugger and carried up the canal to contact with the guard at the apex; the plugger is withdrawn about one-eighth of an inch, and that length of the cotton is crimped upon itself; the remainder of the canal is plugged in the same manner until it is full, when the surplus length of the cotton is cut off and bibulous paper is pressed against the canal filling to absorb the surplus zinc chlorid. The floor of the pulp chamber may be covered with the stiffening paste from the mixing slab.

A method by which cotton fiber loaded with the oxychlorid may be carried to the root apex with great accuracy and precision is as follows: The smallest size Donaldson bristle with smooth sides has its hooked end cut off with the scissors and the cut end made flat by rubbing lightly upon a fine Arkansas stone. This may be readily done by grasping the bristle very near to its point between the thumb and index finger and lightly rubbing it back and forth upon the surface of the stone. The bristle is then laid flat upon a glass slab and burnished from heel to point until the surface is perfectly smooth and any burr turned upon the point by the action of the burnisher is fully removed. A few fibers of cotton wool are then held between the thumb and index finger of the left hand, the direction of the fibers being in the line of the long axis of the index finger. The point of the prepared broach is then laid upon the cotton fibers, and both broach and cotton are rolled together between the finger and thumb. The rolling action of the finger and thumb serves to felt the cotton fiber on to the broach, and should be continued until the cotton is evenly felted over the squared end of the broach. The whole operation is done by the left hand. The broach is not twirled into the cotton with the right hand as is ordinarily done where a roughened cotton-carrying probe is used. With a smooth broach and the cotton fiber felted on as described the broach may be pushed forward with considerable force into a canal without puncturing the cotton, which is securely carried as far as the broach will go. On account of the smoothness of the sides of the broach it may be easily withdrawn for a slight distance, and then engaging in the surrounding cotton it is used as a plugger to pack the cotton ahead of it, and the plugging action continues until the material is all packed in place. The adjustment of the cotton to the broach as described really forms a tube-like arrangement of the cotton with the instrument in its central lumen—an arrangement greatly favoring the operation of carrying the cotton into place and enabling the operator to use the cotton or any suitable fiber as a vehicle for canal dressings or for permanent filling in connection with the oxychlorid of zinc cement.

Fig. 455.



Flagg's dressing pliers.

If gutta-percha be the material selected for filling the canal, a careful examination is made to determine whether the apical foramen be comparatively large or very small; in the latter case chloro-percha may be first pumped into the canals; in the former it is wiser to omit the fluid, owing to the possibility of passing it through the apical foramen. In all cases where a canal filling is to be made of gutta-percha cones it is advisable to first lubricate the walls of the canal with one of the antiseptic oils, cinnamon, eucalyptus, or cajuput; these will facilitate the passage of the point to the apex, and as solvents of gutta-percha will soften its surface and permit a more close adaptation to the canal walls. Should the apical foramen be found large enough to admit the pointed extremity of one of the gutta-percha cones, the end of the latter is cut off. The canal is lubricated with the oil, the cone itself dipped in the same medium, its base caught upon the end of a canal plugger, and it is passed carefully into the canal as far as it will go, when the plugger is withdrawn; blasts of hot air from a hot-air syringe are directed against the exposed end of the cone until it is softened, and it is then pressed firmly into position by means of fine pluggers. A sufficient number of cones are added, softened and packed in position, filling the canal flush with the pulp chamber.

In fine tortuous canals it is the usual practice to first pump them full of thin chloro-percha. A portion of the solution is caught between the points of a pair of Flagg's dressing pliers (Fig. 455) and carried to the opening of the canal, when, if the points are opened, the drop of fluid is deposited there; it is then pumped into the canal by means of a fine smooth broach. To minimize the leakage due to the skrinkage of the chloro-percha in hardening, it is advised to thrust into the fluid material in the canal as large a gutta-percha cone as the canal will admit. Dr. Ottolengui advises that the pieces of silk described in the beginning of the chapter be used and an end left projecting into the pulp chamber, when, should removal of the filling ever become necessary, this end may be caught and the entire filling withdrawn.

Should it be designed to fill the canal with gold, its exact length is measured by placing a small disk of rubber dam over a canal plugger, which may be carried to the apex, and inserting the plugger in the canal. The floor of the pulp chamber engages the rubber dam, and when the plugger point has reached the end of the canal the little gauge piece of rubber dam marks its exact length. Minute pieces of soft gold foil are cut, and one by one are carried to the end of the canal, the rubber upon the plugger being the guide to completeness of access to the root apex. This method is to-day rarely followed. Dr. W. S. How advises the use of shredded tin for sealing the apex of canals. By a series of fine probes the canal length is measured (as shown in Figs. 456–460),

FIG. 456.

FIG. 457.

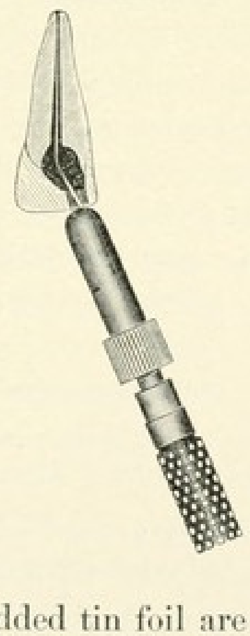
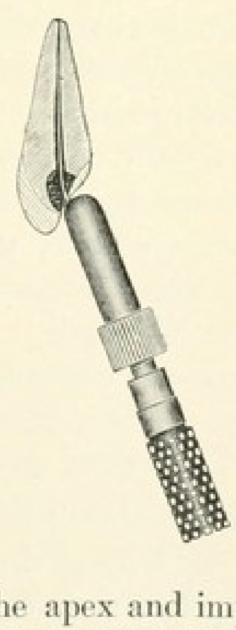


FIG. 458.



and particles of shredded tin foil are carried to the apex and impacted by means of measured probes.

Salol and paraffin are both manipulated after one manner. A very fine probe is passed into the canal to its apex; a portion of the material is caught between the beaks of a pair of dressing pliers (Fig. 455) and held above an alcohol flame until it is melted, when the closed beaks are placed in the canal beside the probe, and opened, and the fluid material runs into the canal. Slowly withdrawing the probe, the fluid runs into the space occupied by the probe, filling the canal to the apex; it is advisable, however, to warm a broach, and by a pumping motion

Fig. 459.

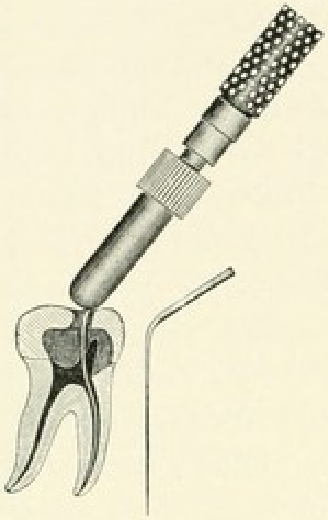
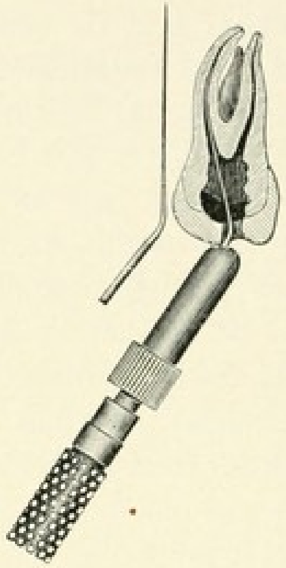


Fig. 460.



insure the carrying of the filling to all parts of the canal. If salol be employed a cone of gutta-percha of such size as may be readily carried to the apex should be thrust into the fluid material, virtually filling the greater portion of the canal with gutta-percha. Several trustworthy observers have noted a disappearance of salol from canals in which it has been placed; the gutta-percha minimizes the risk attendant upon such disappearance. The gutta-percha subserves another purpose: should it ever be necessary to remove the canal filling, blasts of warm air directed against the end of the gutta-percha may be made to melt the salol about it, when the cone may be readily withdrawn. This melting and withdrawal are more quickly accomplished if the central mass be of metal.

Paraffin is unchangeable in the conditions under which it is placed.

Treatment of Root Canals with Mummified Pulps.

The remaining member of the aseptic cases is that of mummified pulp. So long as these cases remain perfectly aseptic they give rise to no symptoms and are, as a rule, uncovered by accident, rarely by design.

Their usual history is as follows: At some time (perhaps years) before, an exposed or almost exposed pulp has been covered with a cap or cavity lining of the oxychlorid of zinc. They have remained comfortable thereafter. At some subsequent time it may be necessary to open the tooth, usually on account of recurring caries: the total absence of dentinal sensitivity is noted, the tooth has changed color but little, if at all, and the operator burs carefully toward the pulp to determine its condition. (It should be remarked here that absence of dentinal sensitivity in a tooth having normal color and which contains a very large filling is an indication of aseptic death of the pulp, and the operator should renew all of his antiseptic precautions as to isolation of the tooth by the rubber dam and complete sterilization of all instruments and of the territory of operation.) The burring is continued without any evidence of sensitivity, and the instrument is finally felt to pass into the pulp chamber. There is no odor, no escape of fluid, the pulp being found dry and shrivelled. If sterilized pulp extractors are passed into the canals, the remnants of the pulp may be withdrawn, exhibiting none of the usual signs of decomposition such as odor and confluent softening.

It is highly improbable that any organisms are present, unless they should have been introduced by the operator from the exterior. The possibility of this occurring should prompt caution, for it is the experience of many that although organisms have not been present in the canals, when introduced from without they find a fruitful soil for development. Reaction indicating infection may occur within a few hours or may be delayed for perhaps two days. This condition may arise even in connection with teeth whose pulps have died under a capping of zinc oxychlorid, from the fact that the quantity of zinc chlorid used in the capping material was insufficient to completely saturate the pulp tissue and render it permanently antiseptic. It is advisable, therefore, to cleanse the canals with some powerful and penetrating antiseptic to destroy any chance organisms and to insert a probationary though perfect root filling until the time of danger has passed. The antiseptic which meets the indications is the ethereal 25 per cent. solution of hydrogen dioxid known as pyrozone, permitted to remain in the canals for several minutes. The canals are then dried, and for the temporary filling salol is the rational indication. At the expiration of three days if no evidences of pericementitis are present the operator may remove the salol, reapply the antiseptic, and fill the canals with oxychlorid or with gutta-percha.

The use of formalin (40 per cent. aqueous solution of formic aldehyde) should be mentioned in this connection. A 5 per cent. solution placed in the canals is a coagulant antiseptic which quickly and certainly penetrates into and sterilizes the finest recesses.

Septic Cases.

The second great class of cases, the septic, comprises those in which the pulp has undergone some extent of decomposition. As a rule, the first organisms which invade pulp tissue are the staphylococci and streptococci, which find a suitable habitat in the live pulp. Advancing first along the lines of the veins, their toxic waste products causing inflammation, the organisms invade, peptonize, and liquefy the inflammatory effusions. As these cocci advance toward the apex of the root, the necrotic and altered tissues which are left behind become the breeding-ground of other organisms, particularly the bacteria of putrefaction. The altered portions of pulp tissue are decomposed into products of progressively simpler chemical composition, until all of the albuminous substances have been transformed: first peptones are formed, further decomposition produces ptomains, next such bases as leucin, tyrosin, and the amines, together with fatty acids;[1] finally the end products are hydrogen sulfid, ammonia, carbon dioxid, and water (see Fig. 398). "*Fermentation and putrefaction can only occur where the fungi concerned live, and the extent of decomposition is conditioned by the number of fungi*" (Ziegler).

As there are several distinct types of decomposition, so is there a corresponding number of varieties of organisms. The septic cases may be divided into two classes: First: Those in which septic invasion has not passed beyond the apical foramen and given evidence of pericemental irritation or inflammation, these tissues being threatened though not invaded. Second: Those in which the pericementum has become the seat of septic invasion. This latter class is subdivided according to the nature and extent of the septic processes: the first subdivision comprises cases of acute pericementitis non-purulent; the second, of chronic pericementitis without evident pus formation; the third, of purulent pericementitis, which may be either acute or chronic.

1. In the first of the first class of these cases—those in which the suppurative process has invaded the pulp to near its end—the necrotic portions of the pulp are undergoing putrefactive decomposition. Toward the end of the process, when the apical portion of the pulp is invaded, it is not uncommon to find evidences of pericemental irritation; this frequently ceases spontaneously, as though the irritation had caused the formation of a barrier between the tissues of the apical region and the suppurating pulp. An increasing discoloration of the dentin shows the contents of the dentinal tubules to be also undergoing decomposition. It is necessary to remove this mass, destroying the products, the causes, and the soil of decomposition: this without carrying infection to the vital tissues beyond the apex. When the odor of hydrogen sulfid may be detected, it is evidence that the ultimate decomposition of albuminous matter is in progress. As it is quite probable and an imminent danger that organisms might, upon a broach injudiciously employed, be carried from the body of the putrescent

[1] Ziegler, *General Pathology*, 1895, p. 437.

mass to the apex of the root, it is the part of wisdom and prudence to destroy the organisms as a primary measure. There is no quicker or effective means of destroying H_2S, and probably the causes leading to its production, than applications of iodin. The reaction involved in the decomposition of H_2S by iodin was pointed out by Dr. W. F. Litch:[1] "In passing a stream of hydrogen sulfid through tincture of iodin, the latter element seizes upon the hydrogen, forming hydriodic acid, which remains in solution, the sulfur falls as a precipitate; the solution is decolorized." Any excess of iodin which remains may be readily removed by an application of ammonia water, a solution of ammonium iodid being formed which may be readily washed away.

A penetrating antiseptic is now indicated, to sterilize to as great a depth as practicable. A 10 per cent. solution of formalin fulfils this indication. It is permitted to act for some time. The contents of the canal are scraped away, never pushing the broach by which the scraping is done, for fear of carrying organisms deeper into the canal. As the end of the canal is approached 5 per cent. formalin is substituted.

As stated, septic canals contain certain fatty bodies and derivatives of albumin, together with more or less partially disorganized pulp tissue and a mixed bacterial infection. Examining the list of therapeutic agents it is seen that one of them, sodium dioxid, possesses properties capable of neutralizing each of the offending elements. This material may be employed either in the solid form or in solution. Solutions of sodium dioxid must be made with great care to prevent escape of the oxygen. A tumbler of distilled water is set in a vessel containing ice-water; into the distilled water the sodium dioxid is dusted very slowly in small amounts. Each addition is attended by the evolution of heat.[2] The sodium dioxid is added to the point of saturation, and reduced to the desired percentage strength by additions of distilled water.[3]

A drop of the saturated solution is placed upon a wisp of asbestos fiber (as it destroys cotton fiber) and is carried into the canal; in a few moments the cavity may be syringed, and a deeper application of the dioxid solution made—this time of 50 per cent. solution. Each time the asbestos is removed it is seen that the discolored dentin surrounding the canal becomes whiter; the discoloring matter in the tubules has been destroyed.

When a broach may be passed freely to the apex of the root, and the solution comes away clear from the root, sterilization is presumably

[1] *Dental Cosmos*, 1882.

[2] Dr. Wm. Trueman advises that the soldered lid of the can containing the oxid be perforated as a pepper caster, and the sodium dioxid shaken into the distilled water through the perforations.

[3] E. C. Kirk, *Dental Cosmos*, vol. xxxv. p. 195; F. T. Van Woert, *ibid.*, vol. xxxvi. p. 499.

complete. A 10 per cent. solution of sulfuric acid is pumped into the canals by means of iridium broaches; this neutralizes any free alkali which may be present. The canal or canals are next washed out with hot distilled water, dried with cotton, filled with alcohol, and well dried by blasts of warm air.

Many operators immediately and permanently fill such canals; however, as there is the possibility that sterilization may not be absolute, it is the usual practice to fill the canals tentatively yet perfectly. Salol and a metallic point make an excellent canal filling in such cases. When the canals and dentinal walls are dried by means of the alcohol and warm blast they are filled with salol made very fluid, and the metallic point thrust into the canal containing it. Some slight pericemental disturbance may follow, but quickly subsides under the influence of a counter-irritant applied to the gum over the root (tr. iodin., tr. aconit. et chloroform. *āā. pars æq.* The crown cavity is sealed with sticky temporary stopping for a few days, when if the condition of the pericementum is found normal, the salol filling is removed (if the operator desires) by heating a pair of tweezers and grasping the protruding end of the metal cone. It is the general practice to then fill the canal with oxychlorid or gutta-percha.

Should the case present evidences of profound change in the contents of the tubules, *i. e.* much discoloration, the 50 per cent. solution of sodium dioxid may be sealed in the canal for a day; the next day the canals are syringed freely with an acid solution of hydrogen dioxid. Dr. Kirk advises that the dentin be saturated with the sodium dioxid solution, then upon the addition of hydrochloric acid, hydrogen dioxid is formed wherever the sodium has penetrated, and drives out the soapy matters formed by the action of sodium hydroxid upon the products of decomposition.

Preliminary to filling the canals it is the usual practice to fill them for a few minutes with an antiseptic, which will exercise an influence over a considerable period of time. Of all antiseptics, oil of cinnamon gives evidence of the most prolonged presence when so placed.

Cases in which Pericementitis is Present.

The next class for consideration includes the cases in which the tissues of the apical region are invaded. The first evidence of such invasion is tenderness of the tooth upon pressure. The cause of this is, no doubt, the inflammatory reaction of these tissues consequent upon contact and absorption of the waste products of organisms which are developing in the pulp canal. In the milder cases the tooth is sore to the touch, is slightly loose and extruded, and the gum over the affected root is redder than normal. Here, as in all grades of this disturbance, the aim is to get rid, first, of the causes of the inflammation; second, when necessary to treat the inflammation itself. In entering the canals of such teeth—and of course they should be opened and cleansed as quickly and as thoroughly as possible—"The tooth should receive lateral support against the pressure of the burs used in excavating; if the cavity be approximal the tip of a finger is placed against the face of the tooth on the opposite side to the bur. Should the direction of entrance be in a perpendicular line a ligature of linen twine having long ends may be tied tightly about the neck of the tooth, and traction exerted as a counter-pressure."[1]

If the conditions permit, the cleansing and sterilizing are to be well done at once. Should the tooth be too tender to permit the usual manipulations, the gross mass is removed by treatment with sodium dioxid solution or by syringing with meditrina and stirring with broaches; then a pellet of cotton saturated with lysol, a strongly alkaline and penetrating cresol, is placed against the putrescent mass; the gum is painted with iodin at a little distance from the site of the inflammation. When quiet is secured, the cleansing and sterilization of the canals should be thoroughly done; and a dressing of a sedative antiseptic introduced. Campho-phénique or cinnamon oil answers well in this particular.

In more pronounced cases the tenderness, extrusion, and looseness of the tooth are more marked; in case the tooth should contain a filling beneath which a pulp has died—and this is a common history of such cases—the release of the imprisoned mephitic gases is imperative. Exercising counter-pressure, a very sharp and small spear-pointed drill is passed into the pulp chamber; it may be necessary in cases of extreme soreness to effect this entrance at the neck of the tooth as the shortest path. After a few minutes the opening is syringed out with meditrina, and a blister is applied over the gum at a distance from the tooth, about two teeth posterior to it. The patient is directed to immediately take a hot mustard foot-bath, and to use frequently a 3 per cent. solution of pyrozone or other strong antiseptic solution as a mouth-wash. When the tooth is much extruded and is kept irritated by striking upon the occluding tooth, it is advisable to place a cap over the tooth posterior to the one affected. A cap may be readily made in a few minutes, by taking an impression in moldine or in plaster of the tooth to be capped, pouring a small die of fusible metal; drive this into a block of soft lead, and then swage a piece of silver or German silver, No. 26, to fit the die. This cap, covering the occlusal face and about half the walls of the tooth, is attached by means of zinc phosphate, thus securing surgical rest for the affected tooth. It was at one time a general prac-

[1] J. Foster Flagg's *Lectures*.

tice to permit the vent hole drilled at the neck of a tooth to remain open for the escape of the gases of decomposition, consequently the cases were in a constant state of sepsis. The practice is obsolete and is to be unqualifiedly condemned.

In cases where the inflammatory action runs high, the tooth is extremely tender, much extruded, and loose, the gum over the tooth becomes livid, the pulse increases, there is some, and it may be marked, febrile action, the tongue is coated and the breath offensive. Energetic measures are necessary to avert necrotic action in the apical tissues. In this, as indeed in all cases without exception, the promptness and thoroughness of relief depends primarily upon the thoroughness with which the exciting cause of the inflammation is removed, *i. e.* the septic contents of the pulp chamber. In any case where direct access may be had to the canals, and this is very frequently the case, every effort short of that producing great suffering to the patient should be employed to wash away and broach away the putrescent material, using, where necessary, sulfuric acid to enter the canals, powerful antiseptics always preceding the broach. Lysol is an excellent medicament in this connection, and campho-phénique another. The canal is syringed freely and repeatedly with 3 per cent. pyrozone, which should also be used as an antiseptic mouth-wash. Local bloodletting, as advised by Dr. G. V. Black,[1] is frequently an effective means for securing relief. Make a deep cut in the gum, clear to the process, the incision to be about one-quarter inch from the margin of the gum and encircling the neck of the tooth ; this will tend toward unloading the engorged vessels of the apical region. Dry cups over the face and to the neck, and always hot mustard foot-baths, are valuable adjuncts.

Should the inflammatory disturbance run high, and a full, bounding pulse, coated tongue, marked fever, constipation, headache, and other febrile symptoms appear, attempts should still be made to abort the inflammatory action. After as thorough a cleansing of canals and antiseptic washing as possible under the circumstances, local bloodletting as described and advised by Dr. Litch[2] is efficient, by means of Swedish leeches, washing the gum, touching it with sugar, then applying the leech, which should be first placed in a test-tube, the mouth of the tube then being placed over the gum ; when the leech is gorged, it drops back into the tube. The mouth is then rinsed with warm water, to continue the bleeding. Quinin in doses never less than gr. vj is given in the hope of limiting the exudation into the inflamed area. As one of the best and most effective means of derivation is the induction of watery alvine discharges, the patient may be directed to take a saline cathartic or a rectal

[1] *American System of Dentistry,* vol. i. p. 927.

[2] *Ibid.,* vol. i. p. 928.

injection of half an ounce of pure glycerin. If the pulse remain full and bounding, and headache persist, tr. aconiti or tr. veratri viridis is to be used as an arterial sedative, gtt. j of the tr. aconiti rad., or gtt. ij of the tr. veratri viridis, repeated every hour, until the pulse slows and lessens in volume and tension. At bedtime, if the inflammation be not markedly lessened, a sedative diaphoretic is administered, Dover's powder in full dose, gr. x, given in hot lemonade; while the patient is drinking the latter he or she is to be well wrapped in hot blankets and the feet and legs immersed in a hot mustard foot-bath. The following morning a saline cathartic—magnesiæ sulph. ℥ss—is given in a goblet of water. These directions (substantially those given by Dr. Litch, *ibid.*), may be followed with gratifying results in many cases; even when the inflammation is not aborted, its violence is almost invariably lessened.

Should the inflammation remain at its height for more than twenty-four hours, it is almost certain that pus has formed, and the indication is to give it exit. A spear-pointed bistoury is thrust through the gum over the apex of the affected root with such decided force as to penetrate the process if possible. In the event of not accomplishing this end, the point of a spear-head drill revolving very rapidly is passed through the process to the apical region. Although this operation may be performed very quickly it may be necessary to administer nitrous oxid to quiet the patient and render the drilling painless. Anesthesia may be secured by means of the injection of a drop of a 15 per cent. solution of cocain. Dr. Black has described a painless method of effecting an entrance to the apical region.[1] A napkin is placed about the parts, the gum dried and touched at the point of election with a drop of 95 per cent. solution of carbolic acid (trichloracetic acid full strength may be used). The necrosed membrane is scraped away by means of a coarsely serrated plugger until sensation is felt, when another drop of acid is applied, and the scratching is resumed until the bone is laid bare; a sharp chisel is then used to open the apical region. No blood should be drawn during the operation except at the last step.

The case in its present stage belongs to and is described in the succeeding chapter, upon Alveolar Abscess. In any case presenting in which there is reason to believe the patient is the victim of syphilis—and alveolar periostitis is an occasional accompaniment of tertiary syphilis[2]—the use of large doses of potassium iodid is imperatively indicated. Unless decided measures are taken to abort such cases—and the usual antiphlogistic measures are of little avail—dangerous involvement of the general periosteum may occur, leading to necrosis. Not less than

[1] *American System of Dentistry*, vol. i. p. 928.

[2] See case—Heath, *Injuries and Diseases of the Jaws*, 3d edition.

gr. vj doses of potassium iodid are to be administered every three hours. Should there be evidence of detachment of the periosteum, evidenced by boggy swelling, a bistoury is to be passed boldly to the bone, making a large and free incision.

Treatment of Chronic Pericementitis.

The most usual form of chronic apical pericementitis is that associated with pus formation. It will be discussed in the succeeding chapter under the head of Chronic Apical Abscess.

A not inconsiderable number of cases may be seen in which pus formation is not evident and yet a chronic inflammation is present in the tissues of the apical region. If the pulp chamber be open the cause is evident, and its treatment has been described. A not inconsiderable number of cases are due to mal-occlusion. This point is to be carefully observed, for it frequently affects teeth containing vital pulps and free from caries. The tooth is slightly loose and sore to pressure. Examination reveals abnormal occlusion, either too severe or in the wrong direction. Should the tooth contain a filling, it usually gives a normal response to applications of heat and cold ; examining the filling a spot is seen marking excessive occlusion ; in both cases grinding off the redundant tooth structure or filling and applying a counter-irritant over the apex subdues the inflammation. Its exciting cause being removed, it subsides.

A class of cases is occasionally met with in which there is evidence of sluggish and persistent inflammation about the apices of pulpless teeth which have been filled ; acute inflammatory disturbance of a severe grade occurs but seldom. The most common cause of this continued inflammation is probably the decomposition of a minute filament of pulp tissue which has not been removed from a canal ; or, again, well-cleansed canals which have not been filled to the apex. Such cases are those of mild sepsis : perfect restoration to health is only possible by re-cleansing, sterilizing and perfectly filling the canals. These teeth are always more or less hypersensitive even though it be unnoticed, and therefore are not of a full measure of service until cured.

Other cases in which there is reasonable assurance of perfect sterilization and complete filling exhibit vascular sluggishness over the apex of the root. Continued and repeated massage is beneficial,[1] the disorder being apparently due to paralysis of vessel walls and not to septic causes. The tonus of the vessels may be improved by application of the galvanic current. This principle has wide application in general medicine and surgery.

It is to be remembered that when the tissues about the apex of a

[1] Dr. W. F. Rehfuss, *International Dental Journal*, vol. xi. p. 581.

root have been irritated, it may be for months, by the products of a decomposing pulp, a series of degenerative changes may have occurred in them which require some time to remedy. Sterilization should be prolonged, and too hasty a stopping of the canal be avoided. In such cases, after each periodical treatment the canal should be dressed with some stimulant antiseptic: campho-phénique; oil of cinnamon, or the admirable 1, 2, 3 mixture of Dr. Black:

Oil of cinnamon,	1 part;
Carbolic acid,	2 parts;
Oil of wintergreen,	3 "

Repeated applications of tr. aconit. et iodin. are to be made to the gums.

A source of chronic apical pericementitis—frequently not detected until abscess has formed and discharged, it may be, at a distant point—is found in the death of a pulp from thrombus or jugulation. At some period the tooth has received a blow, or, it may be, has been moved too rapidly by a regulating appliance, or idiopathic pulpitis has occurred. Years afterward, a chance examination may reveal a deeper color of the gum overlying the tooth than over the others; by reflected light it shows an opacity or discoloration of the body of the tooth. It may be slightly sore to percussion, which elicits a dull sound. "Dead pulp" is diagnosticated; the tooth is opened under extraordinary antiseptic precautions and cleansed freely with sodium dioxid—the ideal material in this instance—dried, and filled at least tentatively with salol.

Another class of cases in which a similar condition of the pulp is found consists of those in which a pulp has died from repeated thermal shock received through a metallic filling placed in too close proximity to it. Although constructive action resulting in secondary deposits is the usual consequence of such irritation, profound degenerative changes in the tissue of the pulp frequently occur at later periods. The treatment is the same as in the preceding case.

Unless the degree of antisepsis stated be employed in cleansing the canals of such cases, an annoying and it may be an obstinate pericementitis is lighted up which is difficult to conquer.

A word of caution should be spoken in regard to the importance of the removal of inflammatory troubles, particularly the subacute forms, which affect the apical pericementum. It is supposed and with good reason that not only may tumor formations have their beginning in chronic inflammations; various reflex disturbances of sensation and of special sense may be traced to such sources; but any inflammation having such an anatomical situation is a smouldering fire which may under certain systemic conditions become a pathological conflagration.

CHAPTER XVIII.

DENTO-ALVEOLAR ABSCESS.

By Henry H. Burchard, M. D., D. D. S.

Definition.—In describing the septic inflammation affecting the tissues of the apical region in the previous chapter, it was stated that a common result of the inflammatory action was cellular necrosis and pus formation; this condition is known as *alveolar abscess* or *dento-alveolar abscess.*

Although alveolar abscess affecting some other portion of the pericementum may and does occur without death of the pulp,[1] septic infection and bacterial invasion of the tissues of the periapical region from infected pulp canals is the most common source and cause of the affection. The term as technically applied refers to septic apical pericementitis.

Causes of Dento-alveolar Abscess.

The **exciting causes** of the disease process will be found in the pyogenic cocci and probably other pyogenic organisms which inhabit and develop in the deepest portions of the putrescent pulp, finding entrance to the periapical tissues through the apical foramen of the tooth. Dr. Schreier of Vienna found diplococcus pneumoniæ to be the excitant of inflammation in seventeen out of twenty cases of dental periostitis examined by him.[2] The ptomains and other waste products formed as the result of the life processes of these organisms cause poisoning and debility of the cellular elements of the part. Even granting that the organisms are present as the exciting cause, there is another factor involved which determines to a great extent the occurrence, time of occurrence, and severity of the disease, *i. e.* the predisposing causes—including under this head the condition of the tissues which favors or deters the development of the organisms.

Predisposing Causes.—It is unquestionably true that different individuals will exhibit in their tissues marked differences in the degree

[1] Cases reported in *Proc. Academy of Stomatology of Philadelphia*, 1895.

[2] *Oesterr.-ungarische Viertelj. für Zahnheilk.*, April 1893.

of resistance to the invasion of disease causes. It is a well-recognized axiom of pathology that one of the most potent antiseptics, if not the most potent, is the inherent resistance of healthy protoplasm; that is, healthy tissues offer a barrier to the development of the exciting causes of disease, while tissues which are debilitated through any of the many causes that affect them exhibit a diminished resistance to the invasion of the causes of acute disease.

Prominent among the causes which favor the development and extension of pyogenic processes are the inherited conditions indefinitely classified as strumous. The tissues of children having a family history of, for example, syphilis or tuberculosis, frequently exhibit evidences of lack of vital resistance. They are attacked and readily succumb to agencies which affect children of healthy parentage but slightly if at all. Inflammations about the teeth or of the soft tissues of the mouth run a severe course; septic affections of the pericementum are attended by involvement of neighboring lymphatics and by evidences of septic intoxication. These predispositions may persist throughout the life of the individual; as a rule, however, they grow less pronounced or less evident with age.

Acquired cachectic conditions of the adult also form a strong predisposition to invasion of the tissues by pathogenic organisms. It is a matter of frequent observation that tuberculosis and, in a more pronounced degree, syphilis are constitutional conditions which markedly diminish the resistance of the tissues. Inflammatory disturbances which in an individual free from cachexia would probably be circumscribed, when they occur in the cachectic are diffuse and virulent. Local predisposing causes consist of faulty hygiene, producing debility of the tissues, for it is noted that abscess is more likely to run a virulent course in unclean mouths than in those kept free from fermenting and putrefying masses; this is a general, though not a universal truth.

Pathology and Morbid Anatomy.

The pathology of septic pericementitis has been described in Chapter XVII. That of alveolar abscess begins as soon as there is death of cellular elements in the exudation. The exudation is liquefied in the focus of the inflammation by the action of ferments; the leucocytes are invaded by and strive to devour the pyogenic cocci which are present—the species of warfare described by Metchnikoff; the leucocytes succumb, die, and form pus corpuscles, which are found to contain the pyogenic cocci. The cellular exudate is then broken down into a granular detritus, which, with the dead corpuscles and peptonized effusion, constitutes pus.

The diplococcus of pneumonia is said to be a constant attendant on alveolar abscess, and this particular organism is believed by Schreier to be the usual excitant of the inflammatory action in these cases.

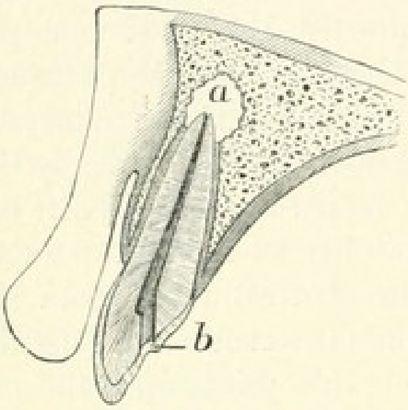
The primary seat of the abscess is usually *in the pericementum*, between its attachment to the cementum and its attachment to the alveolus. From the central cavity of softening the necrotic process spreads peripherally; cell by cell the inflammatory wall forming the outlines of the abscess and the exudates are liquefied and the cavity grows larger. The cancellated bone about the apex of the root is involved and becomes the seat of osteomyelitis and molecular necrosis. Larger and larger grows the volume of the abscess until the periosteum covering the alveolar process is involved, softened, and raised from the bone. The inflammatory action precedes the advance of the pus along the line of least resistance; and if it run high the periosteum may be softened over quite an extensive area and raised from the bone by the exudation beneath it. The pus penetrating the periosteum, the soft tissues are involved and softened, when the pus breaks through the mucous membrane, discharging usually by the shortest route from the abscess to the exterior. The progress of septic destruction is along the line of least resistance, and although as a rule this points upon the external surface of the gum immediately above the apex of the affected root, it may follow other directions. In some cases the pus finds exit through the pulp canal of the affected tooth, forming what is commonly though incorrectly known as blind abscess. This form of abscess differs from that with external fistula as a result of its mode of formation rather than because of any essential difference in its pathology. The history of an acute inflammatory stage is usually absent or it has caused but slight disturbance. Invasion of the apical pericementum by bacteria has been slow and superficial and the inflammatory reaction restricted to the tissue immediately surrounding the apical foramen; the necrotic process has been ulcerative in character, molecular death of the membrane taking place slowly until the tissue about the foramen is lost and the denuded apex projects into a necrotic cavity which allows of drainage of its contents through the foramen and root canal. In these cases the abscess cavity is usually comparatively small, and the inflammatory action is less severe than when the pus has a longer path of exit (see Fig. 461).

The pus may exhibit evidences of semi-encystment. Collections may apparently remain in the tissues of the gum for long periods without fistula. A case in practice presented conditions similar to that exhibited in the illustration (Fig. 462); it had existed for several years about a replanted tooth, and responded promptly to treatment.

In other cases the line of tissue destruction and pus escape is along the pericementum, the pus discharging at the neck of the affected tooth. Many of these cases occur in connection with pulpless teeth which have elongated, or those in which there has already been loss of pericementum.

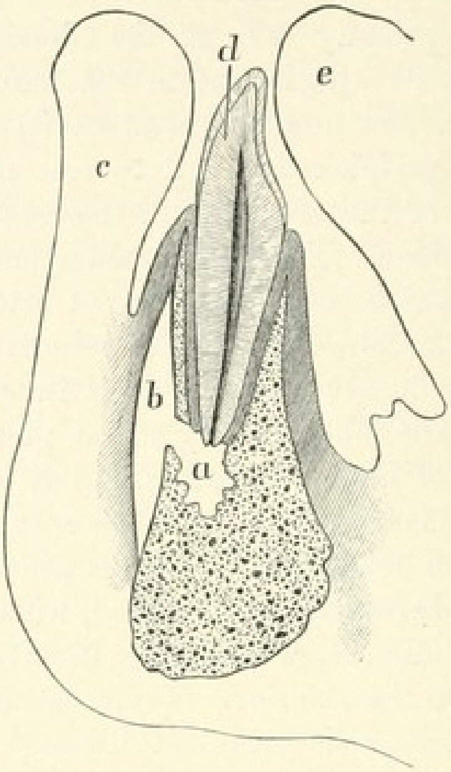
Abscesses upon the upper central or lateral incisors may

Fig. 461.



Blind abscess at the root of an upper incisor (Black): *a*, abscess cavity in bone; *b*, drill hole exposing the pulp chamber for treatment.

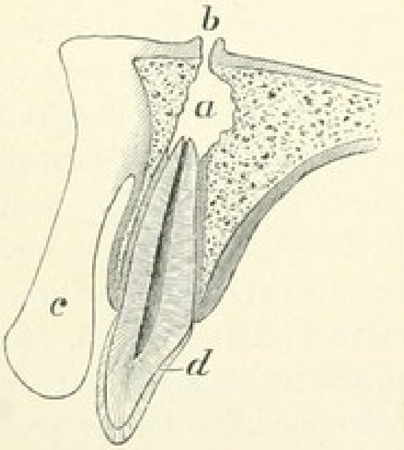
Fig. 462.



Acute alveolar abscess of a lower incisor with pus cavity between the bone and the periosteum (Black): *a*, pus cavity in the bone; *b*, pus between the periosteum and bone; *c*, lip; *d*, tooth; *e*, tongue.

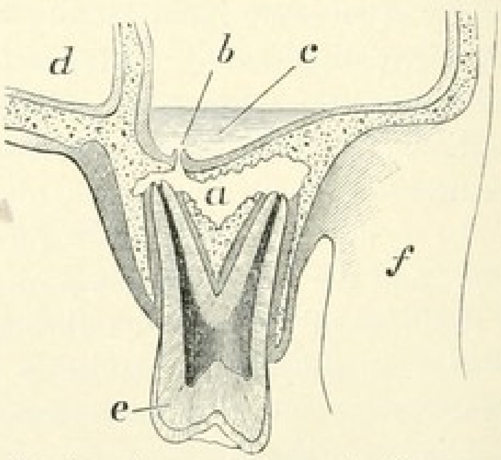
perforate the nasal floor (see Fig. 463). After a period of marked perice-

Fig. 463.



Alveolar abscess at the root of a superior incisor discharging into the nose (Black); *a*, large abscess cavity in the bone; *b*, mouth of fistula on the floor of nostril; *c*, lip; *d*, tooth.

Fig. 464.

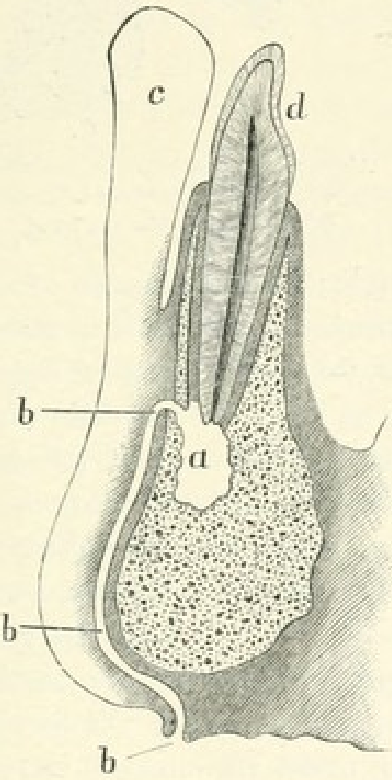


Alveolar abscess at the root of an upper molar discharging into the antrum of Highmore (Black): *a*, abscess cavity in the bone; *b*, mouth of fistula on the floor of the antrum; *c*, pus in the antral cavity.

mental disturbance, the inflammatory action running high, causing pain and swelling of the nostril of the same side, the symptoms may suddenly abate without any evident signs of pus having been discharged. Soon after a purulent discharge may be noted from the nostril, leading to the belief that purulent nasal catarrh (ozena) is present; many of these cases are diagnosed and treated as ozena. In injection of the pulpless incisor, particularly with pyrozone, the pus and fluid are seen to emerge from the nostril, exhibiting the true source of the pus. Abscesses upon upper second bicuspids and molars may perforate the floor of the antrum (Fig. 464).

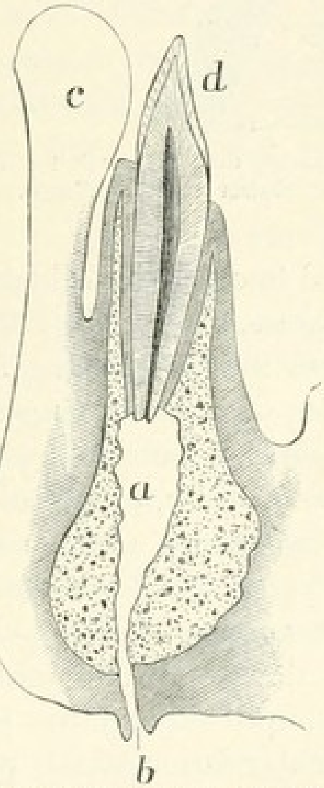
In the lower jaw the pus may pass out of the alveolar process and

Fig. 465.



Chronic alveolar abscess at the root of a lower incisor with a fistula discharging on the face under the chin (Black): *a*, abscess cavity in the bone; *b*, *b*, *b*, fistula following in the periosteum down to the lower margin of the body of the bone and discharging on the skin.

Fig. 466.



Chronic alveolar abscess of the root of a lower incisor with abscess cavity passing through the body of the bone and discharging on the skin beneath the chin (Black): *a*, very large abscess cavity; *b*, mouth of the fistula.

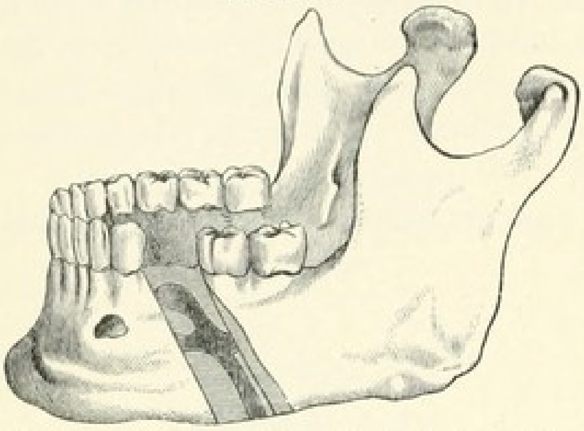
fail to perforate the overlying soft tissues, pursuing a path which may lead to its exit upon the face beneath the jaw or chin (Fig. 465). In others the pus may burrow through the body of the bone and open upon the face. (See Figs. 466, 467.)

In a case of persistent fistula opening upon the side of the face over the body of the lower maxilla, there was no evidence of inflammatory disturbance in the edentulous gum. An exploratory incision, made at a point indicated by a probe passed into the sinus, revealed the presence of a small root-fragment. Healing of the fistula was spontaneous upon its removal. Prof. M. H. Cryer[1] records a case of abscess opening

[1] *Proc. Academy of Stomatology*, 1896.

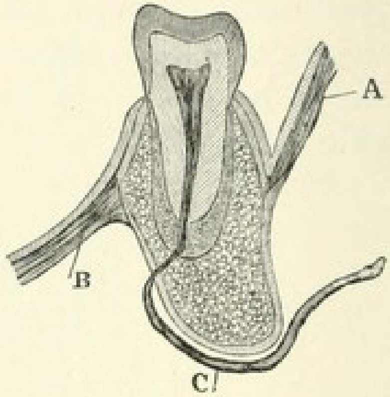
over the body of the lower maxilla immediately anterior to the groove for the facial artery (Fig. 468). A flexible probe passed into the fistula

Fig. 467.



Fistula passing down through the body of the lower maxilla (Black).

Fig. 468.



Abscess with tortuous sinus opening upon the face: *A*, tissue of cheek; *B*, floor of mouth; *C*, abscess tract.

appeared to enter the submaxillary triangle; in the absence of evident dental cause, the case had been diagnosticated and treated as abscess of the submaxillary gland. The direction taken by the probe gave no indication of a tooth being involved. The usual therapeutic measures applied to a submaxillary abscess proving unavailing, a serial examination, one of many, of the teeth of that side was made. In one tooth, the second molar, was a large amalgam filling. The pulp responded, though feebly, to the usual tests for vitality; upon entrance to the tooth the anterior portion of the pulp was found partially vital, the posterior portion dead and decomposing. The pulp was removed; antiseptics were pumped through the posterior root, found exit at the fistula, and the causal relation of the putrescent pulp and the abscess was shown by a prompt disappearance of the disease.

In one case of abscess upon a lower third molar, the pus made entrance into the tissues about the insertion of the internal pterygoid muscle. Cases have been recorded in which the pus from abscess about a lower molar has burrowed through the bone and, caught beneath the platysma myoides muscle, it has passed down the muscle, discharging from an opening upon the neck or upon the shoulder.

Abscess upon an upper molar may find exit upon the face beneath the malar bone. Occasionally the duct of Steno may be involved in the abscess tract and salivary fistula result. Dr. Black states[1] that the cases of abscess opening beneath the malar bone are usually of the acute variety. As a rule, however, cases which exhibit the pus exit at a distance from the seat of abscess are of the chronic variety.

The acute and chronic cases differ as to their clinical histories.

[1] *American System of Dentistry*, vol. i. p. 940.

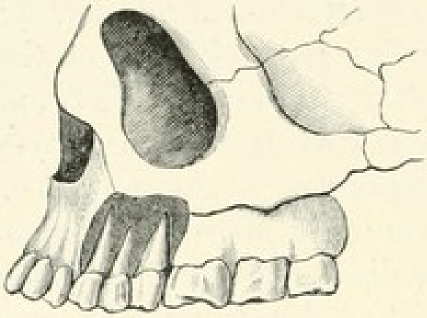
Clinical History of Acute Alveolar Abscess.

Cases of apical pericementitis in which suppuration occurs usually present pronounced evidences of severe inflammatory action. The throbbing and tenderness, swelling and vascular engorgement are marked; there may be, and usually is, more or less febrile disturbance with its attendant symptoms; a full, bounding pulse, more or less œdema of the surrounding parts, the eye of the affected side may be injected, etc., as described in Chapter XVII. under the head of Acute Pericementitis. In from twenty-four to forty-eight hours a spot of fluctuation makes its appearance at the summit of the swelling, the spot becomes yellow and soon opens, affording escape to the abscess contents. As soon as the pus has discharged the inflammatory symptoms subside promptly and a persistent fistula remains, communicating with the abscess cavity. This comparatively benign course and termination is not universal. It is not at all uncommon to find cases which at the height of the inflammatory disturbance exhibit evidences of septic intoxication. The septic substances formed by the micro-organisms, and in other cases the organisms themselves, gain entrance to the lymph channels and are conveyed to the nearest lymphatic glands, producing evidences of inflammation in them; swelling and pain of these glands are very common. Cases are recorded in which streptococci appear to have invaded the subcutaneous tissue, giving rise to marked phlegmonous inflammation. Dental literature contains the records of many cases indicating the occurrence of a pyemic condition consequent upon alveolar abscess; organisms, by gaining entrance to the blood channels, forming septic emboli.

The mild and less severe cases run the average course described. Many of them by finding early exit of the pus through the pulp canal of the affected root have comparatively light inflammatory disturbance; in those cases in which the evacuation of the pus is delayed, or in which the opening occurs at points distant from the disease focus, the inflammatory action may be severe and prolonged. If the pus point toward the face, the skin, the subcutaneous tissues, and it may be the internal periosteum also exhibit evidences of marked inflammation; there is much swelling, the skin may become œdematous, there is redness, heat, and throbbing pain. The external application of poultices by the patient, not at all an uncommon mode of domestic treatment, may aggravate the symptoms, soften the tissues, and induce the progress of the pus to the exterior.

If in any of the cases which point in the mouth an undue swelling is formed at the height of prolonged inflammatory action, pus beneath the periosteum is to be feared, the pus stripping the softened membrane from the bone over a certain area. Should these cases not obtain quick relief by evacuation of the pus, necrosis of the denuded bone may occur (Fig. 469). Reattachment of the periosteum may take place even after extensive separation, provided the pus be evacuated early.

Fig. 469.



Necrosis of the buccal plate of the alveolar process from alveolar abscess (Black).

Cachectic conditions exert a strong modifying influence upon the course and termination of alveolar abscess. In strumous or debilitated persons the disease tends to invade neighboring structures, whose resistance is lessened. This is well illustrated by a case of obstinate maxillary caries which destroyed the entire process of one side, the beginning of the disease being apical pericementitis of a lower bicuspid. The carious process became chronic soon after the extraction of the offending tooth, and persisted until the death of the patient from tuberculosis.

Alveolar abscess occurring in syphilitic patients is prone to involve the deep structures, and more or less necrosis is not an uncommon sequel.

Clinical History of Chronic Alveolar Abscess.

After the subsidence of the symptoms attendant upon the formation and discharge of acute abscess, there is rarely a spontaneous healing or filling of the abscess cavity and tract with healthy granulation tissue; the development of organisms in the abscess cavity and pulp canal continues and produces a continuance of the suppurative process, forming a chronic abscess.

In other cases abscess may have developed without marked inflammatory symptoms, and yet a prolonged and obstinate pus formation occurs in the tissues of the apical region, the pus finding exit through the pulp canal, constituting what is known as blind abscess, one of the most common of the chronic types.

Many of the cases which open upon the face are of the chronic variety; during the development of the abscess and its discharge there may be but little evidence of inflammatory action about the affected tooth. This is a common history of cases which have followed the death of a pulp through trauma, years before the discovery of the abscess. At some period a tooth receives a severe blow, and for some time is the seat of traumatic pericementitis, which subsides: it may be years after that a fistula is established in the mouth or upon the face, without a history of inflammatory disturbance.

As pointed out by Dr. Black, the direction of pus-burrowing in chronic abscess is determined by gravity; thus, if the abscess be upon a lower incisor the pus may burrow, opening beneath the chin, as shown in Figs. 467, 468.

Sir John Tomes[1] has called attention to the tendency of pus to open at the angle of the jaw in abscesses affecting the lower third molars (see cases noted above).

Diagnosis and Prognosis.

Diagnosis.—If the pericementum of a pulpless and open tooth have been the seat of acute and marked apical inflammation of septic origin for a longer period than thirty-six hours pus is almost invariably formed, and alveolar abscess is present. The diagnostic symptoms are those of acute pericementitis described in Chapter XVII. In case any marked inflammatory disturbance is found about the maxillary region either within or without the mouth, examination of the teeth of the affected side should always be made, as a large percentage of such inflammations are of dental origin. Any fistula existing in the maxillary regions, either within or without the mouth, is to be suspected as having origin in a septic pericementitis of some tooth.

A soft silver probe is to be passed along the tract to determine its direction and, if possible, which tooth is affected. As a rule, such a tooth will itself exhibit objective evidences of abscess and the patient will give a history of subjective symptoms—those of inflammation of pericementum.

Should the tooth indicated as the affected one be free from caries, the thermal test is to be applied to indicate the vitality or the necrosis of the pulp. Should the tooth not respond to applications of a pointed piece of ice, it is possible it may offer slight response to applications of heat. It is next examined by light reflected from the ordinary, or better, the electric mouth mirror, when, if the pulp be dead, opacity of the crown will be detected.

An abscess upon an upper incisor opening upon the nasal floor may cause a discharge simulating that of ozena; an examination of the nose will reveal a teat-like elevation upon the mucous membrane covering

[1] *Dental Surgery.*

the nasal floor and an incisor beneath will be found carious and having a putrescent pulp, or, if non-carious, a history of traumatic pericementitis and a present opacity.

It may be mentioned here in connection with death of the pulp from traumatism, that continued thread-biting, biting very hard substances such as pieces of ice, nuts, etc., may cause death of the organ, presumably by thrombosis.

It is possible that the direction taken by the probe which is passed into the fistula will point away from the teeth present, passing into a space from which a tooth has been extracted. In that event the presence of a root fragment, or piece of necrosed process, may be suspected.[1] Should the neighboring teeth be excluded as causes of an inflammation, there should be no hesitation in making an exploratory incision down to the end of the probe which has been passed into the fistula. Cases of dentigerous cysts have been detected in this manner. This condition would, however, be suspected when there was an absence of a tooth or teeth from the arch, no evidence past or present of pericementitis in any of the teeth of the arch, and a cystic tumor present in the jaw, or it may be a fistula discharging upon the face after a history of maxillary periostitis.

Caries or necrosis, although in many cases the result of septic apical pericementitis, may yet exhibit fistulæ opening into the mouth, without evident connection with the teeth. As a rule, cases of necrosis exhibit marked and wide evidences of chronic inflammation of the tissues overlying the dead or dying bone; there are usually several fistulæ discharging from it.

Caries may have but a single fistula and simulate closely ordinary alveolar abscess. Diagnosis is made by passing an excavator through the fistula. Dead bone is readily detected by touch, it has a rotten feel; in caries the instrument may be passed through the dead bone in various directions, and a characteristic dead sound is elicited by tapping upon it. Careful examination of the teeth must be made in all of these cases, to determine the condition of the pulp and pulp canals.

In passing an instrument through a fistula to the apex of an abscessed root, where the disease action has been of long duration, it may be found that the apex of the root is denuded of pericementum, and roughened—that is, the apical cementum is necrotic; foreign deposits may be detected occupying portions of the necrotic area.

Prognosis.—There are several factors which enter into the prognosis of a tooth and its surroundings which are affected by alveolar abscess. First, the severity and character of the inflammatory action and septic invasion. In cases in which inflammatory action is localized and pre-

[1] See case—Dr. Black, *American System of Dentistry*, vol. i.

senting none or but little febrile disturbance the prognosis is, as a rule, favorable; but a slight amount of tissue necrosis occurs. Should, on the other hand, the inflammatory action proceed with volcanic violence, it is possible that not only may the pericementum suffer extensively, but a considerable portion of the periosteum over the process may be raised from the bone during the escape of the pus. Should this separation of periosteum be maintained for more than a few hours, the underlying bone may suffer to the extent of necrosis. In case of marked lymphatic involvement, the neighboring glands being swollen and tender, or even the skin over them exhibiting evidences of glandular inflammation beneath, more or less septic intoxication will probably occur, and unless the focus of infection be promptly sterilized, septicemia is to be feared.

Should evidences of diffuse cellulitis occur, indicating the invasion of streptococci into the adjacent soft tissues, it is a danger signal of threatening pyemia.[1] Heath[2] records a case of œdema of the glottis due to the involvement of the connective tissues about the glottis in the œdema accompanying a developing abscess upon a lower molar.

The prognosis is good in a vast majority percentage of cases, when the offending tooth is extracted early in the attack, or at its height; this applies even with apparently very grave cases; still the prognosis as to the retention of the affected tooth is also very good, unless the abscess run a phagedenic course. In many of the cases of chronic abscess having a distant discharge the abscess may be cured and the tooth retained. Other cases obstinately refuse to heal so long as the offending tooth is present.

TREATMENT.

Treatment of Acute Abscess.—The general principles of treatment of alveolar abscess are those for the treatment of abscess in any part; the details are of course modified in accordance with the anatomical peculiarities of the part to be acted upon. These principles are the removal of all dead matter, together with the active causes of the inflammation and suppuration, *i. e.* micro-organisms and their products, and the induction of a tissue regeneration which shall serve to restore parts lost through the formation of the abscess. The therapeutic means applied are instrumental and medicinal. The instrumental are the instruments employed to gain access to the focus of disease action, and those applied in the mechanical removal of dead parts. The medicinal measures include the agents employed to wash out the abscess tract; second, those applied to destroy the active causes of the suppuration;

[1] See case—Dr. E. C. Kirk, *Proc. Odontological Society of Pennsylvania*, 1892.

[2] *Injuries and Diseases of the Jaws*, 3d ed.

third, the remedies applied to induce new tissue growth ; and next, those employed to maintain asepsis until the healing process is complete.

The great primary objects in the management of acute alveolar abscess are four : First, if the case be seen early, to use every endeavor to abort the inflammation, as described in Chapter XVII. Second, to limit as far as possible the extent of pus formation, hence tissue destruction ; third, the earliest possible evacuation of the pus which has formed ; fourth, the thorough sterilization of the abscess cavity and its walls.

Cases when seen may be at any stage of the disease process from an incipient pericementitis to the establishment of a fistula. The treatment of the early cases is that of pericementitis. In all of these cases one fact is never to be forgotten : that the pulp canals are the centres of infection, and the more quickly and thoroughly they are drenched with powerful antiseptics the more limited will be the inflammatory action both in degree and extent, and the more limited will be the pus formation. Attempts are therefore made to enter and sterilize cavities *pari passu* with the antiphlogistic measures applied to abort or limit inflammatory action.

Treatment of Abscess without Fistula.—Abscess has been described by the older surgical pathologists as the process through which Nature rids herself of an irritant. This is in a measure true, but it is essentially a destructive and not a conservative process. Nature does rid herself of the irritant through suppuration ; but it is done at the expense of tissue loss, and the wise surgeon endeavors to remove the irritant and limit the destruction. After the inflammatory action has persisted at its height for twenty-four hours, pus is probably present in the tissues of the apical region ; if immediate exit be given to the pus the inflammatory symptoms will subside. If the tooth be not so sensitive as to preclude touch upon it, an endeavor is made, after washing the pulp chamber with powerful antiseptics, to pass a very fine Donaldson's bristle through the apical foramen. In many cases this may be done ; the pus escaping through the canal, the inflammatory symptoms begin to subside. This is a case of acute blind abscess ; its treatment will be first discussed.

The conditions existing are more or less remnants of pulp tissue undergoing putrefactive decomposition ; the contents of the dentinal tubules are also in process of dissolution. Beyond the apical foramen is a fibrous tissue containing bloodvessels and nerves, in the meshes of which tissue pus is forming. Beyond the spots of suppuration, the tissues, which are in small part fibrous but are mainly osseous, are the seat of inflammation.

The pus evacuated, the parts tend to spontaneous recovery provided the sources of irritation be removed. The first step in sterilization is the destruction of putrescent matter in the pulp canals. If the tooth be sore after evacuation of the pus through the apical foramen, the patient is directed to use repeatedly an antiseptic mouth-wash, 3 per cent. pyrozone or any of the solutions of hydrogen dioxid, and report in a few hours, when the broach is again passed through the apex of the root, the canal syringed out with hydrogen dioxid and dismissed for twenty-four hours, when the inflammatory symptoms will have so far subsided as to permit working upon the tooth. At this sitting, a slight flow of pus will still be found; the canals are syringed, rubber dam applied, but never with a clamp on the affected tooth. Sodium dioxid either dry or in 50 per cent. solution is placed in the canals, and frequent re-applications made. At the expiration of about a half-hour the canals and abscess cavity are syringed out with an acid solution of hydrogen dioxid, and dried. The canals will now be sterilized and also the general abscess cavity. It is possible, however, and probable, that organisms may still occupy the deeper recesses of the tissue bounding the abscess cavity. The parts forming the abscess wall are of comparatively low vitality and may not dispose of organisms present as would be done in more vascular tissues. It is the usual practice, therefore, to apply to them a powerful antiseptic: campho-phénique, Dr. Black's 1, 2, 3 mixture, and lysol are all admirable agents in this particular; they are pumped into the abscess sac as well as possible, and the excess in the canals wiped away with wisps of cotton.

There will be, immediately following this operation, a greater or less amount of exudation from the abscess walls, which diminishes as granulation proceeds about the apex of the root. The condition is one of granulating ulcer. An escape is provided for this exudation by leaving the dried canals unfilled for twenty-four hours, when a loose cotton dressing may be applied, hermetically sealing the cavity communicating with the saliva after each dressing. In two days the dressing is removed, always sterilizing the tooth walls and isolating it when the cavity is to be opened. On the third day a larger dressing of cotton, dipped in campho-phénique and wrung out, may be applied. After two days, should the cotton exhibit little or no evidence of exudation, a firmer dressing is applied, to remain about four days; the next dressing remains a week, when the abscess cavity should be filled with tender granulations. Pending the organization of the granulation tissue there is probably no better canal filling than salol having a core of gutta-percha. It is unirritating and may be applied without causing irritation. Dilute solutions of formaldehyd have been found to be extremely useful in this class of cases as well as in all cases involving sterilization of the pulp canal. The high antiseptic value of formaldehyd and its great penetrating power place it among the most satisfactory agents in the dental pharmacopœia. For the treatment of root canals with apical pericementitis a wisp of cotton moistened with a 5 per cent. solution of formalin (the 40 per cent. solution of the gas in water) and sealed in the canal will in a few hours completely sterilize it, so that usually the canal may be permanently closed within twenty-four hours. Rarely, a second dressing is required. Stronger solutions of formalin are irritating and should be avoided, as they may cause necrosis if used beyond the strength stated, or even in that strength if used in too large quantity or too frequently.

Should the effort to enter the apical region through the canal fail, and pus be present, an entrance should be effected through the gum. At a point on the gum immediately overlying the apex of the affected root, a pointed bistoury is quickly thrust down to the bone, the bleeding is encouraged by the use of hot water for several minutes, when a pellet of cotton which has been dipped into 95 per cent. carbolic acid is laid against the periosteum at the bottom of the cut. In a few seconds a spear drill driven by the engine is passed through the bone into the tissues of the apical region. Any bleeding which may occur is encouraged as above mentioned. For washing the incisions and the abscess in such cases there is no agent more acceptable than a 20 per cent. solution of phénol sodique, it being both sedative and antiseptic. A thread of floss silk dipped in carbolic acid is passed into the fistula to the seat of abscess, its projecting edge lying upon the gum ; this will prevent too rapid a healing of the fistula. The case now resembles an abscess with a fistulous opening, the next variety of acute alveolar abscess ; the treatment for both is the same.

Treatment of Abscess with Fistula.—Cases of acute alveolar abscess discharging through a fistulous opening are either seen when the pus has perforated the bone and is making its exit through the soft tissues, or in cases where the inflammatory symptoms run high, the usual methods of aborting the inflammation having failed, pus forms and the abscess discharges rapidly, it may be within thirty-six hours. The use of pepper plasters and like devices to induce pointing of an abscess are irrational ; they render no service which cannot be performed better and more expeditiously by an incision made down to the bone by means of a sharp bistoury. In all cases of acute apical pericementitis where the swelling of the gum is marked, an early and deep incision is useful and advisable. If pus be already formed and the abscess pointing, escape is afforded it ; if the pus have not yet perforated the periosteum that structure receives early relief from a condition which might threaten it. The greater the swelling the more imperative is the necessity for this incision, which must be freely made.

A sharp curved bistoury is held as a pen, its point directed always toward the bone, and is passed boldly down to the bone immediately over the apex of the root.

Inflammatory symptoms, as a rule, subside promptly as soon as exit is afforded the pus. As soon as the tooth may be operated upon, its canals are to be treated as virulently and deeply infected centres, opened freely and sterilized with the utmost thoroughness. The usual and satisfactory method of accomplishing this is by means of a 50 per cent. solution of sodium dioxid; after which a stout syringe filled with 3 per cent. pyrozone is to have its contents driven forcibly through the abscess tract, the application to be repeated until the peroxid comes away clear. A few drops of campho-phénique or Dr. Black's 1, 2, 3 mixture are placed in the pulp canal by means of Flagg's dressing pliers. This may be drawn into the abscess sac along its tract, emerging at the fistulous opening, by a little device of Dr. T. M. Hunter.[1] One of the rubber cups used for finishing fillings and cleaning teeth is to have its tool opening filled with gutta-percha, the concavity of the cup moistened and pressed flat against the gum, covering the fistula; removing the pressure from the centre of the cup but keeping its edges closely in contact with the gum, a suction is created drawing the medicament through the abscess tract. The writer has used these cups, but mounted on a No. 300 mandrel (Fig. 470), for this purpose for several years; indeed the discovery that Dr. Hunter had employed and advised it as a means of emptying abscess cavities was a gratifying surprise, as he states that they serve this purpose admirably.

Fig. 470.

The sterilized canals are now to be thoroughly filled with cotton twists or gilling twine which has been moistened with the last-named antiseptic, or 5 per cent. formalin, the crown cavity sealed, and the case dismissed. In twenty-four hours, only a slight serous exudate should be pressed from the fistula. In a week the abscess cavity should be healed. In that time a permanent canal filling may be inserted, but it is wiser to defer the filling of the crown cavity for some time—that is, if it is to be filled with cohesive gold.

In case of acute abscess where marked inflammatory symptoms with involvement of neighboring parts persists after the evacuation of the pus, the gum overlying the tooth being purplish and tumid, the tooth very loose, and no diminution of the attendant fever, neighboring structures in addition to the tooth are in danger, and the latter should

[1] *Dental Cosmos*, vol. xxxiv. p. 82.

be extracted. An early and free incision will frequently avert this condition and necessity for extraction.

Should the case when first seen exhibit marked evidences of involvement of the tissues of the face, a threatening of the abscess toward pointing on the face, prompt and active measures are necessary. As a rule in these cases the pernicious domestic practice of applying poultices to the face has been followed, and in consequence the tissues of the cheek are distended and softened, lessening the suffering but inducing the flow of pus along the line of softening. Compresses wet with lead-water and laudanum—

℞. Plumbi subacet.,	ʒj ;
Tr. opii,	℥j ;
Aquæ,	Oj.—M.

should be laid upon the face, and an incision made at the line of junction of the cheek with the gum, down to the bone over the apex of the root. As a rule, in these cases the pus has found its way into the tissues of the cheek, but drains through the incision ; a cut must always be made away from, not toward the cheek, to avoid cutting the facial artery or any of its branches. Opening upon the face may be averted by this means, even when the pus is beneath the skin. The danger of inclusion of the duct of Steno should be borne in mind should the case be one of abscess upon an upper molar, and energetic measures pursued to prevent the establishment of that annoying trouble, salivary fistula.

When fluctuation of the inflammatory tumor upon the face becomes evident, indicating that an external opening must be made, it is preferable that it be made with a sharp knife and not by suppuration. Scars left by abscesses discharging spontaneously are irregular and disfiguring, those following clean incision are but a line. A curved bistoury is used to transfix the summit of the swelling, the knife is then carried outward, making an incision about an inch long. In this as in all cases of abscess where pus is detected the indication is to give it immediate exit.

It occasionally occurs that abscess may be found upon the lateral aspect of a tooth containing a vital pulp. The tooth is free from caries, and is perfectly translucent. The most usual situations of these abscesses are upon the labial faces of the anterior teeth and the buccal faces of the molars, between the gingival margin, which may be intact, and the apex of the root. As a rule the evacuation of the pus and dressing with antiseptics causes a speedy disappearance of the abscess. Left to themselves they discharge as a rule at the gum margin. They are a frequent associate of the condition graphically described by Dr. G. V. Black as phagedenic pericementitis. Believers in the gouty origin of this disorder note their occurrence in gouty patients.[1] In

[1] Typical cases are recorded in *Proc. Academy of Stomatology of Philadelphia*, 1895.

these cases the abscess is attended by more or less destruction of the pericementum. Cases may be seen in which the abscess involves the tissues near the apex of the root, the pulp being vital; its death, however, will doubtless result from the invasion.

Acute apical abscess may discharge at the margin of the gum, following the pericementum. These cases are to be treated as abscess with fistula. In some cases subsequent to the treatment of the abscess there appears to be a restoration of the pericementum lost in the formation of the fistula. In others a permanent loss of tissue results. This mode of discharge is common about dead roots which have been in the jaw crownless for a long period; a resorption of alveolar process has occurred and the root is retained by fibrous tissue. The treatment in these cases is that accorded any and all roots which may not be made serviceable—extraction.

Treatment of Chronic Abscess.—For purposes of treatment, chronic abscesses are divided into two classes: those discharging through the pulp canal, what are known as blind abscesses; second, those discharging upon the gum, at the neck of the tooth or in fact at any point, through a fistula.

The usual condition existent with the blind abscess, is a cavity which may have any volume, its diameters, however, rarely exceeding three-eighths of an inch; this cavity is bounded upon all sides by a fibrous capsule, analogous to the indurated surroundings of an ulcer; the wall represented by the cementum of the affected tooth may be devoid of fibrous tissue, the pericementum being necrotic. The pulp chamber is the centre of infection; the abscess cavity is the habitat of bacteria, which cause the peptonization of the inflammatory exudate from the wall of circumvallation, and destroy the exudation corpuscles, thus producing a continued pus formation. The observation and statement of Dr. Black have been quoted above, wherein he states that gravity largely determines the direction pursued by the pus in chronic abscess. This tendency will be found to exist with the blind variety also.

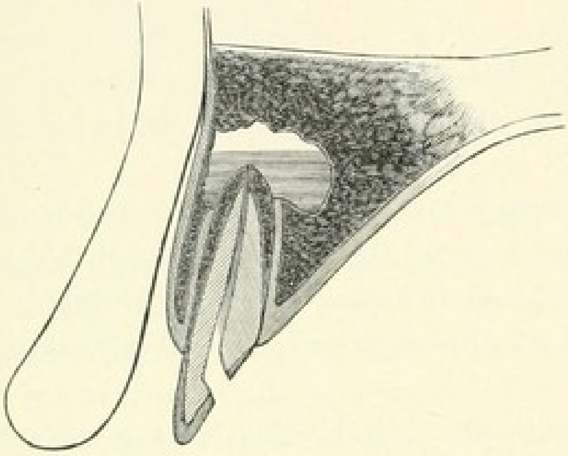
The tendency of long-continued pus formation about the roots of the upper teeth will be to progress along the pericementum, resulting in a molecular necrosis of that structure from the apex downward. The condition is represented in Fig. 471. The extent to which the apex of the root projects into a cavity increases with the progress of the necrotic process.

In the lower teeth, the influence of gravity carries the suppurative process away from the apex of the root, the abscess cavity increasing downward (Fig. 472).

If the case be seen shortly after the subsidence of the inflammatory attack which may have ushered in the suppurative process, the cavity may be very limited in size, only a trifling amount of the pericementum being destroyed.

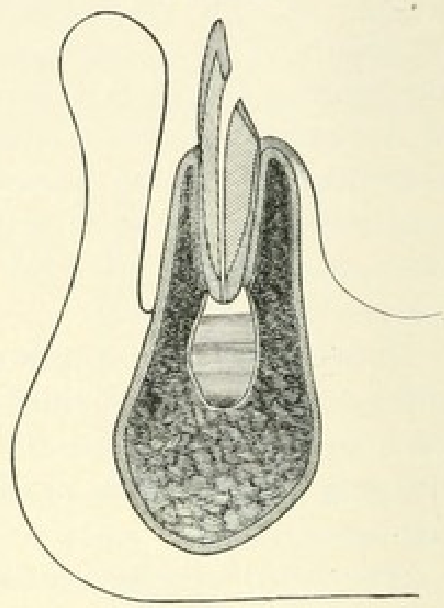
It is advisable in these cases, after thorough sterilization of the canals and dentin by means of sodium dioxid or formalin, to increase the size of the natural drainage-tube, by enlarging the pulp canal ; a fine Donaldson

FIG. 471.



Chronic blind abscess of upper incisor, showing tendency of pus to progressively destroy pericementum owing to the influence of gravity.

FIG. 472.



Chronic blind abscess upon lower tooth, showing tendency of pus to sink into the substance of the lower maxilla owing to the influence of gravity.

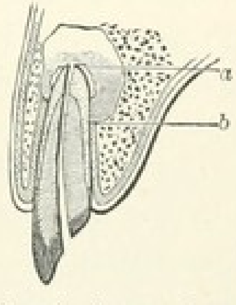
cleanser should pass freely through the apical foramen. The abscess cavity is now forcibly and thoroughly syringed out with 3 per cent. pyrozone. It is advisable after effervescence ceases to mechanically withdraw, or aspirate, the contents of the abscess. This may be readily done by passing the point of a syringe into the canal, filling around it with gutta-percha and withdrawing the piston, when the contents of the abscess will flow into the syringe. Any instrument (syringe) employed for this purpose should soak for hours in an antiseptic before using it in other cases (a 20 per cent. solution of phénol sodique is an excellent sterilizing agent) ; the same syringe should never be used for any other purpose. A small amount of 25 per cent. pyrozone, ethereal, may now be placed in the canals and pumped into the abscess cavity ; then canals and sac are dried by means of warm blasts, and a wisp of cotton dipped in campho-phénique and wrung out is packed in the canal. The patient reports the day following, and if no discomfort be felt the tooth remains closed until the following day. If upon opening the tooth no evidence of exudation is seen, and no effervescence occurs upon application of 3 per cent. pyrozone, the drying and dressing are renewed, to remain about three days. If any evidence of pus be detected, the canals and abscess are syringed with weak pyrozone, and a small amount of campho-phénique, Dr. Black's 1, 2, 3 mixture, or myrtol may be pumped into the abscess, and by repeated blowing of warm blasts driven into all parts of the cavity. In twenty-four hours a slight serous flow should be observed, but if after three days any evidence of pus be detected, it is the signal to establish an external fistula. This is done in the manner before described. The treatment is now the same as that for the next class: chronic abscesses having fistulous opening.

Chronic Abscess with Fistulous Opening.—In these cases the canals are opened and sterilized as in all others by the powerful antiseptics named. The abscess tract is syringed out with 3 per cent. pyrozone until bubbling at the external orifice ceases. The canals are filled with campho-phénique, or the 1, 2, 3 mixture, after the dressing-pliers method, and drawn into and through the abscess cavity and tract by means of the rubber-cup device already mentioned. In cases in which the rubber-cup device fails to cause a flow of the medicament from the pulp chamber out through the fistulous tract, the result may be attained by filling the canals and pulp chamber with the fluid desired; for example, campho-phénique or strong carbolic acid, and then placing over the cavity a pellet of unvulcanized caoutchouc or warmed and softened gutta-percha base plate and exerting strong pressure upon it with a ball-end burnisher just enough smaller than the cavity to force the material well into the pulp chamber. This will cause the medicine to flow out at the fistulous opening, where in the case of carbolic acid its presence will be manifested by its coagulating effect upon the margins of the fistulous orifice.

The canals are to be temporarily filled with cotton saturated with an antiseptic, and as a rule the case proceeds rapidly to recovery. Fresh cleansing and dressing are indicated if all evidences of inflammatory action, seen in the gum color, are not absent in three days; in a week the external fistula should be closed.

If after a week the fistula remain open, discharging serum, a sterilized excavator is passed through the fistula and it may detect denudation and roughness of the apical cementum. After a root has been the seat of chronic apical abscess for a long period, not only may the apical pericementum be destroyed (Fig. 473), but the cementum itself may become saturated with the products of decomposition and invaded by septic organisms. It is not uncommon to find deposits of calculi upon the denuded cementum. Such an apex is the source of constant irritation; it is a foreign body, and is to be removed.

Fig. 473.



Chronic abscess: showing denudation of apex of root (*a* to *b*), with deposits of calculus upon cementum.

The operation of removal is technically known as amputation of the apex. The canal thoroughly sterilized is to be solidly filled with gutta-percha. A vertical incision is made which includes the fistula and exposes the process; the opening through the process is enlarged, by sweeping around its borders a large dentate bur. The incision, opening and abscess cavity are now packed with cotton saturated with phénol sodique, until all bleeding ceases.

The necrosed cementum is now exposed; a small and extremely sharp fissure bur, driven rapidly, is laid against the distal wall of the root and a constant pressure upon the bur maintained until the dead part is amputated. A sharp scaler may now be employed to round the edges of the root and make the cut surface smooth.

The cavity is syringed with phénol sodique, to thoroughly remove all blood-clots—favorable breeding-grounds for organisms; as a final measure the walls are touched with campho-phénique, and the edges of the incision brought together, using if necessary a stitch to unite the upper edges. In the abscess cavity iodoform or nosophen gauze is to be packed, and renewed in a couple of days. For a week the patient is directed to employ repeatedly a mouth-wash of 3 per cent. pyrozone. No attempt should be made to fill such a tooth with cohesive foil for several months.

In some of the cases of anomalous root form, such as a sharp bend upon the upper end of the root, and which renders it impossible to gain access to the apex of the root even through the aid of sulfuric acid, it may be necessary to treat the abscess through the fistulous opening. The roots are sterilized and cleansed to as great a depth as possible by the aid of sulfuric acid and fine cleansers, and the endeavor made to force hydrogen dioxid through the apical foramen and out of the fistula by means of a syringe. The cavity of the crown is filled with pink gutta-percha, and through it the nozzle of a syringe filled with 3 per cent. pyrozone is thrust, well up the canal. The piston of the syringe is forced down; it may be the solution will appear at the opening of the fistula, or it may be the solution will fail to penetrate the foramen and its backward pressure will force the gutta-percha from position. In that event myrtol is placed in the canal, which is filled with thread holding the same material. Three per cent. pyrozone is injected into the abscess cavity through the fistula, until effervescence ceases. The nozzle of a minim syringe (Fig. 441). charged with campho-phénique or the 1, 2, 3 mixture is passed into the abscess sac, and a couple of drops deposited. In very many cases the abscess will then proceed to recovery. The treatment should be repeated if necessary. If several dressings applied at intervals of a week do not cause a disappearance of pus formation, amputation of the offending portion of the root will be necessary. An heroic method of treating chronic abscesses which obstinately refuse to heal is by extraction and replantation. The method applies alone to single-rooted teeth, although it has been successfully performed upon molars.

The patient's mouth is to be sterilized, and the tooth extracted. It is immediately placed in a solution of 1 : 1000 mercuric chlorid at a temperature of 120° F. It has been repeatedly asserted, however, without satisfactory demonstration, that the cells of the deeper layer of the pericementum and the cementoblasts, and also the cement corpuscles retain their vitality for some period after extraction, and immediate replantation results in a re-establishment of the physiological union between the tooth and alveolus. It is certain that means and measures which are necessary to thoroughly sterilize the tooth before its reinsertion would be fatal to any cellular vitality which might exist in the cementum and its covering.

The pulp canal is opened from its apex and cleaned out with canal cleansers, and pyrozone 25 per cent. placed in the canal, where it is allowed to remain for some time. In the meantime the socket from which the tooth has been removed is syringed out with pyrozone, and should the pericementum not be adherent to the tooth, the depth of the socket is scraped by means of large spoon excavators to remove the tissues implicated in the abscess. The cavity is washed out with pyrozone, and a pledget of cotton which has been dipped in campho-phénique is placed in the socket at its bottom. The tooth is dried by means of warm air; the soft tissues, if any be present, at the apex are cut away for about one-eighth of an inch. The canal is filled with gutta-percha or solidly filled with gold, the end of the root cut off as far as it has been denuded of pericementum, smoothed, and returned to the antiseptic solution. The cotton is removed from the tooth socket, which is syringed out with 3 per cent. pyrozone, and the tooth returned to position. It is tied to the adjoining teeth by means of silk ligatures or held in place by an appropriate retaining appliance.

Occasionally the seat of an alveolar abscess may be at the bifurcation of the roots of a molar. This may occur upon vital teeth owing to a foreign body being driven beneath the margin of the gums and into the point of bifurcation. In these cases it is noted that the inflammation affects the gum about the neck of the tooth; over the apices of the roots there may be no evidences of inflammation; pus forms and discharges quickly. Syringing out the tract with 3 per cent. pyrozone usually frees it from pus and the offending substance—it may be a bristle of a toothbrush—and the case heals rapidly.

Cases are seen in which the gum attachment about the neck of the tooth is unbroken; and free access may be had to the apex of each root of a tooth manifestly suffering from acute pericementitis, presumably due to a putrescent pulp. In a day or two a discharge of pus may be noted about the neck of the tooth. Such teeth when extracted exhibit an unmistakable abscess sac in the pericementum at the bifurcation of the roots. Whether the pyogenic organisms have traversed the dentin in the bottom of the pulp chamber and the cementum beneath, and thus inaugurated the suppurative process, is undetermined; it may be, however, that waste products from this source following the channel named may have saturated the cementum with noxious material and caused the inflammation, or the organisms may have found entrance at the gum margin. The diagnosis of such a condition is most uncertain before pus finds exit at the gum margin. Such a case is to be treated by sodium dioxid, full strength, placed in the floor of the cavity, frequently washed away and renewed until the base of the pulp chamber is bleached *white*. The abscess cavity is syringed out with pyrozone.

Another variety of abscess should receive mention: that occurring about lower third molars, affecting the gum tissues partially enclosing the emerging crown. The gum overlying and surrounding the erupting tooth becomes reddened, tumid, and exquisitely sensitive; if the inflammation be not aborted by timely incision and antiseptic washes, pus may form, and the gum acquire an ulcerous appearance. The treatment is free incision, dividing the swollen gum, and syringing with 3 per cent. pyrozone. If there be ulcerous surfaces they are to be touched with 50 per cent. solution of trichloracetic acid.

Occasionally the muscles of mastication may become affected by the inflammatory process, and inability to open the jaws result. Such cases are not uncommon when the eruption of the tooth is delayed by lack of room between the ramus of the jaw and the second molar. The extraction of this latter tooth may be required before relief is secured.

Complications of Alveolar Abscess.

The complications of alveolar abscess are due in acute cases to the involvement of other tissues than those commonly affected in the course of abscess formation and discharge. They depend in great part upon peculiarities of the anatomical relations existing between teeth and their surroundings, and, as anatomical variations are not uncommon in these parts, aberrations of disease process may be found with unwelcome frequency. An examination of some of Dr. Cryer's sections[1] will exhibit in one case the root of a lower second bicuspid penetrating the passageway for the inferior dental vessels and nerves. It is quite possible that an abscess upon such a tooth discharging about the fibrous sheaths of

[1] *Proc. of American Dental Association*, 1895.

these vessels might travel to distant parts—backward through the inferior dental foramen, or forward through the mental foramen.

The roots of molar teeth instead of having their thinnest bony covering overlying their buccal aspects, may have their apices almost perforating the lingual wall of the bone; in others the apex of the root of a lower molar is found beneath the line of insertion of the mylo-hyoid muscle. Abscess from such a case as this would probably discharge not into the cavity of the mouth, but in the submaxillary triangle. (See the case of Dr. Cryer's noted early in the chapter.) Dr. Harrison Allen[1] records one of these cases. The septic roots of a lower third molar were the exciting cause of pericementitis, followed by osteitis and maxillary periostitis. Pus found exit beneath the mylo-hyoid muscle and gravitated, forming a collection about the hyoid bone, and from that point passed upward upon the face in the line of the facial artery. The abscess in addition pressed directly upward against the floor of the mouth and caused unilateral glossitis, from the mechanical effects of which upon the organs of respiration the patient died. The duration of the extra-maxillary complication was but four days.

In the progressive resorption of the inner substance of the superior maxillary bone which results in the formation of the maxillary sinus, a process which certainly continues longer in some persons than in others, the bony structures may be removed to such an extent that but a thin layer of bone, periosteum and mucous membrane covers the apices of the roots of molars. Dr. Cryer's sections exhibit two cases in which the excavation of the sinus has proceeded down between the roots of an upper molar, creating such a condition that abscess upon either palatal or buccal roots must almost inevitably discharge into the sinus. No doubt many cases of incipient empyema of the antrum are aborted by the early extraction of abscessed molars, the antral complication being unrecognized. It is presumable that most of the cases of empyema of the antrum afford subjective evidence comparatively early, owing to the lighting up of inflammation and purulent catarrh.

The student is advised, in studying the relations of the teeth with the maxillary sinus, to a careful and repeated reference to the sections of Dr. Cryer. He calls attention to a fact frequently overlooked and untaught, that the orifice or opening connecting the maxillary sinus with the nasal passage is near the roof of the former, so that while the patient is in the erect position collections of fluid must nearly fill the sinus before there is a discharge. In the recumbent position, however, the fluid escapes and may be found in the nostril of *one* side. This is symptomatic of antral empyema. In acute cases of the antral disease there is much swelling, œdema about the eyelid, etc.; sharp lancinating

[1] Garretson's *Oral Surgery*, 6th edition.

pains dart about the jaw. In the chronic cases, large accumulations of pus may occur and not be detected until the bone is thin and bulged, emitting a crackling sound upon pressure. Extraction of the offending tooth furnishes an outlet for the pus.

It is usual to attempt the passage of an instrument through the pulp canals into the antrum and endeavor to preserve the tooth. Such a drainage is insufficient; the wall of the antrum should be perforated. This little operation is readily done: At a point about one-eighth of an inch or more above the apices of the roots of the molars an incision is made through the mucous membrane of the buccal alveolar wall, clear to the bone; a spear-pointed drill, a large one driven rapidly by the engine, is passed instantly through the outer antral wall. The drill is directed upward and inward. The opening is made sufficiently large to permit free irrigation. Into the opening thus made the point of a syringe, perforated to sprinkle, is placed, and the cavity washed out with 3 per cent. pyrozone which has been diluted one-half and made faintly alkaline by the addition of sodium dioxid. As pointed out by Dr. W. H. Atkinson many years ago, unless the irrigating fluid be made faintly alkaline it is irritating. As a stimulant injection to follow, Lugol's solution (liquor iodi compositus, gtt. xx to the ounce) is excellent. The canal of the tooth is to be thoroughly sterilized and filled.

In the treatment of other complications, if the case be acute, the immediate extraction of the offending tooth and the free use of antiseptic mouth-washes will usually effect a cure. In the treatment of chronic cases, if the focus of infection, the pulp canals, be made antiseptic and the medicinal agents can be introduced into the abscess tract throughout, surprising cures may result, as the literature of dentistry testifies.

Abscess upon Temporary Teeth.—Among the most trying classes of cases with which the dental operator is confronted are those of pericemental disturbance affecting the temporary teeth. The operator is torn by conflicting emotions: the desire to afford quick relief to the little sufferers and the hesitancy or dread of inflicting the amount of suffering necessary to relieve the acute pain. Fortunately the pain is relatively less than in adults; the tissues being softer the child escapes the agonizing pain attending the rapid formation of pus in the apical tissues of the adult. The swelling, redness, and febrile disturbance are usually greater in the child than in the adult; pus forms more quickly and makes its appearance in the gum sooner. The principle of treatment is the same as with the adult—evacuation of the pus. The necessary incision may be made almost painlessly by employing a sharp-pointed bistoury having a razor-like edge. The child, reassured by a gentle examination and firm kindness, is directed to open the mouth and close the eyes, when the bistoury, held as a pen, is passed quickly into the swelling.

The canals of temporary teeth are to be sterilized first with pyrozone, next with oil of cassia, and should be filled with "balsamo del deserto." Dr. W. H. White, to whom we are indebted for the introduction of this material, states that in roots of temporary teeth in which it has been placed the resorptive process is not interfered with.

Abscess occurring upon temporary teeth should receive prompt attention and treatment to avoid possible injury to the permanent tooth beneath; this, however, does not appear to be as frequent as might be supposed. There is a tendency in strumous children toward marked lymphatic involvement attending alveolar abscess; and secondary abscess of the lymphatic glands is not uncommon.

Chronic abscess in the cachectic individual which may not respond to the usual local measures of treatment may be materially benefited by constitutional treatment. This comprises regulation of the functions of the alimentary canal; the use of such foods as beef peptonoids, maltose, etc. Iron and arsenic are administered when the patient is, as is usually the case, anemic. More important than any medicinal therapeutics is systematic exercise in the open air. Raising the bodily tone raises the recuperative power of the tissues, and hitherto resisting disease may be conquered.

Perforated Roots.—Perforation of the walls of a root canal exposing the pericementum occurs, as a rule, in consequence of two causes: first, the invasion of dental caries; second, the injudicious or unskilful use of the reamer employed in enlarging canals, or, it may be, burring through the walls in the forming of a socket for the reception of the post of an artificial crown.

The direct consequence of the perforation is inflammation of the pericementum, and the usual result is ulceration of that structure. The symptoms and their severity are, as a rule, governed by the situation of the perforation. If this be at the lower half (toward the crown) of the root, there is usually a proliferation of tissue which intrudes upon the pulp chamber. This hypertrophied tissue may increase in amount, a resorption of the edge portion of the process occur, and a fungous mass bearing a close resemblance to fungous pulp bulge into the pulp chamber. In fact, in many cases it is impossible to distinguish between the naked-eye appearance of fungous pulp and the condition under discussion. The growth fills the pulp chamber and obscures the perforation; it is in addition, in many cases, exquisitely tender. In either event, whether pulp or hypertrophied gum, it is necessary to remove the growth.

A spray of ethyl chlorid directed against the mass is perhaps the most effective anesthetic; in a few minutes a sharp fine-pointed lancet is passed around the growth as far as it can be, and the excised portion removed. An application of tannin will check the bleeding; pledgets of cotton dipped in tr. iodin. are packed against the remainder of the growth and covered in with cotton and sandarac varnish for twenty-four hours. This dressing is renewed from day to day until, if it be a fungous gum, the margins of the perforation are plainly seen. The canal is cleansed, sterilized, dried, and filled with salol and gutta-percha, or with paraffin and gutta-percha, to about half its depth. The remainder of the canal and crown cavity are washed out with 25 per cent. pyrozone, and a dressing of temporary stopping applied, filling the perforation and yet not exercising much pressure upon the soft tissues. In two days the temporary stopping is removed and the cavity is washed out with 3 per cent. pyrozone and dried. A piece of No. 60 gold is cut, larger than the aperture; this is dipped in chloro-percha and laid over the perforation. A disk of gutta-percha larger than the piece of foil is warmed, laid upon the foil, and pressed against it, sealing it to the cavity walls. The remainder of the cavity is then filled with zinc phosphate.

In case the perforation should be nearer the apex of the root the difficulty is greatly increased. Attempts at passing cleansers to the apical foramen usually result in pricking the pericementum at the perforation and a flow of blood follows, filling the canal. The cleansers are bent so that in passing them to the apex they press against the wall opposite the perforation; the apical portion of the canal may be detected and cleansed after this manner in some cases. The temporary dressings in these canals should be one of the antiseptic oils, cassia or myrtol. A dressing of oil on cotton should remain a week, and no attempt at canal filling be made until all evidences of pericemental disturbance vanish. A fine cone of gutta-percha is passed, when practicable, into the canal beyond the perforation; the remainder of the canal is filled with chloro-percha, and the silk points covered with gutta-percha. The canal at the proximal side of the perforation is filled with the solution, by means of the long dressing pliers, the gutta-percha-covered silk being carried gently in position while the general mass is fluid. Balsamo del deserto should apply well in these cases. The canal is filled, or partially filled, with the material, and a large gutta-percha point introduced.

CHAPTER XIX.

PYORRHEA ALVEOLARIS.

By C. N. Peirce, D. D. S.

Definition.—"Pyorrhea alveolaris" is a generic term which, strictly defined, means a flowing of pus from an alveolus. It describes merely a symptom which may be and usually is attendant upon a variety of disorders. The term is applied in clinical dentistry to a complexus of pathological conditions which more or less clearly indicate a specific disease.

History.—That pyorrhea alveolaris is not a recent disease, or one due to modern constitutional states alone, is rendered evident from the examination of the skulls of ancient as well as modern races. The alveolar processes of many crania widely separated both in time and in locality exhibit marked impairment of structure which bears the closest resemblance to that presented by processes which were known to have been the result of pyorrhea during life.

Recorded observations of this disorder date at least as far back as 1746, when M. A. Fauchard described its essential clinical features, but failed to designate it by any specific term. Following this, communications describing the disease were published by Jourdain in 1778, by Toirac in 1823, and by M. Marechal de Calvi in 1860, in which it was described as a "conjoint suppuration of the gums and alveoli," *pyorrhea inter-alveolo-dentaire*, and *gingivitis expulsiva* respectively.

The most important contribution to the knowledge of the nature of the disease which had up to that date been made was by Dr. E. Magitôt in 1867. In his paper he states that the disease is characterized by a slow but progressive inflammation destructive of the periosteal membrane and cementum, proceeding from the neck to the apex of the root and involving the loss of the teeth. From the exact seat of the lesion he designated the disease *osteo-periostiti alveolo-dentaire*. Soon after the appearance of the periosteal inflammation, it became complicated with diseases of the gums and the osseous walls of the alveolus, though these are never primarily the seat of inflammation. Magitôt regarded the causes of the inflammation as very complex, and to be sought for not in the teeth and gums, but in certain conditions of the general nutrition. The gouty and rheumatic presented the disease most frequently, though its presence in those suffering from diabetes and albuminuria was extremely common. The deposition of tartar on the roots of the teeth, which might at first glance be regarded as playing an important part in the causation of the disease, Magitôt considered as accidental and not to be looked upon as a causative agent. With reference to the efficacy of any treatment, however, he advised the removal of the tartar as an indispensable preliminary. The points of diagnosis differentiating between this condition and the former, that of gingivitis, however severe, were also clearly recognized and noted.

Following Magitôt's able paper was one by Serran in 1880, in which the author took exception to certain of Magitôt's views, as well as to the term by which the latter proposed to designate the disease. He recognized, however, that the disease was most common in middle life and occurred principally among the gouty, the diabetic, and the albuminuric. He believed that the primary manifestation was a local congestion of the gums, followed by an exudation into the peridental membrane which destroyed its vitality and led to the formation of pus and all the other symptoms and pathological conditions characteristic of the disease. A commission composed of MM. Depres, Delens, and Magitôt was appointed by the Société de Chirurgie to consider the statements of Dr. Serran. In this report[1] they denied the *gingival* origin of the disease, and stated their belief that the periosteal membrane and the cementum were the primary anatomical seat of the lesion; that the succession of morbid phenomena completely precluded the idea of an initial gingivitis; that the disease begins without any trace of congestion of the gums; that after its formation the pus burrows toward the gingival border, which it detaches—without, however, for a time destroying its normal aspect; that only after considerable augmentation of the flow of pus and the loosening of the teeth do the gums become implicated; that the disease has nothing in common with the hypothesis of a gingival malady, and that it is most frequently a manifestation of a general state, or a diathesis.

These were the views entertained and published by French surgeons on the nature of "pyorrhea alveolaris" about the period when the disease began to receive consideration from American dentists. Though pyorrhea alveolaris had long been recognized in the United States and various observations regarding its pathology and treatment had been published, it was not until Dr. John W. Riggs, in October, 1875, read a paper before the American Academy of Dental Surgery, entitled "Suppurative Inflammation of the Gums and Absorption of the Gums and Alveolar Processes," that the disease began to attract the attention

[1] *Bulletins et Mémoires de la Société de Chirurgie*, tome vi. p. 411.

its gravity merited. Notwithstanding the views entertained by Magitôt and others regarding the constitutional character of the disease, Dr. Riggs in his communication [1] emphatically denied that the disease is an affection of the bone or of the gums, or that it is hereditary or constitutional, but, on the contrary, that it is the roughened teeth themselves, in consequence of the accretions from whatever source derived, which are the exciting cause of the inflammation ; that it is purely local in origin, the result of concretions near and under the free margins of the gums, the removal of which even in the third stage is followed by cure.

In 1877 Dr. F. H. Rehwinkel [2] entered his protest against the theory of the local origin of the disease, and endeavored to prove that it not only may but does exist independently of foreign deposit and must depend on other than merely local causes, and that it is an hereditary and constitutional disease.

Dr. L. C. Ingersoll, in 1881, published a paper entitled "Sanguinary Calculus," [3] in which it was stated that the persistent flow and discharge of pus along the side of the tooth was caused by an inflammation and ulceration at or near the apex of the root ; as a result of which molecular death the liquor sanguinis escaped from the bloodvessels into the surrounding tissues and became disorganized, the lime salts crystallized on the surface of the roots, and formed the deposit which from its origin he designated "sanguinary calculus." This deposition he regarded as entirely distinct from salivary calculus, and as derived from the blood—the result of inflammatory action and not its cause. In other words, he held that pyorrhea is a local disease but beginning centrally ; that is, at or near the apex of the root.

In 1882, Dr. A. Witzell read a paper before the German Society of Dentists,[4] in which it was asserted that the primary pathological change was an inflammation and caries of the alveolar border followed by a deposit just beneath the free margins of the gums, which became retracted and reverted. The entrance of micro-organisms into this carious region developed pus which became more or less infectious. In consequence he termed the disease "infectious alveolitis." He regarded the disease as a primary local alveolitis, having no constitutional relations whatever, a molecular necrosis of the alveoli or caries of the dental sockets produced by septic irritation of the medulla of the bone.

In 1886, Dr. G. V. Black prepared for publication probably the most exhaustive paper in print in the United States, wherein pyorrhea

[1] *Pennsylvania Journal of Dental Science*, vol. iii. p. 99.

[2] Report of the Committee on Pathology and Surgery, *Trans. American Dental Association*, 1877, p. 96.

[3] *Ohio State Journal of Dental Science*, vol. i. p. 189.

[4] *Vierteljahresschrift für Zahnheilkunde*, 1882 ; *British Journal of Dental Science*, vol. xxv. p. 153.

alveolaris is treated as a local disturbance.[1] Calcic inflammation and phagedenic pericementitis are the terms he employs to indicate its character. Though he believes it to be wholly local, he thinks a serumal or sanguinary deposit may be closely allied with its origin. He describes it as a destructive inflammation of the pericemental membrane, distinct from other inflammations of this tissue though having many features in common with them. The disease, he estimates, is essentially one of the peridental membrane rather than of the alveolus, though the destruction of these two structures is so nearly synchronous that it is difficult to say which has gone first.

In 1886, Dr. W. J. Reese read a paper before the Louisiana State Dental Association on "Uremia and Its Effect on the Teeth,"[2] in which the chemical, physiological, and pathological relations of uric acid to the general nutrition were discussed. In this communication Dr. Reese expressed the opinion that the inflammation of the pericemental membrane followed by suppuration and disorganization when in contact with the secretions of the mouth, is caused by the deposition of uric acid derived from the blood; that the disease should be termed "phagedena pericementi;" that "pyorrhea alveolaris" is a misnomer. He also stated that while the tophus on the roots of the teeth is the usual concomitant of uric acid, it is not necessarily so, but that absorption of the pericemental membrane may take place without any deposit. Though a local treatment was advocated, he stated that without systemic or constitutional treatment the return of the trouble may be expected.

Dr. John S. Marshall, in 1891, expressed his conviction that pyorrhea has a constitutional origin and is closely allied to the rheumatic or gouty diathesis; "that the deposition of the concretions upon the roots of the teeth in those localities not easily reached by the saliva, or in which the presence of the saliva would be an impossibility, is due to the causes which produce the chalky formations found in the joints and fibrous tissues of gouty and rheumatic individuals."[3]

The writer, in a series of papers published during 1892–94–95,[4] presented a number of clinical and pathological facts which in their totality it was believed established a kinship between pyorrhea alveolaris or hematogenic calcic pericementitis and the constitutional state familiarly known as the gouty or uric acid diathesis.

Recent literature by American writers has dealt largely with the

[1] "Diseases of the Peridental Membrane having their Beginning at the Margin of the Gum," *American System of Dentistry*, vol. i. p. 953.

[2] *Dental Cosmos*, vol. xxv. p. 550.

[3] "The Rheumatic and Gouty Diathesis, with its Manifestations in the Peridental Membrane," *Trans. American Medical Association*, 1891.

[4] *International Dental Journal*, vols. xiii., xv. and xvi.

problem of the etiology of the disease in question and has been principally concerned in determining whether it is of constitutional origin or of local origin, or of both. Of the more important recent writings on the subject may be mentioned those of Drs. E. T. Darby, H. H. Burchard, G. V. Black, M. L. Rhein, E. C. Kirk, James Truman, Junius E. Cravens, Louis Jack, R. R. Andrews, and R. Ottolengui.

Terminology.—No disease in the whole domain of surgery has received so many and such diverse names as the one under consideration. Each succeeding title was an attempt at the production of a comprehensive descriptive designation of the disease, but when it is recognized that the essential nature of the pathological processes involved is, even now, not fully made out, it is evident that the many names simply represent as many diverse views and can therefore have no permanency, nor do they, indeed, deserve any.

The following is a fairly complete list of the synonyms of the disorder: Suppuration conjointe; Pyorrhea inter-alveolo-dentaire; Gingivitis expulsiva; Osteo-periostiti-alveolo-dentaire; Pyorrhea alveolo; Cemento-periostitis; Infectioso-alveolitis; Pyorrhea alveolaris; Calcic inflammation; Phagedenic pericementitis; Riggs' disease; Hematogenic calcic pericementitis; Blennorrhea alveolaris; Gouty pericementitis.

Examining the foregoing list, from the pathological point of view, it will be observed that there is a wide divergence of opinion as to the conditions which should be included under the generic title of pyorrhea alveolaris.

As the term is now understood, pyorrhea alveolaris includes all of those cases of morbid action characterized by the following features: A molecular necrosis of the retentive structures of the teeth (their ligament, the pericementum), an atrophy of the alveolar walls, together with a chronic hyperemia of the gum tissue which leads to limited hypertrophy. After a variable period the teeth drop out, and the morbid action ceases with their loss. An examination of the roots of the teeth before or after their exfoliation usually exhibits deposits of calculi upon their surfaces. The disease is generally though not always attended by a flow of pus from the alveoli.

Clinically the cases in which these phenomena are observed may be divided into two classes: First, those in which the disease process appears to begin at the gum margin. The second class, those in connection with which there is much controversy, begin at some portion of the alveolus between the unbroken and apparently healthy gum margin and the apex of the root, the pulp of the tooth being alive. These two conditions are so clearly differentiated from one another that each requires a separate description. Between these two classes, but intimately associated with the latter, are to be included the cases described by Dr. G. V. Black[1] as "phagedenic pericementitis."

Class I. Pyorrhea Alveolaris beginning at the Gum Margin (Ptyalogenic Calcic Pericementitis).

The first class—those cases beginning not at, but immediately beneath the gum margin—are perhaps the most common, are by some erroneously supposed to be the only type of cases, and will require description first, as their causes, progress, prognosis, and treatment differ radically from those of the second class.

Causes of Class I.—As in any disease, the causes of pyorrhea alveolaris grouped as Class I. may be divided into predisposing and exciting. The predisposing causes may all be included under the head of disorders causing a subacute inflammation of the gingivæ. General catarrhal conditions; small but irritating deposits upon the necks of the teeth, as the accumulations upon the teeth of smokers; fermenting deposits of food; spirit-drinkers' stomatitis, mouth-breathers' gingivitis; overcrowding of the teeth, mal-occlusion, and non-occlusion. The predisposing causes may also frequently be the exciting causes. The exciting causes proper are, however, subgingival scaly deposits of calculi.

Clinical History.—In the mouth of a patient of one of the abovementioned classes there will be noted at some period a gingivitis—a swelling of the gum which does not extend far from their margins. It is noteworthy that in these cases, as in the succeeding class, it is usual to find the disease attack teeth which are comparatively or quite exempt from the inroads of caries. Soon after the incipiency of the disease there may be squeezed from beneath the gum margins a detritus of food débris and inspissated mucus. At a later stage a sharp scaler passed beneath the gum margin may detach a flat greenish or black deposit of calculus. Later, the gingivæ are seen to become swollen and are gradually detached from the neck of the tooth, the flattened calculus increases in volume, and the irritation and injection of the gum deepens. "It is probable that these deposits have their origin in a reaction between the altered mucous secretion of the gingival glands and the products of lactic fermentation, their calcic salts being derived from the saliva."[2] The detachment of the gum does not become marked until these dark scaly deposits have encroached upon the margins of the alveolus. Soon thereafter, or indeed before, evidences of infection are observed, from the fact that pus may be pressed from the pockets. The disease progresses, the teeth loosen, and ultimately drop out or are re-

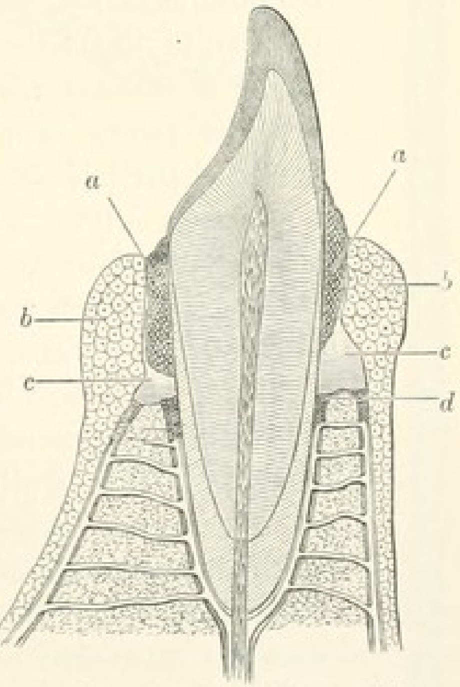
[1] *American System of Dentistry*, vol. i.

[2] H. H. Burchard, *Dental Cosmos*, October, 1895.

moved with the fingers, the injected gum remaining as a flabby mass and all evidences of dental disease ceasing with the loss of the teeth. The process may involve one, two, or more teeth and in some cases an entire denture. The origin of these deposits as well as those of ordinary calculi are so clearly traceable to the saliva that the writer has suggested for the conditions caused by them the name of *ptyalogenic calcic pericementitis.*

Pathology and Morbid Anatomy.—The appended figure, semi-diagrammatic, will illustrate clearly the nature of the disease process (Fig. 474). It represents a longitudinal section through a tooth and its alveolus, with the vascular supply to the tissues. The pericementum and alveolar walls for some distance from the apex of the root are in a healthy condition. At the neck of the tooth are seen two deposits of calculi (*a*, *a*). The overlying gum (*b*, *b*) is seen to be swollen and tumid at its edges. Immediately below the calculus, where it encroaches upon the pericementum, the latter tissue and also a portion of the alveolar periosteum is seen to have undergone necrotic changes (*d*). The portion of alveolar wall uncovered by periosteum is in process of dissolution. In the pocket beneath the calculus a collection of pus is seen (*c*, *c*), so that the tissues beyond the calculus are involved in suppurative degeneration, which may be slow or rapid in its progress.

Fig. 474.



Ptyalogenic calcic pericementitis (Burchard).

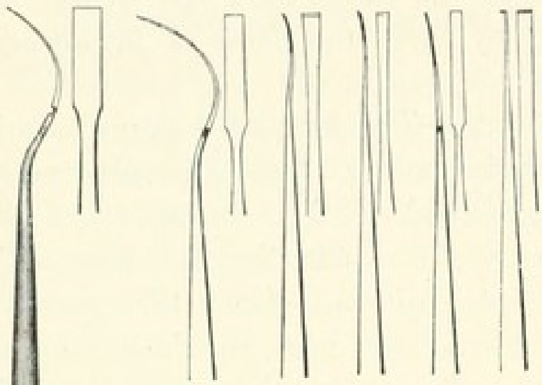
The **diagnosis** is by sight and touch and not infrequently by odor, as particularly in unhygienic mouths an offensive odor attends the progress of the disease. The gums are tumid; from about the necks of the teeth pus may be pressed, and touch demonstrates the presence of flat, dark, and firmly adherent scaly calculi.

The **prognosis** is favorable at even advanced stages, provided certain conditions may be obtained, viz. a removal or correction of the predisposing causes and a perfect removal of the exciting causes.

Treatment.—The treatment is based purely upon the existing conditions, with two main objects in view. The first is to remove every source of irritation; the second, to procure surgical rest until there is a return of the surrounding tissues to a normal condition.

As a general rule the first step of the operation consists in a careful and thorough scaling of the teeth. It is essential that the use of bulky scalers be avoided—first, for the reason that they rarely reach the deepest portions of the deposits; second, that if they do, they cause more or less laceration of the gum, which should be kept as free from injury as possible. The instruments employed for this purpose by a majority of operators are the set known as Cushing's scalers (Fig. 475). Their mode of application and their position relative to the root are shown in Figs. 476, 477. No instrument with a draw cut can remove these deposits with the same thoroughness as one operated with a push cut. With proper guarding it is improbable that these instruments should do harm to the vital parts beyond the calculus. Great care should be exercised in the use of pushing instruments to avoid forcing the dislodged particles into the deeper tissues. The scaling is a tedious operation, but one which should be persisted in until the root of the affected tooth is absolutely smooth. The scaling is alternated with a washing out of the pockets with 3 per cent. pyrozone or hydrogen dioxid, which washes out the detached particles of calculus and disinfects the parts. "When the gums are tumid and interfere notably with the scaling process, applications are made of a solution of trichloracetic acid 1 : 10 upon cotton tents; this checks oozing, shrinks the gum, giving a better view of the parts, and tends to soften the deposits."[1] "It not infrequently happens that the teeth have suffered such extensive loss of their retaining structures that the operation of scaling tends to still further loosen them. In these cases the correction of mal-occlusion and splinting the teeth should be attended to before proceeding farther with the operation. The teeth should be ligatured to their fellows, and the excessive occlusion corrected by grinding away the points of contact with corundum wheels sufficiently to relieve the teeth of strain and to permit the fixing of a metallic splint by means of which the teeth may be held firmly, during and subsequent to the scaling operation."[2]

Fig. 475.



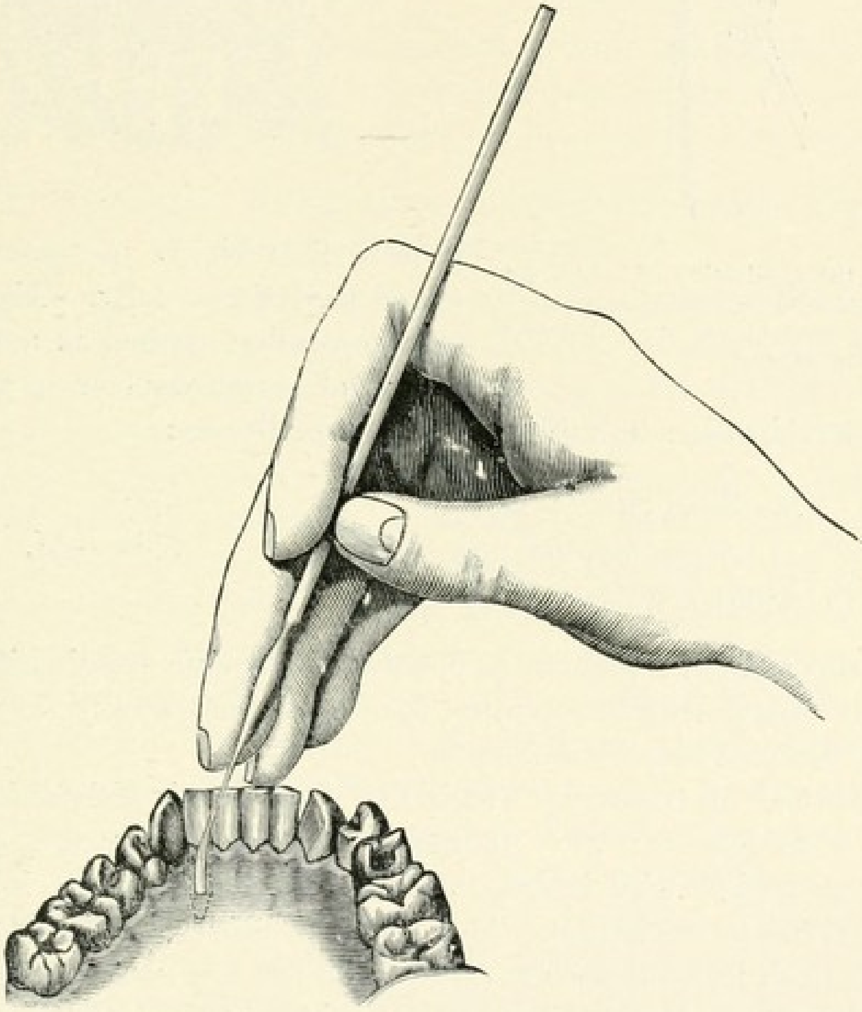

Cushing's scalers.

Splints for these cases are usually swaged metallic caps made of

[1] E. C. Kirk. [2] H. H. Burchard, *International Dental Journal*, August 1895.

No. 31 metal, gold or silver, which are cemented to the teeth (Fig. 478). When the teeth have suitable forms, a succession of rings soldered together may be employed; in other cases the teeth are lashed together by means of fine gold wire. For temporary use No. 31 or 32 annealed brass wire may be used, and when left *in situ* for weeks or months it exerts no deleterious effect. In fact, it appears to possess

FIG. 476.

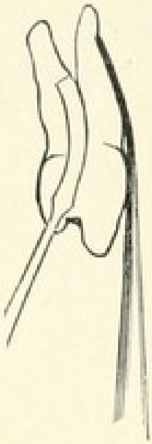


Showing the manner of holding an instrument for detaching calcareous deposits when using the pushing motion. The third finger rests on the edges of the teeth, allowing freedom of the hand to make rapid and effectual movements in dislodging the calculi.

antiseptic properties similar to those attributed to copper amalgam when used as a filling material. Or, if frequently renewed, floss silk may be used. Devices for this purpose are as numerous as designs for bridge work.

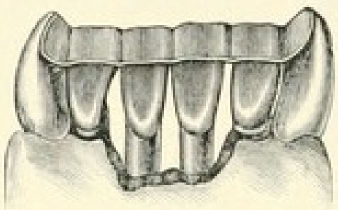
Each root is to be perfectly scaled before proceeding to a second tooth. At the completion of the scaling the pockets are freely syringed out with pyrozone 3 per cent., and an application of an astringent made: a 10 per cent. solution of zinc chlorid, 20 per cent. solution of zinc iodid, or tr. iodin. U. S. P. diluted one-half with alcohol. Preparations of aristol and the officinal tincture of iodin are also used, all of which subserve the desired end, to sterilize the parts and to constringe the dilated vessels of the gum. An antiseptic and astringent mouth-wash is prescribed which the patient is to use several times daily. The following preparation applied on a small roll or tuft of cotton wool or by means of a soft toothbrush admirably meets the conditions:

Fig. 477.



Showing the application of a thin flat instrument to the labial and approximal surfaces of an upper bicuspid (pushing motion).

Fig. 478.



℞. Zinci chlorid., cryst.,	ʒjs;
Aquæ menthæ pip.,	f ℥iv.—M.
S. Apply locally to the gums.	

As early in the treatment as possible a thorough examination should be made with a delicate exploring instrument, so that any calculi which may be detected may be removed.

A method of treatment which has given much satisfaction to the writer is as follows: First thoroughly cleanse the mouth and each particular pocket with hydrogen peroxid, electrozone, or some other equally efficient antiseptic. Then with a blunt but flexible broach, gold or steel, let each pocket from which pus has been issuing be very carefully saturated with trichloracetic acid; this is repeated each visit if pus continues to flow. Following this, the pockets and gingival borders or margins are thoroughly treated with tincture of iodin, followed with solution of hydronaphthol and alcohol. If the gingivæ, however, should be tumefied, an application of carbolic acid will prove advantageous:

℞. Hydronaphthol,	ʒij;
Alcohol,	℥iv.

This must be used with caution, for it is of sufficient strength to give the patient much discomfort if brought in contact with lips and tongue. The frequency of the visits and applications must depend upon the virulence of the disease. A wash for the patient's daily use made from the following formula will be of great service:

℞. Hydronaphthol,	gr. x;
Glycerol,	℥j;
Alcohol,	℥ij;
Aquæ dest.,	℥ij.

The use of hydronaphthol in pyorrhea alveolaris was suggested by Prof. James Truman.

The loss of alveolar walls is permanent; the utmost the operator can hope in extreme cases is a reorganization of the tissues which have been softened as a consequence of the inflammatory action.

Class II. Pyorrhea Alveolaris of Constitutional Origin—Gouty Pericementitis.

The second class of pyorrhea cases—those in which local therapeusis has not been attended with permanent good results—are usually chronic, extending over a variable period of time, owing to the fact that they are but the local expression of constitutional states. Of these many forms of pyorrhea, one is particularly persistent, terminating only, unless properly treated, with the exfoliation of the affected teeth. This particular form, which has been the subject of much discussion during the past twenty-five years, the writer believes to have been shown to be but a local expression of the gouty diathesis and directly dependent on the deposition of the uric acid, urates, and calcium salts in the pericemental membrane; though it is probable that allied and closely related compounds, such as the xanthin or alloxuric bases (xanthin, guanin, and adenin), may also be present in small quantities. Indeed, as the gouty diathesis is largely dependent on a faulty metabolism of proteid compounds and an imperfect elimination of nitrogen-holding derivatives, it is quite possible, though not proved, that any or all derivatives may be present in any pathological deposition. Inasmuch, however, as the amounts of these compounds are small, uric acid and uratic salts must be regarded as the chief of the specific irritants. As the origin of the salts is from the blood, the writer suggested the term *hematogenic calcic pericementitis*. Subsequently Dr. E. T. Darby suggested the happily applicable term *gouty pericementitis*.

Clinical History.—It is noted that many patients who have magnificent dentures almost exempt from caries, at a period about middle life begin to have a loosening of the teeth which if unchecked leads to the loss of the entire denture. The disease may be observed at any stage from a slight loosening to impending exfoliation. An examination of many cases will show that although they present apparently diverse conditions, yet beneath these differences there is a striking uniformity, particularly as to the family history of such patients.

A complete and accurate study of the succession of symptoms which a typical case of gouty pericementitis presents from its inception to its termination is rendered difficult, owing to the lack of extended observation of the disease throughout the entire period of its evolution and dissolution. This is especially true of this disease in its earlier stages. Nevertheless from an attentive study of a large number of individual cases in various stages of development it is believed that a fairly correct picture can be deduced.

First as to the teeth themselves; as stated, they are almost exempt from recent caries. The teeth frequently exhibit a tendency to mechanical abrasion upon their cutting edges or labial surfaces. If the patient be of a sanguine temperament, or this temperament combined with the bilious, the tendency to erosion is much more pronounced. It must be appreciated that this destruction of tooth tissue has nothing in common with ordinary dental decay or with the results of friction in mastication.

In nearly all cases, should excavation of cavities in the teeth become necessary, or sections of lost teeth be examined, it will be found that the pulp has receded, *i. e.* has suffered a continued stimulation of its functional activity to the extent almost of obliteration.

The patient may consult the operator as to the causes of repeated attacks of dental neuralgia, or the reason of consultation may be the alteration of position of one or more teeth. An examination of the organs, however, reveals no evident cause for either the neuralgia or the displacement.

If the malposed tooth be kept under observation it will usually be seen to become elevated, loosen, and finally drop out. Other teeth become affected in a similar manner. Dr. Burchard has classified the course of pyorrhea as in three stages, as follows: "First, tooth induration; second, erosion or chemical solution of the crowns of the teeth; third, a loss of the retaining structures of the teeth. Pathologically stated, there is first a stimulative stage; second, an irritative, characterized by altered secretion (erosion); third, the necrotic."

The altered secretion pertains to the labial glands largely, and the necrosis to the pericemental membrane and the apical end of the root, or that portion which has been denuded of the membrane; while the alveolar process never, in the writer's judgment, undergoes any change except that of absorption and atrophy.

By far the greater number of cases present themselves when the disease has made marked advance about one or several teeth and their immediate loss is threatened.

Assuming that the gouty diathesis however well or poorly developed may be a predisposing cause, and the deposition of some characteristic specific gouty material from the blood into the pericemental tissues the immediate or exciting cause, we have an explanation for the irritation and necrosis of the alveolo-cemental membrane, which even in its early stages is easily recognizable. Coexistent with the pericemental hyperémia there is more or less redness and turgescence of the gums, accompanied by a sense of tenderness, soreness, and in many cases neuralgic pain, which latter symptom frequently precedes all other symptoms. In individuals already suffering from pyorrhea, the early irritative stage of the disorder may be frequently observed in teeth previously free from all signs of the disease. In nearly all such instances the focus of the diseased action is confined almost exclusively to the region toward the apical extremity of the root without there being the slightest evidence of peripheral local gingivitis. Too much stress cannot be placed on this fact, as it unquestionably marks the incipiency of the disease and is one of the early diagnostic symptoms.

Somewhere near the apex of the root a distinct swelling occurs simulating an acute apical abscess. The tooth is sensitive upon percussion, but less so than when affected by purulent apical pericementitis; moreover by isolating the tooth it is found to respond to applications of cold, proving that its pulp is alive. A bistoury passed into the swelling is followed by an escape of blood, and usually by a glairy purulent discharge also, although not always. In some cases a probe passed into the opening may show an absence of alveolar process at that point, and by a roughness reveal the presence of a deposit upon the root of the tooth.

The teeth so affected usually present an appreciable elevation or protrusion from their alveoli in consequence of the enlarged or thickened and congested pericemental membrane. Should this congestion be permitted to continue, the inflammatory stage in consequence of the continued presence of the irritating deposit will supervene, with its concomitant symptoms, heat, pain, swelling, and marked impairment and in some instances total arrest of the functions of the tissues involved.

Inflammation once established will eventuate in localized suppuration with the abatement of the acute symptoms. The location of the suppurative process, if the case be seen and recognized early, will be found in the large majority of cases to be near the apical extremity of the root. As a rule, the pus takes the line of least resistance and burrows directly along the side of the root and opens externally at the gingival border. Occasionally the line of least resistance is toward the labial surface, with the discharge of pus on the gum opposite the end of the root, thereby establishing a fictitious opening simulating the condition observed in an acute alveolar abscess; these cases, however, are very limited in number.

Once established, these conditions of increased vascularity, tumefaction of the gums, and persistent discharge of pus may continue for months or years; the rapidity with which the disease progresses and the extent to which the lesions develop will be directly dependent upon the state of the general nutrition and habits of the individual.

As a result of the continued irritation induced by the deposit, the inflammation extends, the disturbed relation between blood and surrounding tissues increases, and the gums become flaccid, spongy, altered in color, and liable to hemorrhagic discharges. Associated with the congested and thickened condition of the pericemental membrane there is a gradual softening and absorption of the alveolar process, which may advance to such an extent as to almost or in some cases quite expose the root throughout its entire extent. The tooth thus freed from its retentive structures becomes loose, is freely movable in its enlarged and partially destroyed socket, is extremely liable to dislodgment by slight mechanical means, or if by care these are avoided it will within a limited time be exfoliated in consequence of the final and complete destruction of all its retaining structures. With this final result the progress of the disease is arrested. The alveolar socket being freely opened, the partially dead and decomposing tissues are removed and the remaining structures gradually restored to a normally healthy condition by the usual processes of repair.

When once established, pyorrhea alveolaris does not confine itself to any one tooth, but may extend to adjoining teeth or make its appearance in rapid succession in widely separated regions of the mouth in the lower as well as the upper jaws until the whole denture becomes involved, with an eventual exfoliation of all the teeth and a complete resorption of the alveolar process. When these exfoliated teeth are examined there will be found at some point of the root surface, almost always near the apex, an incrustation of a dark, rough calculus, or it may be several of them, all minute. The origin of the deposits being clearly not from the saliva, which is the source of the calculi in the disease described under the head of Class I., it has been called serumal or sanguinary calculus (Ingersoll, Black); the writer has suggested as the name of the disease caused by such deposits, *hematogenic calcic pericementitis.*

These assumed gouty deposits led the writer into an investigation as to the family history of patients affected by this disease. Almost without exception these individuals have been shown to be either the victims of some phase or form of gout, of alleged rheumatism or of rheumatoid arthritis (rheumatic gout), or to have a clear family history of one of these disorders. Careful investigation by several other observers has brought to light similar testimony, particularly within the past three years (Kirk, Darby, Burchard, Jack, and others).

It had been noted by succeeding generations of practitioners that the therapeutic resources (local) of dentistry were insufficient to either check or cure the disease condition. All local means of treatment having been exhausted and shown to be of little or no avail, there was a natural inquiry into the exact nature of the predisposing and exciting causes of the malady, so that the therapeusis might be placed upon a rational basis.

No purely local causes having been found sufficient to account for the dental condition, all constitutional states which were known to affect the teeth or their alveoli were examined and compared with the phenomena of the dental disorder. While it was and is found that several constitutional conditions do predispose to pyorrhea alveolaris, a flow of pus from a tooth socket, and most of these conditions may be included under the heading of diseases of sub-oxidation, none of them was found to cause a disease having the precise clinical phenomena noted in connection with the one under discussion. By a process of exclusion, and finally by direct clinical and experimental evidence, the field of inquiry was narrowed down to the conditions which clinical medicine has included under the heading of the disorders of the gouty diathesis.

In order to clearly comprehend the connection of the general condition with the local disease it is necessary to examine the essential, the intimate, nature of gout and its manifold manifestations. Much confusion has arisen in the discussion of this subject due to the lack of agreement of observers as to what constitutes gout, many apparently assuming that gout is necessarily and inseparably connected with an acute attack affecting the metatarso-phalangeal articulation (the great toe).

Pathology of the Constitutional Morbid Condition.—Pyorrhea alveolaris regarded as a local manifestation of the gouty diathesis is the result of a deposition of uratic salts in the pericemental membrane: these, acting as a local irritant, excite a specific inflammation; while, as in other manifestations, the deposition of the gouty material is determined by an abnormal condition of the membrane, a condition of impaired vitality, the result of some mechanical or other irritation, which predisposes it to the infiltration.

As no special manifestation of the gouty diathesis can be intelligently understood without reference to its constitutional relations, it will not be out of place to briefly consider the phenomena presented by—(1) The gouty diathesis as a constitutional malady; (2) The special manifestation here under consideration as a molecular necrosis of the pericemental membrane, or pyorrhea alveolaris.

The *gouty diathesis*, in the general acceptation of the term, is a constitutional malady which manifests itself under a great variety of forms in different individuals. It is characterized by an excess of uric acid and its congeners in the blood, due either to increased production, through impaired or imperfect assimilation of nitrogenous food, or to imperfect elimination of the normal amount of urates by the kidneys. In either event there is a disturbance of the normal relations between uric acid production and the general nutritional process. The protean forms under which the diathesis manifests itself will vary in accordance with the type of constitution and with the peculiarities of organization and the degree of vitality of individual organs and tissues. The lesions or pathological states observed are believed to be caused by the deposition into the tissues, from the blood, of urate of sodium. This diathesis is undeniably hereditary, as its presence is detectable in one form or another in fully 75 per cent. of all cases in two and even three generations. The diathesis can also be acquired by individuals who are subjected to the causes which rendered the diathesis hereditary. The age at which the local expressions manifest themselves lies between the thirty-fifth and fiftieth years, at a time when growth has ceased and the food supply is required only for tissue repair and heat production. It is most common among those who lead sedentary lives, who indulge in an excess of nitrogenous food beyond the capacity of the individual to perfectly oxidize, and those who consume excessive amounts of fermented and malted beverages and the heavier wines.

The immediate cause of all gouty expressions appears to be the presence of urates in the blood. The amount normally present is so slight that it is almost non-detectable by ordinary chemical methods. It was shown by Dr. Garrod that in gouty conditions the amount was increased to as much as 0.175 per 1000 parts, and that this apparently small quantity was quite sufficient to act as the irritating cause of gout—a fact corroborated by other observers.

The various theories which have been advocated from time to time in explanation of this uric acid increase in the blood plasma are unsatisfactory and contradictory; whether it is the result of imperfect elimination or of increased production through excess of nitrogenous foods it is difficult to state positively in the present state of pathology. It is quite probable that the diathesis is a neurosis which affects simultaneously the assimilative as well as the excretory functions of the body. Whatever the explanation may be as to the accumulation of urates, their presence in the blood is generally admitted to be the immediate cause of any gouty manifestation. Dr. Dyce Duckworth states that "No conception of this malady is possible which should exclude from its purview the part played in it by uric acid;" "The most unequivocal evidence of true gouty disease is that derived from the presence of uratic salts in the tissues." The immediate cause for the deposition of urates in individual tissues is to be sought for in a special vulnerability of the tissues, a loss of vitality, the result of mechanical, chemical, or vital influences. The views of Ebstein concerning the deposition of uratic salts have found general acceptance. He has apparently demonstrated that, in all connective tissues, *previous to the deposition* there is a primary necrosis of tissue elements without which the crystallization could not take place; that this disturbance of tissue vitality is the predisposing factor and the crystallization the exciting factor of gouty changes. The blood plasma transuding through the walls of the capillary vessels carries with it urate of sodium in solution; in the partially devitalized tissue inspissation occurs and in consequence crystallization.

The urate of sodium as it accumulates acts as a specific irritant to the tissue, giving rise to a variety of phenomena in accordance with the character of the tissue involved. The gouty manifestations may be either acute or chronic. In the acute forms the signs and symptoms are those of an acute specific inflammation of a joint, usually that of the great toe. Clinical study of pyorrhea cases strongly indicates that the disease frequently attacks the dento-alveolar articulation before other articulations in point of time. The local symptoms, pain, heat, tumefaction are associated with marked constitutional reactions, disordered digestion, and numerous evidences of general disturbance of nutrition. The duration of the attack may be from a few days to several weeks. Repeated attacks lead to an impairment of the functions of the joint and a permanent alteration of its structure.

In the chronic forms the symptoms are more widely distributed and their intensity is less pronounced according to the tissues involved. The various manifestations may be classified as follows:

Articular gout, in which the deposit occurs in joints.

Tegumentary gout, in which the deposit takes place in the skin and mucous membranes. Disease of the skin, such as eczema and psoriasis, and catarrhal affections of the mucous membranes, such as pharyngitis, chronic bronchitis, gastric and intestinal catarrhs, have long been recognized as expressions of gout.

Visceral gout, in which the deposit occurs in the viscera, such as the lungs, heart, bloodvessels, spleen, liver, kidneys, *i. e.* giving rise to various diseased conditions or giving a peculiar cast to disease already established.

Nervous gout, in which the nervous tissue is invaded, manifesting itself in a loss of mental energy, despondency, irritability of temper, headaches, neuralgia, etc.

The limits of this chapter do not permit, nor is it desirable, to enter upon a detailed statement of the symptoms or diagnostic features of these various phases of the gouty diathesis ; suffice it to say that, under one form or another, they are frequently present and associated with pyorrhea alveolaris. The pathology of pericemental inflammation from uratic deposition unfolds itself logically after a consideration of the diathesis in its constitutional aspects. Bearing in mind the fact that the alveolo-cemental membrane is a member of the connective-tissue group, it is not at all surprising that it also should become the seat of uratic deposits.

Pathology of the Dental Disease.—Unfortunately the anatomical relations of the parts and other factors prevent the dental observer from collecting a complete and connected series of observations as to the exact pathology of the disease, so that our deductions in this direction are necessarily confined to a basis of clinical records.

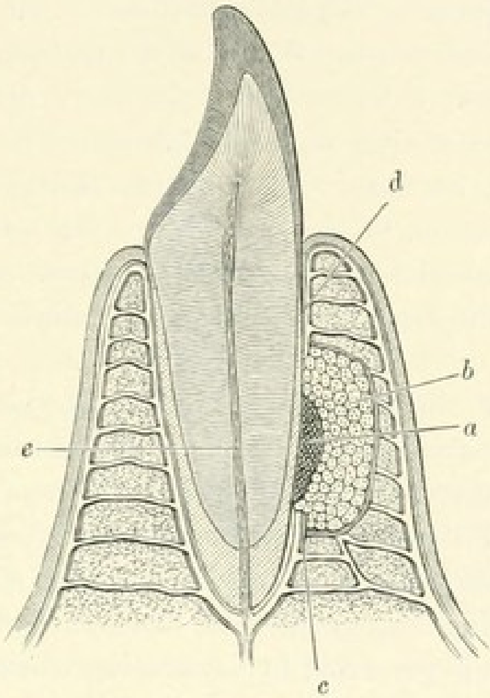
It is a natural inference that the pericementum is the part attacked because it is a point of minor resistance. The decreasing volume of pericementum which attends the progress of the disease in these cases is necessarily followed by a contraction of the caliber of the bloodvessels. It is not at all improbable that, as a consequence of the general physical condition, atheromatous changes occur in the pericemental bloodvessels leading to their occlusion. If it be necessary, as some pathologists maintain, that a death of cells precede the deposits in gout, this vascular change will account for the necrosis. The acid reaction of the necrotic area causes the deposition of urates, which are insoluble in acids.

The deposit is the source of an irritation which in most cases is followed by inflammation, leading to inflammatory degeneration and probably coagulation necrosis of the cellular elements. The alveolar walls melt down particle by particle, the pericementum disappears, the diseased area usually becomes infected by pyogenic organisms, and the process of suppuration is an additional factor leading to the exfoliation of the teeth. As in necrotic areas of other parts, calcareous deposits occur, which cover and almost entirely obscure the primary deposit of urates.

The condition following upon a deposit at the lateral aspect of a root, in its pericementum, is shown diagrammatically in Fig. 479. At *a* is seen the calculus embraced by a territory of inflammatory corpuscles, *b*. The pericementum which has so far escaped destruction is seen at *c* and *d*, that at *d* nourished by the anastomosing vessels from the alveolar periosteum. At a later period this portion of pericementum becomes involved in the degenerative process, and pus escapes at the neck of the tooth. In other cases the inflammatory degeneration extends from the deposit to the overlying gum, which is perforated.

It is conceivable that such tissue changes should exist in consequence of injuries sustained during ordinary dental manipulations, the careless use of the teeth in biting unyielding substances, or even in the unwise use of toothpicks, brushes, etc. This supposition granted—and of its truth there appears to be much evidence, for the disease not unfrequently

Fig. 479.



Hematogenic calcic pericementitis (Burchard).

develops after the operation of wedging, malleting, etc.—it is reasonable to believe that during the transudation of lymph through the lymph channels of the membrane, cementum, and dentin freighted with uratic salts, deposition and crystallization would readily take place in the dento-alveolar articulation as in other localities of the body. Not unfrequently has the writer recognized pus-exuding pockets resulting solely from wedging or long-continued malleting, and these in teeth that previously to the operation were as free from any appearance of either of these conditions as a normal tooth could be, yet an idiosyncrasy or predisposition existed—the exciting cause only being needed to develop it.

With this deposit and accumulations between two unyielding bony surfaces and the pressure on the tissue elements in consequence, these salts will act as specific irritants and engender the well-known phenomena—pain, congestion, swelling, exudation, impaired nutrition, tissue disorganization, the formation of pus, an osteomyelitis resulting in the absorption of the alveolar process, and finally the exfoliation of the teeth characteristic of pyorrhea alveolaris. The most general seat for the deposition of these salts is toward the apex of the root, where the texture of the alveolo-cemental membrane is less firm and compact, and more bulky.

The supposition that pyorrhea alveolaris is a local expression of the general diathesis has been converted into an actuality by the demonstration of the presence of uric acid and its allied salts in the incrustation found on the roots of the exfoliated teeth. The chemical analyses made by Prof. Ernest Congdon of the Drexel Institute have demonstrated the presence of these salts beyond question.[1] All of the established tests for uric acid were employed and in all instances crystals of uric acid, sodium urate, and calcium phosphate were detected. In several instances sodium urates were most abundant. The constant presence of these salts on the surfaces of the roots—the presence of which is ascertained by proper *analyses* and *aided vision*—taken in connection with the fact of the coexistence of gouty disorders in other tissues justifies the belief that the form of pyorrhea alveolaris here described is a gouty inflammation.

The derivation of the salts from the blood, the abundance of the calcium salts present, and the primary location of the inflammatory process suggested to the writer the term *hematogenic calcic pericementitis*, though it is admitted that the single epithet *gouty pericementitis* would be sufficiently explanatory and descriptive. The succession of pathological states is readily explained and justified by the uratic deposit. The formation of pus is preceded by a lowering of the vitality and solution of the pericemental tissues. This having been accomplished, the disintegrating peridental membrane affords a favorable nidus for the entrance and development of micro-organisms, which can be effected either by the route of the circulation or by lesions around the gum margins which give opportunity for direct infection from the oral fluids.

When organisms once gain access to the devitalized tissue they multiply with great rapidity, and in so doing increase the disintegration and solution of the pericemental membrane with the formation of pus. The specific bacteria which have been demonstrated to be present in the pus are the usual forms—the staphylococcus pyogenes aureus, citreus, and albus—which though capable of producing pus are not pathogenic in the sense that they are the causative agents of the pericementitis with the formation of an abscess. The purulent fluid burrows in the line of least resistance, which in the majority of cases is toward the gum margin, whence it is discharged into the mouth, the fistulous tract thus established constituting the well-known pyorrheal pocket.

By the continued irritation of the uratic deposition and the co-operation of micro-organisms, the inflammatory process extends until the membrane is destroyed to such an extent that it is no longer capable of nourishing and supporting the teeth.

The absorption of the alveolar process is in accordance with the laws

[1] See *International Dental Journal*, 1894, vol. xv. p. 1.

governing bone softening and absorption in general. Any constant pressure, whether from inflammatory exudation, from tumors, or from mechanical or infective agencies which interfere with its nutrition, will lead to softening and absorption. In pericementitis the effusion exerts a pressure in both directions, toward the cementum and toward the alveolar walls; as the latter are spongy in character, they readily yield to the absorptive process. Should the pressure continue indefinitely, or until the alveolar walls become denuded, caries or necrosis would inevitably result. Fortunately this termination is seldom if ever seen: the most careful examination of the alveolar process of a large number of patients has failed to show any alveolar denudation; never, in the writer's experience, has there been either caries, necrosis, exfoliation, or sequestration of bone. Nor could there be, for the reason that the teeth are removed either naturally or artificially before complete destruction of the pericemental membrane has been accomplished. With the removal of the teeth and its associated irritants the process of repair at once begins. The dead and dying tissues are removed, and fibrous tissues make their appearance, organization is established, and in a short time all traces of abnormal action have disappeared.

Diagnosis.—The diagnosis of pyorrhea alveolaris becomes comparatively easy when its constitutional relations, its mode of origin, its principal symptoms and pathology are borne in mind. The only diseases with which it might be (indeed, has been) confounded are, first, that form of pericementitis which has been designated a ptyalogenic calcic pericementitis; or, second, a general gingivitis due to some systemic disturbance such as results from mercurial ptyalism or syphilis; or, third, a severe inflammation of continuity due to some local disturbance such as an ill-fitting partial denture or an impacted tooth, possibly a third molar, greatly aggravated by some morbid systemic condition. These forms of pericementitis, however, present many points of contrast, differing in their clinical history, their pathology, symptomatology and susceptibility to treatment. In the hematogenic forms the patient, in the great majority of cases, presents some other manifestations more or less pronounced, of the gouty or rheumatic diathesis.

The age at which it makes its appearance is usually from thirty-five to fifty years. The extreme pain frequently present around the roots of one or more teeth in the early stages, and before there is any evidence of a gingivitis; the deviation in the position, and the apparent or actual elevation of the tooth, with response to pressure; the swelling or thickening of the pericemental membrane; slight tumefaction of the gum with deep red or purplish color opposite the apical end of the root of the tooth or teeth affected—and all of this before the appearance of pus; the isolated character of the inflammation, being usually confined to one tooth or two or more teeth in widely separated regions of the mouth; the exudation and discharge of pus along but one side of the root, detaching the gum at the neck, thus establishing a sinus or pus pocket; the increase of the flow of pus from the interior of the alveolus under pressure; the usually limited amount of calcic deposition as contrasted with the ptyalogenic form; the destruction of the pericemental membrane and the denudation of the cementum; the absorption of the alveolar process; the loosening and exfoliation of the teeth indurated in structure and changed in physical appearance are the main characteristics of the disorder; all these features taken in their totality so individualize this disease that there should be no difficulty in identifying it.

In the *ptyalogenic* form almost the opposite conditions prevail. As a general rule there is no evidence that there is any constitutional diathesis of which it might be an expression. The age at which it presents itself extends from the eighteenth year, sometimes earlier, to any period in later years, varying in its virulence with the varying systemic conditions and food habits of the individual. The presence of a calcic deposition around the neck of the tooth is often most abundant; the primary gingivitis occasioned by the presence of this mechanical irritant is not confined to one tooth nor to isolated regions of the mouth; the subsequent extension (where neglected) and infiltration of this deposit into and beneath the pericemental membrane; the localization of the suppuration in the early stages around the margin of the gums; the delayed loosening of the teeth, the infrequent loss of the teeth and the susceptibility to successful treatment upon the removal of the salivary deposit: these features taken together fully characterize this disease and render its identification easy.

Contrasting these different inflammatory states of the pericemental membrane from their inception to their termination, it becomes evident that distinct yet closely allied diseases are here very frequently confused and associated.

Causation.—If we take as our point of departure the postulate that hematogenic calcic pyorrhea alveolaris is but a special manifestation of the gouty diathesis, we should expect to find in its causation the same predisposing and exciting agencies operative as in the production of all other manifestations of the general diathesis.

PREDISPOSING CAUSES.—1. *Heredity.*—Among the predisposing causes may be mentioned heredity, which may be regarded as one of the most important factors concerned in its development. The writer feels justified in asserting, after a careful investigation into the family history of a large number of pyorrhea patients that fully 90 per cent. manifest an hereditary tendency to this disorder, parents and grand-parents having been victims of the same disease. Magitôt was impressed with the significance of this fact years ago, and stated that pyorrhea extended through two and three generations and made its appearance at corresponding periods of life and in similar types of constitution.

2. *Sex.*—As far as the writer's observations extend, sex does not appear to have much influence in the production of pyorrhea, women seeming to be equally affected with men; eliminate the masculine dietary habit and there would certainly be little difference in the predisposition to the disease.

3. *Age.*—The age at which pyorrhea most frequently presents itself is the period of middle life—that is, between the ages of thirty and fifty. It may be, though it is very rarely seen before the age of thirty, and still less frequently does it make its appearance after the age of sixty. These observations are corroborated by the writings of Magitôt and others. It is very evident that pyorrhea is a disease belonging largely to a period of life when growth has ceased and food is required only for tissue repair and the production of heat.

4. *Diet.*—A careful investigation into the dietary of pyorrhea patients will disclose the fact that there is usually a consumption of excessive quantity of both albuminous and starchy foods, much more than is necessary for the maintenance of the nutrition, and more than can be completely oxidized under the customary or existing modes of the individual's daily life. Coincidently there is also a diminished consumption of water, leading to an imperfect elimination and a retention of the products of this incomplete oxidation. In connection with excessive consumption of food must be also mentioned as co-operative factors the use of fermented malt liquors, the richer claret wines, champagnes, etc. While perhaps no one class of foods can be said to be especially active in the causation of pyorrhea it is evident that excessive quantity and variety, by impairing the activity of the digestive apparatus and giving rise to a large quantity of nitrogenized waste products through imperfect oxidation, would materially impair and lower the functional activity of the system generally and individual tissues in particular.

5. *Sedentary Occupations.*—Occupation is also an important factor in the production of pyorrhea. In the majority of instances the disease makes its appearance in those who are obliged to lead lives of enforced inactivity—school teachers, accountants, etc. All sedentary occupations which necessitate insufficient personal exercise will favor the imperfect oxidation of food and at the same time retard the elimination of waste products.

Exciting Causes.—The immediate agency in the development of pyorrhea is undoubtedly the deposition in the pericemental membrane of waste products of nitrogenous metabolism in combination with calcium salts derived from the blood. This morbific material, playing the part of foreign bodies, irritates and excites the membrane to inflammatory activity and all its attendant symptoms. But even admitting this deposition, there must be some predisposition on the part of the membrane which makes it specially liable to such deposition. This, it is believed, is in harmony with gouty deposition in all other tissues of the body ; it is to be found in impaired nutrition and lowered vitality in consequence of mechanical strain from an overcrowding of the dental arch, contusions or injuries consequent upon the usual and apparently unavoidable dental manipulations, such as wedging and malleting, and similar procedures. It may be from the unskilful employment of toothpicks, toothbrushes, etc.—though these latter are rare as compared with other acts and conditions which may impair the normal nutritional condition of the pericemental membrane. On numerous occasions where the predisposition existed, pyorrhea has developed immediately following operations upon one or more teeth. Prof. Armand Depres[1] attributes considerable importance to the overcrowded condition of the dental arch as a predisposing cause in the development of pyorrhea.

Treatment.—The treatment of gouty pericementitis resolves itself into both local and constitutional.

The *local treatment* is to be directed toward removal of the deposit and the control and the suppression of the inflammation and its concomitants, and has been already described at p. 511 in connection with the study of ptyalogenic calcic pericementitis.

Constitutional Treatment.—Whatever the predisposing cause may be, the immediate or exciting cause must ever be borne in mind. This, it is believed, to a certain extent at least is found in all of those mechanical agencies, so well known to the dentist, which impair or lower the nutritional level of the pericementum, thus rendering it liable, under certain systemic conditions, to a deposition of uratic salts. The question has been raised as to why the membrane of one or more teeth widely separated or occupying positions on opposite sides of the mouth, either simultaneously or successively becomes the seat of inflammation when there is no continuity of structure. The answer to this must be found in the fact that impaired nutrition and lowered vitality in such structures are due in the majority of instances to mechanical injury of these. Malocclusion may be noted as a fruitful cause. It is certainly within the experience of many observant dentists that pyorrhea has not infrequently developed around a tooth after it has been subjected to the necessary mechanical manipulations incident to tooth protection and tooth preservation.

[1] *Leçons de Clinique chirurgicale*, p. 9–656.

This apparent interference with the nutrition of the pericemental membrane before the deposit of uric acid salts takes place is in accordance with what is believed to hold true for other manifestations of the gouty diathesis. As a prophylactic measure, therefore, it is suggested that whenever there is the slightest tendency to pyorrhea, or any other evidence of the gouty diathesis, great care should be exercised in all dental operations, so as not to impair the nutrition of the pericementum and thus establish the necessary condition for the uric acid deposit; also correction of all cases of malocclusion—surgical rest as far as possible.

The constitutional treatment which has been indicated as efficient in the elimination of already established uric acid conditions and the restoration of a faulty nutrition to its normal state may with great propriety be subdivided into hygienic and medicinal.

The *hygienic* treatment embraces systematic outdoor exercise, stimulation of the functional activity of the excretory organs, the skin, bowels, and kidneys, and regulation of the diet, which must be insisted upon in all well-marked cases, and especially with those who, for various reasons, lead sedentary and inactive lives. Increased muscular activity quickens circulation, induces deeper and fuller respiratory movements, leads to greater vigor in the general nutritive processes; waste products are removed more rapidly and the combustion of the food increased by the absorption of a large amount of oxygen. The promotion of the functional activity of the eliminating organs is well recognized as an important hygienic measure.

The perspiratory and sebaceous glands and the surface capillary circulation should all be stimulated by sponging of the skin with cold water, vigorous friction, and an occasional Turkish bath, where such treatment is not contraindicated by pulmonary or cardiac affections. Where the liver and intestinal glands are deficient in secretion with prevailing constipation, they should be stimulated into activity by the use of saline waters; most excellent for this purpose being the Hunyadi Janos and Friedrichshalle. These are especially to be commended because they contain a large percentage of sodium and magnesium sulfates, both of which are useful as eliminating agents.

The kidneys should be assisted in the excretion of waste products by the free use of negative waters, or waters in which the saline constituents are present in minimum quantity.

Hot or distilled water in sufficient quantity will flush the alimentary canal, increase the volume of blood, and stimulate the kidneys to increased activity. It is not only a common observation, but rather a remarkable fact, that gouty patients are inclined to drink but a comparatively small quantity of water. One quart of hot water taken daily, in four doses, before breakfast, between meals, and at bedtime, is considered most beneficial in its effects in dissolving and removing irritating products.

The most important of the hygienic measures in the treatment of all gouty manifestations is that pertaining to the diet. As uric acid is a nitrogenized compound and therefore presumably one of the imperfectly oxidized products of albuminous or nitrogenized food, it is desirable that such foods be excluded as far as possible from the daily diet. The value of this measure is admitted and insisted upon by all clinicians.

In the milder manifestations of the gouty diathesis such as we assume exists in pyorrhea, it is not so imperative that all albuminous food be prohibited; nevertheless, as many patients are consumers of large quantities of meat, it would be well to insist, if the effort to cure is to be made, upon the total exclusion of beef, veal, mutton, and pork, restricting the patient in albuminous diet to white meat of fowl, oysters, fish, and lobsters. Cheese, beans, and the white of eggs are considered objectionable, and in many cases of acute gout are strictly prohibited by the attending physician.

Experience has shown that various alcoholic drinks, such as champagnes, port, madeira, and sherry, are particularly liable to give rise to the accumulation of uric acid. The lighter wines, as claret and hock, are not considered so injurious. The malt liquors, beer, ale, and porter, are also by many clinicians considered in their influence to be great offenders.

The medical and constitutional treatment, it is obvious, should be directed toward the elimination of uric acid and its compounds. For this purpose remedies which promote the formation of soluble and easily diffusible products which are readily eliminated by the kidneys are indicated. From time immemorial the alkalies and alkaline combinations have been used with marked success in the management of all phases of the gouty diathesis.

The treatment of acute gout necessitates, of course, different or more vigorous remedies than those required for the subacute or chronic forms with which the dental practitioner will be called upon to deal.

Of the various alkalies, lithium compounds—the citrate and carbonate—have been found well adapted to the milder phases of the disease. The writer has had much satisfaction in using, on the suggestion of Dr. E. C. Kirk, the tartarlithine lithium bitartrate, also alkalithia prepared in the same form as the above-named compounds—compressed tablets containing five grains each; one tablet three or four times daily will be found sufficient. Should the use of these lithia tablets not agree with the patient, the potassium carbonate in ten-grain doses, in some simple bitter—gentian or quassia water—three or four times daily, may be substituted. A valuable adjunct to the medicinal treatment is the free use of alkaline waters, which assist in the elimination of waste products, though it is probable that the good effects attributed to these are largely due to the quantity of liquid consumed.

The Saratoga, Vichy, alkaline waters of Wisconsin, the Marienbad, Carlsbad, Apollinaris, etc. have all been found efficacious. Should the patient be very dyspeptic, as is frequently the case, remedies directed to the digestive viscera are of course indicated. If anemia be a concomitant, iron and quinin will be necessary. A combination which has been found of great value in improving the quality of the blood is one of iron and a salt of potassium. Blaud's pill, consisting of these two ingredients, is a desirable form for administration; one three times a day will be sufficient.

There is in addition one factor which may be regarded as therapeutic or at least prophylactic, and which is deserving of more than a passing notice, viz. the exercise of great care in the avoidance of injuries to the pericemental membrane, wherever there is a possibility of the presence of the unfortunate diathesis.

However ingenious our interpretation of pathological conditions may be, and however plausible our deductions may appear, the ultimate test of their value will be the readiness with which they yield to and disappear under appropriate treatment.

If pyorrhea alveolaris be a manifestation of the gouty diathesis, and the symptoms and pathological conditions which characterize it be excited and maintained by the deposit and pressure of uric acid and its salts, it should be in general terms amenable to the therapeutic measures which have been efficacious in the treatment of all other forms of gout in other portions of the body. It must be borne in mind, however, that though a case be cured for a period of six months, or even a year, this does not preclude a relapse should the patient return to an improper diet or irregular mode of life. It is hardly necessary to say that this is true of all diathetic diseases. In individuals predisposed to uric acid accumulations, a new mode of life is to be instituted and followed with extreme care for a long period of time.

The conclusions entertained may be represented in a condensed form in the following postulates:

(1) Pyorrhea alveolaris of constitutional origin—which is its most destructive and unyielding form—primarily begins as a local inflammatory disorder in tissues on the side of the root near the apical extremity, and secondarily advances in the very large majority of cases toward the gingival borders.

(2) The cause of this inflammation, or gingivitis and pericementitis, is the plasma exudation from the bloodvessels, freighted with salts

which in their deposition and crystallization upon the cementum of the root and infiltration of the more vascular tissues, exert the influence of foreign bodies and react as irritants.

(3) The salts in question, as disclosed by chemical analysis, are calcium and sodium urates, free uric acid, and calcium phosphate.

(4) The chemical nature of these salts indicates a condition of the blood in which there is an excess of uratic salts and uric acid due to either *increased formation* or *imperfect elimination.*

(5) The excess of these salts, as is well known, is regarded by general pathologists as indicative of a faulty metabolism, and is the immediate cause of a series of local disturbances to which the term gouty has been applied, the nutritional disturbance giving rise to what is known as the "uric acid diathesis."

(6) An attentive study and accurate observation of the various organs and tissues of patients suffering with pyorrhea alveolaris have disclosed the coexistence, in a very large proportion of them, of one or more local expressions of this constitutional diathesis.

(7) Recognition of the fact that a constitutional malady presents itself, one phase of which only has claimed the attention of the dental practitioner, indicates that a treatment designed to be curative must have reference not only to the local expression, but especially to this important systemic condition as well.

(8) Results from constitutional treatment in connection with the usual local applications in a number of well-authenticated cases of pyorrhea alveolaris have been so markedly satisfactory that the writer feels fully justified in his assumptions regarding the origin of the disease.

While the foregoing pages embody views quite consistent with an extended experience, yet the writer fully appreciates the fact that many abnormal conditions closely allied in superficial characteristics to those above recognized and described may exist without any other local expressions indicating a uric acid dyscrasia.

The association of the class of dental diseases included under the generic title of pyorrhea alveolaris with conditions of general malnutrition has been recognized by many writers during the past hundred years, but until within very recent times no systematic attempt had been made at their classification. Dr. M. L. Rhein, who has closely studied the relations existing between general disorders and the dental diseases, finding that many general diseases are accompanied by the symptom pyorrhea alveolaris, and that the dental disorder persists so long as the general disease is in activity, suggests that the diseases known under the latter title be divided into two classes—*pyorrhea simplex* and *pyorrhea complex.*

Under the head *pyorrhea simplex* are included all of those varieties and cases in which local therapeutic measures suffice to effect a cure.[1]

Pyorrhea complex covers those cases and varieties in which local therapeusis fails to subdue the dental disease, and which are associated with some perversion of general nutrition. This class is subdivided into four groups: (*a*) Those due to nutritional disorders such as gout, diabetes, chronic rheumatism, nephritis, scurvy, chlorosis, anemia, leukemia, pregnancy; (*b*) Those occurring during attacks of acute infective diseases, as typhoid fever, tuberculosis, malaria, acute rheumatism, pleurisy, pericarditis, syphilis; (*c*) Those due to nervous disorders, cerebral diseases, spinal diseases, neurasthenia, hysteria; (*d*) Conditions resulting from the action of toxic drugs—mercury, lead, iodids.

Dr. Rhein believes from his studies that each member of the group of pyorrhea complex has a distinctive clinical expression, which might be utilized as *diagnostic* signs of the constitutional conditions.

One who is familiar with oral abnormalities and able to differentiate them must be very liberal in the interpretation of causes in order to embrace the wide range of pathological conditions which, in some stages of development, present appearances that would or could very properly be termed pyorrhea alveolaris, yet whose very ready response to topical remedies would naturally suggest that they were not associated with a uric acid habit. While fully recognizing the fact that this uric acid dyscrasia can be associated with almost any disease which is a concomitant of malnutrition, we must remember and fully appreciate the fact that imperfect assimilation of food and faulty metabolism are often responsible for local abnormalities, and at the same time they may be factors in the establishment of a uric acid dyscrasia.

In one's judgment of the soundness or unsoundness of theories or hypotheses, the fact must not be overlooked that affections of the kidneys, the liver, the lungs, the heart, the mucous membrane, the stomach, etc. may exist without any other recognized expression, or we may have irritation of the pericemental membrane alone associated with any one of them, the disturbance of the normality of this tissue being severe or slight as the functional or organic abnormality of the organ is exalted or inconspicuous.

While in the previous pages the treatment advocated had reference mainly to that form of pyorrhea the concomitant of the gouty diathesis, it must nevertheless be borne in mind that a similar condition of the pericemental membrane is at times associated with other perversions of the general nutrition, as pointed out by Dr. M. L. Rhein, and which

[1] *Dental Cosmos*, 1894, p. 780.

therefore must receive treatment especially adapted to the general constitutional state.

Inasmuch as these constitutional conditions are complex in their manifestations and their medicinal and hygienic management almost exclusively in the hands of the physician, the duty of the dental practitioner is confined largely to the question of diagnosis; the local treatment, however, must be varied in accordance with the peculiarities of the local pathological condition.

CHAPTER XX.

DISCOLORED TEETH AND THEIR TREATMENT.

By Edward C. Kirk, D. D. S.

Discoloration of a tooth is consequent upon death of its pulp. While death of the pulp does not always or necessarily involve discoloration of the tooth structures, yet when the condition does exist the general cause is as stated. Reference is here made to a progressive interstitial staining of the entire dentin structure, and is exclusive of certain metallic stains, and also localized stains resulting from the imbibition of pigmentary matters which occasionally are observed where small areas of dentin have become denuded of enamel covering, or where the latter has been so imperfectly formed as to afford an insufficient barrier to the ingress of pigmentary matters from the food or oral secretions.

Three classes of conditions are presented for consideration and treatment: First, cases where discoloration has resulted from death of the pulp due to causes other than its exposure; second, discoloration from pulp death consequent upon exposure; and third, special discolorations due to adventitious causes superadded to the conditions affecting the cases included in the foregoing second division.

Any of the numerous traumatic causes which bring about death of the pulp, *e. g.* blows, sudden contact with hard substances, biting threads, violent thermal shocks, the injudicious application of continuous force in regulating, or the application of arsenous oxid to the dentin (see p. 425), where no exposure or only minute exposure of the pulp exists, may produce hyperemia and congestion of the pulp, or strangulation of its circulatory system, the formation of emboli, thrombus, hemorrhagic infarct, etc., leading to a breaking down of the corpuscular elements of the blood, the escape of hemoglobin from the stroma of the red corpuscles, its solution in the blood plasma, and resulting infiltration of the tubular structure of the dentin by the hemoglobin solution, giving the tooth a distinctly pinkish hue when examined by direct or transillumination.

Teeth so affected rapidly change in color through various gradations in tint from the original pinkish hue, which becomes yellow; this, growing darker, passes into brown, and after the lapse of considerable time the tooth may become a permanent slaty gray or black.

The violence of the pulpitis preceding the death and disintegration of the pulp, in a considerable degree determines the rapidity of the process of subsequent tooth discoloration. Where congestion of the pulp has been relatively slight and the necrotic process has proceeded slowly, the sudden infiltration of the dentin with hemoglobin does not occur, consequently the initial change in color following complete death of the pulp may be so slight as to escape detection except upon most searching examination with special means of illumination, and even then may be manifested only by a slight diminution in the normal translucency of the tooth as compared with adjoining teeth. Such teeth, however, if permitted to remain untreated, eventually grow darker, and while they may not acquire a degree of discoloration equal to those which have suffered sudden and violent death of the pulp, still they become so unsightly as to demand treatment for the restoration of their normal color.

The Rationale of the Process of Discoloration.—In teeth discolored as a consequence of the death of the pulp without its exposure—viz. those of the first class—it is evident that the sources of pigmentation are internal to the tooth and are to be sought for solely in the products of decomposition of the elements of the pulp tissue and of its vascular supply.

The proteid elements of the pulp tissue are complex combinations of carbon, oxygen, hydrogen, nitrogen, sulfur, and phosphorus, which in their gradual breaking down by the process of putrefactive decomposition are split up finally into carbon dioxid, water, ammonia, and hydrogen sulfid, with possibly the formation of traces of phosphatic salts. The group of substances entering into the composition of the histological elements of pulp tissue contains no constituents which in the progressive changes resulting from putrefactive decomposition should form compounds likely to cause permanent discoloration of the tooth structures.

When, however, the vascular supply is considered as a factor, the explanation of the cause of discoloration in the cases in question becomes reasonably clear. The red blood corpuscles contain as their characteristic component hemoglobin or oxyhemoglobin according as the blood is venous or arterial, and this substance is its essential coloring ingredient. When undergoing gradual decomposition, hemoglobin passes through a variety of alterations in its chemical constitution, accompanied by a corresponding series of color changes.

A familiar illustration of these color changes is furnished by the cycle of color alterations witnessed in a bruise. Immediately following an injury to the flesh, of the character alluded to, an extravasation of blood in the bruised territory occurs, causing undue reddening of the skin; this is soon followed by an increasing darkening of the tissue, until there results what is popularly termed a "black-and-blue spot." Further decomposition of the coloring matter of the extravasated blood induces a variety of color changes ranging through the scale of yellows and browns, until the pigmentary matter is finally removed by absorption through the capillary bloodvessel system of the part.

In passing through its cycle of color changes, hemoglobin undergoes several alterations in composition during which a number of definite compounds are formed, each having marked chromogenic features. Of these decomposition products, methemoglobin (brownish red), hemin (bluish black), hematin (dark brown or bluish black), and hematoidin (orange), are the most important and best known. While the gradual decomposition of the coloring matter of the blood here noted may and doubtless does account for certain phases of tooth discoloration, other factors which exert a profoundly modifying influence upon the process are yet to be considered.

The putrefactive decomposition of the proteid elements of the pulp results, as before stated, in the production of hydrogen sulfid in considerable quantity. The albumins contain from 0.8 to 2.2 per cent. of sulfur (Hammarsten) which in the splitting up of the compound during putrefaction yields a large amount of hydrogen sulfid. In pulp decomposition this hydrogen sulfid is generated in contact with the hemoglobin and necessarily exerts a marked modifying action upon the decomposition process of that substance. Miller says, "If a current of sulfuretted hydrogen is conducted through fresh blood or a solution of oxyhemoglobin in the presence of air or oxygen, sulfomethemoglobin is formed, which is greenish red in concentrated solutions and green in dilute solutions. If we lay a freshly extracted tooth in a mixture of meat and saliva so that a part of the enamel surface remains free, and moisten the surface with blood, it will take on a dirty-green color if kept at blood temperature in an absolutely moist condition for from twenty-four to forty-eight hours. It is quite possible that the dirty-green deposits which form in putrid conditions of the mouth, in stomatitis mercurialis, scorbutica, gangrænosa, etc., or even in inflammatory conditions of less importance, as well as in cases of absolute neglect of the care of the mouth, may owe their green color to the presence of sulfomethemoglobin."

As in pulp decomposition hydrogen sulfid is being formed in the presence of hemoglobin, this fact warrants the belief that a combination takes place resulting in the formation of this same compound, which Miller regards as productive of certain stains upon the external surface of the teeth.

The slaty gray or bluish pigmentation always noticeable upon the visceral walls and frequently beneath the skin of animal bodies undergoing putrefactive degeneration is a familiar example of the action of hydrogen sulfid upon decomposing hemoglobin in hemorrhagic extravasations, and is a process and form of pigmentation exactly analogous to that which is here described as taking place in the dentinal structure from putrefactive decomposition of the pulp. "When red corpuscles are just beginning to disintegrate, the coloring matter formed is hemoglobin; but the yellow and brown granular masses found in cells and lying free in tissues are, as a rule, derivatives of hemoglobin, not hemoglobin itself. These derivatives are divided into two groups according as they contain iron or not, the former being called hemosiderin, the latter hematoidin."[1] "When acted upon by ammonium sulfid (a derivative of putrefactive decomposition of albumin) hemosiderin becomes black, iron sulfid being formed."[2] Grohe[3] believes that as a result of putrefaction iron is liberated from its compound with hemoglobin, so that when thus freed it readily combines with the hydrogen sulfid.

Iron is the most important element to be considered in the list of factors causing the discoloration of this group of cases. It is the iron constituent of the red corpuscles which is the essential chromogenic factor from first to last in their cycle of color changes.

The process of putrefactive decomposition consists of a series of chemical changes wrought out through the agency of micro-organisms, involving the breaking down by successive stages of highly complex organic compounds and their resolution into compounds of much simpler constitution. It is not known to what extent this splitting up of the components of the pulp and its vascular elements is ultimately carried in the series of changes resulting in the permanent discoloration of the tooth. From what is known of the ultimate composition of the compounds involved it may, however, be safely inferred that, reduced to its lowest terms, the result would be the formation of iron sulfid, the elements of which, with the exception of some unimportant alkaline and earthy salts, are the only ones entering into the original compounds which are fixed and therefore capable of forming a stable residuum in the tubular structure of the dentin. While iron sulfid as such cannot be held wholly accountable for the final bluish-black color of a tooth which has reached the stage of permanent discoloration, the pigmentation is almost certainly due either to it or to some allied compound in which iron and sulfur, with some organic constituents, largely enter, and which by a further slight decomposition would yield true iron sulfid.

The significance and importance of a recognition of the possible presence of the iron compound as a factor in tooth discoloration is further brought out in the study of bleaching methods (pp. 542 and 558).

[1] Ziegler, *General Pathology*, 1895. [2] *Ibid.* [3] *Virchow's Archiv.*, Bd. xx.

Discoloration of Teeth following Death of the Pulp consequent upon its Exposure.—When death and decomposition of the pulp is consequent upon exposure of that organ, through caries or otherwise, to the irritative influences of infective agents present in the oral secretions and food, or to thermal shock, etc., the putrefactive process involving the pulp tissues is modified in character and rapidity to a degree which may affect the character of the resulting discoloration. Thus the yellowish or brownish discoloration so often seen in teeth whose pulps have been devitalized through systemic or traumatic causes, and which in many cases appears to be more or less permanent in character, is rarely observed in those teeth whose pulps have been devitalized through exposure by caries.

In these latter cases the progress of the putrefactive process is comparatively rapid, the conditions being more favorable so that the coloring matter of the blood is sooner reduced to its lowest terms in the scale of decomposition products, *i. e.* to the slaty blue or black pigmentation before noted. In addition to the increased rapidity of putrefactive decomposition incident to cases of discoloration following pulp exposure, another and important modifying factor in the process of discoloration is the ingress afforded to the oral fluids, food materials, and other adventitious substances which find their way into the mouth and ultimately, through the open cavity of the tooth, to its pulp canal and thence to the tubular structure of the dentin. These extraneous substances, in the course of time, may infiltrate the tooth structure, and while no especially noticeable or characteristic effect may be observed so far as color is concerned, yet they frequently exert an influence upon the coloration of the tooth which so alters its character as to render successful bleaching treatment extremely difficult and a resort to special methods or a variety of methods necessary.

The introduction of fatty or oily substances or of astringent and coagulant matters, for example, may act upon the coloring matter in such a way as to permanently "set" it in the same manner that mordants form insoluble compounds or lakes with the dye-stuffs used in the dyeing of textile fabrics.

Another and important class of substances which frequently are the cause of staining of the tooth structure are metallic salts which are used in dental therapeutic treatment or are accidentally formed during the application of corrosive medicaments to the teeth, through the action of such remedies upon fillings *in situ* or upon the instruments by which the applications are made. For example, the use of iodin or sulfuric acid in connection with steel instruments and the subsequent use of medicaments containing tannin as an ingredient.

The treatment of these conditions will be separately considered.

Tooth-Bleaching.—Use of Chlorin.

Nature of the Problem Involved in Tooth-Bleaching.—The bleaching process is dependent upon a chemical reaction between a compound having color and some substance capable of so affecting its composition that the color is discharged, or, in other words, of so affecting the integrity of the color molecule as to destroy its identity, which results in a loss of its distinguishing characteristic, viz. its color.

The substances concerned in discoloration of tooth structure, as has been previously shown, are derived from the pulp and its vascular elements and the organic contents of the tubular structure of the dentin, through the gradual putrefactive processes which become operative subsequent to the death of the pulp. These pigmentary products of pulp decomposition we know to be organic in character; and further, that they exhibit the property of color by virtue of definite conditions of molecular composition—that is to say, a certain arrangement of a definite kind and number of atoms has resulted in the formation of a molecule having its individual group of chemical and physical properties, among which latter is a characteristic *color*.

Whatever brings about an alteration in the composition of the molecule at once destroys the identity of the matter so treated. Hence if we can act upon the coloring matter which gives rise to the staining of a tooth by means of an agent capable of effecting an alteration in the atomic arrangement or composition of the color molecule, we may expect to remove or discharge its color feature.

Two general classes of substances have been successfully used as bleaching agents: First, those which act by virtue of their power to evolve oxygen in the active or nascent condition, and known as oxidizing agents; second, those which act in an opposite manner by virtue of their strong affinity for oxygen and which are called reducing agents. The oxidizing bleachers destroy the identity of the color molecule by seizing upon its hydrogen element to form water. The reducing agents act by removing the oxygen atom from the color molecule to form by-products depending upon the character of the reducing agent used.

Chlorin and its associates iodin and bromin act as indirect *oxidizing bleachers;* the dioxid of hydrogen and of sodium are direct oxidizers. Potassium permanganate may also be classed with this group, though its successful use as a bleaching agent depends upon a subsequent treatment of the substance to be bleached with some solvent capable of removing the manganese dioxid formed as a by-product of the action of the permanganate. It has somewhat extensive and satisfactory use as an agent for bleaching sponges, and has been used for bleaching teeth, but is of greatly inferior value to other agents for the latter use.

The only agent belonging to the group of *reducing bleachers* which has thus far been found available for bleaching teeth is sulfurous oxid, either in the gaseous condition or in aqueous solution.

Chlorin as a Bleacher.—The general use of chlorin as a bleaching agent in the arts no doubt suggested its use in the treatment of tooth discoloration. Its introduction as a tooth-bleaching agent, as well as the assembling of the general principles of tooth bleaching into a co-ordinate system, are due to Dr. James Truman, whose method depends upon the liberation of chlorin from calcium hypochlorite, commonly called bleaching powder or "chlorinated lime," in the pulp chamber and cavity of decay in the tooth. Chlorin is liberated from the bleaching powder by the action of dilute acetic acid; this taking place in contact with the discolored structure, it is rapidly bleached as a result of the action of the chlorin upon the coloring matter contained in the dentinal tubules. Numerous modifications of this original method of bleaching tooth structure have been suggested, but, as the ultimate result in each is accomplished through the activity of chlorin, a rational understanding of the mode of action of chlorin in this relation is of importance as an aid to the intelligent use of those methods for tooth-bleaching which are dependent upon or owe their efficacy to that agent.

Chlorin is an elementary gaseous body, greenish in color, soluble in water, having a disagreeable odor, intensely irritating to the air-passages when inhaled, and poisonous when breathed in sufficient quantity. It has a strong affinity for all metallic bodies, entering into direct combination with a number of them, under favorable circumstances, with great energy—forming, as a rule, compounds that are soluble in water.

One of its distinguishing features and one which is directly concerned in its use as a bleaching agent is its strong affinity for hydrogen. So strong is this affinity, that when a molecule of chlorin is brought into contact with a molecule of water under favorable conditions, the hydrogen of the water molecule is seized upon by the chlorin to form chlorhydric acid and the oxygen is set free in the nascent state, a condition under which its oxidizing powers are exhibited in their greatest intensity. This powerful affinity of chlorin for hydrogen enables it to decompose many other hydrogen-containing molecules in a similar manner, forming chlorhydric acid and destroying the identity of the matter acted upon.

It has been shown that all organic compounds which are the products of the vital processes of the animal body contain hydrogen as an important constituent. This applies also to the decomposition products whose presence in the tubular structure of the dentin is the cause of tooth discoloration.

These organic stains exhibit the property of color by virtue of certain definite conditions of molecular composition; hence, if chlorin is caused to act upon the coloring matter which causes the staining of a tooth, by seizing upon and combining with the hydrogen of the organic pigment, the identity of the compound as such is destroyed, and its characteristic feature, that of color, is lost.

The principle here outlined is involved in what is termed the direct action of chlorin in bleaching. There is, however, another method by which chlorin is believed to act as a bleacher in which its function is indirect. In some cases it has been observed that chlorin fails to act except in the presence of moisture, and the *rationale* of this is that the bleaching under such conditions is effected by nascent oxygen liberated from the water molecule when the chlorin combines with its hydrogen to form chlorhydric acid; thus: $Cl_2 + H_2O = 2HCl + O$. That such is the nature of the process in many cases is a reasonable deduction from the behavior of chlorin under analogous conditions where it acts indirectly as an oxidizing agent.

Whatever may be the exact nature of its ultimate action, it is to be borne in mind that its bleaching effect is due solely to the alteration which it makes in the composition of the color molecule, and that it has no solvent power whatever on the organic matter upon which it acts. It changes its characteristics, but does not remove it by solution. It should be also noted in this connection that the chlorin compounds of most of the metallic elements, especially when in dilute solution, are almost colorless as compared with many of the other metallic compounds—the oxids and sulfids for example. Hence it is that where stains owe their color to the presence of certain organic compounds with some of the metals, or even where the coloration is due to decomposition products of hemoglobin, the color may readily be discharged by chlorin, but if the iron chlorid thus produced remains in the tooth structure it is gradually decomposed and new combinations of it are liable to occur, which results in a return of the discoloration.

All tooth-bleaching methods should aim not only to discharge the color by suitable chemical means, but should go farther than this and, as far as it may be possible to do so, remove all organic débris from the tubules, for as long as any remains the tendency to a return of the discoloration is always a possible and indeed probable menace to the complete and permanent success of the operation.

Where the tubular contents cannot be successfully removed, the tendency to a return of discoloration may be combated by hermetically sealing the tubular orifices with an impermeable resinous varnish or permanently coagulating them. This feature is described more fully in relation to the details of the bleaching procedure.

Teeth Suitable for the Bleaching Operation.—In deciding upon the advisability of attempting the bleaching operation in any given case, the general conditions which determine the judgment of the operator with respect to all dental operations should govern his course.

As all therapeutic and restorative measures in dentistry are a series of compromises with disease conditions or their sequelæ, it is the duty of the operator under all circumstances to capitulate upon the basis of greatest advantage to the patient. Therefore if discoloration of a tooth is practically the only factor in the problem presented by a given case, the effort should be made to restore the organ to its normal condition of color. The same rule should be applied to all cases of discolored teeth in which structural loss by caries or fracture has not been so great as to preclude a satisfactory restoration by proper filling or replacement of the lost structure by a porcelain inlay. The cases in which it is not advisable to attempt a bleaching operation are only those in which loss of structure is so extensive as to require a crowning operation.

In the judgment of many operators it is considered useless to attempt the bleaching of any teeth excepting the incisors, because of the difficulty and length of time frequently required for the successful bleaching of canines, bicuspids, and molars, owing to the thickness of their walls and the consequent depth of structure requiring treatment. It is also held to be useless to attempt the bleaching of teeth which have been discolored by metallic stains throughout their structure. The fallacy of such a view is self-evident when it is considered that if any portion of the dentinal structure of a discolored tooth is amenable to the bleaching treatment, its complete restoration is simply a question of continuance or repetition of the operation until the desired end is attained.

With regard to discoloration by metallic stains, while teeth so affected present problems of great complexity, and require not only special study but the application of special methods of treatment based upon proper recognition of the chemical relationships involved between the nature of the stain and that of the agent used for its removal, the attempt should be made in justice to the patient, even though ultimate failure result, in order that the necessity for destruction of the natural crown for the purpose of its replacement by an artificial substitute may, if possible, be postponed for as long a period as may be attainable.

Preparation of the Tooth for the Operation of Bleaching.—Certain general details are necessary to be observed in the preparation of teeth for the bleaching operation, whatever may be the method of treatment employed.

Appropriate treatment for the removal of all septic matter from the pulp chamber and canal, and for the relief of any existing condition of irritation of the pericemental membrane and tissues of the apical region, should have been carried out and the tooth brought to the condition in which permanent closure of the apical foramen of the root may be safely performed.

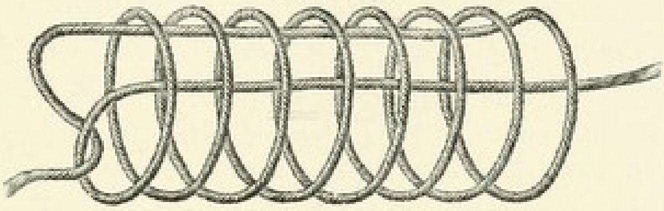
The rubber dam should be adjusted with especial care and only include the tooth to be bleached. If two adjoining teeth are to be bleached* they may both be isolated by the dam, but in no case should one or more adjacent normal teeth be included with the tooth to be bleached. While the inclusion of teeth adjacent to the one which is the subject of any ordinary dental operation is in nearly all cases desirable, there are good reasons why such a plan should not be pursued in the bleaching procedure. The chemicals used for the purpose may possibly have some disintegrating or solvent action upon the enamel structure, and such action, should it occur, should be confined strictly to the tooth undergoing treatment and held within the limits of safety by close observation and appropriate treatment, which conditions cannot be as thoroughly controlled and the process as satisfactorily managed when several teeth are included within the territory of operation.

Furthermore, as nearly all of the bleaching agents used or those which are employed as adjuvants in the process have a more or less irritative or escharotic effect upon the soft tissues of the mouth, extra precautions must be taken, in adjusting the dam, against leakage at its attachment to the cervix of the tooth. As the chances of leakage are greatly multiplied when several holes are punched in the dam for adjustment to as many teeth, it is for this reason also that no other than the tooth to be treated should have the dam adjusted to it.

Supposing the tooth to be an upper incisor, the dam should be slipped over it and the margin of rubber encircling the cervix should be gently carried under the free margin of the gum either by means of a small flat burnisher of suitable angle and curvature, or by means of a waxed floss-silk thread. One or two turns of a ligature should then be thrown around the cervix below the dam to hold it securely in place. The dam may be fixed with greater security, especially as against any accidental traction made upon it during the operation, by fastening it with a ligature made as follows and thrown around its cervix:

A piece of waxed ligature silk about eighteen inches in length has a large knot tied at about its middle portion by making six or eight turns of the thread loosely around the end of the index finger of the left hand. Upon withdrawing the finger a series of loops are had through which one of the free ends of the thread is now passed, as in making the first half of a flat knot, as illustrated in Fig. 480. By drawing upon the free ends of the thread until all of the loops are closed upon themselves, a hard knot of more or less spheroidal shape is formed about midway between the ends of the ligature. The ligature so prepared is placed around the tooth in such a manner that the knot as described shall be located upon and at the middle portion of the palatal cervical margin. A half knot is then made by tying the ligature in front so that it shall rest directly opposite the palatal knot, viz. at the middle portion of the labial cervical margin. The ligature is drawn into fairly close contact with the tooth, and, with both ends held firmly in the left hand and drawn somewhat tense, the portion encircling the tooth is firmly but gently forced up against the rubber

Fig. 480.



dam and gingival margin, the ligature at the same time being drawn tightly until the anatomical constriction of the tooth at its cervix will serve to hold it from slipping downward, especially upon the palatal aspect of the tooth.

When the ligature is found to be securely placed as described, the knot upon the labial aspect is completed and further enlarged in bulk by re-tying the thread four or five times. The free ends of the ligature should then be cut off close to the knot. As an additional safeguard against leakage of irritating bleaching agents through the cervical attachment of the dam, and out upon the soft tissues, it is well after making the tooth perfectly dry to paint the ligature and a narrow band of its adjacent territory with chloro-percha, which will effectually prevent any accident from leakage.

The placing of a large knot upon the palatal aspect at the cervical margin has another decided advantage in that it not only holds the dam more securely against slipping downward, but holds it away from the palatal surface, which is ordinarily the point of entrance to the pulp chamber and canals in these cases. The point of canal entrance may, however, be through an approximal cavity, if such an one affords sufficient access.

The canal filling in all cases of bleaching without exception should be gutta-percha. No other material used for canal filling possesses the generally desirable qualities needed for that purpose in this class of cases. The extent of the canal filling should include one-third, or at least not over one-half, of the distance from the apex. A considerable portion of the canal beyond the level of the gingival margin is thus left unfilled in order that the coronal end of the root may be bleached as well as the tooth crown. This is especially necessary where more or less recession of the gum from its normal attachment has occurred, leaving the cervical cementum exposed to the action of the oral fluids, food, etc., which have a tendency to cause discoloration of the exposed root tissue.

The root being filled as directed, all fillings wherever existent in the tooth should be removed. This is a preliminary procedure which should not be omitted in any case, but where any bleaching method is used which involves the employment of chlorin as the active agent it becomes imperatively necessary for reasons which are explained in connection with the description of the chlorin methods (page 547). Aside from other considerations, the removal of all fillings preparatory to the bleaching operation has a decided value in facilitating the process by exposing an increased area of the dentinal structure and thereby permitting the action of the bleaching agent over a larger territory of ingress.

When all fillings or softened tooth structure have been removed, as well as all septic and extraneous matter of whatever character, by mechanical process, the tooth should be washed thoroughly with dilute ammonia water, or better with a hot solution of borax in distilled water in the proportion of ʒj to f℥j. The object of this treatment is to remove by saponification and solution all fatty matters which may obstruct the ingress of the bleaching agent into the dentinal structure.

In nearly all cases where discoloration has occurred from a decomposed pulp and where the canals and pulp chamber have been left untreated, there will be observed, on opening into such a pulp chamber for the first time, a dark layer of oily or greasy material lining its walls. The thorough removal of this dark layer should be effected prior to any attempt at bleaching, as it appears to prevent the ingress of the bleaching agent into the dentinal structure. The most satisfactory method for removing the dark greasy layer is by the use of suitable instruments—either properly shaped spoon or hoe excavators or round burs in the engine. The thorough removal of this layer necessitates free access to the pulp chamber, which should be as a general rule obtained by means of an ample opening upon the lingual aspect of the tooth in the case of incisors, and through the morsal surface in bicuspids, etc.

Having by mechanical means and through the agency of borax or ammonia and hot distilled water effected a thorough cleansing of the interior portion of the tooth, it should next be dried to the extent of having all superfluous moisture removed, and it will then be in condition for the application of whatever method of bleaching may be chosen for the particular case in hand.

Dr. James Truman's Method.—This, as before stated, was the first method successfully employed for bleaching teeth. It consists in liberating chlorin from ordinary chlorinated lime by means of a weak acid in the pulp chamber of the tooth. Any acid will effect the liberation of chlorin from the bleaching powder, but acetic, tartaric, or oxalic are generally used. Care must be observed in selecting a good quality of bleaching powder, as that substance rapidly undergoes decomposition spontaneously, especially in a moist atmosphere. Good chlorinated lime is a dry powder having a strong odor of chlorin. If it is moist or pasty and has but a feeble odor it should be rejected as worthless. Brands of bleaching powder dispensed in metallic packages should not be used, as they are invariably contaminated with metallic chlorids due to the slow action of the contents upon the containing package. This is particularly the case where sheet-iron boxes are used. The return of discoloration in many cases after bleaching by the Truman method is undoubtedly due to the use of bleaching powder so contaminated. The powder dispensed in glass bottles or in paraffined paper cartons is more reliable.

Its application to the tooth may be effected in several ways:

(*a*) By packing the dry powder in the pulp chamber and then moistening the latter with the acid;

(*b*) By mixing the powder with sufficient distilled water to make a coherent mass which is more easily manipulated, then packing it in the pulp chamber and applying the acid;

(*c*) By first moistening the interior of the tooth with the acid, next dipping the instrument into the powder and then into the acid, each time carrying the mixed materials into the tooth until the desired change of color is produced.

Probably the most satisfactory method is to pack the dry powder into the tooth and apply the acid to it, after which immediately seal the cavity with a single pellet of gutta-percha. By using a 50 per cent. solution of acetic acid the evolution of chlorin will take place with a satisfactory degree of uniformity, and not so rapidly as to interfere with its penetration throughout the discolored tubular structure of the dentin. The bleaching mass may be sealed in place by means of oxyphosphate of zinc if desired, but it is usually unnecessary to use anything other than gutta-percha or one of the soft temporary stopping materials for this purpose.

The case may be dismissed for one or two days and the treatment as outlined repeated at similar intervals until the tooth is restored to normal color.

The instruments used in connection with this process should be of vulcanite, bone, ivory or wood. Upon no consideration should steel, gold, or platinum instruments be used, as chlorin acts directly upon each of these metals, forming soluble chlorids which if carried into the tooth structure will give rise to a permanent staining of most intractable character. The only metals which may be safely used in connection with any chlorin process of bleaching are zinc and aluminum, the chlorids of which are colorless. Aluminum instruments for the purpose may be quickly improvised out of wire or heavy plate. Gold instruments have been recommended, but they are open to the very grave objection of forming a chlorid by direct combination with chlorin, which salt is one of the most important staining media known to the histologist; as a matter of fact the writer has seen several cases where a permanent purple staining of the tooth has resulted from neglect to remove gold fillings before applying the chlorin method of bleaching, and there is certainly no reason why the same result should not follow the using of gold instruments in the same connection.

When the tooth has been restored to its proper color it should be thoroughly washed with very hot distilled water, dried out with bibulous paper and thoroughly desiccated with a current of dry hot air, after which the canals, pulp chamber, and cavities should be filled with oxychlorid of zinc.

The final filling of the cavities of entrance and of decay should be postponed until by a lapse of considerable time the permanence of the operation has been established. This probationary period may with advantage be prolonged to four or six months.

The final washing of the tooth with hot distilled water previous to the insertion of the oxychlorid of zinc filling is a feature of the operation which requires special care and attention. As left after the application of the bleaching agent, the pulp chamber and canals and dentinal structure are filled with free chlorin in solution, calcium acetate, or other salt of calcium depending upon the nature of the acid used in the process, and some undecomposed bleaching powder. These substances should be thoroughly removed by the hot-water douche. At least a pint of water should be strongly injected into the interior of the tooth by means of a large bulb syringe, before the dam is removed. A towel held in close proximity to the tooth will catch the water as it returns from the tooth and protect the clothing of the patient. Distilled water should in all cases be used for this irrigating douche, as river water and many other specimens of water from natural sources contain iron in solution, which could readily become a contaminating factor leading to subsequent return of discoloration.

Oxychlorid of zinc is selected as the permanent filling for the pulp chamber for the reason that it is necessary to so act upon the bleached organic residuum in the tubular structure as to prevent any alteration of its character which may result in the production of a subsequent coloration. Zinc chlorid possesses the property of converting many organic substances into unalterable compounds by its coagulant action, thus tanning or mummifying animal tissue and preserving it indefinitely. A mass of oxychlorid of zinc, before it sets, *i. e.* before chemical combination takes place between the oxid-of-zinc powder and the zinc chlorid liquid, is functionally free zinc chlorid—and as a matter of fact the properties of zinc chlorid are manifested by such a mass for a considerable period of time after the mass has apparently set. When introduced into the pulp chamber and canal, its action upon the organic débris in the tubuli is as stated, and the material, if the operation has been successfully performed, is effectually prevented from further alteration, upon which condition the permanence of the operation depends.

Another method for preventing subsequent alteration of the bleached organic débris in the tubular structure is to thoroughly desiccate the tooth by means of the hot-air blast and saturate the dentin with some insoluble resinous varnish, such as copal ether varnish, or what is still better the solution of trinitrocellulose in methyl alcohol, known in commerce as "kristaline" or at the dental depots as "cavitine." The pulp chamber and canals may then be filled with any suitable filling.

As between the oxychlorid of zinc filling and the varnish lining the choice in general should be of the former. The varnish lining is adaptable more especially to cases of long standing where complete liquefaction of the tubular contents has left them practically empty, and where as a consequence there is nothing upon which zinc chlorid can exert its coagulating effect.

Other Chlorin Methods.—The solution of chlorinated soda known as Labarraque's solution, or Liquor sodæ chloratæ U. S. P., may be applied to the previously desiccated tooth structure until the dentin is saturated with the solution, after which an application of a dilute acid is made which liberates chlorin. The chemical principles involved are exactly analogous to those upon which the method with bleaching powder depends, the only difference being that the source of the active agent, chlorin, is in one case its calcium compound, which is a dry powder, and in the second case the analogous soluble sodium compound of chlorin is the material from which the active agent is evolved.

The precautions necessary to be observed are exactly the same as those required in Truman's method already described. The results obtained by this process are not as thorough or as satisfactory as by the Truman method.

Chlorin *per se* has been used for tooth-bleaching, and was the basis of a method devised by Dr. E. P. Wright of Richmond, Va.

Wright's method involved the use of a complicated apparatus by which a glass vessel of about a half-liter capacity, and filled with chlorin previously prepared in the laboratory, was connected by means of a doubly perforated rubber stopper and two pieces of rubber tubing with a glass adapter, around the open end of which was tied the rubber dam encircling the tooth to be operated upon. About midway of the length of one of the rubber tubes connecting the chlorin reservoir with the rubber dam was interposed an ordinary syringe bulb, so arranged with hard-rubber valves that by repeatedly compressing and relaxing it the chlorin would be drawn from the reservoir and injected through a glass delivery jet into the pulp chamber. Return of the gas to the reservoir was provided for by the second piece of rubber tubing first alluded to. In this way a continuous jet of chlorin was thrown into and about the tooth, which, by means of the rubber dam, was placed in a close chamber forming a part of the apparatus; none of the gas could escape into the surrounding atmosphere. The complexity of the apparatus was a formidable obstacle to the general use of the method and it was abandoned, though the results were in many cases very satisfactory.

The Dioxid Bleaching Methods.

Bleaching by Means of the Dioxid of Hydrogen and the Dioxid of Sodium.—The commercial introduction of solutions of hydrogen dioxid marked a new era in the operation of bleaching discolored teeth. The bleaching property of hydrogen dioxid had been known to chemists for many years, but the application of this property to tooth-bleaching dates from the medicinal use of hydrogen dioxid solutions for the treatment of purulent conditions of the pulp canal and about the roots of teeth. When applied in the canals of discolored and infected teeth it was observed that a noticeable bleaching of the discolored structure resulted. The hint thus given was further studied until it was found that under proper conditions the whole structure of a discolored tooth might be successfully restored to normal color.

The earlier preparations were found to be lacking in strength; aqueous solutions containing more than 3 or 4 per cent. of absolute hydrogen dioxid were found to be too unstable to keep for any length of time, and hence were unreliable. The problem of securing a stable high-percentage solution of the dioxid was solved by using ether as a menstruum, and the 25 per cent. solution of hydrogen dioxid made by McKesson & Robbins of New York and sold as "caustic pyrozone" is now generally used where hydrogen dioxid is employed as a bleaching agent in connection with discolored tooth structure.

Hydrogen dioxid, H_2O_2, belongs to the class of "oxidizing bleachers," and owes its activity in this respect to the weak state of chemical combination in which one of its atoms of oxygen is bound to the water molecule. Many substances serve to disrupt the compound and liberate one of its oxygen atoms. In contact with pus, blood, inspissated mucus, albumin, and in fact almost every kind of dead organic matter, its decomposition takes place, evolving oxygen and decomposing the organic matter either wholly or in part. Hydrogen dioxid does not bleach all of the decomposition-products of hemoglobin with equal facility. It quickly removes the pink discoloration following the initial extravasation of hemoglobin into the dentin, but when the brown stage has been reached indicative of the formation of hematin its action is but slight. Later, however, it bleaches more readily. The refractory nature of hematin with respect to hydrogen dioxid has been experimentally tested upon the substance out of the mouth.

In bleaching discolored teeth with hydrogen dioxid the ethereal 25 per cent. solution known as pyrozone is directly applied to the internal portions of the tooth upon small pledgets of cotton or cotton wisps rolled upon a fine flexible canal instrument. After each application the ethereal menstruum is evaporated by blasts of warmed air from a hot-air syringe, and the applications similarly made are repeated until the desired effect is produced. It has been found in practice that more rapid and permanent effects are produced when the pyrozone solution is rendered alkaline. This may be readily done by the addition of a few drops of liquor ammoniæ fortior or by a solution of one of the caustic alkalies, *e. g.* sodium or potassium hydroxid or sodium dioxid. A very satisfactory method of securing the alkaline effect in this process is that suggested by Dr. D. N. McQuillen. His method is to first treat the pulp chamber and canals with applications of Schreier's Kalium-natrium preparation and after the débris from its action has been mechanically removed with instruments and cotton twists, without washing the canal, an application of pyrozone is made. The bleaching action follows with great rapidity, and has apparently greater permanence than where the pyrozone is used alone. In cases where the action proceeds very slowly, for example when at the end of a thirty minutes' continuous treatment the bleaching is not complete, it is well to seal an application of pyrozone upon cotton in the canal and allow it to remain for twenty-four hours, when a second treatment will usually complete the operation.

In this as in all bleaching operations it is advisable to fill the tooth temporarily with some easily removable filling in order to test the permanence of the operation, and after the lapse of a reasonable time if there is no tendency to a return of the discoloration the canals and cavity may be permanently filled.

Dr. Harlan's method consists in acting upon hydrogen dioxid by aluminum chlorid. The aluminum salt is packed in the cavity and moistened with the dioxid. The technique of the procedure is the same as for the methods already described. This process was originally classified with the chlorin methods, as the decomposition was supposed to take place according to the following equation:

$$Al_2Cl_6 + 3H_2O_2 = Al_2O_3 + 3H_2O + 6Cl.$$

Experimental study of the reaction between aluminum chlorid and hydrogen dioxid by the writer developed the fact that oxygen and not chlorin was given off, and that the aluminum chlorid was unaltered during the process. Hence it was discovered that the reaction was simply due to a catalytic action of the aluminum salt (a property which in this relation it shares in common with many other metallic salts), whereby nascent oxygen is liberated from the hydrogen dioxid. The process, therefore, has no greater value than those in which hydrogen dioxid is directly applied. The aluminum chlorid being an active coagulant is contraindicated as a factor in the bleaching process until a point has been reached where a coagulant is needed as a fixative after the bleaching has been effected.

The Sodium Dioxid Method.—Sodium dioxid, Na_2O_2, is the chemical analogue of hydrogen dioxid, and like the latter is characterized by the readiness with which it parts with its atom of loosely combined oxygen under similar circumstances. The essential difference in its properties is the character of its by-product after its decomposition has taken place. Itself a strong caustic alkali, it still retains its alkaline and caustic properties after the loss of one of its atoms of oxygen, becoming Na_2O, which in combination with water is ordinary sodium hydroxid or caustic soda. This substance as well as the sodium dioxid has not only a saponifying property for all of the vegetable and animal oils and fats, but also a solvent action upon animal tissue. This property is of great value in removing from the dentin structure all of the contained organic matter, whether normal or in a state of decomposition. Having the oxidizing and consequently the bleaching quality in addition to its solvent and saponifying properties it is, therefore, one of the most valuable bleaching and detergent agents at our command. The substance is dispensed as a yellowish white powder in tin cans or glass bottles hermetically sealed, as it is very hygroscopic and after twenty-four hours' exposure to moist air absorbs nearly its own weight of water; it also loses much of its activity.

For use as a bleaching agent it is applied to the dentin in saturated solution. In making the solution especial care is necessary in order to avoid elevation of temperature, by reason of the energy with which it enters into combination with the water. If the solution is allowed to become heated in the making, decomposition of the compound with loss of oxygen occurs and its bleaching power is destroyed. The solution is best made by pouring into a small beaker of about one ounce capacity about two drachms of distilled water, and immersing the beaker in a larger vessel or dish containing ice-water or pounded ice. The can containing the dioxid powder should then have its lid perforated with a number of small holes similar to the lid of a pepper caster, and the powder be slowly dusted into the distilled water in the small beaker; or the powder may be gradually dropped into the water by tapping it from the point of a knife or spatula. The powder is added to the water until the solution assumes a semi-opaque appearance, indicating the point of saturation. On removing the beaker from the cooling mixture, the dioxid solution will in a few minutes assume a transparent, straw-colored appearance and is ready for use.

The applications are to be made similarly to the hydrogen dioxid applications, but upon asbestos fiber instead of cotton, as the latter is acted upon by the sodium dioxid and converted into a glue-like material, amyloid, which is difficult to remove and interferes with the success of the operation.

After the dentin, which should have been previously desiccated, is thoroughly saturated with the dioxid solution an application of 10 per cent. sulfuric acid should be made, which neutralizes the strong alkali, forming sodium sulfate and hydrogen dioxid, thus:

$$Na_2O_2 + H_2SO_4 = Na_2SO_4 + H_2O_2.$$

The reaction is usually attended with some effervescence, which taking place in the tubular structure of the dentin, mechanically forces out its contents and thus exerts a detergent action upon it. The tooth should now be washed with hot distilled water in copious quantity and the dioxid application repeated, omitting the subsequent treatment with acid but washing again thoroughly with the hot water.

Sodium dioxid solution, as prepared for bleaching, may be applied to the pulp chamber and root canal without the preliminary treatment required where other bleaching agents are employed. It is without harmful irritative action upon the apical tissues unless used in excess or forced through the foramen by careless manipulation. It is a powerful germicide and disinfectant, and therefore peculiarly suited to the treatment of putrescent cases, which by its action are rendered sterile and aseptic as well as bleached at one operation. Its saponifying and solvent properties completely remove the greasy dark layer of decomposed material which is found lining the pulp chamber and canals alluded to on page 546, so that the use of the sodium dioxid method makes unnecessary the application of borax or ammonia for its removal as a preliminary. When used for its sterilizing property the foramen should be allowed to remain unsealed until after the bleaching operation has been completed. It sometimes happens that the improvement in color following the application of the dioxid methods is only partial and the result falls short of restoration to normal; or, in other words, the bleaching reaches a certain point beyond which the color resists the further action of the bleaching agent. In such cases the decomposition of the color molecule has probably resulted in the formation of iron oxid as an end-product. In practice this residual discoloration can generally be removed by treatment with oxalic acid. A small crystal is to be sealed in the moist pulp chamber for twenty-four hours, and afterward washed out with a copious irrigation of hot distilled water.

The sodium dioxid method removes more completely than any other the tubular contents, and the result is unique from the fact that not only is the tooth restored to normal color but to normal translucency; the opaque white effect resulting from other methods of bleaching is due to the bleached organic débris remaining in the tubuli, but by the solvent action of the strong caustic alkali this is removed. The final treatment of the tooth is the same in this as in other methods, though the dentin should be desiccated and saturated as thoroughly as possible with an unalterable varnish before the final filling is inserted.

The Sulfurous Acid Method.—Reference has already been made to sulfurous acid as the single example of the reducing type of bleaching agent. Its activity is due to its affinity for oxygen, and it bleaches by seizing upon and combining with that element of the color molecule, thus destroying its identity and consequently its color. Attempts have been made to utilize the bleaching property of sulfurous acid in the treatment of discolored teeth by direct applications of the solution of the gas in water and by igniting small quantities of sulfur in the root canal by means of the electro-cautery wire. These methods have, however, proved inefficient. The gas may be successfully used in bleaching teeth by evolving it from its compounds placed in the cavity and root canal in a manner analogous to that employed in the Truman chlorin process already described. For this purpose the writer's method may be conveniently employed: 100 grains of sodium sulfite and 70 grains of boric acid are separately desiccated and afterward ground together in a warm dry mortar. The powder is then to be transferred to a tightly stoppered bottle. For bleaching purposes the powder is packed into the root canal and cavity of the tooth, and then moistened with a drop of water and the cavity immediately closed as tightly as possible with a stopping of gutta-percha previously prepared and warmed. A reaction ensues between the boric acid and sodium sulfite whereby sulfurous acid is liberated, thus :

$$2H_3BO_3 + 3Na_2SO_3 = 2Na_3BO_3 + 3H_2O + 3SO_2.$$

The process is effective in many cases where the chlorin methods have failed, but is slow in its action and is largely superseded by the dioxid-of-hydrogen and dioxid-of-sodium methods.

Cataphoric Bleaching of Teeth.

Since the revival of interest in cataphoresis and its application to dental operations its possibilities as an adjuvant in the tooth-bleaching process are being investigated with much promise of valuable results. It has been found that aqueous solutions of hydrogen dioxid may be carried into the dentinal structure with great ease by the cataphoric action of the continuous current. The appliances necessary for tooth-bleaching operations by this means are practically the same as those required in the treatment of hypersensitive dentin, and are detailed at length in the chapter dealing with that subject (page 189). The resistance offered by the hard structures of the tooth is much greater after loss of the tooth pulp, requiring a much higher voltage pressure to drive the bleaching agent into the tissue. While in some cases 25 to 30 volts will be all that is necessary, some cases will require as high as 60 volts to carry 1.5 milliampères of current through the dentin. The ethereal solution of hydrogen dioxid has been found to oppose too great resistance to the current, but the aqueous solution containing a slight addition of some salt to increase its conductivity is entirely manageable.

A 25 per cent. aqueous solution of hydrogen dioxid may be quickly made by shaking together in a test tube one volume of water and two volumes of 25 per cent. pyrozone. The H_2O_2 dissolves in the water, and the ether of the pyrozone may be removed by pouring the mixture into a small evaporating dish of porcelain or glass and gently heating it over a water bath until all of the ether has evaporated. The addition of a small quantity of sodium acetate or sulfate will greatly diminish the resistance of the solution to the passage of the current.

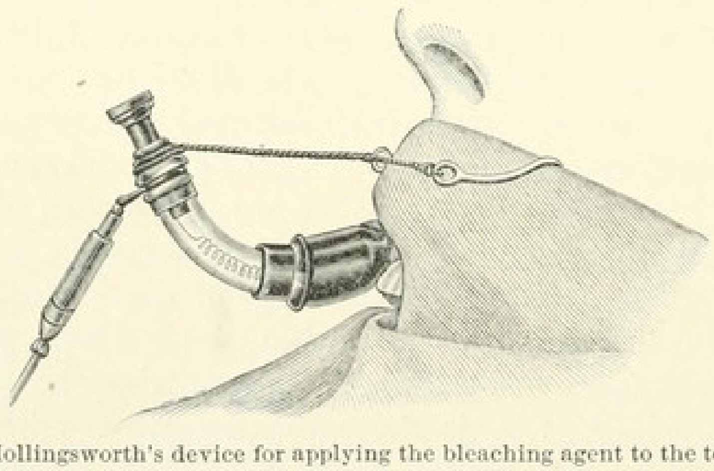
With the tooth isolated by the rubber dam and having received the treatment preliminary to bleaching, as already described in detail, the aqueous solution of H_2O_2 is dropped upon cotton within the tooth cavity and a platinum needle anode is applied in contact with it. The cathode may be a sponge electrode moistened with salt solution and held in the hand or applied to the cheek or neck. The hand, however, is preferable because of the amount of voltage required in the operation. Great care must be exercised that the external surfaces of the tooth are kept dry so that short-circuiting of the current may not take place. In some cases a more rapid effect is obtained by making contact of the cathode pole through a needle electrode upon the external surface of the tooth, and with the anode applied to the pyrozone solution on cotton within the tooth. The cotton must at all times be kept wet with the solution.

The arrangement of the electrical terminals with respect to the bleaching operation is both theoretically and practically correct as described, viz. the flow of current should be from the anode point through the bleaching solution and tooth and the body of the patient to the cathode. In practice it has been found in some cases which have failed to bleach with the elements arranged in the series as stated, that upon reversing the poles and direction of current flow the bleaching has rapidly followed. The explanation of this apparent paradox is that by the application in normal order H_2O_2 was first carried into the tubular structure, and the reversal of the current has acted upon the tubular contents now saturated with the dioxid, and by its propulsive as well as electrolytic effect removed the pigmentary matter pulpward from the tubuli. Bleaching with reversed poles would be impossible without previous saturation of the dentin by the dioxid solution.

Dr. M. W. Hollingsworth has devised an ingenious anode for feeding the bleaching solution or other medicament into the cavity as desired. The instrument (Fig. 154) is described in Chapter VII.

Another device by Dr. Hollingsworth is of especial value, as it makes possible the enveloping of the entire tooth with the bleaching fluid in which it is immersed as in a bath. The appliance is shown *in*

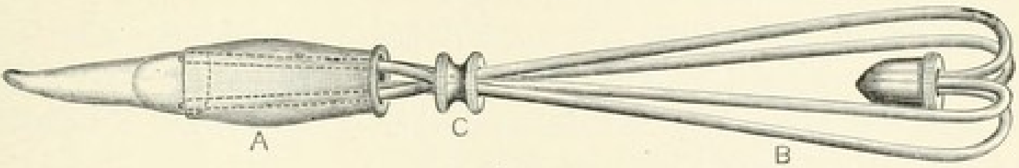
Fig. 481.



Dr. Hollingsworth's device for applying the bleaching agent to the tooth.

situ in Fig. 481, and consists of a thin vulcanized caoutchouc bulb shaped like the bulb of a medicine dropper. Through a perforation at its rounded end made with the ordinary rubber dam punch, the tooth is slipped by mounting the bulb on the applicator (Fig. 482), and forcing it over the tooth as though it were a rubber dam. A glass tube

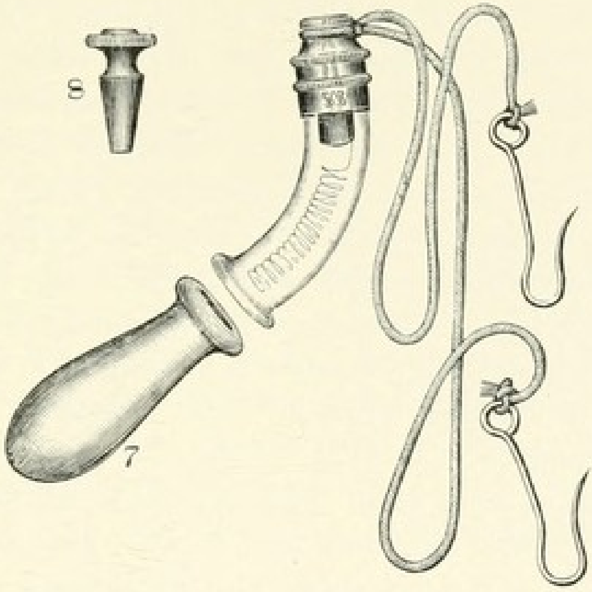
FIG. 482.



Applicator.

is then attached to the open end of the bulb, and to the glass tube is connected a spiral platinum wire electrode (Fig. 483). Before the elec-

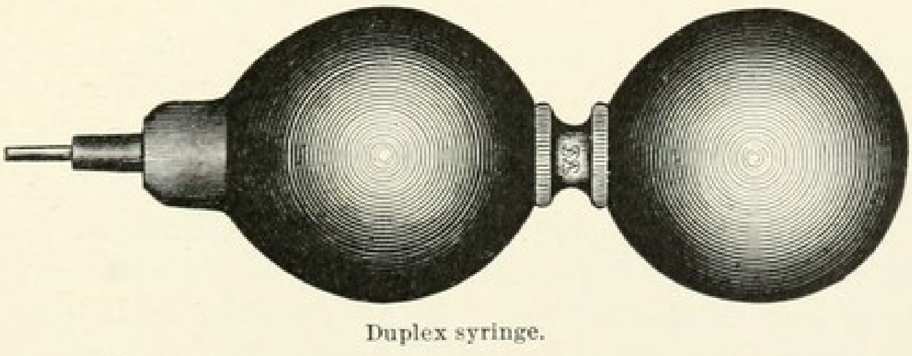
FIG. 483.



Tube electrode.

trode is attached the bulb and glass tube are completely filled with the aqueous pyrozone solution by means of a duplex syringe (Fig. 484), the

FIG. 484.



Duplex syringe.

lower and larger bulb of which exhausts the contained air in the apparatus and the smaller thumb bulb injects the bleaching solution into the exhausted apparatus. Connection is now made with the source of current as usual, and the bleaching is very rapidly effected. Dr. Hollingsworth recommends the addition of about 1 per cent. of zinc sulfate to the aqueous pyrozone solution, which not only diminishes the resistance to the passage of the current, but has a coagulating effect upon the bleached organic matter which gives it translucency and greatly enhances the permanency of the operation. The results obtained by this method are extremely satisfactory.

Bleaching Methods for Special Stains.

Pulpless teeth are especially liable to discoloration from external and accidental causes. If decayed and the cavity has remained unfilled for a length of time many substances which find their way into the oral cavity either as food or as medicine may produce discoloration when absorbed by the tooth through the open cavity walls.

Metallic salts are particularly apt to cause such staining by reaction with the sulfids with which the dentin structure is usually saturated during decomposition of its organic contents. Many of the medicaments used in pulp-canal treatment or even for hypersensitive dentin may stain the tooth structure, and finally the action of sulfids in the structure of a pulpless tooth may react with amalgam fillings, forming salts of mercury, silver, tin, copper, etc., which are absorbed by the tooth, resulting in its discoloration. The treatment of these stains, which were grouped as Class III. at the beginning of this chapter, is extremely difficult and often unsatisfactory. However, there may arise individual cases of discolorations of this class where it is of the utmost importance to remove them, and much may often be accomplished when the causes of the discoloration are known and the proper bleaching method is applied.

Gold stains may arise, as has been already indicated, from the injudicious use of gold instruments or failure to remove all gold fillings when applying some one of the chlorin methods of bleaching. In the course of time where this has happened the tooth assumes a pinkish hue which merges into a characteristic violet or purple, finally becoming black.

Iron stains may arise from the use of steel instruments in connection with the chlorin methods of bleaching or in contact with iodin or any of the mineral acids in connection with canal treatment. The iron stain is yellowish at first, gradually becoming brown and finally black.

Copper and nickel stains may arise from contact with these metals or their alloys, as copper amalgam or nickel or German silver dowels for artificial crowns or anchorages for fillings. The stains from these metals are—for copper, bluish to black, and for nickel a characteristic chlorophyll green which eventually becomes black.

The best general treatment for all of the foregoing stains is to re-bleach the tooth by the chlorin method, with especial care as to the several precautions already recommended, and when the color of the metallic stain has been discharged by conversion of the dark-colored salt into a soluble chlorid, wash the tooth thoroughly first with dilute chlorin water 50 per cent., and afterward with hot distilled water to remove all of the metallic chlorid which has been formed. The process may require repetition to secure permanent results.

Silver stains are comparatively easy to remove, either by an application of the chlorin method or by saturating the tooth with tincture of iodin, thus converting the silver salt into a chlorid or iodid as the case may be, after which it may be dissolved out with a saturated solution of sodium hyposulfite applied as a bath to the tooth. For this purpose the Hollingsworth bulb dam (see Fig. 483) answers admirably, and although the experiment has not as yet been tried, there is good reason to believe that the cataphoric method with electrodes applied in reverse order would under these circumstances greatly facilitate the solution and removal of the metallic salts.

Mercurial stains are always black from the formation of mercuric sulfid, and are removable by the same method as are silver stains, with the exception that where the stain has been converted into a chlorid by the chlorin method, the mercuric chlorid is best removed by an aqueous ammoniacal solution of hydrogen dioxid, or when the stain has been converted into mercuric iodid by the use of a saturated solution of potassium iodid. In both cases a final washing with hot distilled water is a *sine qua non*.

Manganese stains frequently occur from the use of potassium permanganate, in solution or in substance, in the treatment of putrescent canal conditions. The manganese stain is a characteristic mahogany brown. It is very readily removed by a 25 per cent. aqueous solution of hydrogen dioxid in which oxalic acid crystals have been dissolved to saturation. A few applications of this mixture will quickly decolorize the stain, after which a liberal treatment of hot distilled water is required as in the foregoing cases.

In all cases a careful diagnosis of the chemical nature of the discoloration should be made when possible. Much information upon this point may be gained by a detailed study of the present condition of the tooth and its environment, but in addition to this the patient should be questioned as to the history of the case, and especially as to its previous treatment. The data thus obtained should be carefully noted and treatment instituted in accordance with the conditions to be met.

Success in the bleaching of teeth demands a recognition of the fact that each case presents individual peculiarities, that the problem is essentially a chemical one always, and that the bleaching method in any given case must be selected with especial reference to the character of the discoloration and applied with due care as to its details in order that the chemical requirements of the operation may be intelligently met; without which care success is impossible.

CHAPTER XXI.

EXTRACTION OF TEETH.

By M. H. Cryer, M.D., D.D.S.

Indications for the Operation.

It is impossible to formulate a set of exact rules by which the practitioner may be governed, in deciding upon the extraction of teeth. So many circumstances both local and general must be taken into consideration that little more can be done than to suggest the most important causes which demand the operation.

Deciduous Teeth.—The indications for extracting deciduous teeth are—

First: When the teeth are a source of irritation affecting the general health or comfort of the child and do not respond to treatment.

Second: When the deciduous teeth are preventing the eruption of the permanent teeth into their normal positions. Occasionally a deciduous tooth will assist in the proper placing of a permanent one, in which case it should not be removed as long as it is of such use.

Third: When a lower permanent incisor shows signs of erupting on the labial side of the deciduous tooth, the latter should be removed at once, but if the erupting tooth appears on the lingual side the removal of the deciduous tooth may in that case be delayed somewhat longer.

Fourth: When upper permanent incisors show a tendency to erupt on the palatal side of the temporary teeth, the latter should be extracted, but when they are erupting on the labial side the deciduous teeth may be allowed to remain for a time, as they are often useful in forcing the permanent teeth outwardly. This, however, must be closely watched to prevent the permanent incisors from moving too far.

Permanent Teeth.—The indications for extraction of the permanent teeth are—

First: Diseased roots which cannot be cured and so made useful for crowning, or assisting in retaining a bridge, plate, or other prosthetic device.

Second: Teeth of mastication that have lost their occluding teeth and in consequence thereof are being pushed from their alveoli and are a source of trouble. As a rule, this refers only to the second or third molars, and more particularly to the third molar. When it occurs with other teeth the opposite vacant space should be filled by an artificial tooth to prevent the extrusion of the natural tooth.

Third: When incurable abscesses originating from teeth in the upper jaw tend to open into the nasal chamber, maxillary sinus, or zygomatic fossa, the teeth associated with such abscesses should be extracted. When diseased teeth are the exciting cause of an incurable abscess in the lower jaw which opens or threatens to open externally on the chin, jaw, or below the bone into or upon the neck, they should be removed.

Fourth: Teeth which occupy irregular positions in the arch, that cannot be corrected so as to become useful or contribute to the general symmetry of the mouth, should be removed.

Fifth: Erupting teeth that are retarded because of lack of room in the jaw, if giving pain, should be extracted or else the tooth that is preventing the eruption should be removed. A marked example of this is often found in the eruption of the third molar when all the other teeth are of good size and are in place. These molars when retarded cause the greatest distress, sometimes producing serious results, and must be extracted; if they cannot be safely removed the second molar may be extracted, in consequence of which the third molar will usually be erupted near its place. When an upper third molar is erupting under the same circumstances there is usually less difficulty, as having but slight resistance distally it can erupt outwardly or slightly backward, though, should it impinge upon the soft tissues covering the ramus of the lower jaw, it should be extracted.

Sixth: Teeth so badly diseased that they will not respond to treatment and are a source of discomfort to the patient should be removed, as they impair the general health.

Seventh: *First molars.* There has been much discussion regarding the early extraction of these teeth, many claiming that if the pulp of one becomes devitalized at an early period of life and it is deemed best to extract it, the other three should also be removed. No fixed general rule, however, can be given; each case must be considered separately. There are cases where the extraction of all is necessary, and others where it would be a most unwise thing to do. When the anterior teeth are fully in position, the bicuspids occluding correctly with their occluding teeth and the second molars are about to erupt, the case may then be one for extracting the four first molars, provided it be necessary to extract one of them, or if it be likely that one or more of them will be lost in a few years. If, however, the bicuspids are not in good position, it is better not to extract the first molars, as they assist in keeping the jaws the proper distance apart, and preventing the lower anterior teeth from biting against the upper gum.

Removal of Sound Teeth Preparatory to Inserting Artificial Dentures.—When preparing the mouth for an artificial denture the removal of sound teeth may be indicated as a measure of expediency in relation to mechanical and hygienic considerations. For example:

(1) Roots which a plate or bridge would cover, excepting when they assist in holding the device.

(2) Teeth from which the gums have receded to such an extent as to become useless or unsightly.

(3) Teeth that are being extruded from their alveoli from the absence of occluding teeth. The extraction of these depends, however, on the extent of "elevation" and the possibility of placing occluding artificial teeth in position.

(4) Where there is but one tooth remaining, or two teeth standing together, or in certain cases when several isolated teeth remain which cannot be made to contribute to the mechanical adaptation of an artificial denture, extract when in the *upper* jaw. They interfere with the fitting of an upper plate, but in the lower jaw they may be useful in retaining the plate.

(5) When there are two teeth, one on each side of the upper jaw, in good position and desirable shape for clasping, do not extract unless they are the third molars or the oral teeth.

(6) In preparing the upper jaw when two canine teeth alone remain, or when there is also a molar or bicuspid, or both, and it is decided to extract the molars and bicuspids, then extract the two canine teeth also. It has been claimed by some of the very best dental practitioners, whose opinions must be respected, that by keeping these teeth the expression of the face is less likely to be marred. For the following combined reasons, however, extraction is advised:

a. It is very difficult to obtain a correct impression of the mouth while these teeth only are in position.

b. It is nearly impossible to perfectly match, grind, and arrange the lateral incisors beside single canines.

c. The adhesion of the plate to the mouth is interfered with, as air and food work in between the plate and these natural teeth.

d. The plate is very much weakened by being cut out for the accommodation of these teeth at what might be termed the abutments of the arch.

In the *lower jaw* single teeth which are sound are usually of great importance. They should not be removed, as they assist in retaining a denture by means of clasps or other devices. Especially is this true in persons advanced in years, as then the alveolar process is generally much absorbed. If the lower process is much absorbed even an imperfect tooth will do good service of this character for a time, and if it is the first plate the patient has worn it will serve a good purpose by assisting in the retention of the plate until the patient has become accustomed to it, after which the tooth, if giving trouble or if it is unsightly, may be removed and an artificial one placed on the plate.

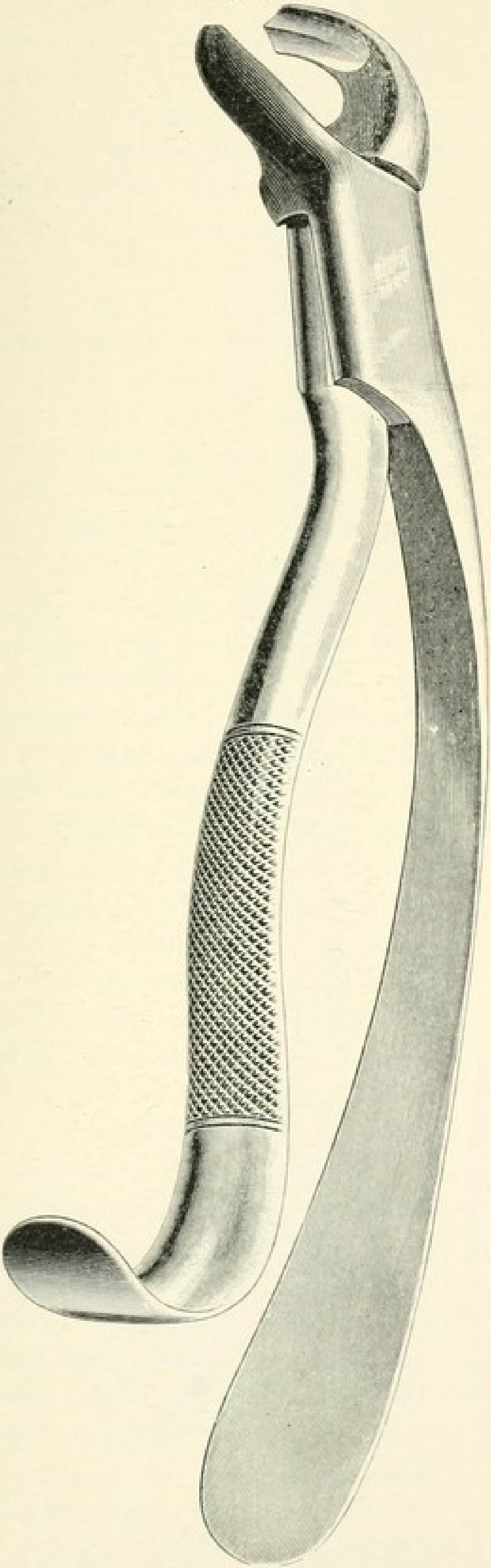
Instruments and Accessories for Extracting.

The instruments used in extracting teeth are forceps and elevators of various shapes and sizes.

Forceps.—The forceps should be made of steel of the best quality for the purpose obtainable, in order to give great strength and stiffness, and at the same time toughness, so that they will not break. Forceps that will spring or bend destroy the sensitivity of the hand using them in such a way as to prevent the operater from discerning in what direction the resistance to extraction is being made. The beaks of the forceps as a general principle should be shaped so as to fit and adjust themselves to as great a surface of the various teeth or roots as possible so that they may take a firm hold. They should be at such an angle in relation to the handles as will permit them to be easily and readily placed in the proper position without obscuring the view of the tooth to be extracted. The inner surface of each beak should be concave in a transverse section and without serrations, as these are of no assistance, but tend to weaken the beaks and are difficult to clean. The edges of the concave portion should be sharp enough to cut through the alveolar process if necessary. The points of the beaks should be sharp and tapering so they can be forced into position. The handles should be of a shape to allow a firm grasp, and as the hands of different operators vary in shape and size it will be evident that the same size of forceps handles will not be perfectly satisfactory to all. The curvature of the handles should vary according to the general or special use of the forceps. The curved ends, as seen in Fig. 485, are of little use, and should be done away with in all forceps excepting perhaps those made especially for the upper and lower molars.

The joints of extracting instruments should be so made that the handles can be separated by some simple mechanism to permit of thorough and easy cleansing. Figs. 485 and 486 represent an instrument of this character. There are others of the same nature, but

Fig. 485.

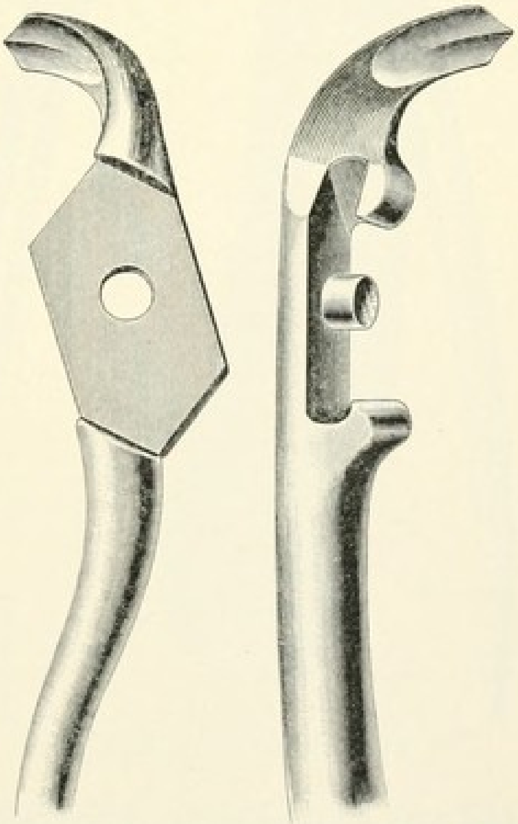


Antiseptic universal lower molar forceps.

this being the most simple and the strongest should be generally adopted unless a similar device can be adapted to the "knuckle-jointed" instrument. (Fig. 487.)

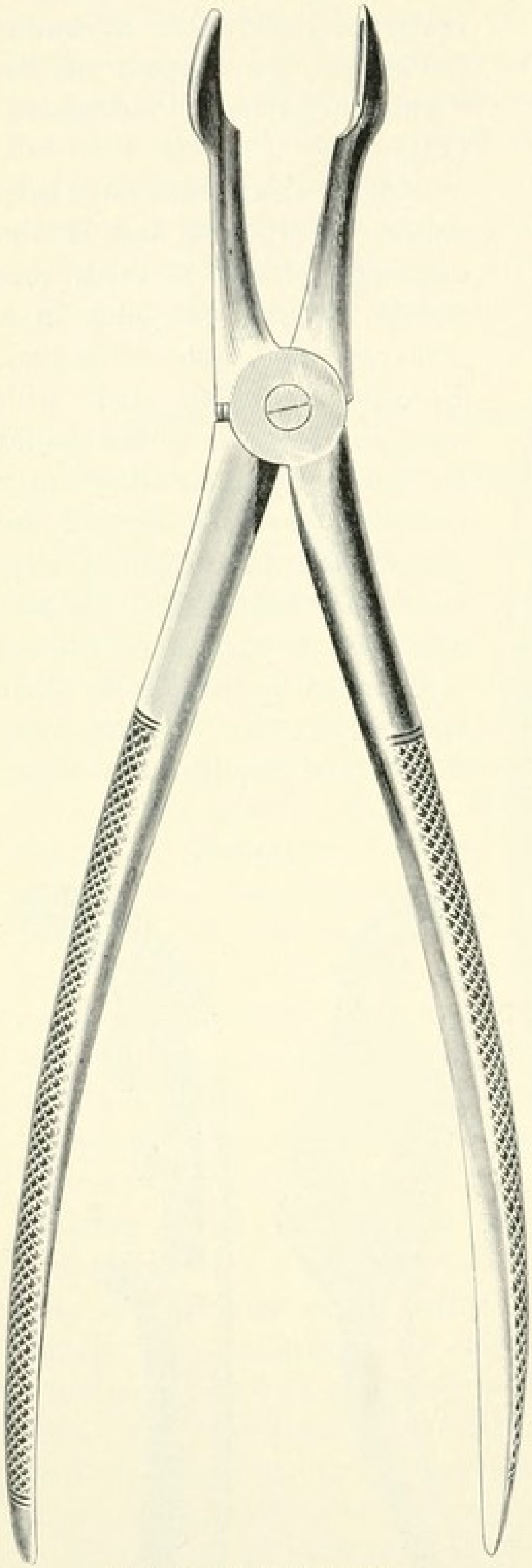
There should be no sharp angles or crevices, and if the ordinary forceps is used, that portion around the joint in a transverse section should be oval. Forceps are often made with octagonal joints, but these should be condemned, as they may not only hurt the lips of the patient, but in case of a slip, which may happen with the best operators, they are more liable to cause injury by striking the other teeth; moreover they are very clumsy and require more room.

Fig. 486.



Joint of an antiseptic lower molar forceps

FIG. 487.



Knuckle-joint root forceps.

Unless the antiseptic joint (Figs. 485 and 486) is used the union of the joints is usually made upon one of two principles: first, by one half passing into a mortise in the other and held in the centre by a pinion (Fig. 488). The second is known as a knuckle-joint (Fig. 487) made by each portion being let half way into the other and held together by a screw. This is a neater joint and does away with many of the objectionable features noted in other forms of forceps joint.

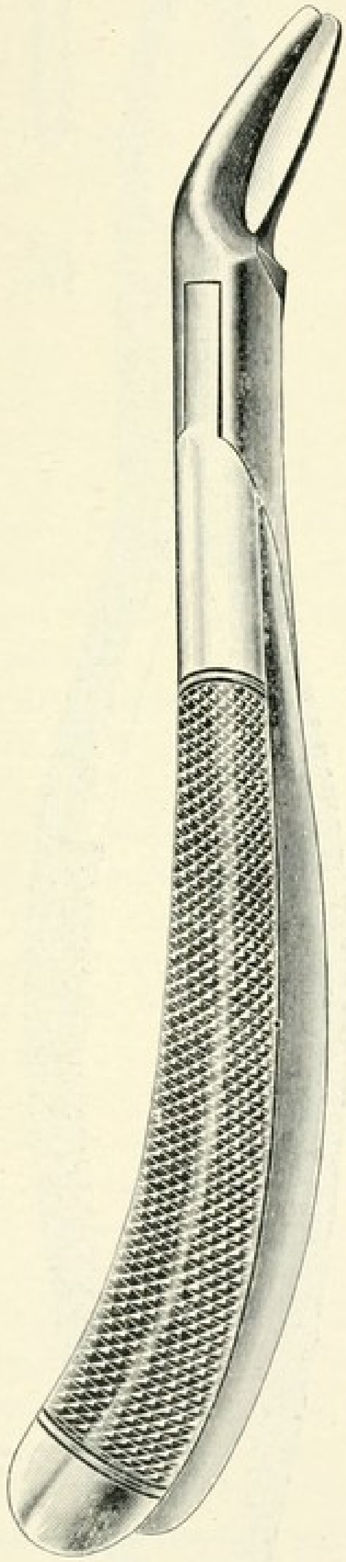
All handles should be serrated as shown in the illustrations, and the instruments if properly cared for need not be nickel-plated. The number of forceps in a practical set will vary with the requirements of every individual who extracts teeth, therefore only the general principles which should govern the selection of a set of instruments will be here given; at the same time the uselessness of a very large selection is here emphasized. As an illustration of the range of tooth extractions which may be performed with a limited number of instruments the forceps represented by Figs. 488 and 489, showing the exact size, will serve as examples. They are smaller than the ones generally used, especially in America.

The instrument shown in Fig. 488 may be used almost universally for the upper teeth.

Fig. 489 is a forceps of the same general character as that in Fig.

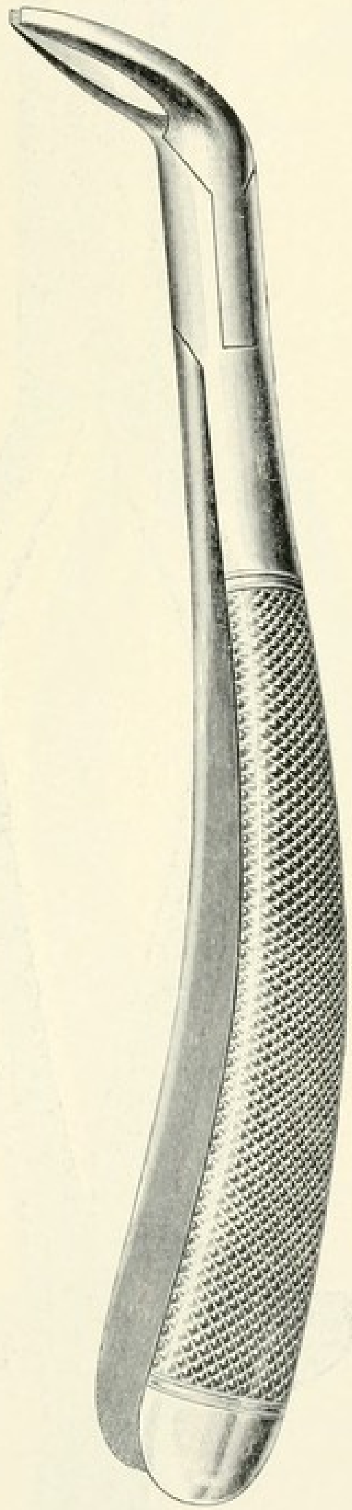
488, only the beaks are at a different angle with the handles. This pair

Fig. 488.



Universal upper incisor and root forceps.

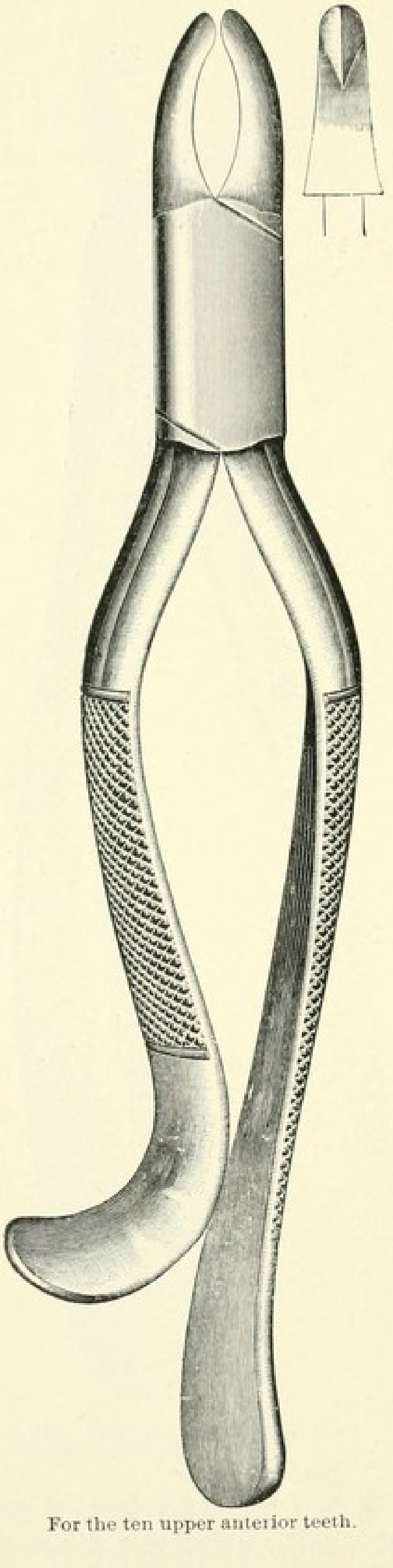
Fig. 489.



Universal lower incisor and root forceps.

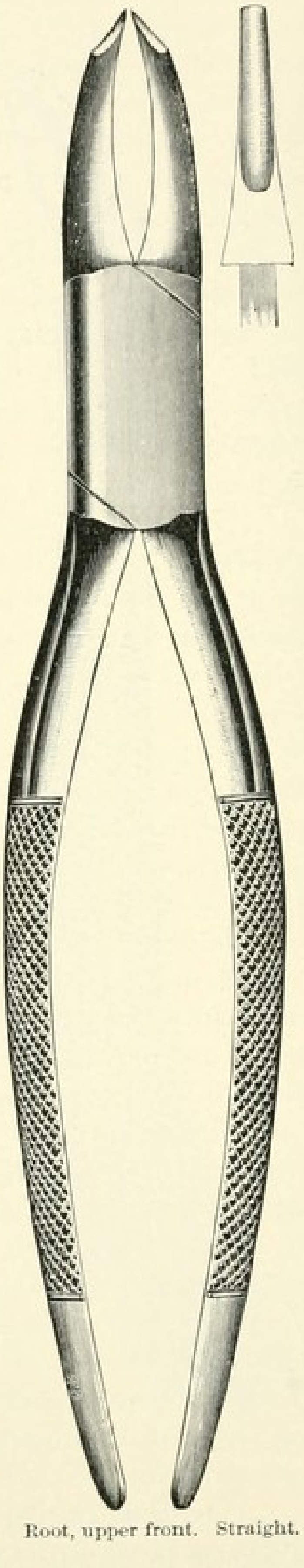
may be used similarly for the lower teeth. These forceps are useful in all cases, except in the full arch, when either a first or second molar is

Fig. 490.



For the ten upper anterior teeth.

Fig. 491.



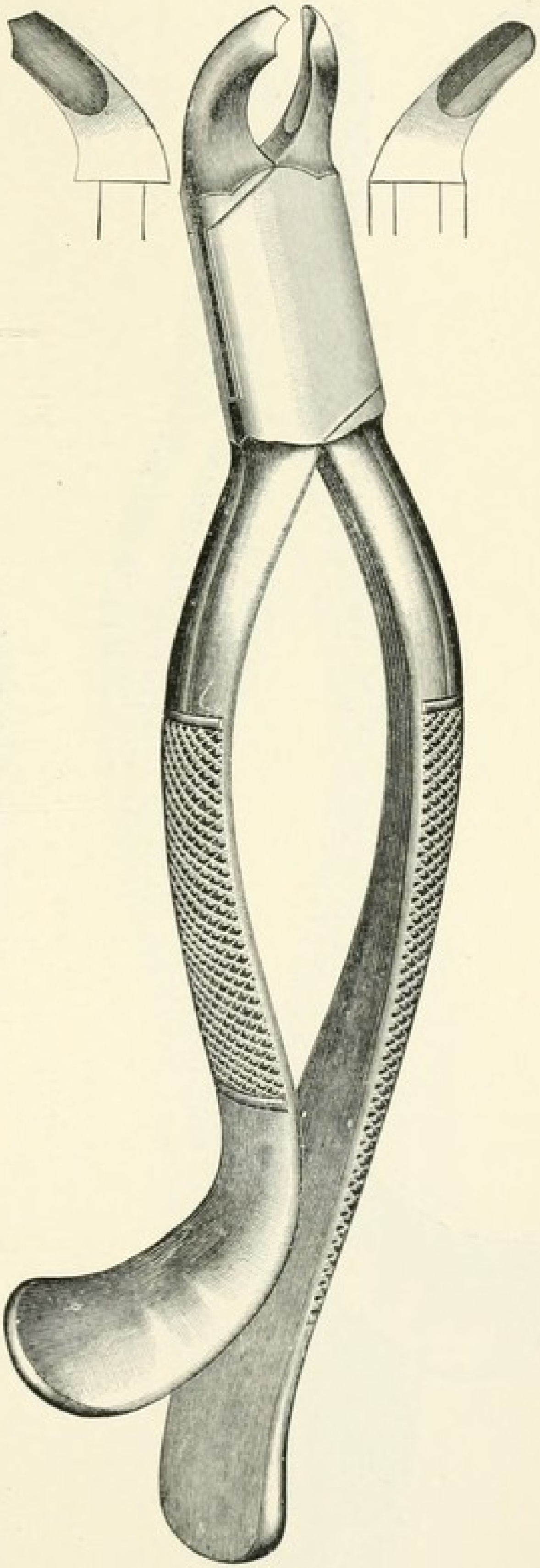
Root, upper front. Straight.

to be extracted. If the teeth are large, the jaw strong, and the line of grinding surfaces concave, it is better to use the special lower molar forceps as shown in Figs. 485 and 498.

Fig. 490 and Fig. 491 represent very useful forceps for extracting the ten upper anterior teeth. Fig. 491 has longer beaks and its points are finer. In skillful hands where too great a force will not be brought to bear on the points they are the better forceps. Under nitrous oxid and where many teeth are to be extracted, thus requiring rapid work, the instrument shown in Fig. 490 is preferable.

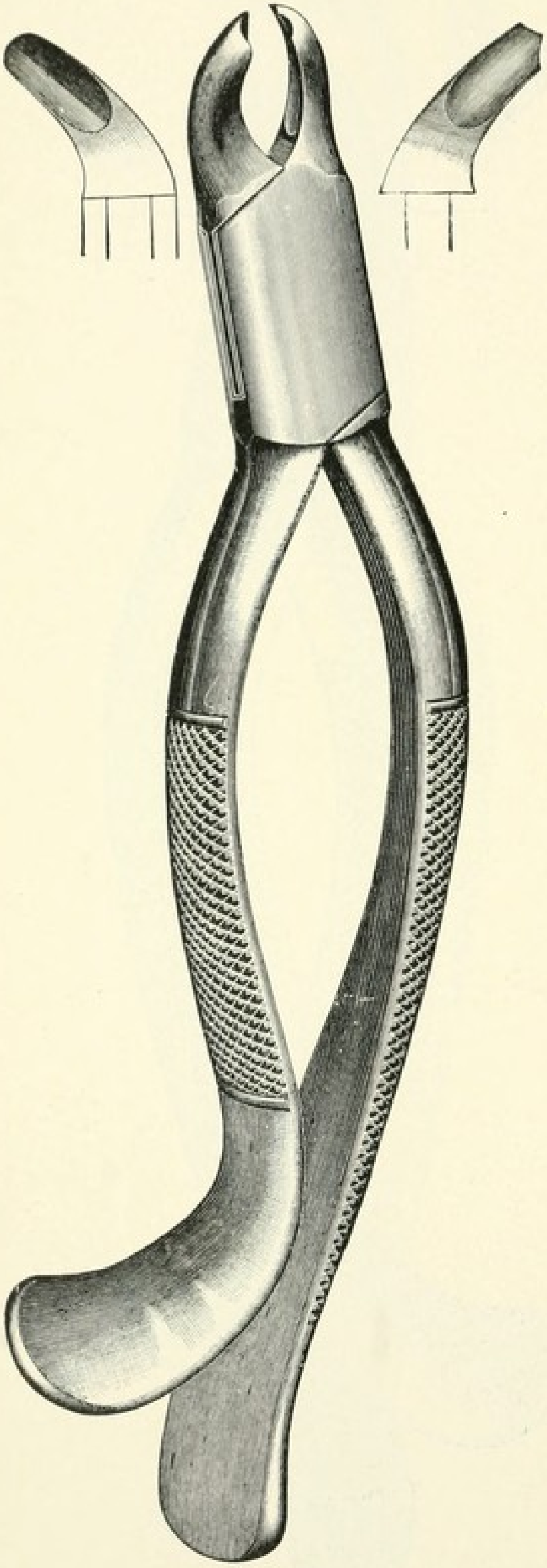
Figs. 492 and 493, right and left, represent forceps specially used for extracting the first and second upper molars on either side. The outer beak is made pointed for the purpose of passing in between the buccal roots, the inner beak is concave in order to grasp the palatal root. Figs. 495 and 496 show bayonet-shaped forceps, that illustrated by Fig. 495 being especially made for extracting the upper third molars, Fig. 496 being used for upper roots. The ends of the handles of all forceps which are forced in by the palm of the hand should have a broad surface as shown in Fig. 496. These forceps are popular with many operators. The writer considers them clumsy, as they obscure the proper view of the tooth and its associated parts.

Fig. 492.



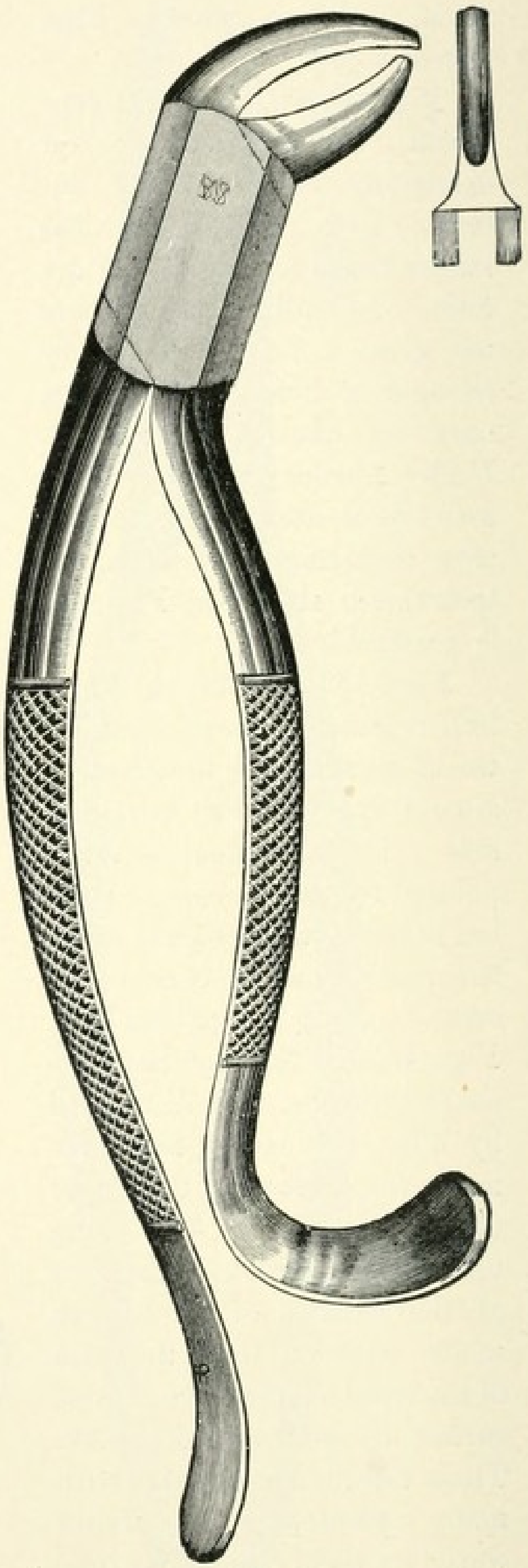
Right upper molar.

Fig. 493.



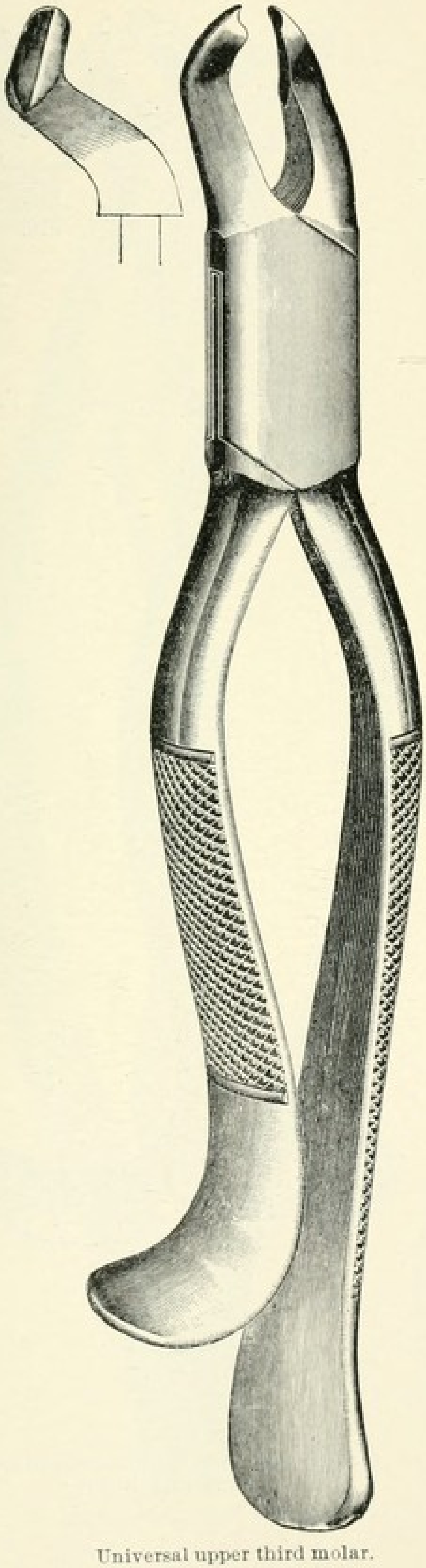
Left upper molar

Fig. 494.



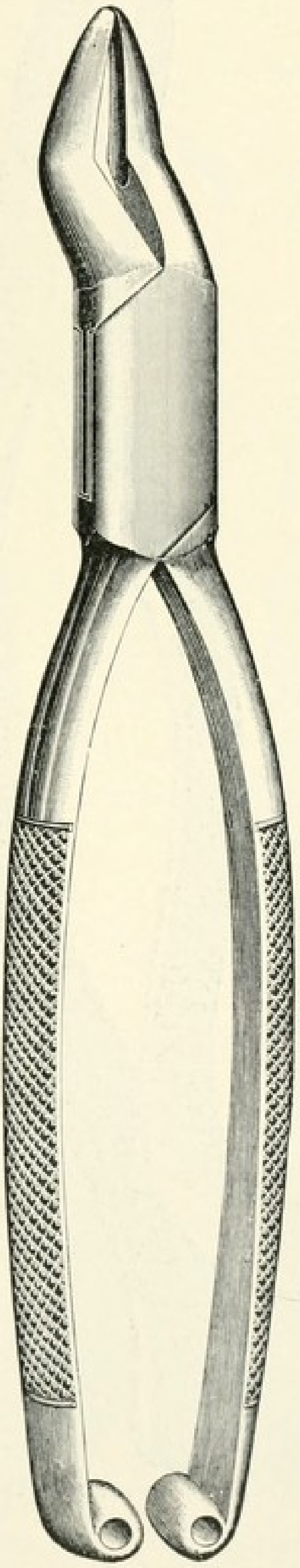
Hawk-beaked forceps.

Fig. 495.



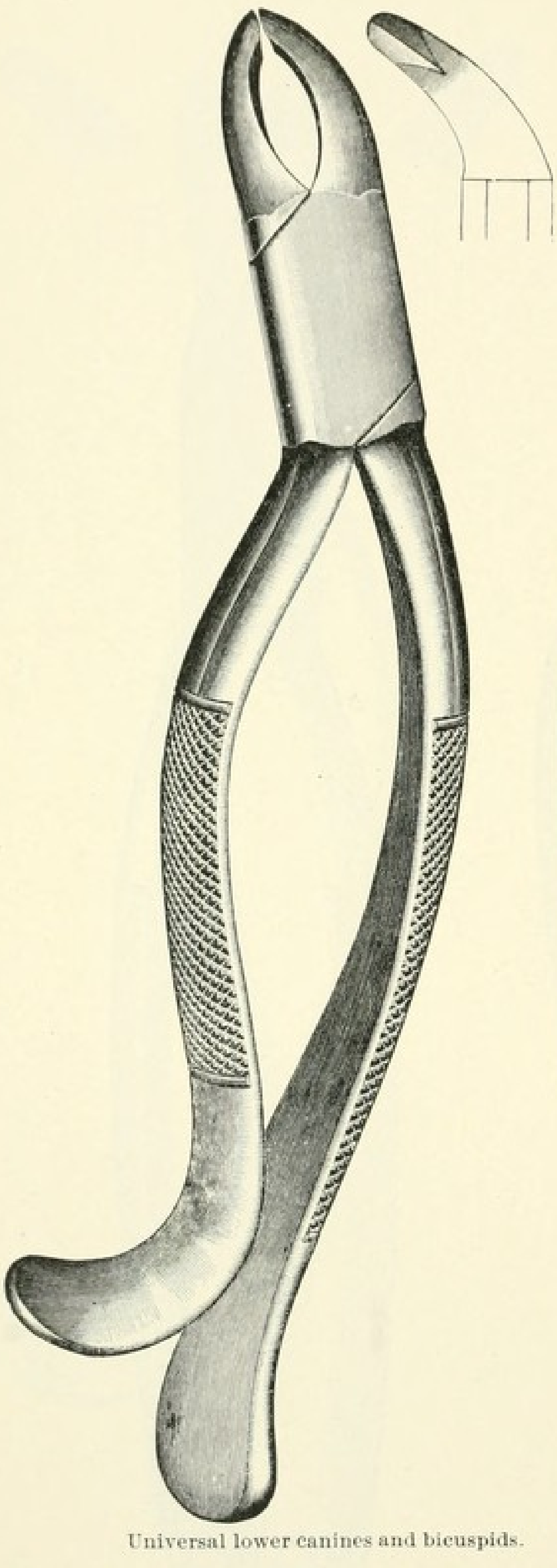
Universal upper third molar.

Fig. 496.



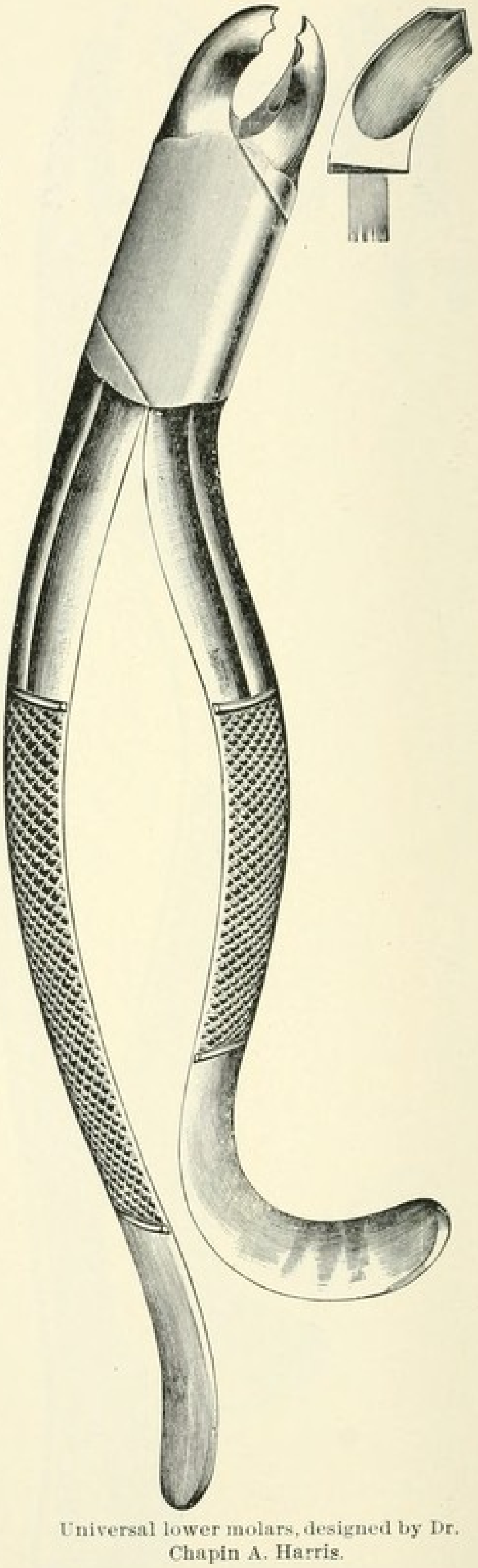
Dorr's upper root forceps.

Fig. 497.



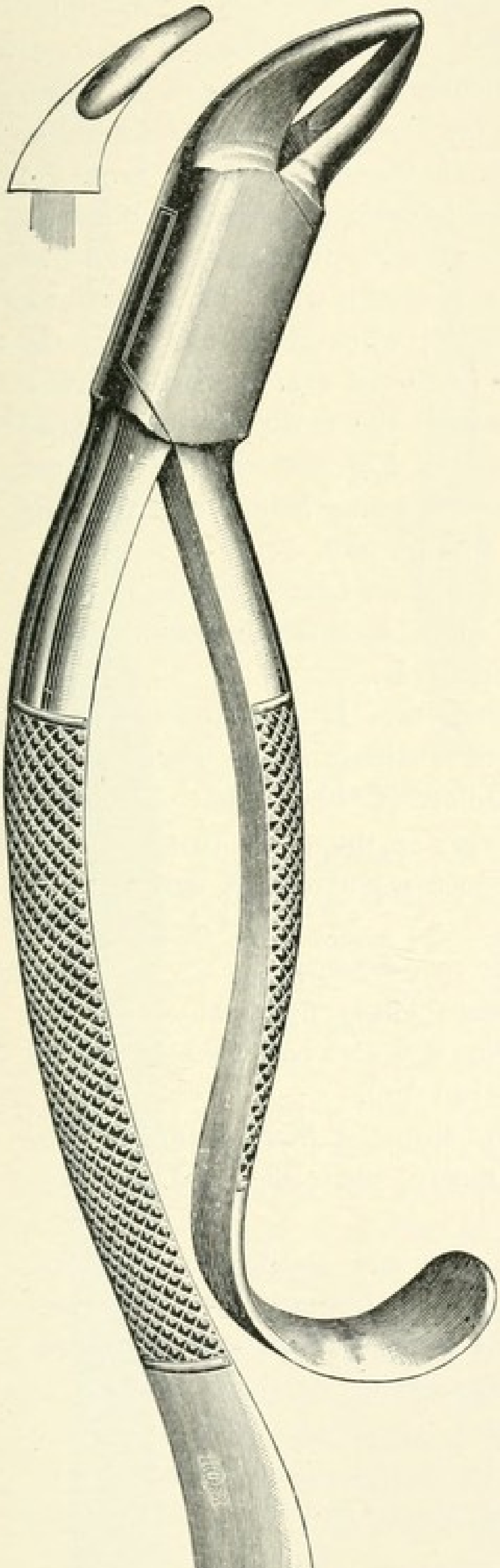
Universal lower canines and bicuspids.

Fig. 498.



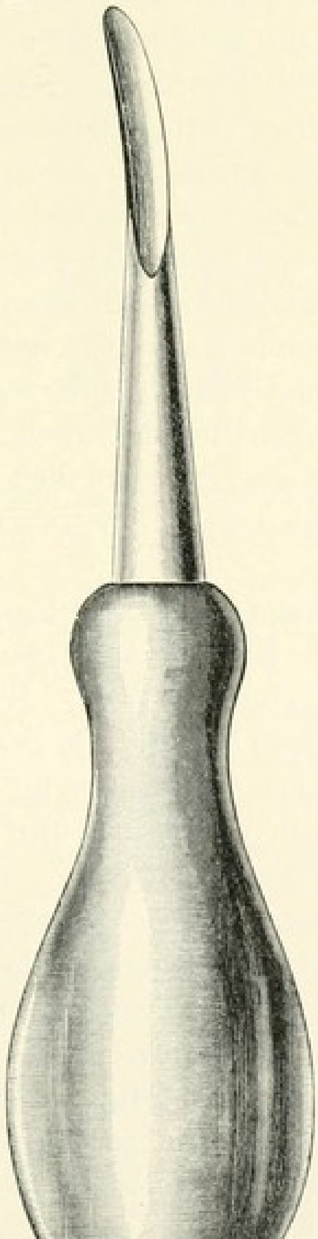
Universal lower molars, designed by Dr. Chapin A. Harris.

Fig. 499.



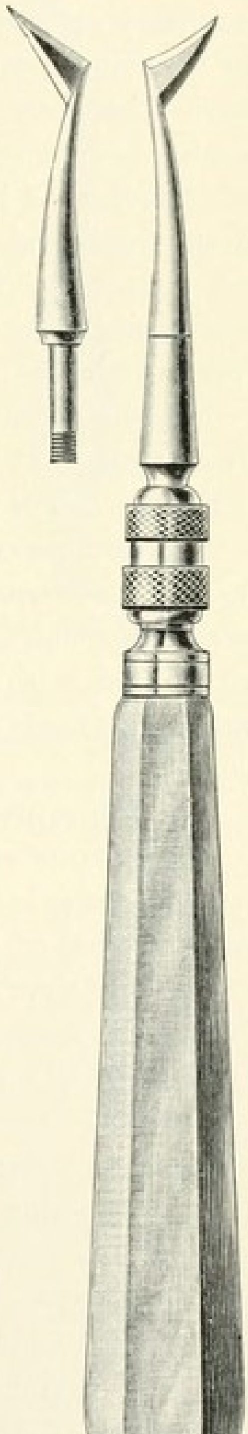
Root, lower. Half curved.

Fig. 500.



Elevator.

Fig. 501.



Right and left scalers used for extracting roots.

Forceps for Extracting Lower Teeth.—Instead of the beaks of the forceps being nearly on a line with the handles as in those for the upper jaw, they are bent at nearly a right angle. For the incisors of the lower jaw there are no better forceps than those shown in Fig. 489. This instrument is very useful in extracting the lower third molar when fixation of the jaw from diffuse cellulitis in the region of the temporomaxillary articulation renders it difficult to open the mouth sufficiently for inserting a larger instrument. In such cases the forceps should be carried backward in the vestibule of the mouth with the inner beak passing between the upper and lower teeth; when the beaks reach the third molar the inner beak can usually be forced over the inner surface of the tooth and into position, after which the tooth can be grasped and extracted. The forceps represented in Fig. 488 can also be used to advantage for these teeth, the operator standing behind and working over the head of the patient, as shown in Fig. 546.

Fig. 494 exhibits a hawk-beaked forceps for extracting the anterior lower teeth. It is very popular with some operators, especially those in Europe. The writer does not recommend it.

Fig. 497 also exhibits a special instrument. It is made for extracting the lower canine and bicuspid teeth of either side. Fig. 498 is a special instrument used for the lower molars of either side. The beaks are pointed, with a convexity on each side of the point to allow it to pass in between the roots. The two concave portions fit against each root.

Fig. 499 represents a universal lower root forceps.

ELEVATORS OR ROOT EXTRACTORS.—There are many kinds of elevators used in extracting roots. Some are also occasionally used in the extraction of teeth (usually the third molar).

Fig. 500 shows one of the most useful forms of this instrument. It is especially useful in extracting third molars when the teeth in front of them are in position.

Fig. 501 represents two elevators; they are similar to right and left scalers, being made somewhat heavier; they are extremely useful in extracting roots. They are so unlike an extracting instrument that patients do not dread the appearance of them as they do that of forceps. By carefully inserting the blade with the point toward the root to be removed, between it and the adjoining root or tooth, and giving a slight rotary motion, the point will force the root from its socket with but little pain.

Figs. 537 and 538 illustrate two other forms of elevator, with their mode of application in the removal of roots.

LANCETS.—Figs. 502 and 503 represent various forms of lancets, the more useful of which are Nos. 1 and 5, which are all that are required for lancing in extracting or for relief of retarded eruption of deciduous or other teeth. They are also useful in general surgery of the mouth. The handles should be made of metal instead of wood, in order that they may be thoroughly sterilized.

Fig. 502.

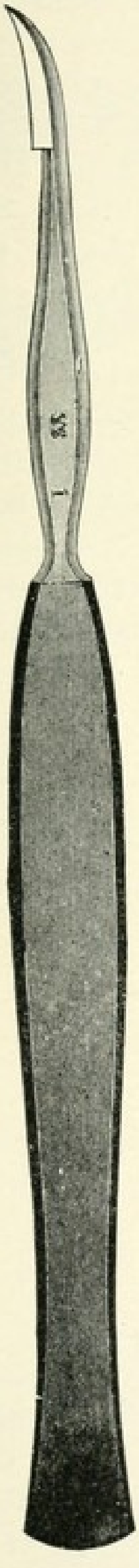
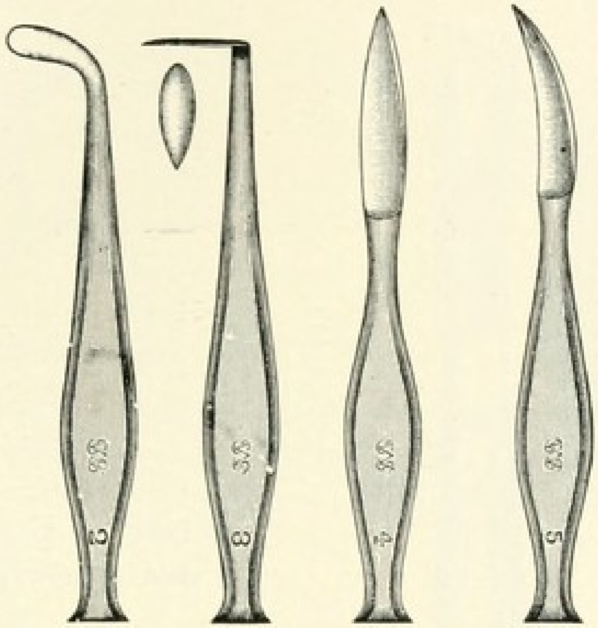


Fig. 503.



Lancets with ebony handles and with solid steel handles.

Scissors.—A good pair of curved scissors, as shown in Fig. 504, should be at hand in case a portion of gum tissue is found to be attached to the root. If the scissors were slightly more curved they would be even better adapted for this purpose.

In connection with the instruments already mentioned, there should be a mouth mirror (Fig. 505) and a few excavators and probes for general examination of the teeth, especially for examining the position and character of a root or impacted tooth which it is purposed to extract.

Mouth Props.—When an anesthetic is to be given it is advisable to use some kind of a mouth prop, in order to keep the mouth well open. Some operators do not use them, as they may interfere with the giving of the anesthetic by impeding respiration upon beginning the administration. The majority of patients, if asked to hold the mouth open while taking the anesthetic, especially nitrous oxid and oxygen, will keep it open during the anesthetic stage.

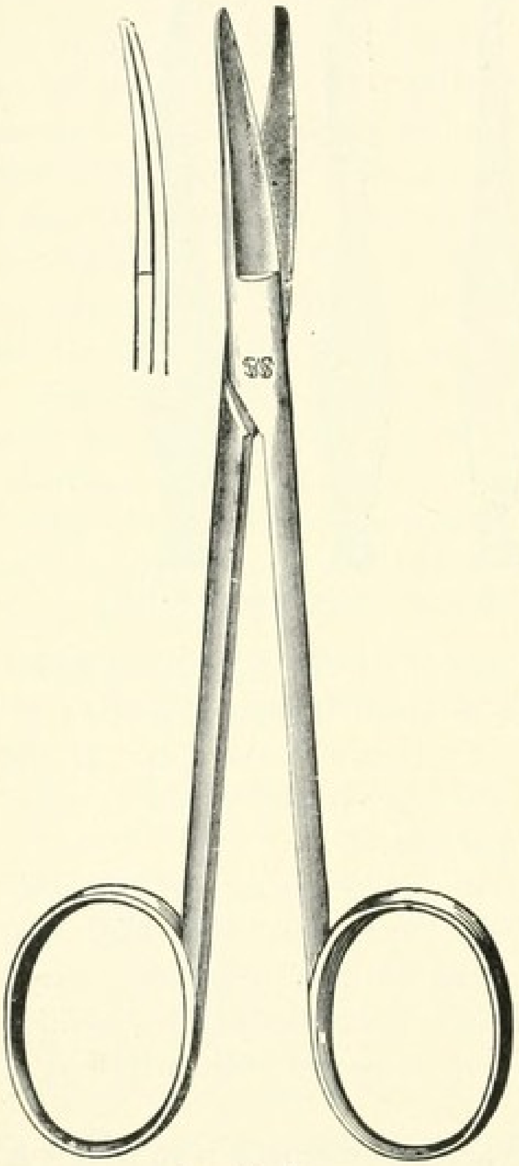
Fig. 506 illustrates excellent props devised by Dr. Frederic Hewitt, of London, England.

The Mechanical Mouth-opener (Fig. 507).—This instrument is made in various shapes and sizes. It is inserted between the jaws when the props are to be removed or in cases of trismus, and may also be used to separate the jaws and retain them so in cases of emergency or during certain operations within the oral cavity.

All dentists, and especially those who extract teeth, should have at least one pair of pharyngeal forceps (Fig. 508). It is possible that they may never be used, but on the other hand an accident may occur such as a fragment or tooth slipping into the pharynx, where if the finger cannot reach it this instrument will be absolutely necessary.

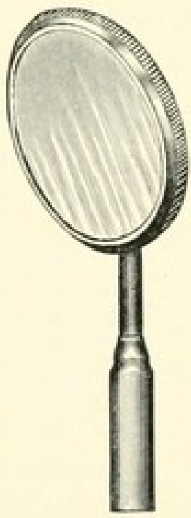
Surgical Anatomy.—To extract teeth successfully it is first necessary to be perfectly familiar with the general shapes of the different teeth and their position in relation to the jaw and to their associates, in order that the operator may intelligently apply the force in the line of the least resistance required for their removal. This knowledge cannot be obtained from books; they are but the guides to it. The jaws of the dead subject must be dissected—both the cleaned bones and those with the soft tissues left upon them. "Dissection" means that not only shall the superficial relations be studied, but that the bones shall be cut in various directions, both with the saw and other instruments, until

Fig. 504.



Curved scissors.

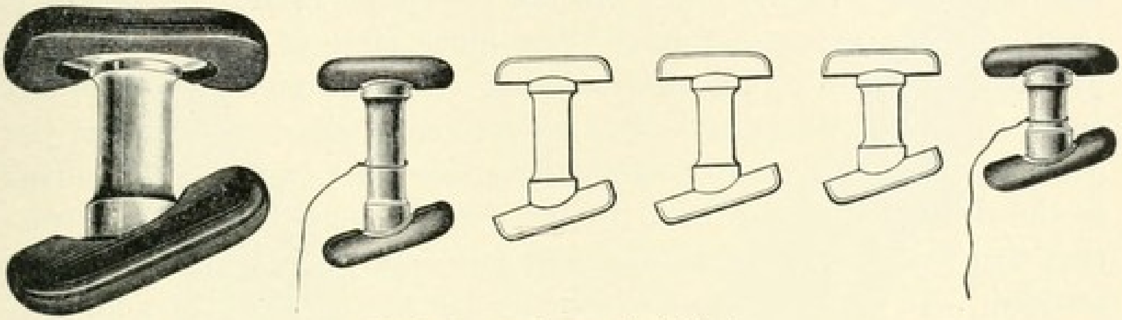
Fig. 505.



Mouth mirror.

the relations of the teeth of the upper jaw with the floor of the nasal chamber and the maxillary sinus are fully understood. In the lower jaw the relations of the teeth with the inferior dental canal and the position of the roots, especially those of the third molar, must also be thoroughly known.

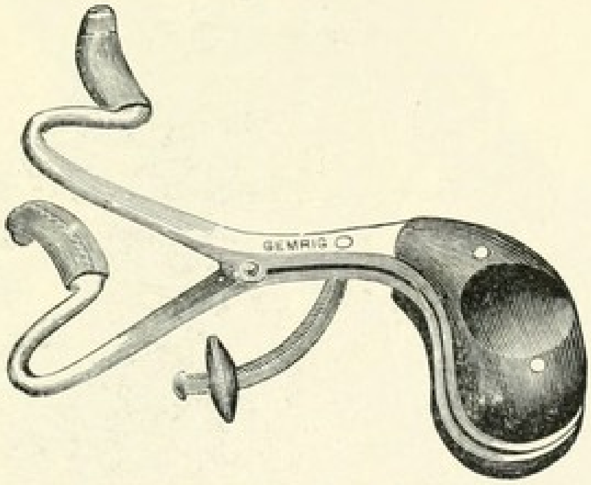
Fig. 506.



Hewitt's mouth props (half size).

The alveolar process of both jaws is made up of two plates, external and internal, consisting of dense compact bone without a true line of de-

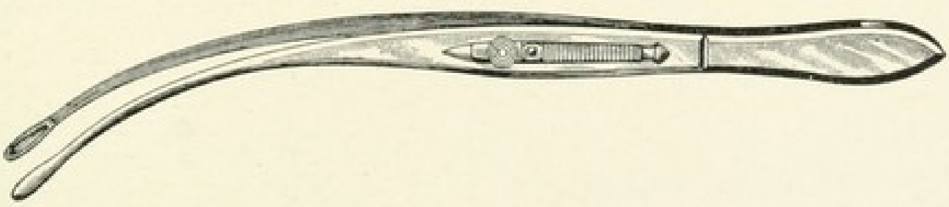
Fig. 507.



Mechanical mouth-opener (half size).

markation between the process and maxilla proper. The interspaces between these plates form the sockets for the teeth and are surrounded by a

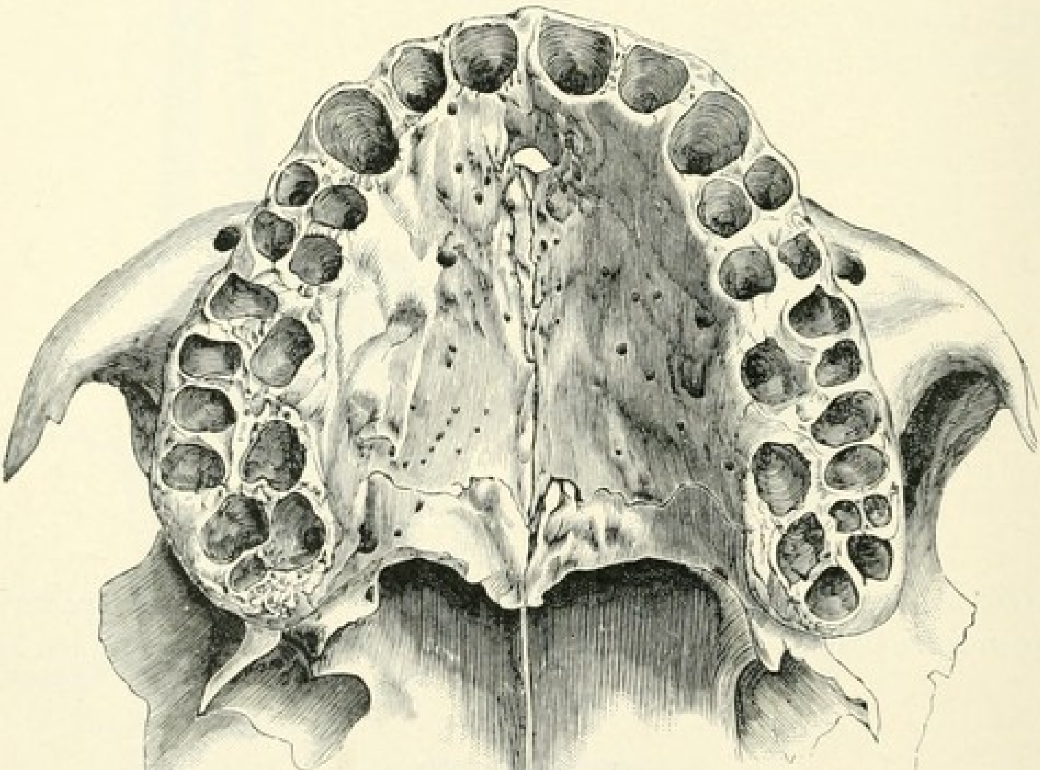
Fig. 508.



Pharyngeal forceps (half size).

very thin cribriform plate of cortical bone. The remaining space is filled with cancellated tissue, small bony channels, connective tissue, nerves, vessels, etc. As this process belongs to the teeth, being developed with them, and is for the purpose of holding them in position, it disappears to a greater or less extent when the teeth are lost. The resorption of this process does not take place alike in each jaw. In the upper jaw the external plate disappears more rapidly and to a greater extent than the inner plate; in the lower jaw the resorption of the two plates is about equal in extent and rate. The inner plate of the upper jaw is partially supported by the external plate of the palatal process, in fact one merges into the other. The outer alveolar plate of the upper jaw being resorbed to a greater extent than the inner one is of advantage to the dentist in fitting teeth to the gums; consequently, in extraction that fact should be remembered and injury to the internal plate avoided. At the same time it does no harm to remove a small portion of the outer plate, though loss of the gum tissue should be avoided if possible. In the lower jaw it is not so important to avoid

Fig. 509.

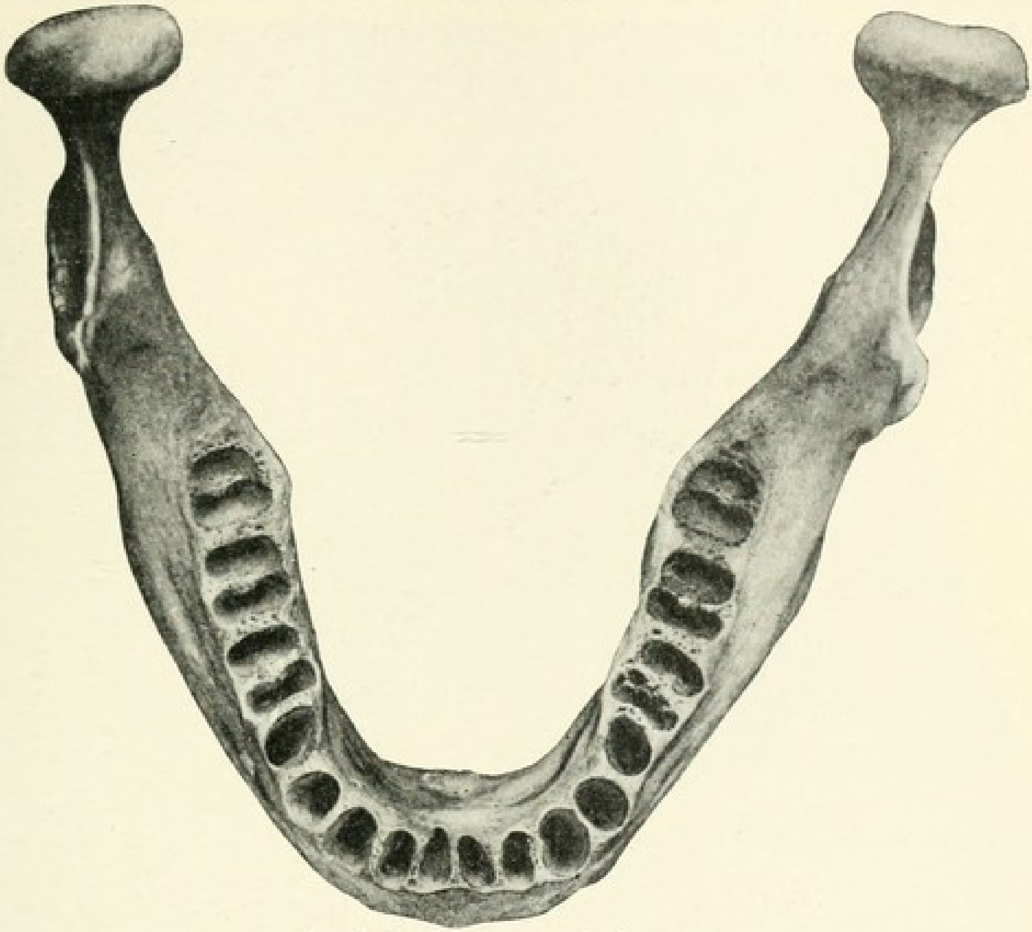


Alveoli of permanent teeth—upper jaw.

removing slight portions of the inner plate, as resorption takes place about equally in the two plates.

These plates may be resorbed in such a manner that a slight ridge is left between the places which they occupied. This resorption of both plates of the alveolar process of the lower jaw makes it more difficult to fit single plain teeth in the lower than in the upper jaw.

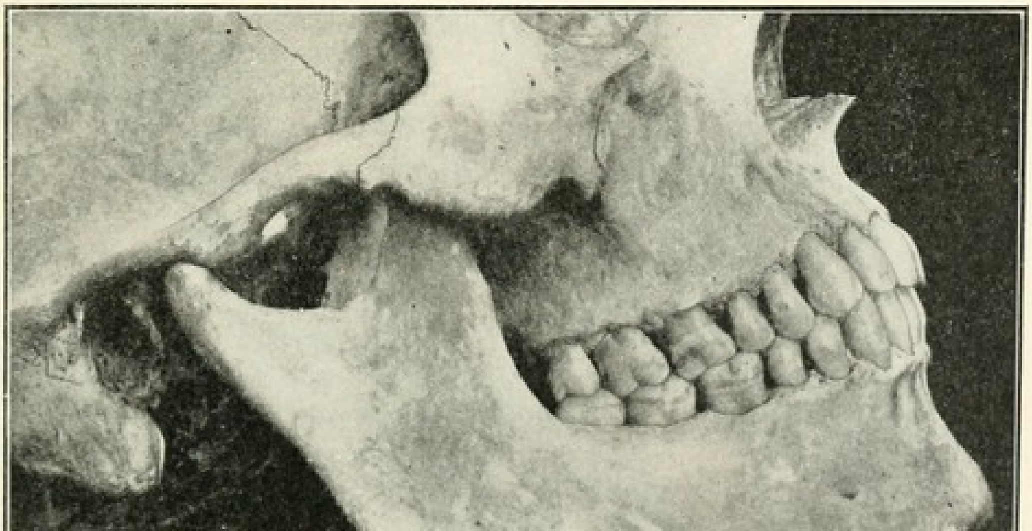
FIG. 510.



Alveoli of permanent teeth—lower jaw.

Fig. 509 shows the alveoli of the upper denture, Fig. 510 that of the lower.

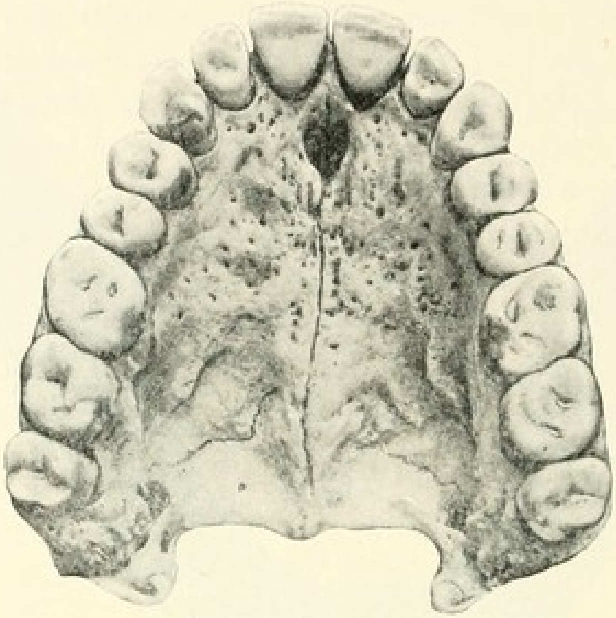
FIG. 511.



Typical upper and lower jaw.

Fig. 511 illustrates a typical upper and lower jaw, the external surfaces of the crowns of the teeth, also a normal occlusion. Figs. 512 and 513 illustrate the occluding surfaces of the teeth and their relations with each other. They are made from the same skull as Fig. 511.

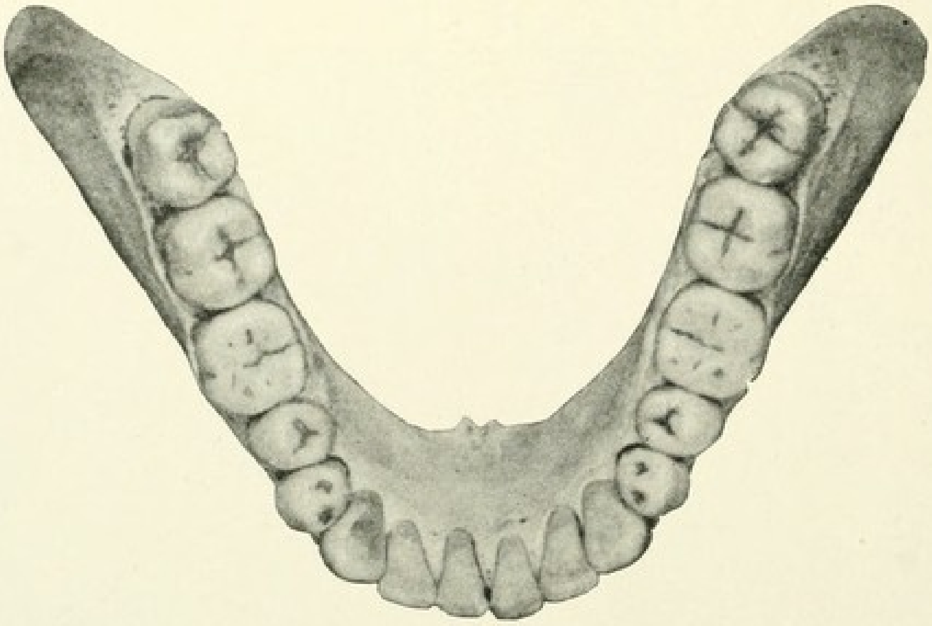
Fig. 512.



Showing the occlusal surfaces of the upper teeth. (From same skull as Fig. 511.)

Fig. 514 is from a photograph taken from the right side of a skull. It gives a good representation of a fairly normal occlusion of the

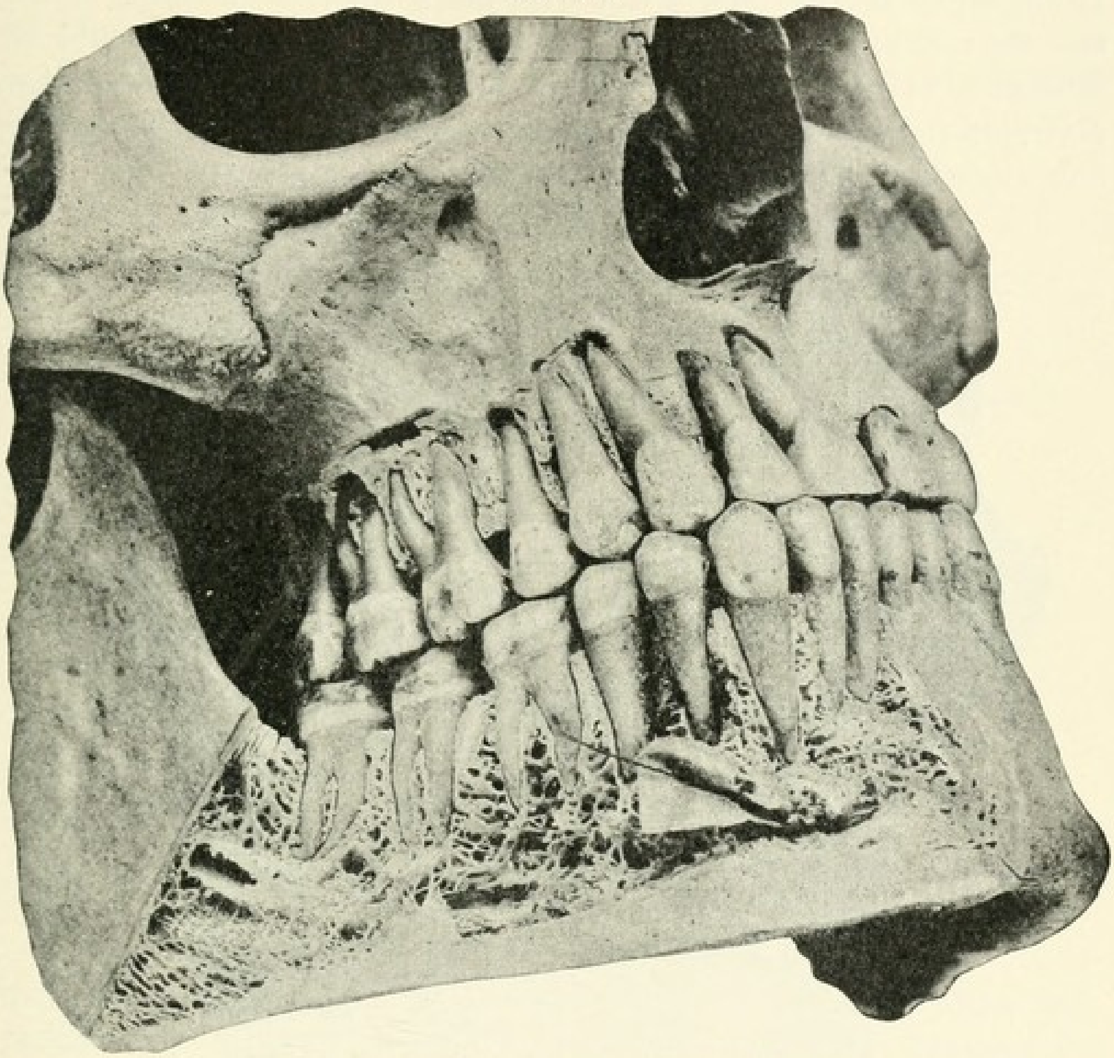
Fig. 513.



Showing occlusal surfaces of the lower teeth. (From same skull as Fig. 511.)

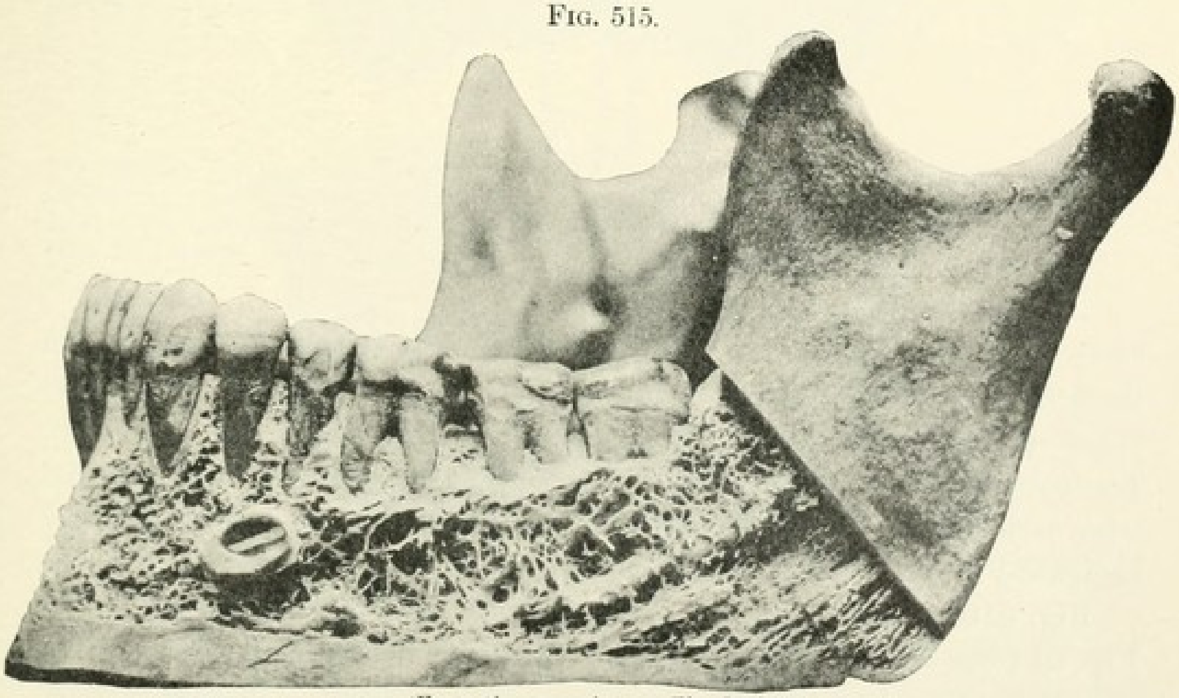
teeth, their shape, roots, and their relation with the cancellated tissue and the inferior dental canal or cribriform tube of the lower maxilla.

FIG. 514.



Showing the buccal surfaces of the crowns and roots in position.

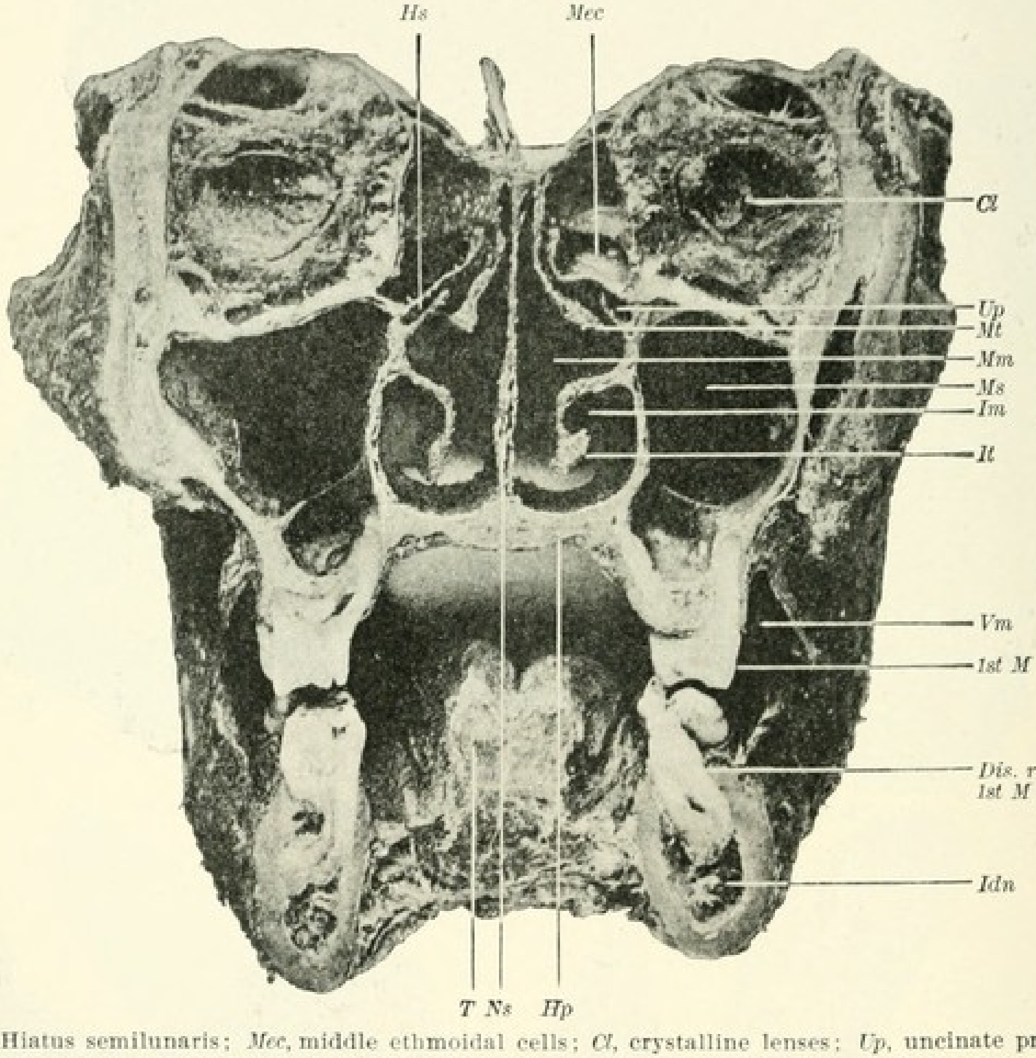
FIG. 515.



(From the same jaw as Fig. 514.)

In the upper jaw the bone is thin over the position of the molar teeth, and their roots are comparatively straight; none of these should be difficult to extract. The buccal roots of the first molar are somewhat divergent from each other. The same roots of the second molar spread only slightly as they leave the crown and close in at the points. The

FIG. 516.



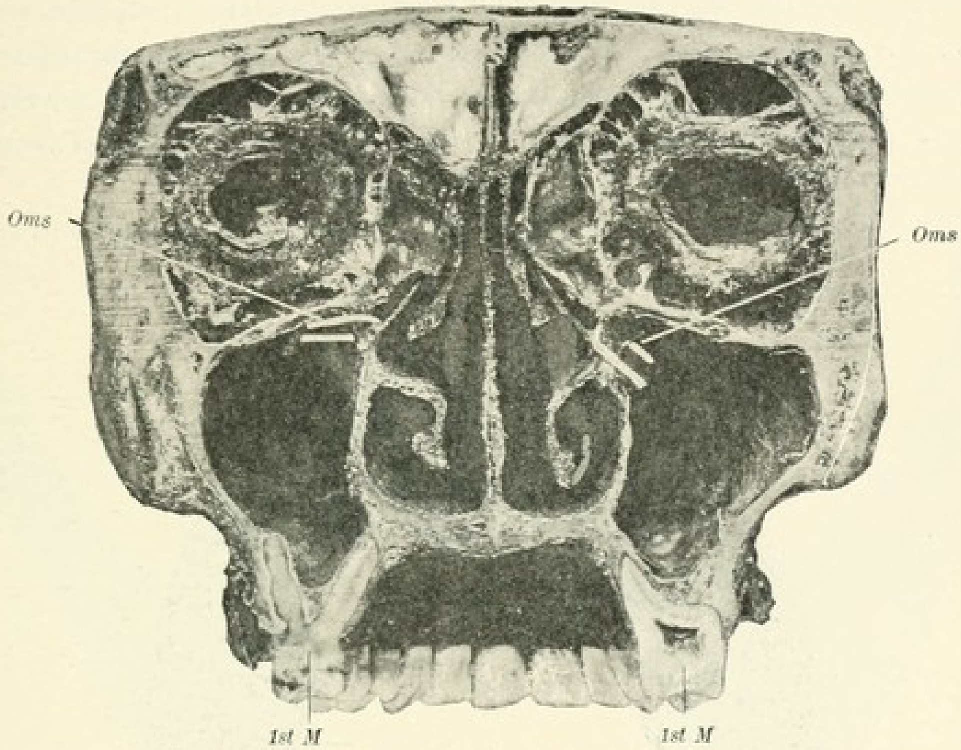
Hs, Hiatus semilunaris; *Mec*, middle ethmoidal cells; *Cl*, crystalline lenses; *Up*, uncinate process; *Mt*, middle turbinated bone; *Mm*, middle meatus; *Ms*, maxillary sinus; *Im*, inferior meatus; *It*, inferior turbinated bone; *Vm*, vestibule of mouth; *1st M*, first molar; *Dis. r. 1st M*, distal root first molar; *Idn*, inferior dental nerve; *T*, tongue; *Ns*, nasal septum; *Hp*, hard palate.

roots of the third molar are together and slightly curved backward. In the lower jaw the roots are comparatively straight. Those of the first molar are spread only a little apart, this being the usual condition. The roots of the second molar are almost straight and are nearly parallel with each other. The anterior root of the third molar curves slightly backward until it joins the posterior root.

Fig. 515 is taken from the left side of the same jaw as Fig. 514. In Fig. 514 the roots have been exposed down to their apices; in Fig. 515 only the external or cortical plate has been removed. These two illustrations give a correct idea of the relations of the teeth to the internal structures of the jaw.

Figs. 516 and 517 are good illustrations of the relations of the roots

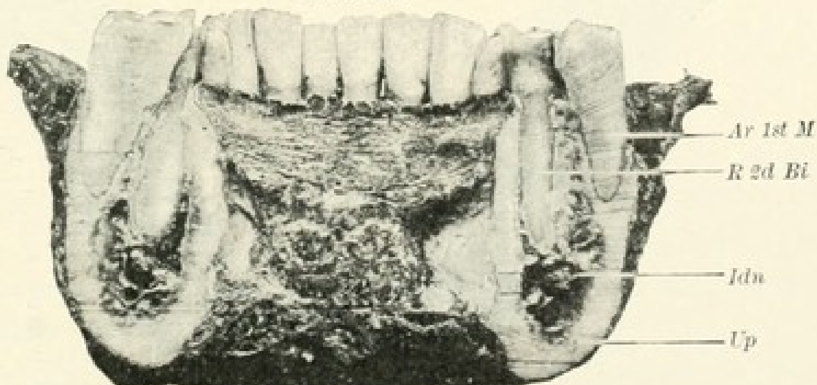
FIG. 517.



Oms, Opening maxillary sinus; *1st M*, first molar.

with the floor of the maxillary sinus usually found in the white race. In the negro there is usually a considerable thickness between the teeth and the floor of the sinus. It will be noticed that the roots of the molars pass up on both sides of the sinus, and because of this fact it is necessary in extracting teeth from a jaw of this character to use

FIG. 518.

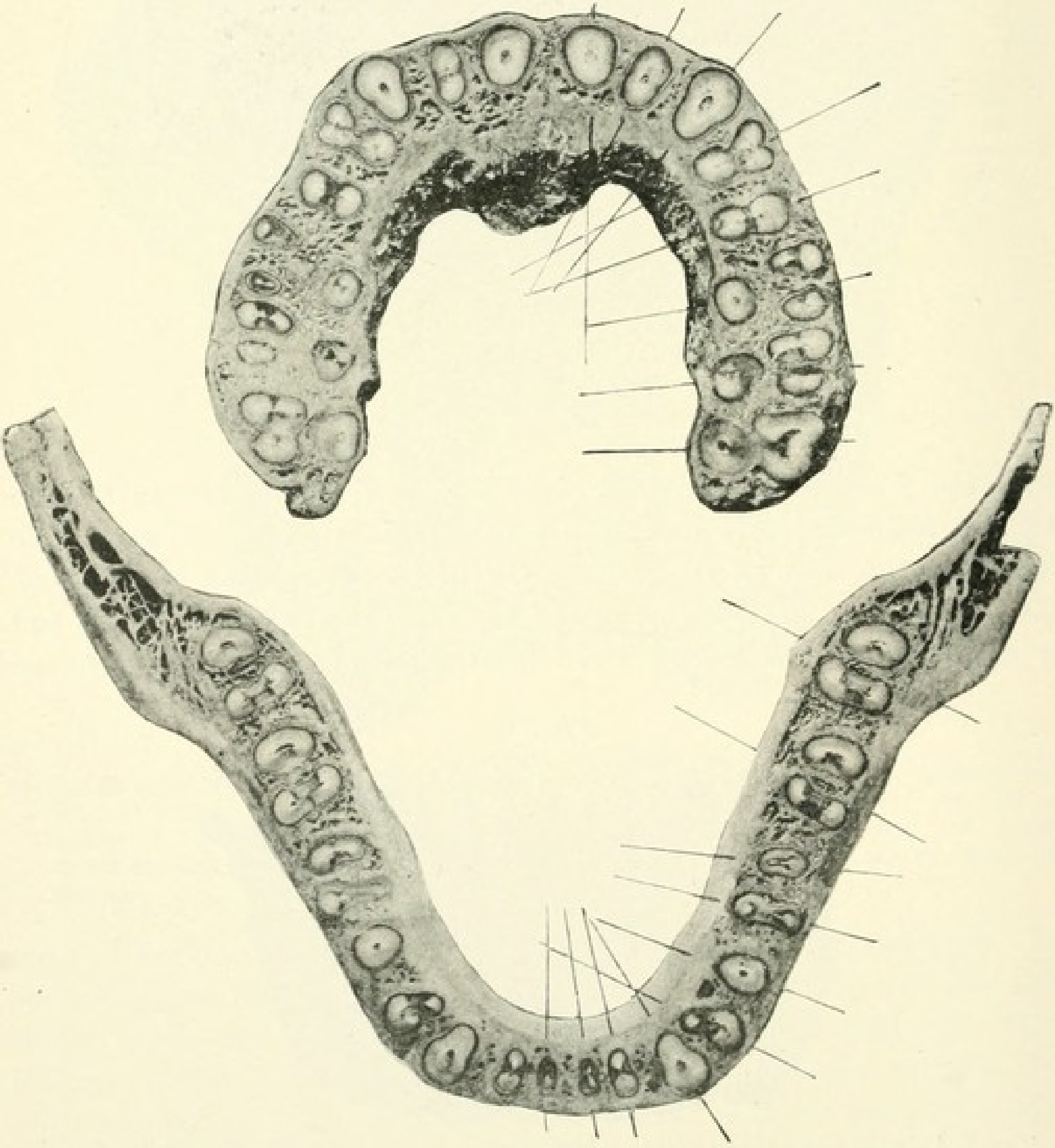


Ar 1st M, Anterior root of first molar; *R 2d Bi*, root of second bicuspid; *Idn*, inferior dental nerve; *U*, U-shaped or cortical portion of lower jaw.

the greatest caution, otherwise a portion of the floor of that cavity might also be removed. Or if a tooth be broken and much upward force used in endeavoring to take hold of the root, the latter could easily be forced into the sinus. The lower portion of Fig. 516 gives a general idea of a transverse section of the lower jaw made posterior to the mental foramen. Especial attention is drawn to the U-shaped formation of the cortical portion of the lower jaw which terminates in the two plates of the alveolar process, and between which the roots are imbedded in the cancellated tissue. It also shows how the roots extend toward the inferior dental nerve. There is no line of demarkation between the alveolar process and the body of the bone.

Fig. 518 shows the relation, length, and position of the second bicus-

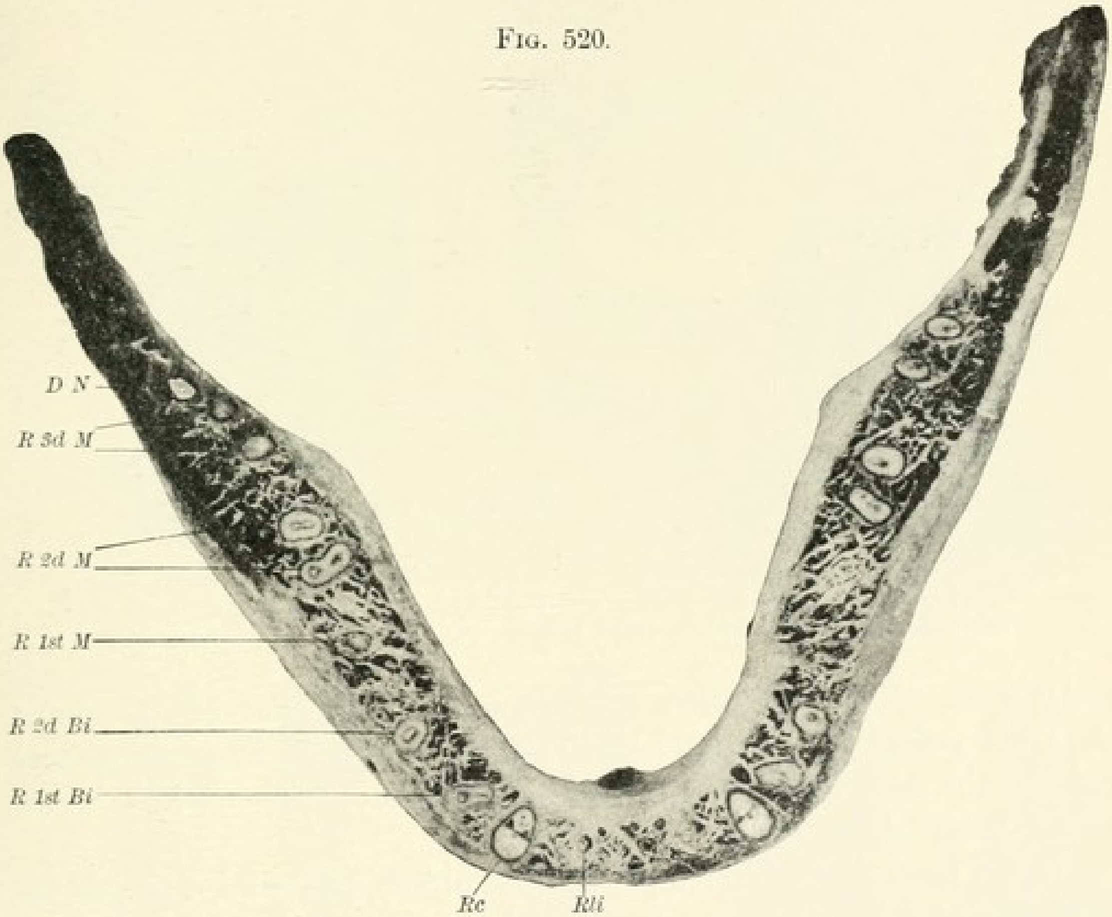
Fig. 519.



pid, showing that its root is sometimes placed to the inner side of the anterior root of the first molar. The roots of these bicuspids are flat, as will be seen by looking at Fig. 533. On taking into consideration their length, position, and thinness it will be readily seen why it is so often difficult to extract them without breaking.

Fig. 519 is taken from horizontal sections of the lower and upper jaws, showing the transverse sections of the roots of the teeth. The section is made a little above the margin of the alveolar process of the upper jaw and a little below in the lower. The illustration shows the shape and position of the various roots, with their relations to the process and to each other. Particular attention should be given to the fact

Fig. 520.



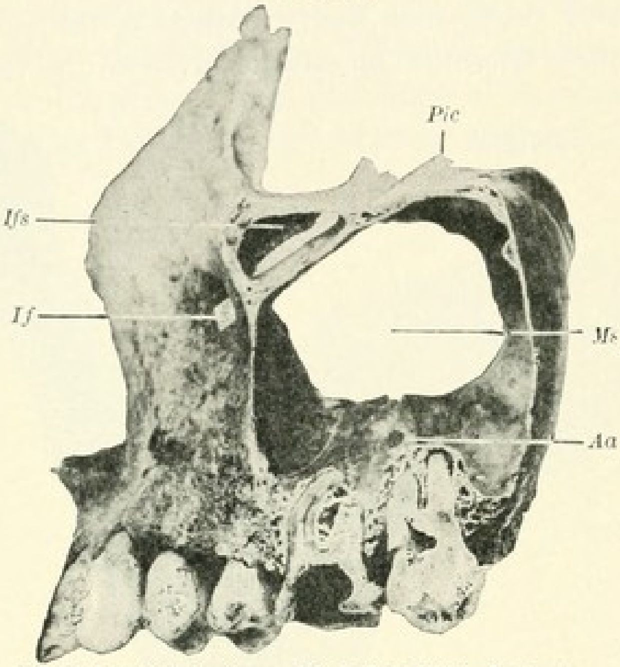
Dn, Dental nerve; *R 3d M*, roots of third molar; *R 2d M*, roots of second molar; *R 1st M*, distal root of first molar; *R 2d Bi*, root of second bicuspid; *R 1st Bi*, root of first bicuspid; *Rc*, root of canine; *Rli*, root of right lateral incisor.

that the roots and process are in such close relation as to make it impossible to force the beak of a forceps between them without breaking one or both plates of the process. The lines leading from the roots show the proper direction for applying what is known in extracting as the "out-and-in motion."

Fig. 520 represents a horizontal section made through the lower jaw near the ends of the roots, and from the same bone as that shown in the lower half of Fig. 519. The cancellated portion with the soft tissue filling the spaces can be plainly seen. The nerve passing into its tube, the ends of the roots of the second and third molars, the tip of one of the roots of the first molar, and the roots of the first and second bicuspids are all plainly shown. A little of the lateral incisor can be noticed, but the centrals do not reach so far down.

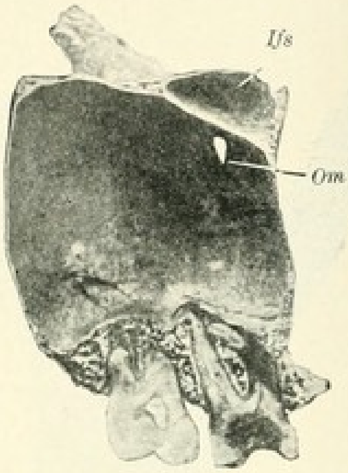
Figs. 521 and 522 are taken from a sagittal section of the upper jaw, external to the infraorbital foramen, and through the roots of the

Fig. 521.



Ifs, Infraorbital sinus; *If*, infraorbital foramen; *Pic*, piece of paper passing through infraorbital canal; *Ms*, maxillary sinus; *Aa*, apical abscess.

Fig. 522.



Om, Opening into malar bone; *Ifs*, infraorbital sinus.

molar teeth. This illustration shows how the roots often extend above the lower portions of the floor of the sinus, an abscess from the palatal root of the first molar having discharged into the floor of the sinus at the point *Aa*.

It has been demonstrated both anatomically and clinically that infectious matter from a suppurating tooth may eventually give rise to an inflammation of the meninges of the brain. Should pus from a dento-alveolar abscess discharge into the maxillary sinus it may pass out into the hiatus semilunaris and ascend into the frontal sinus or in the vicinity of the cribriform plate of the ethmoid through the infundibulum when the passage through the hiatus into the middle meatus is small or constricted, as it usually is when inflamed, or the pus may pass directly through the infundibulum. Recent research has shown that the frontal sinus, the cribriform plate of the ethmoid, and the meninges of the brain are in close relation at the anterior portion of the cribriform plate, a diseased condition at which point is liable to involve all three structures.

Fig. 523 is from a longitudinal section of the lower jaw, and gives a good idea of the cancellated tissue, the relations of the sockets of the teeth to one another, and the position of the inferior dental canal.

FIG. 523.

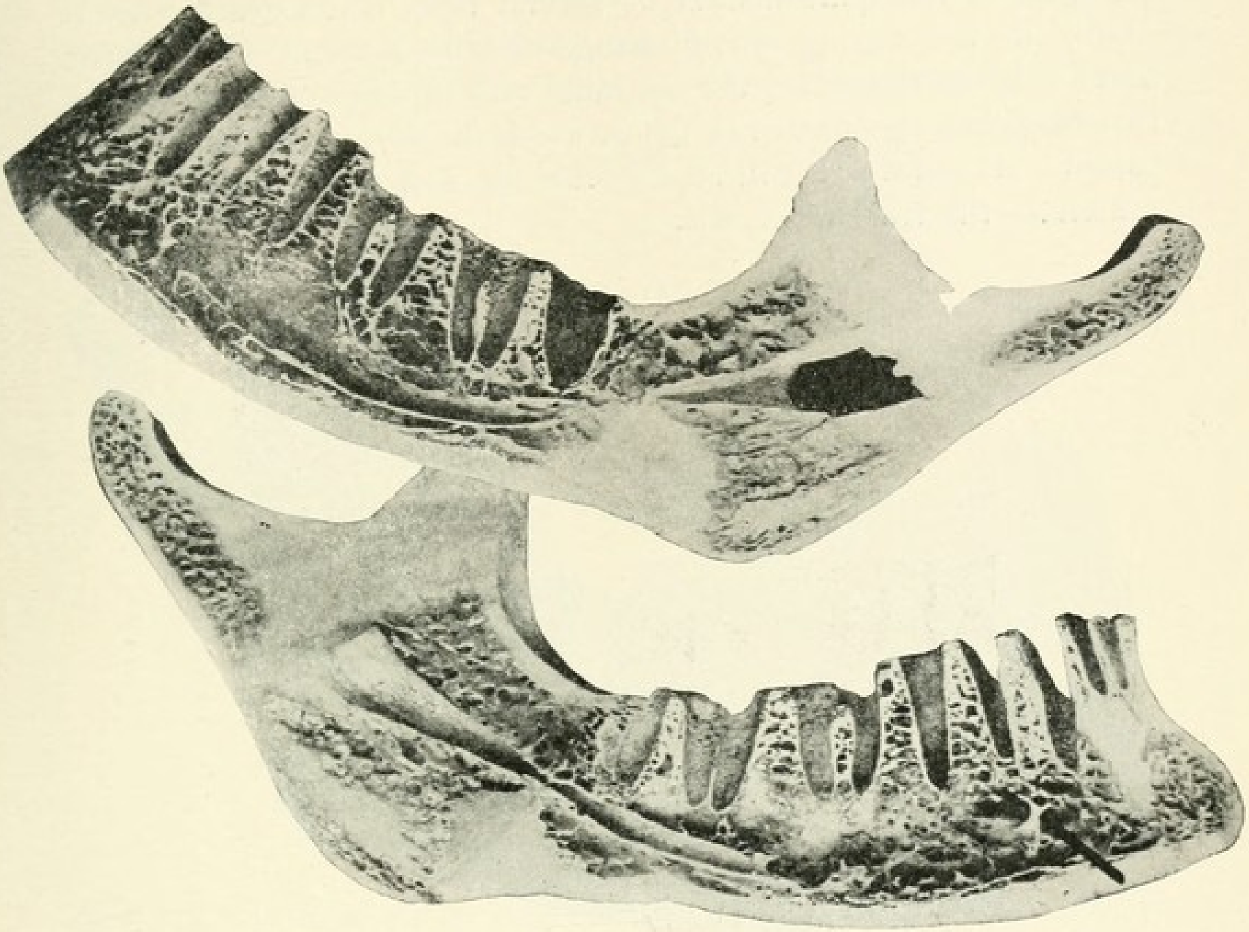


FIG. 524.

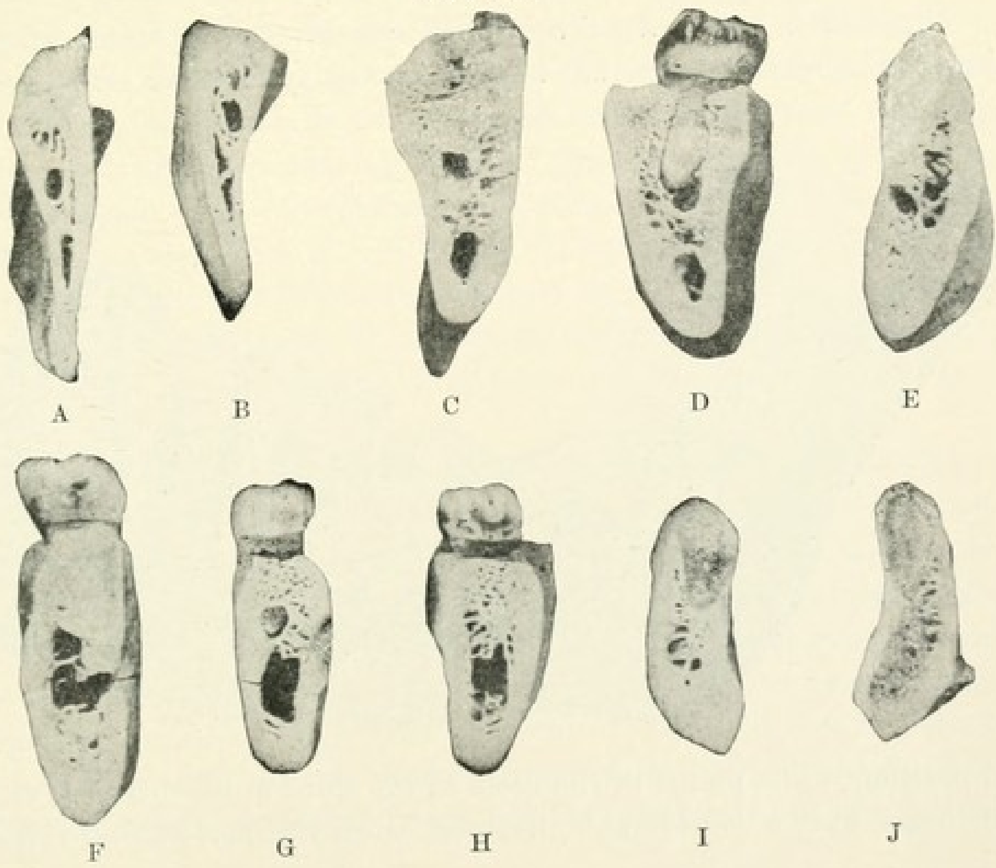


Fig. 524 is taken from several transverse sections of a lower jaw. The bone is not quite normal, as several teeth were extracted before death, the loss having caused changes in the character of the bone. Some of the sections show but one canal while in others there are many, requiring close observation to tell in which the nerves and vessels have passed. At point D it will be seen that the root of the second molar penetrates the true nerve canal.

FIG. 525.

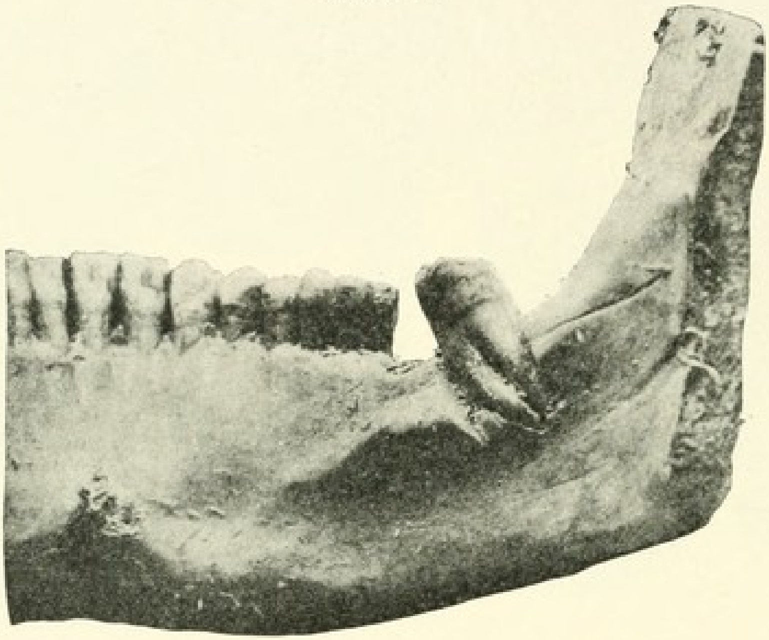


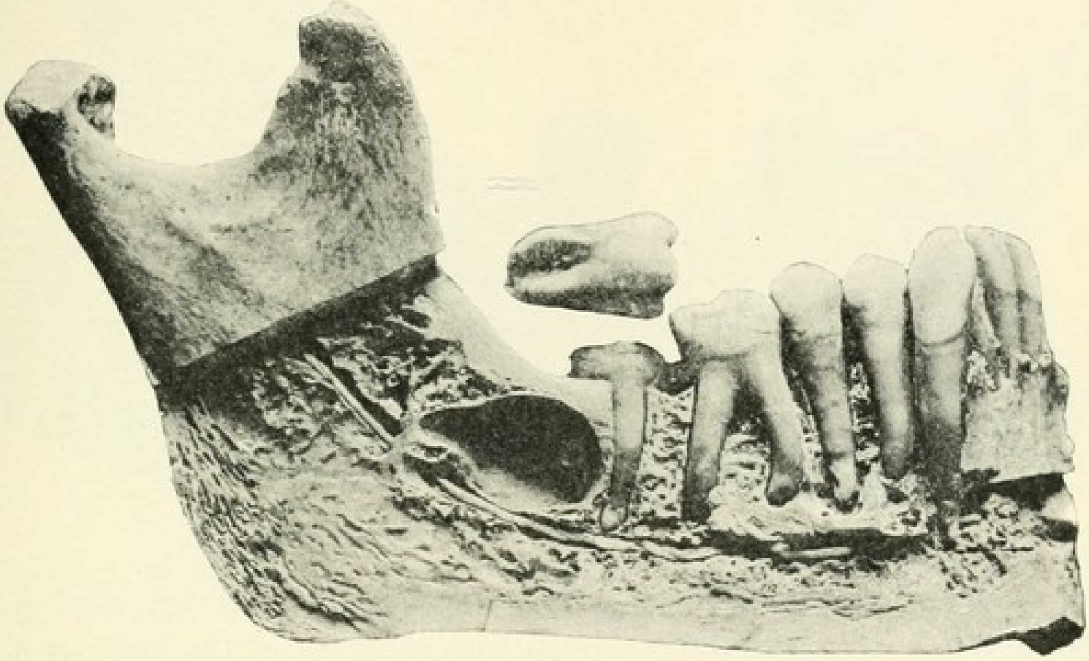
Fig. 525 is taken from the inner side of the right half of a lower jaw. The second molar has been broken off, the roots still remaining

FIG. 526.

in position. The points of the roots of the third molar pass out through the inner wall a considerable distance below the mylo-hyoid ridge. A portion of the ridge has been cut away, exposing the remainder of the internal surface of the roots. This will be further alluded to when extraction of the lower third molar is considered.

Figs. 526 and 527 are from the outer side of the right half of a lower

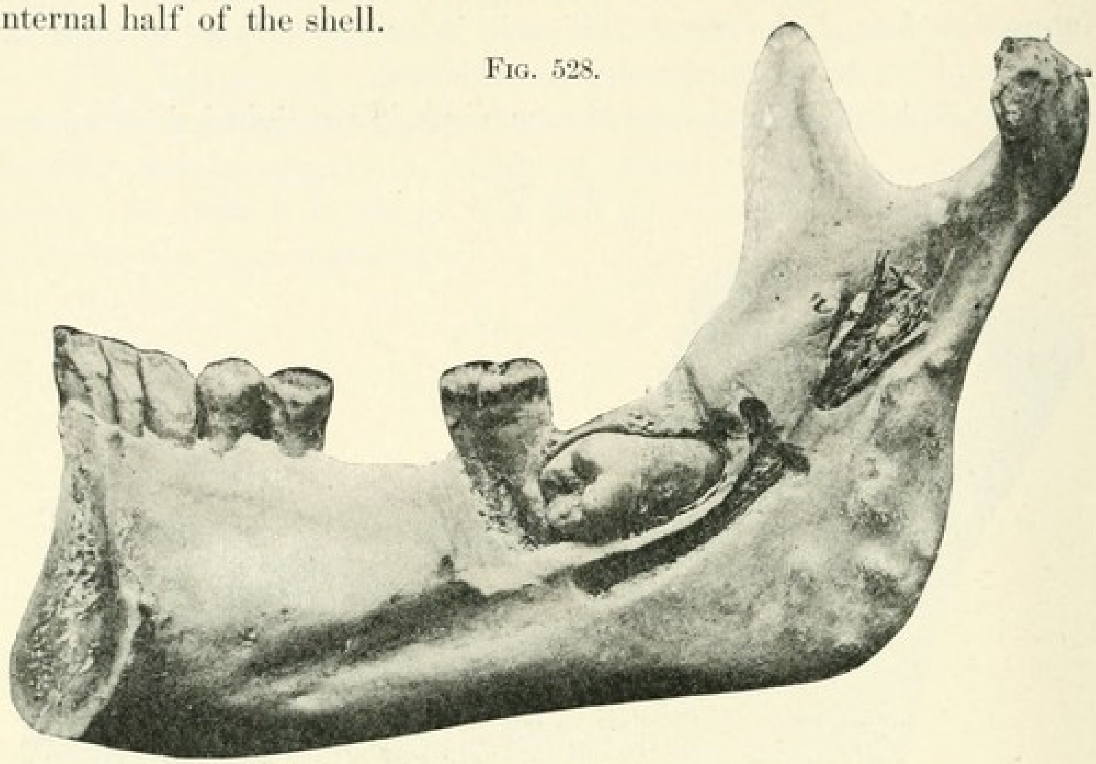
FIG. 527.



jaw, Fig. 526 showing an impacted third molar lying horizontally in the jaw. Fig. 527 is of the same jaw with the tooth removed from its bed, showing the inner surface. The second molar is a pulpless tooth the distal root of which shows where the impacted tooth has pressed against it, causing the absorption of a portion of the root and exposing the pulp canal within, producing death of that organ. This must have caused neuralgia. The cancellated tissue of this bone, it will be noticed, is not like that shown in Fig. 512, the change in the character of this tissue being the result of irritation caused by the impacted tooth. It will be seen that the roots of the other teeth in this jaw are longer than usual, the canine tooth passing below the nerve and to the outer side.

Figs. 528 and 529 represent the inner side of the left half of a lower jaw. It shows an impacted third molar pointing slightly downward. The distal root of the second molar is slightly absorbed. On uncovering the tooth and taking it from its bed, it was found to be incased in a thin shell of bone as though the dental sac had ossified separately around this tooth; this thin incasement of bone may, however, have been an inflammatory product. The inner portion of this shell can be seen in position. The nerve and its accompanying tissue passes into the inferior dental foramen immediately against the shell and has the appearance of being flattened out. It divides and sends a branch around the internal half of the shell.

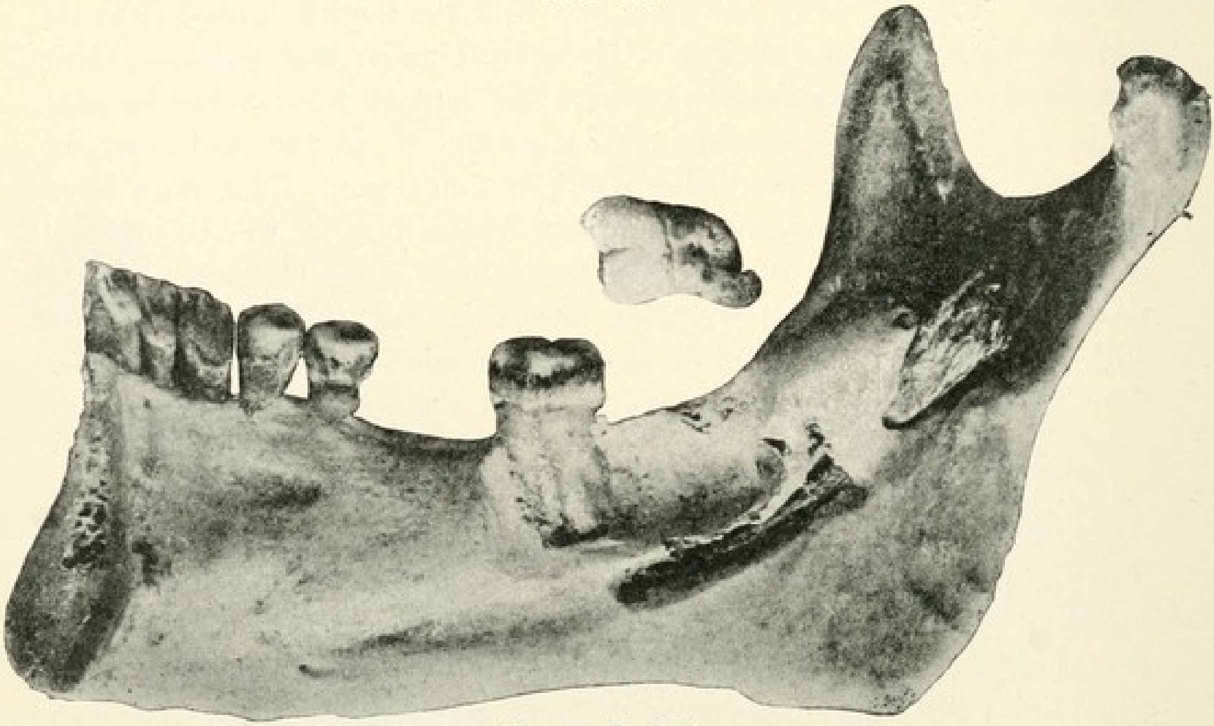
Fig. 528.



Inner side of left half of lower jaw, showing an impacted third molar.

Figs. 530 and 531 are taken from the right and left halves of the lower jaw. Fig. 530 shows the internal surface of the right half;

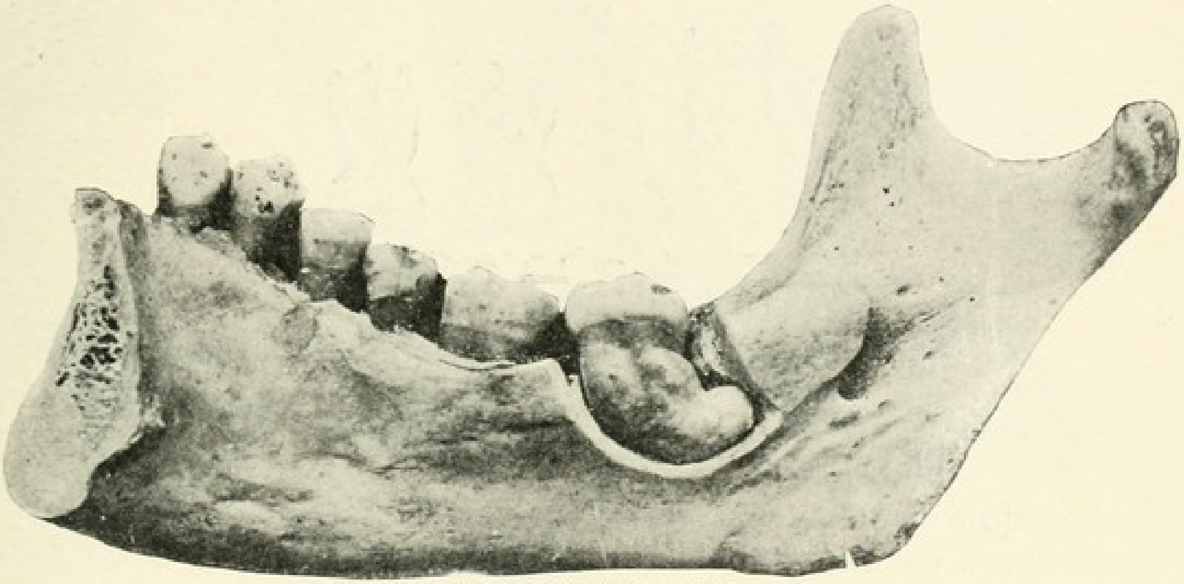
Fig. 529.



(Same as Fig. 528.)

Fig. 531, the external surface of the same. In Fig. 530 the roots of the third molar curve backward, are joined together, and are so enlarged by an abnormal deposit of cementum caused by continued hyperemia due to the prolonged irritation that the form of each root is lost; the bone also is much thickened. Fig. 531 shows an impacted

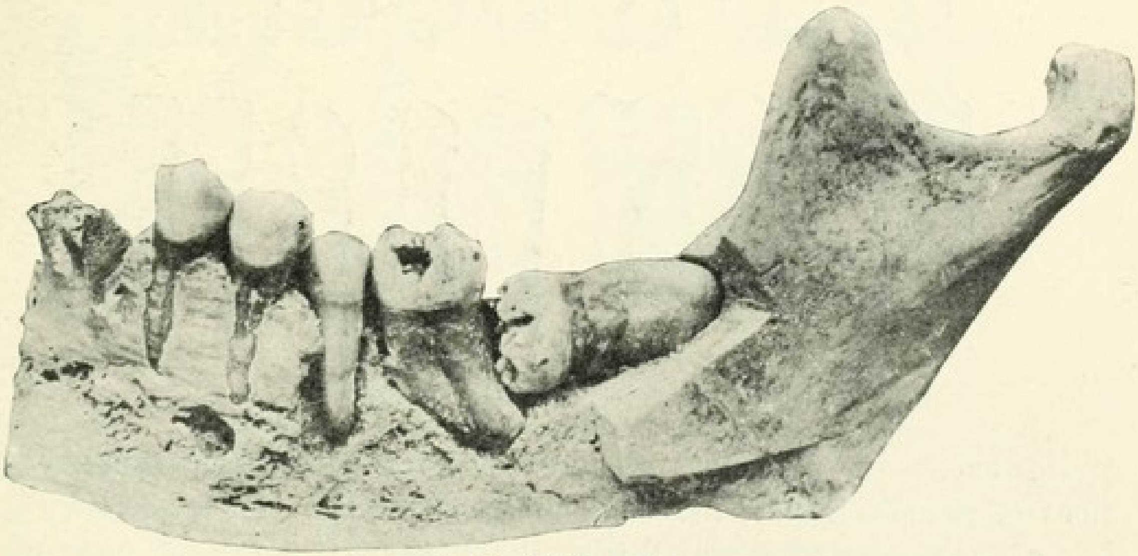
FIG. 530.



Right half of lower jaw.

tooth pressing directly against the one in front of it, the roots of which have become much enlarged by the deposit of cementum. The surrounding bone is also thickened and much more compact than the normal bone. The character of the cancellated tissue of the lower jaw is lost by the deposit of bone caused by continued irritation of that tissue.

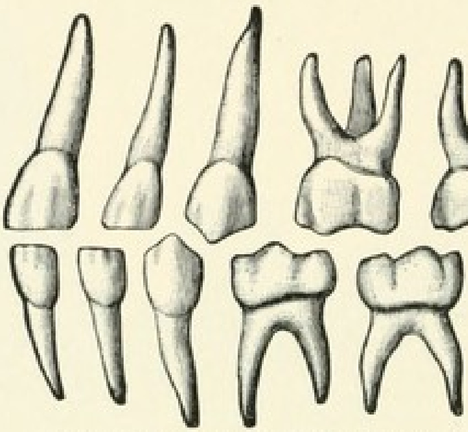
FIG. 531.



Left half of lower jaw.

Figs. 532 and 533 show the normal forms of the teeth, and Fig. 534 is taken from a group of abnormal teeth. If only normal conditions of the teeth had to be considered, as shown in Figs. 532 and 533, extraction would be a very simple operation, but unfortunately this is seldom the case. It often happens that even when the teeth themselves are normal they are situated in abnormal positions, and for this

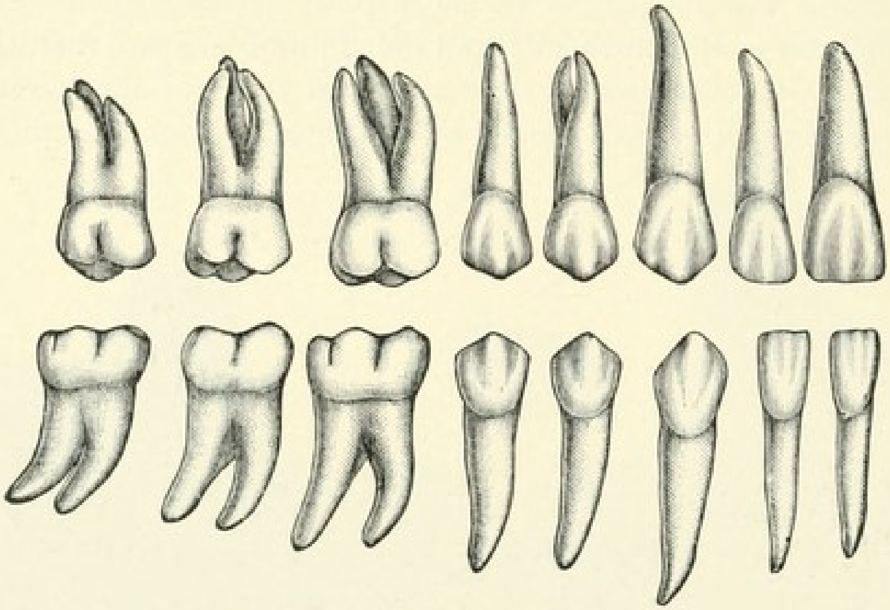
FIG. 532.



Deciduous teeth—left side (Burchard).

reason alone their extraction becomes necessary. In fact, so varied and complicated are the different abnormalities presented that it would be impossible to describe them all. The diagnosis of unerupted teeth occu-

FIG. 533.

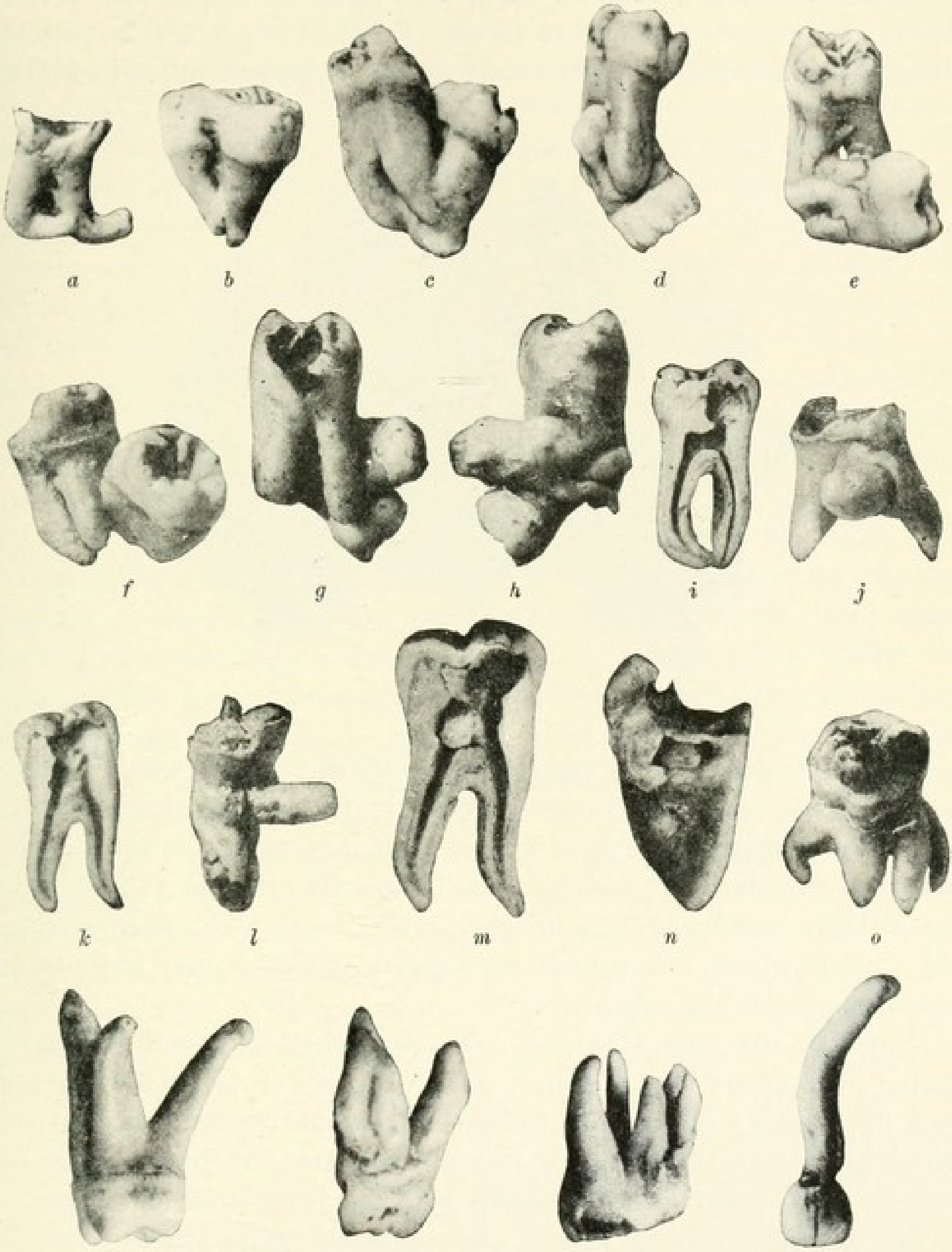


Permanent teeth—right side (Burchard).

pying abnormal positions has been greatly facilitated by special applications of the skiagraphic method. Its general use in this connection is but a question of time and further development. A careful study of the complications most frequently occurring will, however, give good preparation for meeting the emergencies.

Figs. 525 to 531 and 535 show abnormal positions of various teeth. It will be readily seen that no set of rules could be made to govern the

Fig. 534.



Abnormalities in teeth.

extraction of these teeth; therefore only the general principles governing extraction can be here set forth.

General Principles in Extracting Teeth.

These principles may be classified under the following heads:

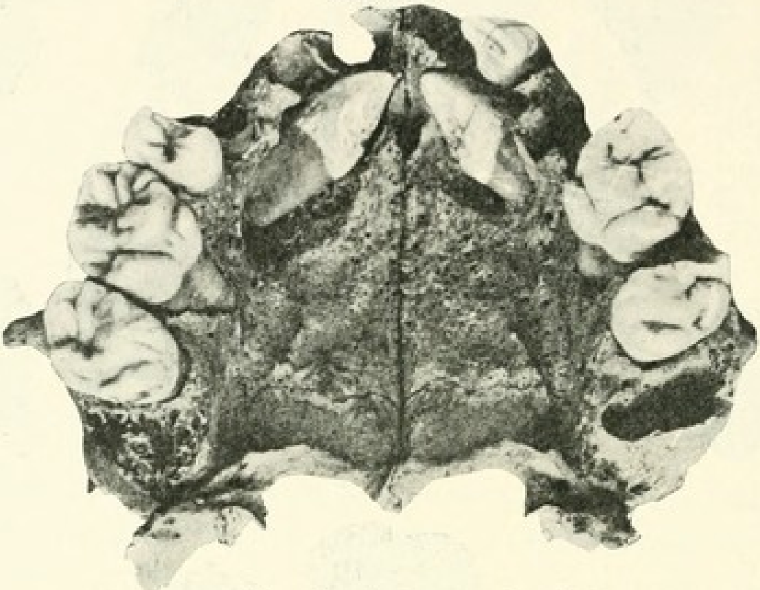
(1) Management and Position of Patients.

(2) Selection of Instruments.

(3) Technique of the Operation.

Management of Patients.—The first important step toward a successful operation in dentistry is to gain the confidence of the patient, who must be brought to rely entirely on the judgment and skill of the

Fig. 535.



Abnormal jaw showing impacted canines.

operator. If the operator feels entire confidence in his own ability to successfully carry out an operation he can, by his manner of approaching the patient, impart a feeling of almost absolute trust in his skill. This feeling of confidence in himself should be cultivated, as it is evident that a slight nervousness on his part, even though he be most skillful, will tend to alarm the patient to such an extent as may cause great interference with the operation.

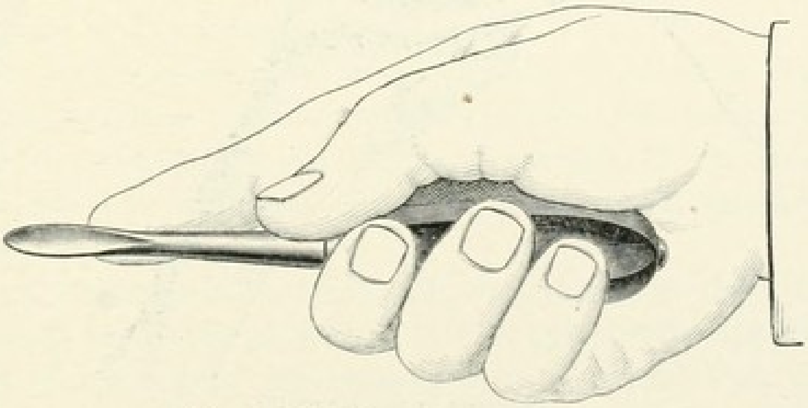
Position of the Patient.—The principal object to secure in placing the patient is to obtain a good view of the affected tooth and contiguous parts; after which the position should be made as comfortable as possible both for the patient and operator, taking care that the territory of operation can be reached with but little strain or effort.

The position both of patient and operator varies slightly for the extraction of each tooth. The main points to be observed are to have the particular tooth to be operated upon in view, and the head of the patient in such a position that it can be controlled by the left arm and hand.

The chair should be steady, strong, and comfortable, with arms and a good head-rest of rather a concave shape. It should also have a suitable foot-rest. When the regular dental chair is not obtainable, an ordinary strong wooden chair can be used. If two of these chairs are placed back to back the extra one gives a good place for the left foot of the operator, and a head-rest may thus be made of his thigh. The patient should be directed to grasp the seat at both sides with his hands. At times it may be necessary to extract while the patient is in bed or on an operating table; in such cases the operator must obtain the best position available. Where an operating table or couch is used it is well, if possible, to stand at the head of the couch or table and a little to one side of the patient. By reaching over the head, the forceps shown in Fig. 488 may be used to advantage in work on the lower jaw; the same forceps may be used for the upper jaw by standing to one side of the patient. If the operator is ambidextrous, so much the better, as it is very advantageous to be able to use the instrument in the left hand, especially in extracting the teeth of the right side of the lower jaw. If, however, only the right hand can be used, the operator should, as a rule, stand at the right of the chair, the left arm and hand being used in various ways to control the head of the patient. The mouth is opened as far as necessary, and the left hand is then used to hold the lips away and keep the jaw as steady as possible. (See Figs. 543, 544.)

Selection and Use of Instruments.—The selection of instruments depends on the nature of the operation to be performed. The means used in extraction should be of the most simple character. Many deciduous teeth and permanent teeth from about which most of the process has been resorbed can often be easily extracted with the thumb and finger. Children feel less apprehension with this method than when an instrument is used. The thumb should be covered with a napkin and placed on the inner surface of the tooth with the fingers against the outside of the jaw. The tooth is then forced outwardly toward the cheek or lips. The roots of the deciduous teeth often break, but this is of little importance, for when extraction is demanded the roots are weakened by the natural process of resorption and will soon disappear. Elevators of the various patterns shown in Figs. 500, 501, 536, 537, and

Fig. 536.

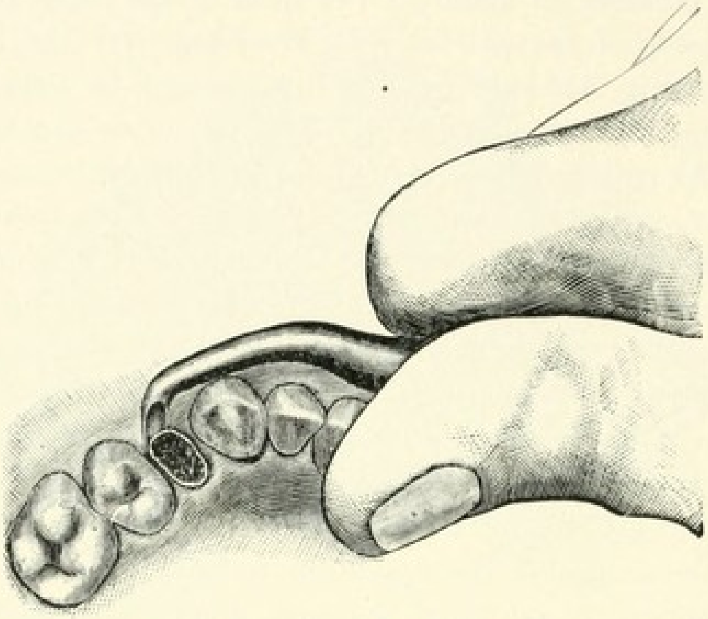


Manner of holding elevator Fig. 500.

538 should be used whenever practicable for removing roots, and in some cases teeth also. Fig. 500 is especially useful in removing the third

molars. When the internal anatomy of the jaws is well understood, this will be appreciated.

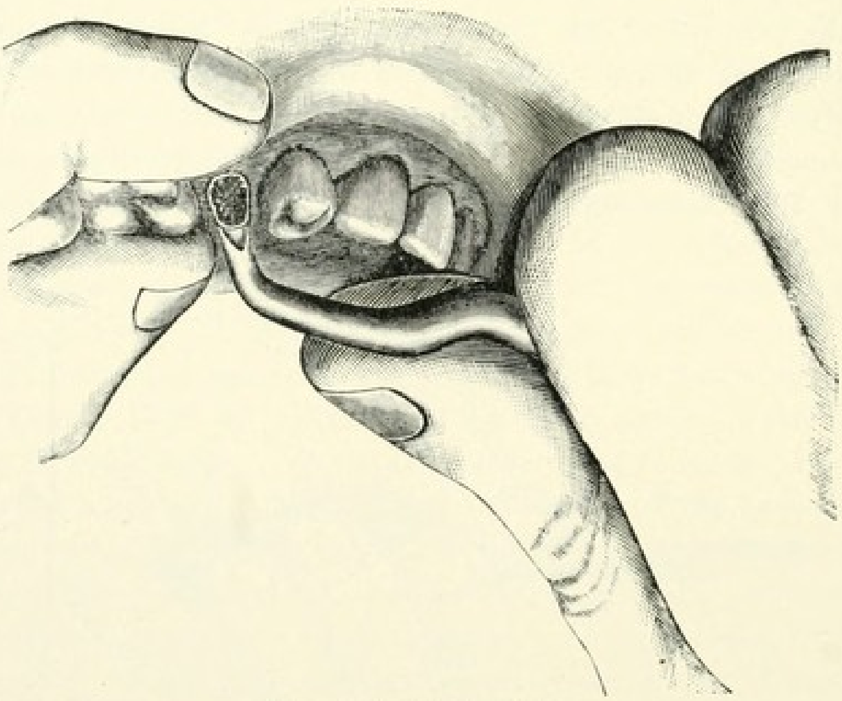
Fig. 537.



Elevator in use labially.

Fig. 519 shows how firmly the roots are embraced at their necks between the two hard plates of compact tissue. It is usually impossible

Fig. 538.



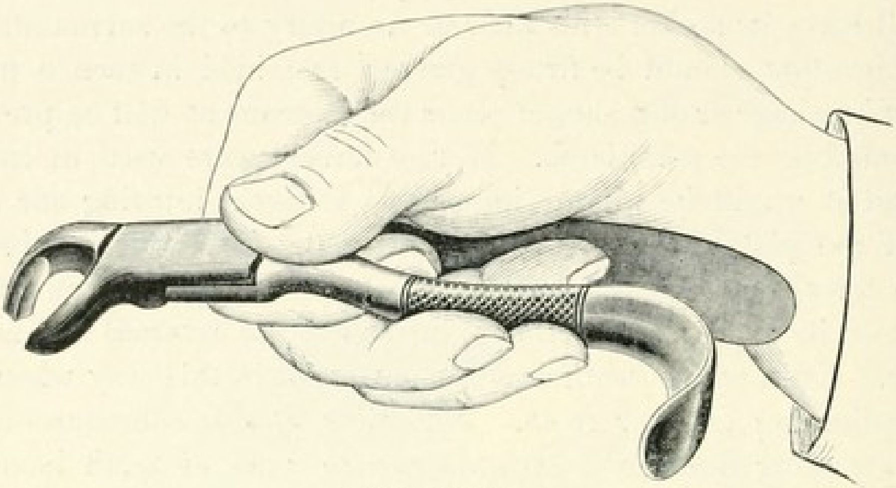
Elevator in use lingually.

to force an instrument between the roots of teeth and these plates without breaking the internal or external walls of the latter. The cancellated tissue between these plates is, however, soft and yielding, and into this a properly shaped elevator can be passed between the roots. After pushing the instrument with the point toward the root to be extracted and the back toward the contiguous tooth or root, using the latter as a fulcrum, revolve the elevator slightly, prying at the same time, and the root will leave its socket with little or no injury to the surrounding tissue. Elevators should be firmly grasped and held in such a manner that if a breakage or slip should occur the instrument will be prevented from wounding the soft tissue. If root forceps were used in cases of this kind it would be almost impossible to avoid injuring one or the other of the plates when removing the root. It is often advisable to use the forceps by passing the beaks between the plates and grasping the root on its approximal surfaces, instead of the external and internal surfaces. Even whole teeth may be extracted in this way when there are no adjoining teeth or roots. A similar plan is sometimes used in rapid extracting under nitrous oxid, where roots or teeth have been extracted on each side of a tooth, the beaks passing into the sockets of the extracted teeth, thus grasping the tooth to be removed on its approximal sides. This mode of operating must be followed with care, especially in teeth situated below the maxillary sinus, as the floor of that cavity may be easily injured. (See Figs. 516 and 517.)

Lancing.—Lancing for extraction is not usually required, though there are cases where it is quite necessary. If the teeth have been standing alone for a long time, especially those in the back part of the mouth, the gums are apt to become firmly attached to them; when this is the case it is well to sever the connecting tissue by the use of the lancet before extracting. In extracting roots where it is necessary to remove a portion of the external plate of the alveolar process, it is well to make an incision in a line over the root, through the gum to the bone; it is even advisable to slightly dissect the gum and periosteum from the bone on each side of the cut. This is done in order that the external beak of the forceps may be passed along the bone as far as desired. By thus lancing, the parts will afterward come together and quickly heal, whereas if the gum is cut by the forceps it will not heal so well. In extracting roots in the lower jaw, if the lancing would cause the blood to cover the parts and obscure the operator's view it should be omitted.

Use of Forceps.—As nearly all operators are right-handed, the instruction as to the use of forceps will be given with that understanding, most of the special instruments being made for that hand. The forceps are grasped in the right hand with the palm toward the body, the thumb on top of and partially between the handles (which will indicate to a great extent the amount of pressure being exerted upon the tooth), pressing against the handle nearest the palm just back of the joint. The first finger should rest a little between the handles, thus giving a firmer grip on the right handle (see Fig. 539), which might be

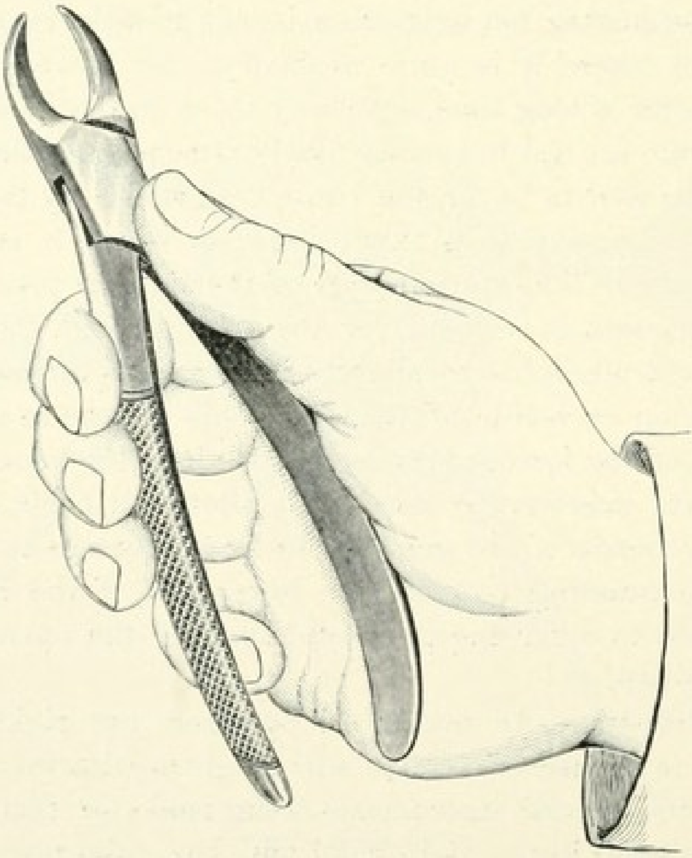
Fig. 539.



Use of forceps.

termed the fixed, or passive, handle; while the other one is the movable, or active, handle. Many operators do not place the first finger between

Fig. 540.



Use of forceps.

the handles (see Fig. 540). The second and third fingers pass to the outside of the left handle and are used to close the forceps, while the little finger resting between the handles is used to open the forceps, the thumb being used to force the beaks into the required position. After the forceps are in position for extracting, the first finger is placed along the side of the second finger to give more power to extract.

After it has been decided to extract by using the forceps, the particular forms indicated must be selected and arranged in a convenient place, ready for immediate use as needed. Especially should this be the case when the operation is done under the anesthetic influence of nitrous oxid. It is under such conditions that the fewer forceps used the better; the writer generally uses but one forceps (Fig. 489) for the extraction of any or all teeth except the first and second molars; for those teeth, when the other teeth are in position, he advises using the special forceps.

Having the patient's head in position, the forceps are grasped as previously described and the beaks adjusted to the tooth. As a rule, the inner beak should be placed in position first, and then the outer one—this is very important, especially for the lower teeth—taking care not to include a portion of the tongue or the soft tissues of the floor of the mouth, as both are liable to get in the way. When the forceps are adjusted to the inner and outer surfaces of the tooth, they should be forced between it and the gum until they come in contact with the edge of the alveolar process. It is a common error of students to use too much force in pressing the handles together; only sufficient force should be used to securely hold the tooth or root. The forceps should grasp as much of the roots as possible, avoiding pressure upon the crown and being careful not to force the beaks between the alveolar plates, as this would result in breaking one or both plates over the tooth or root extracted and also over the adjoining tooth. Cases have occurred in which the entire external plate of one side has been forced off in this way.

At times it may be advisable to take away a portion of the outer plate, in which case the lancet shown in Fig. 502 should be used to cut through the gum a little beyond the point of process to be removed, dissecting up the gum slightly; the inner beak is then adjusted and the outer one passed between the divided gum and the process as far as required; the forceps should then be closed with only sufficient force to cut through the bone and grasp the tooth, taking care not to crush it.

After the forceps are in position the tooth is loosened by rotating it slightly if it be a round conical-rooted tooth, such as a central incisor, but if it be a flattened one it should be removed by an outward and inward movement.

By the "out-and-in motion" is meant that after the forceps are applied the force used in loosening teeth is directed in such a manner that the tooth is worked outward and inward from the median line of the mouth (see Fig. 519, in which the lines show the direction of the motion for each tooth). The individual teeth do not always bear the same relation to the median line of the jaw as shown in Fig. 519. When the axis of a tooth is not regular it should be loosened by moving backward and forward, and the movement should be in line with its strongest diameter, which lessens the danger of breaking the tooth.

In the upper jaw the inward movement is made after the outer, but with not so much force, as the structure on the inner side is more dense.

Rotation of a tooth in extracting is seldom practiced, as the single-rooted teeth are usually flattened and teeth that have more than one root cannot be rotated. Of the single-rooted teeth, the upper central incisors alone have roots nearly conical in shape which permit rotation as well as the out-and-in motion. A rotary motion is usually of advantage in extracting the roots of the upper first bicuspid when double, and of the upper molars after the crowns are broken away so that the roots are disunited. These roots are usually round, conical, and somewhat curved in shape.

If possible, the tooth should be kept in view during the operation so that the results of the movements may be seen. A beginner may let the forceps slip and extract the wrong tooth when he is not observing each movement, but an experienced operator can depend on his sense of touch to a very great extent. The amount of pressure a tooth will stand while loosening it by an "out-and-in motion" depends on the size, condition, and density of the bony tissue surrounding it. Experience is the only reliable guide in this matter. When a tooth resists ordinary effort, if the operator is not quite sure of the cause of the resistance of the tooth, it is better to desist temporarily and allow the patient to rest in order to investigate the condition of the tooth and its surroundings. Fig. 530 will give some idea of the causes of the resistance offered by apparently normal crowns.

After the forceps are applied and the tooth slightly moved, if the operator has a cultivated sense of touch he will feel that the tooth is yielding in one particular direction; as a general rule the tooth should be carried in that way.

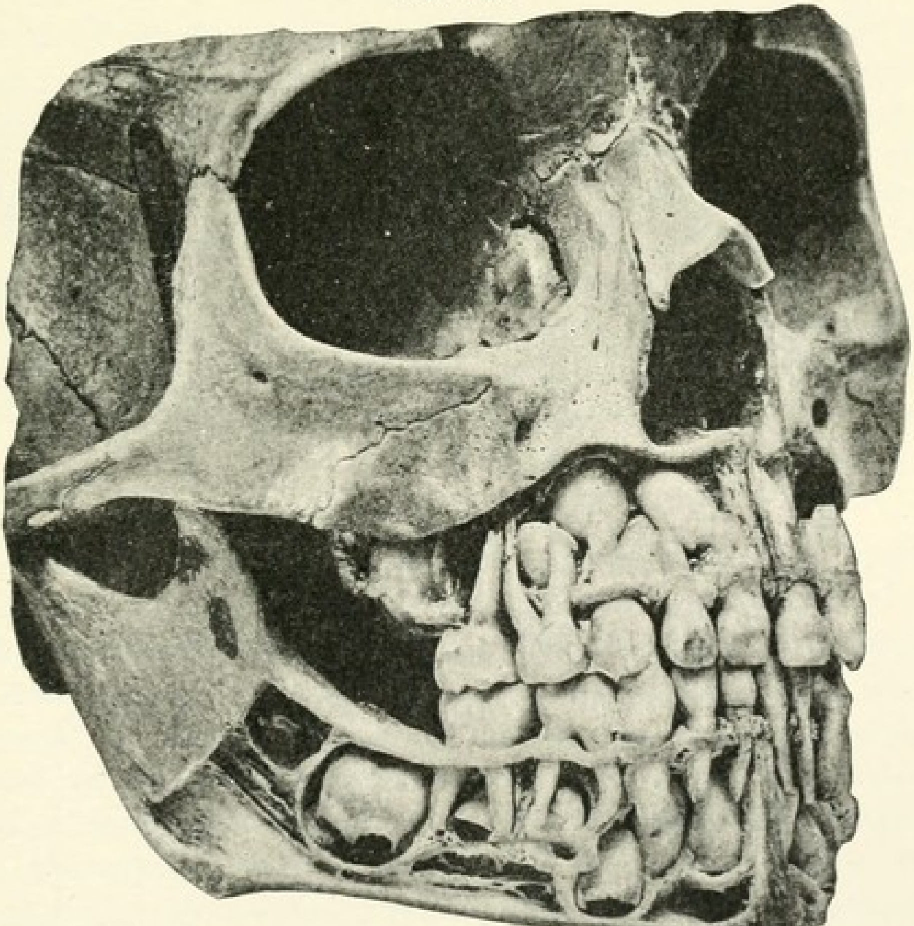
The force applied to safely and judiciously extract teeth should be made with arm and wrist motion; if the whole body is used the sense of touch is blunted and accidents are liable to occur.

Extracting Deciduous Teeth.—In extracting the deciduous teeth the principles involved are nearly the same as for the permanent. A care, however, must be taken that is not necessary with the permanent teeth, *i. e.* to avoid injuring the developing permanent teeth that are situated immediately beneath them.

Fig. 541, which shows all the deciduous and the developing permanent teeth except the third molars, gives a true idea of their relative positions. Special attention is drawn to the position of the crowns of the bicuspids as related to the deciduous molars. It will be seen that they are situated between the roots of the latter teeth, and by using undue force in adjusting the forceps these crowns could easily be misplaced, extracted, or injured.

If the deciduous teeth are extracted at the proper time they can usually be removed by the thumb and finger as described. If not, one of the forceps shown in Figs. 488 and 489 should be used.

Fig. 541.



Dentures of a child six years of age.

Extraction of Individual Permanent Teeth.

The anatomy of the individual teeth and the majority of their often-repeated variations as well as the general principles governing the extracting operation being understood, the extraction of each tooth will now be studied, those of the upper jaw being first considered.

The Upper Teeth.

THE CENTRAL INCISOR.

This tooth has a strong, round conical root. The forceps are carried into position by placing the inner beak at the palatal surface of the neck of the tooth; the outer one is then placed in position and the instrument forced upward with a slight rotary motion between the gum and the tooth until it comes in contact with the alveolar process. As the root is round and conical, it is loosened by rotation and the out-and-in motion and then removed by drawing it directly from its socket. It is, as a rule, easily extracted.

THE LATERAL INCISOR.

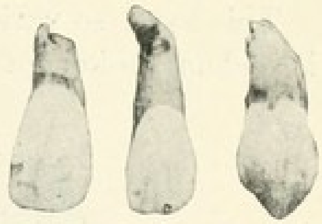
This tooth is much smaller than the central. The root is flattened and somewhat curved, the apex being often bent in the direction of the canine teeth. After applying the forceps as directed for the central incisor, the motion should be outward and inward. As the tooth has a delicate root, the force used must be light. When loosening and removing it, care must be exercised, as its root is not straight. The tooth is carried in the direction of the least resistance, which is usually toward the canine tooth.

THE CANINE.

This tooth is usually more firmly set in the jaw than any other, and it often requires considerable force to break up its attachments. The root is long and slightly flattened. After applying the forceps its attachments are broken up by the out-and-in motion. After loosening it is usually easily removed from its socket. As this tooth is erupted after the adjoining teeth are in position, it is often malposed. If the deciduous canine has been lost before its proper time, and the first bicuspid has pushed forward, there is no room for the canine to take its true position. This irregularity varies to a great extent. The canine may also be out of position from unknown causes. A marked specimen is seen in Fig. 535, where both canines are impacted. They were entirely covered by a bony lamina.

Sometimes the roots of these teeth project into the maxillary sinus, or even into the nasal chamber, while the crowns are impacted between the palatal plate and the plate forming the floor of the nose. Fig. 542 represents a canine, lateral, and central incisor which were extracted from the sinus, the roots being imbedded in its inner wall. Teeth thus impacted are often a source of trouble in various ways and when discovered should be removed. When the tooth is so covered by bone that the forceps cannot be applied the bone must be cut away sufficiently to allow the forceps to grasp it. A very good instrument for removing the bone in the upper jaw is the elevator shown in Fig. 500; after the point has been sharpened it may be used as a chisel or gouge.

FIG. 542.



Canine, lateral, and central incisor extracted from maxillary sinus.

THE BICUSPIDS.

The *first bicuspid* usually has a bifurcated root and the only motion that can be used safely for loosening is the out-and-in, as these roots are sometimes considerably divergent. The removal after loosening is not always easily accomplished, a little outward pressure being frequently necessary. If the force required is used too suddenly the inner root is liable to break.

The *second bicuspid* usually has a single flattened root, though occasionally it is bifurcated. The motion used to loosen this tooth is the outward and inward, using the same precaution as with the first bicuspid on account of the possibility of a double root.

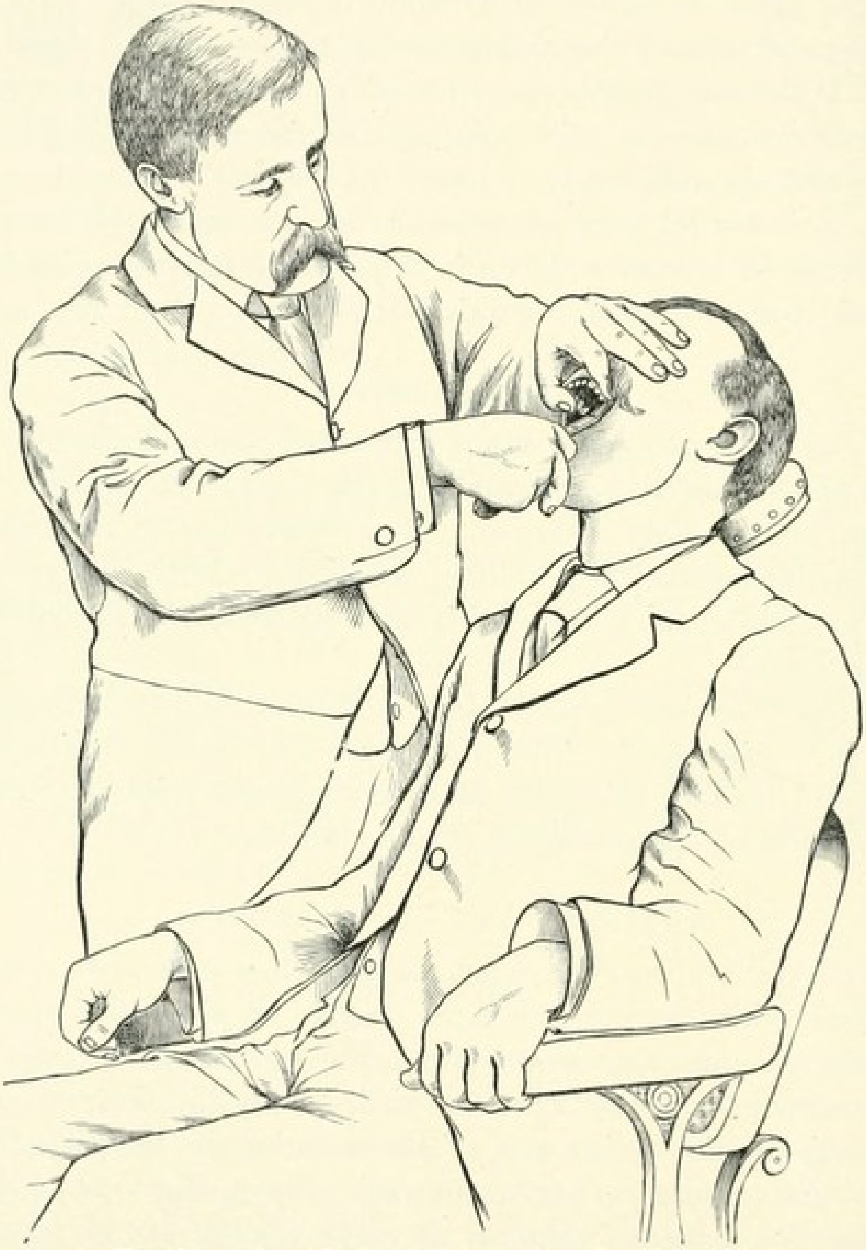
THE FIRST AND SECOND MOLARS.

These teeth are nearly similar, having three roots, two buccal and one palatal, which vary so much in degrees of separation that no set rule can be given for their extraction. The roots of the first are usually more divergent than those of the second. Only the out-and-in motion can be used, rotation being out of the question in loosening them, as the roots often diverge to a great extent. (See *p*, Fig. 534.) After the tooth has been loosened there is at times a difficulty in removing it, on account of the distance around the three roots; owing to their divergence this distance is greater than the size of the anatomical neck of the tooth corresponding to the opening of the socket. The only general rule that can be given is to carry it in the direction of the least resistance. Each tooth has more or less of an individual character, and therefore the operator must be governed by circumstances. The main precaution to be observed is not to be in too great haste, as there is danger of breaking one of the roots or removing a large piece of the outer plate of the alveolar process. (See Accidents, p. 612.)

THE THIRD MOLAR.

This tooth so varies as to the shape and number of its roots that it is seldom spoken of as an abnormal tooth, no matter in what form or

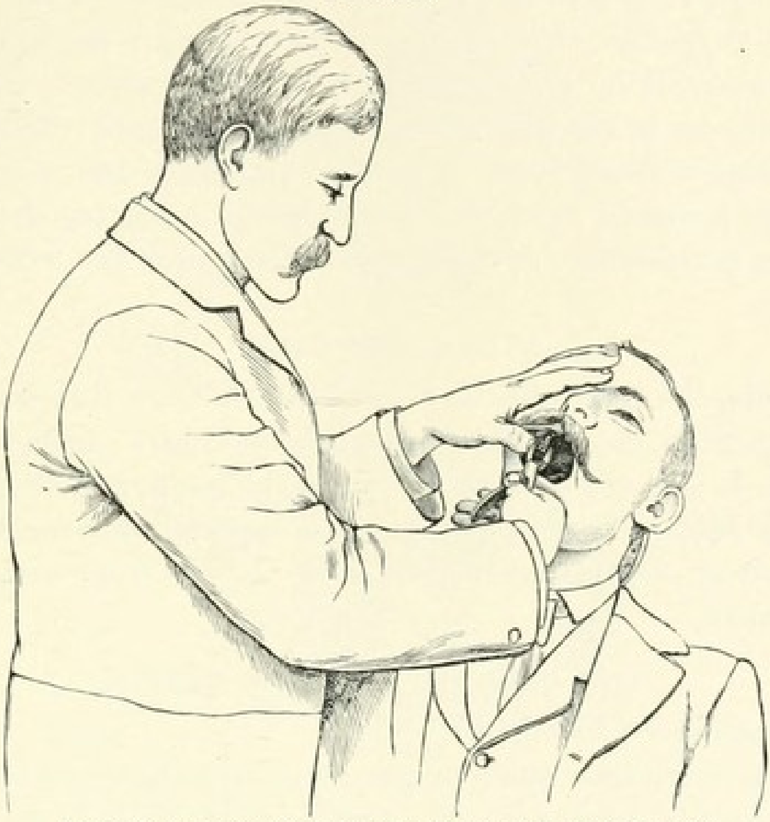
FIG. 543.



Showing position for extracting upper teeth of left side.

position it may be found; the greater number have roots curved backward and outward. Their position in the jaw also varies considerably. The forceps shown in Fig. 488 is the instrument to use in extracting. After the forceps have been firmly placed, the principal motion is the out-and-in, though more out than in. If there is much resistance the hand should be carried outward and upward, or in the direction of the least resistance. This tooth is sometimes erupted at the side of the alveolar process (Fig. 545) with its occlusal surface pointing toward

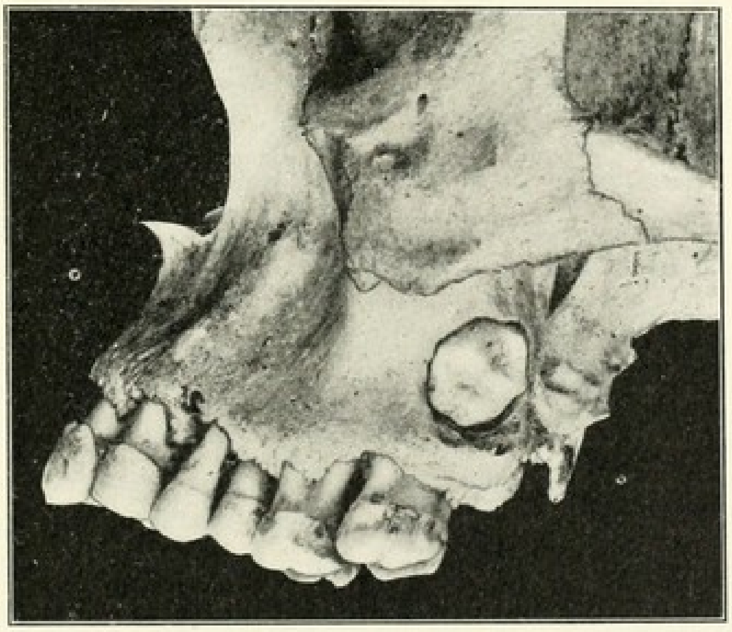
Fig. 544.



Showing position for extracting upper teeth of right side.

the cheek. It is not well to have the mouth opened too far, as it brings the coronoid process of the lower jaw in the way.

Fig. 545.



An impacted third molar.

In stating the general rules of extracting, caution was given not to make the movements faster than could be seen ; this applies very particularly to the third molar. It is so near the ascending ramus in the lower jaw that it is possible, especially when the roots are curved and spread out, to fracture this angle, or in the upper jaw the tuberosity may be broken away, thus opening into the maxillary sinus. The gum tissue often adheres to the posterior portion of this tooth ; when this happens it is best to desist from attempts at extraction and sever the tissue from it with a curved lancet or scissors before removing the tooth with the forceps, or, as before advised, dissect the gum away before applying the forceps.

The Lower Teeth.

As a rule, the teeth of the lower jaw are more difficult to extract than are those of the upper jaw, the lips and cheeks being in the way. The tongue is also troublesome, covering the tooth, and when the inner beak of the forceps is placed in position especial care must be used to prevent part of the tongue or floor of the mouth from being caught in the instrument.

THE ORAL OR ANTERIOR TEETH.

(For position see Fig. 546.)

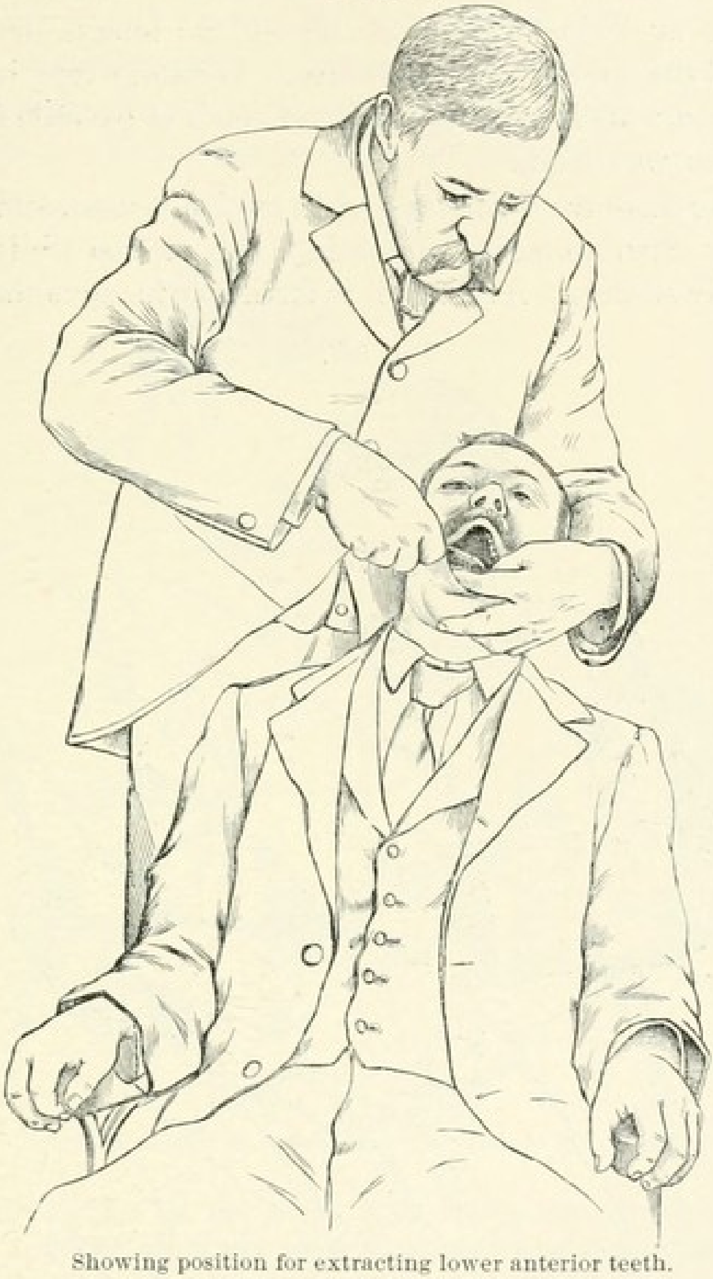
These six teeth have small single, straight, compressed roots. Their extraction is only necessary when they become loosened by accident or from disease or when it is necessary to clear the mouth for inserting artificial teeth. The operator should stand a little back and to the right side of the chair, being somewhat elevated above the usual position. Pass the first finger of the left hand between the lips and the alveolar border, and place the remaining fingers beneath the chin with the thumb on the inside of the teeth. For the incisors use the lower root forceps shown in Fig. 499 or the universal forceps shown in Fig. 489. The canines are larger and more firmly set ; delicate root forceps, therefore, are not usually suitable ; the instrument shown in Fig. 489 or, better, the bicuspid forceps (Fig. 497) are much to be preferred.

An out-and-in motion is proper for loosening all these teeth.

THE BICUSPIDS.

The lower bicuspids have compressed roots seldom bifurcated, and are generally extracted by the out-and-in motion. The special forceps for these teeth should be made so that they grasp a considerable portion of the surface of the tooth. These teeth are often difficult to extract without breaking when all the teeth are in position, the roots being long and narrow and often situated in an awkward position. As shown in Fig. 518, the position of the roots of the second bicuspid is a little to the inner side of the anterior root of the first molar. The tooth illustrated in this particular case would be very difficult to extract without breaking.

Fig. 546.



Showing position for extracting lower anterior teeth.

THE FIRST MOLAR.

(For position see Fig. 547 for the left side, Fig. 548 for the right side.)

The first molar, if in a mouth where all the teeth are in position, is generally the most difficult of all the teeth to extract. The roots are usually long and diverging. It is lower in the arch than the other teeth, and is in fact similar to an inverted keystone; consequently, when extracted it is drawn through the arch. When the teeth are close together the second bicuspid and second molar yield a little, but great care must be taken that one or both of these teeth are not extracted with the first molar. In placing the forceps on the lower molars the points of the beaks of the special molar forceps (Fig. 485 or 498) are placed in between the roots on each side of the tooth. Care should be exercised to avoid including a portion of the tongue or soft tissues of the floor of the mouth in the forceps. If the forceps are not well placed the wrong tooth may be extracted, as it is possible for them to slip in between two teeth.

In loosening these teeth the out-and-in motion is used, and as they are wedged in it is often necessary to continue this motion while extracting them from their sockets. At times it is advisable to move the tooth outwardly after it has been slightly lifted from its socket. Occasionally the roots diverge so far that either the crown has to be broken from the roots at their bifurcation or the tooth divided in the line of bifurcation with splitting forceps; each root being then extracted separately.

Fig. 547.

Showing position for extracting lower teeth of the left side.

THE SECOND MOLAR.

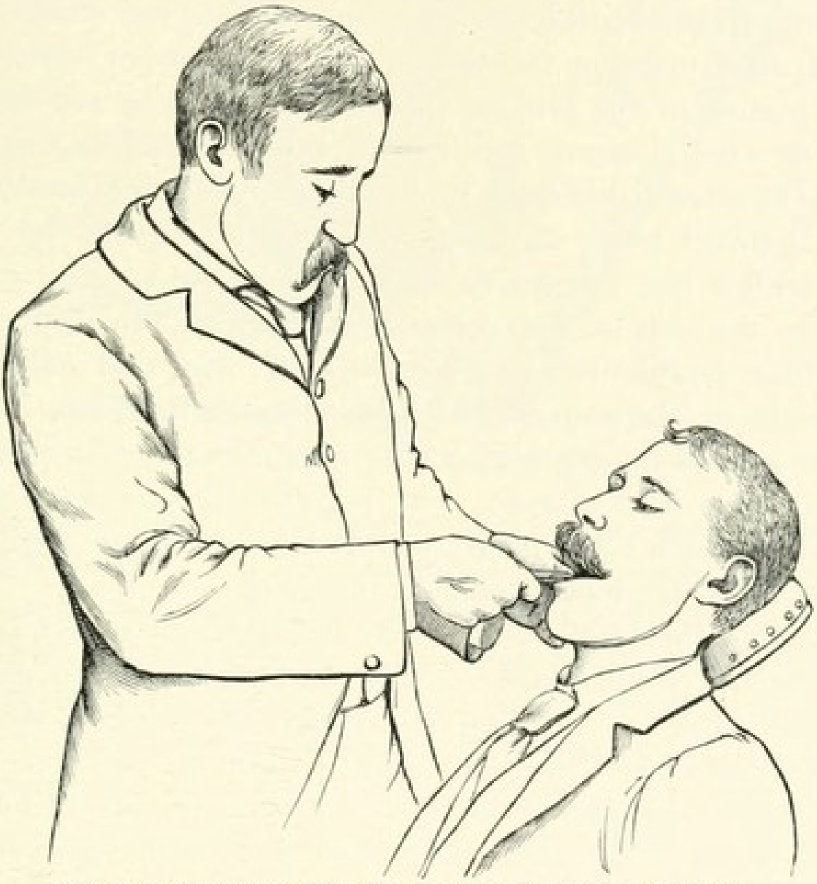
The roots of this tooth are not as diverging as those of the first molar, as may be seen by examining Fig. 514, nor is the tooth wedged in as tightly as in the case of the first molar.

The out-and-in motion is required for these teeth, using the same precautions that are necessary in the extraction of the first molar.

THE THIRD MOLAR.

In these teeth the roots may vary so much in number and shape that there can hardly be said to be a typical third molar. Fig. 514 shows what might be called a normal third molar, but these are only found in well-developed jaws, where the teeth are not so large as to cause crowding. They vary in character from the one shown in Fig.

Fig. 548.



Showing position for extracting lower teeth of the right side.

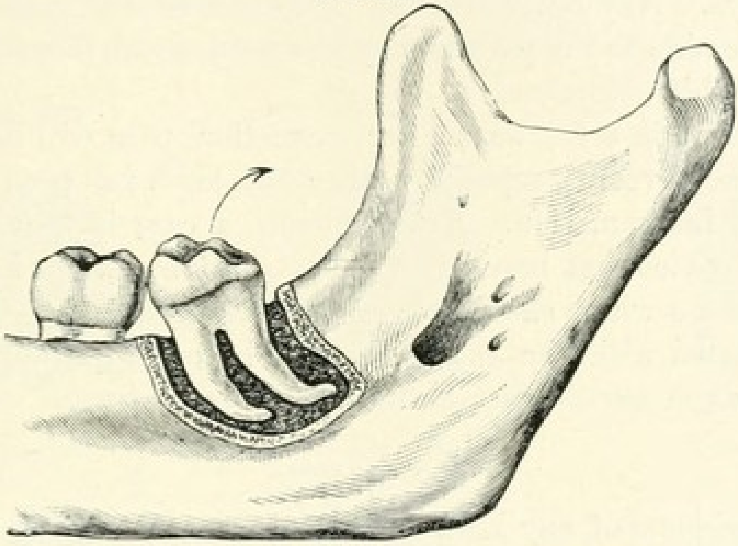
514 to the two shown in the right and left jaws represented in Figs. 530 and 531. Figs. 526, 527, 528 and 529 show other forms and positions of the third molar. There are also third molars having three, four, or five roots. *a*, Fig. 534, shows another form of the third molar; *b*, *c*, *d*, *e*, and *f* show where the third molar has united with the second molar; *g* and *h* illustrate three molars united; *j*, *k*, *l*, *m*, *n*, *o*, and *p* show variations of roots. The positions these teeth occupy may vary in all degrees from that shown in Fig. 514 to those shown in Figs. 525–531.

Where the third molar is in the position shown in Fig. 514 and there are no other complications, its extraction is easy. The tooth is removed by placing either the special lower molar forceps shown in Fig. 498 or the forceps shown in Figs. 488 and 489 in position, and using the out-and-in motion with a slight raising of handles. If 488 be used the beaks should be turned downward and the handles carried upward. But when it is of irregular form and position, as shown in the various illustrations, the difficulty increases with the degree of variance from that of the normal tooth shown in Fig. 514. These cases should be closely studied. If portions of the teeth are in view, as shown in Figs. 530 and 531, they will assist to some extent in the diagnosis of the position of the roots. In this particular case, the bone as well as the roots being much hypertrophied, it would be impossible to extract the roots without fracturing the process to a greater or less extent. It will be noticed, on examining the section Fig. 530, that to have fractured the inner portion of the jaw the inferior dental nerve and vessels and also the mylo-hyoid nerve and vessels would be endangered. If in attempting to extract this tooth it should not yield to a pressure which if increased would break the bone, it is better to desist and cut away the bone with a bur (shown in Fig. 587) in the surgical engine, as was done in the case of the specimen from which the illustration was made. Those represented in Figs. 526, 527, 528, and 529 would be more difficult to diagnosticate, as no portion of the teeth is in view. If trouble existed in this region, the explorations would have to be made with sharp steel probes. The bone would then have to be cut away until the tooth could be grasped by the forceps, the forceps shown in Fig. 488 being the most useful for this purpose.

In Fig. 525 the third molar is in such position as to be easily extracted, though if proper care were not used the extraction might have serious consequences. It will be noticed that the points of the roots are just through the inner U-shaped cortical portion of the lower jaw below the mylo-hyoid ridge and project into the submaxillary region. Now, should this tooth or the roots be pushed downward in attempted extracting, as is sometimes taught, it might be forced into the submaxillary region and consequently be lost for a time, with the possibility of having to perform a subsequent surgical operation to cut it out from the neck.

An impacted third molar often causes great distress by initiating an inflammation which extends to the region surrounding the angle of the jaw, and often including the temporo-maxillary articulation and soft parts within the mouth. Under these conditions the jaws can only be partly opened, deglutition is impaired, and solid food cannot be taken. One of two things must be done: either the offending tooth or the one in front of it must be extracted. Every effort should be used to extract the third molar; if any part of the tooth can be seen, the difficulty is not so great; the inflammation of the adjacent parts will generally quickly subside. As the mouth can only be opened slightly, it is impossible to use the large special molar forceps. An elevator is sometimes recommended in these cases, but it may prove to be a dangerous instrument to use under such conditions, for when the tooth is lifted out of its position in the mouth, it might easily slip back into the larynx. It is well in some cases to loosen a tooth with an elevator and then remove it with the forceps shown in Figs. 488 or 489,

Fig. 549.



Showing the direction in which the lower third molar is to be extracted.

as they are small and are so shaped that the beaks can be carried back to the tooth mainly along the vestibule of the mouth, the inner blade being placed between the teeth by passing the forceps back of the second molar. Often it is impossible to see completely what is being done, therefore it is not well for a beginner to undertake this kind of extracting. After the forceps is in position the tooth should be worked in any direction in which it will yield; this is generally outward, upward, and backward, in the manner of unfastening a hook. (See Fig. 549.) When the third lower molar is impacted near the angle of the jaw, it may be necessary to open it from the outside through the soft tissues. When such is the case the surgical engine should be used for cutting the bone.

Treatment after Extraction.

The operator should recognize immediately any accident that may have happened during the operation of extraction, and treat it as the circumstances indicate; but if nothing unusual occurs, then the patient may be allowed a few moments' rest, after which the mouth should be carefully examined. If there are any loose portions of the process or pieces of gum hanging to the parts operated upon, they should be removed by any convenient means, such as a curved pair of scissors or a curved lancet (Figs. 502 and 504).

When several teeth have been extracted leaving ragged edges of the outer walls of the alveolar process, these should be removed with the excising forceps, or better still, by the use of either forceps Fig. 488 or 489, according to circumstances, as the beaks can be carried between the gum and the process better than can the blades of the excising forceps.

An antiseptic mouth-wash consisting of a tablespoonful of phénol sodique to a glass of water should be used several times daily for the next few days. Any other suitable antiseptic mouth-wash which may be more agreeable to the patient may be used instead, though the phénol sodique is highly efficacious.

Occasionally, in a few days after extraction, pain will be noticed in and about the alveolus, especially when the tooth has been the seat of pericemental inflammation. Relief in such a case is usually given by removing any clot that may have formed, and breaking down the degenerated tissues which should have adhered to the root. A pledget of cotton saturated with the full-strength solution of phénol sodique or campho-phenique should then be inserted as a dressing.

Accidents.

When accidents of any kind whatever occur, the operator should be calm and appear perfect master of the situation. He should be prepared to successfully deal with whatever conditions may arise.

One of the most common accidents is the breaking of a whole or portion of a tooth or root. If the operator has any doubt of his ability to remove the tooth entire, he should inform the patient that there is a possibility of its breaking, in which case not to be alarmed. If the tooth is removed without breakage so much the better; even if it does break it will not cause alarm to the patient. It is more desirable that all of a tooth should be removed, for if its surrounding membrane has been inflamed, or if a root has been broken having a portion of the pulp attached, either will be the source of obstinate pain.

It is better, however, under some circumstances, to let certain roots remain if they are broken, than to break away a large amount of process. Roots are sometimes so situated that they can be easily forced into the maxillary sinus (see Figs. 516 and 517), or into the submaxillary region (see Fig. 525), or upon the inferior dental nerve. If there are good reasons for believing that the root will not cause undue pain, and there is danger of breaking a large amount of process, it is preferable to let it remain, as in a short time the contraction of the soft parts and the expulsive efforts of Nature will force the root outward and it can then be removed without danger. If roots are forced into the maxillary sinus they must be followed and removed.

When several teeth are to be extracted under an anesthetic, if the gum should adhere unduly to one of them, the operator should desist from its removal and proceed with the other extractions, after which the adherent gum should be severed with a curved lancet or a pair of curved scissors and the tooth then removed. If the gum be much torn and the bone exposed to a great extent, it should be held in place by a few interrupted sutures. If, however, proper care is taken in extracting, this should not occur.

In extracting crowded teeth, or those having frail alveolar surroundings, it is possible to remove a piece of the alveolar plate, especially in

Fig. 550.

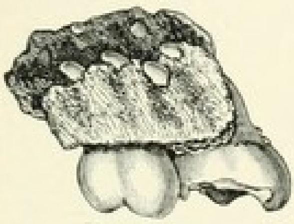


Fig. 551.

Fig. 552.

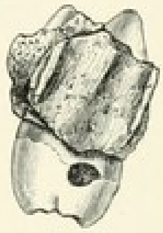


Fig. 553.

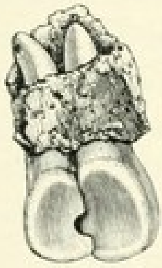


Fig. 554.

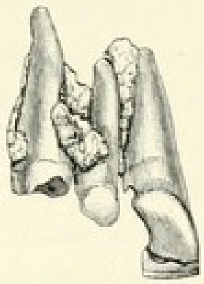


Fig. 555.

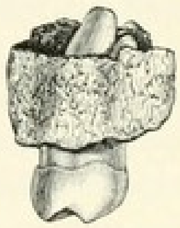


Fig. 556.

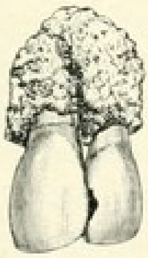


Fig. 557.

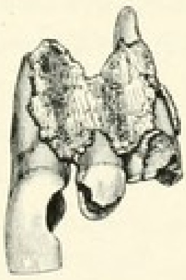
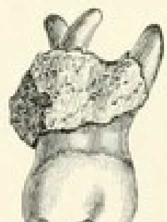


Fig. 558.



extracting the first and second molars, the broken piece extending backward, forward, or in both directions to the adjoining tooth. (See Figs. 550 to 558.) The tooth in front may even be partially lifted from its socket. As soon as the operator sees the impending accident he should either stop and see if his method of extraction could be improved, or, this point being negatively decided, hold the parts in position with the left hand as well as he can, and after the tooth is removed force the injured parts into position; they will usually stay, but if not, appliances of appropriate form can be used for retention.

In extracting the upper third molar, the tuberosity is sometimes broken away, opening into the maxillary sinus (see Figs. 550, 551, 552, 555, and 558, showing where teeth have been carried away with the tuberosity). If it is a simple fracture the parts can be forced into place and they will in a short time reunite. But if the parts are torn loose it will be of little use to try to replace them; the best course is to trim away the ragged edges, using the curved scissors for this purpose.

After such a fracture it is possible that hemorrhage may occur from rupture of the superior dental artery. This is sometimes difficult to control. One of the best remedies, however, is to tightly pack the parts with medicated gauze. This application must be left in for a few days and then be carefully removed. It is sometimes well to take out only part of the gauze at a time, the loosened portions being cut off with a pair of curved scissors. Hemorrhage after extraction usually ceases in a short time, and then there is no occasion for treatment; when, however, the adjoining parts are much inflamed, or the patient is in an anemic condition, or the case is one of hemorrhagic diathesis, special treatment will be necessary.

Hemorrhage of extraction may be divided into two classes, arterial and capillary. When arterial, it is usually located in the socket of the tooth, and may usually be stopped without much difficulty by taking a twist of absorbent cotton, shaping it into a thin tapering roll, and thoroughly packing the socket. Before inserting the cotton tampon, it should be rolled in tannic acid until the fibers will hold no more, then the cotton is to be packed tightly into the alveolus with a dental plugger. In packing the cotton it is well to begin at one end and crimp it upon itself until the socket is entirely filled. A narrow strip of iodoform gauze when packed in the same way makes a good plug, and the more rapid healing of the parts afterward and freedom from any offensive odor makes it a more satisfactory tampon than the tannic acid and cotton plug, though the styptic quality of the latter makes it a more efficient hemostat. The plug in a few cases may require retention in position by compression. This is accomplished by holding a few folds of muslin or similar material over the plug, closing the mouth and binding the jaws together with a few turns of a Barton's bandage. (See Figs. 559 and 560.) The 25 per cent. ethereal solution of hydrogen dioxid in small quantity on cotton packed into a bleeding socket is a most efficient styptic, and will effectually control severe hemorrhage after extraction. Care must be exercised not to use the solution in excess, as it may cause injury to adjacent parts.

Where hemorrhage occurs from the surrounding tissue, as in patients in an anemic condition or in cases of hemorrhagic diathesis, the case usually falls into the hands of a general practitioner for systemic treatment, but the local treatment usually employed by physicians in these cases is often unsatisfactory, many using Monsel's solution of persulfate of iron, which, although it may be a good styptic for use in

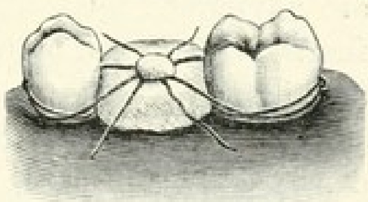
Fig. 559.

Fig. 560.

Barton's head bandage.

other parts of the body, should not be used in the mouth. The local treatment in such cases, whether soon after extracting or not, is first to remove all clots from the wound and find the exact place or places from which the blood is exuding. A suitable styptic and compression are the principal means used for stopping it, the latter perhaps being the most important. Tannic acid applied on cotton, lint, or similar substances, is a good styptic to use in the mouth. Iodoform gauze, for the reasons already given, is better, although it has not been generally used in this connection. Compression can be applied as the ingenuity of the operator may direct. When a hemorrhage occurs from a socket between good teeth, it can be readily controlled by two ligatures, making one fast to each tooth, then placing in position and tying the four ends together over the compress, as shown in Fig. 561. In a few rare cases an impression of the parts should be taken in wax or other modelling compound in order that a rubber or metallic plate can be made to hold the styptic compress in position. After the compress is in position warmed modelling compound can be placed over it and the jaws brought together and retained in place by a head bandage. A plug of hardening plaster of Paris may be made and forced into the bleeding socket in obstinate cases, or *in extremis* the extracted tooth might be soaked well in phénol sodique and reinserted.

Fig. 561.



Showing compress and ligatures.

The systemic treatment is often important; if the patient is seen to be anemic or known to be of the hemorrhagic diathesis, the treatment should be begun before extracting. This is done by thoroughly building up the system by a course of hygienic and tonic treatment. The cause of bleeding in cases where the hemorrhagic diathesis exists is but imperfectly understood; the blood may be so defibrinated that it has lost the power of coagulation and so will not form a clot, or the muscular coats of the vessels have lost their tonicity, either through general debility or the lack of energy in the vasomotor nervous system, which prevents their contracting so as to close the lumen. Certainly the walls of the capillaries permit free transudation of the blood. In good health the proper coagulation and the contraction of the blood-vessels will stop the hemorrhage even when an artery of considerable size is lacerated, especially if the flow be held in abeyance by artificial means for a short time. It is when the blood will not coagulate and the vessels fail to contract that a thorough systemic treatment must be given. This lack of normal function on the part of the blood and vessels may arise from various diseases, and in order to judiciously treat a patient exhibiting the hemorrhagic diathesis a thorough examination must be made and such treatment given as the diagnosis indicates. Among the most common causes of hemorrhage are anemia, syphilis, purpura, tuberculosis, and a generally impaired vitality, rarely an over-acting heart; the passive hyperemia attendant upon a weak heart is a potent factor requiring a course of preliminary treatment.

Specific and special diseases must of course receive the treatment peculiar to these conditions. On general principles the following tonics are advisable: Quassia, cinchona and its alkaloids, iron in its various forms, sulfuric and hydrochloric acids, arsenic, phosphorus, nux vomica and its alkaloid strychnin. With these general tonics various hemostatics can be given, such as alum, tannic acid, ergot, erigeron Canadensis, and gallic acid, Very frequently the digestive organs require special medication, when such remedies as pepsin, pancreatin, hydrochloric acid, and bismuth subnitrate are indicated.

The following prescriptions have proved to be very excellent in their special province.

As general tonics:

℞. Strychniæ sulphatis,	
Acidi arsenosi,	*āā*. gr. j;
Quiniæ sulphatis,	gr. xxx;
Ferri sulphatis exsiccat.,	gr. xv.
M. et ft. pilulæ No. xxx.	
S. One immediately after each meal.	

℞. Elixir ferri, quiniæ et strychniæ, f℥iv.
S. Teaspoonful four times daily.

To improve digestion and assimilation:

℞.	Acidi hydrochlorici diluti,	f℥ij;
	Ext. ignatiæ amaris fld.,	f℥j;
	Pepsin,	ʒiss;
	Ext. ipecacuanhæ fld.,	♏iv;
	Infusi gentianæ comp.,	q.s. ut ft. f℥vj.—M.

S. Dessertspoonful in sherry glass of water immediately after meals.

In cases of undue hemorrhage after extracting, it is well to administer a hemostatic while at the same time styptics and pressure are being applied locally. The following are very good:

℞. Vin. ergotæ (Squibb's), f℥iij.
S. Teaspoonful every two hours.

℞.	Ext. ergotæ solidificat.,	ʒj;
	Ext. cannabis indicæ,	gr. v;
	Strychniæ sulphatis,	gr. ss.

M. et ft. pilulæ No. xxx.
S. One pill three times a day.

Gallic acid and aromatic sulfuric acid may be administered.

Digitalin exhibited in doses of $\frac{1}{10}$ to $\frac{1}{2}$ a grain three or four times daily for a series of weeks will often effect such change in the capillaries as to overcome the hemorrhagic tendency. This has been repeatedly and successfully accomplished in epistaxis, and as the conditions are analogous it can be employed in this diathesis with expectation of similar results.

Extraction under the Influence of General Anesthetics.

While it is undoubtedly true that the extraction of teeth under the influence of a general anesthetic is in accordance with the general spirit of the age which seeks to spare all suffering or cause the infliction of but slight pain, yet many evils attend such general and too often indiscriminate use. "A patient under the effect of so powerful a drug that consciousness is destroyed is nearer death than an ordinary human being, since the primary depressive influence upon the high nervous centres may speedily pass to the lower vital centres in the medulla oblongata."[1]

The indiscriminate use of general anesthetics, beside their possible danger to life and health, has an accompanying evil in the demand for the extraction of teeth which are salvable and useful, but which

[1] H. A. Hare, in *Park's Text-Book of Surgery*, vol. ii.

a patient insists upon having removed in order to avoid the discomfort attendant upon their treatment and filling. No one questions or denies the enormous benefit of general anesthetics in dentistry, particularly when painful operations are to be performed upon nervous women and children, but if the patient be willing to suffer a little pain it is generally better to extract without a general anesthetic, as in that case the patient can assist the operator by keeping the head in a desired position with the mouth and lips well open, and in various other ways, while under the influence of an anesthetic the muscles supporting the head, jaws, and cheeks are so relaxed that it is difficult to keep the mouth and lips well open.

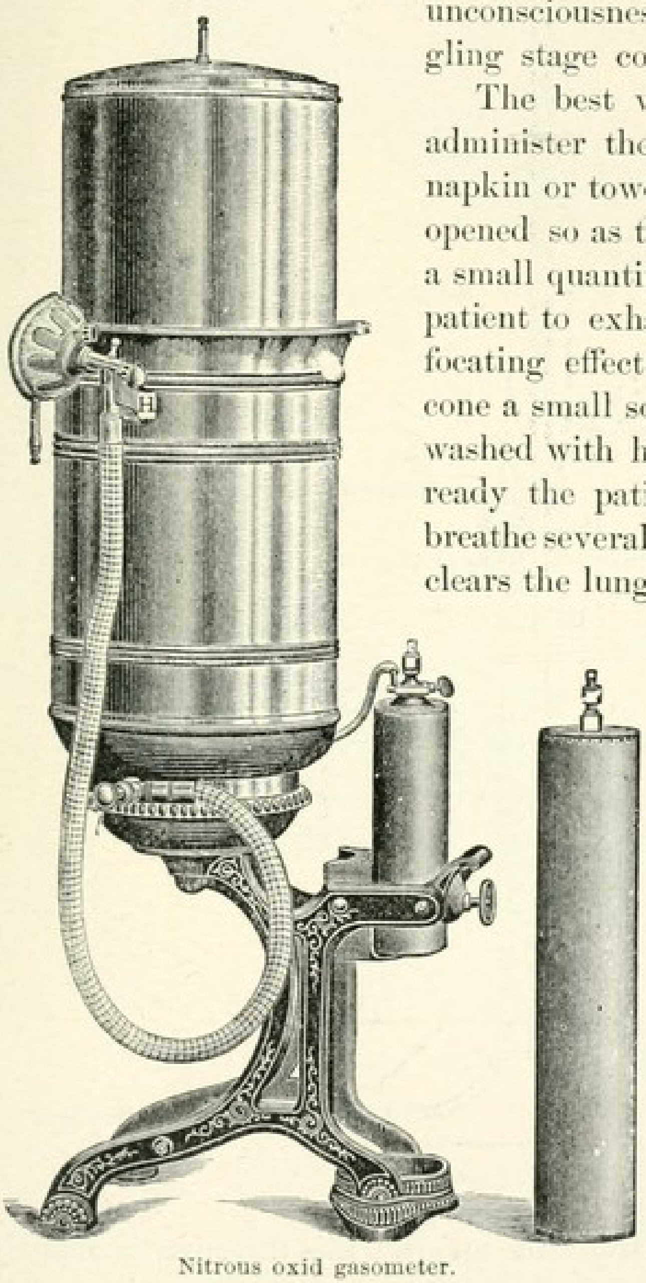
If the operation is to extract a difficult tooth, the operator is limited to the time when the patient is under the influence of an anesthetic, and in the case of nitrous oxid the time is very short; but without an anesthetic there is not this limitation as to time, and the extraction may be done with that care and deliberation essential to a proper operation. It is an important rule in any branch of surgery that the time required to do an operation must be sufficient to do it properly and without unnecessary injury to the adjoining tissues.

Examination of a Patient before the Administration of a General Anesthetic.—The physical examination should be made in such a way that it will not cause alarm to the patient. The result of this examination governs the selection of the anesthetic, and to some extent shows how far the patient should be carried under its influence. It has been said that a greater amount of care should be used if the patient has or is suspected of having organic or functional disease of either the heart or the lungs. This is quite true, but at the same time the greatest amount of care should be observed in all cases. For the physiological action of various anesthetics the student is referred to special works on this subject.

The question often arises whether anesthetics should be used at all if the patient has either organic or functional disorder of the heart. That depends to a large degree on other conditions of the patient. If the shock of extraction will be less under ether or nitrous oxid, then by all means give the anesthetic and carry the patient fairly well under its influence, so that there will be neither pain nor knowledge of the operation. Occasionally patients suffering from heart disorders can bear a certain amount of pain without shock; in such cases it is better, if the operation be a simple one, to extract while in the normal condition.

The use of ether for extracting has certain advantages. If for any reason the operation requires longer time for its performance than the influence of the nitrous oxid will last—say from one to two minutes—it is better to use ether. Ether can be given after the patient has become anesthetized by nitrous oxid and oxygen and he may be kept under its influence for a considerable time; in this way the struggling stage of ether is avoided. When the teeth are to be extracted at the patient's home or at any other place outside of the office, ether is more conveniently carried than nitrous oxid. If properly used and the patient has perfect confidence in the operator, it can be so administered that one, two, or three teeth may be extracted during what is known as the first stage of ether anesthesia, before complete unconsciousness and long before the struggling stage commences.

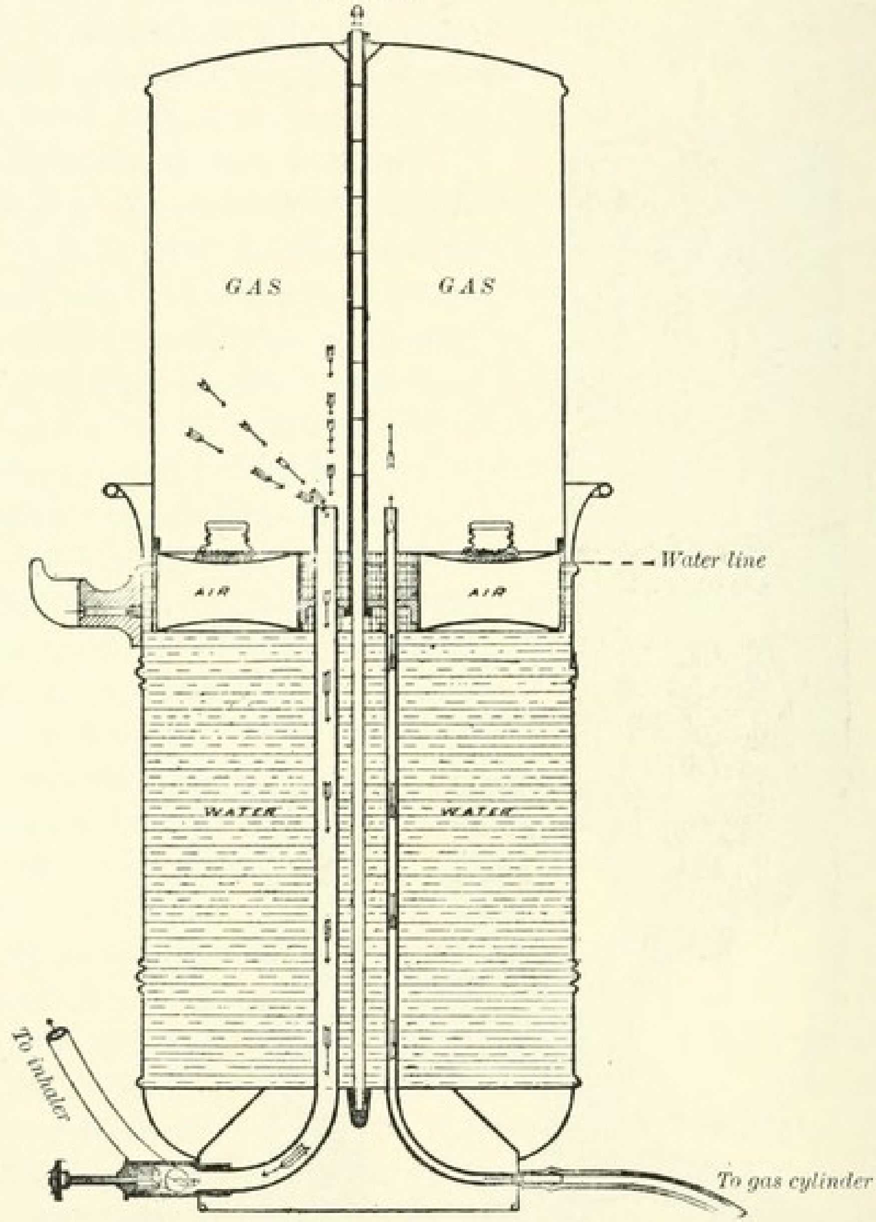
Fig. 562.



Nitrous oxid gasometer.

The best way to accomplish this is to administer the ether in a cone made by a napkin or towel, with the small end slightly opened so as to allow the patient to inhale a small quantity of air; it also permits the patient to exhale freely and with a less suffocating effect. It is well to place in the cone a small soft sponge that has been well washed with hot water. After the cone is ready the patient should be instructed to breathe several long and full inhalations; this clears the lungs of much impure air and accustoms the patient to the kind of breathing required. Then the appliance is placed in front of and some distance from and above the mouth and nose, being careful to allow none of the ether to drop from the cone upon the face, as it will demoralize the patient. The inhaler is to be advanced toward the face slowly and gradually, watching the effect upon the patient; if there is a tendency to cough, the advance should be interrupted until this has passed. After the cone has closed tightly over the mouth and nose, it is a good plan to ask the patient to hold up the left hand as long as possible; this will concentrate his thoughts upon the act and away from the operation. When the hand begins to fall, the request to raise the hand should be repeated; it will soon fall, and in a few seconds afterward one, two, or three teeth may be removed, the number depending entirely upon their position and the difficulty to be overcome in their extraction. As soon as the teeth are extracted the head of the patient should be raised from the head-rest and the body carried forward, and, having a hand cuspidor in front, the patient should be

Fig. 563.

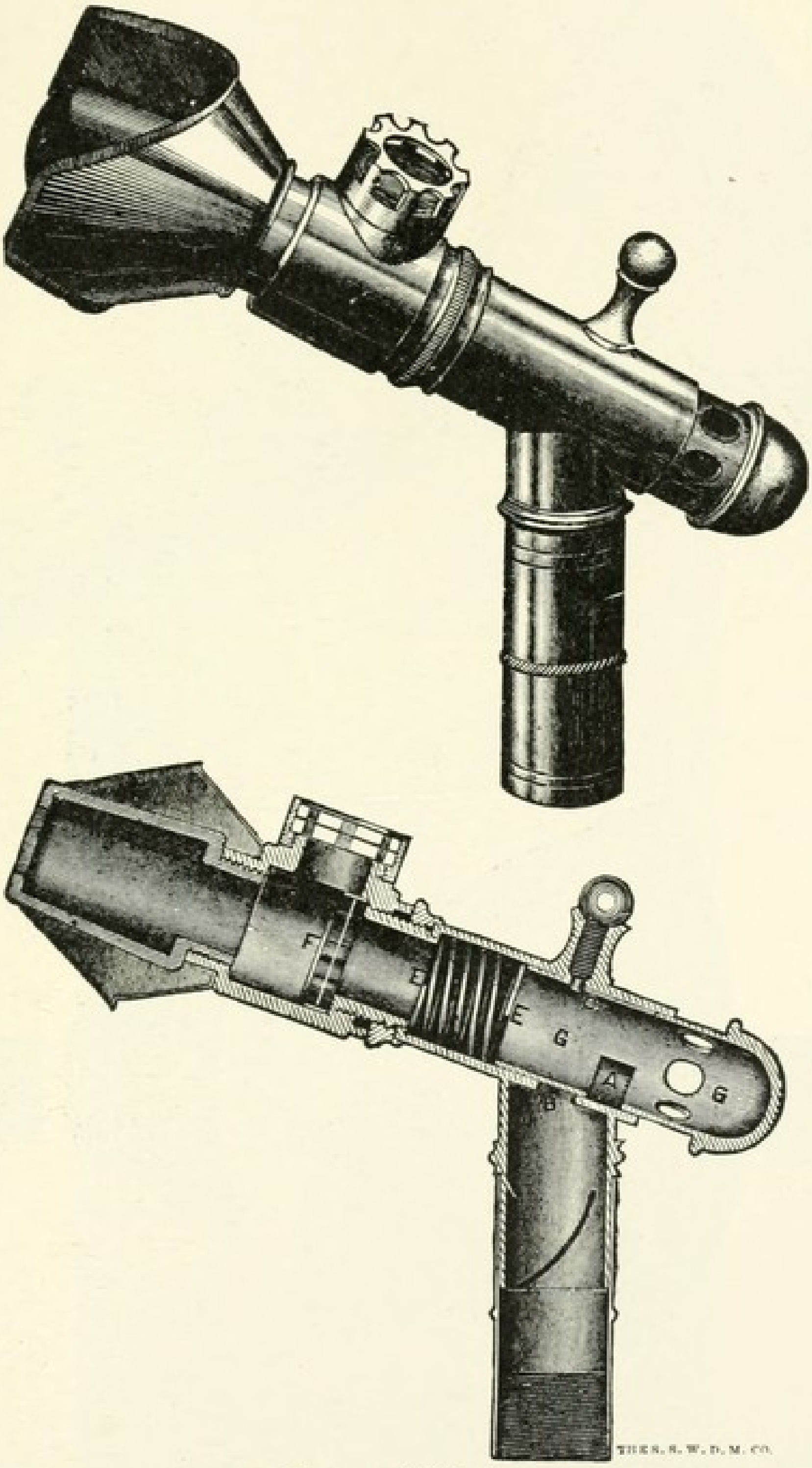


Sectional view of gasometer.

requested to eject the blood from the mouth ; this direction is usually complied with. The patient in most instances recovers in a few moments and with no disagreeable after-effects, but if the ether is carried beyond the struggling stage to the point of complete surgical narcosis the nauseating after-effects are very disagreeable unless the patient has been thoroughly prepared for the occasion.

Nitrous oxid is the anesthetic most commonly administered for the extraction of teeth, and under ordinary circumstances is the best. Until lately every operator was his own maker of the gas—this was a great disadvantage—but now it can be procured in a liquefied form com-

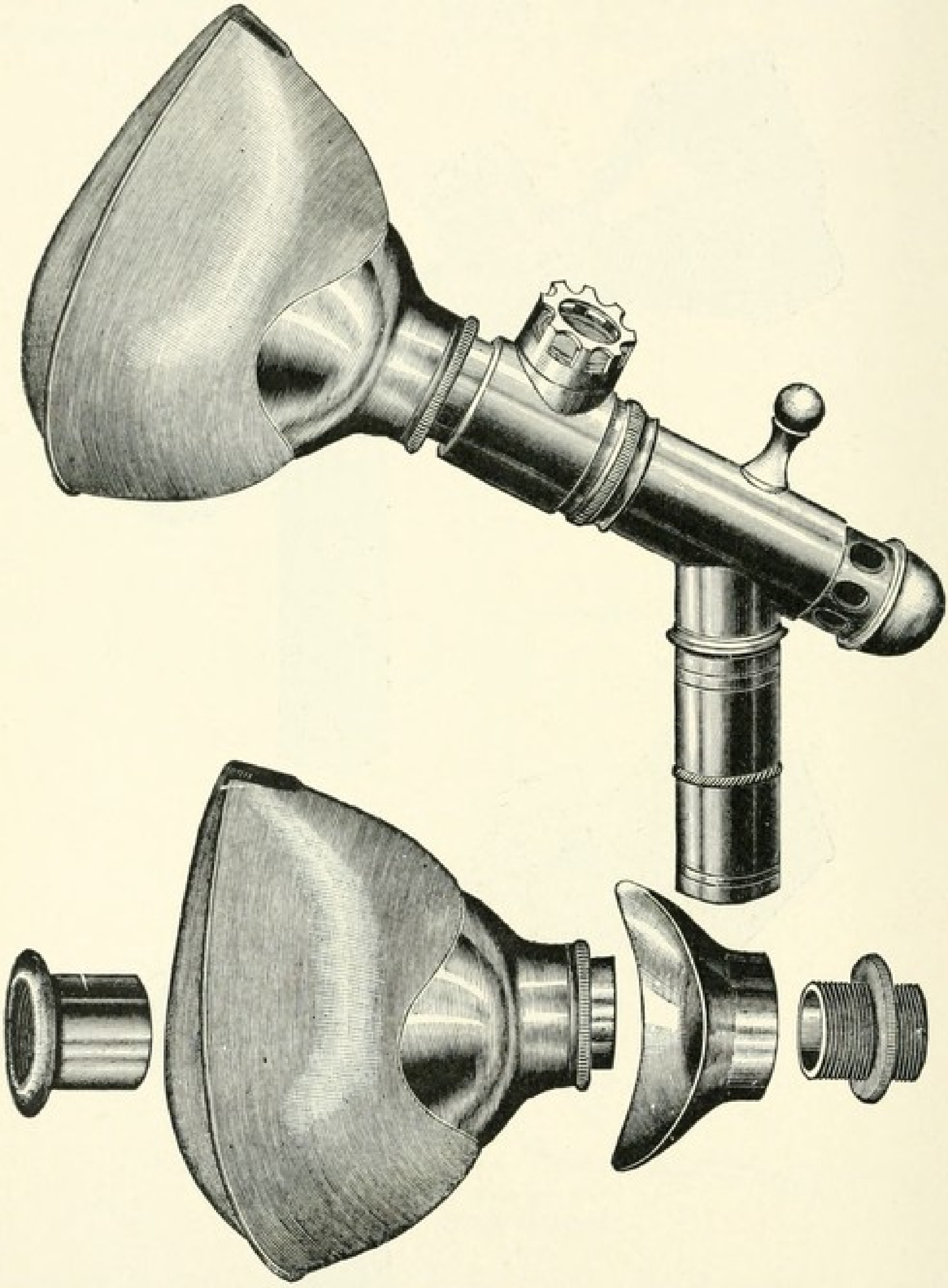
FIG. 564.



Nitrous oxid inhaler.

pressed in cylinders. There are many different appliances used for the administering of this gas even when using it in a condensed form. One of the most prominent is that shown in Figs. 562 and 563, in which the gas is drawn into a reservoir and then passes through a flexible tube to the mouth-piece (Figs. 564 and 565).

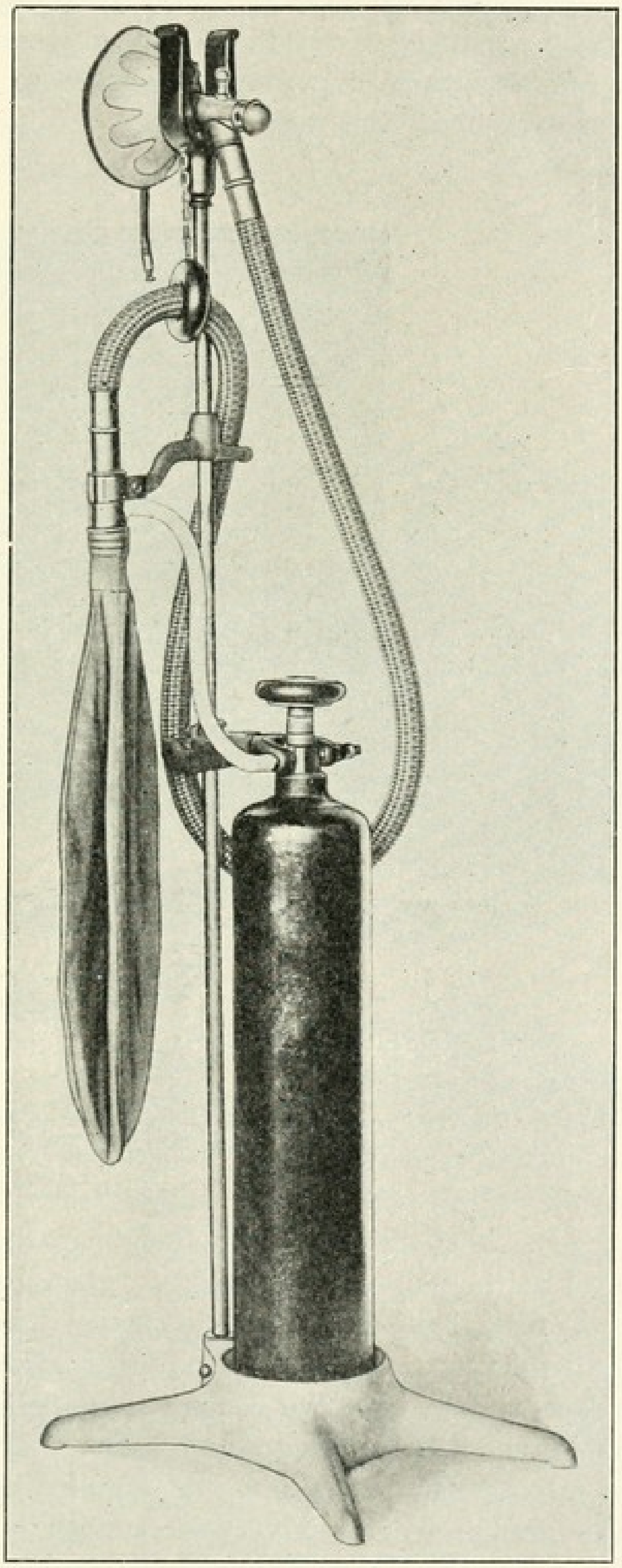
Fig. 565.



Hood inhaler.

The two principal mouth-pieces are Fig. 564, which should have the detachable lip-shield removed so that the tube may be placed directly into the mouth and the lips compressed around the tube by the operator, at the same time closing the nostril by the thumb and finger, and Fig. 565, which is known as a hood inhaler; it is

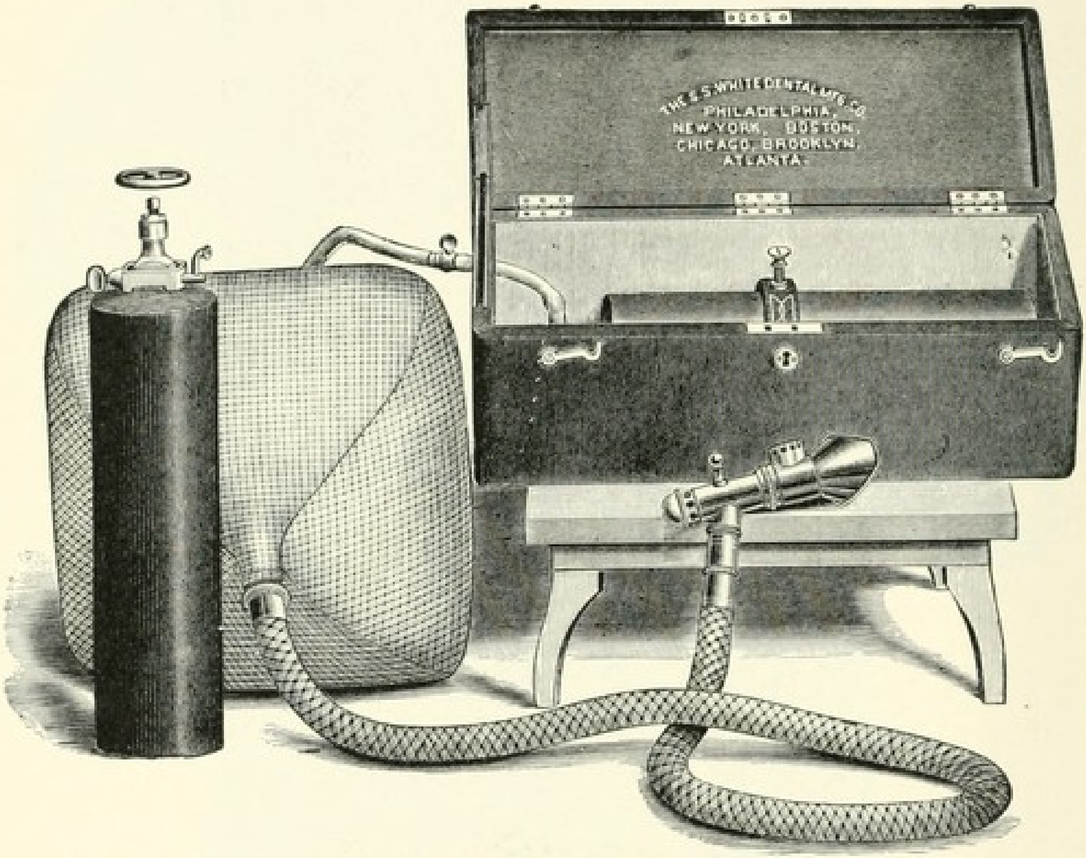
FIG. 566.



Stand for compressed gas cylinder, gas bag, tube, and inhaler.

made to cover the nose as well as the mouth. The advantage of the first mouth-piece is that the lips may be closely watched for the change of color denoting oxygen-starvation of the blood, which the experienced operator combats by admitting a certain amount of air with the gas as required. Fig. 567 represents a portable appliance to be used at a patient's home or away from the regular office.

FIG. 567.

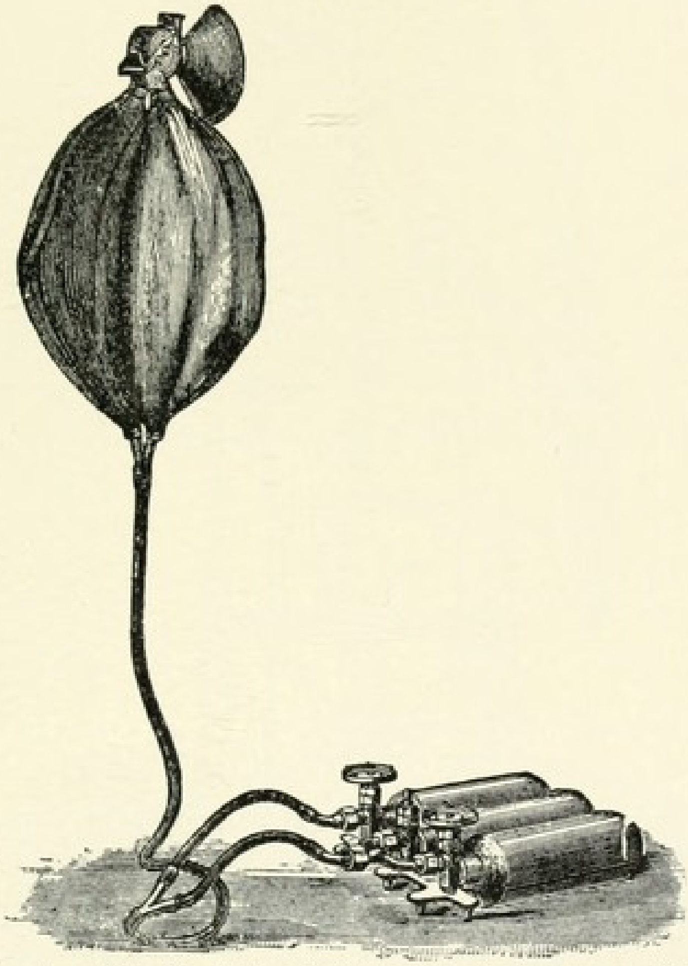


Portable nitrous oxid apparatus.

Dr. Hewitt's Method.—Dr. Frederick Hewitt of London, England, has devised the apparatus shown in Figs. 568 and 569. The three cylinders contain the compressed gas, two being filled with nitrous oxid and one with oxygen. The valves of the cylinders are opened by a key which is controlled by the foot of the operator. The tube passing from the cylinders to the receiving-bag is double, a smaller tube being placed within the outer larger tube. The receiving-bag is also double, being divided by a rubber septum into two compartments which have their outlet in the double tube which leads to the inhaler. To the receiving-bag is attached a mixing-chamber, and to this the inhaling-tube or hood is fastened. This appliance is used very successfully in England and has been introduced into the United States. It has proved satisfactory to all who have tried it. The bags and tubing should be made of more durable material when intended for use in the American climate.

The manner in which the appliance is used is as follows: The valves in the mixing-chamber (Fig. 569) are closed, then oxygen is let into its compartment of the receiving-bag until the latter is nearly filled, when the nitrous oxid is admitted into its compartment. The patient being prepared, the inhaling-tube or hood is placed in position, and the patient is directed to breathe—long, full, and steadily. If the tube is used it is necessary to close the nose by the thumb and finger.

Fig. 568.

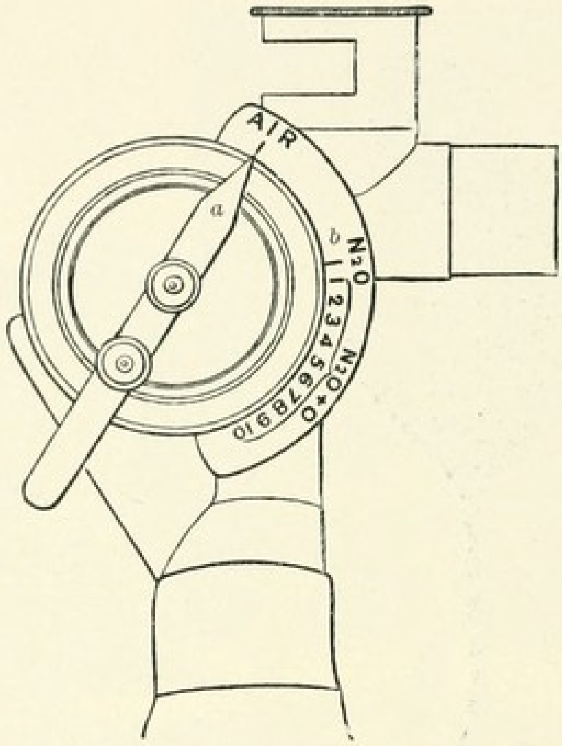


Complete apparatus of Dr. Hewitt for administering mixed nitrous oxid and oxygen.

The valves are not changed for a few inhalations, during which time only air is inhaled; then, pressing the indicator *a* downward to the first notch *b*, the air is cut off, and the patient receives pure nitrous oxid; this is allowed for a few more inhalations, and then the indicator is carried to the next notch and one part of oxygen is allowed to pass into the respiration. When the indicator is carried to the third notch two parts are received by the patient, and so on until the maximum amount of oxygen required by the patient has been reached.

It has been found by careful study of many thousands of cases and by special scientific investigation that the asphyxial condition incident to most cases of nitrous oxid inhalation is quite unnecessary to the production of nitrous oxid anesthesia. It is also justly considered to be subjecting a patient to an unwarrantable danger to permit the asphyxial effect to manifest itself to a profound degree, as in many cases it is a menace to life and health, and might have a fatal effect. The object of Dr. Hewitt's method is to control or eliminate the asphyxial element by administering a requisite amount of oxygen.

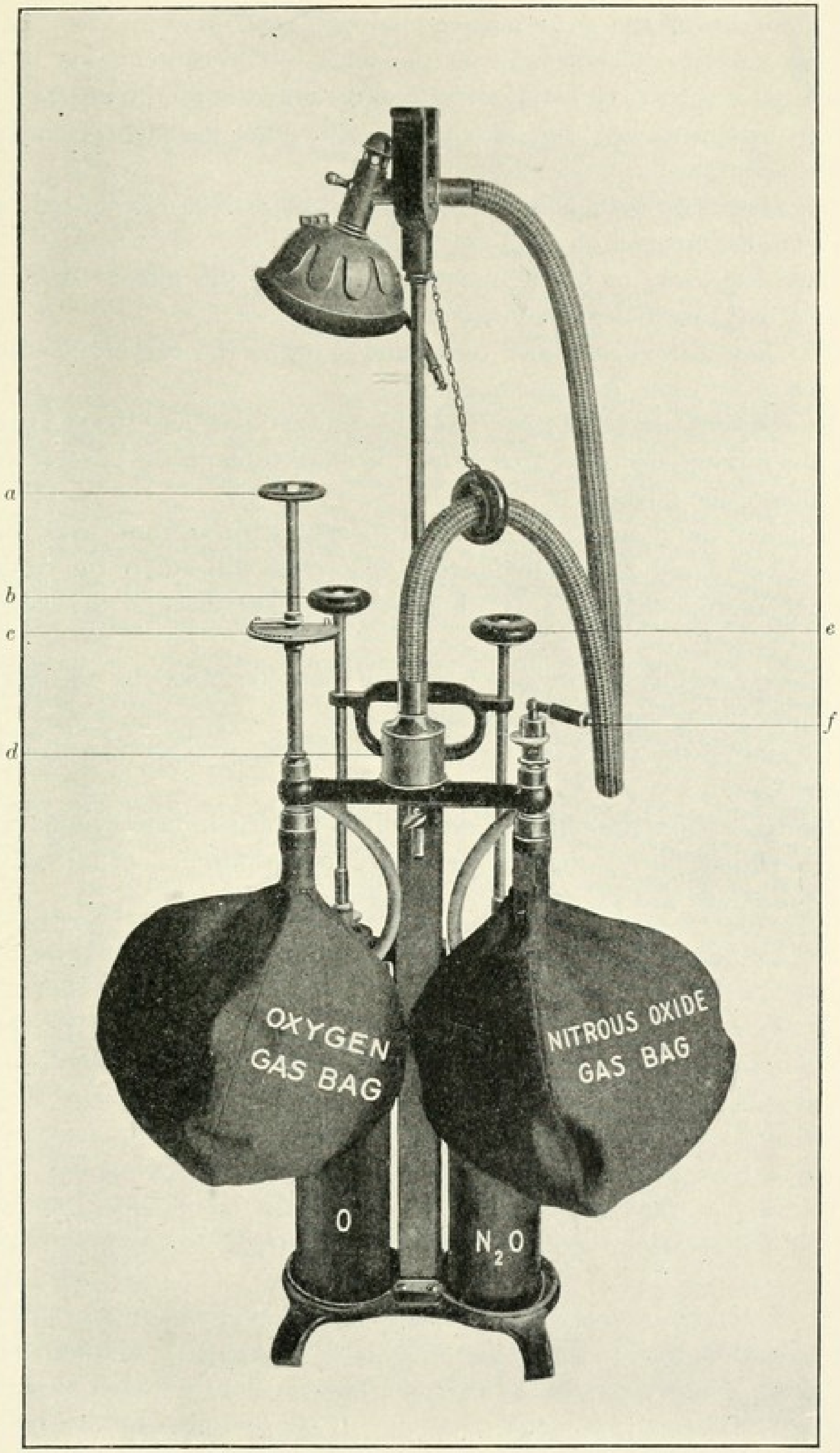
FIG. 569.



Showing arrangement of the mixing-chamber, with dial and valve for controlling the relative proportions of the gases.

No fixed rule can be laid down for the quantity of oxygen to be added, as each case will require a different amount and this amount varies during the several stages of the anesthetic procedure. The operator is guided entirely by the symptoms of the patient during the administration, his object being to avoid on the one hand the tendency toward asphyxia indicated by cyanosis of the lips, and return of consciousness and sensation on the other hand, which is easily produced by an excess of oxygen. By the admixture of oxygen, as in Dr. Hewitt's method, the anesthesia is somewhat prolonged over the ordinary nitrous oxid method and is slower of induction, but there is entire absence of cyanosis, stertorous breathing, jactitation, or any of the symptoms of asphyxia. The modification of the Hewitt apparatus that has been lately introduced embodies certain features that make it an improvement on the original apparatus. The arrangement of the mixing-chamber in reference to the bags containing the gases is such as to enable the operator to more accurately control the mixture that is

FIG. 570.



Apparatus for administering nitrous oxid and oxygen combined: *a*, key to oxygen bag; *b*, key to oxygen cylinder; *c*, gauge showing percentage of oxygen being administered; *d*, mixing-chamber; *e*, key to nitrous oxid cylinder; *f*, key to nitrous oxid bag.

administered to the patient. By a turn of the levers *a* and *f* (Fig. 570) any gradation of the gases may be obtained, from pure nitrous oxid on the one hand to pure oxygen on the other. The construction of the apparatus is such as to better withstand the climatic conditions than the Hewitt apparatus. A brief description will suffice to show the working of the apparatus.

There are two cylinders, one containing compressed nitrous oxid and the other compressed oxygen.

Two bags, one of black material containing the nitrous oxid, the other of red material containing the oxygen.

The key to each cylinder (see *b* and *e*) opens the valve and allows the gas to pass into its respective bag.

By opening the valve (see *f*) of the nitrous oxid bag the gas passes into the mixing-chamber, from which it flows through the covered rubber tube to the inhaler.

When it is desired to combine oxygen with nitrous oxid, open gauged valve (see *a*, *c*) to the oxygen bag; this will admit the oxygen into the mixing-chamber. Both gases will pass through the tube to the inhaler.

The proportion of oxygen used will be determined by the degree to which the gauged valve is opened.

By closing the valve of the nitrous oxid bag, oxygen can be given separately.

Similar results are obtained when air is admitted, instead of oxygen, to the patient during the nitrous oxid administration. The details of this procedure are set forth in the following chapter.

CHAPTER XXI. (Continued).

EXTRACTION OF TEETH UNDER NITROUS OXID ANESTHESIA.

By J. D. Thomas, D. D. S.

Where the operation would cause excessive pain, the extraction of a tooth without the aid of an anesthetic is to-day little short of barbarous. It is cruel to the patient, and if the subject be a child, wantonly so. Very few people can submit to the operation without more or less physical resistance, and even though this be involuntary no operator can do full justice in such a case, no matter how skillful he may be. Such resistance causes more or less unnecessary strain to be applied in one direction or another against the process, which results in increased inflammation as a sequence. Besides, as a rule the liability of breaking the tooth or portions of the alveolar plate or other accidents is increased a hundredfold.

Nitrous oxid is in all respects the very best anesthetic for the purposes of the dentist. Properly used, it is almost entirely free from danger and is rarely productive of nausea or depression as an after-effect, even temporarily. It seldom requires over sixty seconds to produce anesthesia, and in less than that period of time the patient is fully recovered, with no knowledge of the operation, and is ready to depart as soon as bleeding ceases. To accomplish such a result, of course, requires experience and some degree of dexterity, but the conditions are such that any dentist with a fair amount of experience can operate successfully with it for the removal of from one to four or five teeth, and perhaps more—the main essential in operating by the aid of nitrous oxid being to utilize every second of time during the period of anesthesia, and not to waste it in hunting forceps or deciding how they should be used.

The best success is obtained by formulating a system of working by which one can accomplish the most in the shortest space of time. The operating period seldom extends over forty-five seconds and often less, so that every second wasted in any way whatever is so much time lost, and success is diminished to just that extent.

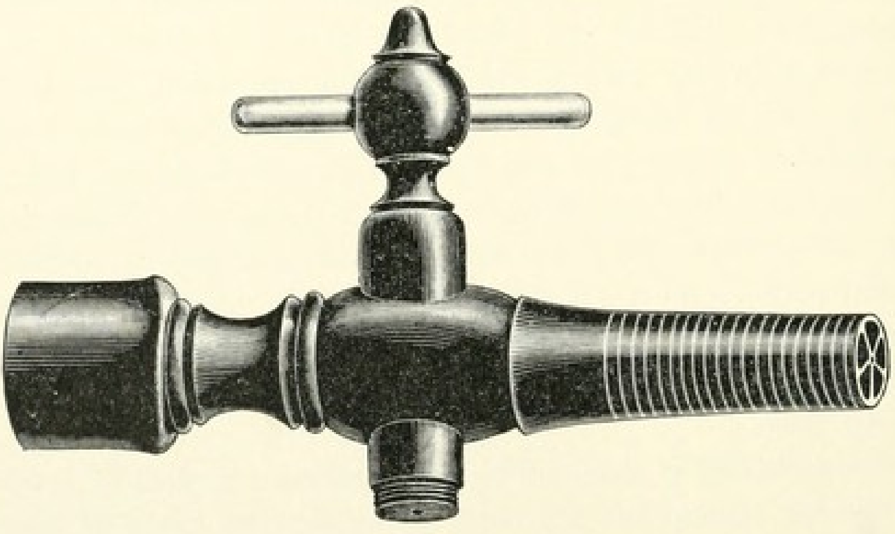
Nitrous oxid must be absolutely pure, and if be kept over water it must be fresh. In former times when the dentist manufactured his own gas, to insure perfect purity it was necessary to test the ammonia nitrate before using it for making the nitrous oxid, but at the present day the pure gas is made with great accuracy by the manufacturers and is supplied chemically pure, compressed in cylinders, so that the individual dentist is relieved of the responsibility of manufacturing his own gas and of the troubles necessary to secure purity.

The first essential to success in its administration is a perfect INHALER. This should be sufficiently large to permit the patient to breathe without the slightest exertion. Patients are always in a more or less nervous state upon approaching the dental chair for extraction. There is usually accelerated heart-beat and consequently deranged respiration, and unless they can breathe through the inhaler with perfect freedom they labor under a sense of suffocation which adds greatly to their apprehension and disturbs their equanimity while passing under the influence of the anesthetic.

The inhaler shown in Fig. 565 is perhaps the best one upon the market, but has the disadvantage of having hard disk valves, and while the size is sufficiently large for most purposes the space between the outer circumference of the disk and the inner circle of the pipe is so small that it does not at all times permit of free ingress of the gas to the lungs, and, besides, such valves are not always airtight.

The best inhaler is one made of vulcanized rubber turned to the proper dimension and fitted with valves made of rubber dam (Fig. 571). These valves have the property of fitting closely, making the

FIG. 571.



Thomas's inhaler.

passages airtight, and being flexible they admit the gas to the lungs with little or no obstruction. This inhaler is the one employed by most operators who make a specialty of extraction, and is made only upon special order.

In giving nitrous oxid it is necessary that the valves of the inhaler shall be airtight, for if there is a leakage by which air is constantly being admitted, it will interfere greatly with the production of the desired results. *The hood face-piece should never be used.* Aside from the impossibility of fitting the face so closely as to preclude the admission of some air during the administration, particularly when beard exists, it covers the lips from view, and these are an important index during the process of anesthesia; the color of the blood as shown through the mucous membrane of the lips should never be lost to sight.

There is no separation of the elements of nitrous oxid at the temperature of the human body, or during its inhalation, consequently it is practically an inert gas so far as its power to support life is concerned. It possesses strong anesthetic properties but it is also to a degree productive of asphyxia, and the color of the lips must be observed as a guide to indicate the extent to which asphyxia is taking place. It has been previously said that the valves of the inhaler must be airtight, for a constant leakage of air will prevent the production of complete anesthesia, and yet at the proper time during the inhalation the admission of air, controlled by opening the nose or raising the lips, is not only desirable but essential to the proper and successful exhibition of the anesthetic.

By the judicious admission of air at the proper time the accompanying symptoms of approaching asphyxia are obviated and perfect anesthesia is secured without any of the convulsive muscular twitching which takes place when the pure gas is given. Dr. Hewitt of London advocates the admixture of oxygen with nitrous oxid, for which he has introduced the appliances described on p. 624, but by admitting air as here suggested similar results are obtained with less manipulation.

The use of props to keep the jaws open is necessary to insure success. They give free scope for operating, and there is no time lost in prying the mouth open, as nearly always happens when props are not used. Props made of hard wood and of different sizes are the most satisfactory; they should have strings attached, more to reassure the patient than for any other reason. Unfortunately, a number of years ago a patient died as a result of getting a cork in the larynx, and this has never been forgotten. Consequently the string is an assurance to the patient that the prop cannot slip down the throat.

The ordinary dental chair is not desirable for use in administering nitrous oxid, particularly those chairs having stationary footstools attached. Patients are sometimes restless, and every motion made by the feet upon a fixed footstool will produce a responsive movement of the body, thereby increasing the risk of accident to the part being operated upon. A detached stool upon casters is easily pushed away, so that any disposition to move the extremities may be permitted without affecting the stability of the upper part of the body.

This apparent resistance on the part of the patient is not necessarily the indication of a knowledge of what is being done; the upper brain function may be paralyzed while the sensory peripherals and motor ganglia are not, under which circumstances the patient is not thoroughly anesthetized. Resistance may take place at the beginning or just at the termination of the anesthetic procedure, and if the operator ceases at once the patient will declare absolute unconsciousness of the operation. It is, however, sometimes permissible to operate during the stage just noted in cases where the systemic conditions are such that it would be unwise to carry the patient to the state of profound insensibility. These are, however, exceptions and not the rule. To have the exhibition perfectly satisfactory there should be no resistance or outcry.

A competent *assistant* is necessary, not only as a protection against charges which might be suggested by lascivious dreams—as has occurred when ether has been employed (though the period of insensibility under nitrous oxid is so short that it would seem that no one, however evilly or honestly disposed, could ever sustain such a charge)—but an assistant can render much aid by holding the tube, lowering or raising the head, taking care that the operator does not bruise the lips, holding the patient if restless, particularly the hands, and waiting upon the patient during recovery from the anesthetic.

The assistant should be a woman, as it adds very materially to the comfort of female patients to have such a person in attendance.

The operator should receive the patient in such a manner as to inspire entire confidence. If necessary, any doubts or possibilities of accident should be clearly explained to the patient, so that in the event of untoward results there will not be a humiliating sense of failure.

The patient is seated, and after a careful examination has been made and the condition of the tooth or teeth is ascertained, the prop is placed where it will be least in the way. The assistant then places the tube in the mouth and the patient is directed to close the lips and breathe through the mouth instead of the nose; in the meantime closing the nostrils with the third finger and thumb of the left hand, the first and second pressing the upper lip about the mouthpiece, while the thumb and fingers of the right hand support the lower lip.

While inhaling the gas it is desirable that patients should breathe as in ordinary respiration, for two reasons: First, if instructed to take long and deep breaths they exert themselves beyond their natural rhythm, and with unconsciousness comes involuntary suspension for some seconds, and should it occur in one who becomes quickly asphyxiated the few seconds of suspension are sufficient to produce alarming symptoms which will require some effort to counteract. Second, if the patient breathe slower or less deeply than is natural there is a sense of suffocation produced which grows in intensity until unconsciousness supervenes, when the lungs and diaphragm will exert their function, producing violent respiratory effort which will be followed by marked exhaustion upon recovery. None of these effects need be produced if the operator have complete control of the situation.

No one can explain the symptoms of approaching and complete anesthesia in such a manner as will inform a novice sufficiently well to undertake the responsibility of administering the gas; these can only be learned through observation and experience, but the first prominent indication will be a discoloring of the lips and subsequent pallor of countenance, which is not, however, an indication of cardiac depression, but is due to the blood color shown through the skin. Should the patient be of the blonde and florid type this appearance will be more marked, and it is here that the admission of a small amount of air is called for, particularly if the blueness seems to approach more rapidly than the anesthesia.

If the pure gas is given to complete narcosis, there will be twitching of the muscles of the neck and wrists. Stertor and irregular breathing and sometimes decided convulsive action occur, which to one inexperienced becomes distressing, if not alarming, to behold.

All these symptoms are at once relieved by air-breathing, and if there is a judicious admission of air during the administration of the anesthetic they will be avoided entirely.

The patient being anesthetized—and the instruments being always in place so that there will be no delay in picking up the pair of forceps required, so that every second of time may be utilized by the work in hand—the next step is the extraction.

The Operation of Extraction.—The proper way to perform the operation is to stand in one position, at the right side of the patient, during the whole proceeding. For extracting with the greatest facility the operator should assume such a position that in standing erect the patient's head will be about opposite his upper waistcoat pocket. To do this a pair of stools should be used, one just back of the chair and one by the side which may be easily pushed aside when not needed. While administering, the operator can stand upon the floor, and ascend the stool just before the time for operating. This position is assumed by the most successful operating specialists, and is adopted as the result of long experience and dictated by the desire to bring about a position for work which permits of its most rapid performance and at the same time enables the operator to bring to bear the greatest amount of force with the least physical exertion.

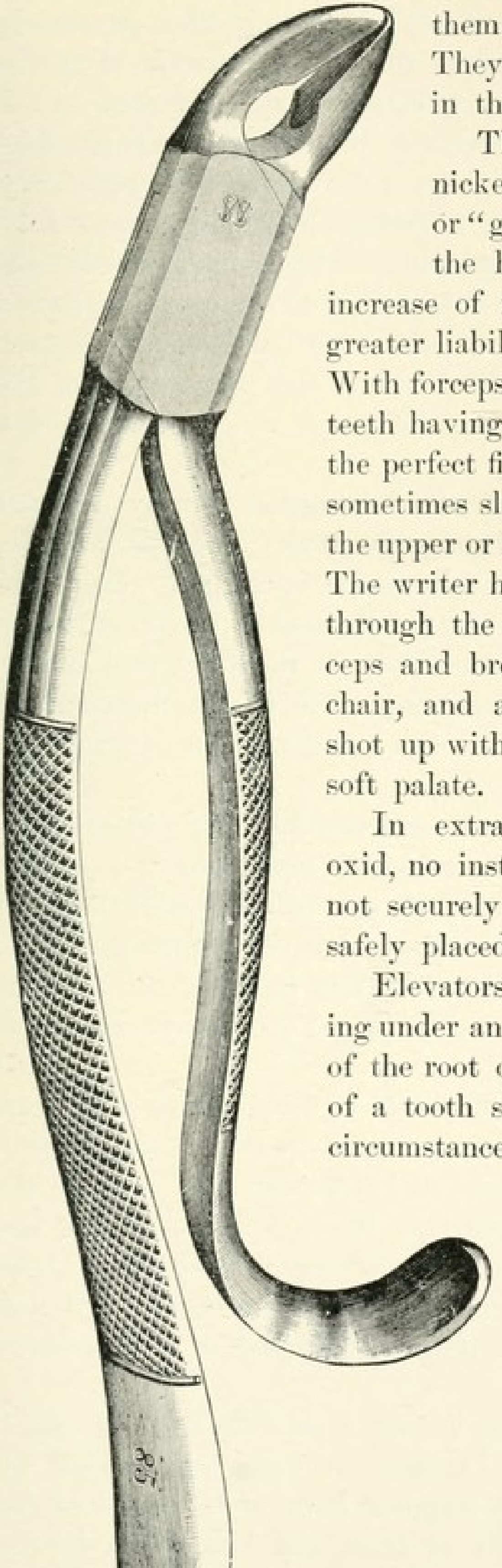
When extracting, for example, a lower tooth, and it is necessary to force the beaks of the forceps well down through the process, the instrument is manipulated by the hand and wrist with the arm held closely to the body to steady it. The weight of the body is allowed to descend to the proper degree by bending the knees, and when the forceps are fixed, should force for pulling be required, the straightening of the knees will raise the body, the arm being held firmly as described. The hand will be used exclusively for manipulating and guiding, while the force will be supplied by straightening the knees much the same as is applied in lifting weight from the ground. Of course, to become expert one must have all of his limbs equally trained.

In operating on the upper jaw the method is much the same, only reversed, bending the knees first to lower the body and forcing the instrument to position by straightening and throwing as much of the bodily weight upon the arm, by bending the knees, as is necessary for pulling. By so doing a tooth will never be allowed to leave the socket suddenly as by a jerk, for the operator has perfect control of his hand and wrist, and the danger of bruising the opposite teeth in either jaw by the forceps is avoided.

THE FORCEPS.—Seven pairs of forceps are all that are used by the writer for extraction in ordinary cases. For the upper teeth, a right and left pair for the molars, a bayonet-shaped instrument with the outer beak pointed to fit between the buccal roots, and both beaks serrated. In working upon both sides of the mouth a pair without pointed beaks may be used with advantage to avoid changing. One alveolar pair suffices for the roots of all molars and bicuspids on either side. These are made bayonet-shaped with smooth concave beaks, but having well sharpened edges. The pair for the incisors is straight, with beaks similar to the alveolar pair, and when extracting, say all the upper teeth, can be used upon all ten front ones with equal facility.

For teeth in the lower jaw the molar pair is made with both beaks pointed, serrated, and gracefully curved so as to bring the force as nearly direct as possible; these are equally applicable for all the molars on either side and are shaped the same as the alveolar pair. The alveolar pair are shaped the same as those for the molars, have smooth concave beaks with sharp edges, and are used for all molar roots and bicuspids (Fig. 572). The pair for front teeth is curved under the handle and may have serrated beaks, as the roots of the lower centrals and laterals

Fig. 572.



Alveolar forceps.

are so flat that a sharp beak is apt to cut them off, if too much grasp is applied. They seldom require the force necessary in the extraction of other teeth.

The writer prefers forceps that are not nickel-plated, as this imparts a slippery or "greasy" feeling to the handle, making the hold less secure, which induces an increase of force in the operator's grasp, with greater liability of cutting or crushing the teeth. With forceps having beaks that are not serrated, teeth having conical tapering roots will prevent the perfect fitting of the cutting edge; these will sometimes slip through the posterior opening of the upper or lower alveolar pairs with great force. The writer has seen, in one instance, a tooth slip through the beaks of an unserrated pair of forceps and break a pane of glass in front of the chair, and an under single molar root which shot up with sufficient velocity to penetrate the soft palate.

In extracting, particularly under nitrous oxid, no instrument should be used which will not securely retain any tooth or root until it is safely placed outside the mouth.

Elevators are wholly out of place when working under an anesthetic. They permit no control of the root or tooth whatever, and the liability of a tooth slipping into the throat under such circumstances is too great to warrant the risk.

The art or "knack" of extracting does not consist of giving a rotary motion to one kind of tooth and a lateral or "in-and-out motion" to another, but rather of "working" the tooth in the socket without any pulling until it is started or loosened from its attachment, when the pulling force may be applied, and to do this the forceps must be placed upon a tooth so nicely that the tooth and instrument will feel to the hand as one continuous object, so that the slightest motion in any direction will have immediate effect in "starting" the tooth. The operation is completed by continued working while the pulling is applied in the direction which will prove the most effective in dislodgment.

This "working" should be done with as little motion as is possible, for the smallest degree of straining upon the process laterally only adds so much more distention to the alveolar plates, and increases the inflammation and pain after the operation. When nitrous oxid was first introduced and extracting was transferred to those who made it a specialty, it was noticed that there was less soreness of the mouth following the operation, and it was thought by some that the oxygen of the gas produced a beneficial effect upon the blood which caused better healing, but such is not the case.

The object, in extracting, of one who becomes expert by constant practice is to save the surrounding parts from all unnecessary strain, consequently less pain and soreness follows the operation. There are teeth having curved and divergent roots, and cases of exostosis, which will require great effort to remove, but even in these the position assumed and the process of "working" the tooth in the direction of the force applied all tend to accomplish the result with less injury than would be otherwise produced.

In this way the breaking of a tooth need seldom occur unless intentionally. If in extracting an upper or lower molar one finds by the extra amount of force required that it will not readily yield, then it is better to break the crown off and with the sharp alveolar forceps remove the roots separately. This can be done with less injury to the alveolar plates than if much greater force were applied to remove the tooth as a whole.

There will be cases of fracture of points of roots which are much curved or divergent, but many of these retained fragments may be permitted to remain until in the process of exfoliation they come to the surface if their retention is regarded as likely to give rise to less trouble than the injury incident to their removal would cause. But these need rarely occur if the operator has by experience acquired that sense of feeling which tells him at once the direction of the curve or the size of the exostosis.

Inverted or impacted third molars are the most difficult cases which present themselves for extraction. Instead of being surrounded by pliable process they are planted in compact bone at the angle of the jaw, bound in by the second molar in front and hard bone on the buccal side, so that above it in the angle is the only direction offered for removal, working them toward the tongue where the bone is thinnest.

In addition to the difficulty in removing these teeth, this severe process of pressing the inner alveolar plate toward the tongue excites a state of inflammation, easily communicated to the soft tissues of the throat, and the after-effects assume in many cases such serious conditions that it is better practice to remove the second molar.

If the third molar is sound it may remain and will cause no further trouble, as the primary difficulty was caused by crowding and pressing upon the second molar; and should it be necessary, from decay, to remove it, the extraction of the second molar first, renders the operation simple and easy of accomplishment.

CHAPTER XXI. (Concluded).

LOCAL ANESTHETICS AND TOOTH EXTRACTION.

By Henry H. Burchard, M.D., D.D.S.

Prior to the discovery and application of cocain, the local anesthetics employed to produce a condition of analgesia of the structures surrounding a tooth to be extracted were sprays of extremely volatile substances. Through the rapid evaporation of a spray of one of the lighter hydrocarbons, a condition of refrigeration of tissues was brought about during which a tooth could be extracted painlessly. Sprays of rhigolene and of ethylic ether have been superseded by those of ethyl and of methyl chlorid, these substances being more volatile; directed in a fine spray over the gum of the tooth to be extracted, an intense local anemia is produced, and as a consequence analgesia results. If the refrigeration be rapidly produced and the operation be performed promptly upon the attaining of analgesia, the frozen tissues recover with but slight reaction. It is to be remembered that the tissues are frozen, and if the action be prolonged a condition akin to chilblain is present. The mode of application is as follows: All of the mucous membrane, except that over the roots of the doomed tooth, is to be protected from the spray by means of napkins. The spray is directed against the exposed gum, the vial containing the ethyl chlorid being held about a foot from the mouth. When the gum becomes intensely anemic, indicated by pronounced whiteness, the tooth is to be extracted. Ethyl chlorid must be kept in a cool place, and far from any flame; it is inflammable and explosive.

Preparations containing cocain (benzoyl-methyl-ecgonin) have to a great extent superseded all other local anesthetics employed for this purpose. It was clearly shown soon after the introduction of this alkaloid that its local anesthetic action when applied to the gums did not extend beyond the depth of the mucous membrane, so that its epidermic application does not render the operation of tooth extraction painless. The hypodermatic application was found to render the tissues infiltrated perfectly analgesic. A recklessness was evinced in its use after this method which was promptly followed by repeated disasters;

a formidable list of casualties grew. Reports of cases of respiratory and of cardiac paralysis following its employment were not uncommon. It apparently needed disaster to demonstrate that cocain belonged in the category of actively poisonous alkaloids, being by no means the bland and safe agent many operators seemed to think it. This lesson, learned at great cost, is one the operator is ever to heed, particularly in the hypodermatic employment of the agent. Dr. M. H. Cryer has reported[1] cases of ascending degeneration of the trunks of the maxillary nerves following upon cocain injections about the jaws.

For the origin, composition, physiological effects, and toxicology of the drug the student is referred to the standard works upon materia medica. There are several points, however, which cannot be over-emphasized, the first being in regard to the drug itself. A full dose of cocain hydrochlorid by the stomach is about gr. $\frac{3}{4}$. The composition of the commercial specimens is not constant; some of them appear to contain the actively poisonous alkaloid isatropylcocain. A safe dose when applied hypodermatically is not in excess of gr. $\frac{1}{8}$.

The lethal effect of cocain is upon the respiratory centre. Its absorption is followed by a stimulation of the cardiac and respiratory functions, which is commonly followed by a reaction, the stimulation giving way to depression. Idiosyncrasies as to the effects of cocain are common; cases of susceptible women have been noted in which gr. $\frac{1}{8}$ produced toxic effects. It is to be noted that the depression following as a secondary effect upon the primary stimulation may not occur for an hour or later.

In prescribing cocain for hypodermatic injection, the analgesic is the first element to be considered in the prescription. The dose is not to exceed gr. $\frac{1}{8}$. The second factor demanding attention is a physiological antidote, one which will not neutralize the analgesic effect and yet will prevent the toxic action of the cocain upon the cardiac and respiratory functions. Morphin is that agent. As its full physiological effect is not required, a small dose, gr. $\frac{1}{12}$, will be sufficient. The next ingredient of the prescription is an agent which shall prevent abrupt spastic contraction of the arteries and heart. Trinitrin is this agent. One drop of the 1 per cent. solution is the indicated dose.

Fungi develop freely in solutions of cocain, so that if the prescription is to be a permanent solution, an antiseptic is required to prevent decomposition. Cinnamic alcohol answers well for this purpose. One drop of carbolic acid to each half-grain of cocain is an efficient antiseptic. By boiling cocain is split up into methyl, benzoic acid, and ecgonin, so that cocain solutions cannot be sterilized by boiling.

[1] *Proc. Academy of Stomatology, Philadelphia*, 1896.

The dose commonly employed of the components of the prescription is—

℞.	Cocainæ hydrochlorid.,	gr. $\frac{1}{8}$;
	Morphinæ sulph.,	gr. $\frac{1}{12}$;
	or Atropinæ sulph.,	gr. $\frac{1}{150}$;
	Trinitrin. (1 per cent. sol.),	gtt. j;
	Acid. carbolic.,	gtt. j;
	Aquæ,	q. s. ℥ss.—M.

S. The above represents a half-syringeful and is a full dose.

This solution has been employed with general success, provided strict antiseptic precautions have been taken. Untoward results are occasionally found even with this seemingly safe formula.

In the hypodermatic use of cocain the relatively safe maximum dose should never be exceeded and the exact amount administered in a given case always definitely known. A common error has been the dependence upon solutions of a given percentage composition. The danger of such dependence becomes evident when it is considered that the safe maximum dose of cocain salt may be easily exceeded by the use of a sufficient quantity of a low-percentage solution, while on the other hand it is quite possible to keep within the limits of safety by using minute quantities of a high-percentage solution. The supposed harmlessness of a dilute cocain solution is erroneous and misleading unless the factor of the absolute quantity of the drug contained in a given amount of solution is constantly kept in mind.

A method which is in all respects safer and which enables the operator at all times to know the exact amount of cocain salt injected is to make the solution upon the basis of eight grains of the salt to one ounce of the menstruum, which will give one grain in each drachm and $\frac{1}{60}$ of a grain in each minim. Of such a solution from five to eight minims may be injected about a tooth with a reasonable degree of assurance that the safe limits of physiological effect have not been exceeded.

The menstruum in which these ingredients are combined is an interesting feature. It has been repeatedly shown that the injection of a quantity of water will produce anesthesia of a region. The nerve filaments are compressed by the fluid and do not transmit painful impressions.

Dr. Schleich of Greifswald[1] follows, for the induction of local anesthesia for operations in general surgery, an infiltration method. The injection is divided and the punctures made *seriatim* about the territory to be operated upon. The remarkable feature of his procedure is the minute dose employed. He uses a 1 : 4000 solution of cocain, to which

[1] T. Parvin, *Proc. Phila. Co. Med. Soc.*, Nov. 13, 1895.

is added $\frac{1}{5}$ of 1 per cent. sodium chlorid and a small quantity of 4 per cent. tricresol. One syringeful, about a drachm, is sufficient to infiltrate the tissues about a tooth and render its extraction painless. A drachm of the 1 : 4000 solution contains about gr. $\frac{1}{70}$ of cocain. The strongest solution employed by Schleich is a 1 : 500. A drachm of such a solution would contain less than gr. $\frac{1}{8}$ of cocain. Dr. W. F. Litch (*ibid.*) has pointed out that low-percentage solutions will give a safer result than those of high percentage, even though the absolute amount of the drug should be the same. It is seen, therefore, that the quantity of menstruum in which the dose of cocain is suspended is an important consideration.

Tablets for making Schleich's solutions may be had of pharmaceutists. Tablets for making the strong solution contain—

℞. Cocainæ hydrochl.,	gr. $\frac{1}{5}$;
Morphinæ hydrochl.,	gr. $\frac{1}{40}$;
Sodii chlorid.,	gr. $\frac{1}{5}$.

S. Dissolve in ♏ 100 of distilled water.

Almost without exception the nostrums advertised and sold under high-sounding titles, for employment in this field, contain cocain. Neither their names nor any information vouchsafed by their venders give any indication of the amount of alkaloid present, and so all of them should be tabooed. It is nothing short of criminal to employ these nostrums without a knowledge of their exact composition.

Tropacocain (benzoyl pseudo-tropin) has been employed to render the operation of tooth extraction painless. It possesses decided advantages over cocain. It is only one-half as toxic; has but slightly depressant action upon the cardiac ganglia; has no paralyzant action upon the respiration; anesthesia is more quickly produced, and its solutions are slightly antiseptic. Solutions of the drug are made in distilled water; the full dose is gr. $\frac{1}{3}$ to $\frac{2}{3}$.

The reader, of course, at once draws the correct inference that Schleich's method gives promise of safety. Applications made hypodermatically of the elaborated prescription presented are not without danger even in physiological dose.

It is necessary that the field of operation be made aseptic before injection. The mouth should be washed repeatedly with a powerful antiseptic, 3 per cent. pyrozone, 10 per cent. electrozone, or 3 per cent. formaldehyd solution.

The syringe should be aseptic; repeated washing of syringe and points in a 25 per cent. solution of phénol sodique will serve this end without detriment to the syringe piston or the metallic parts of the syringe. A syringe having stout finger-rests and holding one drachm is employed. The needles should be reinforced for half their length, and should have sharp, fine points.

The gum is to be dried and touched with a 20 per cent. solution of cocain; in five minutes the needle may be inserted painlessly. The syringe is filled with the analgesic solution, the needle screwed on, and the piston pressed down until all air is expelled from the syringe and needle. The latter is now thrust into the gum about midway between the neck of the tooth and the apex of the root, until it comes in contact with the alveolar process, when it is slightly withdrawn and a few drops of the solution are driven into the tissues. A second injection is made over the apex of the root; if the strong solutions be used, the amount of fluid injected must not contain more than gr. $\frac{1}{8}$ of cocain; even though several punctures be made. Care must be exercised to confine the injection to the tissues of the gum; if the submucous tissue beneath the junction of the cheek and gum be injected into, alarming emphysema may result.

For multirooted teeth an injection is made over each root. If Schleich's solution be employed, a full drachm of fluid should be injected, until the gum over the tooth is tense and white, when extraction may be accomplished painlessly.

In some instances the intense anemia present at the moment of extraction may be succeeded by local hemorrhage as soon as reaction is established. An antiseptic hemostatic should be applied to the alveolus after extraction; phénol sodique, full strength, is an admirable agent for this purpose.

The imminent dangers to be feared in this connection are: first, the toxic effects of the drug. As these are usually manifested in contraction of the bloodvessels the antidote is amyl nitrite. A supply of pearls each containing ♏iij of amyl nitrite should be kept in the medicine cabinet. When a patient exhibits great pallor, a small pulse, and bluish-white lips, one of these pearls is crushed in a napkin and the nitrite quickly inhaled. The conjoint administration of gtt. xx. aromatic spirits of ammonia, or about half an ounce of brandy, is advised. Should these measures not prove promptly effective, artificial respiration should be immediately begun and be prosecuted vigorously.

The second danger is septic infection, either through imperfectly sterilized instruments or by carrying septic organisms from the mucous membrane covering the gum into the deeper tissues during the operation of injection. This is avoided by a careful sterilization of the syringe before it is used, and the repeated applications of antiseptic mouth-washes previous to injection. Prescriptions which contain a large percentage of carbolic acid are liable to cause sloughing.

Injections forced between the periosteum and bone may produce serious injury.

The introduction of **eucain** as a local anesthetic was due to the observed chemical similarity of that synthetic body with cocain; an instance of presaging the physiological effects of a drug by its chemical composition. Its local effect upon bloodvessels is to produce hyperemia, instead of the ischemia induced by cocain. It is less poisonous than cocain and its solutions are chemically more stable. Its primary action upon the central nervous system is one of exaltation, and this is followed by paralysis, the effect being central, not ascending. The sedative central influence causes a quickening of the heart-beats through sedation of the inhibitory (pneumogastric) nerves. Although eucain is less toxic than cocain it also produces a greater degree of analgesia; so that the dose need not be greater than that of cocain, about $\frac{1}{2}$ to $\frac{3}{4}$ of a grain being the maximum.

Eucain may be kept in permanent and stable solution in distilled water. A 10 per cent. solution may be made in distilled water (48 grains of eucain hydrochlorid to the ounce of distilled water) and the solution sterilized by boiling, which does not decompose eucain. From five to eight minims of such a solution is a proper dose. The precautions to be observed and the mode of application are the same as for cocain.

Besides the dangers arising from the hypodermatic administration of a physiological overdose of this class of analgesic drugs, and the local danger of infection from non-sterile solutions or instruments, there is to be strongly emphasized the danger of local necrosis due to the poisonous effect of the drugs themselves upon the tissue elements when directly injected. In nearly all cases in which extraction is sought the tissues about the tooth are in a condition of lowered vitality, brought about by the local toxemia resulting from the infection which has produced the inflammatory process. The injection of a protoplasmic poison, such as cocain, eucain, and their congeners, into the inflamed territory causes a still further depression of vital resistance, which, if sufficiently pronounced, may become total and permanent. Hence, tissue-death or necrosis, with subsequent sloughing, will necessarily result.

Where the inflammatory process about a tooth is at all pronounced, it is much wiser to discard local anesthetic methods for the far safer procedure of general anesthesia induced by nitrous oxid or ether.

CHAPTER XXII.

PLANTATION OF TEETH.

By Louis Ottofy, D. D. S.

The transplantation of a tooth signifies the insertion of a natural tooth into a natural alveolus other than the one it originally occupied. The tooth may be an old and dry specimen transplanted into an alveolus from which a tooth has been recently removed, or it may be a freshly extracted tooth transplanted from one part of the mouth of an individual to another part of the mouth of the same individual, or it may be a freshly extracted tooth transplanted from the mouth of one person into that of another.

Replantation signifies the replacing of a tooth in the alveolus whence it had been removed by design or accident. The operation may be performed at once or at any time before the socket is filled with new tissue.

Under the term implantation are included all those operations which involve the formation of an artificial alveolus for the reception of the root of a human tooth. The operation of altering the size or form of an existing alveolus to receive a tooth belongs to this class, although it is a combination of trans- and implantation.

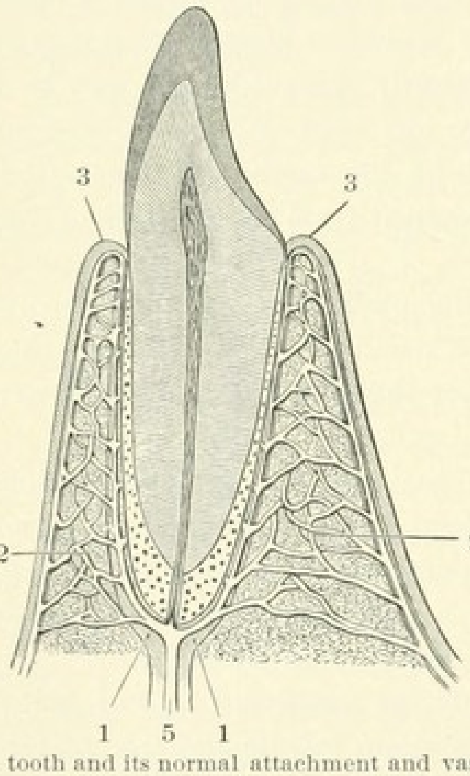
The operation of replantation probably far antedated that of transplantation, as the latter preceded implantation, but its definite history is unknown. It is safe to presume that it has been practiced ever since mankind conceived of the natural healing power of the body. Even when performed with crudity and without any clear comprehension of the mode of repair, favorable results have been reported. The operation is at present an uncommon one: the condition for the relief of which it was at one time practiced with comparative frequency, chronic alveolar abscess, has been found amenable to less radical treatment.

The operation of transplantation is first noted in the writings of Ambroise Paré in the sixteenth century, though credit has generally been given to Dr. John Hunter, who gave the subject considerable attention. Hunter's experiment of implanting a tooth in the comb of a cock is classical. The records of the operation do not exhibit any great measure of success attending it. Hunter noted cases of transplantation of dead teeth which remained for years.

No one disputes with Dr. Younger of San Francisco the authorship of the operation of implantation. The date of his first operation was June 15, 1885, although Bourdet in 1780 was the first to mention the operation, stating that "irresponsible persons claim to make a socket, and implant into it a tooth." An attempt at partial implantation is recorded in *Dental Cosmos*, vol. xix. p. 258.

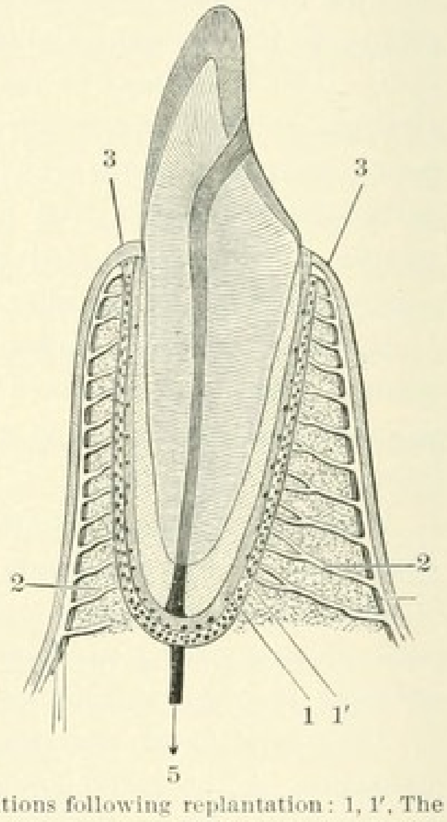
In order that an intelligent conception may be had of the intimate nature of the biological conditions which surround the teeth after insertion by either of these operations, it is essential to study the general

FIG. 573.[1]



A tooth and its normal attachment and vascular supply: 1, 1, Apical pericementum in which is seen the main pericemental artery, 5; 2, 2, anastomosing bloodvessels or channels of the alveolar walls; 3, 3, the marginal anastomosis of alveolar and pericemental arteries.

FIG. 574.



Conditions following replantation: 1, 1′, The pericementum and inflammatory effusion between pericementum and alveolar walls; 2, 2, source of blood-supply to the area of repair; 3, 3, terminations of alveolar arteries; 5, obliterated apical artery.

processes which attend the repair of tissues, and their behavior toward foreign bodies.

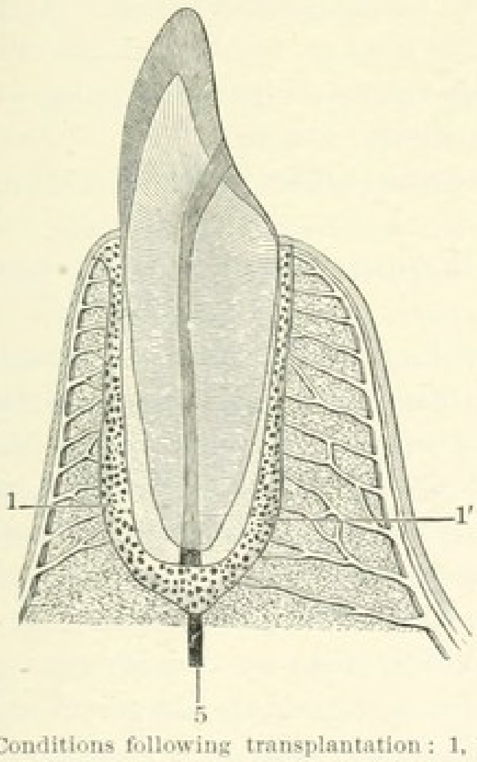
As all of these operations are performed under the strictest antiseptic precautions, the consideration of bacterial influence is omitted at this juncture. As it is impossible to secure specimens which would show these several parts in their true relations, the illustrations are necessarily diagrammatic and theoretical.

[1] Figs. 573–576 are from drawings by Dr. H. H. Burchard.

Fig. 573 exhibits a longitudinal section of an incisor, its attachments and support, together with its vascular supply, in its normal relations, the bloodvessels from the pericementum anastomosing with those of the alveolar periosteum. The pericemental space is filled with fibrous tissue. To avoid confusion the nerves and veins have been omitted.

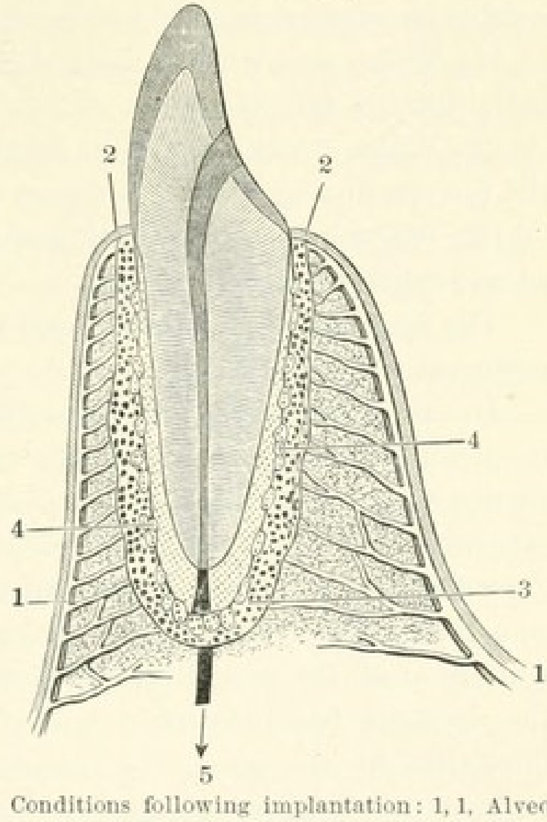
Fig. 574 represents the conditions following replantation. The tooth has been sterilized and its pulp canal hermetically sealed. The pericemental bloodvessels have been destroyed in extraction. Portions of the pericementum are seen clinging as fibrous remnants to the cementum. The remainder of the alveolus is filled with inflammatory corpuscles. The vascular supply to the regenerated pseudo-pericementum is derived first from the vessels of the alveolar periosteum *via* the alveolar process.

FIG. 575.



Conditions following transplantation: 1, 1′, Embryonic tissue which will be organized into repair tissue replacing the original pericementum; 5, obliterated apical vessels.

FIG. 576.



Conditions following implantation: 1, 1, Alveolar arteries; 2, 2, gingival margin; 3, inflammatory still unorganized tissue filling the space between the cementum and walls of the artificial alveolus; 4, 4, phagocytes, multinucleated cells attacking cementum of implanted tooth; 5, obliterated apical vessels.

Fig. 575 shows the conditions existing soon after the operation of transplantation. The mechanical violence of extraction has irregularly enlarged the natural alveolus. The tooth, its apex rounded, is shown with the blunted extremity. The vascular supply is similar to that of Fig. 574. The alveolar space is filled with inflammatory corpuscles.

Fig. 576 exhibits the conditions probably existent soon after an implantation operation. The vascular supply is the same as shown in Figs. 574 and 575. Instead of having a layer of periosteal bone, the formation of the artificial alveolus is into the spongy medullary bone. The artificial alveolus, being necessarily different in size and outline from the tooth, is filled with inflammatory products. Some of the cells, becoming multi-nucleated, are seen to be exercising their phagocytic—or, in this connection, resorptive—function upon the cementum.

Replantation and Transplantation.

Replantation.—In the present state of dental practice the following conditions may be regarded as warranting replantation:

(1) When a tooth has been dislodged by traumatism, a blow by a ball, club, or fall, etc.

(2) When a tooth has been accidentally removed by the slipping of the forceps during the performance of a dental extraction.

(3) When some disease, otherwise incurable, affects either the root or some portion of its alveolus.

The first two causes are practically the most frequent under which replantation is justifiable.

In case a tooth has thus been dislodged and found, it should at once be cleansed of all foreign matter and then be carefully examined for fractures or other injury. Any cavities present should be filled, the contents of the root canal removed, and the space filled in the manner described later; fractured or abraded portions or surfaces are to be made smooth, and the tooth placed in an antiseptic solution. A careful examination of the socket should then be made. It will be noticed when the accident has befallen a young individual, that as a result of the flexibility of the bone, the alveolar process is seldom fractured—an accident more prone to happen in adult life.

Some discrimination should be exercised as to the promptness with which to replant the tooth. If there is considerable inflammation as the result of injury, it is not advisable to immediately replace the tooth. In that event the socket should be made aseptic and if possible normal hemorrhage re-established. As a general rule several days should be allowed to intervene when the inflammation is excessive; otherwise a tooth may be replaced at any time as soon as it has been prepared.

The governing pathological principle is as follows: Immediately after an injury, a certain amount of inflammation takes place and there is retrograde metamorphosis—a destruction or breaking down of tissue; and this is not the most favorable time to expect re-attachment to take place. As a rule, within a few days a building-up process, constructive metamorphosis, has set in, and the replacement of a tooth at this time is likely to be followed by more favorable results. This period sets in at any time from three days to a week, the socket being then partially filled with active living cells. Just prior to the replacement of the tooth the socket and the gum surrounding it having been cleansed and sterilized, the tooth itself being brought forth from its antiseptic medium, it must be promptly replanted. As a rule, constant but not severe pressure will permit the tooth to assume its original position in the socket, although sometimes it is necessary to remove a part of the apex of the root or slightly deepen the socket by means of a suitably shaped bur. It happens occasionally that the location of the tooth and the general surroundings are such that a tooth like this may be retained without any further attachment, but as a rule it is not safe to trust to uncertainties regarding the attachment of the tooth. An impression of the tooth and its neighbors can be quickly secured with Melotte's compound or in clay, a die is easily made, from which a cap, such as will be described, is quickly made.

It is needless to dwell upon the second cause mentioned. No dentist can ever be excused for accidentally removing a sound tooth, but in case the accident does happen the above procedure is indicated.

The opportunities enumerated under the third section are also, fortunately, exceedingly rare. The cases in which formerly replantation was resorted to, on the ground that the case was incurable, are now much less frequently met with, and when they are encountered they often yield to treatment, which is now more clearly understood—such as amputation of the root, removal of the necrosed portion of the alveolar process, etc. When, however, it has been decided to extract a diseased tooth and to replant it, diseased portions of the root should be removed and a sufficient time allowed to elapse before replantation for the socket and tissues to have assumed a healthy aspect, even if this should necessitate the enlargement of the socket.

In cases of pyorrhea alveolaris, which sometimes has been suggested as coming under this class, treatment by replantation is out of the question, provided the case has made sufficient progress to suggest such a course. Replantation implies the presence of a socket, and when pyorrhea alveolaris has made any great degree of progress, the socket is wanting. Hence it is but in rare cases that an attempt to cure by this method is justifiable.

Dr. Louis Jack[1] has recorded marked success in several cases attending an operation of modified replantation for the cure of some of the earlier phenomena of phagedenic pericementitis, notably the common malposition due to what has been termed voluntary tooth movement.

[1] See *Trans. Academy of Stomatology*, 1895.

Transplantation.—There is a broader range for the practice of transplantation than either of the other operations treated in this chapter. As has been seen, replantation is limited in its application, and implantation must, from the nature of the operation, be also confined to a comparatively circumscribed sphere.

The operation may be performed at any period of an individual's life, although as a rule young, vigorous, and mature adult life offers the greatest promise of success. Any socket in any part of the mouth, when placed in a healthy condition, is a more or less favorable location for the reception of a tooth about to be transplanted. It is true that sometimes a socket needs to be enlarged or deepened for this purpose, but this is a comparatively simple matter. Before the advent of the intelligent practice of crown and bridge work, treatment of diseases of the pulp and peridental membrane, the bleaching of teeth, and the intelligent practice of orthodontia, transplantation was resorted to as a remedy for the correction of many trivial disorders. In the light of the present day, transplantation is confined to sockets whence teeth have been removed for any cause which could not be remedied by some other method of treatment: sockets which remain as the result of the loss of teeth from accident of any kind (the lost teeth not having been recovered); from which roots beyond salvation have been extracted; from which diseased teeth must be removed; from which roots have been removed having carried crowns or having served as abutments for bridges until their period of usefulness has passed.

The same rule laid down for the care of a socket previous to replantation holds good for transplantation; namely, that inflammation must be reduced, and the tooth transplanted into the socket at a time when progressive constructive metamorphosis is taking place. This period is stated as usually from three to seven days after the removal of the tooth. In instances where considerable disease, such as a chronic alveolar abscess of years' standing has been present, even a longer time should be allowed to intervene before transplantation.

Preparation of Teeth for Plantation.

With the exception of such special directions as are necessary in each class of the operations described in this chapter, the following general directions are applicable to all cases.

The Scion Tooth.—For replantation a recently dislodged tooth is supposed to be at hand, hence there is a fresh tooth. For transplantation it is implied that the tooth is either at hand or about to be secured, but in a case of transplantation or implantation the age of the tooth may be unknown and indefinite. Teeth have been planted whose age and origin have been absolutely unknown, and they have become firm in their new locations. Nevertheless it seems reasonable to take the ground that whenever it is possible, teeth should be fresh and something of their previous environment should be known. There are no cases on record where disease has been transmitted through the medium of a planted tooth, although portions of the early literature of this subject do indicate such results. The principal objection to old and dry teeth is that, the water having been evaporated, these teeth are almost invariably fractured or cracked from shrinkage. When these fractures extend to the crown portion, the enamel frequently chips off within a short time after the tooth has been planted; while in some instances the entire root has been fractured. Another objection to teeth promiscuously gathered is that it is seldom possible to find teeth in which the crowns are sufficiently perfect to be serviceable and to be presentable in the mouth. The crown of a dry tooth permits of but slight alteration with the grinding stone or sandpaper disk without endangering its integrity; while if it is affected by caries to such an extent as to require an extensive operation, the life of the filling is likely to be of shorter duration than a similar operation performed on a freshly extracted tooth or a tooth with living connections. For this reason it is preferable to use only the roots of teeth, attaching to them artificial crowns. This permits the selection of a crown suitable in size, color, and shape, and which may be ground for articulating purposes—an important matter in these cases.

If therefore an old, dry tooth must be used, let it be carefully selected with regard to the absence of checks or cracks or fractures, and if it be impossible to secure a tooth with such a crown, let there be selected a good root to which a crown, as described later, can be attached.

If a freshly extracted tooth can be secured, even though the crown may be slightly carious, the necessary filling operation is advisable, and such a tooth should be used, if possible.

Root-filling.—Roots may be filled either from the apex or through an opening or cavity in the crown. Gutta-percha seems to answer all the necessary purposes, but for a short distance from the apical extremity it is well to fill with gold wire or foil.

Pericementum.—The theory that the pericementum becomes revivified does not seem to be tenable; at least the proposition that life is maintained in the pericementum for any considerable period of time after the tooth has been removed from vital attachment is not in accord with general physiological laws, although periosteum as a tissue maintains its vitality for a time after separation.[1] For the purpose of securing an attachment there is no necessity for the presence of the perice-

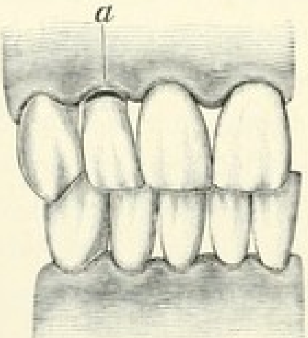
[1] See Ziegler's *General Pathology.*

mentum; but it is reasonable to assume that the nearer to natural states the root and the socket are in, the more favorable will be the prognosis. It is therefore a safe rule to follow, to preserve as much of the pericementum as is possible. The preservation of the pericementum has an advantage from the fact that after the tooth has been planted, the pericementum under the influences of bodily heat and moisture expands and thus acts in the nature of a sponge graft, enabling the tissues to more quickly obliterate spaces which are present and to attach themselves to the root.

Subsequent Care of Planted Teeth.—Numerous methods for the retention of planted teeth have been recommended by various authors at different times. While many of them are original and ingenious, all are to be condemned except those means which look to the firm, rigid, immovable retention of the planted tooth for a definite period, that of surgical repair. Neither the rubber-dam splint, silk ligature, nor gold or other metal wire comes under this heading. Planted teeth must be retained immovably for a period of two to six weeks, occasionally from two to eight, ten, or twelve weeks. The shortest time of immobility consistent with subsequent attachment is preferable. The tooth to be transplanted or implanted should be fitted after preparation in a model, made from an impression of the gum where the tooth is to be planted and of the adjoining teeth, as shown in Fig. 577.

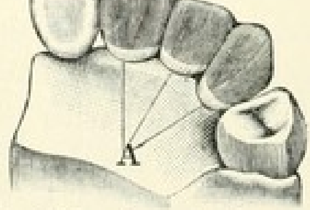
An impression is then taken of it and of the adjoining teeth on each side. A retention cap is then swaged to cover the grinding surfaces of three or more teeth, half the length of the crown on the labial surface and nearly the full length on the lingual or palatal surface, as shown in Fig. 578.

FIG. 577.



Model showing prepared tooth in place: *a*, Gold filling at cervical joint.

FIG. 578.



Model showing retention cap *in situ*.

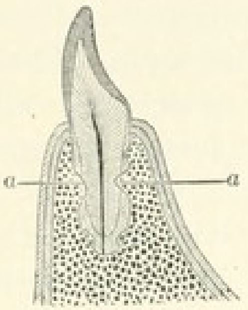
The cap may be made of pure gold, platinum, or German silver. The gauge, according to the metal used, should be from No. 32 to No. 38. This cap is cemented upon the crowns adjoining the planted tooth in such a manner that it may be removed without disturbing the planted tooth. The operator can remove the cap by springing the metal away from the teeth, examine the condition of attachment of the planted tooth, and replace the cap if it should be necessary. Where the articulation interferes with the retention of the cap, the latter may be ligated to the adjoining teeth in addition to being cemented to them, and still admit of removal without disturbing the planted tooth. There is at present no method of ligaturing or banding the teeth which will permit removal of the ligature or band without more or less disturbance of the planted tooth.

Aside from the necessity of immobility for a certain period, the planted tooth and surrounding tissue generally require but little attention. In occasional cases the tissues may be stimulated, by painting the gum with a mixture of equal parts of tincture of aconite root, chloroform, and iodin paint (the latter is a saturated solution of iodin in alcohol), or by the use of stimulating mouth-washes, notably those containing capsicum. The patient should be cautioned to encourage the downward growth of the gum by the use of the toothbrush, to prevent the accumulation of remnants of food or saliva, and to prevent their subsequent putrefaction should particles become unavoidably lodged around the tooth or cap. This is best accomplished by using a camel's-hair brush dipped in hydrogen dioxid or pyrozone, electrozone, meditrina, etc., washing out the interstices frequently. A syringe or spray from an atomizer may be used.

Artificial Roots.—Experiments have been performed looking toward the use of roots other than those of natural teeth. Roots made of ivory, corrugated or perforated porcelain, lead, gold, platinum, and other metals have been used. The writer's experiments in this direction have all resulted in failure. There is no recorded evidence that any have resulted successfully.

Mode of Attachment.—As to the mode of attachment of planted teeth the subject is clouded in obscurity. From the nature of the conditions it is difficult to secure definite information. Dr. Younger holds to the belief that the pericementum becomes revivified and hence the attachment is almost physiological. Others maintain that the filling of the space around the root of the tooth with compact bone tissue is sufficient to account for the retention of the tooth. In the appearance of planted teeth which have failed there should be found the best illustrations of the causes of success. It is probable that a planted tooth, by reason of the absence of the cushion formed by the living pericementum, causes more or less irritation in the socket; that this irritation leads to resorption of the root; that in this resorption and the subsequent filling up of these resorbed surfaces are found reasons for the success of the operation. Fig. 579, at *a*, *a*, shows how a partially resorbed root may be retained in place. The length of time during which a planted tooth is retained depends entirely upon the rapidity of the resorptive process and the activity of the tissues in maintaining a healthy condition. Replanted and transplanted teeth have been known to do good service for from twenty to forty years. The time of the observation as to implanted teeth is shorter, the oldest cases being less than twelve years old. In the writer's observations, extending over a period of nearly ten years, a number of teeth have been noted which have been retained successfully for that period; how much longer they will remain serviceable, and what percentage of success will attend later cases, will require further time to determine. Dr. Younger has had successfully implanted teeth under observation for eleven years.

Fig. 579.



An implanted tooth *in situ*: *a*, *a*, excavations of the cementum due to resorptive process.

Precautions.—There is no special danger connected with any of the operations described in this chapter, provided the usual antiseptic precautions are observed and dangerous anesthetics avoided. Aside from these, during the operation of replantation and transplantation no special skill is necessary; certain precautions are, however, essential. Inasmuch as implantation is an essentially esthetic operation, it should be borne in mind that it is confined principally to the ten anterior teeth, and that it is more frequently performed in the upper jaw than in the lower. The territory involved is therefore limited. The operator who contemplates forming in this territory a socket for the reception of the root of a tooth should be intimately acquainted with the anatomical and histological relationships of the various parts.

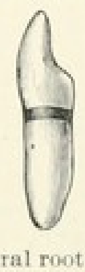
In the first place it should be remembered that where alveolar resorption has taken place, the relative depth of bone is considerably less than where a tooth is still *in situ* and surrounded by the abnormal alveolar process. The operator must therefore not penetrate deeper into the bone than the original depth of the socket may have been. Indeed, it is not as a rule necessary to penetrate so far.

In the upper jaw the principal danger in making a socket for the reception of central incisors lies in the proximity, posteriorly, of the anterior palatine nerve, artery, and vein, which have their exit from the bone through its foramen, often near the roots of these teeth. With the lateral incisor the principal precaution necessary is the preservation of the labial plate of the alveolus. If the lost tooth has been absent for some time, and much resorption has taken place, it is sometimes impossible to drill a socket so that the tooth has a proper direction and prominence in the arch, and yet be able to secure a bone covering for its labial surface. As a rule there is sufficient process in the canine region to enable the operator to secure all the attachment desirable. The bicuspid and molar regions present the danger of perforation of the floor of the maxillary sinus. This is liable to happen anywhere from the first bicuspid to the second molar. Extreme caution should be exercised to avoid it. In two instances in practice the perforation was followed by no unpleasant complications. Care was taken not to infect the sinus, the teeth were implanted in the usual manner, and the cases resulted successfully. Subsequently one of these teeth was lost, but during the process of root attachment or encystment the perforation into the sinus was closed.

In the lower jaw the principal difficulties encountered are the following: In the incisive region there is a deficiency of alveolar process, and hence much difficulty is encountered, at times, in securing a sufficiently deep bony socket. At the location of the canine tooth the lower jaw becomes broader and there is usually sufficient room to enable the making of a good socket. In the bicuspid region the principal precaution necessary is in regard to the mental foramen. It must be borne in mind that normally the exit of the nerves and vessels at this point is directly below the second bicuspid tooth and that when resorption of the alveolar process has taken place this foramen is often near the upper border of the jaw. From this point posteriorly implantations are rarely performed, and when done the principal precaution must be in regard to the inferior dental canal, which is near the surface if much resorption has taken place.

Artificial Crowns.—The precautions necessary in the selection of a tooth for transplantation or implantation have been noted, and it might be proper at this time to describe the preparation of a root with an artificial crown, presuming that it is only in rare instances that a suitable entire natural tooth can be obtained. Attention was called to the necessity of securing asepsis of the root, and the filling of the root-canals has been described. The most suitable form of crown has been found to be the Logan, which is ground to suit the occlusion and cemented into the root canal without much regard as to a careful fit at the cervix of the crown to the root. After the cement has hardened, the margin between the root and crown is prepared with engine burs, and a filling of gold introduced, making a circle around the tooth. When this is polished down there is a perfect gold filling level with the root and crown, which is preferable to a soldered band. (See Fig. 580.)

Fig. 580.



Natural root with artificial crown.

General Considerations.

Asepsis.—The operations described in this chapter must always be performed under perfect aseptic conditions; that is, the hands and person, instruments and other accessories, the tooth about to be planted, and the field of surgical operation, must be maintained in a clean, aseptic condition.

Any of the usual, accepted methods can be resorted to. As a rule, however, the drugs selected for this purpose should not be of an irritating nature. For the hands and person, pure soap followed by a 5 per cent. solution of carbolic acid is sufficient. The instruments and other accessories can be kept free from inoculating bacteria by the use of pyrozone, formalin, euthymol, or a 5 per cent. solution of carbolic acid. The use of bichlorid of mercury in the proportion of 1 part to 2000 of water is also permissible, although it is not as advisable on account of its irritating nature. The sterilization of the tooth about to be planted differs according to circumstances. A tooth whose source is unknown, and which has been kept in a dry state for a long period, will not be benefited by being placed into an antiseptic solution until just prior to the time when it is to be used. Hence dry teeth can be kept in any clean box covered with clean cotton until they are ready for use. After the necessary preparation hereinafter described, the dry tooth should be placed in a solution of glycerol and carbolic acid (about 5 per cent. of the latter), and just before using, it can be placed in a pyrozone solution or in a solution of carbolic acid and water. Freshly extracted teeth should, of course, have their pulp chambers and root canals cleansed and hermetically sealed, and then be placed at once in fluid, preferably in glycerol to which a few drops of carbolic acid have been added.

The field of operation may be quickly sterilized and cleansed of adhering mucus by mopping the surface with a ball of cotton saturated with hydrogen dioxid 3 per cent. solution just previous to operating.

It is, of course, of exceeding importance that the socket into which a tooth is about to be planted shall be free from disease germs or bacteria. As a general rule flowing blood is the best of antiseptics, washing away any bacteria which may become lodged from external sources, hence so long as a socket is constantly being filled with flowing blood during an operation, but little further care need be bestowed upon it. As a general rule the socket and the tissues surrounding it will react more quickly after operation the less the medication has been; hence the very slightest and mildest of antiseptics are indicated. Zinc chlorid 2 to 5 grains to the ounce of lukewarm water, hydrogen dioxid 3 per cent., or the 5 per cent. solution of carbolic acid in lukewarm water, give most satisfactory results. These solutions will be found quite sufficient to maintain the field of surgical operation aseptic.

Anesthesia.—For the purpose of allaying pain, the use of anesthetics is justified when imperatively demanded, but unfortunately, in the plantation of teeth the benefits derived are frequently outweighed by the disadvantages accruing from their use.

Anesthetics are either general or local. An operator would scarcely be justified in assuming the risks attendant upon the use of chloroform, ethylic ether, ethyl bromid, or any of the combinations in which these anesthetics are administered. Nitrous oxid would, in the majority of instances, be contra-indicated by reason of the shortness of the period of anesthesia which it induces.

There do not appear to be any records of satisfactory results with hypnosis. That field is open to the intelligent investigator whose inclinations lie in that direction. Local anesthesia, therefore, is the means generally employed. The use of cataphoresis with local anesthetics has not as yet been satisfactory for this purpose.

The method adopted has usually been confined to the injection or other introduction of cocain, the dose being variable, but usually about 5 to 15 minims of a 4 per cent. solution of the hydrochlorid. A serious objection has been noted to injection through the gum, viz. that more or less sloughing or destruction of the tissues may result, and this is very unfavorable for subsequent success. In replantation or transplantation, sufficient anesthesia is often obtained from the wash used in cleansing the socket; but in implantation the formation of the new socket is often an exceedingly painful operation, and in these cases good results may be had by dipping the instrument with which the socket is being made, into crystals of cocain, and thus by the friction of the instrument rubbing it into the parts that are being operated upon.

The subject of anesthesia may be dismissed with the sole injunction that its use should be resorted to only in those instances where it is absolutely necessary. The majority of the cases of plantation are performed with no more pain than is inflicted in filling operations.

The same care should be given to the retention of transplanted teeth as is given to the retention of replanted teeth. Teeth thus carefully transplanted, in individuals of good health, often remain as useful members for a number of years. In the past insufficient attention has been given to asepsis, and this, coupled with the fact that the root had not always been properly filled, has not resulted in as much success as is attained with present methods, and yet transplanted teeth are known to have remained in a healthy and serviceable condition for from twenty to forty years.

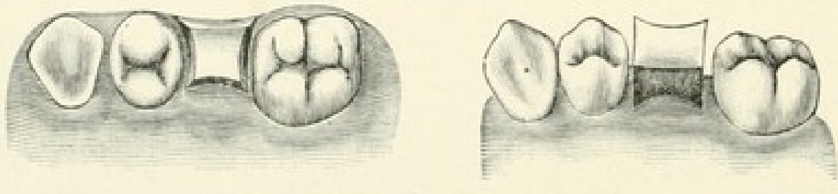
The Operation of Implantation.

Implantation, in order to yield the best results, should be confined to mouths which are habitually clean and free from disease, and to a part of the individual's life during which the power of the developed mental processes is not impaired. Unclean personal habits, the excessive use of stimulants, and occupations calling for an unusual expenditure of nerve force are unfavorable. A suitable case having been selected, an impression of the space and of the teeth adjoining it is taken. A plaster cast is made, the proper-sized socket drilled therein, the tooth is selected and prepared, either with or without an artificial crown in the manner previously described, the occlusion is adjusted, and a retention cap is made. These preliminaries having been satisfactorily accomplished the case is ready for the operation. Under the heading of General Considerations the question of anesthesia has been already treated.

The first step in the operation is the making of an incision through the gum tissue. A number of different kinds of incisions have been recommended by different operators, nearly all of them looking toward the preservation of the largest amount of gum tissue. Some recommend a crucial incision X, turning back the four corners of the gum tissue. Others have recommended an incision in the shape of the letter H, turning back the two flaps thus made.

The principal objection to all of the incisions recommended lies in the fact that they all look toward the preservation of the gum tissue equally for the labial and lingual surfaces; while, as a matter of fact, if proper provision is made for the protection of the cervical line on the labial surface, the lingual surface will take care of itself, for it will be noticed in cutting through the gum tissue that it is much thinner where it reflects over the alveolar border upon its labial aspect than upon its lingual. Hence, frequently, if no attention whatever has been paid to the retention of gum tissue on the lingual surface, the neck of the tooth will nevertheless be sufficiently protected.

Fig. 581.

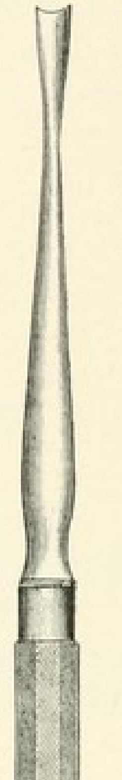


Incision in gum for implantation.

Another serious objection to an incision which leaves two or more points or margins to be preserved, is that the tenacity of the gum tissue makes it utterly impossible to preserve these various flaps and projections intact from the cutting instruments.

The writer's method consists in an incision resulting in one flap, with a view of protecting the labial surface of the tooth to be implanted, and of preserving this single flap from injury during the progress of the operation. A combination, or rather a modification, of the most suitable incisions recommended is therefore the one shown in Fig. 581.

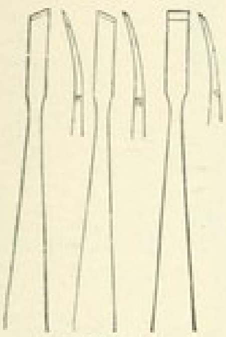
FIG. 583.



Instrument for holding flap during the operation.

This incision is made with ordinary chisels as shown in Fig. 582, cutting with the chisel to and including the periosteum, lifting it forward and holding it out of the way of the operator by means of an instrument similar to the one shown in Fig. 583.

FIG. 582.



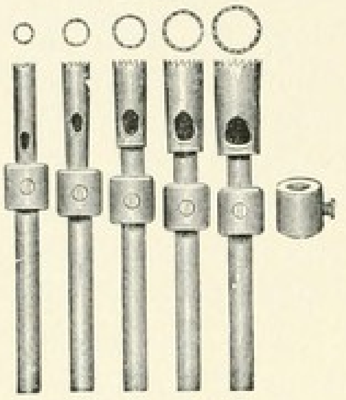
Chisels.

The operation thus far is usually simple and as a general rule not very painful. The drilling of the socket varies with different individuals according to the density of the bone, the length of time that the tooth has been out, etc. In some instances the reamer or trephine or knife progresses rapidly, while in others progress is very slow, or sometimes variable as the instrument enters into medullary spaces or passes through the more or less dense partitions which divide these medullary spaces from each other.

The operator will determine during the operation, by the progress he is making with different instruments, which are the best to use. In some instances the entire socket can be made with an ordinary engine bur, while in others the strongest instruments especially designed for implantation are none too strong. In some instances an instrument which clears itself well during one operation clogs annoyingly during another. It is desirable to describe at this point the various useful instruments which have been designed and are now upon the market. While all of them are not necessary, some one or more of each class are indispensable. The trephines of Dr. Younger, of San Francisco, which have been improved by Dr. W. W. Walker of New York, have (as shown in Fig. 584), a set-screw collar, also shown detached, which slides on the shank and is first fixed by a set-screw as a gauge of the length of the tooth root. As will be noticed the trephines cut only on the edge, and hence they do not entirely clear themselves;

the reamers described on a previous page are then used to remove the core and enlarge the socket.

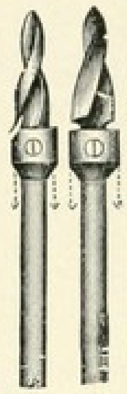
Fig. 584.



1 2 3 4 5

Younger-Walker trephines.

Fig. 585.



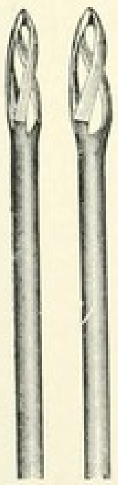
1 2

Rollins' spiral knives.

The spiral knives (Fig. 585) devised by Dr. W. H. Rollins of Boston are in many cases very useful.

They are also open to the objection of clogging. As an improvement upon these the spiral crib knife shown in Fig. 586 has the advantage of permitting the core to pass within it.

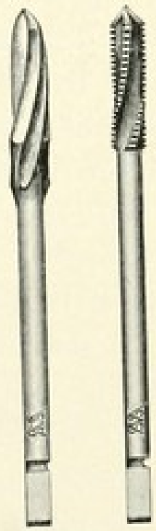
Fig. 586.



1 2

Ottofy spiral crib knife.

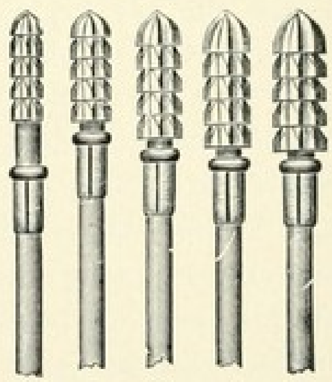
Fig. 587.



1 2

Two forms of Cryer's spiral osteotome.

Fig. 588.



1 2 3 4 5

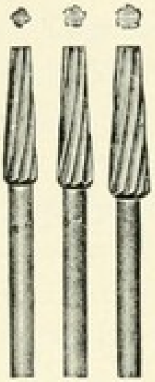
Ottolengui's reamers.

Dr. R. Ottolengui, of New York, has devised a set of reamers (Fig. 588). There are nine leaves to each reamer and each leaf is divided into five teeth. Three of the leaves reach the apex of the cone point and thus allow a more rapid forward drilling into the bone. A sliding collar forms a gauge to indicate the proper depth to drill.

The reamers designed by Dr. Younger, illustrated in Fig. 589, are also very suitable for this purpose. Dr. Cryer's spiral osteotome—two forms of which are shown in Fig. 587, one with dentate edges the other without—is an admirable instrument for forming the artificial socket.

When it is necessary to deepen or alter the shape of the socket, it is done very simply with either the ordinary burs of the dental engine or what is preferable, a bur with a long shank such as shown in the accompanying illustration (Fig. 590).

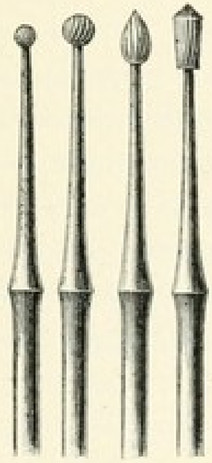
Fig. 589.



1 2 3

Dr. Younger's reamers.

Fig. 590.



1 2 3 4

Engine burs with long shank.

The following are to be recommended: Nos. 1 and 3 of the Walker-Younger trephines, Nos. 1 and 3 of the Younger reamers, Nos. 1 and 2 of the Rollins spiral knives, Nos. 1 and 2 of the Ottofy spiral crib knives, and Nos. 1, 3, and 4 of the Ottolengui reamers and Cryer's osteotome.

During the progress of the drilling of the socket, the tooth should be frequently inserted until a proper adjustment has been secured. Occasionally these teeth can be implanted and so perfectly fitted that it is almost impossible to remove them with the unaided fingers; while at times the bone is so cancellated, and the tissues so flabby, that a socket drilled never so carefully will not retain the tooth in place. Nothing is gained by a too close adjustment of the root, as pressure must undoubtedly be exerted, and pressure causes resorption, and may be followed by inflammation. A fair, moderate fitting of the root is all that should be aimed at. Just before the final adjustment the socket, gums, tooth, and all parts contiguous thereto, should be placed in an aseptic condition and the cap adjusted in the manner before described. Though the tooth may be adjusted to its socket so that immediately afterward it exhibits much firmness, yet in a few days subsequent to the operation it invariably shows less rigidity and an apparent tendency to loosening. This result is probably due to the resorption of those areas of contact between the tooth and its artificially formed alveolus where the greatest amount of pressure is exerted. The period of loosening is generally quickly followed by a progressively increasing firmness and immobility of the tooth caused by calcification of the exudate thrown out by the walls of the alveolus in the process of repair of the surgical injury to which it has been subjected by the operation. Planted teeth, when lost, are lost as a rule as a result of resorption of their roots. The process seems analogous to the resorption of the roots of deciduous teeth. Present records seem to indicate that resorption of the roots is slowest in progress in replanted teeth; it is more rapid in transplanted teeth, and most rapid in implanted teeth. Intelligent observation over replantations and transplantations extends from twenty to forty years. The observation of Dr. Younger of implanted cases extends at this writing to about twelve years, and he has had successful cases under observation which have remained in the mouth over ten years. The writer has the records of cases which have remained and done good service for ten years.

CHAPTER XXIII.

MANAGEMENT OF THE DECIDUOUS TEETH.

By Clark L. Goddard, A. M., D. D. S.

Eruption.—The first operation the dentist is called upon to perform for the deciduous (temporary) teeth is lancing the gums as an aid to eruption of those organs. This is not necessary in normal but only in pathological cases. Although gum tissue in its normal condition is comparatively insensitive, when it is inflamed it is exceedingly tender.

The principal source of pain, however, is not in the tissue overlying, but when a tooth, bound down by the dense gum tissue above it, by its own growth presses upon the formative organ below, it causes pain which in many cases may be so excessive as to cause reflex disorders of alarming character.

Dr. J. W. White[1] says: "The manifestation of functional inharmony from pathological dentition will depend, as in trouble arising from any other disturbing cause, upon the temperament and health of the child, its dietetic management, and its hygienic surroundings. In some cases there is a gradual development of biliary, gastric, enteric, and cerebral complications, a slow but steady loss of vital power, with no effort at recuperation and feeble resistance to the undermining influences which gradually but surely wear out the young life.

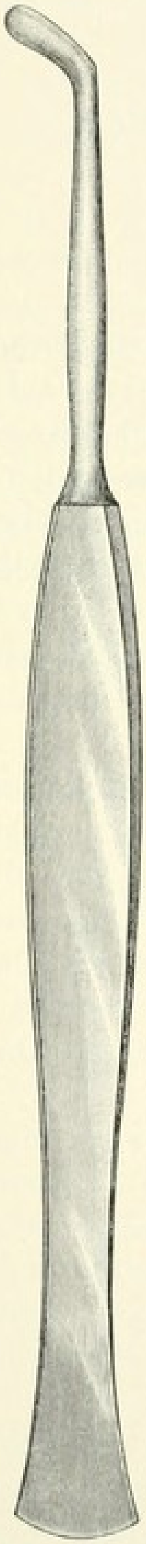
"In other cases the indications of disturbance of function are manifested primarily in the nervous system: the symptoms are all characteristic of acute derangement and are dangerous from their violence and uncontrollability. High fever, vomiting, choleraic diarrhea, meningitis, convulsions, stupor and death are the rapidly succeeding phenomena. Between these two phases there is every conceivable grade of symptoms, every imaginable complication."

By many, as an objection to lancing the gums it has been urged that, in case the tooth does not erupt immediately, cicatricial tissue is formed over it which will bind the tooth down more rigidly than before. Cicatricial tissue is, however, of a lower degree of organization than normal tissue, and is more easily broken down.

[1] *Amer. System of Dentistry*, vol. iii. p. 327.

The indications for interference are not so much local as general—the fretfulness, inability to sleep, and other symptoms mentioned by Dr. White. The gum tissue over the erupting tooth may or may not be highly inflamed, but the absence of such inflammation does not contraindicate lancing. In fact some of the gravest systemic disturbances occur where no local manifestations are evident.

FIG. 591.



Gum lancet.

The object is to divide the gum tissue which binds down the tooth and to allow it free egress. The most suitable instrument is shaped like that shown in Fig. 591 and sometimes used for lancing around teeth before extraction. It should be held like a pencil in writing, so that one or more fingers can form a rest and guide.

For operating on the lower jaw the child is best seated in the lap of the operator with the head against his breast. By passing the left arm around the infant's head and inserting the left thumb in its mouth with the fingers under the chin, the lower jaw can be held rigidly while the right hand performs the operation.

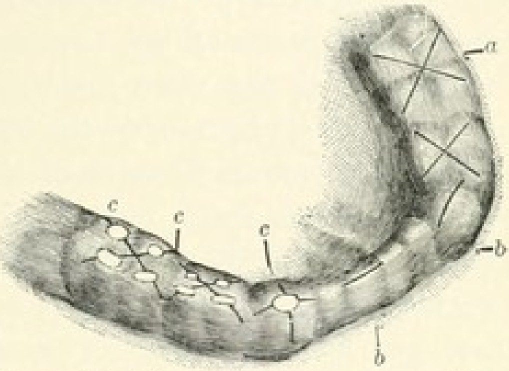
For operating on the upper jaw it is best to lay the child across on the nurse's lap. The operator takes the head on or between his knees, opens the mouth by inserting one or more fingers of the left hand, and holds the thumb and forefinger on each side of the alveolar ridge, thus preventing injury to contiguous parts during possible struggles of the child.

For *incisors* a simple longitudinal incision is made, a little longer than the cutting edge of the tooth. The lancet should be sharp, so as to easily penetrate to the tooth. No harm will be done except to the blade of the lancet. For the *canines* a single incision is good, but a crucial incision is better. Sometimes lancing is necessary for the canine after it is partially erupted, as the gum tissue, pierced by the point only of the tooth, may form a dense ring around this point and interfere with further eruption. In such a case a division of this ring in two or more opposite places will give relief.

For the *molars* a crucial incision is best, one cut extending from the posterior buccal to the anterior lingual cusp, and the next from the posterior lingual to the anterior buccal. Sometimes lancing is necessary for these teeth after partial eruption. After the cusps have pierced the gum, the tooth may be held back by the bands of tissue in the sulci. In such cases division of these bands in the same direction as before described for an unerupted tooth will give relief. Sharp-pointed curved scissors are well adapted to this latter operation.

Fig. 592 will illustrate the direction of the incisions described. The relief afforded is generally immediate. In one case a child who had been fretful for several days, and who had not slept at all during the day, was asleep in the writer's arms within five minutes after the operation. The gum tissue is not very sensitive, so the operation is often painless. The little sufferer will often recognize the relief obtained and point to other portions of the gums for further relief.

Fig. 592.



Lines of incision in lancing: *a, a,* over the molars; *b, b,* over the canines and incisors before eruption; *c, c, c,* over the molars and canines after partial eruption (J. W. White).

Duration of the Deciduous Teeth.—The importance of filling cavities in the children's temporary teeth is often overlooked, even by dentists themselves, as these teeth are supposed to be lost so early as to render such operations unnecessary. This is generally true with the incisors, is less true with the canines, while the molars often need attention. Fig. 541 (see Chapter XXI.) shows the relations of the deciduous to the permanent dentures in a child of about six years of age. A study of the following table will show that while the incisors are superseded early by their successors the molars are in place nearly twice as long:

Time of Eruption.		Loss.	Duration.
Central incisors	6–8 months.	6th–7th year.	5½ to 6½ years.
Lateral	7–9 "	7th–8th "	" " " "
First molars (1 yr. 2 m.–1 yr. 4 m.)	14–16 "	9th–10th "	7½ " 9 "
Canines (1½ yrs.)	17–18 "	Inf. 8th–10th " / Sup. 11th–12th "	7 " 10 "
Second molars (1½ yrs.–2 yrs.)	18–24 "	12th–13th "	10 " 11 "

The temporary molars should be preserved for three reasons:

1st. To prevent the child suffering pain.

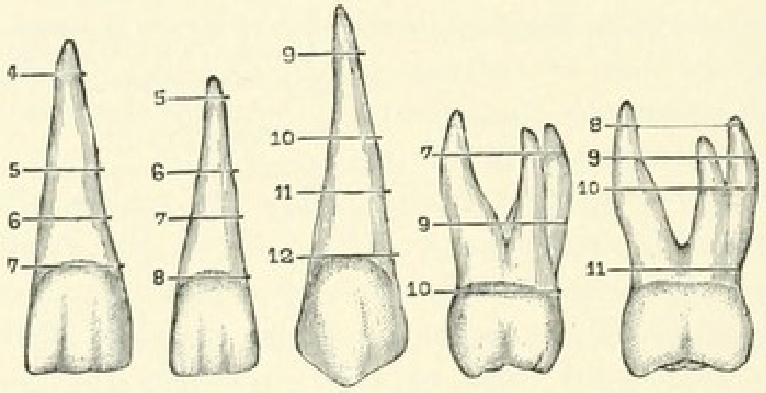
2d. To allow proper mastication of food.

This latter is of extreme importance, as these years are especially important ones in the child's growth. If he is prevented by pain from properly masticating his food it will not be assimilated, and a habit of swallowing food without masticating may be continued even when the permanent teeth have erupted.

3d. To preserve the fulness of the arch for the permanent teeth. Early loss of the deciduous second molar will allow the first permanent molar to move forward and occupy room that should be preserved by the bicuspids. Early loss of the first temporary molar will allow the second temporary and the first permanent molar to move forward.

The crowns of the temporary molars are much larger than the necks, and caries of the approximal surfaces will allow them to crowd together with the same result. Approximal fillings inserted should be so shaped as to preserve the original contour. If the first permanent molar thus moves forward of its natural position a smaller arch is left for the successional teeth. The result may be a constricted arch, a pointed arch, upper protrusion, or the labial displacement of the canines.

Fig. 593.[1]



Decalcification of the deciduous teeth. The numbers indicate years.

Odontalgia.—The first visits by children are usually for the relief of "toothache," and may occur at any age from two years upward.

The first treatment of most children's teeth should be palliative. In many cases a fear of the dentist has been engendered, which it should be the prime object to remove. Make the acquaintance of the little patient in the reception room, talking perhaps of things altogether foreign to the case in hand, and distract its attention. If the child is very timid examine the teeth while it is seated in an ordinary chair, or in its parent's lap, and apply some dressing to relieve the pain.

In the operating room the chair should be adjusted to its smallest size; a special child's seat may be used, or a cushion half the size of the chair seat, and not too soft. The child's head should be made comfortable in the head-rest. The operator should not let the child detect him in an endeavor to hide instruments; the necessary ones may be shown to him if they arouse his curiosity, and their purpose explained.

[1] Prof. Pierce in *Amer. System of Dentistry*, vol. iii. p. 639.

On account of the difficulty the child has in making himself understood, or from his not knowing what he wishes to describe, diagnosis is difficult. A child cannot always distinguish just where pain is felt, nor always remember its exact location. In most cases the first occurrence of pain is during mastication.

It is necessary to ascertain whether pain is caused by an erupting tooth, a nearly exposed pulp, a pulp inflamed and dying, a putrescent pulp, or an alveolar abscess. If the nearly exposed pulp is suspected, test it by the application of a drop of cold water. Pain during mastication may be caused by thermal changes, by pressure of food in the cavity, or by pressure on a tooth whose pericementum is inflamed.

If the tooth is aching while the child is in the chair, syringe out the cavity with warm water, dry it with bibulous paper, and apply a pledget of cotton saturated with oil of cloves, campho-phénique, or whatever has been found effective with permanent teeth. Fletcher's carbolized resin[1] has been invaluable for this purpose in the writer's practice. Applied on a pellet of cotton it acts as an anodyne, and the resin hardens in the cotton, forming with it a temporary stopping which will even bear the force of mastication for a few days. It is sometimes best to renew this dressing a few times before attempting a more permanent treatment or filling.

If the child cannot be brought to the office again within a few days, let the parent provide himself with a bottle of the carbolized resin and an inexpensive pair of dressing pliers. Instruct the patient how to apply the cotton dressing. This is the best domestic remedy for odontalgia. Other medicaments may be used by the parent, such as oil of cloves, campho-phénique, etc., but their effect is much more temporary. A more durable dressing may be made by mixing zinc oxid and carbolized resin to the consistence of putty and applying it in the cavity previously dried. It hardens under moisture, and makes a stopping that will remain, in some cases, for several weeks.

During such palliative treatment, sometimes unavoidably extended over several weeks or even months, the child is growing older, is gaining experience, is becoming used to manipulation, begins to recognize the benefit of treatment of the teeth—in a word, is being trained or educated for a good patient for whom more permanent operations may be attempted.

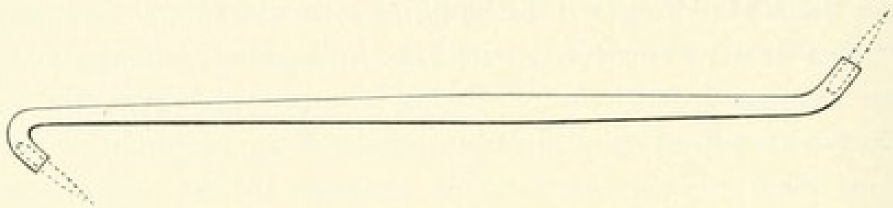
Prof. L. L. Dunbar says: "As a domestic palliative always at hand, in the treatment of pulp exposure and restricting odontalgia, use ammonia on cotton: its repeated use will devitalize the pulp, at the same time effecting its removal by saponification."

[1] Carbolic acid,
Resin (colophony), *āā.* ℥j;
Chloroform, f℥ss.

Treatment with Silver Nitrate.

More than forty years ago the application of silver nitrate for arresting decay was advocated, but for many years no notice was taken of it. Within the last five years it has been advocated again, especially for use in the temporary teeth. The fact that it blackens the decayed surface is not as objectionable as with permanent teeth. Dr. Stebbins[1] advocated the use of a solution of the crystals of silver nitrate in carious cavities in temporary teeth. He applies it by means of a small stick inserted in a socket instrument as shown in Fig. 594. Many

Fig. 594.



cases will need no further treatment, decay being completely arrested. Some cases will need secondary treatment after a few months. In many cases he advises filling the cavity with gutta-percha after the application.

Dr. C. N. Peirce[2] advises saturating pieces of blotting paper with 40 per cent. solution of silver nitrate, and keeping these on hand for use.

Dr. E. C. Kirk advises the use of asbestos felt for saturation with the solution in preference to blotting paper or cotton. He says:[3] "The contact of silver nitrate with vegetable fiber of any sort involves not only a destruction of the fiber but also of the silver nitrate, so that the preparation in a short time loses its desirable qualities." He advises that the asbestos felt be heated before the blowpipe before saturation, to burn out any organic material which may be present.

Dr. A. M. Holmes[4] advises its use as follows for approximal cavities: "Cut away the walls to a V shape, and with a piece of gutta-percha, softened by heat, of the proper size to fill the space, bring the surface to come in contact with the diseased part of the teeth, into contact with the powdered crystals of silver nitrate and carry it to the place in the tooth or teeth prepared for its reception, packing it firmly and leaving it there to be worn away by use in mastication. When that takes place, the surfaces of the teeth treated will be found black and hard, with no sensitiveness to the touch or to change of temperature, and they will remain so indefinitely. In case the child is so timid as to

[1] *International Dental Journal*, 1891, p. 661.
[2] *Ibid.*, 1893, p. 152.
[3] *Dental Cosmos*, 1893, p. 667.
[4] *Ibid.*, 1892, p. 982.

prevent this course, dry the cavity, take out as much softened dentin as the patient will permit, carry the crystals on softened gutta-percha into the cavity and pack it, leaving it until such time as desirable to make a more thorough operation."

In the writer's opinion it is better to open approximal cavities from the occlusal surface rather than make V-shaped spaces, as the full diameter of the teeth should be left to preserve the fulness of the arch.

Silver nitrate in its action penetrates but a short distance.

The Character of the Patient.

The conditions of operating on the deciduous teeth vary so much from those pertaining to the permanent teeth that a different consideration must be taken of filling materials.

The little patients' mouths are small. They are often too young to reason with or to understand the purpose of the operation. They have been too often frightened by thoughtless remarks of their elders in speaking of their dentist.

Oftentimes the first sitting must be utilized merely to make the acquaintance of the child, perhaps cleaning the teeth a little, or introducing some palliative dressing in an aching tooth. The greatest care should be taken not to hurt the child. After it has gained a little experience it recognizes the benefit of the treatment, and will often submit to operations that older patients even shrink from.

Filling Materials.

Gutta-percha.—Pink base-plate gutta-percha is a most valuable filling material. In approximal cavities where it is not exposed to wear and where the shape of the cavity is such as to retain it, it is practically indestructible. In occlusal and compound cavities in which it is exposed to wear it has wonderful durability, lasting in some cases for several years.

Directions for Use.—Cut the gutta-percha in small pieces and place them on a gutta-percha warmer (see Fig. 304), where they can be kept soft but not heated enough to injure the material. The instruments also should be warmed (see Fig. 293).

Occlusal Cavities.—Cut away the margins of thin enamel with suitably shaped chisels, and remove the decayed and softened dentin with scoop and hatchet excavators. Do this as thoroughly as the patient will permit, but do not sacrifice the patient to thoroughness, for the thorough removal of softened dentin is not as essential as with permanent teeth, because the gutta-percha is, by mastication, kept in such accurate contact with all the walls of the cavity that further softening will go on very slowly if at all. No special attention need be paid to the form of the cavity, except that its mouth should not be larger than the rest, nor should any parts of the cavity be inaccessible to the filling material. After excavating, dry the cavity with bibulous paper, and apply campho-phénique, oil of cloves, or carbolic acid, to sterilize any softened dentin which may not have been removed. For drying cavities, prepare paper cylinders, of different sizes, as follows: Tear the bibulous paper in strips from half an inch to two inches in width. Roll or twist each of these strips into a rope, but not too tightly—just enough to retain the shape. Cut these ropes into cylinders from a quarter to half an inch in length. Some of these will be as large around as a lead pencil and others no larger than the lead itself.

Protect the tooth from moisture as well as possible. For lower cavities fold a small napkin diagonally from the corner till it is about half an inch wide. Put the end of this between the gum of the upper canine and the lip and extend the napkin back between the upper molars and the cheek beyond the last tooth, then down behind the last lower molar, and press it between the lower teeth and tongue. Tell the patient to raise the tongue as it is applied, then to lower the tongue and hold the napkin with it. The part of the napkin between the upper teeth and the cheek will cover the mouth of the duct of Steno, and prevent or absorb the flow of saliva. It is better to cover the mouth of this duct with a piece of spunk about half an inch in diameter before applying the napkin. The folds of napkin between the lower teeth and tongue and under the tongue will absorb the saliva from the submaxillary glands. This part of the napkin can be held in place with a mouth mirror or other blunt instrument, by the operator or assistant. After applying the napkin use a large bibulous paper cylinder to absorb the moisture from the tooth to be filled and also from contiguous ones. With smaller cylinders or pellets dry the cavity. Apply once more campho-phénique or other medicament, and absorb the excess.

The gutta-percha having been meanwhile warmed and softened, pick up a small piece of it with a cold round-pointed instrument and press it into the cavity. If the cavity is not large, a single piece of gutta-percha of a diameter less than that of the cavity, but longer than the cavity is deep, can be pressed in quickly and at one movement. For medium-sized cavities select a piece of gutta-percha large enough to cover the floor of the cavity and press it into place with a cold instrument, as a warm instrument might drag it from its place. Add similar pieces, pressing each one to the place in which it is to remain, till the cavity is full. If at any time the gutta-percha in the cavity becomes so hard as to lose its plasticity, apply a warm instrument to soften the surface, so that the next piece will adhere to the others. As the filling nears completion select a small piece for the last, just large enough to complete the filling and no more, so that none will have to be trimmed away, for in trimming the surplus away the filling may be drawn from contact with the walls of the cavity.

In filling large cavities it may be necessary to hold the first piece in position with another instrument till sufficient material is added for self-retention. At the completion of the filling slight pressure with a warm instrument should be made in such a manner as to force the material against all the margins of the cavity.

Approximal Cavities.—Where possible, approximal cavities should be opened from the buccal surfaces, as advised by Dr. Bonwill, as in such cases gutta-percha fillings will not be exposed to the force of mastication. This plan is not often practicable because the patient is seldom presented till the cavity has become visible by opening into the occlusal surface of the tooth. In such cases cut away the enamel only enough to give access to the cavity, excavate the decayed dentin, and trim the buccal, lingual, and cervical walls until a smooth, firm margin is obtained.

In filling such a cavity use small pieces of softened gutta-percha, pressing each piece where it is to remain, and avoid a surplus. Press the gutta-percha against the adjoining tooth as if it were a matrix or a fourth wall of the cavity and let it remain. It is useless to trim it away from the adjoining tooth, because the force of mastication would soon spread the filling against it again.

If an approximal cavity cannot be readily shaped so that it will retain the gutta-percha, it may be packed against the adjoining tooth, as if it were an occlusal cavity. It will prevent decay, especially if silver nitrate is applied as described on page 668, and may be retained till the patient is older, when a more thorough operation may be performed.

The spreading of the gutta-percha by the force of mastication will tend to separate the teeth—which is sometimes an advantage; and also to press upon the gum in the interproximal space—which is a disadvantage. In filling children's teeth we cannot always reach the ideal, but must select the method and material which will have the greatest advantage with the least disadvantage. If the teeth separate so much that the pressure of the gutta-percha upon the gum tissue becomes a serious annoyance, some other material must be substituted. Zinc phosphate cement is probably the best.

To prevent the impinging of the gutta-percha upon the gum in the interproximal space, Dr. M. W. Hollingsworth[1] has invented a space

[1] *Dental Cosmos*, 1896, vol. xxxviii. p. 553.

guard, consisting of a concave elliptical piece of metal coated on the convex surface with gutta-percha. This guard is to bridge over the interproximal space. It is placed in position with the instrument shown in B, Fig. 595, which is warmed slightly, so that the point can

Fig. 595.

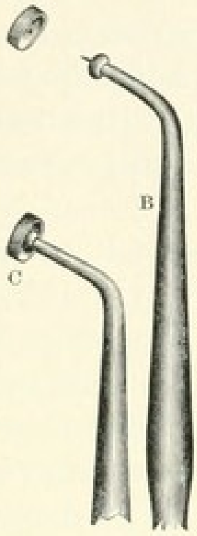
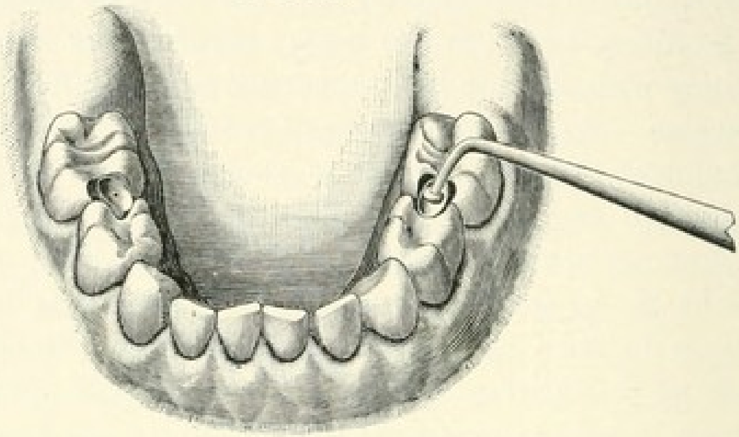


Fig. 596.



enter a small hole in the guard and adhere to the gutta-percha on the under side, as shown at C. The guard is placed in the cavities, after warming the gutta-percha, as shown in Fig. 596, and thus covers the cervical borders. Gutta-percha is now filled in over the guard as if the two cavities formed a single crown cavity.

Advantages of Gutta-percha.—It is easily applied to the cavity; it is insoluble; is durable even when masticated upon; is a non-conductor of thermal impulses; the filling is finished as soon as the cavity is full; it spreads under the force of mastication, and is thus kept in contact with the walls of a cavity; it can be used even under moisture.

Disadvantages.—Gutta-percha is softer than other filling materials, and hence wears away more rapidly. In approximal cavities it will spread the teeth apart, and may then press upon and irritate the gum.

Dryness of the cavity, though very desirable, is not absolutely necessary.

Advantages of Zinc Phosphate Cement.—It is a poor conductor of heat; it withstands the force of mastication better than gutta-percha; it adheres to the walls of the cavity, and hence will remain where no other material can; it is easily applied; its color may be selected to match the tooth.

Disadvantages.—Absolute dryness of the cavity is a prerequisite to its success; it must be kept dry for several minutes after it is inserted in the cavity. Zinc phosphate cement disintegrates in some mouths much more rapidly than in others. If placed too near the pulp it may by chemical irritation devitalize it.

Application of the Rubber Dam.—While many hesitate to attempt the use of the rubber dam with children, it will be found upon trial that most of them will submit to it without trouble, and many will prefer it to other means of keeping cavities dry.

Although there is an advantage in applying the rubber dam before excavating—because dryness makes the teeth less sensitive, and a clearer view of the cavity is obtained—still, for the sake of not tiring the little patients by too long restraint in one position, it is better to do most of the excavating before its application.

The small size of the necks of the deciduous teeth compared with that of the crowns renders the retention of the rubber dam easier than with permanent teeth. Even considering the smallness of the patients' mouths, the application of the rubber dam is not difficult in many cases.

For retaining the rubber dam on the second molar a clamp will sometimes be necessary, but for the other deciduous teeth a floss silk ligature will be sufficient. Having punched holes of suitable size through the rubber dam, apply it over the teeth affected. If the cavity is in the occlusal or buccal surface only, it will not be necessary to apply it over more than one tooth, but if the cavity is in the approximal surface it will be necessary to apply the rubber dam over two or sometimes three teeth, or even more, if several cavities are to be filled at one sitting.

It is not always necessary to tie a ligature around the neck of the tooth, as merely passing the waxed floss silk between the teeth will often force the rubber around the neck of the tooth enough to retain it even above an approximal cavity. The silk may then be removed by drawing the end through between the teeth.

With a thin burnisher or spatula turn up the edge of the rubber around the neck of the tooth toward the gum. The tendency of the rubber then will be to slide in that direction and not off over the crown. If a ligature be necessary to hold the rubber above the edge of an approximal cavity tie it tightly around the neck of the tooth, even forcing it toward or under the edge of the gum with an instrument when necessary. The clamp on a second molar may often be dispensed with after a ligature is applied, unless it is needed to hold the rubber out of the operator's way. The only object in omitting the clamp is to prevent pain or discomfort to the child.

If a simple ligature will not retain the rubber on a second molar before the first permanent molar has appeared, its efficiency may be greatly increased by stringing a bead, about an eighth of an inch or less in diameter, on the thread and tying a simple knot in it so that the bead will be in about the middle of the ligature. Tie the ligature around the tooth so that the bead will lie against the distal surface of the second molar on or near the gum. This bead will prevent the rubber slipping off the tooth. A short cylinder of bibulous paper can be tied in the ligature and applied with the same effect, and even a large knot in the ligature on the distal surface of the tooth will often answer the purpose.

The corners of the rubber dam should be held out of the way by a suitable holder extending around the head. The lower border may be held out of the operator's way by small weights, hooked in the edge.

Dry the cavity and the whole tooth or teeth, and complete the excavation.

Filling Cavities with Cement.—As cement can be applied easily in undercuts and very irregularly shaped cavities it is not necessary to cut away the enamel more than is sufficient to enable the operator to thoroughly remove the disintegrated dentin. Even the thorough removal of the latter is not as essential for a cement filling as for other materials, for, if the edge of the cavity can be made smooth and the softened dentin be thoroughly sterilized, the cement will hermetically seal it and prevent further disintegration until it is worn away beyond the sound edges.

The operator may take much greater risks in leaving disintegrated dentin than with permanent teeth, for the object is simply to retain the tooth till the time arrives for its successor to appear.

It must be remembered in excavating cavities in deciduous teeth that the pulp is much larger in proportion to the size of the crown than in permanent teeth, and that in trying to make undercuts or retaining grooves deep enough to retain a filling, the pulp may be exposed—an accident which should be carefully guarded against, for the pulp has not even the recuperative power possessed by the pulp of a permanent tooth, and in case of its death it is more difficult to give a deciduous tooth proper treatment. Moreover, death of the pulp prevents normal resorption of the root and may thus cause irregularity of the permanent teeth.

For most cases the cement should be mixed as thick as can be easily and quickly manipulated, but if the pulp is nearly exposed the cement should be used so thin that it can be applied without pressure, by flowing it over the floor of the cavity. Cement mixed moderately thin will adhere better to the walls of the cavity than when it is as thick as it is possible to apply it. The thinner the cement, the longer time it will take to harden, but the thicker it is mixed the more durable it will be. Do not keep the little patient in a constrained position longer than necessary. The easier the first operation is for him the more readily will he return for the second.

If the pulp is very nearly exposed apply Fletcher's carbolized resin over the floor of the cavity. For this purpose remove the stopper of the bottle till by evaporation the carbolized resin has thickened to the consistence of molasses. Dip a small probe in this thickened mass, so that a small drop will adhere to the end. This drop may be then conveyed to and spread over the floor of the cavity. This will prevent contact of the cement with the most sensitive dentin and lessen the possibility of deleterious action on the pulp.

Where it is possible to apply the rubber dam and excavate thoroughly the same excellent result with cement may be expected as when it is used in permanent teeth, but often it is not possible to operate as thoroughly.

By applying *melted paraffin*[1] or *sandarac varnish* to the cement the rubber dam may be removed sooner than otherwise, and the cement will be protected from moisture by the coating of paraffin or varnish.

As paraffin is insoluble in any agent that can attack it in the mouth, the more it is absorbed by the cement the longer it will protect it from everything but wear; therefore, do not be content to merely flow the melted paraffin over the cement, but hold a heated instrument in contact with the filling and keep the paraffin melted until all that is possible is absorbed. If an approximal filling has been inserted pass a very thin heated spatula between the cement filling and the adjoining tooth to make sure that the paraffin covers it to its cervical margin.

When the rubber dam cannot be applied, cement may still be used with success if the cavity can be kept dry with napkins or rolls of cotton or spunk until it is inserted and quickly covered with melted paraffin.

Deep cavities may be advantageously lined with cement and protected with paraffin till the cement is hard, when the paraffin may be removed and gutta-percha or amalgam inserted.

Cavities in Incisors.—Decay in deciduous incisors is much more rare than in the other teeth, and they are lost so early in child life that it is seldom necessary to fill them. Zinc phosphate cement is the best filling material for these teeth, because they are so small that it is very difficult to shape the cavities properly for retaining other materials.

If it is found that cement disintegrates rapidly in approximal cavities, an attempt should be made to shape them so as to retain gutta-percha. The first filling of cement may have removed the sensitiveness sufficiently to allow deeper excavating at a subsequent sitting, or there may have been a deposit of secondary dentin, thus removing the pulp from danger of exposure in properly shaping the cavity.

Amalgam.—While amalgam is a valuable filling material, its use

[1] Dr. Bonwill's suggestion.

necessitates much greater care in the preparation of cavities than is necessary with gutta-percha or cement, for it neither spreads under mastication like the former nor does it adhere to the walls of a cavity like the latter. The spreading of gutta-percha will stop a leak that would be fatal to an amalgam filling, and cement will adhere in a cavity from which amalgam would be easily dislodged.

Amalgam should be used when the decay can be thoroughly excavated and the cavity prepared with strong smooth edges, and good undercuts or retaining grooves. As amalgam is a better conductor of thermal impulses than either of the materials before mentioned it will not be tolerated so near the pulp, hence deep cavities must be lined with either gutta-percha or zinc phosphate.

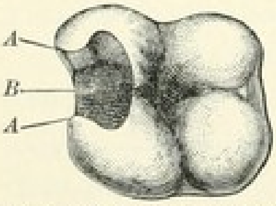
The large size of the pulp of deciduous teeth—greater in proportion than that of the permanent teeth—must not be forgotten in excavating, and often it is impossible to make suitable retaining grooves for amalgam without cutting dangerously near the pulp, especially in approximal cavities.

The preparation of occlusal cavities is comparatively simple, as the enamel may be easily cut away so as to make firm edges, slightly bevelled, and to allow thorough excavation of softened dentin.

The burring engine can be used to greater advantage with children than many would suppose. The whirring noise often distracts their attention from a slight pain they might otherwise notice, and the assurance that the work can be done more quickly is a great encouragement.

In preparing approximal cavities for amalgam a free opening should be made in the occlusal surface and given a dovetail shape, extending farther upon the occlusal surface in proportion to the size of the cavity than in permanent teeth, because more reliance must be placed on it for retention than upon lateral grooves, for there is not much depth of dentin in which to make them. The cervical border of the cavity must be smooth and the floor at right angles to the long axis of the tooth. The lateral walls must be cut smooth and bevelled, and may be slightly grooved. If the cavity extends below the margin of the gum the latter should be crowded away with a temporary stopping or by packing a tightly rolled pledget of cotton between the teeth and relying on its swelling.

Fig. 597.



Prepared cavity showing bevelling of enamel edges, *A*,*A*, and square base for filling, *B*.

While the application of a rubber dam is not as essential as in using cement, it is a great advantage, for it renders the proper preparation of the cavity more certain, but it need not be applied till the cavity is nearly prepared. Its use is more often necessary with the lower teeth than with the upper.

Amalgam should not be mixed too dry, but should be plastic enough to be packed easily without crumbling. In occlusal cavities introduce a piece half as large as the cavity, and with a small ball burnisher spread it over the floor of the cavity toward the walls. Introduce other smaller pieces and proceed as before until the cavity is nearly full. Excess of mercury is thus forced to the edges of the cavity, whence it can be brushed away with cotton or bibulous paper.

The last pieces of amalgam should be "wafered," as recommended by Prof. J. Foster Flagg—that is, squeezed in chamois skin with large flat-nosed pliers till as much mercury as possible is pressed out (see Fig. 288). This leaves the amalgam in a thin, brittle wafer, too hard for ordinary use. Break it up in pieces half the diameter of the cavity. Press one of these in the middle of the nearly completed filling. It will readily absorb the excess of mercury that has been worked to the surface, and can be spread toward the margins with a round burnisher. Other pieces can be burnished on till the filling is quite hard.

In filling approximal cavities the same plan may be followed if a matrix of thin steel or German silver be used. In lieu of the matrix a very thin spatula may be held between the teeth.

Whenever possible, fillings in deciduous molars should be contoured to avoid the crowding of food between the teeth and also to prevent the first permanent molar from crowding them together and thus taking up room which will be needed by the bicuspids.

The child should be cautioned against masticating too soon upon approximal fillings, though no caution is needed in case of occlusal fillings hardened by the "wafering" process.

Tin and **gold** are excluded from the list of desirable filling materials for temporary teeth, not because they are not good filling materials but because the circumstances are such that they cannot be used to advantage. Though a small gold filling may be inserted in a few minutes in an occlusal cavity, the insertion of a large gold filling would be inflicting a needless cruelty on a child on account of the length of time it must be held in one position.

As the insertion of a tin filling is nearly if not quite as difficult and tedious an operation, it is open to the same objection.

Exposed Pulps.

On account of the difficulty of properly capping an exposed pulp in a deciduous tooth, the operation should seldom be attempted. It is better to devitalize the pulp and remove it.

The writer has found the following formula[1] an excellent one:

[1] Used by Dr. E. N. Clarke in the "fifties."

℞. Acidi arseniosi,
Morphiæ acetatis,
Pulv. opii, *āā. pars æq.*
Creosoti q. s. to make paste.

Why opium and acetate of morphia should both be used in the same prescription is not clear, as their properties are so nearly the same, but the paste has been satisfactory in devitalizing pulps with no pain, or with a minimum amount. Other formulas may be equally satisfactory.

In *occlusal cavities* its application is simple. Excavate the softened dentin as thoroughly as possible without inflicting pain, using spoon-shaped excavators to prevent puncturing the pulp. If the excavation can be carried far enough to apply the paste directly to the pulp its action will be more rapid. Dry the cavity, apply a small amount, not larger than half a pinhead in size, with a small probe and cover it with a pellet of cotton, or place in the cavity a small pellet of cotton one side of which has been touched to the paste. Add enough pellets of dry cotton to fill the cavity, then apply a drop of sandarac varnish, sufficient to saturate at least half the depth of cotton. This is a better plan than dipping the pellets in the varnish before inserting, because an excess of the latter is apt to come in contact with the pulp and cause pain, or, penetrating between the paste and the pulp, may render the former inoperative. Temporary stoppings such as Gilbert's, White's, or Fowler's are excellent for sealing the cavity, but take a little more time than cotton and varnish. Such temporary stopping should be well softened by heat to prevent pressure on the pulp in its insertion. A good plan is to warm the end of the long stick of stopping and press it into the cavity, using the remainder of the stick as a handle, then remove the surplus and smooth with a warm instrument.

In *approximal cavities* extending near or under the margin, the gum should be protected, before applying the paste, as follows:

Make, by rolling between the fingers, a cylinder of cotton as long as the width of the tooth and about the size of the lead of a pencil. Saturate it with sandarac varnish and pack it between the teeth upon the gum, extending part of it below the edge of the cavity, thus sealing this portion of the cavity and reducing it nearly to the form of an occlusal cavity. Paste applied in an approximal cavity so protected cannot flow upon the gum unless too great a quantity has been used. The paste should be applied and sealed as in an occlusal cavity.

"Devitalizing fiber" is very satisfactory and may be used with less fear of its affecting the gum tissue.

The paste may be allowed to remain in the cavity for from twelve to forty-eight hours. The possibility of the dressing being dislodged, so as to allow the paste to come in contact with the gum tissue, should warn one to have the patient return much sooner than when the case is an occlusal cavity from which it is impossible for the paste to escape.

Much has been said about the danger of application of arsenic in deciduous teeth when the roots are undergoing resorption, but the writer has never seen any bad effects from such use; still it must be admitted that the ratio of danger varies with the degree of resorption of the root. An examination of Prof. Peirce's diagram (Fig. 593) will show the average amount of resorption at different ages, and enable one to discriminate. The writer believes that the sensitiveness of a deciduous pulp varies inversely with the amount of resorption of the root, and that devitalization is called for in very few cases in which there is danger of deleterious action.

Prof. L. L. Dunbar advises the use of aqua ammoniæ for devitalizing the pulp of a temporary tooth, by applying it on a pledget of cotton in the cavity, one or two applications being sufficient in most cases. This plan is not open to the objections urged against the use of arsenous oxid.

When the pulp is devitalized, open the cavity freely into the pulp chamber and apply on cotton a solution of tannic acid in glycerol. Leave this about a week, by which time the pulp tissue will have become so hardened by the tannin that it may be removed much more readily than without such treatment.

The application of mummifying paste is advised by many, after devitalization, to avoid the necessity of removing the pulp. If a real mummifying paste can be found, its application will be the ideal treatment.

Filling Pulp Canals.

In the pulp canals apply iodoform paste made by mixing iodoform and glycerol to such a consistence that it can be readily applied on a probe.

Fill the pulp chamber with "temporary stopping" or gutta-percha, and the cavity with cement, gutta-percha, or amalgam according to indications.

If the tooth be very frail, fill the cavity with cement, because, owing to its adhesive properties, it strengthens the tooth. If the cavity be approximal and it is desirable to wedge the teeth apart, use pink gutta-percha.

If the walls be strong and some time will elapse before the natural exfoliation of the tooth will occur, fill with amalgam.

If absorption of the roots occurs, the iodoform in the canals will not interfere.

Salol, which was advocated as a root filling for permanent teeth by Dr. A. E. Mascort[1] of Paris, France, is well adapted also for filling the canals of deciduous teeth. "It is a white crystalline powder, insoluble in water and glycerol, but soluble in alcohol, ether, chloroform, etc.; fuses at 40° C. but crystallizes quickly again." Melted together, salol and aristol, salol and iodoform, or salol and paraffin, become liquid like salol alone. After a pulp canal is thoroughly dried the salol may be fused on a small spatula and carried to the canal, into which it will be taken by capillary attraction or a broach may be heated and inserted in the salol. A small quantity will adhere like a drop of liquid and may thus be carried to the canal. The heated broach may be again introduced in the canal to insure thorough application. Dr. Mascort uses the hypodermic syringe with a small needle for introducing into the canals. It will crystallize in a very short time, making a solid filling. Though the writer has not had much experience with salol as a root filling, he is so far well pleased with the result. (See Chapter XVII., p. 439.)

Alveolar Abscess.

The treatment should be the same as with the permanent teeth, that is, removal of the cause—which is, almost invariably, a decomposed pulp. Even with a decomposed pulp an abscess seldom occurs if there be any opening from the cavity of decay to the pulp chamber, unless such opening has become stopped by some foreign substance.

Make a free opening into the pulp chamber and with a syringe wash out as much of the contents as possible. Dry the chamber and with a "minim" syringe (see Chapter XVII., Fig. 441), or drop tube, apply hydrogen dioxid. While capillary attraction will carry this into a dry canal, the application of a nerve broach, preferably platino-iridium, will serve to mix it thoroughly with the contents of other canals, and increase its efficiency.

If a fistulous opening has formed through the outer alveolar plate but not through the gum, an opening should be made through the latter with a sharp lancet about five minutes after the application of 4 per cent. cocain hydrochlorid solution on a wad of cotton.

If hydrogen dioxid can be forced from the pulp chamber through the root canals and fistulous opening, the accumulated pus will be thoroughly evacuated and the cure hastened. As a rule, however, the abscess disappears after the cause is removed, that is, the putrescent or decomposed contents of the pulp chamber and canals.

After drying the pulp chamber and canals, apply iodoform paste

[1] *Dental Cosmos*, 1894, p. 352.

therein and seal the cavity for a few days with temporary stopping. When the inflammation of the pericementum has disappeared the pulp chamber and canals may be filled as before directed.

In many cases the inflammation of the pericementum will be so great, or in popular expression the tooth so "sore" to the touch, when the case is presented that at the first sitting nothing more can be done than to make an opening into the pulp chamber to allow the escape of pus or gases of decomposition. By this means the pain will be relieved and the rest of the manipulation and treatment may be left till the inflammation has subsided.

Prophylactic Treatment.

This lies more in the hands of the parent than of the practitioner, but should be strongly urged by the latter upon the former. The nurse or parent should begin early to clean the child's teeth by means of a cloth wrapped around the finger. If the teeth cannot be kept clean in this manner a small brush should be used, especially after eruption of the molars. Floss silk should be used daily between the teeth. One end of the silk should be held in each hand in such a manner as to pass over the end of each index finger and be made taut between them. This taut part can be pressed down between the teeth and passed up and down against the approximal surface of each tooth, then one end of the thread should be released from one hand and pulled through the interdental space with the other.

This will drag out any particles of food that may be there, and is much better than the toothpick for the purpose. If particles of meat or other food have lodged so firmly that the plain waxed silk will not dislodge them, tie a single knot in the thread and pull that through.

This cleansing with the cloth, brush, and silk should be done before the child retires at night, for that is the "period of decay." The parts are at rest longer than at any other time, and the fluids of the mouth are not kept in circulation between the teeth by means of the tongue, lips, and cheeks. Theoretically the teeth should be thus thoroughly cleaned after each meal, but "satiety breeds disgust," and it is not best to insist on more than will probably be accomplished.

Children will soon learn to use the brush and floss silk themselves, and finding the mouth much more comfortable when "clean" they will endeavor to keep it so. Many a child has been denied candy for years from the belief that "sweets decay the teeth," but parents may be assured that no harm will be done if the "sweet" is not allowed to remain between and around the teeth till it becomes acid, and that may be prevented by cleansing the teeth after the candy or sugar is eaten. A child may be taught cleanliness in this manner who would be only taught rebellion by the repeated denial of sweets, the reason of which he cannot understand.

Prophylactic mouth-washes should be used—such as listerine diluted to a 10 per cent. solution.

CHAPTER XXIV.

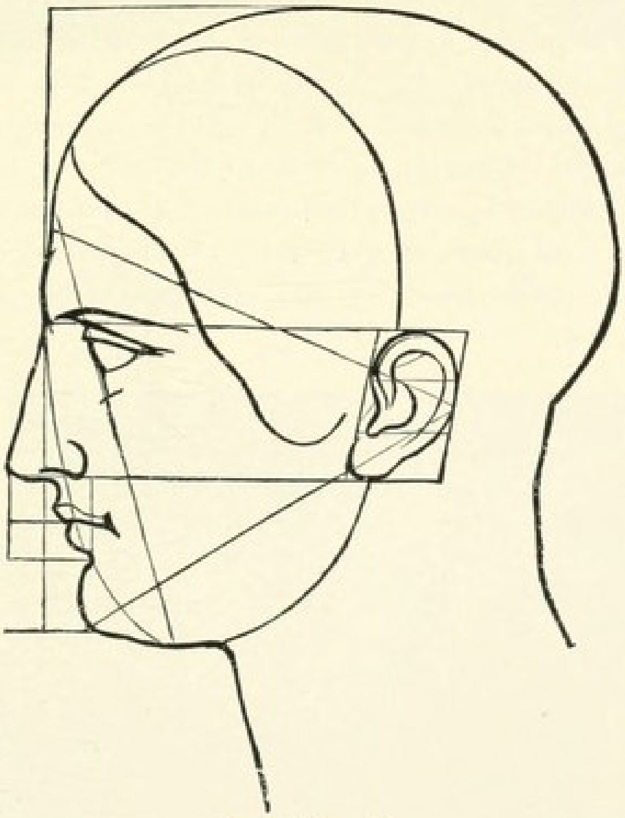
ORTHODONTIA EXCLUSIVELY AS AN OPERATIVE PROCEDURE.

By Clark L. Goddard, A. M., D. D. S.

The Normal Arch.—As the study of physiology is necessary before the study of pathology, so is a study of the normal arrangement of the teeth necessary before the treatment of their irregularities should be undertaken.

The ideal facial profile is shown in Fig. 598. The face from the

Fig. 598.

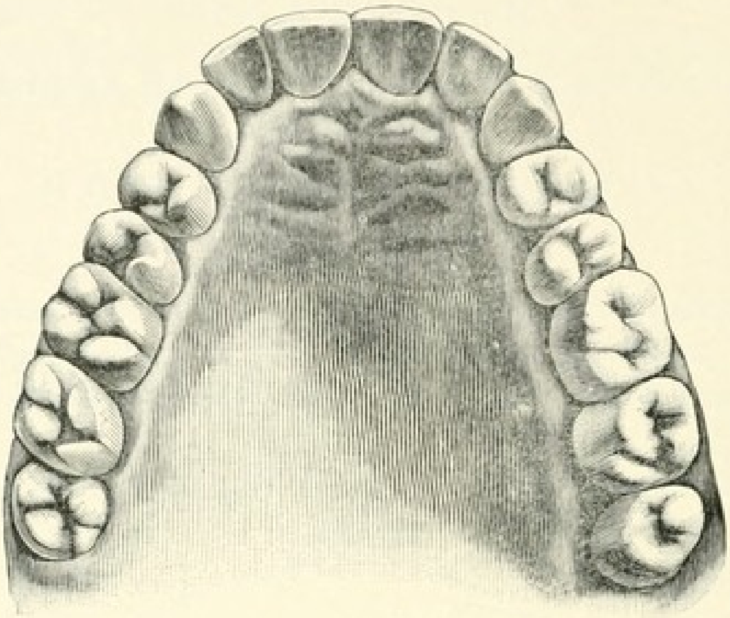


The facial profile.

hair to the chin measures three-fourths of the whole height of the head. The forehead to the root of the nose measures one-fourth, the nose one-fourth and the mouth and chin one-fourth. The distance vertically from the root of the nose to its lower border is equal to the distance from this point to the bottom of the chin. Of this latter distance one-half is occupied by the lips and one-half by the chin. The nose, then, equals in length the lips and chin.

The upper dental arch is shown in Fig. 599. The six anterior teeth are arranged in the segment of a circle. The bicuspids and molars

Fig. 599.

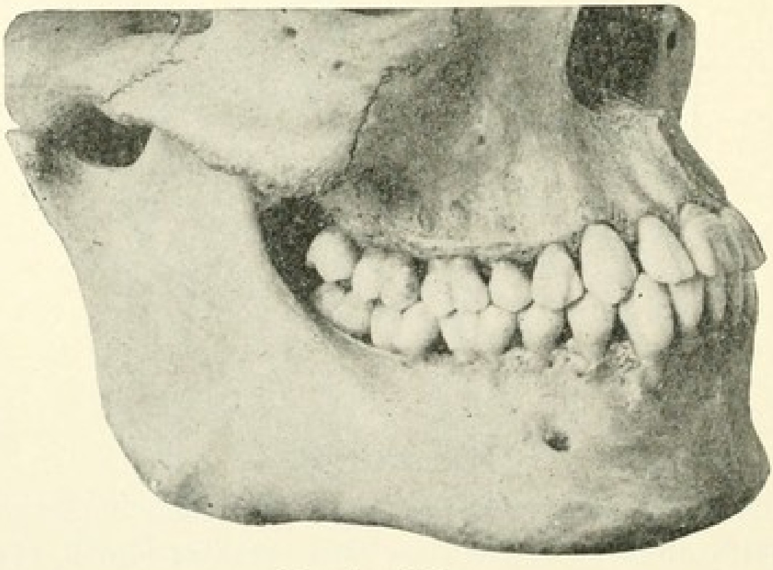


Normal upper dental arch.

form almost straight diverging lines from the canines, though the position of the third molar is somewhat outside of that line.

The normal occlusion of the teeth is shown in Fig. 600. The six upper anterior teeth close over the six lower from a third to a half

Fig. 600.



Normal occlusion.

of the length of the latter. The lower second bicuspid occludes between the cusps of the two upper bicuspids and is the *key to the occlusion;* this is a point easily remembered. Each bicuspid and molar of each jaw, excepting the upper third molar, is antagonized by two of the teeth of the opposite jaw. The buccal cusps of the lower teeth close between the buccal and lingual of the upper, and the lingual cusps of the upper close between the lingual and buccal cusps of the lower.

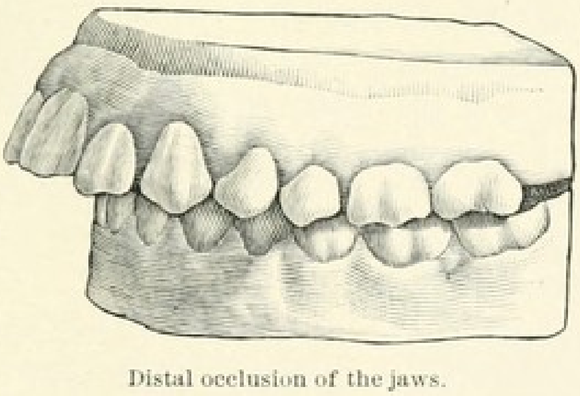
As the lower jaw moves laterally during mastication the cusps of the bicuspids and molars grind upon each other, while the six anterior teeth, overlapping but not touching, pass by each other and escape wear. In order to touch the cutting edges of the upper and lower incisors upon each other the lower jaw is protruded, and at such a time the masticating teeth do not occlude.

Mal-occlusion may be of many kinds and degrees, to which no general description can be given. The eruption of a single tooth labially or lingually or turned on its axis may disarrange the occlusion of all the neighboring teeth or even all the teeth of both arches. Likewise the loss of a single permanent tooth or its failure to erupt may have a more disastrous effect.

There are many cases, however, in which both arches are normal, yet their relation to each other is such that it results in mal-occlusion.

The nature of such mal-occlusion of the arches as a whole may be indicated by the position of the second lower bicuspid, which is the

FIG. 601.



Distal occlusion of the jaws.

key to the occlusion; according to its position, the occlusion of the arches may be described as normal, distal, mesial, lingual, or buccal.

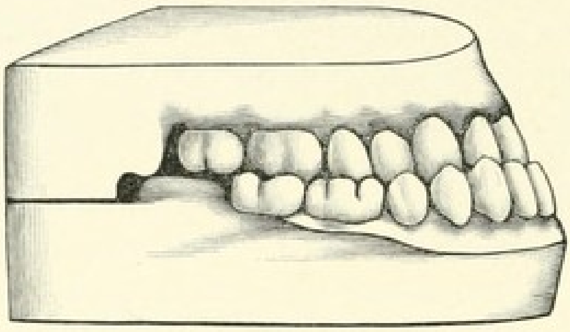
If the key tooth, the second lower bicuspid, closes between the upper bicuspids, with its buccal cusp between their buccal and lingual cusps, the occlusion, both of the key tooth and all the others, is normal (Fig. 600).

Distal Occlusion.—If the key tooth closes posteriorly or back of the normal position to any degree, even to the width of a bicuspid or more, the occlusion is distal, as shown in Figs. 601 and 603. This mal-occlusion may be on one or both sides of the mouth. It may be due to lack of development of the lower maxilla, or the fault may be in the temporo-maxillary articulation.

An upper protrusion may be described as a distal occlusion of the lower jaw on both sides (or a bilateral distal occlusion).

Mesial Occlusion.—If the key tooth closes anteriorly or mesially to the normal position to any degree, even to the width of a bicuspid or more, the occlusion of the jaws is shown to be mesial (Fig. 602). This may occur on one or both sides of the mouth and may be the fault of the teeth themselves, if the abnormality is slight. It may be due to lack of development of the upper maxilla, as in Fig. 779; or abnormal development of the lower maxilla, as shown in Fig. 780, both

Fig. 602.



Mesial occlusion of the jaws (also buccal occlusion and mesio-buccal occlusion).

being cases of lower protrusion. Hence lower protrusion may be described as mesial occlusion of the lower jaw (or lower maxilla).

Buccal Occlusion.—If the lower arch is wider than the upper, so that the buccal cusps of the lower bicuspids and molars do not close between the buccal and lingual cusps of the upper teeth, but close outside in any degree, even to the width of a cusp or more, the key will be found in a buccal position, and the whole occlusion is buccal, as shown in Figs. 602 and 781.

This may occur on one or both sides of the arch (unilateral or bilateral), and may be due to a narrow upper arch or a wide lower arch.

Lingual Occlusion.—If the lower arch is so narrow that the buccal and lingual cusps of the lower bicuspids do not close between the buccal and lingual cusps of the upper teeth, but close inside or toward the median line of the mouth to any degree, the key tooth will be found in a lingual position and the whole occlusion is lingual (Fig. 807).

This may be due to a slight disarrangement of the teeth themselves, or to abnormal development of the upper or lack of development of the lower maxilla.

Lingual occlusion may occur on one or both sides of the arch (unilateral or bilateral), or there may be lingual occlusion on one side and buccal occlusion on the other.

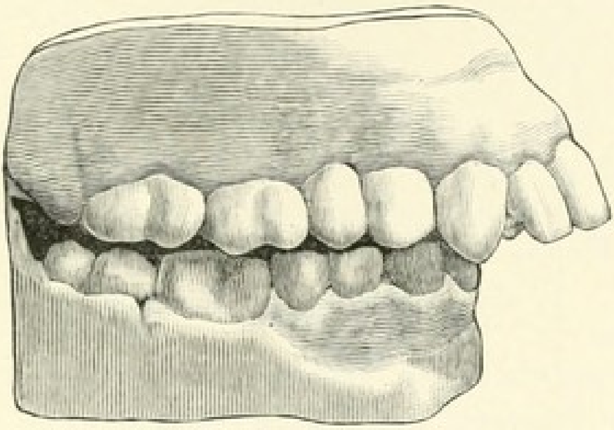
In cases of bilateral mal-occlusion either buccal or lingual expansion of the lower or upper arch is indicated.

Two of these positions may occur at once while the single arches themselves are comparatively normal.

A disto-lingual occlusion is shown in Figs. 603 and 807.

A mesio-buccal occlusion is shown in Figs. 602, 780, and 781.

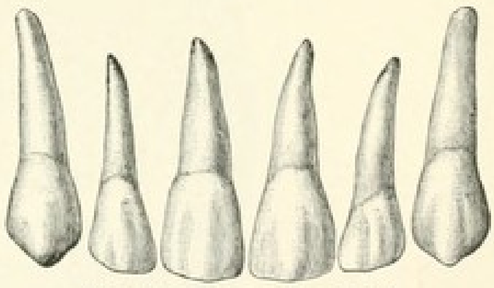
FIG. 603.



Disto-lingual occlusion of the jaws.

Labial Aspect.—In examining the upper six anterior teeth from the labial aspect (Fig. 604) it will be seen that they touch each other at one point only, about one-fourth of the distance from the cutting edge to the gum; also that the long axes of the teeth are not parallel, but the crowns slant toward the median line. Of the six upper anterior teeth the central incisors are the longest, the laterals next, and the canines shortest, though popularly the canine is thought to be the longest tooth because of its prominence and the length of its cusps. It will be noticed that the gum line is higher on the canine, thus adding to its apparent length.

FIG. 604.



The six anterior upper teeth.

A line connecting the cutting edges and cusps of half the upper teeth forms a double curve, highest at the third molar and lowest at the central incisor, the line of beauty, while such a line on the lower teeth forms but one curve, highest at its ends.

While the aim of the student of orthodontia will be to correct all irregularities and reduce the abnormal to the normal, it will be possible in many cases to do this only in degree. The normal may always be approached, but not always attained.

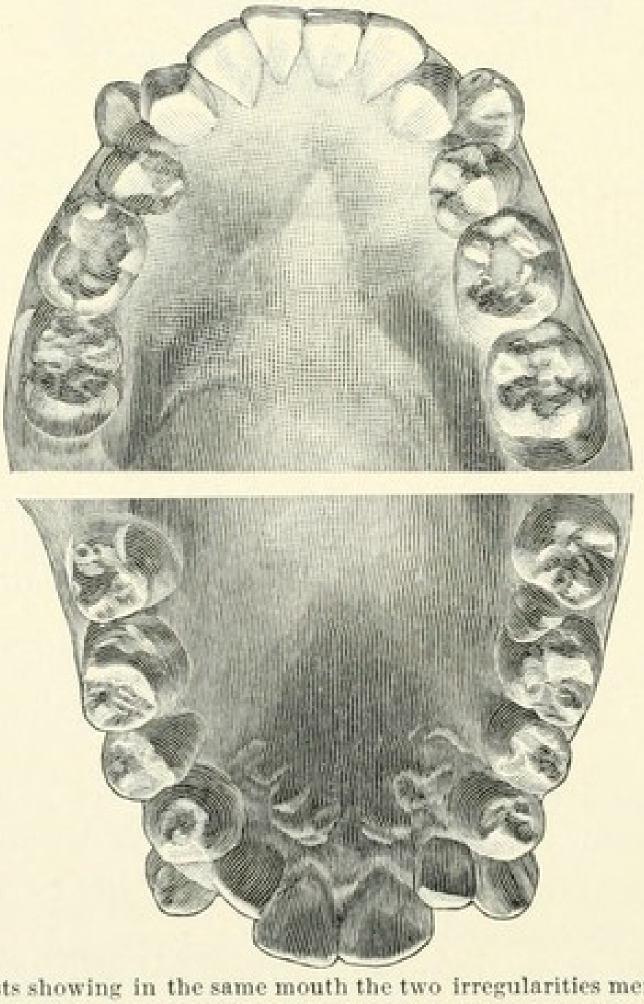
Order of Eruption of Permanent Teeth.[1]

1. Central Incisors—	from	6th	to	8th	year.
2. Lateral "	"	7th	"	9th	"
3. Lower Canines	"	8th	"	10th	"
4. First Bicuspids	"	9th	"	10th	"
5. Second "	"	10th	"	12th	"
6. Upper Canines	"	11th	"	12th	"
7. First Molars	"	5th	"	6th	"
8. Second "	"	12th	"	14th	"
9. Third "	"	17th	"	25th	"

While most tables place the eruption of all the canines after that of the bicuspids, it will be noticed that in this the lower canine precedes and the upper canine follows both bicuspids.

The lateral incisor fails to erupt more often than any tooth except the third molar. It also erupts out of line more often than any tooth except the canine.

Fig. 605.



Upper and lower casts showing in the same mouth the two irregularities mentioned on page 689.

The lateral incisor is duplicated more often than any other tooth, cases of five or six incisors sometimes arranged in the normal curve

[1] Farrar, *Treatment of Irregularities of the Teeth*, vol. i. p. 483.

of the arch, but more often crowded out of line, being seen occasionally. This is evidently a reversion to the six incisors of the normal mammalian formula:

$$I\frac{3-3}{3-3}\ C\frac{1-1}{1-1}\ Pm\ \frac{4-4}{4-4}\ M\frac{3-3}{3-3}=44.$$

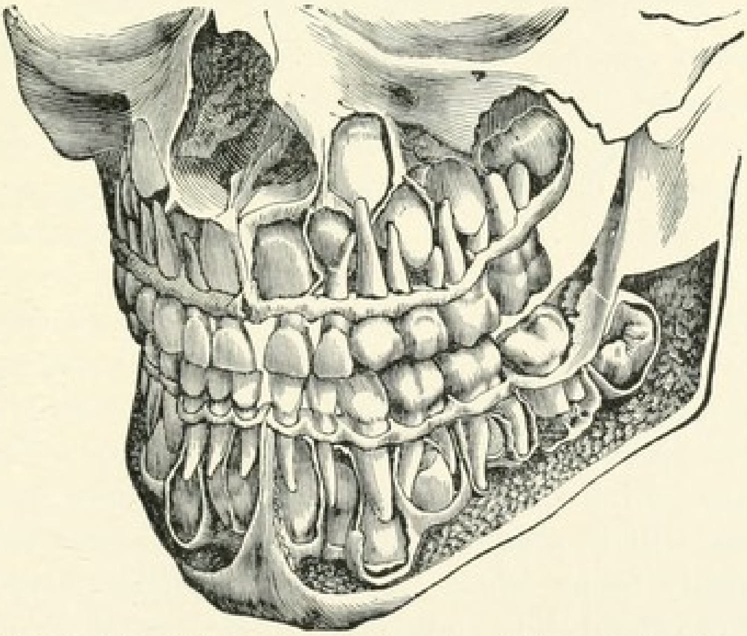
Occasionally a bicuspid (premolar) is duplicated, a reversion to the before-mentioned type, in which four premolars are normal.

The difference in the order of eruption of the upper and lower canines has an effect upon the position of those teeth. The upper canine erupts out of line more often than the lower, while irregularity of the lower bicuspids is more frequent than of the upper. In each case, being the last of the successional teeth to erupt, there is often insufficient room to enable them to assume their normal positions. (See Fig. 605.)

The Deciduous Teeth.

The position of the deciduous teeth is almost always normal. One or two teeth may be misplaced, either by an inherited tendency or by

Fig. 606.



Upper and lower jaws of a child aged about six and a half years, showing portions of the developing permanent teeth and the roots of the deciduous teeth.

pernicious habits, such as sucking the thumb. The irregularity, however, is so slight and so infrequent, and the deciduous teeth are retained in the mouth for so short a time, that there is no occasion for treatment.

A regular arch of the deciduous teeth does not, however, foretell a regular arch of the permanent teeth. Fig. 606 will make evident that the crowns of the permanent incisors, canines, and bicuspids are formed in the jaw before the roots of the deciduous teeth are absorbed. From want of space they are crowded together, and already present all phases of irregularity.

The late Prof. J. H. M'Mullen said of such cases: "When we are examining a series of jaws of different ages, arranged so as to show deciduous and permanent teeth, it is not a surprising matter that there should be irregularity in the permanent set; but when observing their crowded and irregular arrangement in the jaw prior to eruption, it is rather a matter of astonishment that they should ever assume a regular symmetrical appearance."

As the permanent teeth are larger than the deciduous, the question naturally arises, How is room provided for them?

This may be answered, first, by dividing the permanent teeth into two classes: those which replace the deciduous teeth and those which do not. For the first class—that is, the incisors, canines, and bicuspids—room is made by interstitial growth and by the fact that the biscuspids are smaller than the deciduous molars which they replace. For the permanent molars room is made by growth of the posterior portion of the jaw.

Etiology of Dental Irregularities.

The causes of irregularities of the teeth may be divided into three classes—hereditary, constitutional, and acquired.

As children inherit other peculiarities of structure from father, mother, grandparent, or even from more remote ancestors, so may irregularities of the teeth be inherited. The causes are operative before the birth of the child.

Hereditary causes may be divided into two: (*a*) *Direct*, in which a child inherits some distinct irregularity just as he may inherit some other distinctive feature. (*b*) *Indirect*, in which he inherits separate peculiarities which combined will cause an irregularity. For example, large teeth may be inherited from one parent and small jaws from the other, and thus will be produced an irregularity of some kind, but not inherited directly from either. A child may inherit tone of voice, peculiar gait, or other habit; so he may inherit a habit which will cause an irregularity. The intermarriage of different races is a prolific cause of irregularities of *indirect heredity*.

Dr. Talbot[1] defines as **constitutional** irregularities "those that develop with the osseous system," such as those due to excessive development or to lack of development of either the upper maxillary, intermaxillary, or lower maxillary bones, or of the ramus or body of the latter; too high vault, too narrow vault, etc.

[1] *Etiology of Osseous Deformities of Head, Jaws, and Face*, 3d ed. p. 16.

A constitutional irregularity may be hereditary or may be due to some cause affecting the osseous system, such as lack of development of the bones about the nasal cavity from lack of circulation of air through this cavity and connecting sinuses, due to mouth-breathing. The result may be a high vault with a small and narrow arch, and consequent crowding and various irregularities of the teeth.

An acquired irregularity may be due to—

(*a*) Too long retention of deciduous teeth.

(*b*) Too early extraction or loss of deciduous teeth.

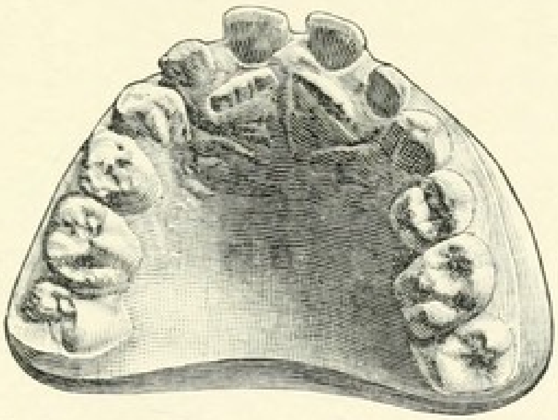
(*c*) Injudicious extraction or early loss of permanent teeth.

(*d*) Delayed eruption of permanent teeth.

(*e*) Pernicious habits (thumb-sucking, etc.).

(*f*) The presence of supernumerary teeth, etc. (See page 697.)

Fig. 607.



Lingual eruption of permanent incisors due to too long retention of deciduous incisors.

Too long retention of deciduous incisors may cause lingual eruption of permanent incisors (see Fig. 607) or rotation of the same.

Too long retention of deciduous canines may cause either lingual eruption (Fig. 700) or labial eruption of permanent canines (608).

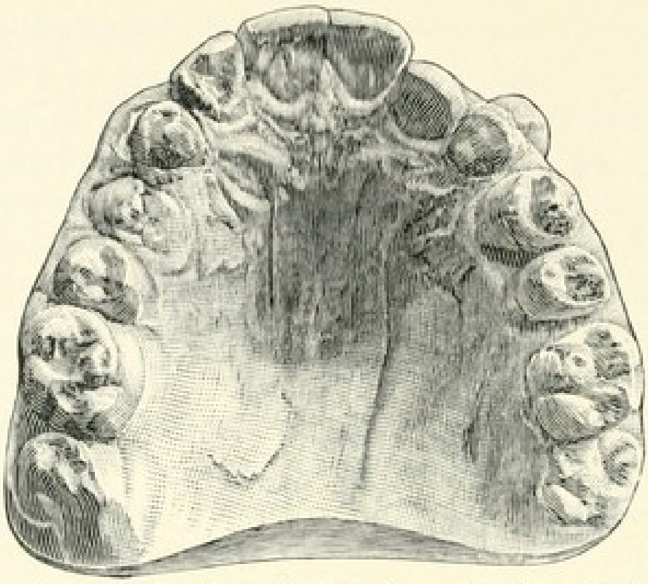
Too long retention of deciduous molars may cause a constricted arch (Figs. 609 and 610; also page 785).

(*a*) **Long Retention of Deciduous Teeth.**—A tooth may be deflected from its normal position in erupting by the presence of a supernumerary or deciduous tooth the root of which has not been absorbed. Death of the pulp of a deciduous tooth will prevent its normal or physiological resorption. It may then be removed by a pathological process which is much slower, or it may not be removed at all, but remain indefinitely, or till removed by the forceps.

(*b*) **Too Early Extraction of Deciduous Teeth.**—As Nature provides for the shedding of the deciduous teeth at the proper time, interference by extraction should be avoided in all possible cases.

Unless the deciduous teeth are retained, the natural expansion of the

Fig. 608.



Labial eruption of permanent canines due to too long retention of deciduous canines.

Fig. 609.

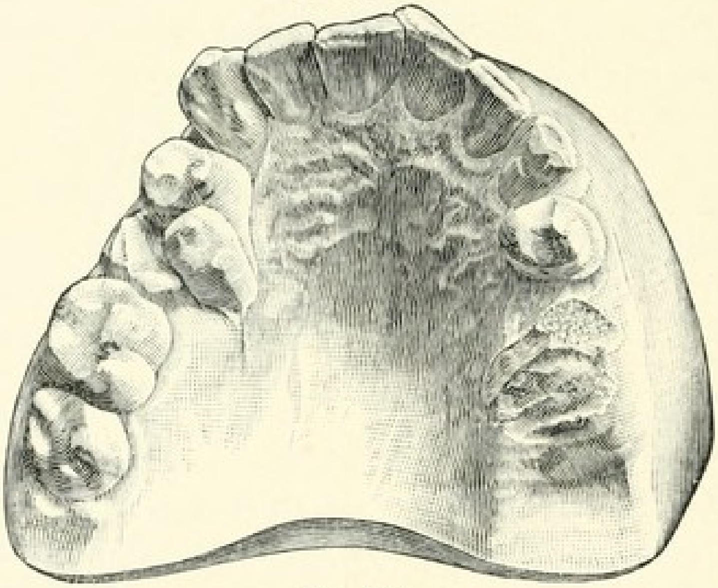
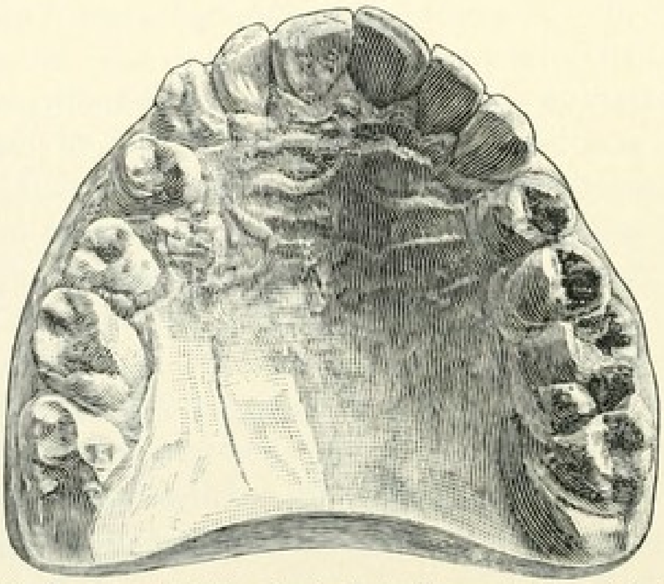


Fig. 610.



Figs. 609 and 610: Semi-constricted arch due to too long retention of deciduous molars.

jaw by interstitial growth will be interrupted. When a deciduous tooth is extracted, the contiguous teeth, whether deciduous or permanent, tend to move toward each other and occupy the space which should be preserved for the succeeding tooth.

But one rule is needed, as follows: *Extract a deciduous tooth only when it deflects its successor.*

RULES AGAINST EXTRACTION OF DECIDUOUS TEETH.—1. Do not extract a deciduous *lateral* to make room for a *permanent central* incisor.

2. Do not extract a deciduous *canine* to make room for a *permanent lateral incisor*.

Requests for such extraction will often be made by the parent, to whom the explanation should be made that such extraction is liable to prevent the natural growth of the jaw for the accommodation of the permanent teeth; also that, while the six anterior deciduous teeth are replaced by larger permanent ones, the four temporary molars in each jaw are replaced by the smaller bicuspids, and that when this takes place, irregularities of the incisors, especially the lower ones, will correct themselves, unless the teeth are too large for the jaw, which cannot be foretold with certainty at this age. Even if it could, no extraction of deciduous teeth would be of benefit, but rather positive harm.

3. Do not extract a *deciduous second molar* till the first permanent molar is firmly fixed in place, and not then unless the second bicuspid has erupted or is about to erupt out of position.

Requests for extraction of deciduous molars are made on account of cavities of decay, which should be filled and the teeth preserved for service in mastication.

The only exception to these rules is in cases of incurable alveolar abscess, which may endanger the alveolar border and the tooth forming beneath.

(*c*) **Early Loss of Permanent Teeth.**—Irregularities may be due also to early loss or injudicious extraction of permanent teeth.

An early loss of first permanent molars may cause upper or lower protrusion.

An early loss of lateral incisors causes a narrowing of the anterior portion of the arch and deprives the angles of the mouth of their proper contour.

A loss of canines causes a depression of the angles of the mouth and wing of the nose.

(*d*) **Delayed Eruption of Permanent Teeth.**—The delayed eruption of any permanent tooth, after the loss of its deciduous predecessor, will allow the teeth on each side of the space to move toward each other and thus prevent eruption, or crowd the erupting tooth out of the line either labially or lingually.

It is often of the utmost importance to ascertain whether a tooth is delayed in eruption or is permanently absent. The tooth most likely to be absent is the third molar. The one next most likely to be absent is the lateral incisor, generally referred to as the "missing lateral."

In case the permanent laterals do not erupt at the proper time, the question often arises with a crowded arch, whether to preserve space for them in hopes of their eruption, or to allow the other teeth to crowd along and occupy the space. Hitherto it was impossible to answer this question, but lately science has come to our aid, and by the skiagraph the uncertainty can be made a certainty.

Fig. 611.

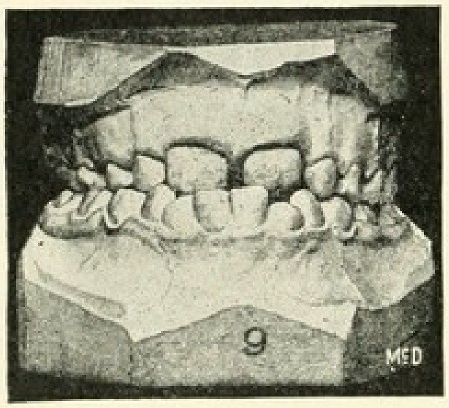
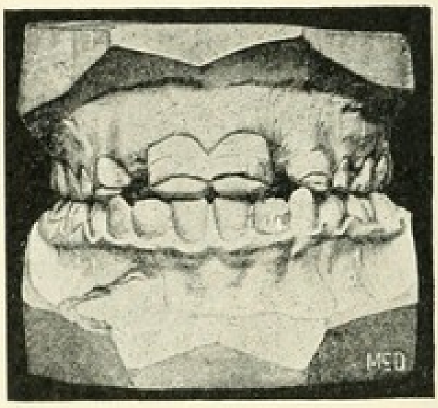


Fig. 612.



Figs. 611–614, and the following description[1] by Dr. J. N. M'Dowell, will illustrate the subject of delayed eruption:

Fig. 613.

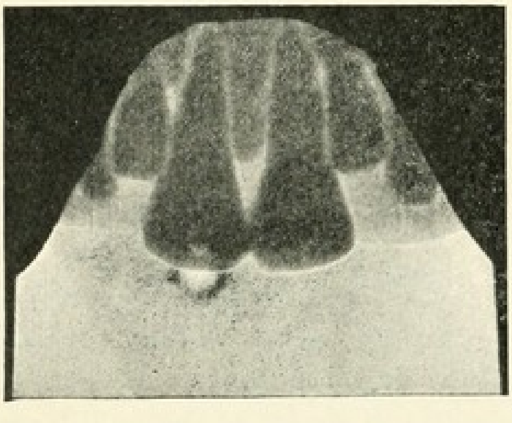
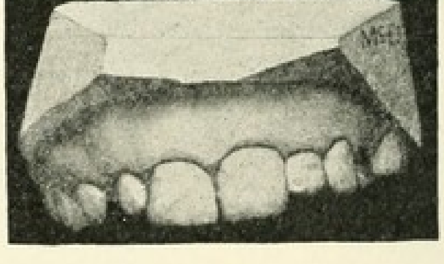


Fig. 614.



"Fig. 611 shows the models of a boy eight years old. The space for the laterals is entirely closed up. The teeth in both the upper and lower arches were regulated, making the necessary room for the laterals in the upper arch (see Fig. 612). This space was retained for two years, and at the end of that time there was still no sign of the

[1] Dr. J. N. M'Dowell, *Dental Cosmos*, March 1900, vol. xlii. p. 237.

laterals. Examination gave no indication of delayed teeth, but the result of the x-ray (Fig. 613) showed the laterals high up in the process still only partly developed. It was several months later before there were any indications of the laterals making their appearance. Fig. 614 shows the same case eight months after the x-ray was taken."

Oftentimes the occlusion is sadly impaired by the non-eruption of a bicuspid impacted between contiguous teeth. The skiagraph Fig. 615 reveals the exact position of the delayed tooth and shows the importance of making room for its eruption. Fig. 616 shows a second bicuspid caught under the shoulder of a first bicuspid, and suggests that it can be released by forcing the latter into an upright position.

The exact position of a delayed canine may be revealed, and the question settled whether it be possible for it to erupt without assistance, or whether it can even be forcibly erupted.

Fig. 615.

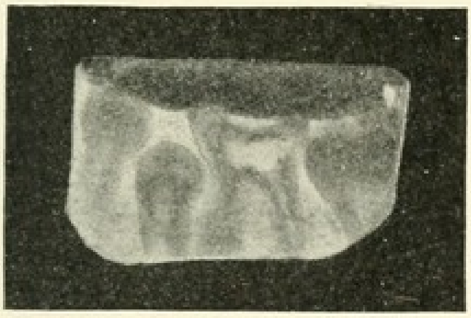
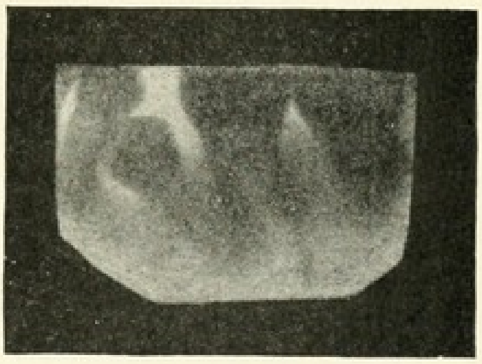


Fig. 616.



In some cases a deciduous tooth remains in place long after the time when it should have fallen out. It may be so firm as to cause serious doubts about the advisability of extracting it, even though there is malocclusion while it is in place. The skiagraph will reveal the presence or absence of the bicuspid, and show whether extraction should be resorted to or not.

The method of making the skiagraph is thus described[1] by C. Edmund Kells, D. D. S., of New Orleans:

"One of the requirements in obtaining a skiagraph is that the object to be pictured and the plate or film must be held perfectly still during the process. It is frequently possible to cut the film the proper shape, inclose it in a black (light-proof) envelope, and allow the patient to hold it in the mouth in the desired position; but on general principles this is not satisfactory, more especially with children, as it is liable to be moved during the exposure.

[1] *Dental Cosmos*, October 1899, vol. xli. p. 1014.

"The method now employed, after much experimenting in that line, is as follows:

"A cast is made of the portion of the mouth to be skiagraphed, and a small piece of modeling compound moulded over the crowns of the teeth thereon. A piece of aluminum (this metal being almost transparent to the rays) of about 26 or 28 gauge is cut to the desired size and shape and bent to fit the cast as well as possible. This is slotted along the edge toward the crowns of the teeth, and thereby attached to the modeling compound referred to above. This forms a convenient little film-holder, which when placed in the mouth will allow the patient to close the teeth upon it, and thus hold it securely in position, without danger of its moving, for a much longer time than is necessary to take the picture.

"The next step is to cut the plate or celluloid film, whichever is to be used, to the proper size and envelop it neatly in black paper, gluing down all the edges with paste, and securing it to the plate-holder by two or more small aluminum clamps.

"This is all that is usually necessary; but if it is deemed advisable to protect the envelope from moisture, as is sometimes the case, more especially for lower teeth, then it is covered with thin tin foil or waterproof paper neatly pasted down, care being taken not to have the foil (if that is used) doubled upon the side to be exposed. While this may appear to be a long process, it is quickly accomplished, and the invariably satisfactory results obtained warrant the trouble taken.

"The patient is then seated in a chair with a photographer's head-rest to hold the head, the Tesla screen put in place, and the tube brought to about ten or twelve inches from the face and placed so as to throw the best shadow of the parts upon the film. The length of exposure depends upon the thickness of the parts to be penetrated, the working condition of the apparatus, and the distance of the patient from the tube, the time being proportional to the square of the distance. From sixty to ninety seconds are necessary for ordinary cases, ranging perhaps up to one hundred and twenty seconds for third molars and heavy jaws, while twenty to forty seconds are sufficient for some favorable cases in thinner bones."

In some of the large cities skiagraphs can be readily obtained from experts with the Röntgen ray, who make it a business to accommodate physicians and others desiring their services. Any expert dentist with a slight knowledge of photography can readily prepare the film for the purpose.

(*e*) **Pernicious Habits.**—The habit of *thumb-sucking* may cause upper protrusion (see Fig. 757), lack of anterior occlusion (Fig. 801), or a constricted arch (Fig. 798).

The habit of sucking the finger or lip may cause protrusion of either jaw according to the position of the finger or lip.

While thumb-sucking sometimes causes the irregularities mentioned, it is not a frequent cause, and it is a singular fact that the habit does not cause irregularity of the deciduous teeth.

The habit of *mouth-breathing*, whether owing to nasal obstructions or not, may cause lack of anterior occlusion—see (*e*), page 786—or apparent lower protrusion—see (*e*), page 774.

(*f*) **Other Causes of Irregularity.**—*Obstruction of the nasal cavity* by a deflected septum, enlarged turbinate bones, polypi, adenoid growths in the nasopharynx, enlarged tonsils, or any other cause, by preventing free circulation of air through the nasal cavity, may be the cause of a lack of development of the frontal, sphenoidal, ethmoidal, and maxillary bones. This lack of development may produce a high and contracted vault, with a narrow and small arch and consequent crowding of the teeth into various irregularities.

Lack of development of the intermaxillary bone may cause (*a*) a pointed arch (page 757), (*b*) lack of anterior occlusion (page 786), or (*c*) prominent canines and depressed laterals—see (*a*), page 745.

Disparity in size between the teeth and the jaw may be due to either of two widely different causes, and yet produce several similar irregularities.

(1) This disparity in size may be due to teeth too large for the jaw (indirect heredity—page 690).

(2) It may be due to premature loss of deciduous second molars and a forward movement of the permanent first molars, thus shortening the arch and making it too small for the ten teeth that are to occupy it.

The result may be—

(*a*) Prominent canines and depressed laterals (Class 7, page 745).

(*b*) Pointed arch (Class 8, page 757).

(*c*) Upper protrusion (Class 9, page 760).

(*d*) Constricted arch (Class 12, page 784).

(*e*) Lower protrusion (Class 10, page 773).

The same condition in both jaws at once may cause similar irregularities in both jaws. One of the most notable of these is double protrusion (Class 11, page 782).

Loss of the deciduous second molar on one side may cause any of these irregularities on that side only, such as a semi-constricted or semi-pointed arch.

Changes in Surrounding Tissues when Teeth are Moved.—1. Resorption and Deposition.—When a single tooth is moved in any direction, there is first a *compression* of the soft and then of the hard tissues in front of the tooth, and at the same time a stretching of the peridental membrane behind the tooth. This is succeeded by *resorption* of the hard tissues in front by osteoclasts and a *formation of new bone* by the osteoblasts behind the moving tooth.

This latter action is much slower than the former, and depends on the tooth being held firmly in its advanced position. Any slight return will interfere with the formation of new tissue, and a tooth repeatedly moved forward and allowed repeatedly to recede will never become firm.

When a tooth is rotated in its socket, there must be a stretching of the fibers of the peridental membrane. If the fibers had not considerable elasticity, those opposing the rotation of the teeth would be ruptured instead of stretched, and would not tend to twist the tooth back to its old position. A tooth is sometimes forced back by the pressure of adjoining teeth, but such contingencies are not here under consideration. If the root is curved or is not round, there may be some resorption and rebuilding of the walls of the alveolus.

2. Bending of the Alveolar Ridge.—When several teeth are moved in the same direction at the same time there is a movement of the alveolar ridge as if it were a semi-plastic mass. This movement is easily proved by the following observations:

After a case of upper protrusion is reduced the labial portion of the alveolar ridge appears no thicker than before. If the only movement were of the roots through the ridge by resorption in advance of the moving tooth and formation of new bone behind, the labial portion would remain as prominent as before.

In spreading the arch rapidly, if movement took place only after resorption, the teeth might be pushed out of the ridge, but the external plates of the alveolar process will be found no thinner than before, while the vault of the palate is perceptibly broadened.

Dr. C. S. Case says that when teeth and roots are moved forward, sometimes ridges will appear on the outer surface of the alveolar process, but that the spaces or hollows between will soon fill up so as to present an even surface.

3. Separation of the Superior Maxillæ at the Symphysis.—When strong pressure is applied upon molars and bicuspids to spread the arch the superior maxillæ may be separated at the symphysis. (See Figs. 617 and 618.)

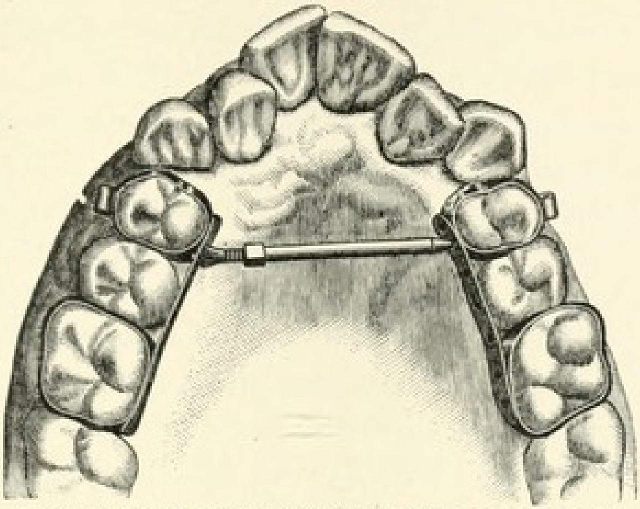
Such separation was first recorded by Dr. E. C. Angell of San Francisco[1] in 1885, and has been noticed by Guilford, Black, Talbot, Farrar, Ottolengui, and others since. Drs. Talbot[2] and Ottolengui[3] regard it as an advantage as giving room for re-arranging crowded incisors more

[1] *Dental Cosmos*, vol. ii. p. 540.

[2] Discussion in *World's Columbian Dental Congress*, vol. ii. p. 722.

[3] *Dental Practitioner*, vol. xxxv., No. 4, October 1894.

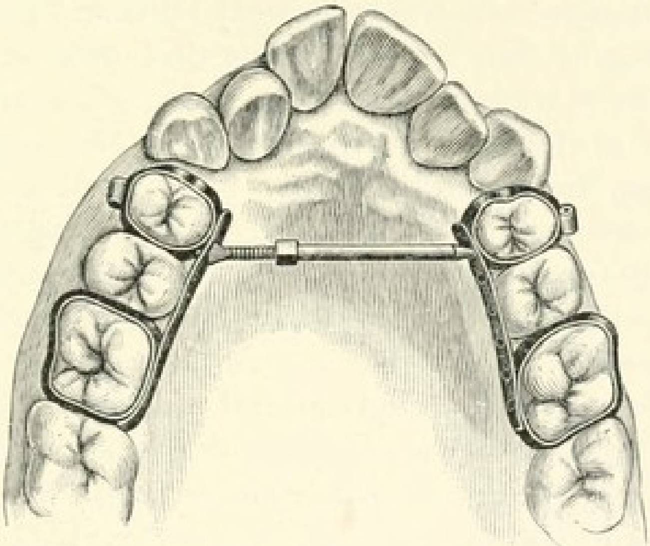
FIG. 617.



Symphysis of superior maxillæ, before spreading arch.

quickly than in any other way and maintaining crowns and roots in an upright position.

FIG. 618.



Separation of superior maxillæ at symphysis, after spreading arch.

4. DEPRESSION OF THE ROOTS IN THE SOCKETS.—In reducing cases of lack of anterior occlusion by means of elastics extending from a chinpiece to a cap to the top of the head, Prof. Guilford[1] says: "The condyles of the lower jaw will be tipped somewhat out of their cavities, and the latter be partially filled up with new ossific material; at the same time the tendency will be to shorten the posterior occluding teeth by forcing them farther into their sockets."

Charles S. Tomes[2] in a similar case questioned whether "the closure of the front teeth was effected by an elongation of the ascending ramus of the jaw or by the antagonizing teeth being depressed and, so to speak, forced farther into their sockets," and concludes, "I am inclined to think the latter is the true explanation."

[1] *Orthodontia*, 2d ed., p. 196. [2] Kingsley's *Oral Deformities*, p. 121.

Pathological Conditions which may be Caused by Irregularities of the Teeth.

Under this head may be mentioned dental caries, gastric disorders, and deposition of salivary calculus.

Caries.—In the normal arch the teeth touch each other at one point only, and fluids are freely circulated between and about them by the tongue, lips, and cheek. When the teeth are irregularly arranged broad surfaces often come in contact, the convex surface of one incisor may be partially imbedded in the concave surface of another, or three teeth arranged as in a triangle form between them a cul-de-sac. In all such cases the maintenance of cleanliness is difficult if not impossible, and caries is the probable result.

Dyspepsia.—Any deviation from the normal arch will cause also a deviation from the normal occlusion, so that proper trituration of the food is interfered with if not positively prevented. Such lack of thorough mastication will throw unusual burdens upon the digestive organs, resulting in their greater or less derangement.

The question of *occlusion* is exceedingly important, and often decides the method of treatment of an irregularity or of making room, or of undertaking any treatment whatever.

In most cases of complicated irregularity there is already mal-occlusion of the masticating teeth, and every endeavor should be made to move the teeth, so as to improve the occlusion and make it as nearly normal as possible.

When the occlusion is already normal and the irregularity is slight but cannot be reduced without seriously deranging one or both sides of the mouth, it may be best to permit the irregularity to remain, as the least of the two evils.

In any case of widening or spreading, should either arch be made too wide for the other, that also should be spread to restore or improve the occlusion.

If either arch be too small for the other, the sole object in spreading may be to improve the occlusion.

If in any case room must be made by extraction, the most serious consideration must be given to the choice of the tooth or teeth whose removal will least derange the occlusion, if already good; and if otherwise, selection may be so made as to improve it.

The tooth most often under discussion in this respect is the permanent first molar. This is a very valuable tooth for mastication, and its loss may render all the teeth on that side of the mouth useless for that function. The teeth back of the space may tip forward and those anterior to it may tip backward, so that they all present only points and cusps to the cusps of opposing teeth, instead of the normal interlocking of cusps which gives the greatest efficiency.

The question as to the extraction of a tooth will depend also on its condition. In the writer's opinion it will be better in many cases to crown the roots of a molar decayed too much for filling, and remove some other tooth that is less useful in mastication. (This question is further discussed on page 745.)

Salivary Calculus.—As the accumulation of salivary calculus is impossible upon parts of the teeth subjected to use in mastication or easily cleansed with the brush, so any abnormality of arrangement that prevents thorough use of the brush favors the deposit, with all of its possible consequences.

Accidents which may Happen during Treatment.

Death of the Pulp.—This may occur from strangulation at the apical foramen from too rapid movement of the tooth. The possibility of this accident is least when movement is begun while the apical foramen is large, before the root is completely formed ; it increases with the age of the patient, and is greatest after the root is fully formed and the foramen is constricted to its permanent size.

Death of the pulp may also occur from rupture of the bloodvessels at the apex of the root from too rapid elevation of the tooth. The liability of such accident will vary according to the age of the patient and size of the apical foramen.

Rupture of the Pericementum.—This may occur also from too rapid elevation of a tooth. After such an accident, a tooth returned to its socket would be in the condition of a replanted tooth, subject to the same chances of attachment and retention.

Permanent Enlargement of the Alveoli.—Dr. Talbot[1] says: "The probability of a perfectly satisfactory result in regulating decreases yearly after the age of puberty, and after the age of twenty-six the chances of a really satisfactory result are very meagre, for at this time the entire osseous system is fully developed and there is little probability of extensive deposit of ossific material."

The writer would, however, fix the date later than that—perhaps at thirty years.

Pressure at any age will cause resorption, therefore teeth may be moved in the case of adults, though more slowly on account of the greater rigidity of the alveolar process. Greater force will be needed to produce resorption in advance of the moving tooth, and there is a possibility, even a probability, that no ossific deposit will take place behind the

[1] *Irregularities of the Teeth and their Treatment*, 2d ed., p. 172.

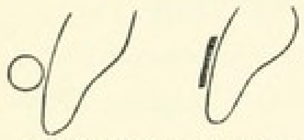
root. The result is an enlarged socket in which the tooth never again becomes rigid.

Permanent enlargement of the alveoli may occur also from not retaining teeth fixedly in their new position but allowing them to move back and forth. The action of the osteoblasts in forming new bone is thus interfered with so much as to absolutely prevent it, and the result is an enlarged alveolus.

Injury to the Enamel (Caries).—This may occur from too long retention of either regulating or retaining appliances in contact with the teeth.

Bands that are to be retained more than a few weeks should be cemented upon the teeth and carefully watched, as a loose band will surely result in a softening of the enamel under it, sometimes even to the extent of forming a cavity.

Fig. 619.



Round and flat contacts in regulating fixtures.

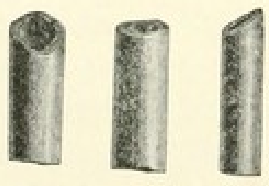
Retaining appliances should be so constructed that no flat or broad surfaces remain in contact with the teeth. A round wire is as efficacious as a flat bar, and the tooth under it is easily kept clean, as the point of contact is so small. (See Fig. 619.)

Appliances, Materials, Methods, and Forces Employed.

Definitions.—To prevent repetitions a few appliances and materials will be briefly described.

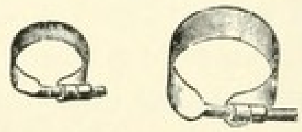
Rubber Band.—A section cut from French rubber tubing from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch in diameter and from $\frac{1}{64}$ to $\frac{1}{8}$ of an inch wide. (See Fig. 620.) These lose their elasticity by remaining stretched, and should be changed at least twice a week.

Fig. 620.



Rubber tubing for bands.

Fig. 621.



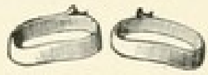
Bicuspid. *Molar.*
Adjustable bands (Angle).

Gauge.—In indicating the thickness of plate and size of wire the number referred to is that of B. & S. gauge, *e. g.* wire No. 20, plate No. 27, etc.

Tube or Tubing.—Made of a strip of platinum-gold or German silver No. 27 to No. 32 gauge and $\frac{1}{4}$ of an inch or less wide, drawn through successive holes in a draw-plate until a tube is formed and reduced to the desired size. (See Fig. 628.) To make a tube to fit any desired wire or screw, take a strip three and one-third times the diameter of the wire or screw.

MAGILL BAND.—The invention of Dr. W. E. Magill. A strip of platinum, gold plate, or German silver, No. 30 to 36 B. & S. gauge, preferably the latter, from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch wide, bent around a tooth in the mouth or on a plaster cast, and soldered at the overlapping ends. This is cemented to a tooth with zinc phosphate. (See Figs. 622, 647, *et seq.*)

FIG. 622.



Magill bands.

ADJUSTABLE BAND (ANGLE'S).—A band of German silver from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch wide and No. 36 B. & S. gauge, to one end of which is soldered a short tube and to the other a screw, which is passed through the tube and tightened around the tooth with a nut. (See Fig. 621.) Cement should be placed inside the band before applying it.

BAND RIBBON.—This is best made from platinum or German silver wire No. 13, rolled to No. 34 or No. 36 plate. This is tougher than when cut from plate of the same thickness. For the anterior teeth the writer often uses, however, gold-faced platinum rolled to the gauge mentioned. It has the strength of platinum and the color of gold, which is preferred by many patients.

To this band may be soldered a tube, hook, screw, or any appliance desired.

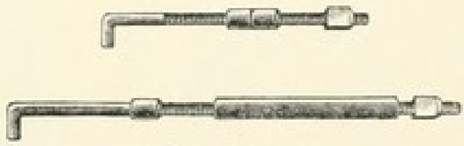
JACK-SCREW (ANGLE'S).—A tube pointed at one end, in which is inserted a screw about No. 16 B. & S. gauge, with a nut resting on the open end of the tube. The end of the screw is flattened or bifurcated. The length of the tube determines the length of the jack-screw. (See Figs. 623 and 643.)

FIG. 623.

Angle's jack-screw.

DRAG-SCREW (ANGLE'S).—A wire bent at right angles at one end, threaded at the other with a nut. (See Fig. 624.)

FIG. 624.



Angle's drag-screw.

PIANO WIRE.—Piano strings. Steel wire, elastic, yet soft enough to bend easily with pliers, from No. 20 to No. 24 B. & S. gauge: used for springs and elastic levers. (No. 20 B. & S. gauge corresponds to about No. 15 of piano wire gauge.)

LIGATURES.—Floss silk well waxed.

TWISTED LIGATURES.—Twisted silk No. A 0 or 00 or linen thread unbleached No. 50, well waxed.

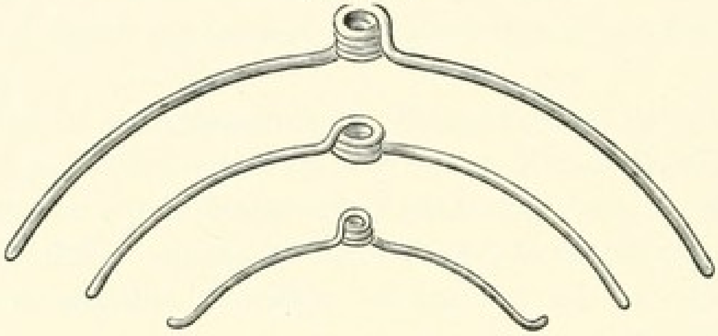
These are very useful in moving teeth, either ligated directly on the teeth or in connection with other appliances. When tied tightly from one tooth to another there is an immediate movement by slight compression of the peridental membrane; then as the twisted fibers swell the ligature is shortened and more pressure exerted.

It is to be understood that in the majority of illustrations in this chapter in which rubber bands are shown as the moving force, ligatures may be substituted. They should be renewed every day or two.

TWISTED WIRE LIGATURES of platinum, copper, brass, or German silver wire are excellent for intermittent movement of teeth. Dr. Angle suggests No. 28 B. & S. gauge as the best size (Figs. 726 and 727).

NORTON-TALBOT OR COIL SPRING.—A spring of piano wire No. 20 to No. 24 B. & S. gauge coiled upon itself one or more times.

FIG. 625.

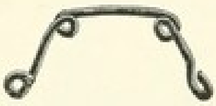


Talbot springs.

The best size of coil is that made around a piece of the same wire. (See Figs. 625, 741, and 742.)

MATTESON SPRING.—A spring of piano wire No. 20 to No. 24 B. & S. gauge, with two coils a half-inch or more apart. (See Figs. 626, 651, and 744.)

FIG. 626.



Matteson spring.

FIG. 627.

Swaged caps.

FIG. 628.

Metallic tubing.

CEMENT.—Zinc phosphate is more adhesive than oxychlorid of zinc; it should be mixed thin and applied to the tooth and band or cap. Rubber dam should, if possible, be applied to the teeth before using the cement.

SWAGED CAPS (MATTESON'S).—Caps swaged to fit over the whole or part of a tooth and secured with cement. To these caps are soldered hooks, bars, tubes, levers, etc. (See Fig. 627.)

LOCK-NUT.—A second nut screwed up against the first—necessary in some cases to prevent retrograde action by the patient's tongue.

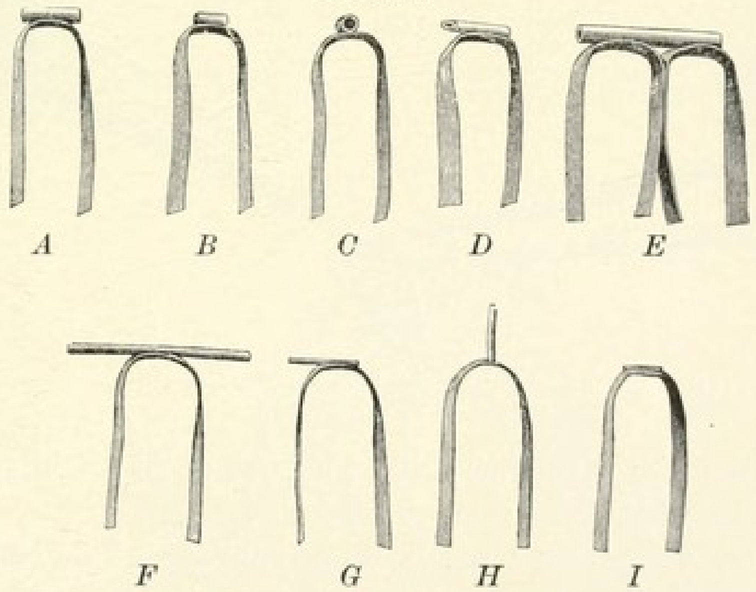
LABIAL BOW.—A bow of stiff wire, German silver, or clasp gold, about No. 16 B. & S. gauge, extending from the buccal surface of the teeth on one side of the mouth around the arch to a corresponding position on the other side. It may be held in place by inserting the ends in a plate (Fig. 711) or in tubes soldered to bands cemented on suitable teeth (Figs. 713, 729, 759). The ends of the bow may be screw-cut and furnished with nuts, as shown in these figures, or bent in bayonet-shape (Fig. 741).

LINGUAL BOW.—A similar bow on the lingual surface of the arch, with the ends inserted in tubes on the lingual surface of bicuspid or molar bands, screw-cut with nuts (as in Fig. 715 or 716) or bent into hooks (as in Fig. 667).

Labial and lingual bows are often used advantageously together and attached to the same teeth, as in Fig. 669 or 713.

AUTHOR'S PARTLY-MADE APPLIANCES.—Fig. 629 shows the writer's system of partly-made appliances. Each consists of a piece of band-

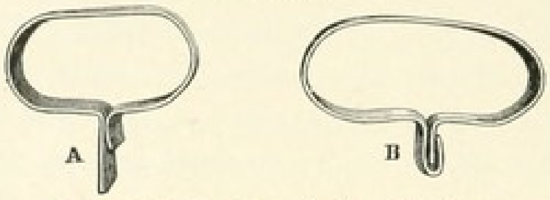
FIG. 629.



Partly-made appliances.

ribbon bent into an open loop. To each is soldered a tube, horizontal or crosswise, round or flat, or a wire, in line or at right angles. These can be made by the practitioner in leisure moments, and kept in stock. When a patient is in the chair, one of the open bands can be bent around any tooth, with the tube or wire in any position desired. The open ends can then be drawn tightly around the tooth and the sides burnished to fit accurately. Remove the band, cut the ends as shown in Fig. 630, A, bend one over the other, as in B, pinch them tightly together, so as to hold while soldering. Grasp the band with the pliers as shown in Fig. 631, and apply solder and heat to the inside of the joint. The pliers will protect the tube or

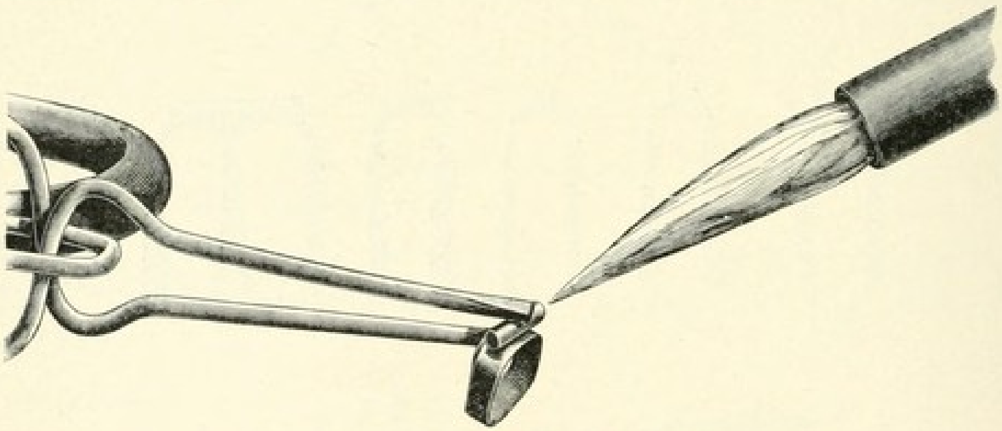
FIG. 630.



A, Band fitted; *B*, ready for soldering.

wire from unsoldering. The surplus ends can then be cut away, as in making a plain band. *E*, in Fig. 629, shows two open bands soldered to a long tube for making a double anchorage appliance, such as shown in Fig. 730. *D* has a flat tube, which may be used as in Fig.

FIG. 631.



Soldering joint in open band.

739. *F* will make a retainer, like Fig. 653 or 677, while *G* and *H* can be bent into hooks for various purposes.

The writer finds these "partly-made appliances" a great saving of time, as a great variety of complete appliances can be made from them while the patient is in the chair.

Figs. 745 and 746 show how an expander can be made in a similar manner.

FORCE.—"*Constant Force.*"—That exerted by compressed rubber or a spring of clasp gold or piano wire.

"*Intermittent Force.*"—That exerted by a screw, which allows periods of rest after each application; also that exerted by compressed wood or twisted ligatures of silk or linen.

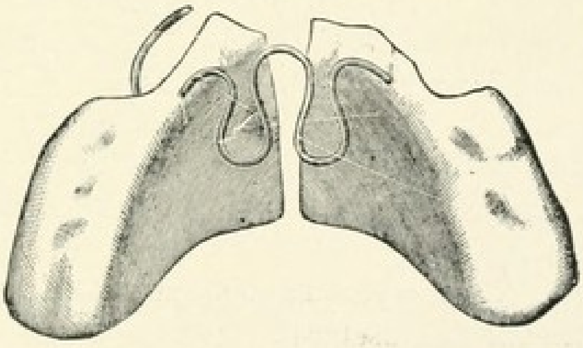
Methods.—No one "method" is applicable to all cases, so that it is necessary to select from various methods the simplest and most efficient for treating each kind of irregularity. During the last twenty years there have been presented by specialists in orthodontia many different plans of regulating. These are known as their special "methods" and are designated by the names of their originators.

The first extensive description of regulating appliances was that by Dr. Norman W. Kingsley, in his book on *Oral Deformities*, in 1880. Most of the appliances described in his book were taken from original articles previously written by him for dental journals, while a number were selected from articles by other well-known writers.

The first to claim a distinct method or system was Dr. J. N. Farrar in articles published about 1875, and further elucidated in book form in 1888. His system is based upon the adoption of the screw as a motive force. The originator claims the screw to be the only force which should be used, because it is intermittent and gives the parts a period of rest after each application. Very ingenious devices have been invented by him by which the screw is applied successfully to all kinds of movement, but as a rule his appliances are more complicated than those of any other system.

The Coffin method was introduced at the International Medical Congress in London, in 1881, by Walter H. Coffin. The elasticity of

Fig. 632.



Coffin split plate for spreading the upper arch.

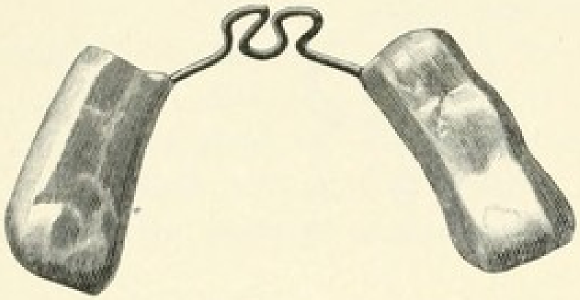
piano wire is used as a motive force, by anchoring it in vulcanite plates. The most notable example of this method is the Coffin split plate for spreading the arch. (See Figs. 632, 633, and 634.)

The Angle method depends chiefly on the screw for force, though piano wire and twisted wire ligatures are also used.

Dr. Angle was the first to advocate extensive use of German silver for regulating appliances. The advantages of this alloy are such that it now is more largely employed than any other material.

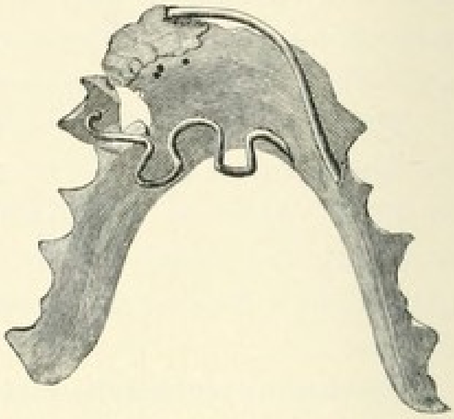
A new application of force has been lately introduced, viz. the elongation of wire by pinching or compressing it with special round

Fig. 633.



Coffin spring plate for lower arch.

Fig. 634.



Coffin spring plate for single teeth.

pliers, shown in Fig. 676. This may be used in many places instead of the jack-screw.

The construction of jack-screws and drag-screws has been greatly simplified. Thin soldered bands are cemented to the teeth, or "anchor bands," the ends of which are united by screw and nut. To these bands tubes are soldered for the attachment of appliances which are so constructed that force once applied need not be withdrawn till the entire movement is accomplished. A rest may be allowed, but no backward movement. Thus no interference is made with building up the tissues behind the tooth.

Appliances, complete or in parts, to be adapted to special cases have been put on the market by Prof. Angle. These more nearly fill the want of one who cannot make all his appliances.

Dr. V. H. Jackson's method consists in the use of piano wire or other elastic wire for force and the attachment of the wire to the teeth, in most cases, by means of a "crib" made of the wire itself, and not by means of bands or plates.

For full descriptions of these methods the student is referred to the writings of the authors themselves.[1]

General Directions.

All metallic bands which are to remain in contact with the teeth for any length of time should be cemented to them with zinc phosphate, to prevent deleterious action of acids of fermentation which would be generated and retained between bands and teeth. The rubber dam should be applied whenever possible to the tooth to be banded, and to one or

[1] In the *American Text-Book of Prosthetic Dentistry*, edited by Dr. Charles J. Essig, will be found a chapter on "Orthodontia Technic," by the writer, in which the making of regulating appliances is described much more fully than is possible here.

more teeth on each side. In some cases it may be applied to fourteen teeth at once. The teeth should be thoroughly dried and cleaned; the cement mixed thin is applied to the tooth and to the inside of the band, and the latter is pushed or malleted firmly to place. The teeth should be kept dry for ten minutes or longer after the cement is applied. If this is not possible, where napkins are used, varnish or melted paraffin may be applied over the cement at the edges of the band for the purpose of excluding moisture as long as possible. Bands may be fastened in a similar way by chloro-percha.

During the time of regulating and while retaining appliances are in position, bands should be examined frequently. If one becomes loose it should be removed, and cemented on again.

The patient should keep a brush at the office for use when appliances are removed, and the appliances should be very carefully cleansed by the operator before they are replaced. When plates are used especial care should be taken.

During the time that immovable appliances are worn, the patient should be provided with a bulb syringe with which dilute listerine or other antiseptic mouth-wash can be thoroughly applied under bars, screws, springs, etc., or wherever the brush cannot reach.

Teeth should generally be moved a little farther than the desired position, because there is almost always a slight return of the tooth toward its old position after the retaining appliance is removed. This retrograde movement is less likely to occur with canines when room has been made by extraction.

The age at which correction should be begun depends on the presence of sufficient teeth for anchorage. It should be commenced as soon as appliances can be used to advantage.

The writer believes in early correction, in some cases as early as the age of seven years. The advantage of early correction is that the alveolar process is less rigid and the alveoli larger than when the child is older, and hence less resistance is offered. At the age mentioned the deciduous molars are firm, and in some cases remain so until the child is ten or twelve years of age. (See page 712 and following pages for cases that demand early treatment.) At an early age new tissue is built up around the tooth more quickly, as the osteoblasts are in a more active condition; hence retaining appliances need not be worn so long.

Teeth tend to move into their proper positions if room is made for them. This seems especially true of the canines. In many cases after extraction of a first bicuspid the canine will move to its place without assistance. (See Figs. 723 and 724.)

Sufficient explanation should be made to the child to overcome any dread or fear which may have been engendered.

The parent or guardian should see that the child follows the operator's directions carefully, and should be given instructions as to the course to pursue in case any appliances become dislodged. When screws are used an intelligent parent or guardian may assist by turning them according to instructions. If the patient is old enough, and desirous of aiding, he may be intrusted with such duties. Screws or nuts should be given about half a turn twice a day.

Rubber bands should be renewed at least twice a week. Piano-wire springs should have their force renewed by bending (or straightening), about twice a week.

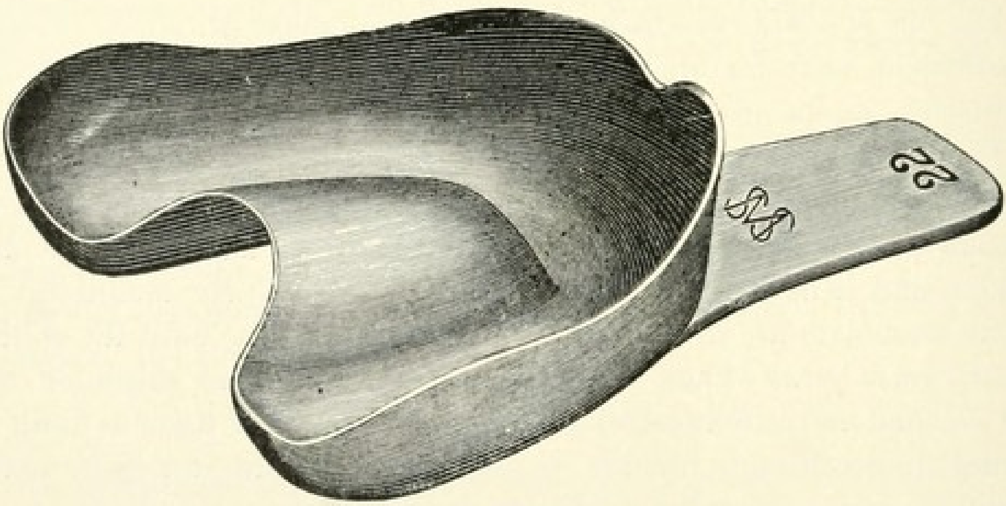
Silk or linen ligatures should be renewed daily or at least every other day. They should be well waxed, as then they are applied more readily. Moisture soon penetrates the wax and swells the fibers, producing pressure in the direction intended.

Wire ligatures should be twisted daily (Figs. 726 and 727).

The amount of force which may be used will vary with individuals. When a new appliance is used, no force should be applied for a few days, till the patient becomes accustomed to the apparatus, then slight force may be applied, and increased after a few days, but in no case should excessive force be used. That is, in no case should force be used strong enough to cause continued pain or loss of sleep, nor should it make the teeth "tender" enough to prevent mastication.

Impressions should be taken of the teeth of both jaws in all but very

FIG. 635.

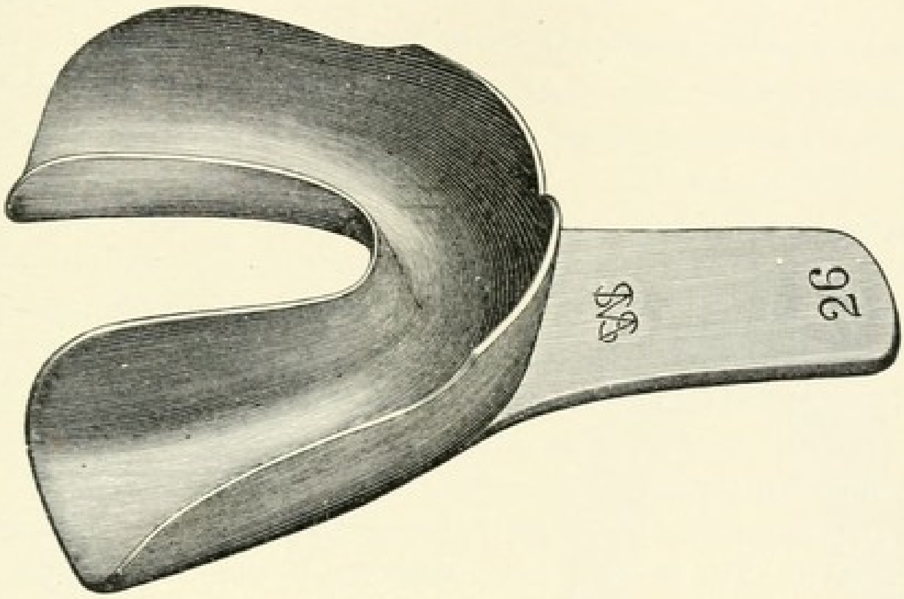


Angle's impression tray.

simple cases. Trays with high sides and flat floor should be used. Those designed by Prof. Angle are especially adapted to the purpose (Figs. 635 and 636).

MODELING COMPOUND is best adapted for impressions of most cases. It should be placed in cold water and slowly heated in order to soften it uniformly. It should not be used hot enough to be painful to the patient. Warm the tray before filling it so that the impression material may adhere to it when it is removed from the mouth. When the compound has been placed in the mouth and pressed against the teeth, draw the lip over the edge of the tray, and press on the lip so as

Fig. 636.



Angle's impression tray.

to force the material as far up on the ridge as possible, thus obtaining an impression of the alveolar walls.

Special cases may need the more absolute accuracy of plaster-of-Paris, but such cases are rare.

Avoid an excess of material in the palatal portion of the tray, as the surplus pressed backward is apt to drag at the necks of bicuspids and molars. When the material has been pressed into correct position, apply cold water with a syringe to the tray and under the lip and cheeks till the material is hard.

Casts made from these impressions should be articulated either with wire hinges or by extending the rear portions, and preserved for frequent examination. If the casts are held together by a "plaster articulator," it should be open in the rear, so that the lingual surfaces and cusps of the teeth can be examined while the teeth occlude. An extra cast will often be needed, on which to make appliances. During treatment, casts should be made at interesting stages to record progress.

Before deciding upon treatment study the case in action and repose; observe the movements of the lips in speaking and laughing; notice how much the gums are disclosed, if at all, or with what difficulty the teeth are covered by the lips. Study the profile. If the irregularity affect the contour of the lips, have a photograph taken which will show the profile, or take impressions of the lips, nose, and chin, or of the whole face, with plaster.

Study the casts also before deciding on the treatment or appliances. In some cases make an extra cast, cut off the malposed teeth with a thin saw and re-arrange them in normal relationship. Much may be learned by such means.

Classification of Irregularities.

Aberrations from the normal arch are almost numberless, and almost every writer adopts a different nomenclature to express the malpositions that he wishes to describe.

In speaking of single teeth, it seems the best plan to describe their positions in relation to the normal curve or arch (Fig. 599) or the lines of normal eruption (Fig. 600). Thus, a tooth erupted within the normal arch is well described by the term *lingual eruption*, or as a tooth erupted lingually. A tooth erupted *outside* the normal arch is well described by the term *labial eruption*, or as a tooth erupted labially. A tooth in the normal line, but turned on its own axis, is *rotated*.

For convenience in description, irregularities are here arranged in fifteen classes. The first six have reference to single teeth, and nearly all the rest to the arches as a whole in relation to each other and to the contour and profile of the face.

1. Lingual eruption: A tooth erupted lingually.
2. Labial eruption: A tooth erupted labially.
3. A tooth rotated.
4. A tooth extruded.
5. A tooth partially erupted.
6. Several teeth in any or all of these positions.
7. Prominent canines and depressed laterals.
8. Pointed arch. (V-shaped.)
9. Upper protrusion.
10. Lower protrusion.
11. Double protrusion.
12. Constricted arch. (Saddle-shaped.)
13. Lack of anterior occlusion.
14. Excessive overbite.
15. Separation in the median line.

Class 1. **Lingual Eruption: A Tooth Erupted Lingually.**—The operations and appliances presented for the first four classes are for single teeth, but they will apply in most cases to two or more teeth in the same malposition. In Class 6, appliances will be described which are better suited to several teeth than to single ones.

The earliest cases requiring treatment are of Class 1, and often present as early as the age of six or seven years, and before the tooth has fully erupted. If an upper central has erupted inside the normal line so as to bite inside of the line of the lower incisors when it is not more than half erupted, the case demands immediate treatment, because the farther the tooth erupts the greater will be its malposition, for it occludes on the inclined plane formed by the lingual surface of the lower incisor.

One of the oldest appliances for moving a tooth forward or outward consists of a vulcanite plate with a piece of soft rubber or compressed wood attached to the edge so that it will press upon the malposed

Fig. 637.

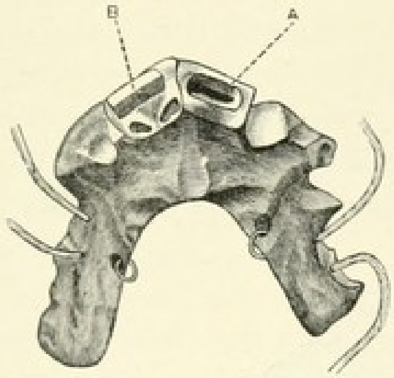
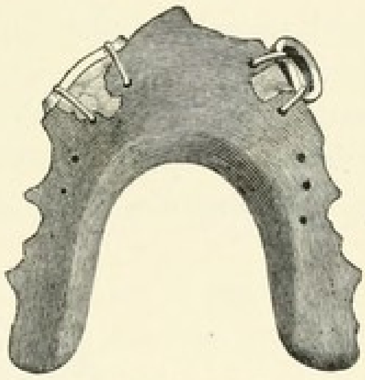


Plate with box, A; B, rubber or compressed wood in box.

Fig. 638.



Rubber tied on a plate.

tooth. The plate may be ligated firmly to the deciduous molars. The soft rubber may be held in a box cut in the edge of the plate (Fig.

Fig. 639.

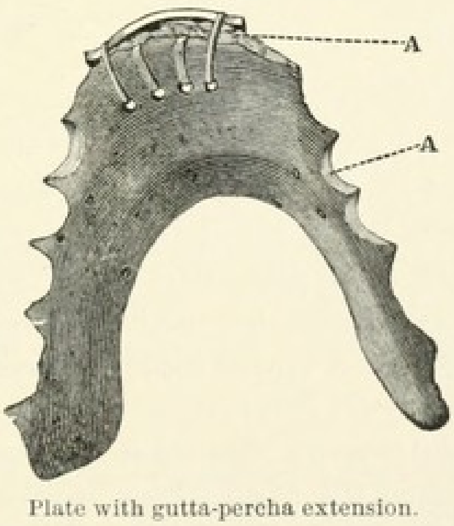
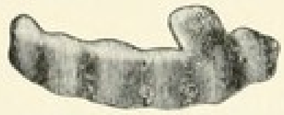


Plate with gutta-percha extension.

637), and increased in thickness as the tooth advances, or a piece about $\frac{1}{16}$ of an inch thick may be ligated to the edge by silk passing through holes near by (Fig. 638). As the tooth moves forward the plate may be built out at this point by gutta-percha filled into a box cut in the edge and pressed against the tooth while still soft. The rubber may be ligated on the outer edge of the gutta-percha, which may be increased in amount at each visit (Fig. 639).

The INCLINED PLANE, as illustrated in Fig. 640, may be made in various forms. It is one of the oldest forms of regulating appliances, and one of the most inefficient. It depends for its success wholly on the co-operation of the patient. With young patients its use is not as successful as with older. The principle is, that biting on the inclined plane slides the tooth forward, but soon the biting produces inflammation in the pericemental membrane, a "soreness" of the tooth as popularly expressed, when every bite causes pain and the patient naturally refrains from biting. It is efficient only with older patients who exhibit a determination to help the operation. The most efficient appliance is one which does not depend on the will of the patient for its action.

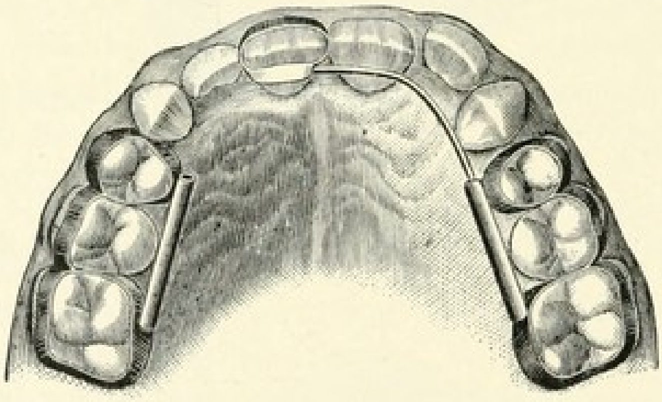
FIG. 640.



Inclined plane.

Fig. 641 shows a very efficient appliance used by Dr. Matteson.

FIG. 641.



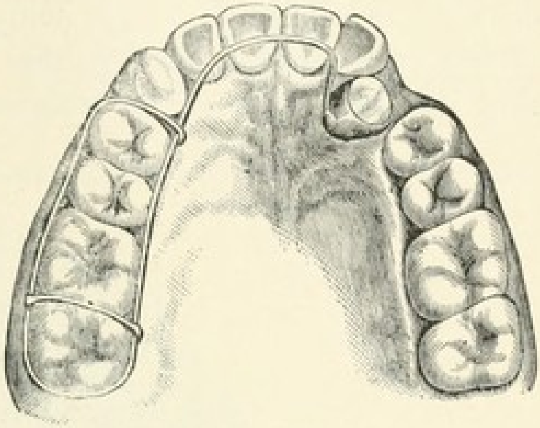
"Tube, band, and spring" appliance (Matteson).

With young patients he prefers "to band the first deciduous and first permanent molars, and joining these bands by a connecting strip on the buccal surface and a piece of metal tubing closed at one end on the palatal surface." A piece of piano wire is inserted in the tube and the free end allowed to press against the tooth to be moved. It is best kept in place by a band cemented on the tooth with a lug or half-section of tubing soldered to its lingual surface.

If the band is made as recommended by Prof. Angle, by drawing the band material around the tooth with a pair of pliers and soldering together the projecting ends, this projecting portion may be left long enough so that a notch may be cut in it for the piano wire to rest in.

In many cases of the age under consideration the second deciduous molar alone will be firm enough to be banded for anchorage. With an older patient whose teeth are more firmly set, a bicuspid or first molar alone will often be sufficient for anchorage.

Fig. 642.



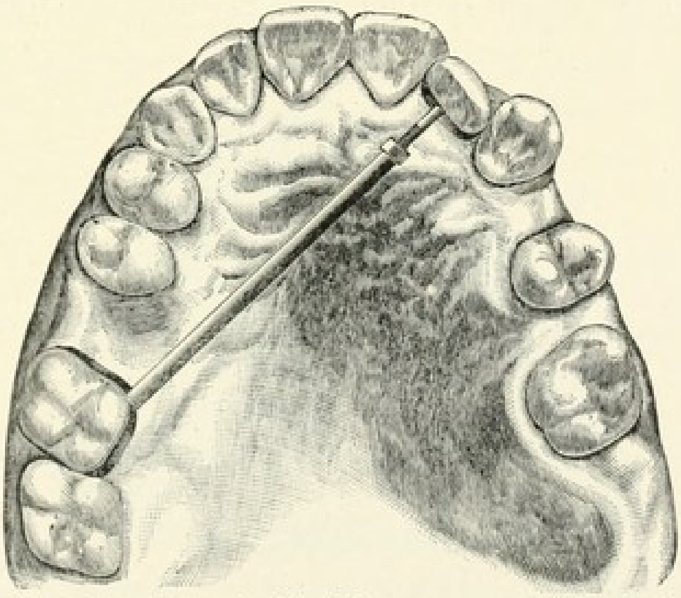
Crib and band (Jackson).

For short teeth, such as deciduous molars or partially erupted bicuspids or molars, Dr. Matteson uses swaged caps, made with Mellotte's moldine and fusible alloy, so as to fit over the whole crown and be cemented in place. Two or more teeth may be included in one cap, and tubes may be soldered on either side for the attachment of springs, etc. (See Fig. 627.)

A similar use of the piano-wire spring, but retained by the Jackson crib, is shown in Fig. 642. Fig. 647 shows a different form of crib. Both Matteson's and Jackson's appliances are applicable to any of the six anterior teeth.

A jack-screw with the flattened end resting in a slot in a band cemented on the tooth to be moved and the other end soldered to a

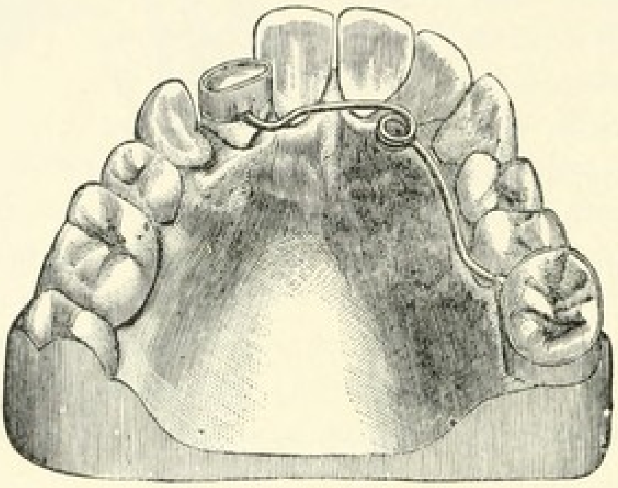
Fig. 643.



Angle's jack-screw.

band on a second bicuspid or first molar for anchorage, or resting in a socket in said band, is very efficient for moving a tooth outward, but is more applicable to laterals and canines than centrals. (See Fig. 643.) Another plan of retention of the anchor end of the jack-screw is to slip the open end of the tube over a pin or lug projecting from the molar band. The lug may be easily made by properly shaping the projecting ends left after soldering the band. The teeth selected for anchorage should be as nearly as possible in line with the movement desired, and it is best in many cases to solder a bar on the lingual surface of the anchor band, so that it will rest on contiguous teeth and thus increase the power of resistance.

Fig. 644.



Talbot's spring with bands.

Fig. 644 shows Dr. Talbot's coiled spring, with one end inserted in a small socket soldered to an anchor band on a molar and the other in a socket on a band on the lateral. If the bands are thickened on one

Fig. 645.

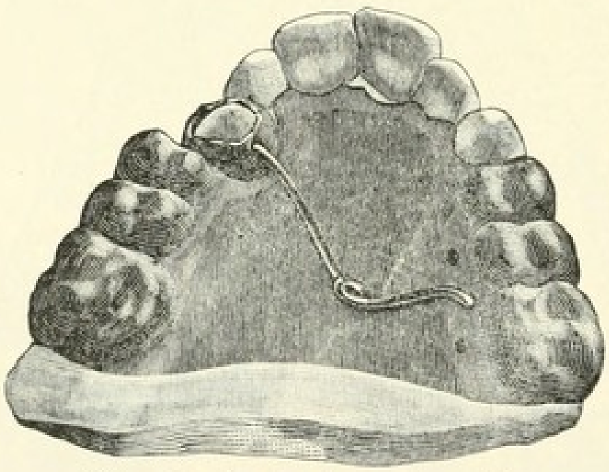


Plate and coil spring for moving canine.

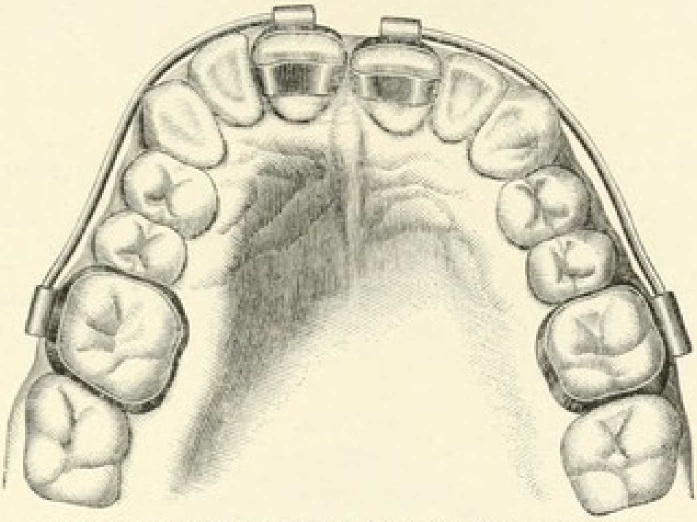
side, holes may be punched for the reception of the ends of the spring. Piano wire may be anchored in a plate so as to force a tooth outward. (See Fig. 634.)

In some cases the lower incisors impinge so closely upon the necks of the upper as to leave no room for appliances unless the bite is opened, which is seldom necessary.

Plate Anchorage.—The canine is such a difficult tooth to move that very firm anchorage is necessary. A plate constructed so as to cover the crowns of the bicuspids and molars will anchor all the teeth together and give plenty of resistance to a spring inserted as in Fig. 645 and pressing against the tooth to be moved. The end of the spring may rest in a hole or socket in a band cemented to the tooth.

Fig. 646 shows an appliance operating outside the arch. A band

Fig. 646.



Writer's appliance, close bite: band and outside spring.

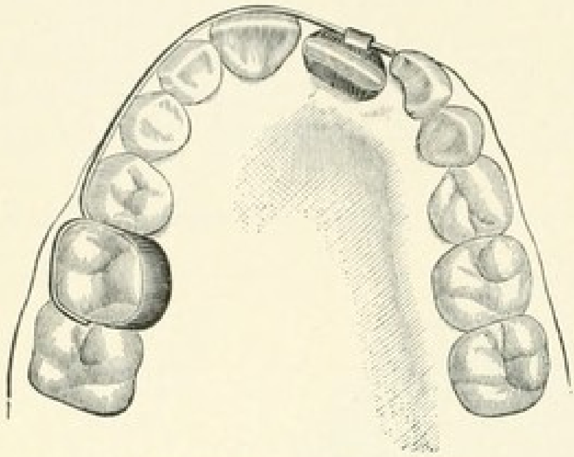
cemented on the first molar with a tube on its buccal surface forms the anchorage. In this tube is inserted a piano wire, which is bent to conform to the arch of the teeth and its free end inserted in a tube or hook on the labial surface of a band cemented on the tooth to be moved. It may be applied to any of the six anterior teeth. If applied to a central or lateral the wire may rest on the cuspid as a fulcrum, which gives it greater power.

The Jackson crib may be used for anchorage instead of the band and tube, as shown in Fig. 647.

A bicuspid is easily moved out into line by the appliance shown in Fig. 648. The screw, which passes through a bar about $\frac{1}{8}$ of an inch wide, soldered to a band on a convenient tooth, may be cut off as the tooth is moved out. The same appliance may be used as a retainer.

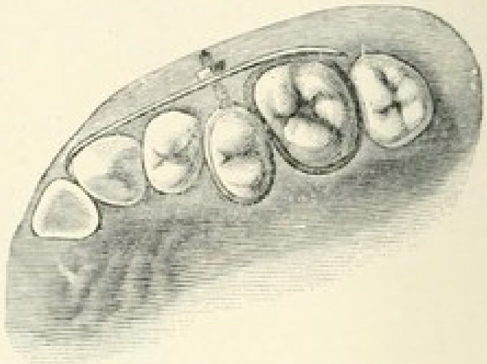
The appliance shown in Fig. 649 is highly recommended by Dr. Talbot, and described by him as follows: It is made of German silver, which possesses all the requisite qualities. He has three thicknesses of it ready for use, Nos. 29, 31, and 32, U. S. gauge. Strips are cut $\frac{1}{16}$ to $\frac{1}{8}$ of an inch wide accordingly as strength is required, and bent with small round-nosed pliers into the shape represented at A to fit the teeth. This is removed every day and with round-nosed pliers the ends are bent, and the spring shortened and forced to place upon the teeth. The

Fig. 647.



Crib, spring, and band (Jackson).

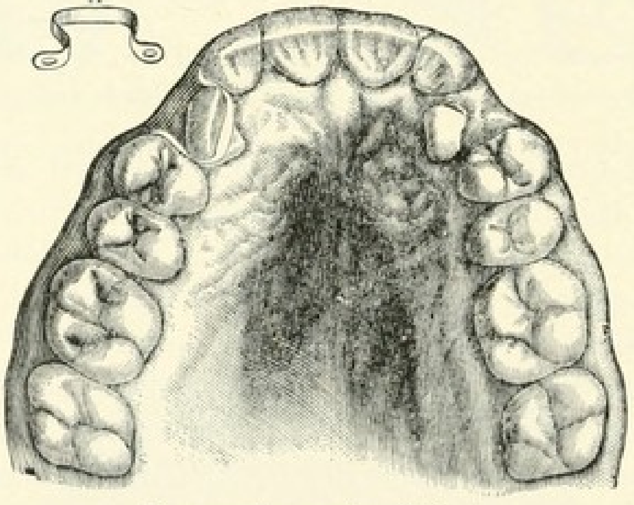
Fig. 648.



Bar, band, and screw.

little spring acts in two directions—first, to carry the teeth laterally and thus provide room; secondly, to draw the irregular teeth into position. In the hands of the writer this has been a very efficient appliance.

Fig. 649.

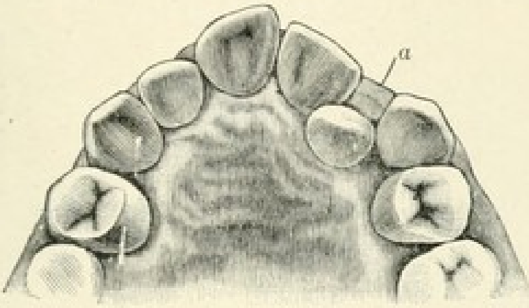


German-silver spring (Talbot).

Making Room.—If the adjacent teeth overlap the one out of position it is best to make room before attempting to move it, because it cannot advance until room is made for it, and force spent on it will be of no avail unless the tooth acts as a wedge to force the others apart. A piece of compressed wood, one of the oldest forces used in orthodontia, can be used in many cases as shown at *a*, Fig. 650. Cut a piece of wood about a third larger than the space, compress it with pliers or the vise, and insert it with the grain parallel to the axis of the teeth. If the sides are made slightly concave, it will hold in place better. As the wood absorbs moisture it will swell and press the teeth apart.

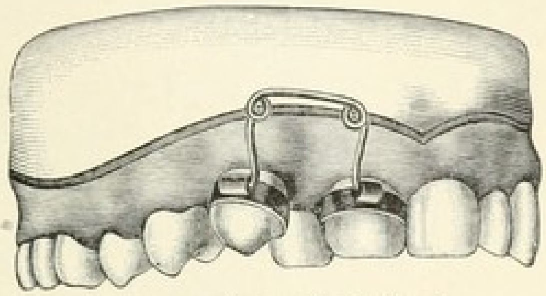
A better method of gaining room is to cement bands on the two adjacent teeth with tubes on the labial surfaces. In these tubes insert a Matteson spring, as shown in Fig. 651. As soon as sufficient room

Fig. 650.



Compressed wood for making room.

Fig. 651.

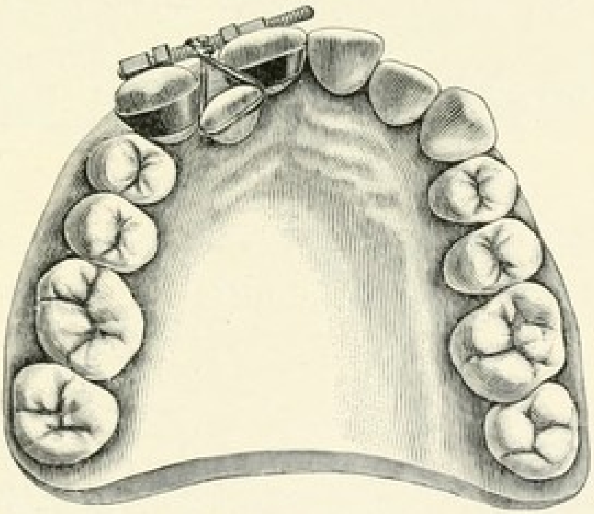


Matteson spring applied to bands.

is gained, a straight wire may be inserted in the tubes across the space. A rubber band stretched over the malposed tooth from this wire will soon move it into place.

Fig. 652 shows a very satisfactory modification of the above appliance, using intermittent force instead of constant. A screw with two

Fig. 652.

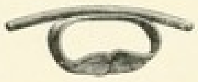


Writer's appliance for making room and moving tooth out.

nuts on it, or one collar and one nut, is inserted in the tubes, and the nuts screwed against the tubes. If one of the nuts is turned two or three times a day, the teeth will soon be moved apart. The nuts will hold the teeth apart while a rubber band or ligature passed over the screw and the malposed tooth will soon draw it forward, or if the rubber band is applied while the contiguous teeth are being spread apart, the tooth will move forward as room is made for it.

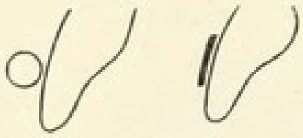
Retainer.—The best retainer for a single tooth moved forward consists of a Magill band with a round wire soldered on its labial surface. (See Fig. 653.) A round wire is better than a flat bar, because it rests on the tooth at one point only and there is less liability of food lodging under it, as illustrated in Fig. 654.

Fig. 653.



Writer's retainer band and round wire.

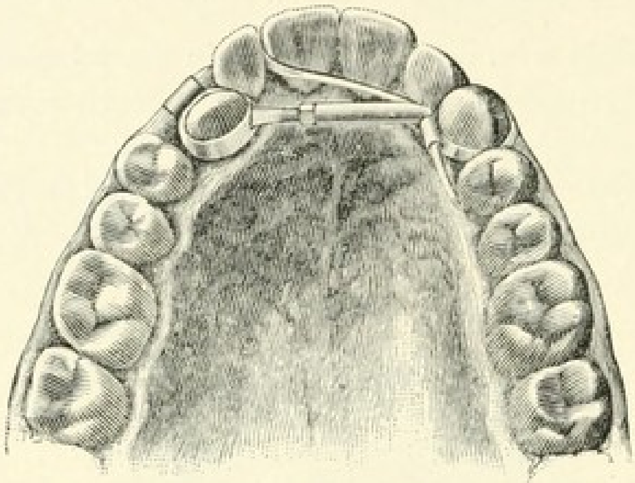
Fig. 654.



Round and flat contacts in regulating fixtures.

When a band is to be used as part of an appliance for moving a tooth into place, as in Fig. 643, a tube can be soldered to its anterior

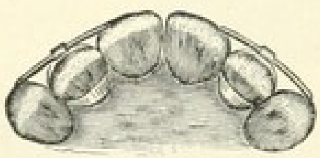
Fig. 655.



Providing in advance for retention (Angle).

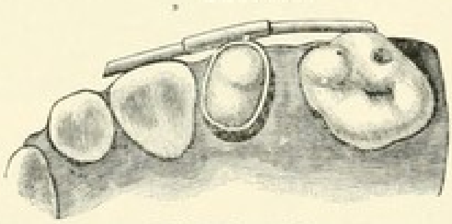
surface. After the tooth is moved into position this same band may be used as a retainer by passing a wire through the tube so that its

Fig. 656.



Angle's retainer.

Fig. 657.

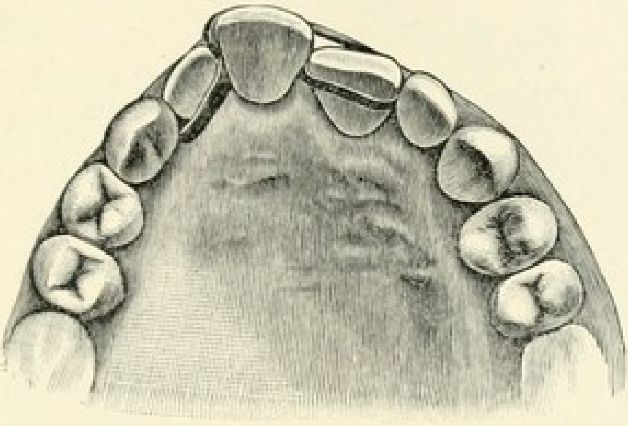


Talbot's retainer.

ends will rest on adjacent teeth. This wire can be fastened in the tube with cement. (See Figs. 655, 656, and 657.)

Class 2. **Labial Eruption: A Tooth Erupted Labially.**—The simplest method of moving such a tooth backward is by a rubber band or ligature looped over one tooth on each side of the prominent one, and passing over its labial surface. (See Fig. 658.) Although this is effective in simple cases there is the theoretical objection that the rubber band or ligature tends to draw the contiguous teeth toward the prominent one and thus to impede the very movement desired. One practical objection is that the rubber band tends to rotate the teeth over which it is looped. The rubber band may be ligated to the second tooth on each side and passed under the first.

FIG. 658.



Rubber band and ligature.

The next simplest method is the strip of elastic German silver as described by Dr. Talbot—just the reverse of that shown in Fig. 649.

One of the oldest appliances and an excellent one is shown in Fig. 659. It consists of a plate fitting the roof of the mouth, held by atmos-

FIG. 659.

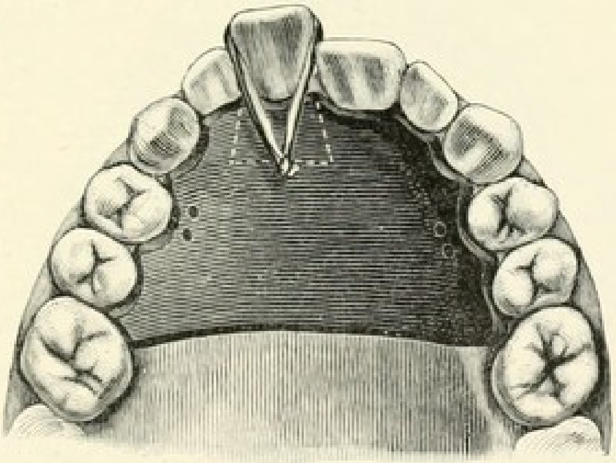
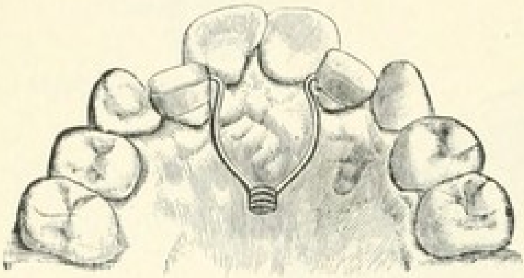


Plate and rubber band.

pheric pressure in contact with the lingual surfaces of the teeth except with that of the prominent one. A rubber band stretched over this tooth is attached to the plate at some point directly in line with the movement desired, and far enough from the tooth to give the desired amount of force. For attachment a hook may be vulcanized, or a hole drilled in the plate at an acute angle, and a wooden peg inserted, which is kept tight by swelling. Another simple way to attach the rubber band is to drill two holes through the plate and tie with thread. This has one advantage, that the patient may be allowed to remove the plate for cleansing without danger of losing the rubber band.

If the adjacent teeth need to be moved apart to make room, the rubber band may be fastened to the plate at two points, as shown by the dotted lines in Fig. 659, or farther apart, so as to press laterally as well as backward.

Fig. 660.



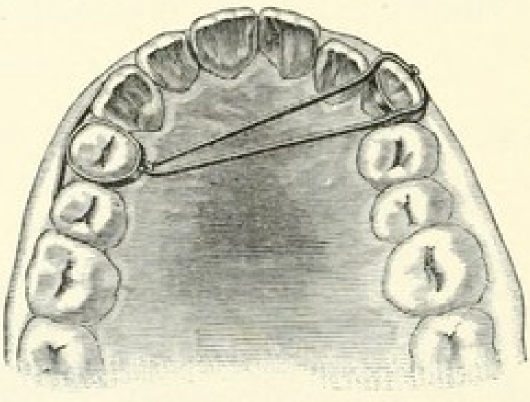
Talbot's spring with bands, for making room.

The plate may be ligated to teeth on each side of the mouth to hold it more securely, and a silk or linen ligature may be substituted for the rubber band.

Fig. 660 shows Dr. Talbot's plan of gaining room by means of a coiled spring with the ends resting on the teeth to be spread apart.

The plate may be dispensed with by cementing a band, to which a hook has been soldered, on some tooth in line with the movement desired, and stretching a rubber band from the prominent tooth over this hook. The anchorage may be increased by a wire or bar soldered to the outside of the band so as to rest on contiguous teeth. (See Fig. 661.)

Fig. 661.

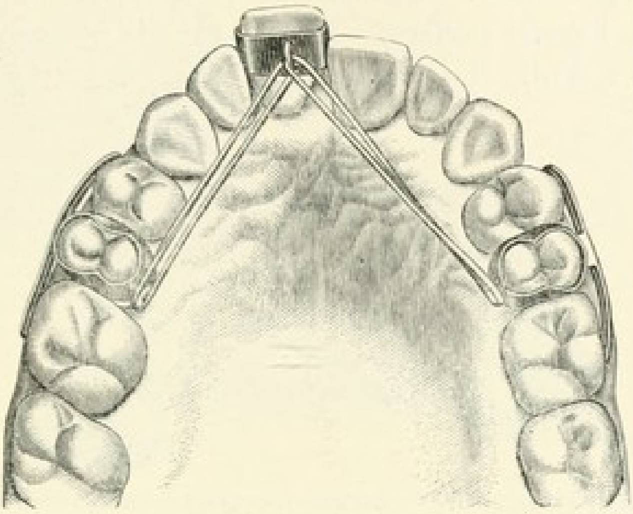


Band and bar for anchorage; rubber band for drawing tooth in (Guilford).

In order to apply the force in the proper direction in moving a central incisor, it may be necessary to use a tooth on each side of the mouth for anchorage, in which case it is better to extend a rubber band from each anchor tooth to a hook on the lingual surface of a band on the central. (See Fig. 662.)

The occlusion may be such that the cutting edges of the lower incisors nearly or quite touch the necks of the upper or the gum, and thus prevent the use of any appliance on the lingual surfaces of the teeth without opening the bite, which it is best to avoid if possible. In such cases (see Fig. 663) cement a band on a bicuspid or first molar on each side, with a tube on the buccal surface. Through these tubes around the arch, and in contact with the prominent tooth, extend a

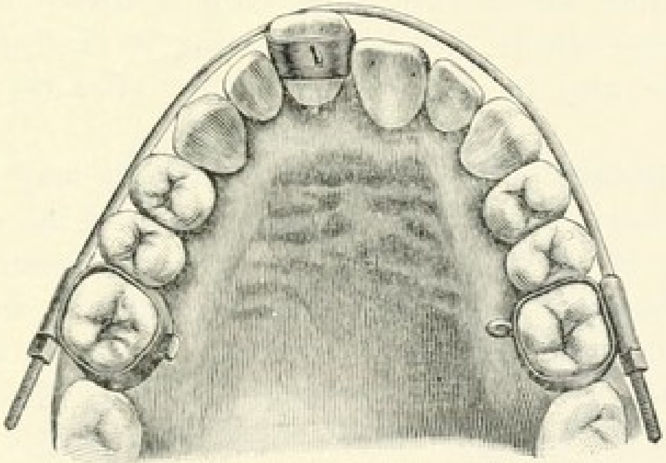
Fig. 662.



Double anchorage for elastic traction.

labial bow of stiff wire, No. 16 B. & S. gauge, screw-cut at the ends. Place nuts on the ends of the bow spring behind the tubes. By turn-

Fig. 663.

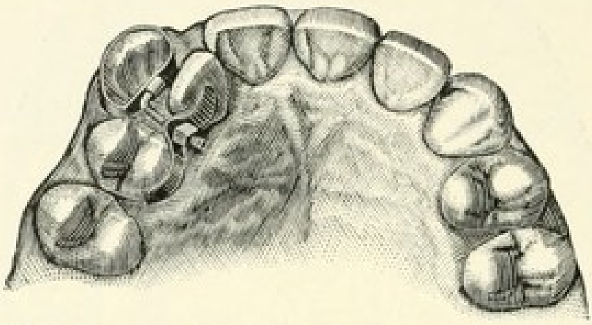


Labial bow for drawing tooth in.

ing the nuts pressure is brought to bear on the prominent tooth. To prevent the wire sliding on the surface of the tooth, cement on it a band on which is soldered a lug or a half-section of tubing in which the wire can rest; or use Angle's notched band. (See Fig. 771.) If elastic wire, such as platinum-gold or German-silver wire, drawn hard, is used, constant force can be applied, as, when the nuts are turned, the wire will be bent and in its tendency to straighten will press on the tooth.

Fig. 664 shows an appliance which may be used with much satisfaction. In this case the first molar has been previously extracted. The line between the central incisors is to the right of the median line of the face. The bicuspids are to be pushed back and the incisors toward the left at the same time. The appliance works on the principle of two wedges drawn toward each other. On the canine is cemented a band with a short tube on its lingual surface. In this tube is placed one of Angle's short drag-screws, while the other passes through a strip of metal about

FIG. 664.



Writer's appliance for making room and drawing cuspid in.

$\frac{1}{8}$ of an inch wide which rests on the first bicuspid and the lateral. This strip is bent so as to form one wedge while the canine serves as another. The nut on the end of the screw draws the two wedges, that is, the canine and the strip, toward each other and spreads the lateral and bicuspid from one another. The strip is altered in form as the work progresses—always, however, retaining its wedge shape. The same appliance may be worn as a retainer after the canine is in place.

CLASS 3. **Rotated Teeth.**—While attachment may be made to a tooth for rotating it by ligatures (a modification of the clove hitch) or by drilling pits in which are inserted screws or pins secured by cement, the first of these serves only a temporary purpose, and the second mutilates the tooth more than is warrantable except in extreme cases.

For the incisors the best attachment is a Magill band not thicker than No. 36 B. & S. gauge, to which is soldered a hook, pin, or tube. For the canines a swaged cap is better, as it may be cemented more firmly in place.

To rotate an incisor which overlaps the adjacent tooth, cement a band on the tooth with a hook on either the labial or the lingual surface. From this hook extend a rubber band or ligature to a vulcanite plate held by atmospheric pressure. Secure the rubber band to the plate by ligating through two holes. (See Fig. 665.) The plate should be cut away slightly as the tooth rotates. The point of the attachment to the plate will vary according to the direction of force needed. By attaching at *C*, Fig. 712, room may be gained by attaching the rubber band so that it will press against the adjacent tooth, over which the offending one may be lapped.

The plate may be dispensed with by attaching the rubber band to some other tooth for anchorage (Fig. 666), or to a lingual bow as shown in Fig. 667.

Fig. 665.

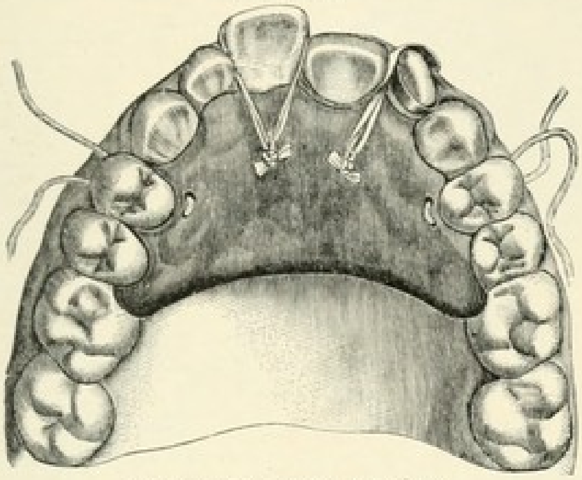
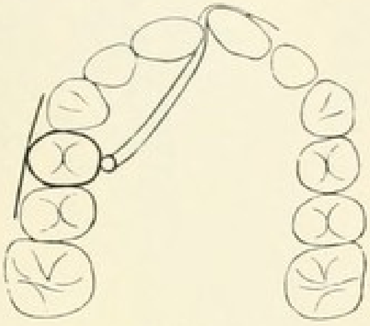


Plate and band for rotating.

Fig. 666.

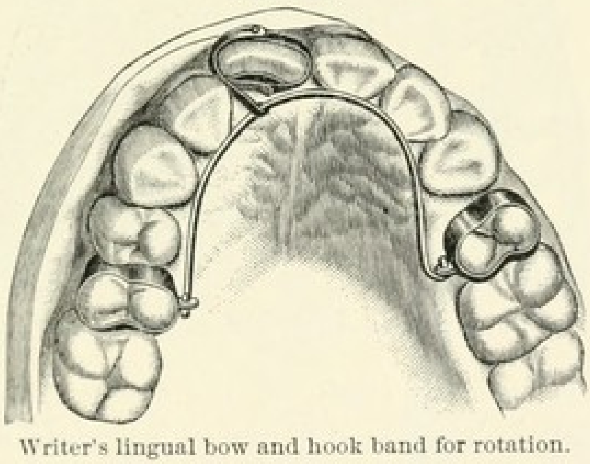


Two Magill bands for rotating.

Extra force may be gained in rotating by passing the rubber once around the tooth after attaching it to the hook, as a rope is wound around a windlass.

If it be necessary to rotate a tooth outwardly, attach bands with tubes to any two convenient teeth such as canines or bicuspids; extend

Fig. 667.

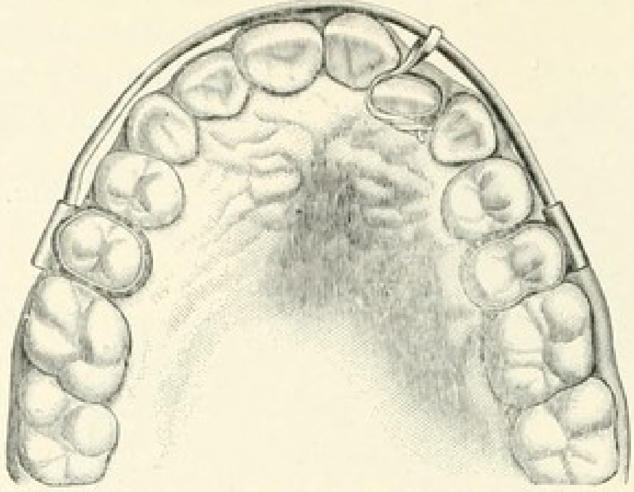


Writer's lingual bow and hook band for rotation.

a wire bow from one to the other, as in Fig. 668, and use this as a point of attachment for the rubber band. The ends of the bow are prevented from passing too far through the tubes by the bending in bayonet shape or by pinching the posterior ends of the tubes. If the canines are used for anchorage, solder the tubes vertically to the bands and bend the ends of the bow at right angles.

Force may be applied to the tooth from two directions by making hooks on both sides of the band and extending a rubber band or ligature from one hook to a labial bow and from the other to the lingual bow, as shown in Fig. 669, *A* and *B*.

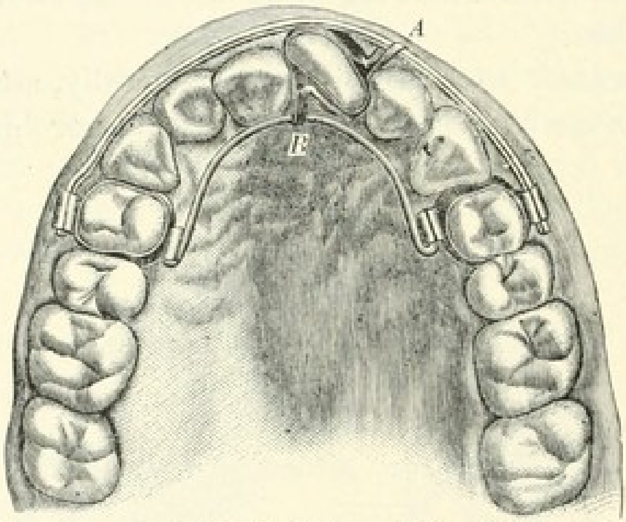
Fig. 668.



Labial bow and hook band for rotation.

In many cases another tooth which needs rotating may be used for anchorage, and thus double rotation is accomplished, either in the same

Fig. 669.



A, Rubber band from lingual hook to labial bow; *B*, from labial hook to lingual bow.

or opposite directions. A study of the illustrations Figs. 670–673 will show the student how the different movements are accomplished.

Fig. 670.

Fig. 671.

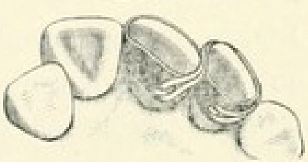


Fig. 672.

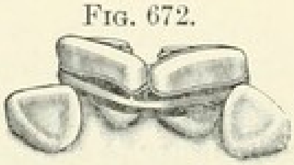
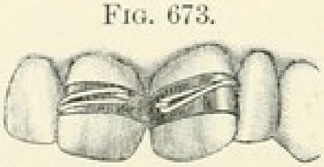


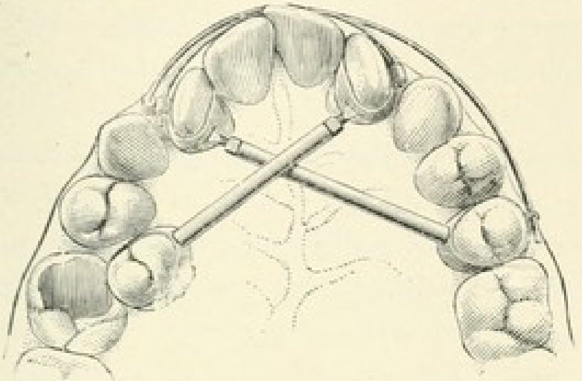
Fig. 673.



Bandage for double rotation.

In many cases a tooth may be moved out of or into the normal line and rotated at the same time by applying the force to a hook on a band. Where a jack-screw is used it can be applied at the mesial or distal portion of the tooth as needed. (See Fig. 674.)

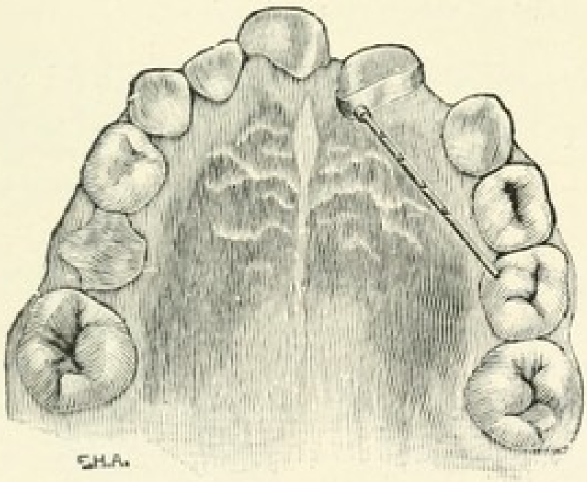
Fig. 674.



Angle's jack-screw for moving tooth outward and rotating.

Fig. 675 shows one of Prof. Angle's methods, which he describes as follows:

Fig. 675.



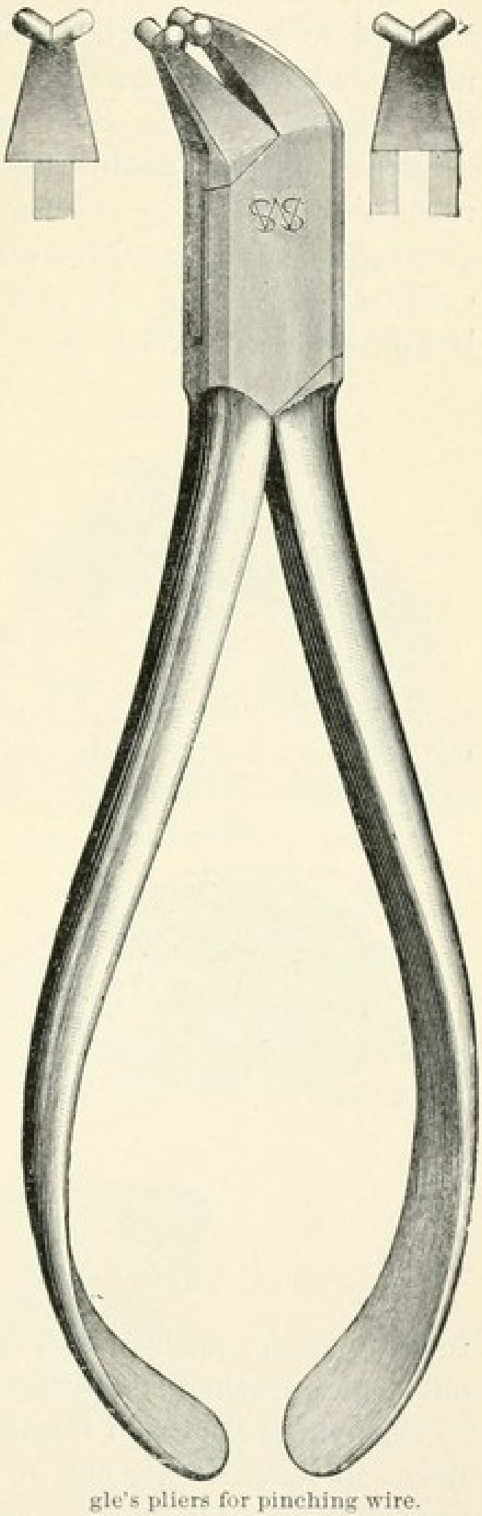
Angle's pinched wire for extension and rotation.

"The tooth was banded and one of the pipes soldered to the mesio-lingual

Fig. 677.

Retainer.

Fig. 676.



gle's pliers for pinching wire.

angle of the band; one end of a piece of wire of suitable length was inserted into this pipe and the other end secured in a pit formed in the enamel of the second deciduous molar. Force was exerted upon the tooth to be moved by occasionally pinching this wire with the regulating pliers (Fig. 676), two or three pinches being enough to lengthen the wire sufficiently to move the tooth as far as should be done at one sitting.

"The simplest retainer is a band with a short piece of round wire soldered to it, so that it will impinge upon the adjacent tooth. It is necessary sometimes to fasten such a lug on each side of the band." (See Fig. 677.)

When double rotation has been accomplished, the teeth may be retained by soldering the bands together at the points of contact.

Angle's appliance for double rotation is easily understood from an examination of Figs. 678 and 679. The piano-wire spring should not be larger than No. 24 B. & S. gauge.

FIG. 678.

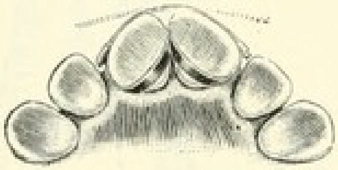
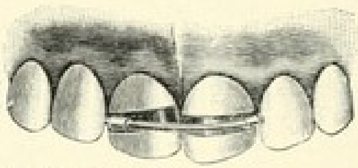


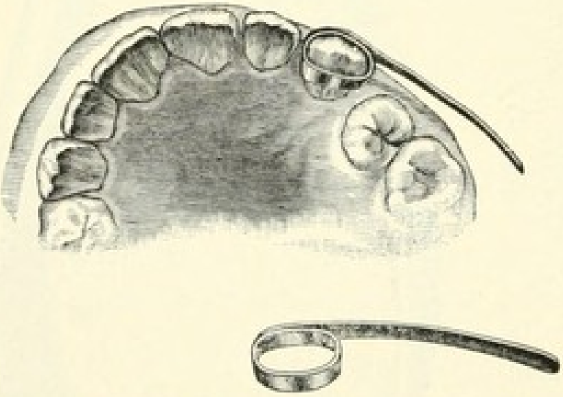
FIG. 679.



Angle's appliance for double rotation.

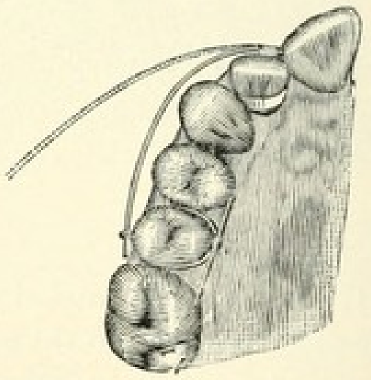
Although this appliance is very effective, two difficulties attend its use. Sometimes the spring fails to slide through the tubes as the teeth

FIG. 680.



Guilford's lever for rotating.

FIG. 681.



Angle's detachable lever for rotating.

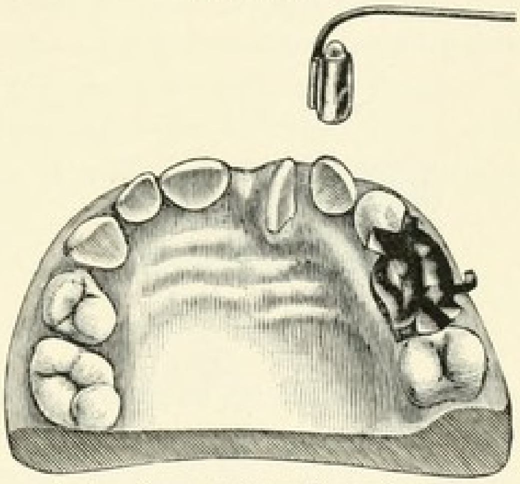
rotate and the teeth are spread slightly apart. This tendency can be obviated by tying a silk ligature from one tube to the other.

Sometimes the distal surfaces of the teeth will turn forward, so that they will stand wholly out of the line of the other teeth. This can be prevented by soldering lugs on the lingual surfaces of the bands, to rest on the laterals. In some cases, as the centrals turn, these lugs will slide on the inclined plane formed by the lingual surfaces of the laterals and either push the laterals up in the socket or elongate the centrals. This may be prevented by bands on the laterals with a projection on each, under which the lugs will rest and be prevented from moving.

Another method of rotating is by means of a lever attached to a band on the tooth as shown in Fig. 680. The end of the lever is bent in the form of a hook, from which a rubber band passes over some convenient tooth. Prof. Angle has made the lever detachable (Fig. 681) by soldering a tube to the band and inserting in it a piece of piano wire. The other end of the wire is bent in the form of a hook and ligated to some convenient tooth, or placed under a hook soldered to a band on such tooth.

Fig. 682 shows Dr. Matteson's swaged cap on a deciduous molar, with a hook for this purpose. In using the lever special care must be taken not to let it rest on any tooth between the anchorage and the offending tooth, otherwise it will move the tooth out of line.

Fig. 682.

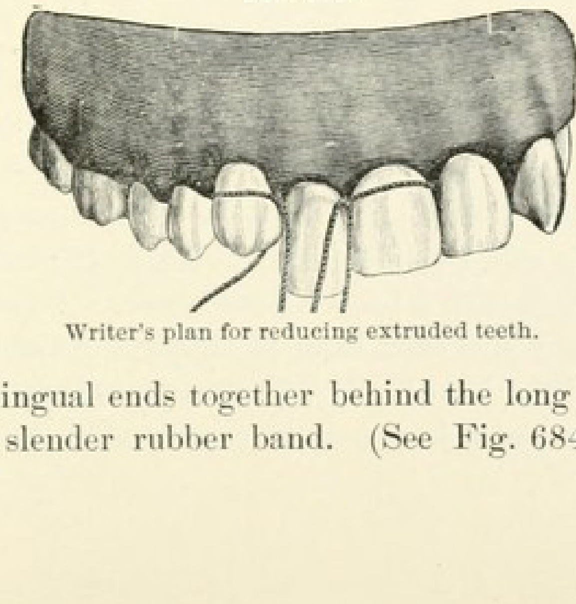


Matteson's swaged cap for anchorage.

Class 4. **Extrusion, or a Tooth Extruded.**—The simplest treatment for a tooth that is extruded is to grind it shorter. As grinding alters the natural shape of the tooth in proportion to its extent, other means are sometimes necessary.

A tooth sometimes elongates, in regulating, by the carelessness of the patient or operator, or by unforeseen complications. In such a case an immediate, even though temporary, appliance is necessary. Tie a ligature around the necks of the adjacent teeth with the knots between each and the offending tooth. Extend one end of each ligature lingually and one labially. (See Fig. 683.) Tie the lingual ends together behind the long tooth, and in the same knot tie a slender rubber band. (See Fig. 684.) Tie the labial

Fig. 683.



Writer's plan for reducing extruded teeth.

ends together in front of the long tooth. Next stretch the rubber band, from the lingual surface of the neck, over the cutting edge, and tie it

Fig. 684.

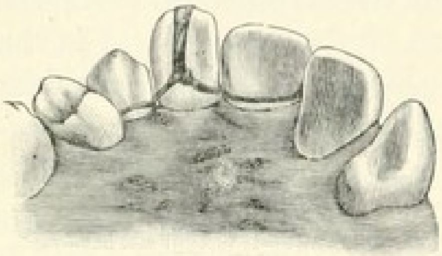
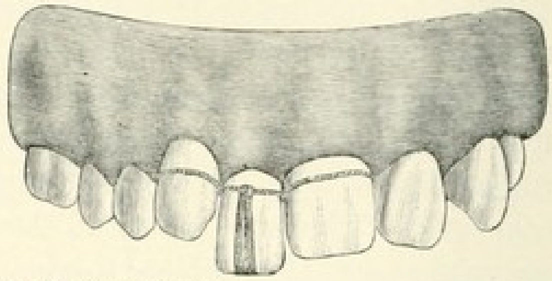


Fig. 685.



Writer's plan for reducing extruded teeth.

to the knot on the labial surface. (See Fig. 685.) The tooth is thus hung in a sling which will force it up into place.

Another simple plan is that suggested by Dr. William Herbst for retaining a replanted tooth. It is shown in Fig. 687. It consists in

Fig. 686.

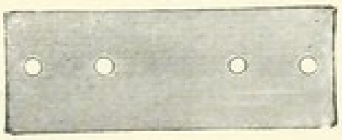
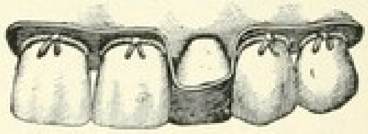


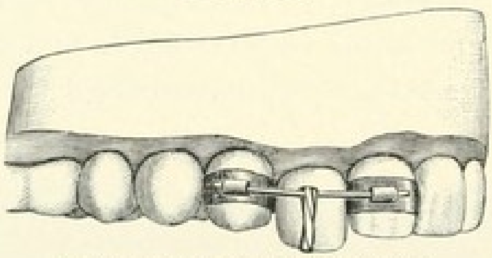
Fig. 687.



Herbst method of reduction and retention.

cutting a short and narrow strip from a piece of rubber dam (Fig. 686) and perforating it in such a manner that when in position the crowns of two teeth on either side of the one affected will protrude through the openings while the elongated tooth will be partly covered and pressed upon by the intervening portion of the rubber. (See Fig. 687.)

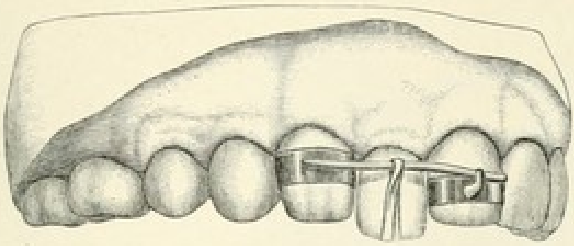
Fig. 688.



Appliance for reducing extrusion.

A better plan is to band one tooth on each side and connect the bands on both labial and lingual surfaces by a wire soldered to both bands, or resting in tubes soldered to the bands (Fig. 688), or soldered to one band and resting in a hook on the other. A twisted ligature or slender rubber band stretched from the lingual to the labial wire, over the cutting edge of the long tooth, will soon force it up. (See Fig. 689.) A small cap with a notch in it may be cemented to the end of the long tooth, to prevent the rubber band from slipping off. When the tooth is moved to its desired position it may be retained by substituting a small

Fig. 689.



Writer's appliance for reducing extrusion.

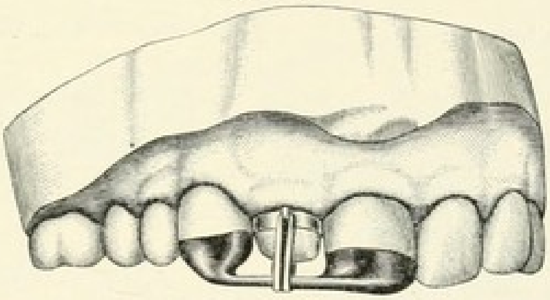
Fig. 690.

Details of appliance shown in Fig. 689.

platinum wire or silver suture wire for the rubber band, or three bands may be soldered together and cemented to the teeth.

Class 5. **Partial Eruption.**—A tooth may need elevating because it has not fully erupted or because a piece has been broken from the cutting edge. If the short tooth is an incisor, proceed as follows: On the adjacent teeth cement bands or caps which are connected by a wire at or near the cutting edge. On the short tooth, as near the gum as

Fig. 691.



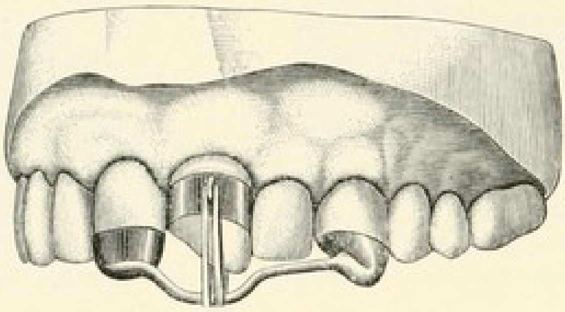
Writer's method of elevating.

possible, cement a wide band which has a hook or pin on both labial and lingual surfaces. From one hook stretch a very slender rubber band or twisted ligature over the wire to the other hook. (See Fig. 691.) Less force is required for elevating a tooth than for any other movement, as a conical root is drawn from a conical socket, and care must be taken not to move the tooth too rapidly lest the pulp be ruptured at the apical foramen or the peridental membrane be ruptured. If the wire is soldered on the cutting edges of the caps, it will prevent the possibility of drawing the tooth too far. For retention substitute a small platinum or silver suture wire for the rubber band, or apply three bands soldered together. A broken tooth may be elevated by means of the same kind of appliance (see Fig. 692), and then the cutting edge ground to conform to the other teeth.

For a partially erupted canine an excellent plan is that of Prof. Angle, shown in Fig. 693.

Where the canine has not erupted far enough for cementing a band or swaged cap on it, a small hole may be drilled in the tooth, in which

Fig. 692.



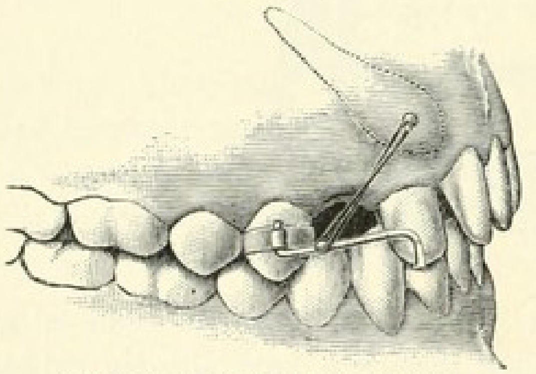
Writer's method of elevating broken tooth.

a small screw or pin is secured by cement. This may be afterward filled with gold, or with a piece of a small glass rod, as described by Prof. L. L. Dunbar.[1]

In some cases it is advantageous to use teeth of the lower jaw for anchorage, as shown in Fig. 694.

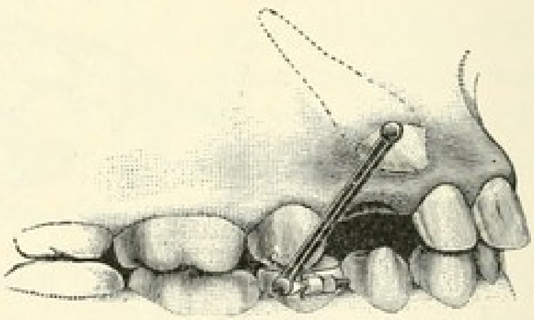
The patient may remove the rubber band from the upper tooth while eating. As rubber bands are liable to be broken by a too sudden

Fig. 693.



Angle's method of forcible eruption.

Fig. 694.



Angle's method of using the lower jaw for anchorage.

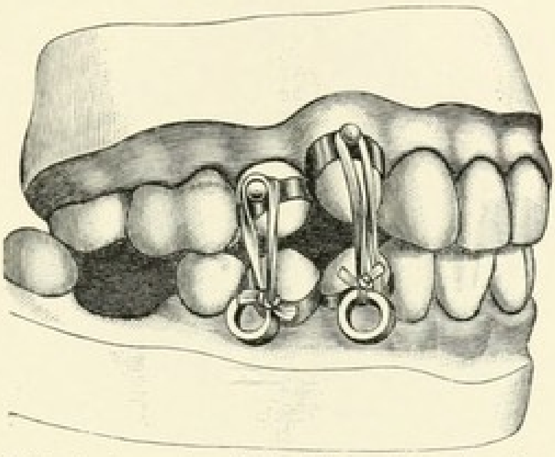
opening of the patient's mouth, it is well to attach two or three to the lower tooth, as a reserve in case one is broken between visits of the patient. The lower metal band may be dispensed with by ligating the rubber band to the neck of the tooth. As the rubber band tends to draw the ligature away from the gum, inflammation is not likely to ensue as in many other uses of such a ligature.

Figs. 695 and 696 show how this plan has been successfully applied by the writer for elevating bicuspids and molars which do not occlude. Bands with hooks are attached to both upper and lower teeth and a rubber band stretched from each upper hook to a corresponding lower one, or the place of either upper or lower band is supplied by a liga-

[1] *Pacific Coast Dentist*, vol. i. p. 14.

ture. The teeth, being drawn out of their sockets toward each other, will soon meet and adapt their occlusal surfaces to each other. This

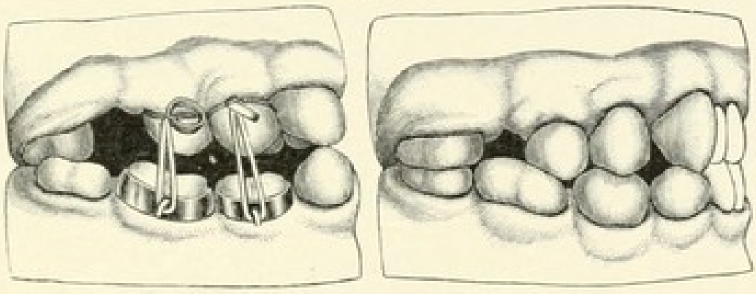
Fig. 695.



Writer's plan of occluding bicuspids and molars.

adaptation may be assisted by grinding or re-shaping any cusps that may be an obstruction. The case shown in Fig. 696 was treated in

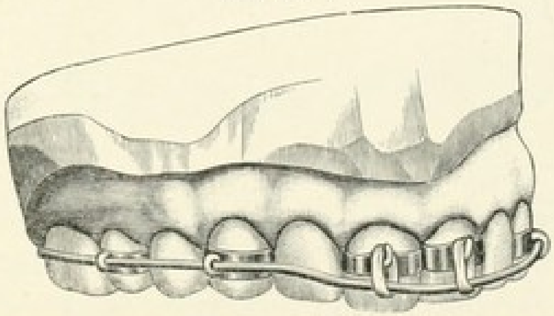
Fig. 696.



Restoration of occlusion.

the infirmary of the Dental Department of the University of California by a senior student under the writer's directions. An unexpected result was also obtained. The upper arch was much narrower than the

Fig. 697.



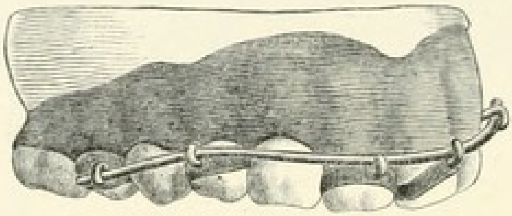
Labial bow for elevating centrals and depressing canines.

lower. The upper teeth were drawn outward as well as downward and the arch was widened.

The following case will serve to illustrate reciprocal movement:

The central incisors of a patient about twenty years of age were partially denuded of enamel for about $\frac{1}{16}$ of an inch from the cutting edge. The lateral incisors had the same defect at the cutting edge only. It was thought best to elevate the central incisors, and grind off the portion denuded of enamel. Bands were fitted to the centrals (Fig. 697) with hooks on their labial surfaces pointing upward, also on the canines

Fig. 698.

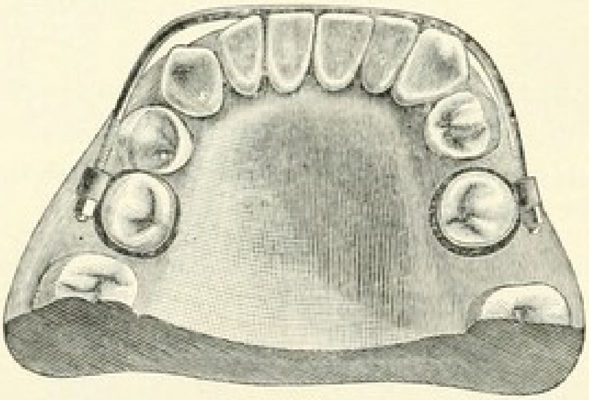


Labial bow for retention.

with hooks pointing downward, and on the second bicuspids with tubes on their buccal surfaces. A wire bow was extended from the tube on the left bicuspid to the tube on the right, and caught under the hooks on the canines. Slender rubber bands were then stretched from the wire over the hooks on the centrals, and soon elevated them sufficiently to grind off the denuded portion. The same appliance was used as a retainer by bending the bow wire upward slightly and hooking it over the hooks on the incisors.

The elevation of a broken upper incisor is sometimes interfered with by occlusion of the lower incisors on the slanting lingual surface

Fig. 699.



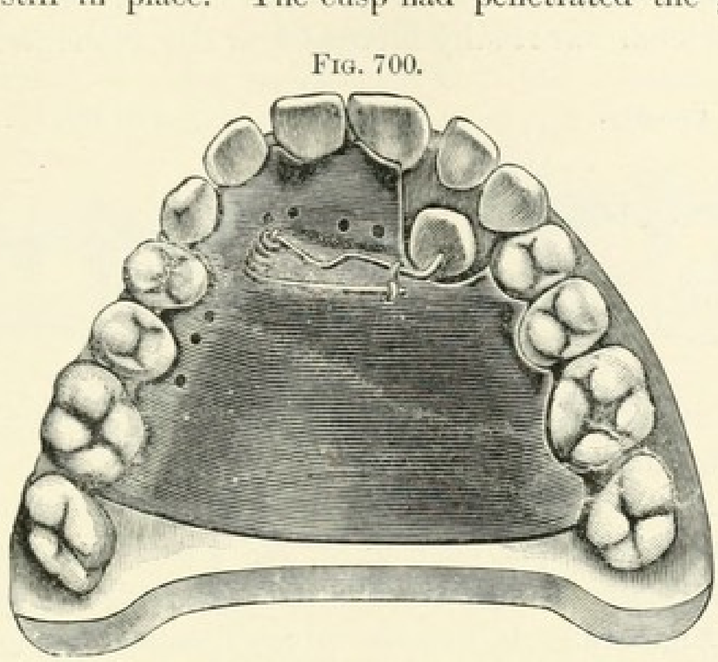
Flattening lower arch with labial bow.

so that it is necessary to shorten the lower incisors by grinding. In some cases it is warrantable to grind away the upper incisor on the lingual surface, where too much grinding of the lower teeth would mar their appearance. In the case just described it was necessary to press the lower incisors back by flattening the arch as shown in Fig. 699.

The following case of forcible eruption may be instructive:

Miss R. W., aged eighteen, presented herself with the point of the upper left canine erupting behind the lateral incisor while the deciduous canine was still in place. The cusp had penetrated the gum about a

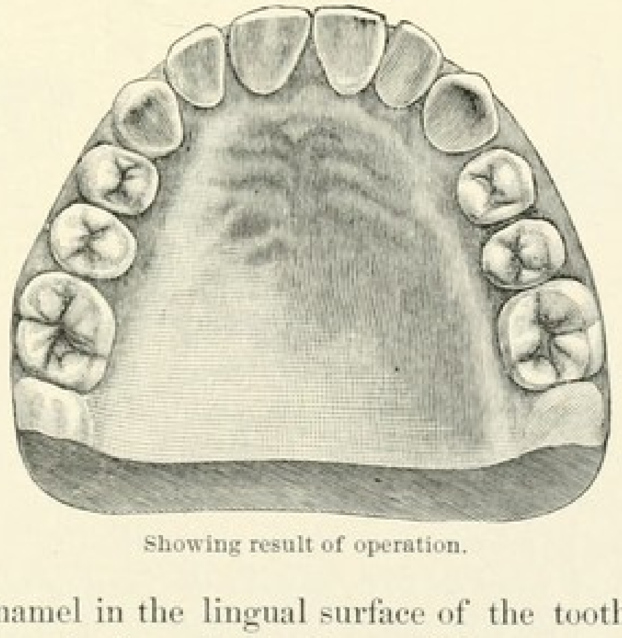
Fig. 700.



Forcible eruption of canine.

year before, but had during that time made no progress in eruption. The writer decided to cause the tooth to erupt forcibly, by means of a coiled spring as suggested by Dr. Talbot. As the deciduous canine was large and firm and but slightly decayed, it was thought best to let it remain in place till the permanent tooth was erupted far enough to see if it were well formed. By depressing the gum slightly a hole was

Fig. 701.



Showing result of operation.

drilled in the enamel in the lingual surface of the tooth. In this hole was inserted one end of a coiled spring, which was attached to a plate, as shown in Fig. 700, which shows the cusp emerging from the gum. The tooth was soon erupted to its normal length, when the deciduous canine was extracted. By means of a rubber band from a labial bow, the ends of which rested in tubes attached to bands on right and left bicuspids, the tooth was readily brought into line as shown in Fig. 701.

Fig. 702.

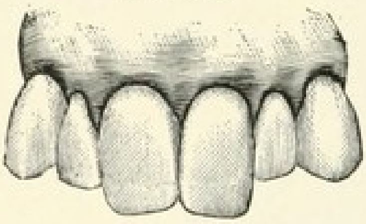
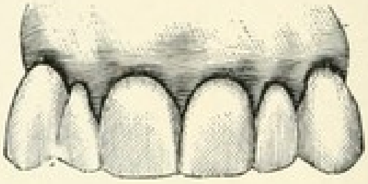


Fig. 703.



A band-and-bar retainer (Fig. 653) was applied to keep the tooth in place till it became firm.

Tooth Shaping.—The operation of grinding has been referred to in the shortening of an extruded tooth, and also for re-shaping a tooth from which a corner has been broken after having first elevated the tooth. (See Fig. 692.) It may be advantageously employed for re-shaping teeth which have been left longer than the contiguous ones by the wearing away of the latter, as shown in Figs. 702–705, suggested by Dr. W. S. How.[1]

In many instances upper incisors are worn away on their lingual surfaces, leaving thin edges of labial enamel which are easily broken away irregularly. (See Fig. 706.) These broken edges may be removed and the teeth improved very much in appearance by grinding.

The cusps of bicuspids and molars sometimes interfere with the

Fig. 704.

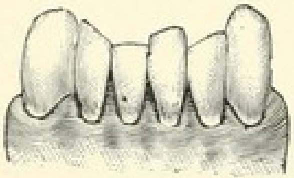


Fig. 705.

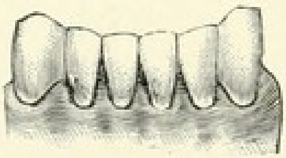
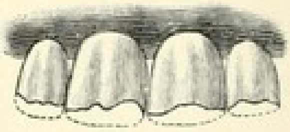


Fig. 706.



Worn or broken teeth (Farrar).

desired movement of an antagonizing tooth and may be reduced by grinding so as to present no obstruction.

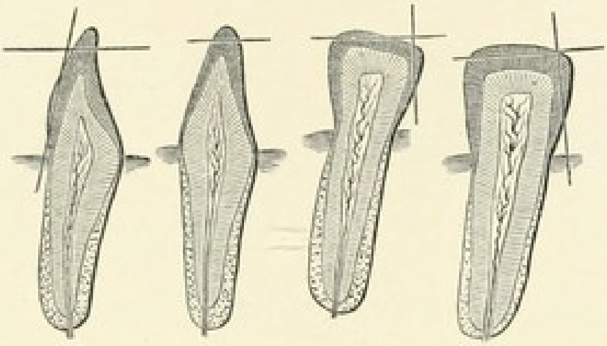
Lower canines which prevent upper canines or lateral incisors from moving into their proper position may have the apex of the cusp ground away, and in some cases even a portion of the labial enamel may be removed to advantage. An incisor which inclines toward the contiguous tooth so much as to present one angle lower than the other may have this corner ground away so as to present the cutting edge in line with the other teeth. Fig. 707 shows how much of the enamel of a tooth may be removed in various cases without exposing the dentin.

[1] *Dental Cosmos*, vol. xxviii. p. 741.

"Truing up" is a term applied by Dr. Farrar to the process of removing overlapping portions of teeth so that they will present a normal appearance. (See Figs. 708 and 709.)

Much discomfort may be prevented if the corundum wheel be held as in Fig. 710, as the tooth is supported by the contiguous ones

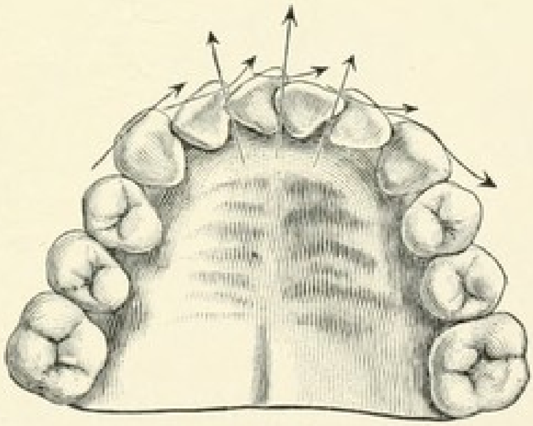
FIG. 707.



Showing thickness of enamel (Farrar).

and less jar is felt. Fine-grained wheels should be used and the surface should afterward be thoroughly polished by means of cuttlefish disks, or with felt or wooden wheels carrying polishing powder. If the grinding should not be carried so far as to be painful a slight sensitiveness may be felt for a few days, when the operation may be resumed. Cataphoresis has been successfully applied by the writer for allaying sensitiveness. If a tooth needs to be reduced considerably in length

FIG. 708.

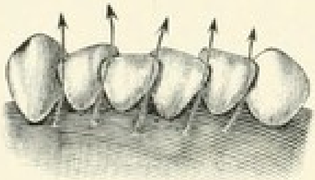


Truing up (Farrar).

the dentin may be exposed on the cutting edge with impunity, as it is kept free from decay by the tongue and lips. The enamel may be beveled on one or both surfaces to reduce the thickness of the cutting edge.

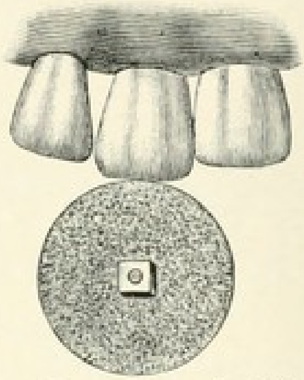
Approximal Surfaces.—In rare instances the removal of a slight amount of enamel from approximal surfaces of incisors or canines is permissible for the purpose of making room. The operation should be confined to teeth easily kept clean, to teeth unusually rounded on their approximal surfaces, and they should be reduced only to a normal contour and

Fig. 709.



Truing up (Farrar).

Fig. 710.



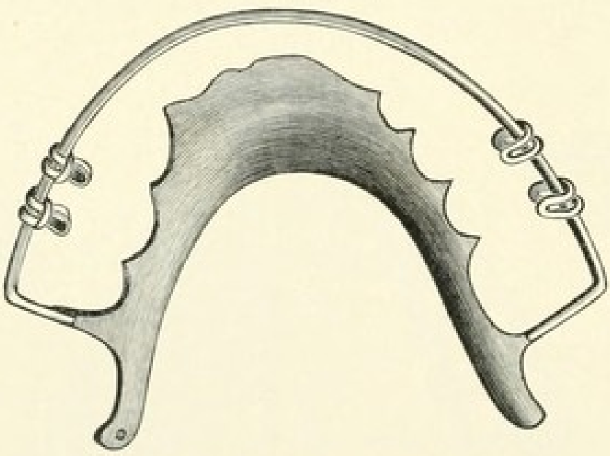
Position of corundum wheel (Farrar).

be thoroughly polished. Flat approximal surfaces should never be produced, as caries is almost sure to be the result. The patient should be warned to use extra care with the brush and floss silk.

Disks or strips of sandpaper, emery, or garnet may be used for removing a portion of enamel, after which cuttlefish disks or strips should be used for polishing.

Class 6. **Two or More Teeth in Any or All of the Five Malpositions.**—One of the oldest and simplest appliances, which requires very little skill in its construction, is shown in Fig. 711. It can be

Fig. 711.



Labial bow and plate. (From Kingsley.)

used with either upper or lower jaw, and consists of a vulcanite plate fitted against the lingual surfaces of the teeth. Imbedded in this plate are the ends of a wire which extends through such gaps, when the jaws are closed, as are most favorable, and around the buccal and lingual surfaces of the teeth. A round wire is much better than a flat strip of plate for this bow, as it can be bent up toward the gum line or down toward the cutting edges of the incisors according to the necessities of the case. The cut shows the manner of attaching rubber bands by which teeth may be drawn forward. The bow should be from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in advance of the teeth to be moved, and may be elongated from time to time by hammering the sides on the beak of an anvil. By attaching rubber bands or twisted ligatures to the plate, teeth may be drawn into the arch, as shown in Fig. 712, *B*. By stretching rubber bands or twisted ligatures from either the wire or plate to hooks such as shown in Fig. 712, *A*, teeth may be rotated. For such purpose it is in some cases best to solder hooks on both labial and lingual surfaces of a band, and thus apply force from wire and plate at the same time.

By attaching a rubber band at that part of the wire which emerges from the plate (Fig. 712), a tooth may be drawn backward along the ridge. If the wire extends near to the cutting edge, an incisor may be

FIG. 712.

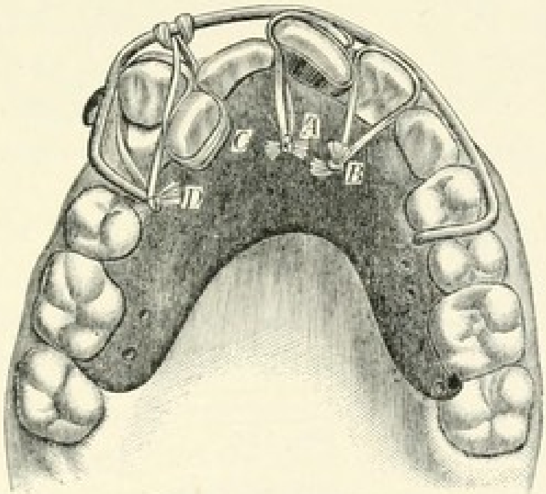


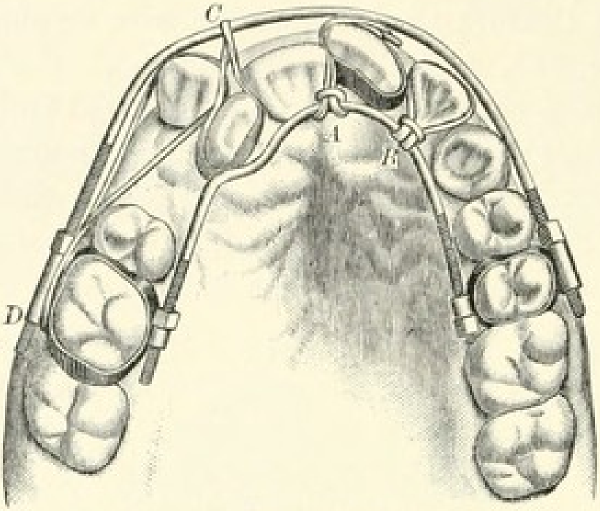
Plate and wire bow for moving teeth in all positions.

extruded by ligating a rubber band at the neck and extending it to the bow, or by applying a twisted ligature in the same manner. In some cases it is necessary to ligate the plate firmly to temporary molars or bicuspids. This has a wider range of use than any other single appliance, for with it teeth may be moved outward or inward, rotated or elongated, or the arch may be spread. (See Fig. 712, *A*, *B*, *C*, *D*.) It is, however, much less stable and much more uncleanly than are many other appliances attached directly to the teeth.

The same movements may be made with the bows shown in Fig. 713. Bands are cemented on one or two teeth on each side of the mouth, preferably two for stability, in which case the bands should be soldered together. Tubes are soldered on both buccal and lingual sides of the bands. In these tubes are inserted wire bows, screw-cut on the ends and supplied with nuts. One bow extends around the labial and the other around the lingual surfaces of the teeth.

To these wire bows, rubber bands may be attached to move teeth in all directions, for instance at *B*, for moving a lateral incisor into the arch; at *A*, for rotating a central incisor; at *D*, for drawing a canine backward along the ridge; and at *C*, for drawing a lateral forward.

Fig. 713.

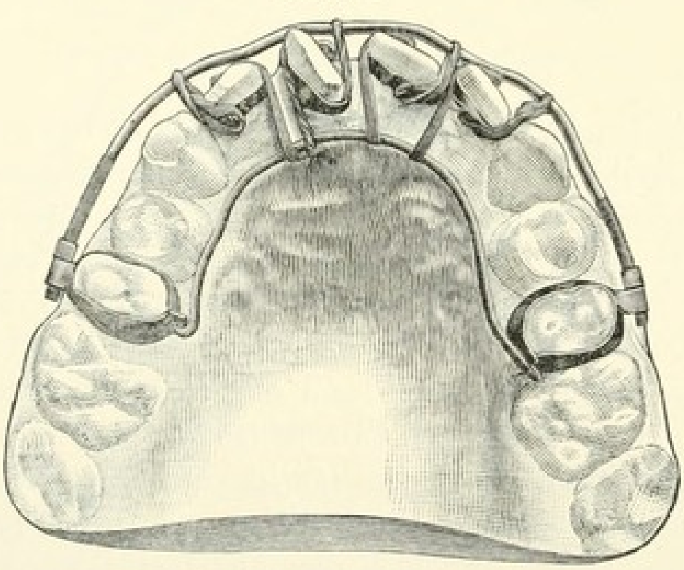


Labial and lingual bows for teeth in all positions.

This last rubber band should not be applied till after the canine has been moved out of the way.

This appliance, made up of labial and lingual bows, has as wide a range of application as the plate and bow, and is much more stable as

Fig. 714.

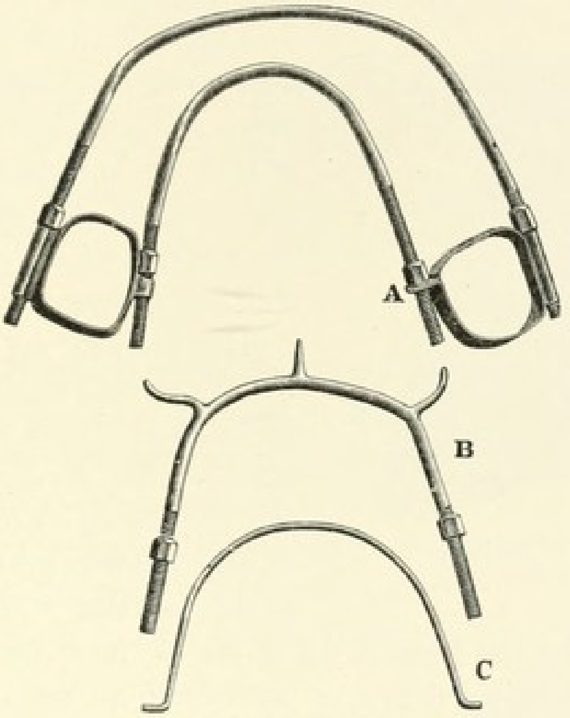


Appliance for rotating several teeth at one time.

well as much more cleanly. Fig. 714 shows the use of this appliance for rotating several teeth at one time.

The bows may be used independently as follows: The labial bow may be used for moving incisors backward by placing the nuts behind the tubes (Fig. 663), or for moving incisors forward by placing the nuts in front of the tubes and ligating the wire to the incisors, or putting it

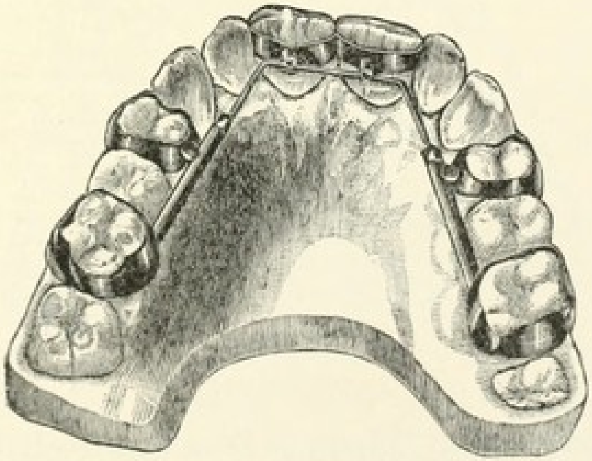
Fig. 715.



Labial and lingual bow.

under hooks soldered to bands on the incisors. It may be used for the attachment of rubber bands or twisted ligatures for drawing incisors forward (Fig. 729), in which case the wire may be bent in a bayonet shape at the ends, or the rear ends of the tubes may be closed.

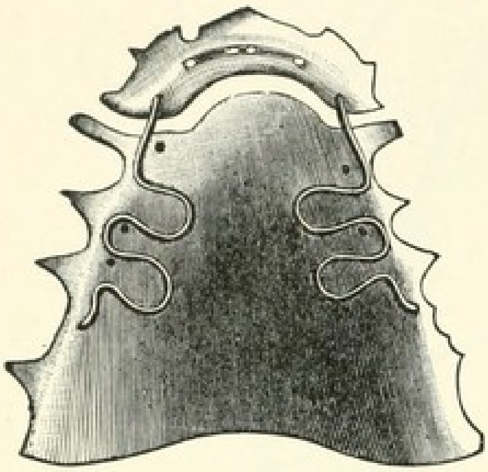
Fig. 716.



Lingual bow for moving incisors forward (Matteson).

The lingual bow may be used for moving any or all four incisors forward by placing the nuts in front of the tubes. The anterior portion of the wire may rest in notches in the bands on the incisors (Fig. 716), or a short piece of wire may be soldered to the front of the bow and inserted between the centrals above the points and their mesial surfaces. Other short wires may be soldered on so as to engage the distal borders of the laterals to prevent their being moved sideways. (See Fig. 715, B.)

FIG. 717.

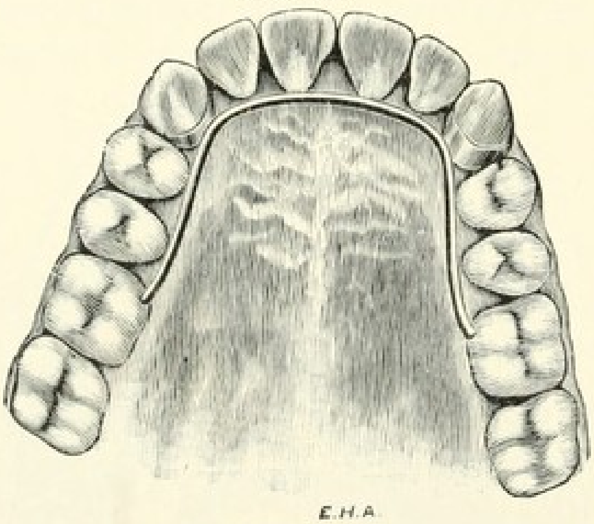


Writer's modification of Coffin split vulcanite plate.

Fig. 717 shows the writer's modification of the Coffin spring plate for moving incisors forward. A wire should be imbedded in the anterior portion of the plate to project between the centrals to prevent sliding on the inclined surfaces.

RETENTION OF TEETH MOVED FORWARD.—This has often been accomplished by a simple vulcanite plate retained by atmospheric pressure and impinging on the lingual surfaces of all the teeth involved. Objections to this are that it is easily displaced, even sometimes by the incisors on whose inclined surfaces it impinges; retention of fermenting débris or secretions in contact with the teeth, and liability to be left out by the carelessness of the patient, when the teeth return partly to their malpositions. Fig. 718 shows a retaining

FIG. 718.



Angle's retainer.

appliance of Prof. Angle's, consisting of a wire bent so as to rest in contact with the lingual surfaces of the teeth involved, soldered to bands on the canines, and the ends cemented in pits drilled in the molars. It may be used in the lower arch as well as the upper. In many cases the anterior portion only of this appliance may be used.

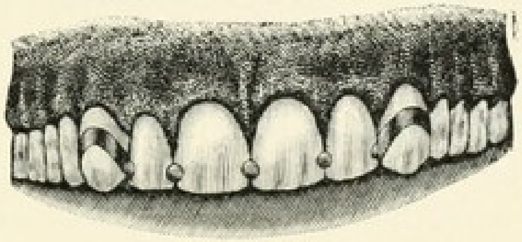
Several teeth moved in different positions may be retained by bands soldered together and cemented in place. (See Fig. 719.)

Fig. 720 shows Dr. Case's retainer,[1] which consists of a series of bands soldered together at their points of contact with an excess of

Fig. 719.

Bands soldered together for retention.

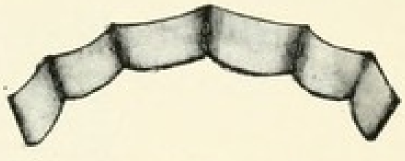
Fig. 720.



Case's retainer.

solder in front. The labial surfaces of all but the end bands are then cut away so as to leave only a small portion between the teeth, and these portions filed so as to resemble gold fillings. The appliance is stiffened by soldering a piece of swaged plate to the lingual surfaces. (See Fig. 721.) The bands should be constructed of very thin gold-faced platinum or German silver, preferably the former, and the whole appliance firmly cemented to the teeth.

Fig. 721.



Swaged strip for strengthening.

Retaining Plugs.—It not infrequently happens that on account of the crowded and irregular positions of teeth, cavities of decay have been formed which can be used, as suggested by Dr. Farrar, for the insertion of gold retaining plugs or fillings. For instance, approximal fillings may be inserted in an incisor and built out so as to touch the contiguous teeth for retaining a tooth; or a tooth that has been moved into line may be retained by gold fillings inserted in approximal cavities and built out laterally so as to rest on the labial or lingual surfaces of contiguous teeth; or a tooth that has been rotated may be retained by one such filling.

This method of retention is especially useful with patients who have advanced beyond the years in which it is generally considered advisable to regulate teeth. The writer had a patient forty-five years old for whom he moved two teeth forward into line. After an immovable retaining appliance had remained in place for over two years the teeth upon being released moved back perceptibly. Gold fillings were inserted in approximal cavities and built out as suggested above, with the intention of leaving them indefinitely.

Care should be taken to make these projections as slender as the

[1] *Ohio Dental Journal*, January 1898, vol. xvii. No. 1.

strength of the gold will permit, so that the point of contact with the enamel will be as small as possible.

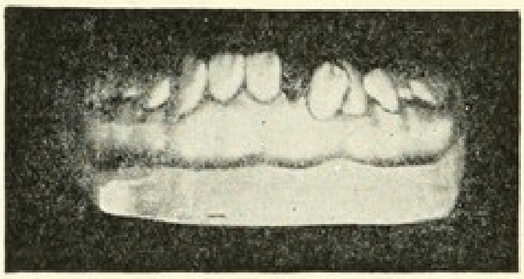
Lower Incisors Crowded in All Positions.—This is a very common irregularity owing to the teeth being too large for the incisor space, or the space being encroached upon by the canines.

The simplest way to make room is to extract one of the crowded teeth. The four teeth are so nearly of the same size that few can tell without counting whether there are three or four between the canines.

When room has been made, the remaining teeth may be brought into line by the same means that have been described for upper incisors. The labial bow attached to bands on bicuspids or canines will form attachment for rubber bands or ligatures for moving the incisors into position. In some cases it is better to spread the arch as shown in Fig. 733. Owing to the relative positions of the alveoli of the central incisor and canine to that of the lateral incisor there is always a tendency for the lateral incisor to erupt within the arch of the adjoining teeth.

In selecting the tooth for extraction in such cases it would seem most natural to take the one most out of position labially or lingually; but

FIG. 722.



that is not always best, because it often happens, as Dr. Case has shown, that the contiguous teeth already lean toward each other, and if drawn together after removal of such teeth will only lean toward each other all the more noticeably with quite a V-shaped space at the gum.

If possible, the tooth for extraction should be so selected that the contiguous teeth lean from each other (Fig. 722), so that when drawn together they will be forced into an upright position. If, however, a wrong selection should have been made, the roots of the contiguous teeth may be forced toward each other by the appliance shown in Fig. 821.[1]

Caution.—Before deciding on extraction in such cases the operator should satisfy himself that the lower arch does not need expanding to make room for the crowded incisors.

If by removing a tooth the lower arch is allowed to contract and the

[1] Dr. Case, *Dental Review*, 1898, p. 584.

bicuspids move nearer the median line, their cusps may by wedging contract the upper arch and cause crowding of the upper incisors. Fig. 733 shows an appliance for expanding the lower arch.

Class 7. **Prominent Canines and Depressed Laterals.**—*Etiology.* This common form of irregularity may be due to—

(*a*) Lack of development of the intermaxillary bone—constitutional.

(*b*) Teeth too large for the jaw—indirect heredity: teeth from one parent and jaw from the other. (See page 690.)

(*c*) Premature loss of the deciduous second molars and forward movement of the permanent first molars—acquired.

(*d*) Premature loss of the deciduous canines—acquired.

(Figs. 605, 723, and 725 illustrate irregularities under Class 7.)

Treatment.—To make room for proper arrangement of the teeth in this class, it is necessary either to expand the arch or to extract one or more teeth.

If the irregularity is slight, and the arch is narrower than the occluding one, expansion is indicated.

If both arches are narrow, both should be expanded to restore proper occlusion.

Unless the arch will admit of expansion to advantage, extraction is better.

If expansion would make the arch too large, or the anterior teeth too prominent, extract.

If the superior maxilla itself is so narrow that expansion would make the bicuspids and molars slant outward too much, extract.

If caries is prevalent, extract.

In favor of *expansion*, it may be said that if the full number of teeth are retained, the pain of extraction is obviated, and the narrow arch is widened to correspond with the other features.

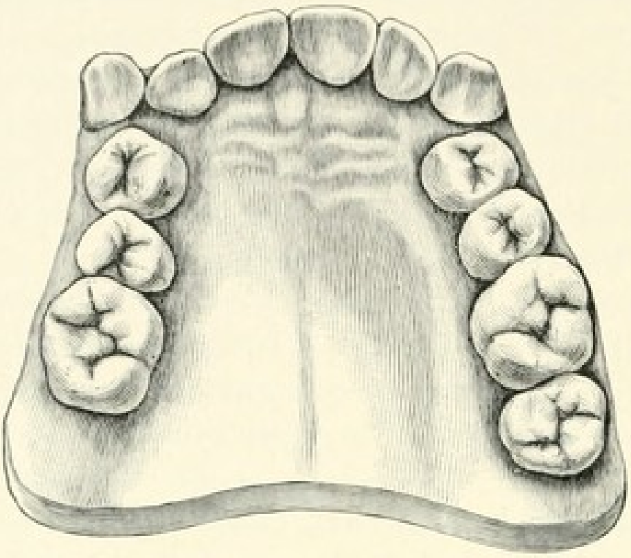
In favor of *extraction:* Room is gained more easily; the treatment is simplified, as there are fewer teeth to be moved; the teeth are retained in their new positions more easily, because if the full number of teeth be retained the same cause that produced the irregularity may tend to reproduce it, while if room be made by extraction the action of the lips and tongue tends to move the teeth into the normal arch.

In many cases no other treatment than extraction is necessary, as shown in Figs. 723 and 724.

Having decided upon extraction in any case under consideration, the choice lies between a lateral incisor and some tooth posterior to the cuspid. The canine should never be extracted, as on account of its long root and prominent position its loss causes a depression of the corners of the lip and wing of the nose which can never be remedied.

The choice between a lateral incisor and some tooth posterior to the canine depends on the position of the apex of the root of the canine, and also of the lateral. If the apex of the root of the canine is so

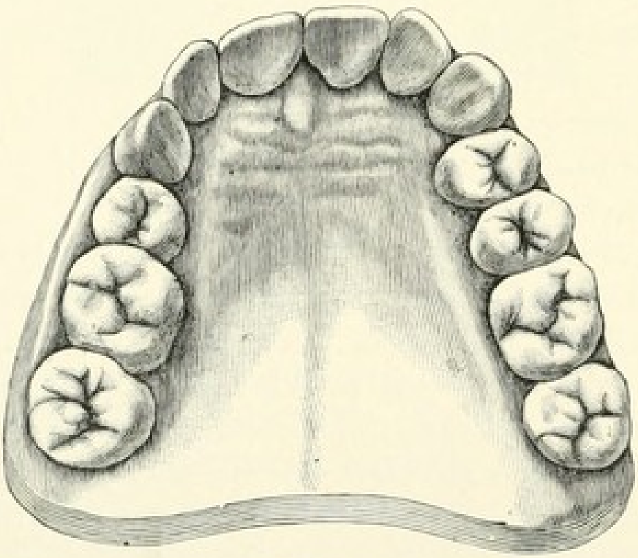
Fig. 723.



Case treated by extraction only.

situated that the crown slants away from the median line, or will do so after being moved into its normal position, the extraction of one or both laterals may be admissible. If a lateral is unusually far back of the normal line and the apex of the root also, when the tooth is moved

Fig. 724.



Showing the same denture as Fig. 723 a few months after extraction.

forward till the cutting edge is in line with the centrals the neck of the tooth will be back of its proper position—that is, the tooth will have an unnatural slant forward. This is not of as much importance as the position of the apices of the roots of the canines, but it should be taken into consideration in connection with the other factors.

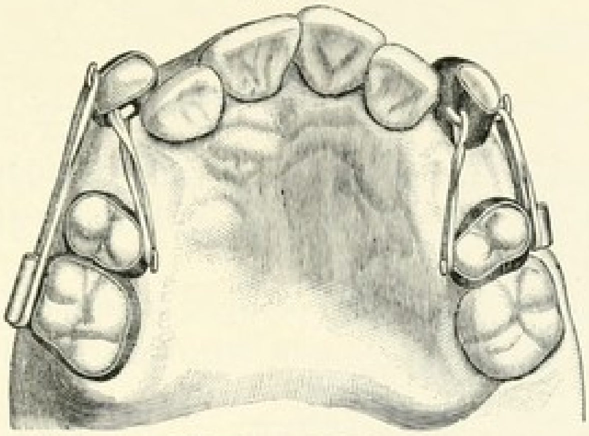
One method of moving incisor roots is shown in Figs. 823–827.

In very rare cases a central incisor may be extracted to gain room—that is, if very badly decayed, if an incurable abscess exist, or if only the root remain and cannot be crowned to advantage.

In the lower arch an incisor may be extracted to advantage in many cases; the four teeth are so nearly alike in appearance that the absence of one is not noticed.

If in a given case it seems best to extract some tooth posterior to the canine, the choice will be between a bicuspid and the first molar. If the bicuspids and first molar be equally sound, extract the first bicuspid. That will leave two teeth for anchorage in retracting a canine (Fig. 725, *left*), or, if the second molar be erupted far enough,

Fig. 725.

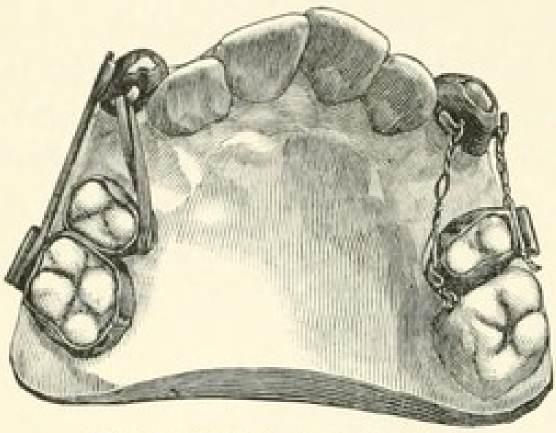


Writer's modification of Guilford's appliance.

three teeth may be utilized. Very secure anchorage is necessary in this instance, for the canine is the most difficult tooth to move, and oftentimes the two anchor teeth will move more readily than the canine. In some cases the canine needs to be moved back but little; then the second bicuspid only need be used for anchorage (Fig. 725, *right*), and the two teeth moved toward each other to fill up the space. The molar will follow, owing to the tendency of the posterior teeth to move forward. This forward movement or migration of molars is very curious, and is often a very great hindrance in regulating, since they offer less resistance as anchor teeth from that very cause. Fig. 728 shows a case in which a molar has moved so as to touch the canine, yet still retains its upright position. The upper molar in migration has less tendency to tip forward than the lower. If, however, the second bicuspid or first molar be so defective as not to be preserved by filling, the defective tooth should be extracted. This, however, will complicate the case, as there are more teeth to be moved and fewer for anchorage. On account of the value of the molar in masticating and in preserving normal occlusion, it should not be extracted unless caries has advanced so far that there is a doubt whether the tooth can be saved by filling or crowning. (See page 744 on extraction.)

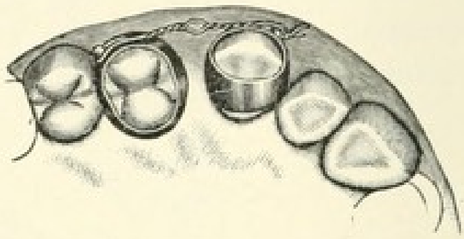
In using the appliance shown in Fig. 725 rubber bands are generally utilized for applying force, but twisted ligatures of silk, linen, or wire may be used, as shown in Figs. 726 and 727, in which case there is less liability to pericemental inflammation.

Fig. 726.



(Same as Fig. 725, but with wire.)

Fig. 727.

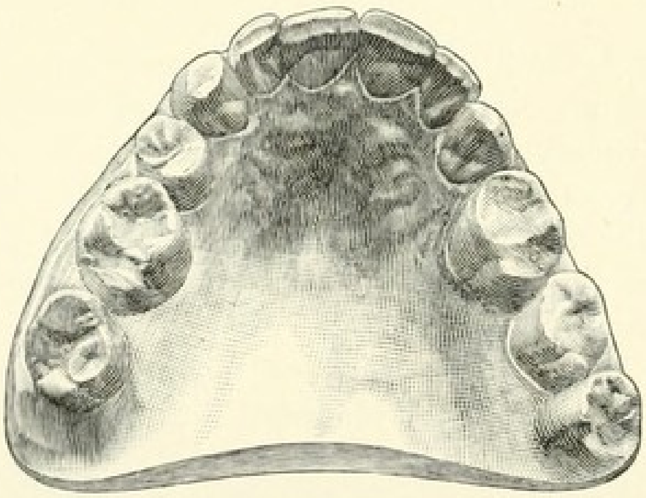


Twisted ligatures of silk, linen, or wire.

Tubes are soldered on the buccal surfaces of the bicuspid or molar bands and shaped so as to serve for hooks. They are afterward utilized for holding a labial bow (Fig. 729).

After the canine is moved into position, it may be retained by substituting fine platinum or silver suture wire for the rubber bands. The

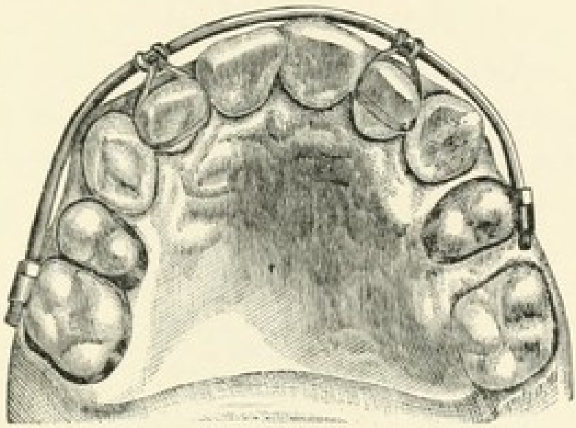
Fig. 728.



Showing migration of molars. Right first molar in contact with first bicuspid, and left touching the canine.

buccal tubes, which served as hooks in the first case (see Fig. 726), may now be utilized for inserting the ends of a wire bow which passes in front of the incisors. Rubber bands or twisted ligatures from this bow will draw the lateral incisors forward. (See Fig. 729.) An inner bow may be placed in the lingual tubes and utilized for drawing central incisors backward, or rotating them, as is often necessary in such cases.

FIG. 729.

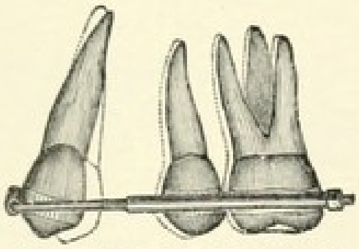


Labial bow added to retracting appliance.

If either canine needs rotating, a rubber band will be needed on one side of the tooth only, and the hook may be so placed on the band that the tooth will be rotated while it is being drawn back.

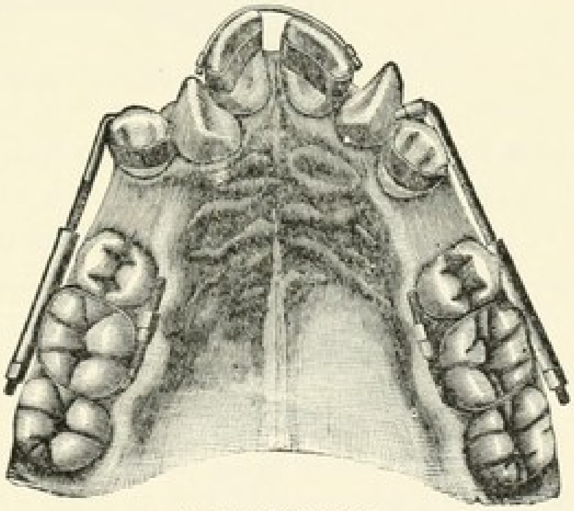
Prof. Angle advises the use of the drag-screw for retracting canines, as shown in Fig. 730. By soldering a long tube to two bands which are cemented to two teeth, and extending the drag-screw through this tube, he reduces to a minimum the possibility of the teeth tilting. This appliance is very effective. The position in which the hook is attached to the canine band will depend on whether it should be rotated or not in retraction. (See Fig. 731.)

FIG. 730.



Stationary anchorage (Angle).

FIG. 731.



Angle's drag-screw.

After the canines are moved to their new position the same appliance may remain as a retainer. It will be found that a canine moved into its proper place, when room has been made by extraction, will need retention less than any other tooth.

Greater anchorage may be obtained by a plate such as shown in Fig. 732, for it impinges upon the anterior alveolar ridge and incisors as well as upon the posterior teeth. Its use is especially advantageous when a second bicuspid or first molar has been extracted, for then one or two teeth must be moved before the canine. The cut will explain the method of applying force to the teeth to be moved. The wire or clasp should encircle the posterior tooth, for greater anchorage. After the second bicuspid has been drawn back, the first can be moved in the same manner; then the canine. In many cases it will

Fig. 732.

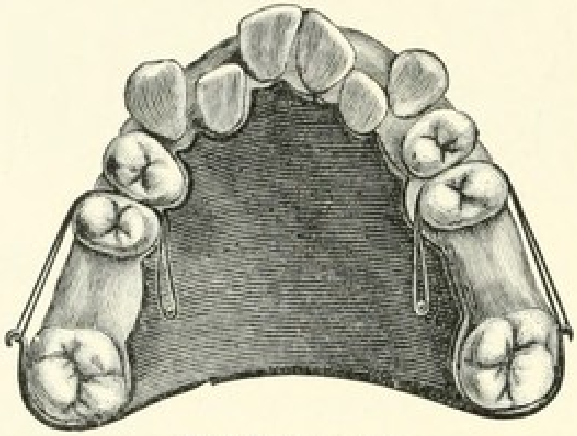


Plate for retraction.

be best to move the canine by the reciprocal appliance shown in Fig. 733, so as to relieve the anchor teeth from undue strain.

It is to be clearly understood that the condition shown in Fig. 732 must be one of necessity, not of choice.

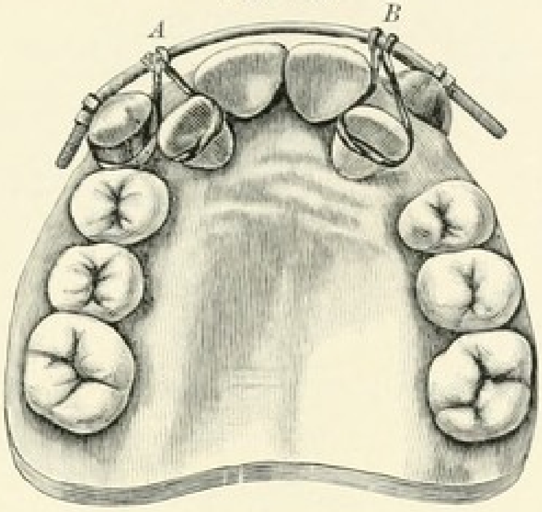
The molar is so important in masticating and in preserving the normal relation and interlocking of cusps of occluding teeth that it should not be removed if it can be avoided.

Present methods of crowning molars are so successful and permanent that in most cases crowning should be resorted to if the tooth is too far gone to be filled, even if a sound bicuspid must be removed to give room.

Fig. 733 shows a reciprocal appliance for these cases by Dr. R. L. Taylor, of San Francisco. The laterals are drawn forward and the canines pushed back and elevated at the same time, after the first bicuspids have been extracted to make room. This has proved a valuable appliance and is well adapted to such cases as are shown in Fig. 732, after the bicuspids have been moved back.

Fig. 734 shows a valuable appliance by Prof. Guilford for moving four incisors forward, and bicuspids back, to make room for canines. He thus describes it: "Magill bands were made to fit the laterals, with gold spurs extending along the palatal surface of the centrals to insure uniform movement of the four incisors. Palatal bands were also attached to the first bicuspids. All of these bands were reinforced with an additional piece of platinum soldered to the portion next to the space. Through these reinforcements, at about the centre of the tooth,

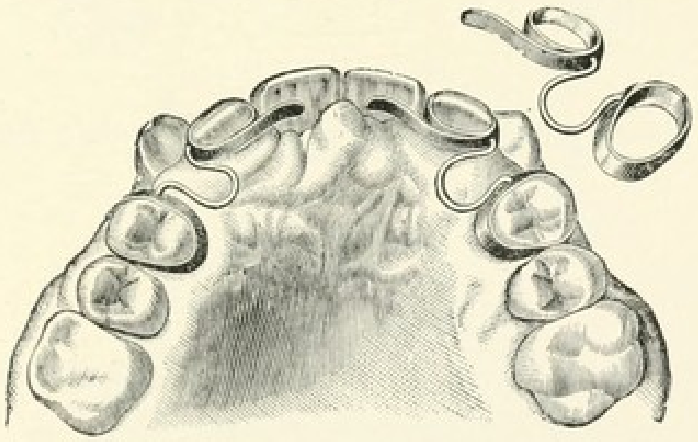
FIG. 733.



Dr. R. L. Taylor's reciprocal appliance.

holes were drilled entirely through the bands. Piano wire was next bent into the form of small U-shaped springs, with the ends at right angles, similar to Dr. Talbot's plan but without the coil. Grasping these near the neck with a pair of narrow-beaked right-angle forceps,

FIG. 734.



Guilford's appliance for increasing space.

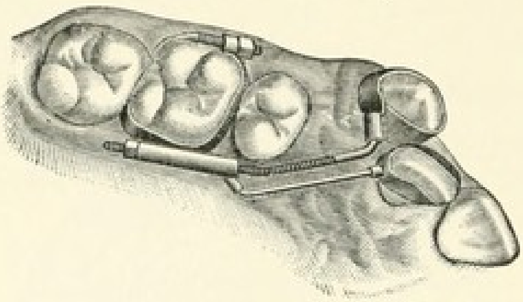
transversely grooved near the points to seize the wire, the springs were placed in position with their ends resting in the holes in the bands. As from time to time the force of these springs became spent they were removed and their power renewed by enlarging their curves."

In case of extraction of first molars, the bicuspids may be moved backward and the incisors forward by Prof. Guilford's appliance.

Fig. 735 shows Prof. Angle's method of reinforcing the anchor teeth by a wire bar extending to the lateral incisor.

In many cases, after extraction of a first bicuspid the only problem

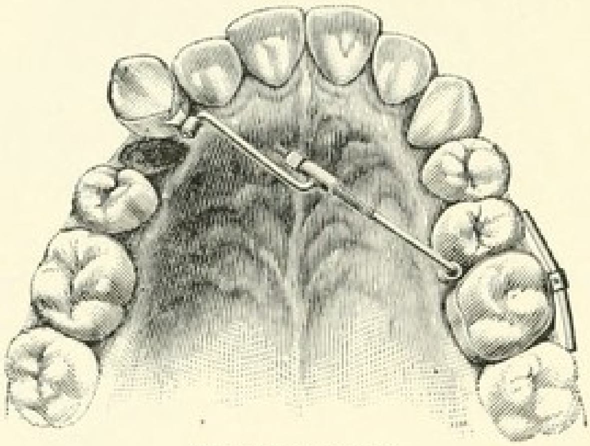
FIG. 735.



Angle's reinforcement.

is to draw the canine into line or move it lingually. This may be accomplished by any of the appliances described in Class 2.

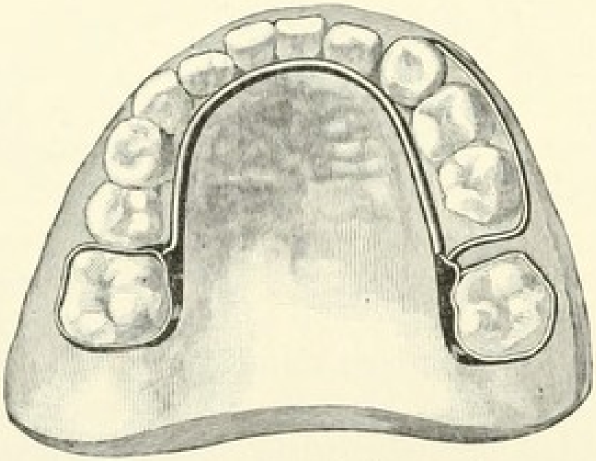
FIG. 736.



Drawing canine in.

Fig. 736 shows another method of Prof. Angle's for drawing the canine in.

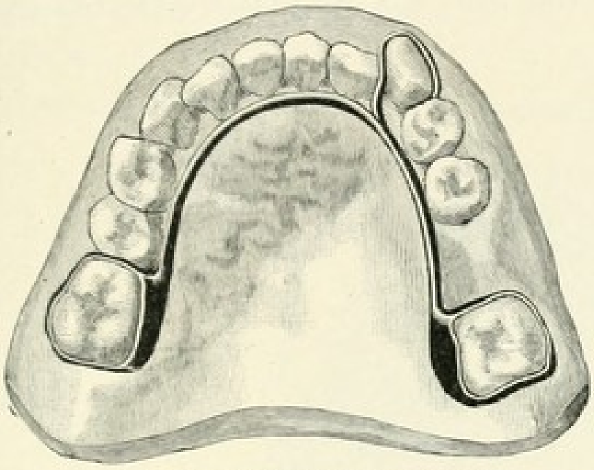
FIG. 737.



Jackson's appliance for lower arch.

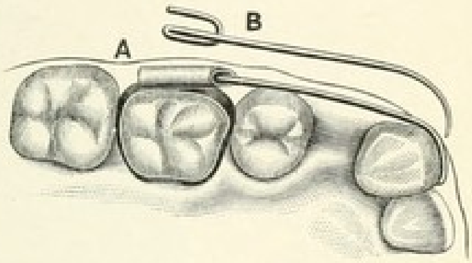
The *lower canine* is the most difficult tooth to move. If the first bicuspid be extracted to make room, the second bicuspid and first molar will in many cases be moved forward in an attempt to use them as anchorage in retracting the canine either with a screw or elastics. If a first molar has been lost, we have the sum of difficulties,—three teeth to move and only the second molar for anchorage. It is often necessary to construct an appliance of such a shape that all the other teeth can be used as anchorage.

Fig. 738.



Jackson's appliance for lower arch.

Fig. 739.

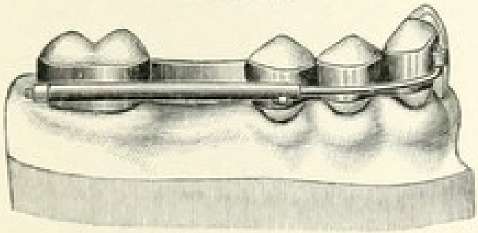


Flat tube for piano-wire spring.

Figs. 737, 738 show Dr. Jackson's method of retracting the lower canine in such cases. The base wire rests against all teeth that it is not desired to move and gives effective anchorage.

Fig. 739, A, shows another method of applying a piano-wire spring by bending a loop on one end and inserting it in a flat tube soldered to a molar band; the spring is thus prevented from turning. The loop may be so bent that the spring may be inserted in the posterior end of the flat tube, as shown at B, Fig. 739.

Fig. 740.



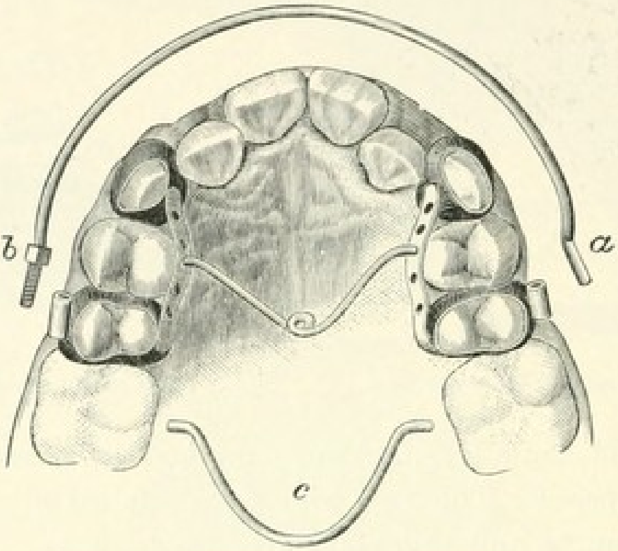
Stability of anchorage.

"When great immobility of the anchorage tooth is required, use for banding material German silver or platinized gold, No. 30 gauge and as wide as the tooth will permit. When these are contoured and fitted, solder the power tube at the gingival margin. (See Fig. 740.) This should be sufficiently long to permit reinforcing it at either end with solder to the full width of the tooth, and large enough to carry a power rod that will be inflexible. Where it is possible, the power tube may rest above the gingival margin, soldered to an extension plate that is fitted or swaged to the surface of the crown, and so shaped as to freely clear the gum.

"If the power tube is extended forward to the first bicuspid and its anterior end allowed to rest upon a narrow projection soldered to the bicuspid band, it will add greatly to the stability of the anchorage.

"It will be seen that any tendency of the molar to tip forward will carry the anterior end of the tube almost directly toward the

Fig. 741.

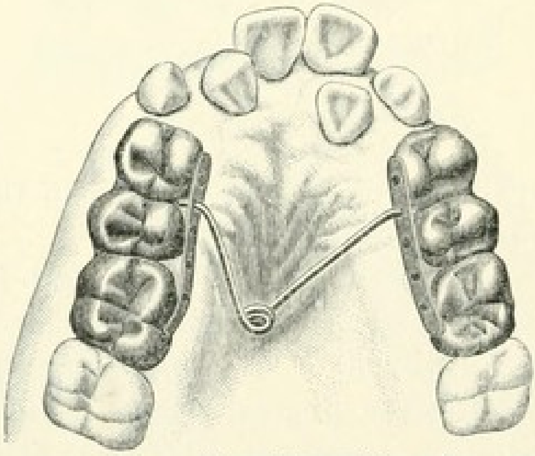


Author's combination for expansion.

root of the bicuspid, the movement being prevented by the rest. Nor will any such device offer any special obstruction to the movement of the bicuspid, the rest sliding along the tube."

The "power bar," or drag-screw, should end in a hook engaged in a tube on the canine or any other tooth that needs to be moved.

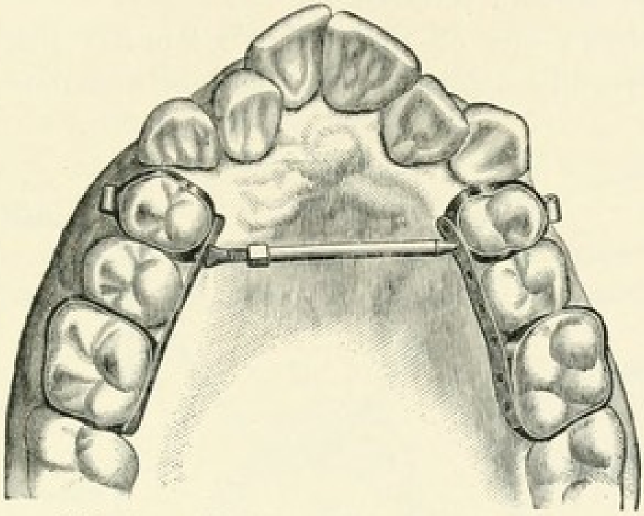
Fig. 742.



Matteson caps in place of bands in appliance for expansion.

Spreading the Arch.—For spreading the arch an appliance should be firmly fixed upon the teeth and should have sufficient power, which can be well regulated. For such an appliance the writer has made a combination of Magill bands, Angle's jack-screw, and the coil spring, as shown in Fig. 741. While resembling other devices for the same purpose, it has this distinction: The bar connecting the bands on the lingual surfaces of the teeth is perforated at short intervals by holes in which are fitted the ends of a Talbot spring or an Angle jack-screw. This bar should be stiff, about No. 23 B. & S. gauge. The position of the screw or spring may be changed, according to the part which needs the greater expansion. If necessary, two springs or two

Fig. 743.

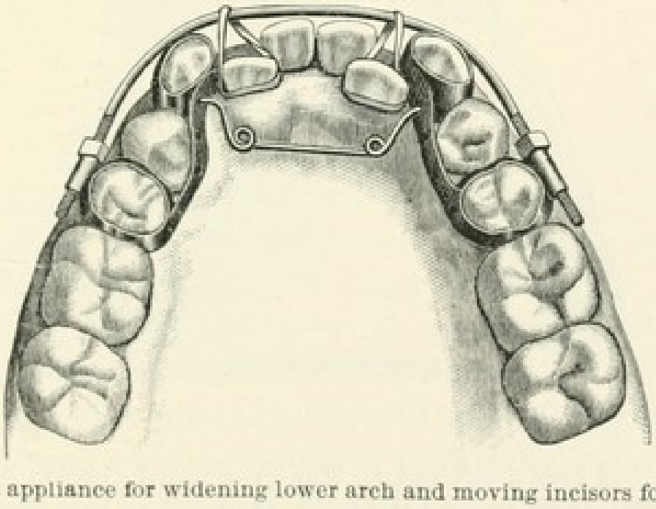


Writer's combination with Angle's jack-screw.

jack-screws may be used at the same time. The coiled spring should be bent to conform to the palatal vault, so as to interfere but little with the patient's tongue as does the jack-screw.

In case of very short molars and bicuspids it is best to use Matteson caps in place of bands, as shown in Fig. 742.

Fig. 744.



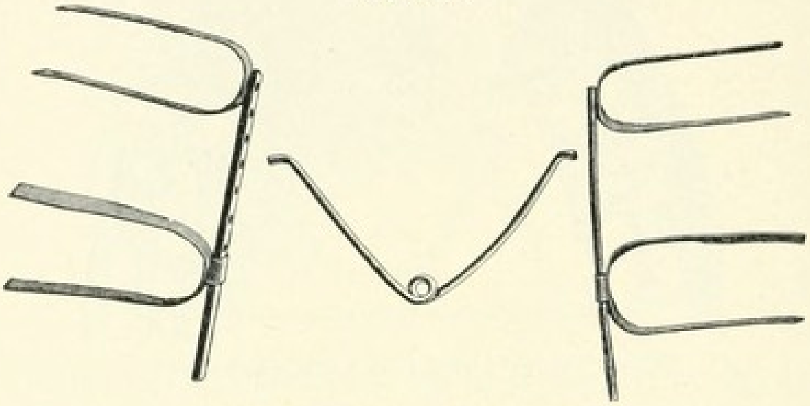
Writer's appliance for widening lower arch and moving incisors forward.

Fig. 743 shows the use of the jack-screw and Fig. 744 the appliance for the lower arch. In this the Matteson spring is used with two coils between which is a straight part which lies near the floor of the mouth.

When the arch has been spread the bent wire *c*, Fig. 741, is substituted for the spring or jack-screw for retention. It may lie along the necks of the teeth, and in such position be utilized for attachment of rubber bands for retracting or rotating incisors, as shown in Figs. 667 and 713. The long wire *a*, *b*, Fig. 741, is used for moving incisors forward, as shown in Fig. 729. These two wires are the labial and lingual bows previously referred to.

Fig. 745 shows one of the author's "partly made" appliances, which can be readily applied to the teeth of a patient or to a plaster

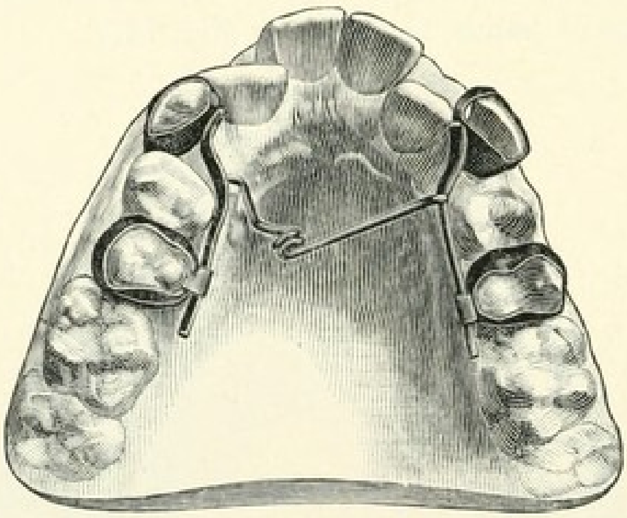
Fig. 745.



Partly made appliance for expansion.

cast by bending the partly made bands around the teeth and completing them as in Fig. 630.

Fig. 746.



Partly made expander applied to plaster cast.

The perforated bar soldered to the first band ribbon slides through a flat tube on the second band ribbon, and thus allows adjustment according to the amount of room desired between the bands. Fig. 746 shows the completion of the appliance.

CLASS 8. **The Pointed or Gothic Arch (the V-shaped Arch) (called the Lancet Arch by Dr. Guilford).**—*Etiology.*—The pointed arch (generally miscalled the V-shaped arch) may be due—

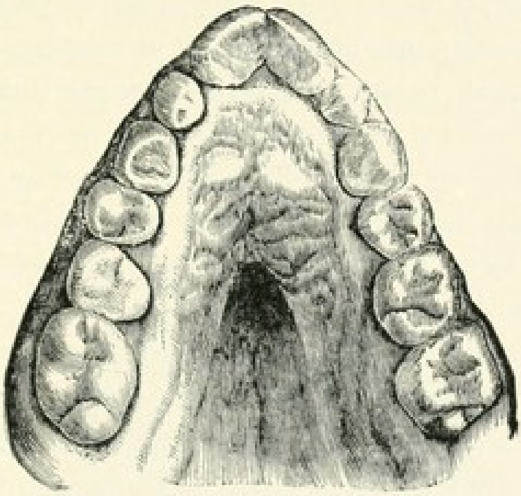
(*a*) To the presence of teeth too large for the jaw—indirect heredity; or

(*b*) To the first permanent molar having moved forward from its normal position on account of premature loss of the second deciduous molar—acquired.

In either case, taking the first molar as a fixed point for the base of the arch on each side, the teeth forward of that point must arrange themselves in a portion of the jaw which is too small for them. The incisors erupt first, the bicuspids next, and the canines last. It depends on the manner of approximal contact whether the result is a pointed arch, a constricted arch, or results in Class 7—"Prominent canines and depressed laterals."

If all of these teeth erupt in proper alignment, they will touch each other approximally like the stones of an arch; the second bicuspid not

FIG. 747.



Pointed arch (V-shaped arch).

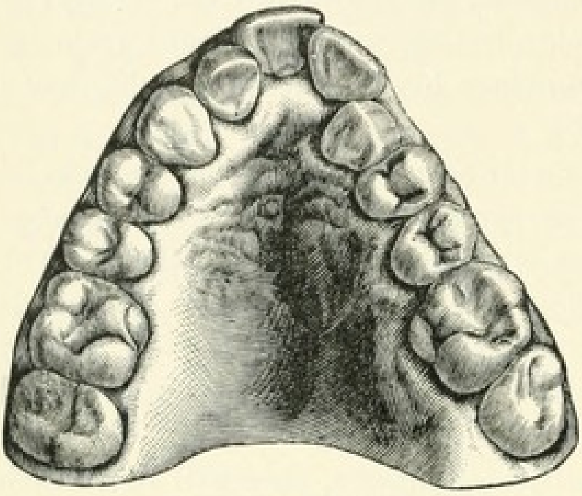
having sufficient room—either from its extra size or because the first molar has taken part of its room—will crowd the first forward, and the canine, erupting as a wedge in front of the bicuspids, which are immovably fixed against the first molar, will crowd the incisors forward, because they are situated in a thin alveolar process which is easily moved. As the incisors move forward, crowding upon each other, they rotate in their sockets and assume the V shape.[1]

(*c*) The teeth may assume a pointed arch from having too much room, either on account of extraction or from being too small for the jaw. When the teeth are deprived of approximal support there is a tendency for the sides of the arch to flatten or move toward the median line.

[1] See Talbot, 3d ed., chap. xxxii., and Ottolengui, *Dental Cosmos*, June 1892.

The semi-V of Dr. Talbot's classification is one in which the causes named have operated on one side only of the arch. Fig. 748 shows a semi-V arch due to the last cause mentioned.

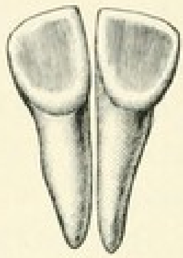
Fig. 748.



Semi-V-shaped arch.

(*d*) The V shape assumed by the central incisors may be due to lack of development of the inter-

Fig. 749.



Apices of roots too near together.

maxillary bone at the median suture. This would bring the apices of the roots of these teeth nearer each other than is normal. As the teeth erupt they may come in contact with each other above the gum line, but be separated from each other at the mesio-incisal angles. If they are now crowded together by the lateral incisors, or if an attempt be made to draw them together by means of a rubber band or ligatures, they will roll upon each other in such a manner that when the mesio-incisal angles touch they have also assumed a V shape with the apex of the V pointing forward.

Conversely, when a V shape of this kind is reduced by double rotation,[1] the teeth will assume the position shown in Fig. 749.

The old theory that it was due to mouth-breathing is no longer tenable, as it has been demonstrated that the pressure of the muscles upon the teeth in such action is not sufficient to cause this deformity. This has been proved by examination of a great number of children in schools and public institutions.

Treatment.—The treatment of the pointed arch depends on the relation in size between the jaw and teeth. If the teeth are not too large for the jaw, and the deformity consists in the flattening of the sides of the arch, the operation is comparatively simple. If pressure be brought to bear on the summit or point of the arch while the base on each side is fixed, the sides will spring outward like an arch of whalebone. (See Fig. 750.)

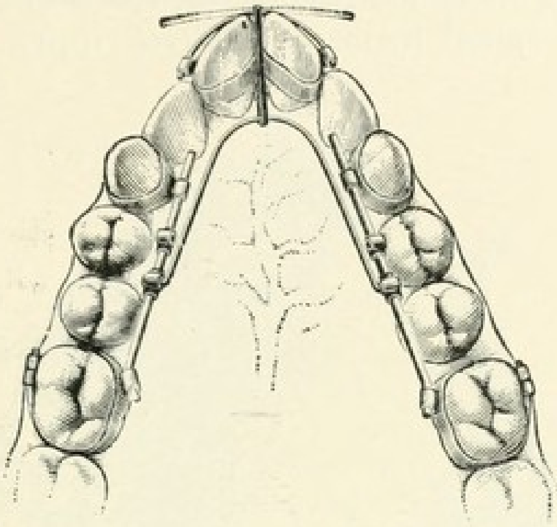
Many pointed arches are also cases of upper protrusion, and will be treated of under that division.

One of the oldest appliances and a very satisfactory one is shown in

[1] See Class 3.

Fig. 751. The posterior teeth should be partially surrounded by the

FIG. 750.



Angle's appliance for spreading arch and reducing V shape.

plate, or by wire or clasps imbedded in the plate, to give firm anchorage. The rubber bands attached to the T-piece between the central incisors should be attached to the edges of the plate as shown, in order to apply the force in a direct line with the movement desired.

FIG. 751.

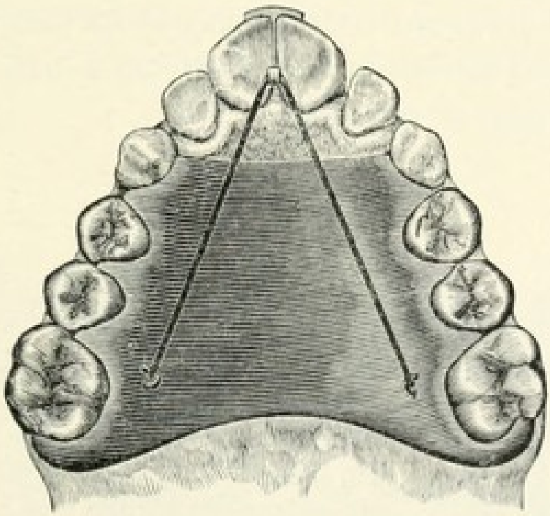


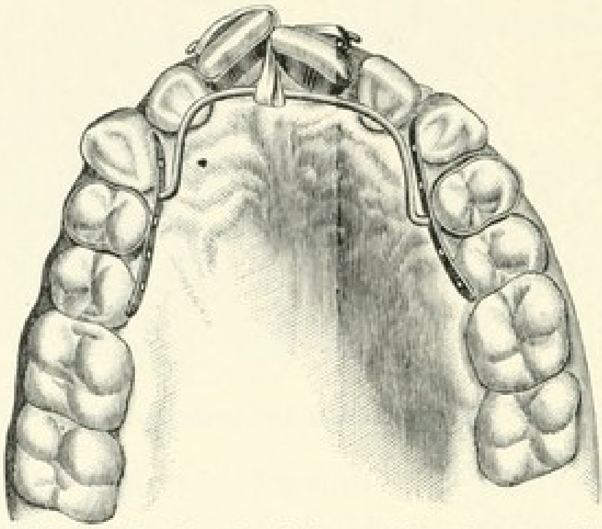
Plate for reducing V arch (Kingsley).

Bands and a labial bow (Fig. 759) may be used, in which case the bands should be applied to the posterior teeth. The bow should be of elastic wire, not smaller than No. 16, and so shaped as to press on the centrals only at first. As these teeth move back and press on the laterals, and these in turn on the canines, and so on, the arch will spread out and can thus be moulded to the shape that has been given to the bow. This may be assisted by rubber bands from the bow over the bicuspids and canines.

In some cases the arch must be spread before attempting to reduce the V shape, in which case the appliance shown in Fig. 741 may be used.

Fig. 752 shows the second stage in the treatment of a pointed arch. The arch is first spread by means of a coil spring acting on a band

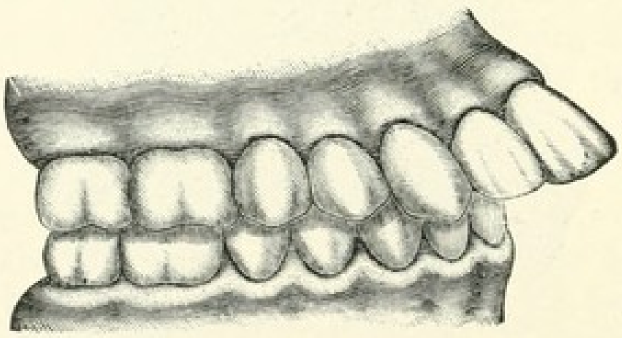
Fig. 752.



Writer's lingual bow and rubber bands for rotation after spreading the arch.

on the first bicuspids, reinforced by bars resting on the canines and second bicuspids. After sufficient room has been gained the lingual bow may be inserted to retain the width of the arch. From this bow a rubber band or a twisted ligature should be extended to a T-piece between the central incisors or to a hook on a band on each central incisor for the purpose of rotating.

Fig. 753.



Upper protrusion—cause (*a*) or (*b*).

Class 9. **Upper Protrusion.**—*Etiology.*—Protrusion of the upper anterior teeth may be due to several causes:

(*a*) Abnormal (excessive) development of the upper maxilla—constitutional.

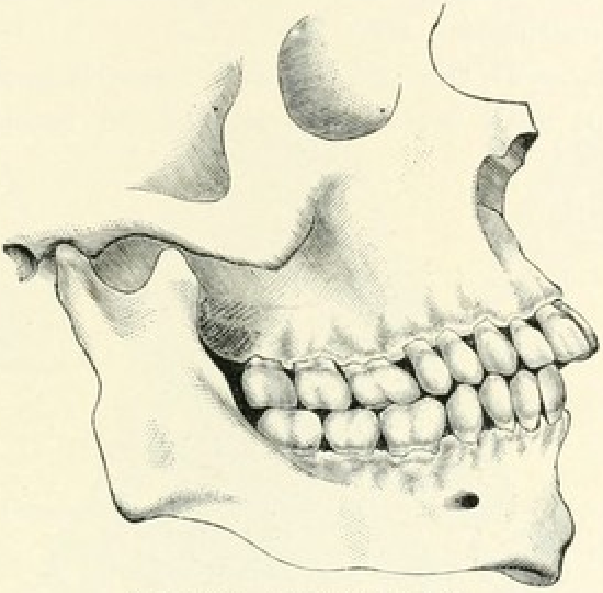
(*b*) Teeth too large for the jaw—indirect heredity.

(*c*) Premature loss of the second deciduous molar, and forward movement of the first permanent molar—acquired.

(*d*) Thumb-sucking—acquired. (See Fig. 757.)

(*e*) Lack of development of the lower maxilla (the upper protrusion is then apparent rather than real)—constitutional.

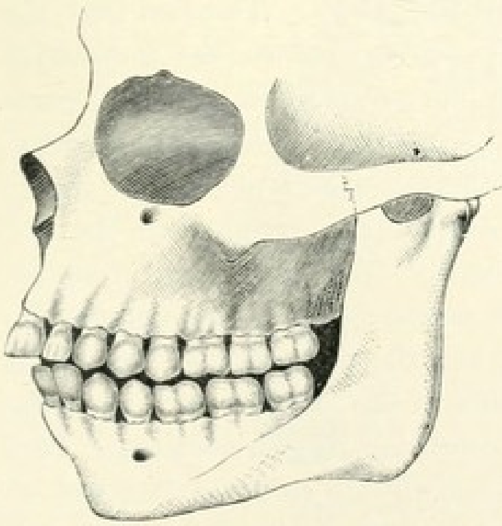
Fig. 754.



Protrusion—cause (*c*) (Talbot).

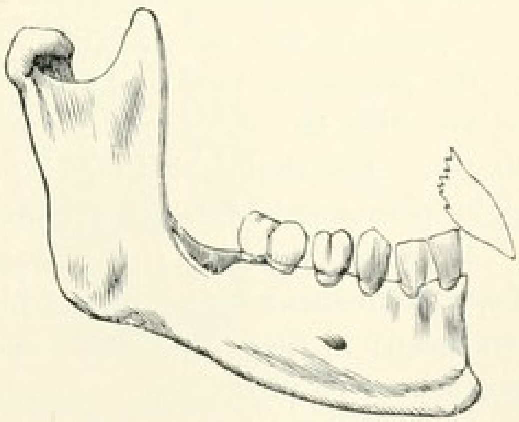
(*f*) Premature loss or injudicious extraction of the first permanent molars—acquired. Prof. Guilford says of such extraction: "The result is that the lateral pressure so necessary to proper expansion is lacking in one jaw while in the other normal enlargement continues."

Fig. 755.



Apparent protrusion due to lack of development of lower maxilla (Talbot).

Fig. 756.



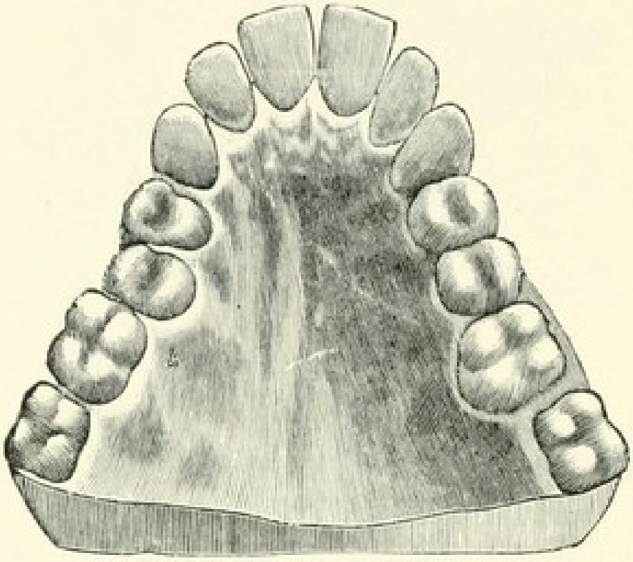
Dr. Louis Jack's drawing (in *Dental Cosmos*) showing deformity from too early extraction of first permanent molar.

(*g*) Weak structure of the upper maxilla, which allows the teeth to be forced forward by occlusion with a large lower maxilla of hard and dense structure with short rami—acquired. (See Fig. 757.)

(*h*) It may be due to extraction of the lower first molars at an age when they were the only masticating teeth, as might be the case during an interval between the loss of the deciduous molars and the eruption of the bicuspids. The impaction of the lower incisors upon the inclined lingual surfaces of the upper incisors might move them forward, thus causing upper protrusion. (See Fig. 756.)

Thumb-sucking.—To this practice were formerly ascribed all cases of upper protrusion, until inquiries developed the knowledge that in a

Fig. 757.



Upper protrusion—cause (*d*), from thumb-sucking. (Talbot.)

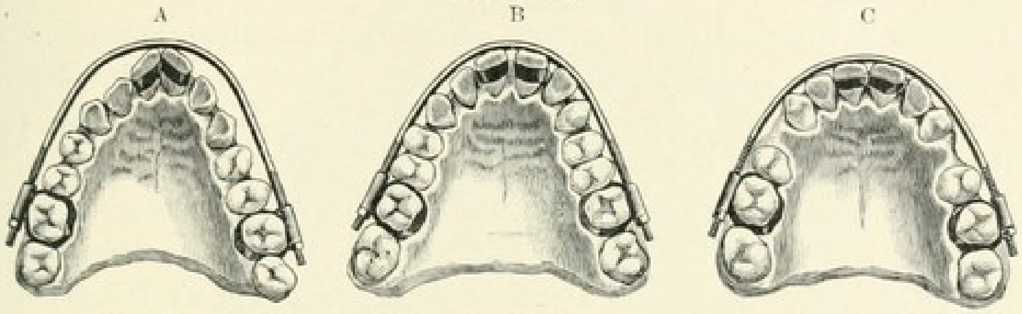
majority of cases no such habit had existed, or, if so, had been abandoned before the eruption of the permanent teeth. The fact that the habit of thumb-sucking, which usually begins before the temporary teeth are erupted, is indulged in during the years when the bony parts are especially soft and yielding and is discontinued before the eruption of the permanent teeth, and that nevertheless upper protrusion rarely occurs with the deciduous teeth, has completely overthrown the old theory. Yet thumb-sucking is occasionally persisted in till twenty-eight permanent teeth are erupted, and occasionally causes protrusion.

Dr. Ottolengui says:[1] "It seems to me that if it is ever true at all that thumb-sucking can cause a protrusion of the jaw, we have it within our means to determine when such a condition has so resulted. If a given case of protrusion is attributable to thumb-sucking, it must of necessity follow that had the child not practiced the habit the jaw would not have protruded. Admitting this, then, we come to this—that the protrusion has occurred in one of two ways: First, the length of the arch around the circle has not been enlarged, but the projection has been produced by a flattening of the sides—pointed arch. The teeth

[1] *Dental Cosmos*, 1892, vol. xxxiv. p. 447.

being normal, but simply distorted, it must follow that such a case could be restored without extracting any teeth, or in plainer language, that by widening the jaw and reducing the forward prominence we may obtain a normal mouth with all the teeth in proper position. The second class of cases is where the length around the arch is increased, thus accounting for

Fig. 758.

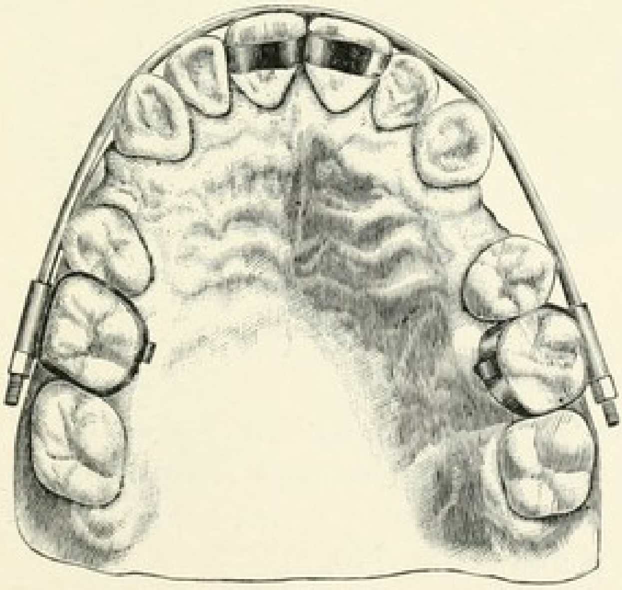


Pointed arch. *Protrusion with spaces.* *Protrusion—teeth too large.*

Labial bow for three cases of protrusion.

the anterior prominence. In such a case the pressure would be supposed to have moved the teeth forward, new tissue forming the while. The result would be a normal occlusion from the bicuspid region backward, but a protrusion forward, with a distinct spacing between the teeth. This of course would be another condition which could be corrected without the loss of a tooth."

Fig. 759.



Labial bow for reducing upper protrusion.

Treatment.—The treatment of upper protrusion will be considered under four heads:

A. Where there is a flattening of the sides of the arch (pointed arch).

B. Where there are spaces between the teeth.

C. Where a tooth must be sacrificed on each side to make room.

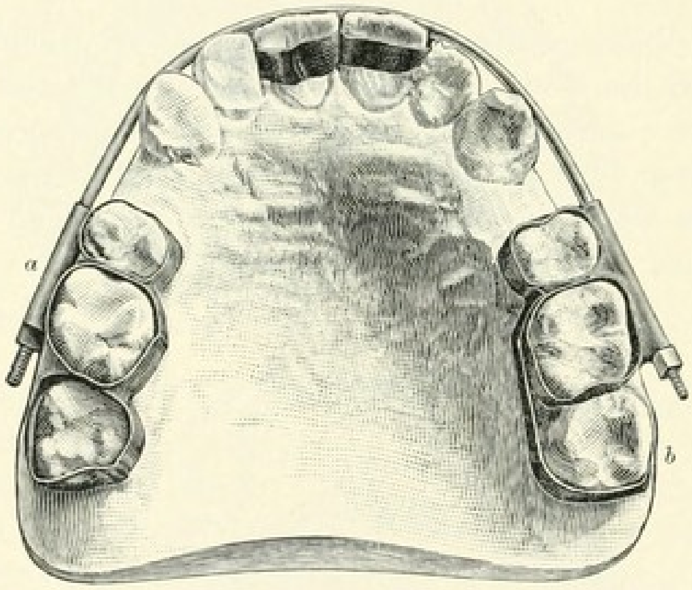
D. Where there is not sufficient anchorage inside the mouth.

The first three classes may be treated in the same manner, by means of the labial bow shown in Fig. 759. The bow should be of stiff elastic wire, not smaller than No. 16, which will retain its shape, and should be bent at first into the exact form desired for the arch in the finished case, and should be prevented from sliding toward the gum by notched bands on central incisors.

In class *A* (pointed arch) it will press on the central incisors only, and cause the flattened sides of the arch to spread outward. If they do not readily do so, rubber bands may be extended from the sides of the bow over any teeth desired.

In most cases the greatest possible stability of anchorage is necessary; then bands for the bicuspid; and both should be soldered together (Fig. 760, *a*). Such bands should be made of No. 30 band

Fig. 760.



Increased anchorage.

ribbon as wide as the crown will allow. Fig. 629, *E*, shows the double band partly constructed.

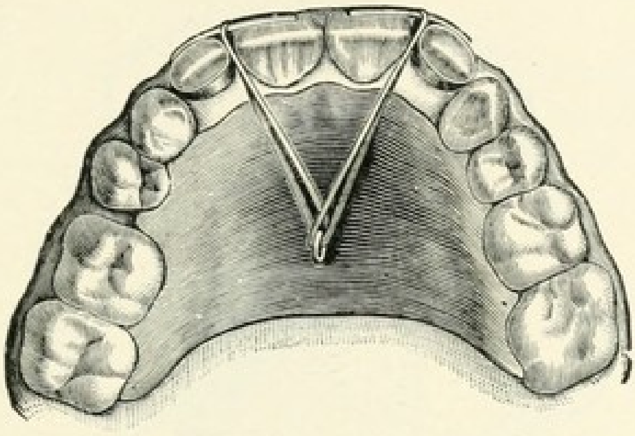
In many cases the second molar is too short for a band, but sometimes a stiff wire may be extended back from the first molar band so as to hook around the second molar, perhaps extending slightly under the gum or pressing it away (Fig. 760, *b*).

In class *B* the teeth will be drawn toward each other and the spaces closed; and in class *C* if the first bicuspids are extracted the six anterior teeth will be drawn back till the canines occupy the vacant spaces. If these six teeth were in the curve of the normal arch they will be moved back in the same position. If some are more prominent than others, the more prominent ones will be drawn back first and all moulded into the desired alignment.

The tooth to be extracted will depend on the same rules as in Class 7—"Prominent canines and depressed laterals."

In some cases the upper protrusion is slight, so that the anterior teeth do not need to be moved back more than half the space left by

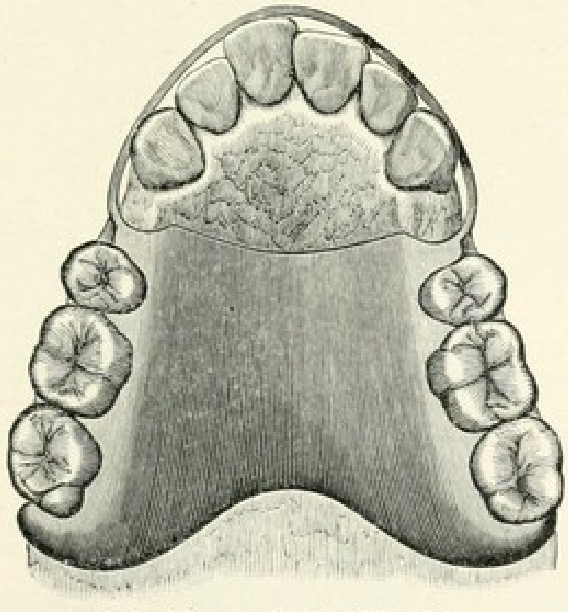
FIG. 761.



Guilford's appliance for retracting upper incisors.

the first bicuspids. Then it is an advantage to have the posterior teeth —the anchor teeth—move forward half the distance and fill up the gap, unless that plan would disarrange the occlusion, in which case the

FIG. 762.



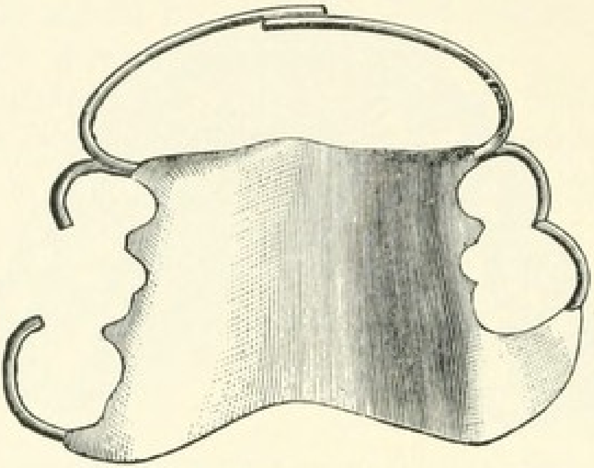
Labial bow and plate (Kingsley).

bicuspid only may be moved forward so as to divide the space. The cusps of the upper bicuspid and the occluding teeth may in some cases be advantageously ground so as to improve the occlusion.

Fig. 782 shows Prof. Angle's appliance for reducing the lower arch, which can be applied also to the upper. By a careful examination it will be seen to be practically a labial bow made up in three sections.

In obstinate cases it would be the best appliance, for sometimes with the bow the teeth crowd together and tend to overlap. This is impossible with Angle's appliance, for all the force is applied to the canines, which in turn draw the incisors along with them.

Fig. 763.

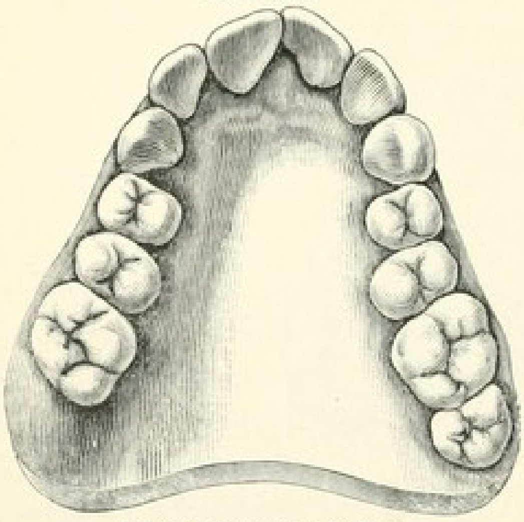


Jackson's method.

The anterior teeth may be moved back by means of a plate and elastic bands such as shown in Fig. 761. The plate should be well secured by clasps around the molars.

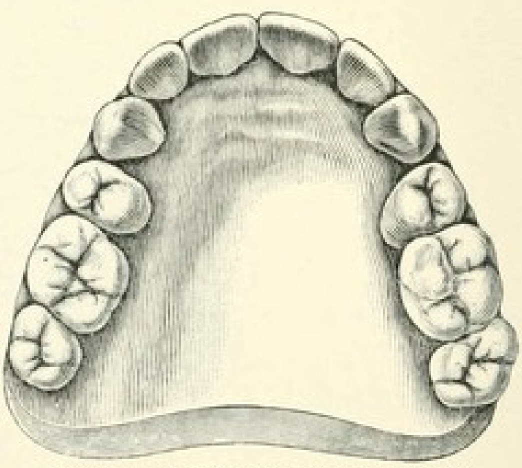
Fig. 762 shows Dr. Kingsley's plate with a labial bow of stiff wire, the elasticity of which is depended upon for moving the anterior teeth. At each visit of the patient the ends of the bow are bent so as to re-

Fig. 764.



Case of upper protrusion.

Fig. 765.



Result of treatment with cap and bit.

new the pressure. This is an excellent appliance for reducing a pointed arch.

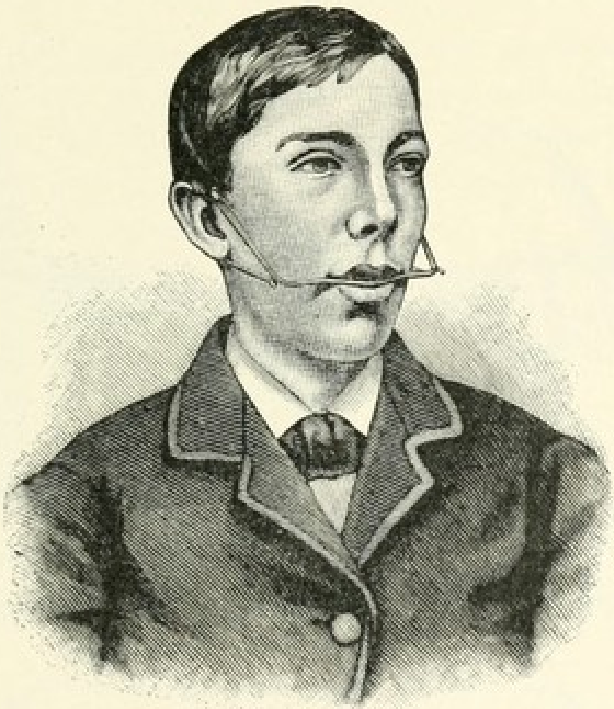
It is sometimes advisable to retract the canines first, by some of the methods described in Class 5, and then the incisors by the plan just mentioned.

Fig. 763 shows the use of piano wire after the method of Dr. Jackson, which explains itself. The springs attached to the vulcanite plate or to the Jackson base wire and crib "following around from each side of the labial surfaces of the canines and incisors, pass each other at the median line" and press like long fingers.

For moving back the roots of the teeth after the crowns have been moved, see page 796.

Class *D* may include any of the others. The anchorage may be insufficient for the first two classes on account of the loss of posterior teeth from caries. In class *C* the teeth to be moved may exceed in

Fig. 766.



Writer's form of cap and bit for retraction.

number the anchor teeth so that the latter will move instead of the anterior teeth. Figs. 764 and 765 show such a case. In such in-

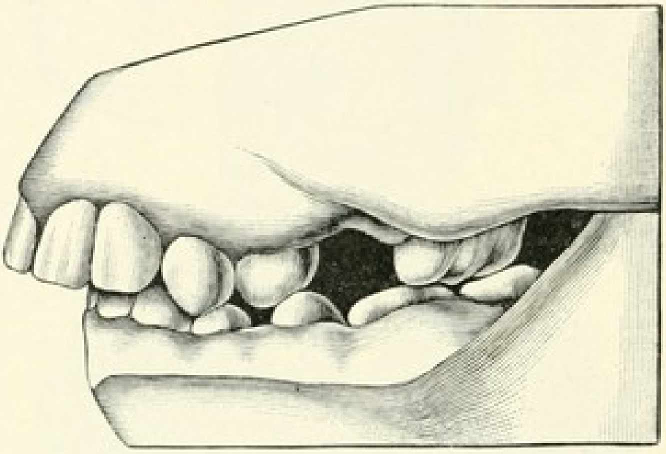
Fig. 767.

The bit.

stances it is necessary to use the back of the head for anchorage. The first recorded instance of such use was by Dr. Norman W. Kingsley in 1865.

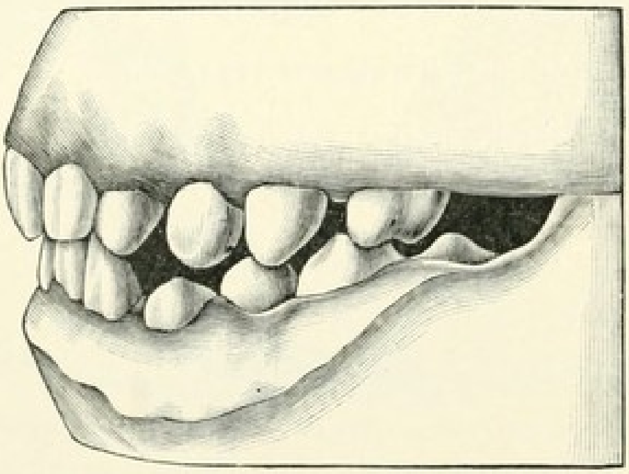
Various complicated appliances for attachment to the anterior teeth have been described by different authors. Fig. 766 shows a very simple one first used by the author in 1880. It consists of a vulcanite cap fitting the labial and part of the lingual surfaces of the anterior teeth (Fig. 767). In this is imbedded a steel or German-silver wire, about No. 12, so that the ends will protrude between the lips at the corners of the mouth. These ends are bent into hooks, and extended far enough so that elastics from them to the cap on the back of the head will not touch the cheeks. These extended arms may be bent to conform to the curve of the cheeks, but should not touch them. The cloth cap is such as any seamstress can make easily, and extends forward above and below the ear. On these projecting ends are sewed dress-hooks. For power use round or flat elastic cord. Tie a knot in one end, place it in the hook

Fig. 768.



Ten teeth moved at once. Condition before treatment.

Fig. 769.



Same denture after treatment.

above the ear, extend it forward over the hook of the "bit" and back to the hook on the cap below the ear, and tie a knot in it to secure it. In most cases two or more strands will be needed; if so, extend the cord forward again over the hook on the bit, and back again to the upper or to the lower hook. By thus varying the number of strands from the hook above or below the ear, the movement may be made directly backward from the cutting edges, or upward and backward somewhat in the line of the roots, in which case the teeth will be forced up into the sockets, or shortened. The ends of the wire passing out of the corners of the mouth may be adjusted by bending upward to just the right degree, so that the pressure of the "bit" will not be on the cutting edges, but at the necks of the teeth, or even higher, so as to move the roots and process also. To insure this, the vulcanite portion of the "bit" should pass over the cutting edge so as to grasp the lingual surface.

This cap-and-bit appliance may be worn at night only, or at such other times as will not prevent the patient from attending school. The movement will be facilitated if a retaining appliance be worn during such times as the cap is not in use. The posterior teeth will often afford sufficient anchorage for retention.

This appliance is especially valuable in cases in which it is necessary to select for extraction second bicuspids or first molars on account of caries, for then the number of teeth for anchorage is decreased and the number to be moved is increased.

Figs. 768 and 769 show a case in which ten teeth were moved at once, by this appliance.

Fig. 770.

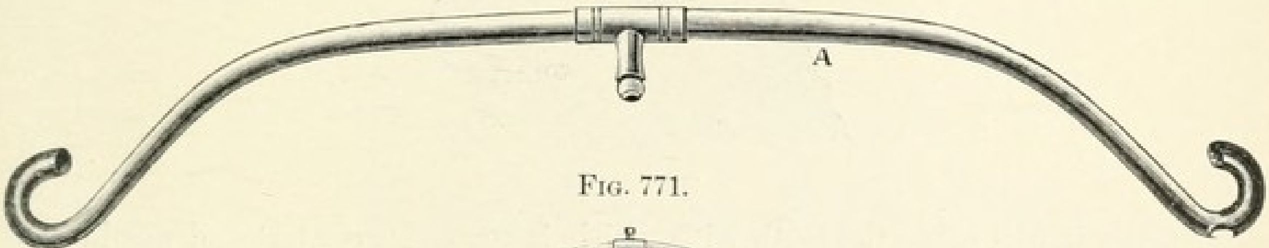
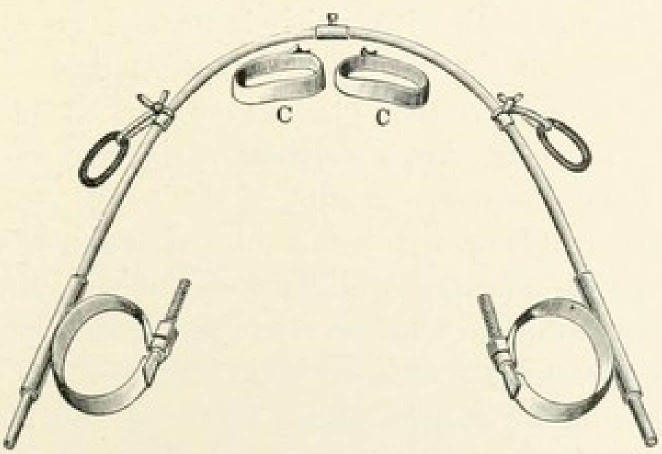


Fig. 771.



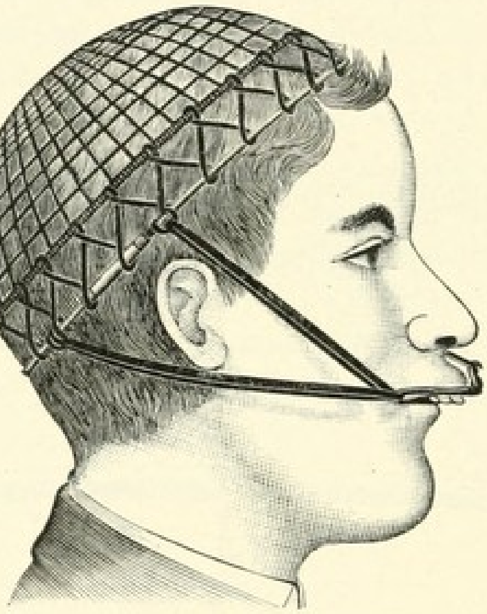
Angle's appliance for retraction.

During the daytime, when the cap is not worn, the teeth may be retained by the labial bow shown in Fig. 759, which explains itself.

The nuts should be turned in the morning only enough to retain but not to move the teeth.

If the upper protrusion is complicated with other irregularities, such as a pointed arch, or single teeth in any of the first five positions, Prof. Angle's appliance shown in Figs. 770, 771 will be found very satisfactory. The labial bow is held in position by bands on the central incisors, having notches formed in the united ends on the labial surfaces, C, C. The ends slide through tubes on molar bands. From the front of the bow projects a short wire ending in a ball on which is adjusted the socket of the traction bar, A. From the ends of this traction bar rubber bands extend to a cap on the back of the head, as shown in Fig. 772. As this wire bow is moved backward by the external

Fig. 772.



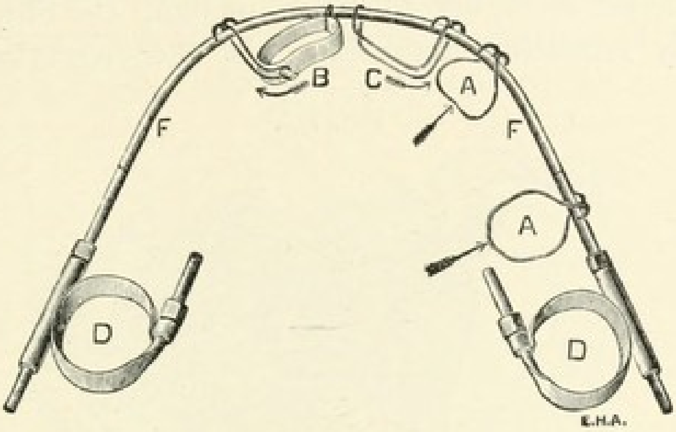
Angle's cap.

force, it will move the teeth with which it comes in contact and mould the arch to the shape of the bow; or, if single teeth need special movements such as rotation, elevation, etc., it may be accomplished by means shown in Fig. 713. Dr. Angle advocates the use of wire ligatures with the bow for various movements of the teeth, as shown in Fig. 773. The rubber bands shown on the sides of the bow are for retaining the teeth during the day, while the cap is not worn.

For retention, nothing is better than the labial bow, as shown in Fig. 759; but Dr. Case's retainer (Fig. 720) is much less conspicuous. The anchor bands may be placed on the second bicuspids or first molars, or on both.

"Jumping the Bite."—Many cases of apparent upper protrusion are due to lack of development of the lower maxilla, so that the lower teeth close one cusp back of the normal position and the lower second bicuspid closes behind the upper second instead of in front of it, which is the normal articulation. Fig. 774 shows such a case of disto-lingual occlusion.

Fig. 773.

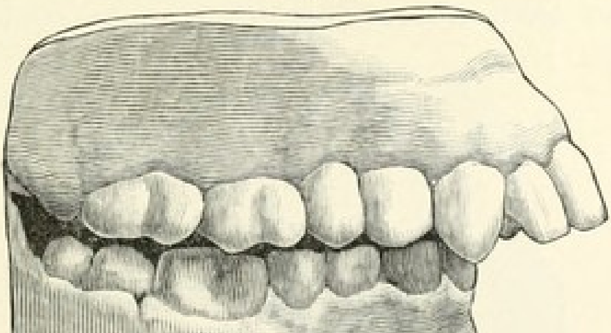


Wire ligatures with the bow, for various movements of the teeth.

If the lower jaw can be moved forward the width of a bicuspid, or less, sometimes, the normal occlusion will be produced. This movement is termed "jumping the bite," and originated with Dr. N. W. Kingsley more than twenty years ago.

The lower jaw may be voluntarily moved forward but not backward. Any patient with an abnormal occlusion can move the lower jaw for-

Fig. 774.



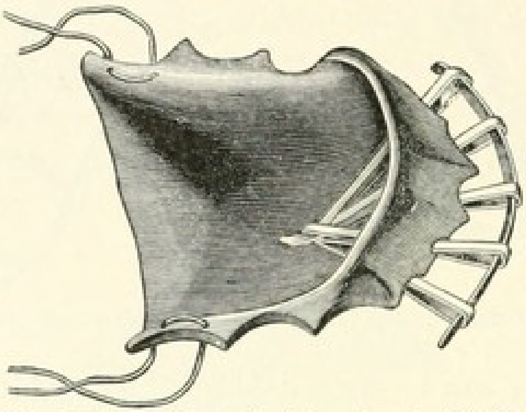
Disto-lingual occlusion.

ward the width of a tooth and thus occlude normally. If this can be made a permanent habit, the patient will have "jumped the bite."

Unless some change takes place in the glenoid cavity, such as a filling up of its posterior portion, or in the condyle, such as the bending of the neck, as suggested by Dr. Case, or in the angle of the jaw itself, so as to prevent the jaw from moving back into its old position, the new position cannot be maintained.

The first recorded operation of this kind was described as follows by Dr. Kingsley:[1] "Fig. 775 shows another application of the inclined plane somewhat out of the ordinary course. It was adapted to the inside of the upper dental arch, and the inclined surface projected below and caught the lower incisors. The object was, not to protrude the lower teeth, but to change or jump the bite in the case of an excessively retreating lower jaw. In the engraving is shown a

FIG. 775.

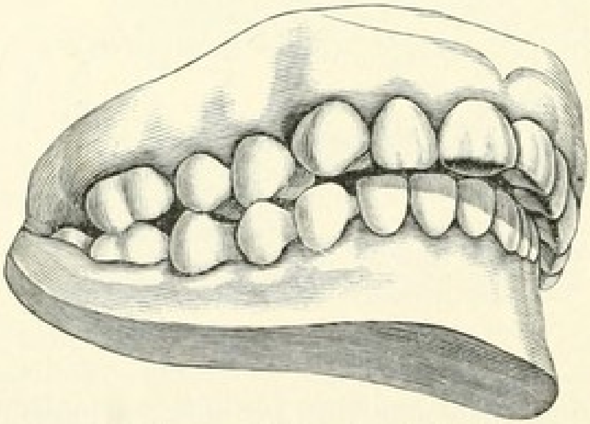


Kingsley's appliance for "jumping the bite."

gold bar worn across the front of the upper incisors to reduce their prominence."

Figs. 776, 777 illustrate a case treated by Dr. E. H. Cutter of Cambridge, Mass., and show the bite jumped half the width of a bicuspid. He says:[2] "I made a plate for the upper arch . . . . thickened only behind the front teeth where depressions were made to receive the

FIG. 776.



Cutter's case of "jumping the bite."

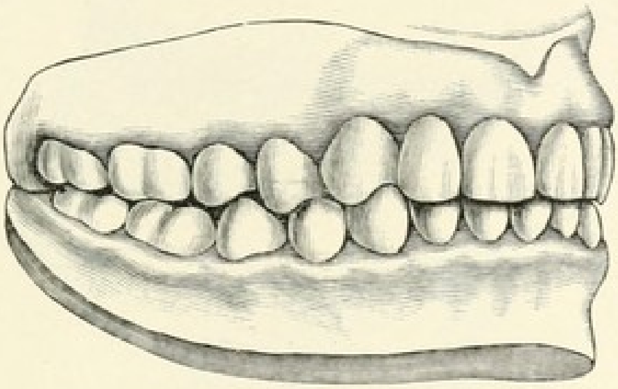
points of the lower incisors . . . . and held firmly in place by wire clasps encircling the first molars. . . . . I made several plates of this character, as the amount to be gained had to be gradually accomplished. The patient was twelve years old, and but one permanent second molar had erupted; when the work was completed all four of these molars

[1] *Oral Deformities*, p. 84. [2] *International Dental Journal*, vol. xv. p. 355.

had erupted and interlocked with each other. The result was that the patient could comfortably bring her jaws together only as they had been newly related."

Dr. Talbot says:[1] I have never been able to jump the bite . . . . Were such a thing possible, one of two things must take place. First, absorption and deposition of bone cells at the weakest part of the jaw; namely at the angle . . . . Second, there must be a forward movement, by absorption, of the condyle in the glenoid cavity."

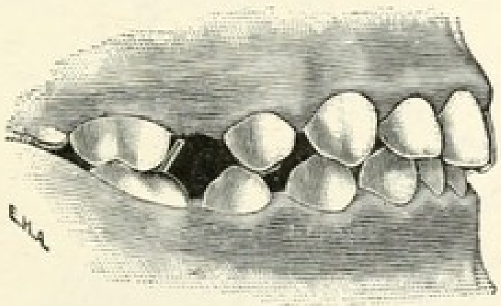
Fig. 777.



Cutter's case after adjustment.

Fig. 778 shows Prof. Angle's method of "jumping the bite" by means of a spur imbedded in the lower permanent molar, thus compelling the normal closure of the jaw.

Fig. 778.



Angle's method of "jumping the bite."

Class 10. **Lower Protrusion.**—*Etiology.*—This irregularity is in most cases constitutional and may be attributable to the following causes:

(*a*) Excessive development of the ramus of the lower maxilla, as shown in Fig. 780—constitutional.

(*b*) Excessive development of the body of the lower maxilla, as shown in Fig. 781—constitutional.

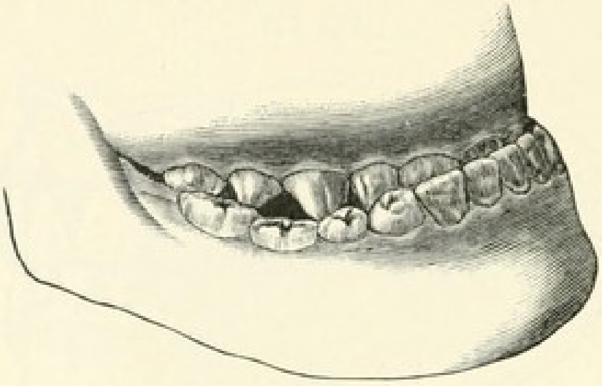
(*c*) The habit of finger-sucking, in which the finger is hooked over the lower teeth—acquired.

[1] *Dental Cosmos*, vol. xxxiv. p. 791.

(*d*) Teeth too large for the jaw and therefore projecting forward of their natural position—indirect heredity.

(*e*) The lower protrusion may be apparent and not real, owing to lack of development of the upper maxilla. This may be due to nasal

Fig. 779.



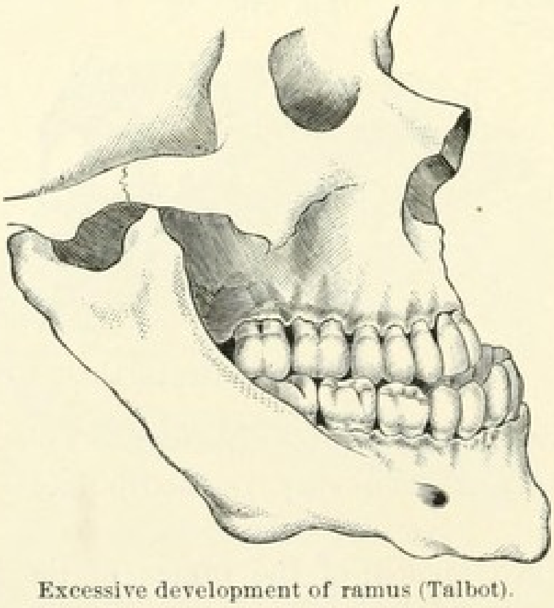
Lower protrusion (Talbot).

obstruction (page 697) or to the injudicious extraction of the first permanent molars, as in cases of apparent upper protrusion—acquired.

(*f*) It may result from the upper oral teeth having erupted back of their proper position, so as to bite inside of the lower incisors.

(*g*) Mal-occlusion of incisors.

Fig. 780.



Excessive development of ramus (Talbot).

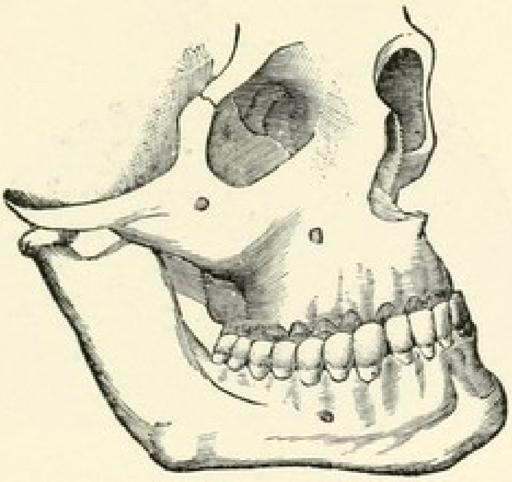
Treatment.—If the teeth are too large for the jaw, room may be made by extraction of the first bicuspids, unless teeth posterior to them are selected on account of caries.

The anterior teeth may be moved back by the labial bow shown in

Fig. 759. Teeth as far back as possible should be selected for anchorage. The anterior portion of the bow should be as near the cutting edges of the incisors as the occlusion will allow and may be prevented from sliding toward the gum by one or more small hooks over the cutting edges of the teeth or by bands on incisors or canines with lugs or notches. (See Angle's notches in retracting appliance, Fig. 771, c, c.)

Dr. C. S. Case utilizes the upper teeth for anchorage. The labial bow previously referred to is applied to the lower teeth and has a button attached to it near the canine on each side. From this button a rubber band is extended to a similar button soldered to a band on an upper molar, as far back as possible. The tendency of this is to

Fig. 781.

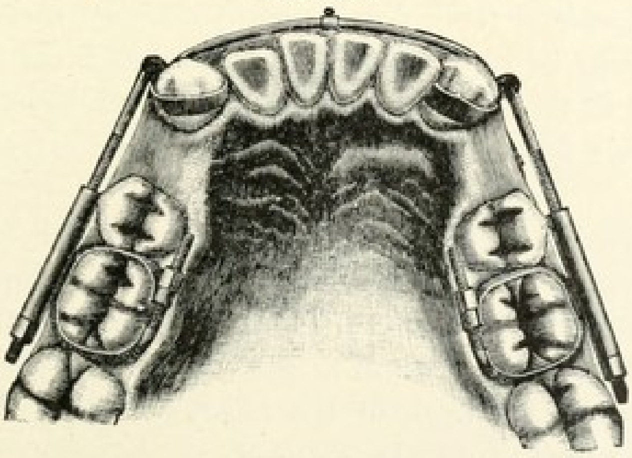


Excessive development of body of lower maxilla (Talbot).

draw the upper teeth forward, but more especially to draw back the anterior lower teeth and also the jaw itself.

Fig. 782 shows Prof. Angle's appliance for this purpose—"the large

Fig. 782.



Angle's appliance.

traction screw being attached to clamp bands which encircle the first lower molars and the angles of which are hooked into small staples soldered to bands upon the distal angles of the canines, while a piece of gold wire attached by solder connects these bands and passes in front of the incisors." This cap and traction bar may be used in connection with this appliance by applying the latter to the projection in front.

FIG. 783.

Allan's appliance.

While more complicated than the appliance shown in Fig. 760, it must be very efficient.

Constant force may be used by such an appliance as is shown in Figs. 762 or 763. The form of plate should be modified for the lower arch.

When the posterior teeth do not give sufficient anchorage, an external appliance must be resorted to. The cap and bit shown in Fig. 766 may be applied to the lower teeth, or Angle's appliance (Fig. 770) may be used if the six anterior teeth are not in proper alignment in respect to each other.

If the protrusion is an example of true prognathism—that is, due to the lower maxilla being larger or longer than the upper from either of the causes mentioned—external force alone can be of use.

By a cup of metal swaged to fit the chin and connected by rubber bands with a cap on the back of the head, as shown in Fig. 783 or in Fig. 784, the protrusion may be reduced.

How this is accomplished is a matter of dispute, some maintaining that the lower maxilla is bent at the angle and others that the condyle is pushed back in the glenoid cavity. Dr. G. S. Allan said in 1878, "The jaw at that period of life is completely developed and hardened . . . . consequently any efforts that may be made will not affect the jaw-bone itself. The only way in which the change can be made is by pushing the jaw back into the glenoid cavity. . . . Absorption takes place at the posterior side of the condyles, with filling in of the anterior." Prof. Angle says, "The object is by continued pressure to bend

Fig. 784.

Angle's chin retractor.

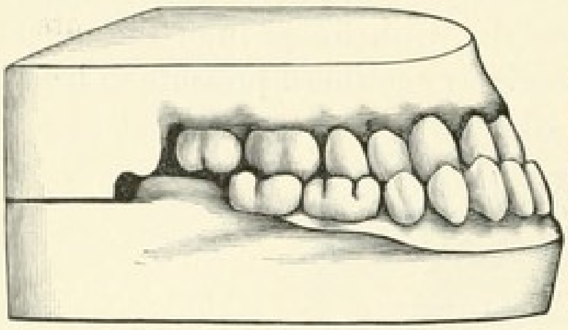
the jaw at the angles, but only in very young patients do we believe this even possible. We think that in two cases we have succeeded."

Cases sometimes occur in which the fault is in both jaws; the upper jaw is not prominent enough while the lower is too prominent, and the result is lower protrusion. Fig. 788 shows such a case, in which the fault lies partly in the spaces between the lower bicuspids and the first molar. The appliance was made after a similar one by Dr. Case. It consists of bands on the lower canines joined by a wire that encircles the incisors and the ends of which are bent into hooks. On the upper first molars are cemented bands with buccal hooks. A strong rubber band was extended from the hook on the lower canine to the hook on the upper molar band. The result is shown in the second cast (Fig. 789). The patient was lost sight of after that. Just what changes took place is uncertain,—whether the movement was wholly of the lower teeth or whether there was a forward movement of the upper teeth also. The writer is inclined to the latter opinion.

When the prognathism is apparent and not real—(*e*) and (*f*)—the proper treatment is to move the upper incisors forward, and in some cases the canines also. (For appliances adapted to this purpose see Figs. 716 and 717, in Class 6.)

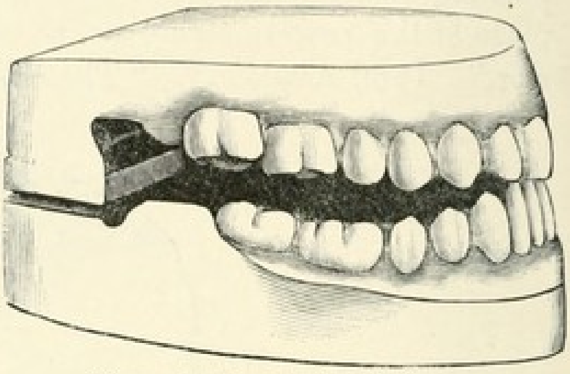
In some, lower protrusion from this cause is apparent only when the patient masticates. Figs. 785 and 786 will illustrate this condition.

Fig. 785.



Apparent lower protrusion—during mastication.

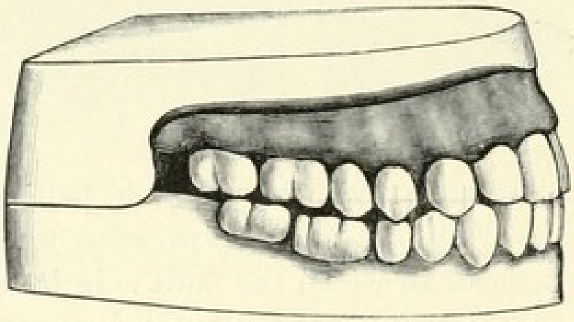
Fig. 786.



The patient's natural occlusion.

If the upper incisors erupt slightly back of their proper position the cutting edges will occlude with the cutting edges of the lower incisors. As eruption continues they will open the bite (Fig. 786) so that the patient must throw the lower jaw forward in order to occlude the bicus-

Fig. 787.



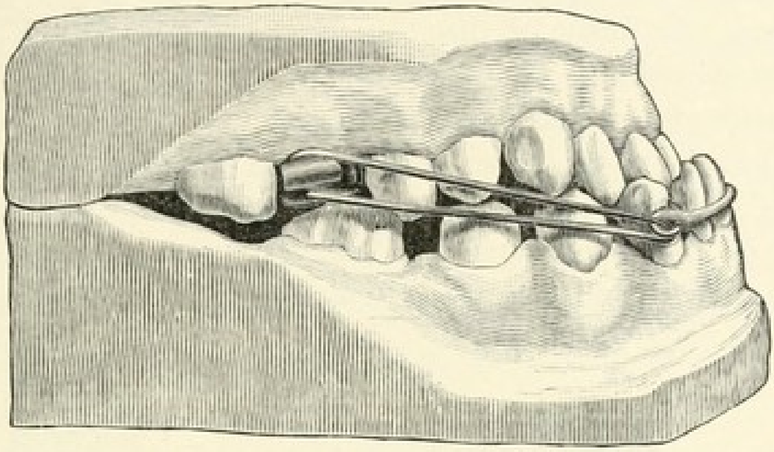
The same denture after treatment.

pids and molars. (See Fig. 785.) It is quite possible that this will result in a permanent protrusion of the lower jaw. The case shown in Figs. 785 and 786 was an argument against that, however, and against the possibility of "jumping the bite" (see page 770), for the patient was thirty years old, and never protruded his lower jaw except when masticating. For many years mastication had been attended with neuralgia in the temporo-maxillary articulation, caused by the unnatural strain, yet this neuralgia disappeared entirely after the upper incisors and canines had been moved forward enough to close in front of the lower. The teeth were moved by the split plate shown in Fig. 717.

In moving forward the upper anterior teeth in cases of "apparent lower protrusion," such as shown in Fig. 785, or those due to lack of development of the upper maxilla, it sometimes occurs that when the cutting edges overlap the lower incisors the crowns have a very unnatural slant forward, and the roots need to be moved forward.

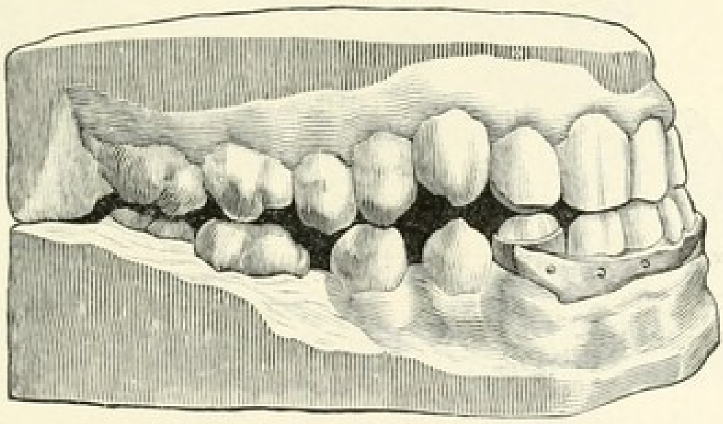
At the World's Columbian Dental Congress in 1893, Dr. C. S. Case presented casts and appliances for this operation, which are shown in Chapter XXV., Figs. 839, 842, 893, and 895.

Fig. 788.



Lower protrusion (fault in both jaws).

Fig. 789.



Result of reciprocal appliance.

By this means the entire anterior plate of the alveolar process is moved forward with the roots of the teeth and the sunken lip restored to its natural fulness.

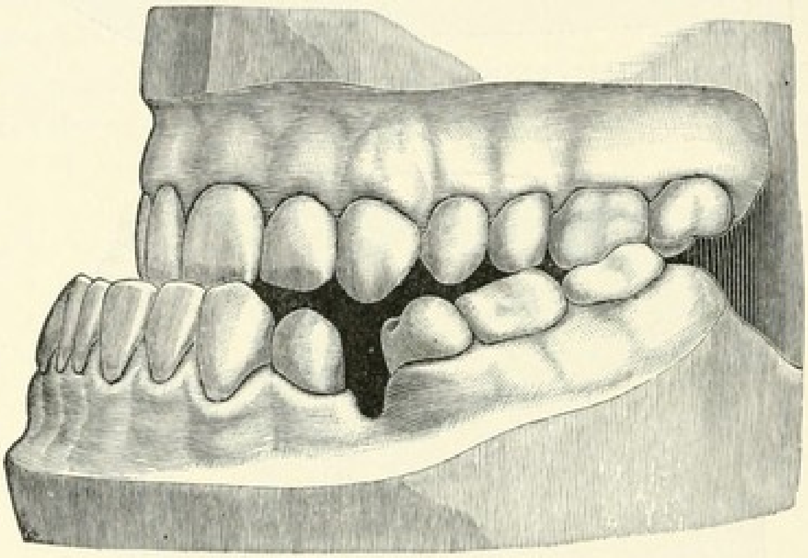
See facial contour in Figs. 840 and 843.

Surgical Treatment of Lower Protrusion.—The following extracts are from a description, by Dr. J. W. Whipple of St. Louis, of the case shown in Fig. 790.

There had been apparently an abnormal growth of the body of the maxilla between the first and second bicuspids on the left side and between the first molar and second bicuspid on the right side, the space separating these teeth being respectively one-quarter and one-eighth of an inch, causing the elongation of the jaw horizontally, which projected the lower teeth a quarter of an inch beyond and in front of the upper ones. The occlusion was destroyed. This elongation, Dr. Whipple states,[1] had taken place between 1891 and 1896, the patient being eighteen years of age when he first saw him. Dr. Whipple advised the patient "to consult Dr. E. H. Angle, who first suggested the advisability of resorting to double resection in this case." About a year afterward an operation was performed, and about a quarter of an inch was removed from the body of the bone on each side, Dr. V. P. Blair being operator-in-chief.

"An incision was made about half an inch in length along the base of and just interior to the lower border of the maxilla. A cross incision was made of the same length, about on a line with the mental foramen. The centre of these incisions was interior, upon the borders of the neck. The muscles and other integuments were now detached from the

Fig. 790.



Lower protrusion. (Dr. Whipple's case.)

jaw-bone. Dr. Blair had devised or had constructed a double bone-saw, consisting of two saws, four inches long, attached to a single handle, and so adjusted as to make a cut in the clear just as wide as the space between the two bicuspids on the left side. The sawing was done through the incision from and through the internal surface of the bone from the upper border down to the base. No vessels were ligated, as the hemorrhage was not profuse after the vessels emptied themselves. The bone was cut almost, but not quite, through. No attention was given to the inferior dental canal.

"A small hole was now drilled through the bone on each side of the cut, near the lower border, for the reception of a wire ligature.

"The second right bicuspid having been previously extracted, the operation just described was repeated on the right side.

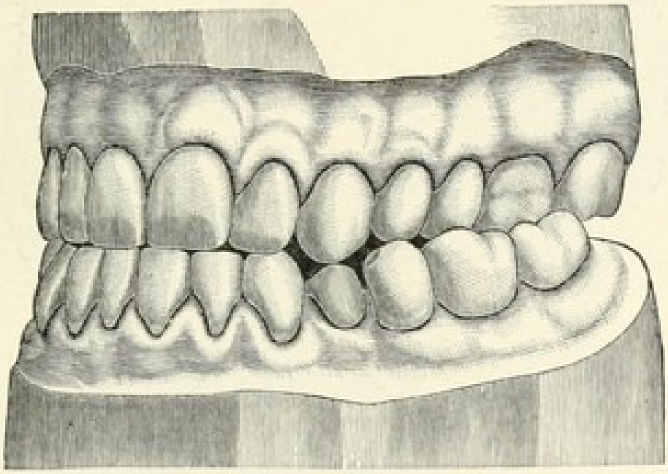
[1] *Dental Cosmos*, 1898, vol. xl. p. 552.

"After the holes were drilled the remainder of the sawing was done on both sides, and the two small sections of the jaw removed.

"Soft copper wire ligatures were now passed through the holes from the external surface. These were crossed on the internal surface, grasped with a pair of pliers, and twisted until the several parts were drawn together at the lower border, forming an apparently close and smooth abutment of the opposing ends.

"The copper wire ligatures proved ineffectual, so clamp bands, with buccal tubes, were applied to the molar and bicuspid on one side, and to the molar and canine on the other, and traction screws extended through the tubes. By tightening the nuts on these screws the parts of the jaws were brought again in contact. As an additional precaution, 'bicuspid fracture bands' were placed on the first upper and second lower bicuspid.

Fig. 791.



Result of surgical treatment of lower protrusion. (Dr. Whipple's case.)

"A figure-8 ligature of brass wire was adjusted to the little knobs on these bands, and the rear fragment was firmly ligated to the upper jaw. All the various parts were held absolutely without change for five weeks. The patient lived on liquid food and suffered no great inconvenience physically.

"A four-tailed plaster bandage was adjusted and retained without change for four weeks."

Within eight or nine weeks the appliances were removed from both sides, osseous union having taken place. Subsequently some of the posterior teeth were lengthened by means of gold crowns, and the occlusion restored. The final result is shown in Fig. 791.

There was "an entire loss of sensation in the lower lip, caused by cutting the sensory parts of the inferior dental nerve.

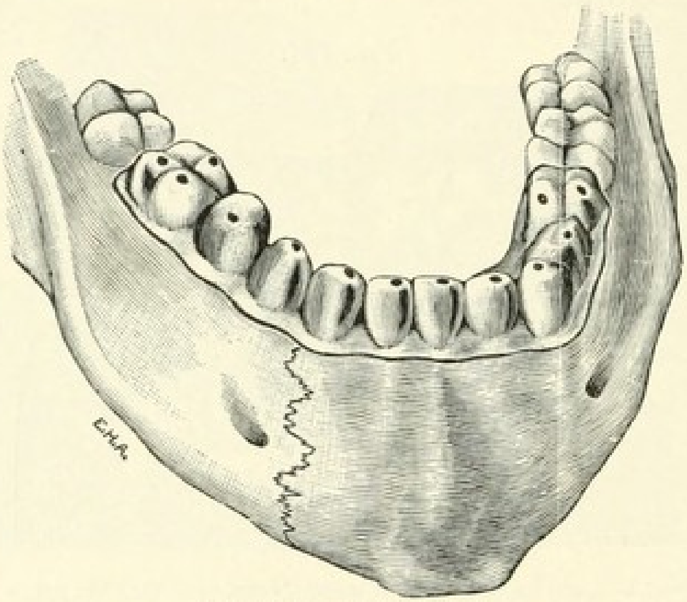
"The pulps of the middle part of the jaw do not seem to have been affected at all.

"The gentleman's appearance is greatly improved. No one would suspect that such an operation had been performed."

Dr. Angle suggests[1] that in such cases the chin is usually very prominent, so that there is more or less lingual inclination of the lower incisors and that the section of bone removed should be wedge-shaped, wider at the lower border, instead of with parallel sides.

He also suggests that the best way to hold the parts of the jaw in place would be to make a cap or splint of metal or vulcanite that would fit over the crowns of the teeth and cement it in place, as is done in the fractures. To properly construct such a cap or splint, plaster models should be made of both upper and lower jaws, then sections cut out of the lower one so that the teeth could be properly adjusted to the upper,

Fig. 792.



Vulcanite or metal splint.

taking careful measurements of the parts. On this reconstructed model a vulcanite or metal splint should be formed, as shown in Fig. 792. After the sections of the jaw are removed and the anterior portion forced back in contact with the remainder, the splint can be cemented on the teeth to hold the parts firmly in correct position.

Class 11. **Double Protrusion, or Protrusion of Both Upper and Lower Teeth.**—Occasionally there is protrusion of both upper and lower teeth on account of their being too large for the jaws. The lips appear very much thickened, or are unable to cover the teeth. A case of this character (shown in Figs. 793 and 794) was treated by the writer primarily with the cap and bit, such as are shown in Fig. 766, and secondarily by means of labial bows, shown in Fig. 795. The vulcanite bit was made to fit over the anterior part of the bows upon both upper

[1] *Dental Cosmos*, 1898, vol. xl. p. 635.

and lower incisors when the mouth was closed, and was worn except during school hours, the patient being a school-girl aged seventeen.

Fig. 793.

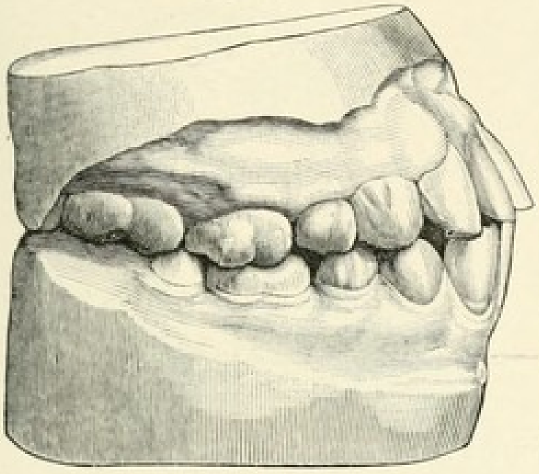
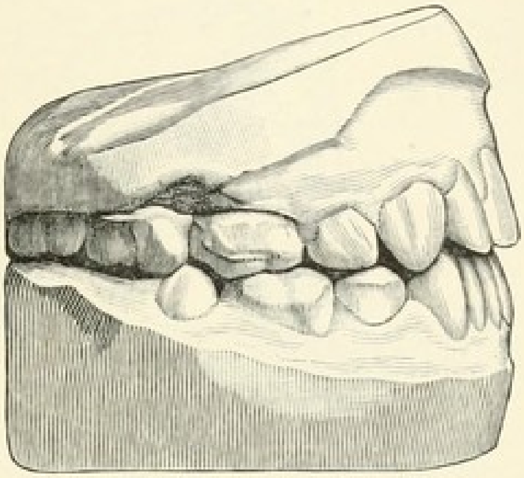


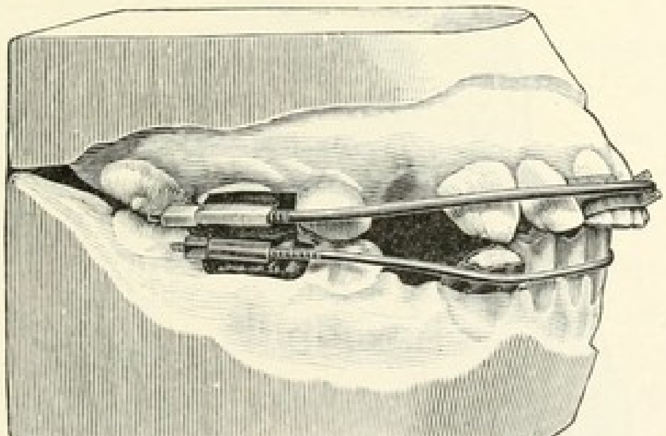
Fig. 794.



Double protrusion. (Corrected.)

The bows, which were used only for retention, had their ends secured in tubes on bands cemented to the first molars. The anterior part of the upper bow rested in notched bands cemented on the central incisors. The anterior part of the lower bow was held in place by notched bands on the lower canines. The nuts of each bow were tightened every

Fig. 795.



Retaining appliance.

morning just enough to make up for the movement produced by the cap and bit during the night. There were thus utilized four anchor teeth in each jaw, the right and left first molars and second bicuspid. This was sufficient for retention of the six anterior teeth, though it would not have been sufficient for their retraction. If these anchor teeth moved forward it was not noticeable, for no space was left between the first and second molars, though that fact might be accounted for by a forward movement of the second molars of their own accord. Treatment of this case was begun in March, 1895, and in August the six

Fig. 796.

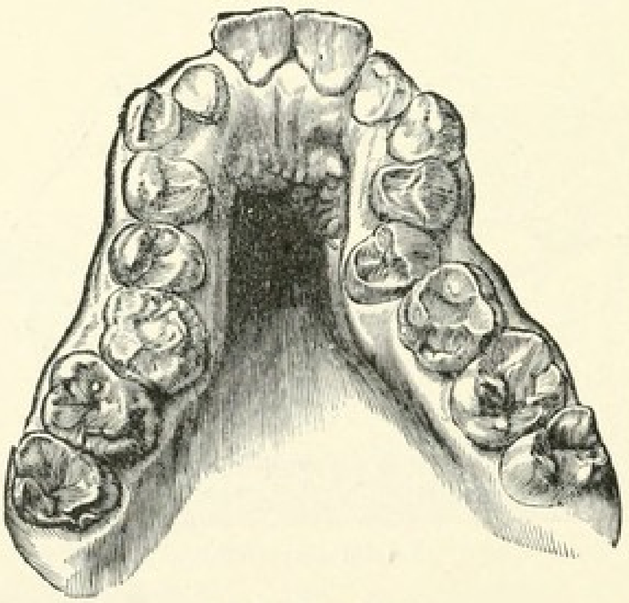
Fig. 797.

Before. Double protrusion. *After.*

anterior teeth had been moved back till the canine touched the second bicuspids. (Figs. 793 and 794.)

The same bands and bows were worn about two months longer for retention, after which the teeth remained firmly fixed. The change in the contour of both lips was most marked. (See Figs. 796 and 797.)

Fig. 798.



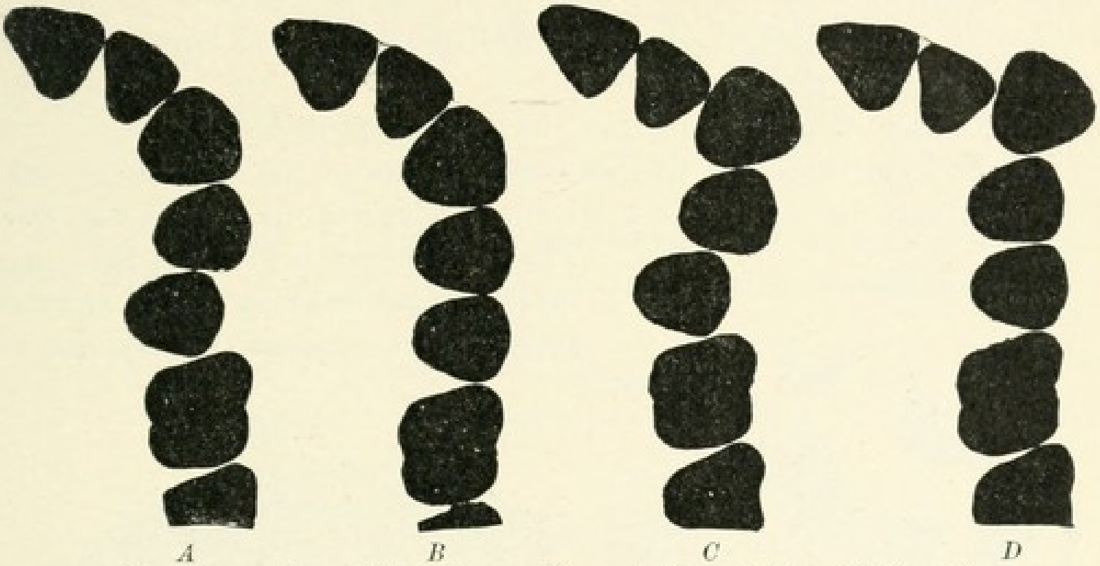
Saddle-shaped arch.

The relation of these cases of protrusion to facial contour is discussed at length in Chapter XXV.

Class 12. **Constricted Arch** (**Saddle-shaped**).—*Etiology.*—The constricted arch may be due primarily to the same cause as the pointed arch; that is, (*a*) teeth too large for the jaw, or (*b*) the first permanent molar being forward of its natural position on account of premature loss of the second deciduous molar. (*c*) Too long retention of deciduous molars, which may deflect the erupting bicuspid toward the median line.

In either of the first two cases the position of the second bicuspid in eruption will determine the character of the arch. If it erupts in an exact line between the first bicuspid and the first molar it will crowd the anterior teeth forward (Fig. 799, *B*), but if it erupts to the slightest degree to one side of the direct line, it will itself be crowded out of the arch lingually or buccally (Fig. 799, *A*). The former occurs much more

FIG. 799.



Showing crowding of bicuspid or canine, or both, out of line (Ottolengui).

frequently. When the canine erupts between the lateral and first bicuspid in proper alignment it will gain space in the line of least resistance, and thus crowding the first bicuspid will force it back against the second, which in turn will be crowded still more inside the arch, thus producing the constricted arch.

If the canine erupts before the bicuspids, it forms with the incisors a firm base and is not easily moved on account of its long root. The first bicuspid erupts next, and the second bicuspid, coming later, will, for want of room, be crowded inside the arch. The conditions may not be the same on both sides of the mouth. The crowding may be on one side only, producing the semi-saddle arch, or varying on the two sides may produce the semi-saddle on one side and on the other the semi-V, or the canine may be crowded entirely out of the arch (Class 7).

Treatment.—The treatment of the constricted arch will depend upon whether the case is one of normal teeth and a small arch which will admit of enlarging, or whether the arch when spread would be too large for the other features.

If the arch will admit of enlarging, it may be done by banding the teeth that are inside, and applying a jack-screw or Talbot spring between them, as shown in Fig. 741, thus forcing them outward till they are in proper alignment.

In case of a semi-saddle-shaped arch (Figs. 609 and 610)—that is, one in which the irregularity is confined to one side—three or more teeth on the opposite side should be grouped together for anchorage.

If the case is an aggravated one which will not admit of expansion, extraction must be resorted to—selecting, of course, the tooth or teeth most out of line.

CLASS 13. **Lack of Anterior Occlusion.**—*Etiology.*—This irregularity is generally of constitutional origin, and may be due—

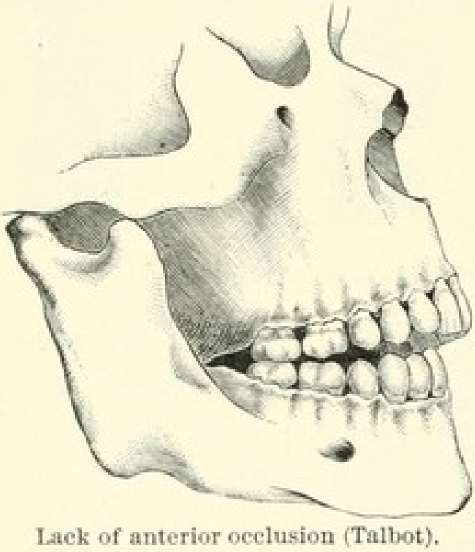
(*a*) To lack of development of the ramus of the lower maxilla. (See Fig. 800.)

(*b*) To lack of development of the anterior portion, or

(*c*) To hypertrophy of the posterior portion of the alveolar process.

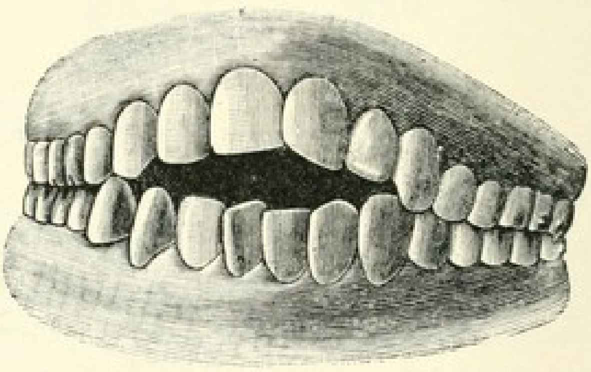
(*d*) It may be acquired by thumb-sucking, as shown in Fig. 801. The jaws being held apart thus prevents normal eruption of the anterior teeth and consequent development of the anterior portion of the alveolar ridge, or allows excessive development of the posterior portions.

FIG. 800.



Lack of anterior occlusion (Talbot).

FIG. 801.

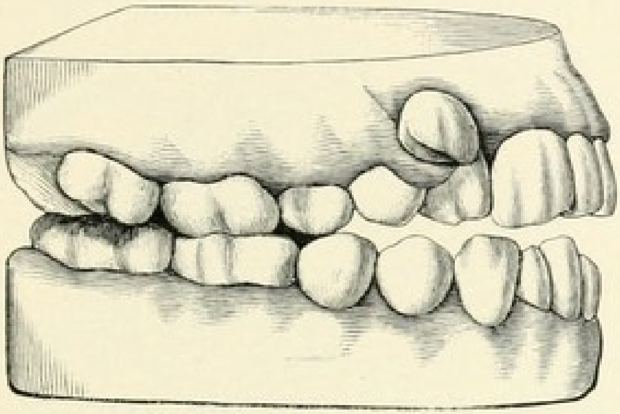


Lack of anterior occlusion caused by thumb-sucking (Talbot).

(*e*) It may be acquired from the habit of mouth-breathing, which, relieving the molars from pressure, permits abnormal development of the alveolar process containing them. A case recently occurred in the writer's practice which illustrates this. The patient was fifteen years of age, and was a mouth-breather. There was a space of an eighth of an inch between the cutting edges of the upper and lower incisors, while three or four years before she could bite off a thread with these same incisors.

That the opening was not caused solely by the eruption of the second molars was shown by the fact that the first molars occluded equally well. The case was reduced by grinding the molars till the incisors touched, yet not enough of the teeth was removed to render them sensitive. Figs. 802 and 803 illustrate this case.

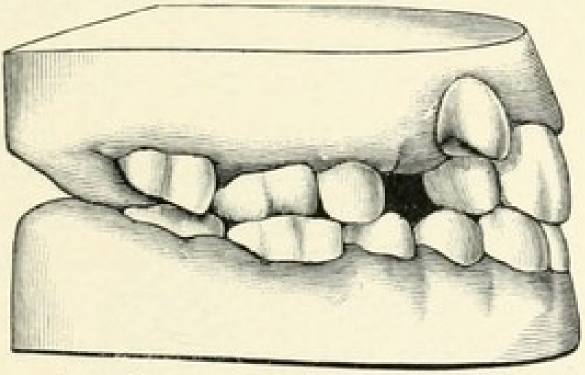
Fig. 802.



Lack of anterior occlusion.

Lack of anterior occlusion is often accompanied, as shown in these figures, by other irregularities, which may be treated subsequently.

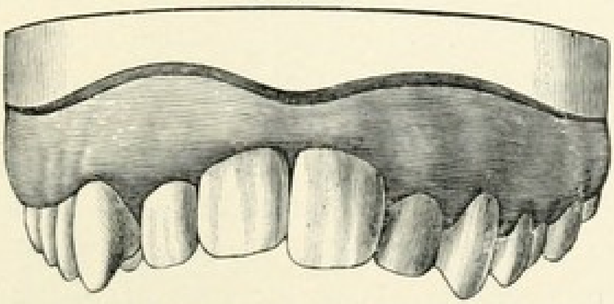
Fig. 803.



First bicuspid removed to make room for canine; occlusal defect remedied by grinding.

(*f*) Fig. 804 shows a case due to lack of development of the intermaxillary bone. When nine years old both upper central incisors were

Fig. 804.



Lack of development of intermaxillary bone.

knocked out without fracturing the teeth or the process. The writer replanted the teeth after removing the pulps and filling the canals with gutta-percha. The teeth at that time were about two-thirds erupted, and did not erupt any farther. The growth of the process surrounding these teeth was arrested and that of the intermaxillary bone and adjacent part of the upper maxilla retarded as shown. The cast was made at the age of sixteen, at which time one of the teeth was still so firm as to permit the insertion of a gold filling, while the other was so loose from resorption of the root that it was extracted. The socket was deepened and enlarged and a tooth implanted.

The influence of heredity may be prominent in this deformity, several members of one family presenting the condition.

While this irregularity is generally of constitutional origin it is not always developed till the eruption of the second and third molars, or, if slight, while the first molar is the posterior tooth, is increased in degree by the eruption of the second and the third molars, just as a pair of dividers kept open a certain distance by a prop two inches from the joint will be opened farther if a prop of the same height be placed between the first one and the joint.

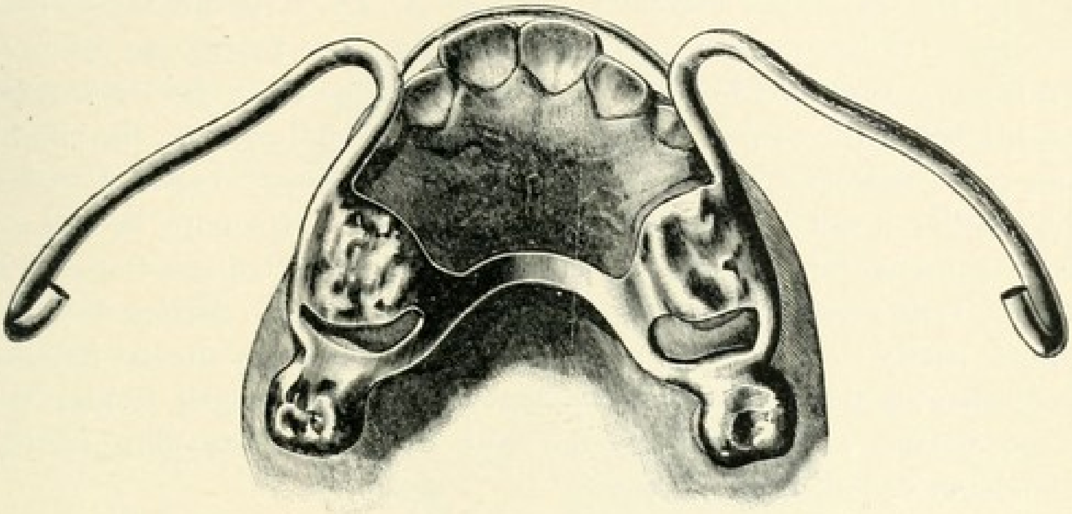
The writer has been fortunate enough to be able to watch the development, in its later stages, of such a case. The occlusion at the first visit of the patient was entirely with the second molars, and the cutting edges of the upper and lower incisors were a quarter of an inch apart. As the patient had suffered during childhood from what she called "bone disease" she was afraid to submit to any treatment for bringing the anterior portion of the jaws nearer together. Gold crowns were placed over the lower first molars, to occlude with upper teeth, and increase the power of mastication. Within two or three years afterward the third molars erupted and opened the jaws to such an extent that the gold crowns lacked more than a sixteenth of an inch of touching the upper teeth. This case was undoubtedly due to the shortness of the ramus of the lower jaw.

Treatment.—The simplest treatment of such cases is to grind down the cusps of the occluding teeth. In simple cases this can be done so as to enable the incisors to bite upon each other. (See Figs. 802 and 803.) The third molars may interfere so much that their extraction will be indicated. By the use of articulating paper the occluding points which need grinding may be easily located.

In some cases there may be a mal-occlusion of the cusps only, so that grinding them away will be sufficient, while in other cases a considerable portion of the tooth must be ground away. Prof. Guilford suggests grinding as much as possible without causing too great pain, and then administering an anesthetic and continuing the grinding. "The sensitiveness of the exposed dentin may afterward be obtunded by repeated applications of either zinc chlorid, caustic potash [potassium hydroxid], or silver nitrate. Where neither of these will avail sufficiently, it may be advisable to devitalize the pulps of two or more of the teeth most interfering with occlusion, and then continue grinding until the necessary change is effected."[1]

The writer has lately applied cataphoresis successfully after having

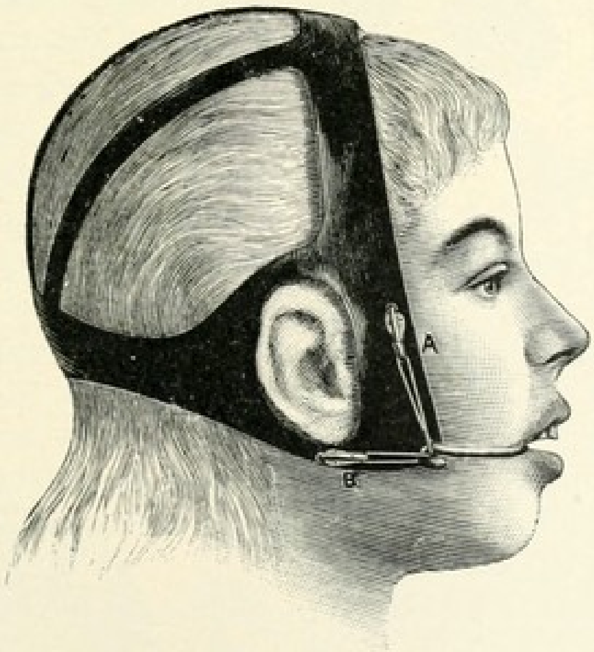
FIG. 805.



Kingsley's appliance for forcing molars into their sockets.

ground the teeth away till they were quite sensitive. The operation was thus continued two or three times in succession till the required reduction was effected.

FIG. 806.



Kingsley's appliance for forcing molars into their sockets.

By the use of a chinpiece and cap on the head similar to that shown in Figs. 783 and 784 for reducing lower protrusion the anterior portion of the jaws may be closed. There are three possible solutions as

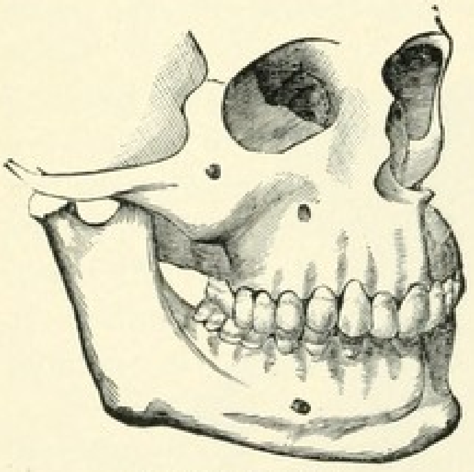
[1] *Orthodontia*, 2d ed., p. 195.

to how the change is effected—(1) filling up of the glenoid cavity, (2) elongation of the condyle, or (3) the forcing of the molars into their sockets. The latter is the most plausible explanation, judging from experience in cases of Class 4.

Fig. 805 shows an appliance devised by Dr. Kingsley for forcing the upper molars into their sockets, and described by him as follows: "A frame covered the bicuspids and molars of the upper jaw, with arms coming out of the corners of the mouth and extending along the cheeks to a point exactly opposite the centre of the pressure required within the mouth; a small wire passed in front of the incisors to keep them from springing forward and two elastic straps connected this frame with the skull-cap exactly as seen in Fig. 806. Both these elastics were required, partly to prevent any tendency of the recently moved incisors from carrying the whole apparatus forward, but particularly to keep the proper balance of the skull-cap, the strain of either elastic alone having a tendency to pull it out of place."

CLASS 14. **Excessive Overbite.**—*Etiology.*—Overbite as illustrated in Fig. 807 is due (*a*) to lack of development of the posterior portions of the jaws and process, or (*b*) to excessive development of the anterior portions of the same so that the upper incisors and canines close entirely over the lower and hide them from view, while the cutting edges of the lower teeth impinge either upon the necks of the upper or upon the gums behind them, sometimes to such an extent as to penetrate the gum tissue.

FIG. 807.



Overbite (Talbot).

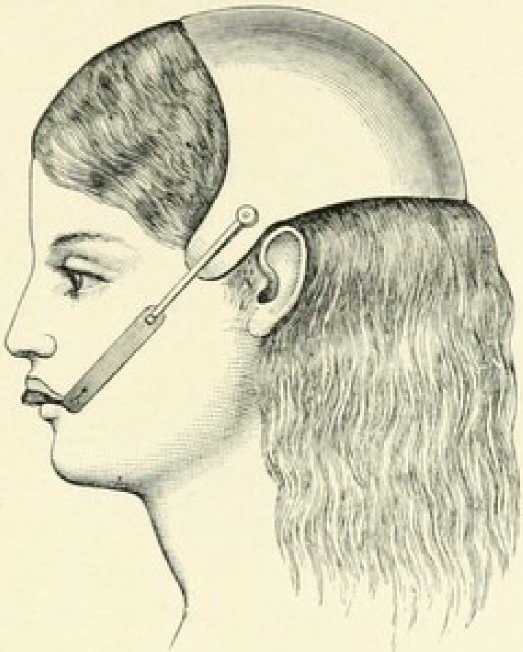
This condition is often associated with other irregularities; particularly protrusion of the upper incisors, of which it may be the cause.

While many cases may be improved by grinding the cutting edges of the lower incisors, it is not always sufficient, as the relative conditions remain the same.

The *treatment* of such cases consists in (*a*) forcing the upper anterior teeth up into their sockets, (*b*) depressing the lower anterior teeth in their sockets, (*c*) causing the bicuspids and molars to erupt far enough to overcome the deformity, or (*d*) all three movements combined.

If the whole fault lies with the upper incisors and canines from their having erupted too far, they may be forced up into their sockets by an appliance such as is illustrated in Fig. 808, reported by Dr. Kingsley in 1866. It consisted of a gold frame over the cutting edges of the incisors and canines. From this frame a post projected from each corner of the mouth, and from these posts strips of brass (detachable) extended upward and backward and were connected by elastic ligatures with a

Fig. 808.



Kingsley's appliance.

cap on the back of the head. It will be noticed that the attachment to the cap is above and forward of the ear. The cap should be so adjusted as to bring the pressure as much as possible in a line with the roots unless it be desirable to move the crowns backward at the same time, in which case attachment to the cap may be made below the ear as well as above it, as shown in Fig. 766.

Figs. 809 and 810 show a

Fig. 809.

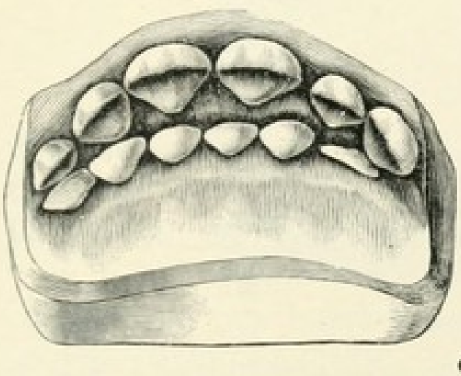
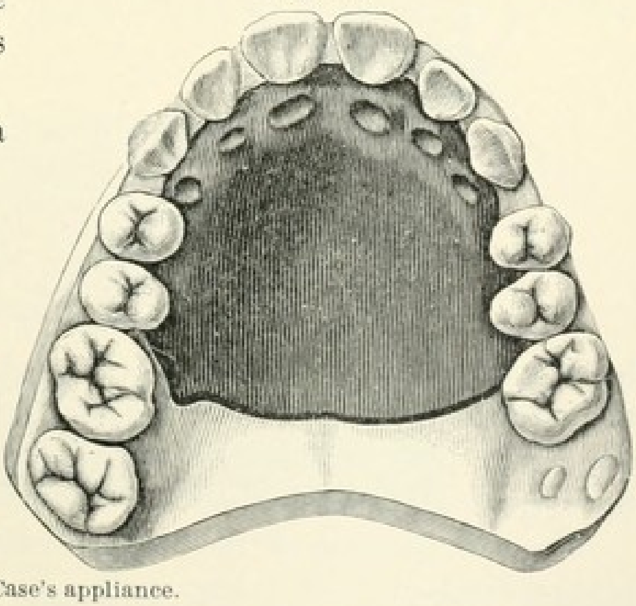


Fig. 810.



Case's appliance.

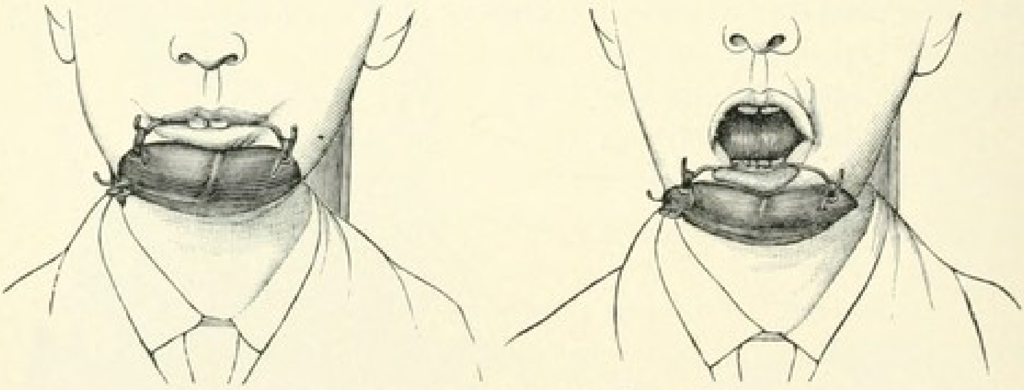
case of overbite treated by Dr. C. S. Case, in which, he says, "the jaws were opened by permanently lengthening the posterior teeth." His method of treatment he describes as follows: "I inserted a simple black rubber plate that covered the roof of the mouth and possessed a thickened portion in front to receive the thrust of the six lower anterior teeth . . . . The posterior teeth were thus prevented from forcible occlusion until Nature had produced in them a sufficient growth and fixed them permanently in their extended positions."

Unless such a plate rests on the inclined surfaces of the canines (and incisors also, in some instances) the force in biting will cause it to injure the soft parts on which it rests. To prevent it from moving the canines outward clasps should be extended around them, or the plate should be provided with a labial bow and clasps or extensions of the plate around the first or second molars, similar to the plate shown in Fig. 762, except that the plate should extend forward to the incisor teeth. The bow will prevent any forward movement of the upper incisors, and may even be used to reduce their prominence by pressure upon them.

Dr. Cutter[1] of Cambridge, Mass., describes a case in which the posterior teeth were lengthened by a similar plate, and the lower jaw brought forward at the same time, by so shaping the plate that the lower incisors bit upon an inclined plane. (See Figs. 776 and 777.)

Dr. Andrews[2] describes a similar case as follows: "I had a patient a little over twelve years of age, the cutting edge of whose lower incisors touched the upper gum so as to irritate it. A platform plate such as Dr. Cutter describes was worn for about two months. The

Fig. 811.



Writer's appliance for depressing lower incisors.

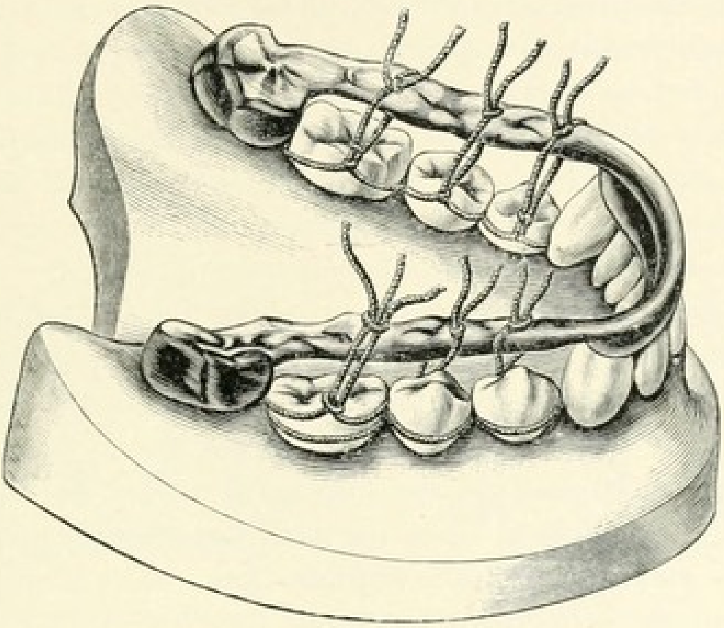
lower centrals, laterals, and canines struck against the plate and allowed the bicuspids and molars to elongate. After a time I found there was one-eighth to a quarter of an inch space between the lower incisors and the upper gum in closing the mouth."

Fig. 695 shows how the writer elongated upper and lower bicuspids and molars so that they could occlude. The same plan might be followed with all of the bicuspids and molars at the same time, while the jaws are held open with such a plate as that shown in Fig. 810.

[1] *International Dental Journal*, vol. xv. pp. 353–355. [2] *Ibid.*, pp. 382, 383.

Fig. 811 shows a plan for forcing lower incisors into their sockets. A metal cap is swaged to fit over the occlusal edges. To this is soldered a wire which extends out of the corners of the mouth and is bent into hooks at each end. From these hooks rubber bands extend to a chinpiece. To prevent this chinpiece from sliding forward it is neces-

FIG. 812.

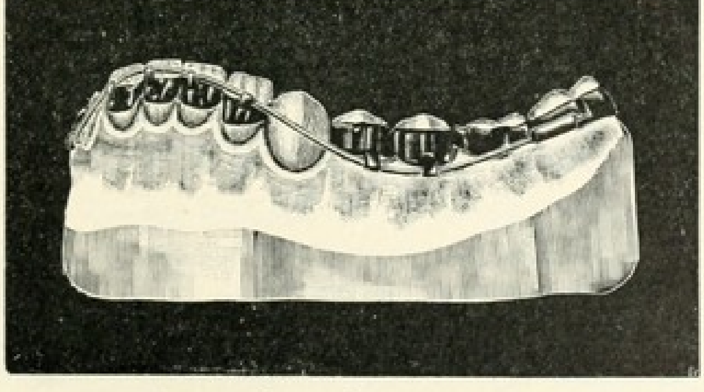


Davenport's appliance for raising the bite.

sary to extend a tape from it around the patient's neck. This appliance was suggested by the interdental splint.

Fig. 812 shows an appliance for raising the bite, by Dr. W. S. Davenport, exhibited at a meeting of the American Dental Society of Europe, Aug. 5, 1895. "The means employed for correcting the irreg-

FIG. 813.



Case's appliance for raising the bite.

ularity was to insert a bridge appliance, which was fastened by means of gold caps to the second molars, and brought forward a few lines above the molars and bicuspids, resting with a gold saddle on the six front teeth. In two weeks the arch was spread and the teeth were drawn up to a normal position by the use of ligatures which were looped around the bicuspids and molars, and fastened at the lingual surface, then tied to the masticating surface of the bridge above."[1]

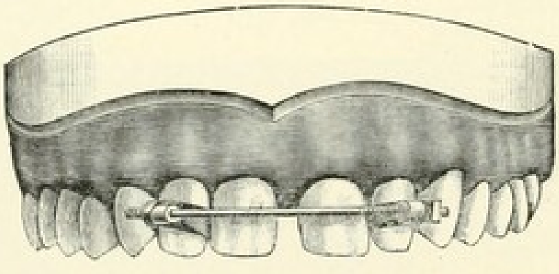
Fig. 813 shows an appliance of similar character devised by Dr. C. S. Case.[2] The object of the appliance is to depress the lower incisors in their sockets, and raise the bicuspids, and first molar also, when possible, so as to change the whole line of occlusion and open the bite.

On each molar—first or second according to the age of the patient—is placed a hollow crown, on the buccal surface of which is soldered an open tube or trough, opening upward. On each bicuspid is soldered a band with a buccal hook pointing downward, also on the first molar if the second has been used for supporting the hollow crown. On the incisors are cemented bands with hooks turned upward. A labial bow of elastic German silver or piano wire has its ends inserted in the troughs of the hollow crowns, its front resting above the hooks on the incisors and its sides pressed under the hooks on the bicuspids and first molar. The action is such as to depress the incisors and elevate the bicuspids and, if possible, the first molar also. The hollow crown should be high enough to open the bite the required distance.

Class 15. **Separation in the Median Line.**—The simplest treatment of this irregularity is to draw the centrals together with a rubber band or with twisted silk or linen ligatures passed two or three times around the teeth. They can be retained by a wire band passing around both teeth.

In some cases it is better to cement on the lateral incisors bands with tubes on the labial surfaces and draw them toward each other by means of a long drag-screw, as shown in Fig. 814.

Fig. 814.



Appliance for regulation and retention.

The same appliance serves for retention by adding cement to the screw behind the nut to prevent its loosening. The advantage of this plan is that the space is left next to the canines instead of between the centrals and laterals, and also that the centrals will be more easily retained in their new position if they are supported by the laterals. If the central incisors are far apart and the roots are parallel, they will slant too much when moved together as described. It is necessary

[1] *Dental Review*, Feb. 15, 1896, p. 126. [2] *Ibid.*, Dec. 1895, p. 867.

to also move the roots of these teeth; the method of performing that operation is described in the following section.

Moving the Roots of Teeth.

In the foregoing methods of moving the teeth the apex of the root remains stationary and the crown swings from that point like a pendulum. In most cases that is the only movement necessary, in others it is the only movement possible, yet in many cases it is very undesirable.

The first published appliance for moving the apices of the roots of teeth was that described by Dr. J. N. Farrar.[1] (See Figs. 815 to 818.)

Fig. 815.

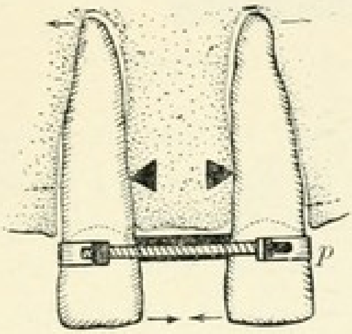


Fig. 816.

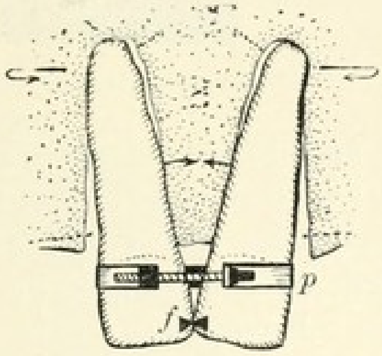


Fig. 817.

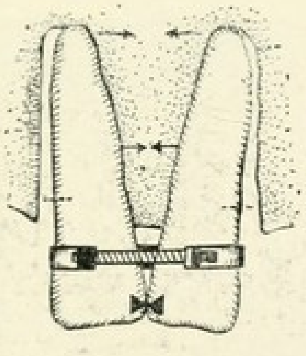
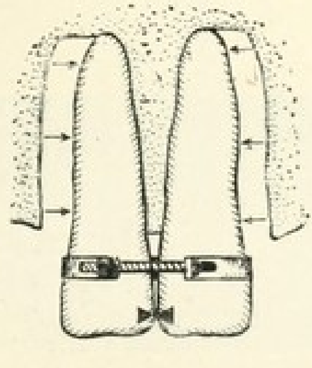


Fig. 818.



The central incisors were separated as shown in Fig. 815, the roots being parallel. In drawing them together by a clamp band (*p*) the teeth tilted toward each other until they touched at the mesio-incisal angles (*f*, Fig. 816). Up to this time the apices of the roots were practically the fixed points, and the alveolar process between the roots was condensed and absorbed as the teeth moved. As soon as the crowns touched each other at the mesio-incisal angles these became the fixed points, and, as the power was still continued at the necks of the teeth, the roots began to move

Fig. 819.

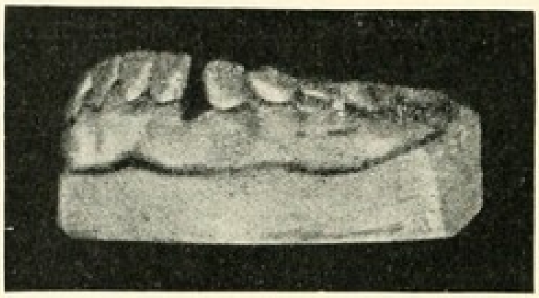
Incisor guide.

[1] *Dental Cosmos*, vol. xxiv. p. 190.

till they were practically parallel (Fig. 818). To prevent the crowns sliding past each other and overlapping, a guide was constructed as shown in Fig. 819. The same appliance will serve for retention.

If after extracting a crowded lower incisor the teeth on each side of the space are found to lean toward each other, as in Fig. 820,

Fig. 820.



Appliance for moving roots of lower incisor and cuspid.

the roots may be moved toward each other so that the crowns will be parallel to each other. Dr. C. S. Case has devised an appliance for this purpose, shown in Figs. 821 and 822. Bands are fitted to the teeth on each side of the space, and sometimes to the second tooth also. From these bands stiff bars extend downward parallel with the surface of the gum from an eighth to a third of an inch below

Fig. 821.

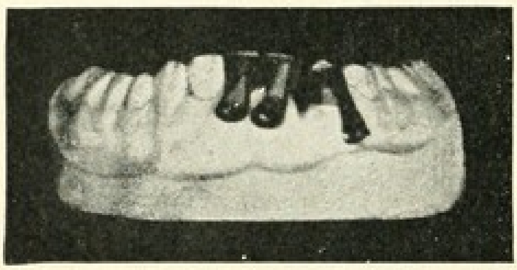
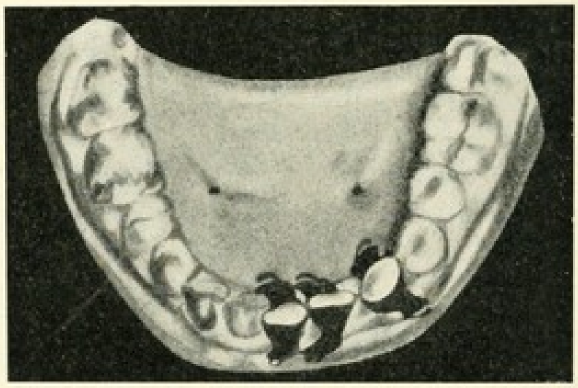


Fig. 822.



Appliance for moving roots.

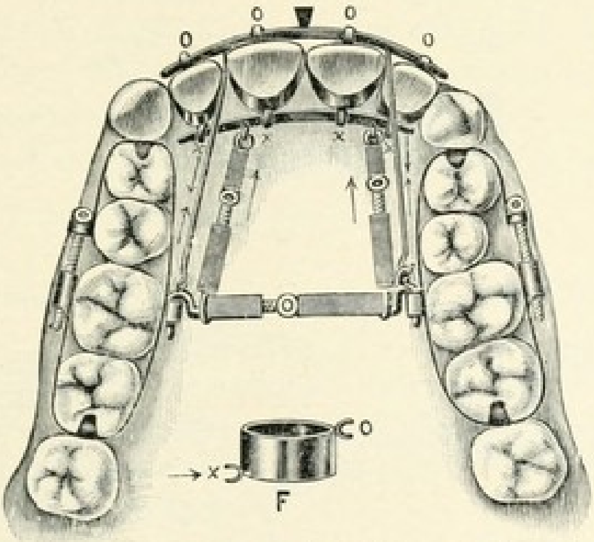
the margin. On the lingual surface similar bars extend about the same distance. On the free ends of the bars are soldered hooks or headed pins, so that a rubber band or a ligature can be extended from one labial bar to the other, and from one lingual bar to the other. The direction of force is thus brought low enough to move the roots as well as the crown of the teeth. Suture wire may be substituted for the rubber band or ligature for retention.

In some cases of upper protrusion the alveolar process is so prominent that when the crowns of the teeth are moved back to the desired position the roots have not moved with them, and the upper lip is still too prominent. So also in some cases the palatal portion of the alveolar ridge is so dense that it does not yield readily, and as the crowns move backward the edge of the process acts as a fulcrum and the ends of the roots move forward. The prominence of the lip is thus increased.

In the World's Columbian Congress, 1893, Dr. C. S. Case showed casts and models of such cases and appliances by which the roots and the whole anterior alveolar process can be moved back and the prominence of the upper lip reduced to a normal contour. For illustrations and descriptions of this operation the reader is referred to Chapter XXV., and especially to Figs. 847, 853, 854, 855, 896, and 897.

Fig. 823 shows Dr. Farrar's appliance for moving forward the roots of incisors by working on the lingual side of the arch. "The

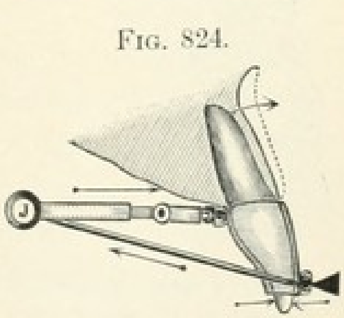
Fig. 823.



Farrar's appliance for moving incisor roots forward.

base of support is a transpalatal screw-jack, anchored by two clamp bands that embrace the side teeth; from this jack to the posterior sides of the necks of the incisors and lying close to the sides of the arch are two other screw-jacks to press against these front teeth. To hold these jacks upon them, each incisor has upon it a broad ferrule (cemented) with a U-shaped lug on the lingual side, near the gum (see *F*, in the lower part of Fig. 823), in which a bar connecting the anterior ends of the jacks rests. To hold firmly the end of the crown of each incisor, and prevent them from moving forward when these jacks are set at work against the necks of the teeth, the ends are tied to the transpalatal jack by two wire cords connecting with a crossbar lodged in other U-shaped lugs soldered to the labial side

Fig. 824.

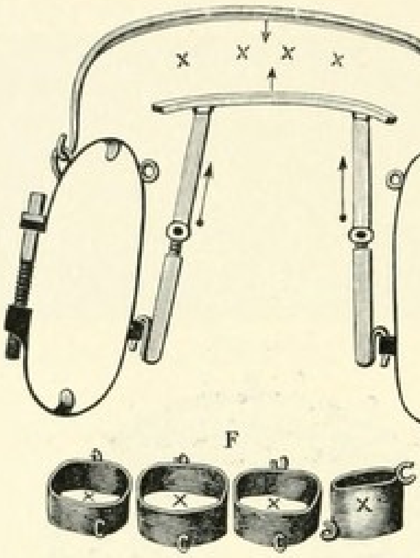


Showing attachment of crossbar.

of the ferrules near the ends of the teeth, as represented by Fig. 824."

Fig. 825 shows another of Dr. Farrar's appliances for the same purpose, which makes use of a labial bow for retaining the ends of

FIG. 825.

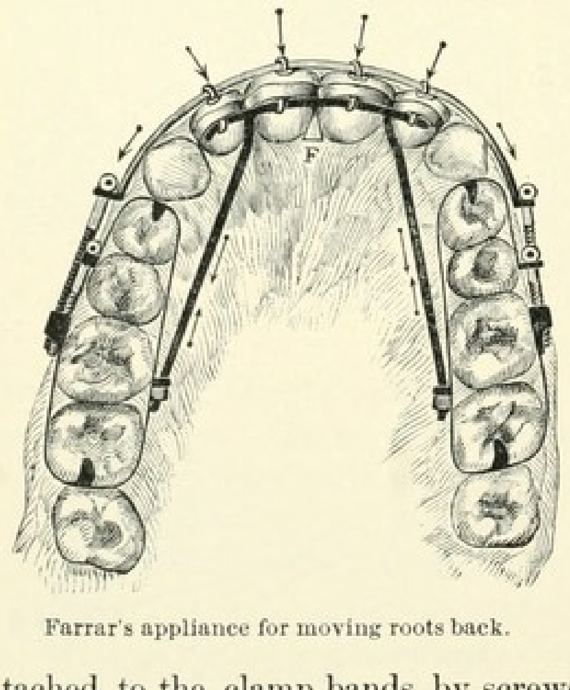


Farrar's appliance for moving roots forward.

the incisors, and omits the transpalatal jack, thus simplifying the apparatus.

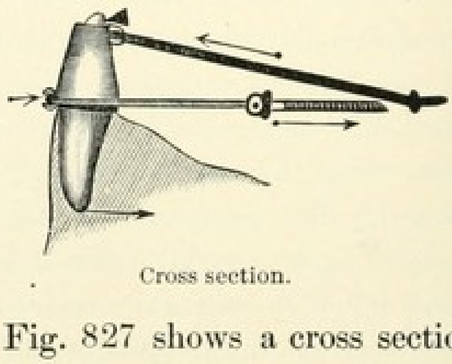
Fig. 826 shows Dr. Farrar's appliance for drawing back the roots of upper incisors. "The crowns are stayed by an inside rectangular frame resting in U-shaped lugs at the ends of the crowns and braced against nuts soldered to two anchor clamp bands on the side teeth. The roots are drawn back by a labial bow, attached to the clamp bands by screws. Fig. 827 shows a cross section of such an appliance.

FIG. 826.



Farrar's appliance for moving roots back.

FIG. 827.



Cross section.

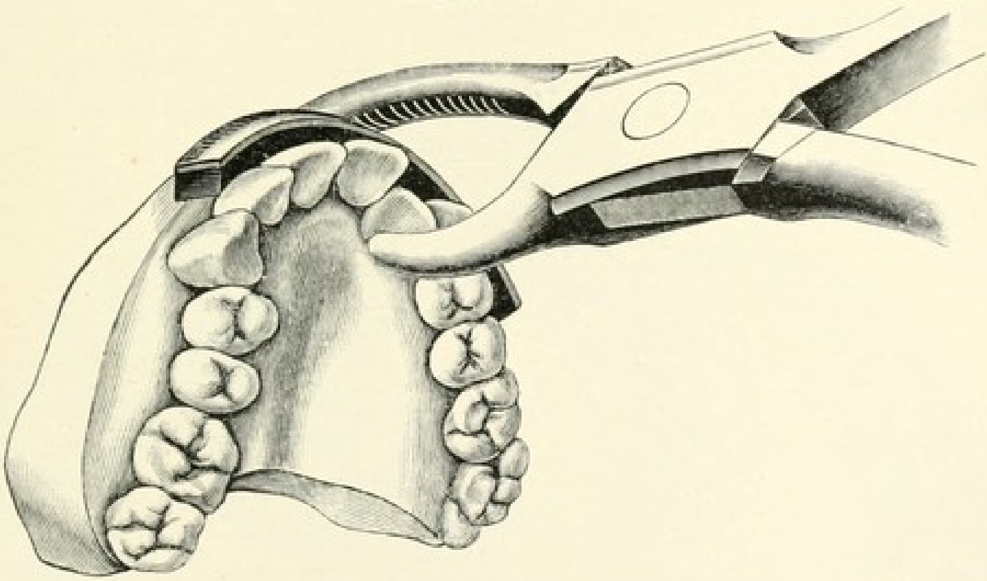
Immediate Movement of Teeth.

The forcible rotation of a tooth by the forceps was recommended by Mr. John Tomes.[1] He said the operation had been frequently performed by himself and others, without devitalizing the pulp except in one hospital case ; that the best age for the operation was eight or nine years ; that he had performed it for patients thirteen years of age and for one patient of fifteen. The operation has been performed by many since then, and for older patients also, being preferred by some to the longer but less painful plan usually followed.

The beaks of the forceps should be carefully fitted to the neck of the tooth, which should be protected by sandpaper, emery cloth or lead foil. Tomes recommends that in some cases the tooth be rotated half way at first, then allowed to rest for a couple of weeks before being rotated to place. The operation is confined, of course, to teeth with straight conical roots. Even a slight curve in the root such as is frequently found with the lateral incisor would render the operation impossible.

Immediate Regulating of Inlocked Teeth.—Dr. L. C. Bryan[2] has advocated the immediate movement of single teeth, situated inside the

Fig. 828.



arch, especially canines and laterals. The following is his description of the operation : "The treatment which I have finally adopted is to inject cocain and either partially cut away the thick intervening alveolar process with drills and fissure burs, or, when the process is thin, bodily wedge the outer alveolar wall away with a half-round wedge-shaped chisel, by inserting the point of the instrument between the crown and the bone and forcing it up along the root until enough space is secured for the tooth to be brought out into place outside the lower tooth. This

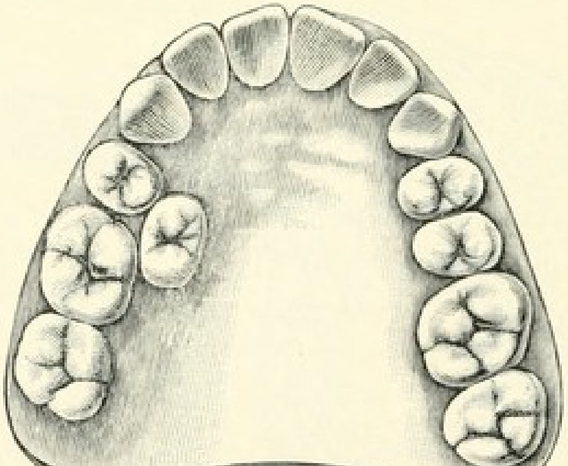
[1] Tomes, *Dental Surgery*, 2d ed., p. 162. [2] *Dental Review*, 1892, vol. vi. p. 859.

latter I formerly accomplished by pressing the wedge-shaped instrument or the inner beak of a suitably formed forceps up along the lingual surface of the tooth until the crown was forced outward sufficiently to be firmly grasped. It was then brought gradually out into place."

Another and better plan was by the use of forceps specially made for the purpose, shown in Fig. 828.

Following is a description of an operation by Dr. Bryan, at the World's Columbian Dental Congress in Chicago, August, 1893, from the report of the Committee on Clinics:[1] "The patient, a fifteen-year-old girl, had a right upper lateral incisor locked behind the lower incisors with sufficient space between the upper central and canine for immediate regulation. Cocain was injected and a perpendicular incision was made with a small circular saw through the gum and half through the alveolar septum on both sides of the root of the lateral from the apex of the root to the crown of the tooth. A three-inch flat steel guard, lined on the gum side with rubber $\frac{1}{16}$ of an inch thick, was fitted to the curve of the gum and formed a rest for the long, round front beak of the forceps; the other beak rested against the distal wall of the lateral up to the gum. With slight pressure the connection of the tooth with the distal alveolar wall was severed, and the tooth came

FIG. 829.



Immediate movement of bicuspid (Cunningham).

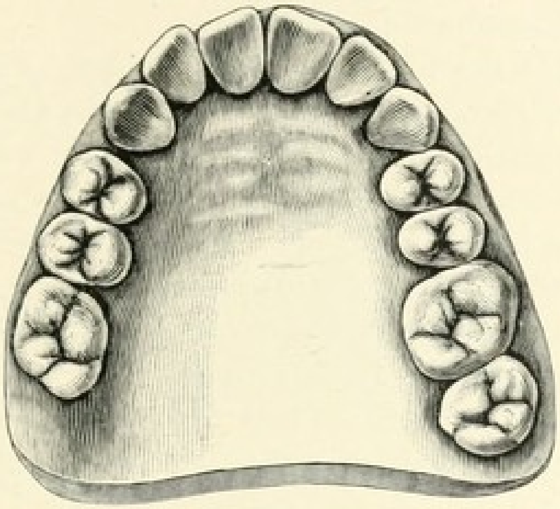
easily forward to its place in the arch in front of the lower teeth, bringing with it the front wall of the alveolus, firmly attached to the root and ready to heal quickly and reunite with the neighboring borders of alveolus. The apex of the root was not disturbed in its position, so that the nerve and vessels would remain intact, as will always be the case if the operation is correctly and carefully performed."

Moving Several Teeth by the Immediate Method.—Dr. Geo. Cunningham of Cambridge, England, began the use of this method in

[1] *Transactions*, vol. ii. p. 997.

1886 by forcing with the forceps an inlocked bicuspid into the position of a molar which he had just extracted. The tooth became firm in its new position, but the pulp did not survive the operation. Figs. 829 and 830 were made from photographs of casts of the case, before and after treatment.

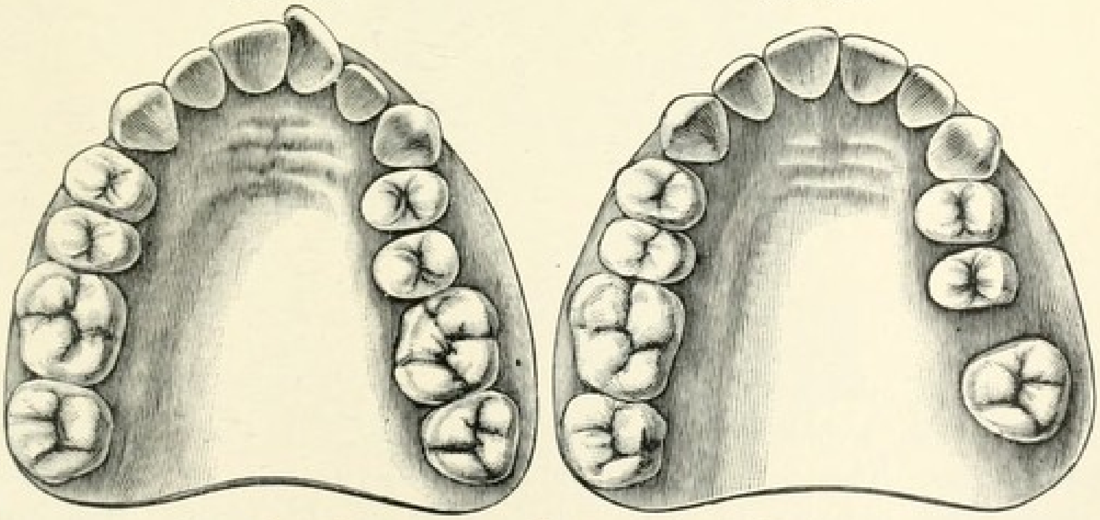
FIG. 830.



Immediate movement of bicuspid (Cunningham). After treatment.

Figs. 831 and 832 show casts of a case in which he forced five teeth into new positions. The following is his description: "The patient having been anesthetized (nitrous oxid and ether), the molar was extracted, and after fracture of the alveolar process between the teeth both bicuspids

FIG. 831. FIG. 832.



Immediate movement of five teeth (Cunningham).

were luxated backward by means of Physick's forceps. The canine and lateral incisor were similarly treated with the additional help of guarded ordinary forceps. On endeavoring to luxate the central incisor, owing to a curved and distorted root, it slipped down between the beaks of the forceps, and thus became completely dislocated from its socket and all its normal attachments . . . . Considerable force had to be exerted to thrust it into its new position." The teeth were ligated, etc.

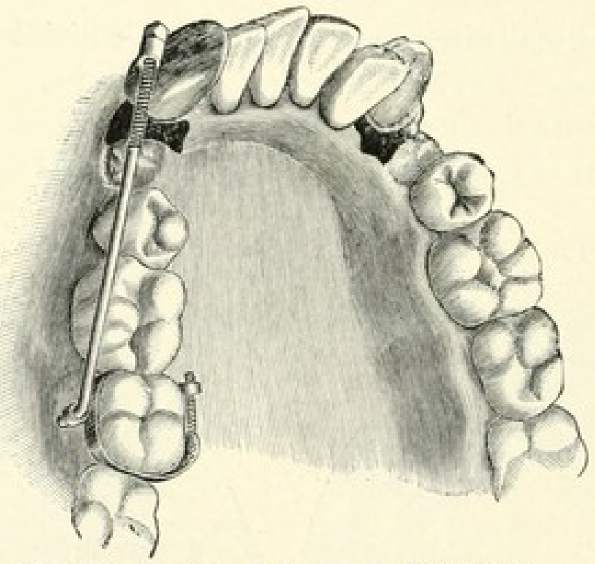
Among other directions he gives the following: "All being ready, cut the alveolar process with a thin saw $\frac{7}{8}$ of an inch to $1\frac{1}{4}$ inches in diameter, not thicker than note-paper, into such sections as are necessary . . . . Forceps, elevator, or other instrument is used for pushing, pulling, or rotating the tooth sections into place."

He advises that the teeth should be retained by ligatures of silk or wire or a splint of German silver or platinum bands soldered together, and that the articulation of the teeth be adjusted by grinding, etc.

Immediate or surgical regulating is not recommended by these advocates for all cases, but only for those in which all circumstances favor it, such as lack of time for other treatment, desire of patient, yielding alveolar process, abundance of room, etc. While it is a possible operation, it will never become a frequent one.

Combined Method, Surgical and Mechanical.—Dr. Talbot advocates the surgical removal of a portion of the alveolar process in

Fig. 833.



Surgical retraction of lower cuspids (Talbot).

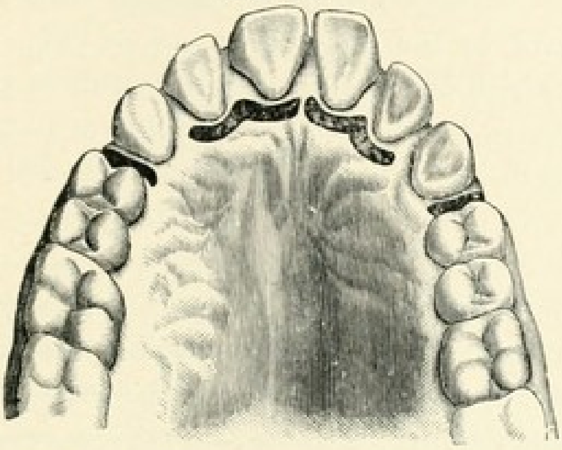
the path of the advancing tooth while a tooth is moved by usual means, thus avoiding the delay caused by the slow process of absorption. This is especially advantageous in case of very dense tissue and in cases in which it is difficult to secure sufficient anchorage. By thus removing the chief obstruction, teeth may be moved by depending on an anchorage that in ordinary cases would be entirely inadequate. He says:[1]

"For seventeen years I have adopted surgical treatment, but have not made public my methods, since incidental conversation with some

[1] *Dental Cosmos*, 1896, vol. xxxviii. p. 909.

of the best men from time to time revealed that they had not taken kindly to it. I therefore wished to give it sufficient trial before recommending it to the profession. I have met with such markedly uniform success that I do not hesitate to recommend it to all practi-

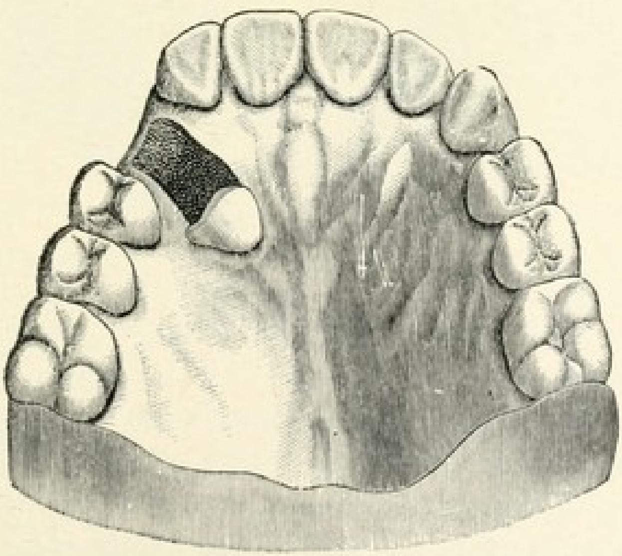
FIG. 834.



Surgical retraction of incisors and cuspids (Talbot).

tioners as perfectly safe and reliable with the antiseptic care required in surgical operations. This method consists in removing entirely the alveolar process in the line of travel of the tooth to be moved, leaving a small amount of process about the root of the tooth, holding intact

FIG. 835.



Surgical correction of malposed cuspid (Talbot).

the peridental membrane. This is accomplished with coarse-cut Revelation burs, or those that will cut in all directions. They can thus be used as drills in certain conditions to be mentioned later on.

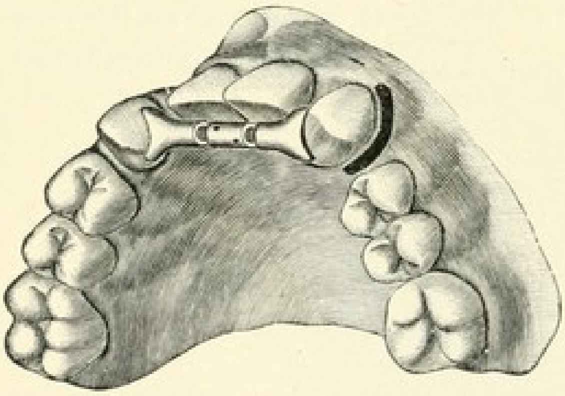
"If the canines require to be carried backward, make an appliance with bands about the first and second molars, with cap upon the canines and a bar with screw and nut upon the end, as recommended by Dr.

Farrar. Extract the first bicuspid and adjust the appliance; use a sharp new bur dipped in five per cent. carbolic acid or one per cent. corrosive sublimate or listerine. Then, resting the hand against the canine, cut out the palatal and buccal V-shaped plate, making a concave surface of the alveolar process, as illustrated in Fig. 833.

"If the upper incisors are to be carried back, cut semicircular spaces just posterior to the teeth to be moved (Fig. 834). To carry a canine into place which is erupting into the vault of the mouth, remove the alveolar process in the direction of the line of travel (Fig. 835).

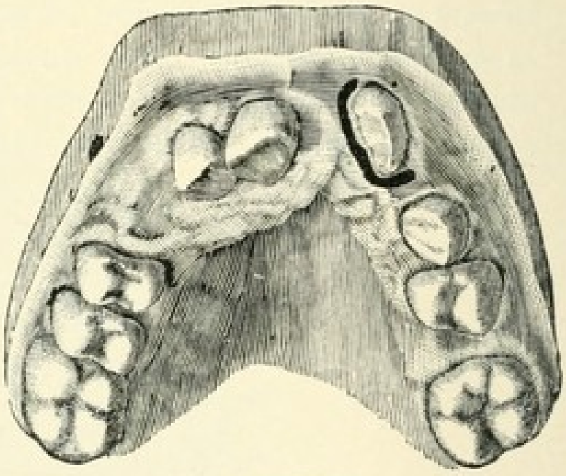
"In moving teeth laterally by a jack-screw, it will be found that not infrequently one tooth moves faster than the other. To bring both to their proper position cut out the alveolar process on the side of the slowest-moving tooth, and both will come into proper position (Fig. 836). To rotate a tooth, cut a circular groove as deep as possible around the tooth, leaving enough process to hold the peridental membrane intact (Fig. 837). In this manner teeth may be moved very rapidly and without much pain. This should always be done by means of screws. By this method we have the tooth or teeth to be moved completely under control. Any of the teeth in the mouth may be used for the fixed point of resistance, thus doing away with all unsightly appliances outside the mouth. When in place, they should be anchored in the usual manner. Antiseptic washes should be used from time to time, such as one per cent. corrosive sublimate, listerine, or five per cent. carbolic acid.

FIG. 836.



Spreading cuspids (Talbot).

FIG. 837.



Rotation (Talbot).

"In operations of this nature the peridental membrane and also the periosteum are apt to be injured. This was the particular question in recommending it to the profession. Although I have had a few cases of infection, I am quite certain now that such injuries are not of any serious consequence, since with proper precaution no bad results will follow."

CHAPTER XXV.

THE DEVELOPMENT OF ESTHETIC FACIAL CONTOURS.

By Calvin S. Case, D. D. S., M. D.

I. Influence of the Teeth on the Physiognomy.

In the developmental processes of animal life the teeth have probably been more influential than any of the other organs in shaping the bones of the head—especially in determining the physical characteristics of the physiognomy. The physical shape and structure of the jaws conclusively show the influence that the teeth have exerted in different species in response to Nature's law to propagate that which would best subserve them in the performance of their functions. The importance of the teeth, therefore, and their inherent demand upon surrounding anatomical structures for proper means of development, sustenance, and use, is evidence that they exert, during development, a more or less immediate influence in determining the size and shape of the maxillary bones, and thus indirectly are extensively influential in characterizing the individual shape of the human face.

Often the position of the anterior teeth and alveolar process is such as to impress upon the contiguous features, even in repose, certain conditions which vary from a slight imperfection in esthetic contour to a most distressing facial deformity. Nor are these dento-facial imperfections always wholly due to a malposition of the teeth, so much as to a lack of normal symmetry in the size or shape of the maxillary bones upon which so large an area of the face is dependent for its contour. These conditions may have arisen from the direct inheritance of a parental deformity, or from the inharmonious union of unaltered types, as the teeth of one parent and the jaws of another. It is equally true that the union of harmonious types often results in symmetrical conditions which neither parent possesses.

Among local causes, or those which operate after birth in the production of facial imperfections, may be mentioned habits, impaired dentition, delayed and injudicious extraction of the deciduous teeth or first permanent molars, and mal-occlusion.

The influence of the teeth during the time of their eruption (producing on the one hand the excessive pressure of large teeth and concomitant alveolar development, and on the other a lack of pressure from an irregularity or injudicious extraction) in effecting a change in the inherent shape or size of the maxillary bones beyond that which the alveolar process is forced to assume to accommodate them, has been a question of considerable controversy. It is reasonable to assume, however, that natural influences exerting a slight force upon the immature maxillary or other bones, during early stages of their growth, would

Fig. 838.

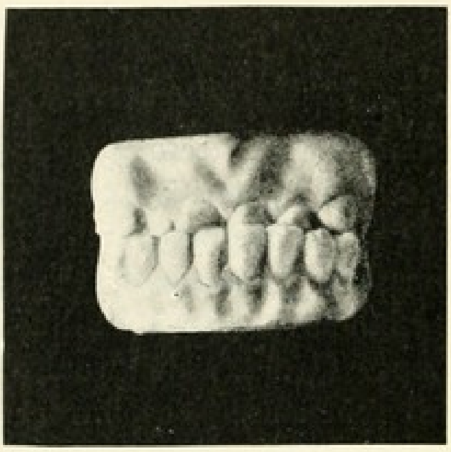
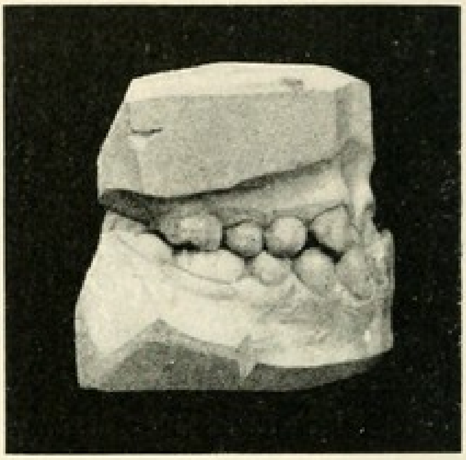


Fig. 839.

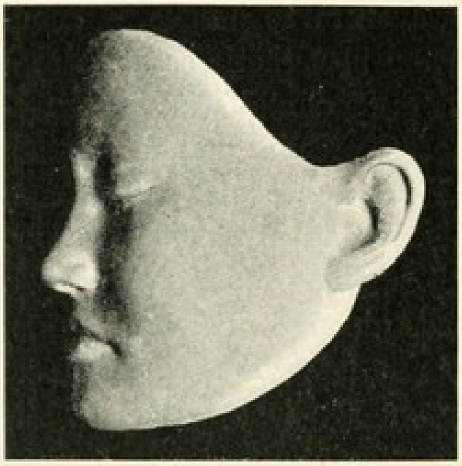


have somewhat the same effect that is known to be possible later by artificial force.

The following case will serve to illustrate this principle:

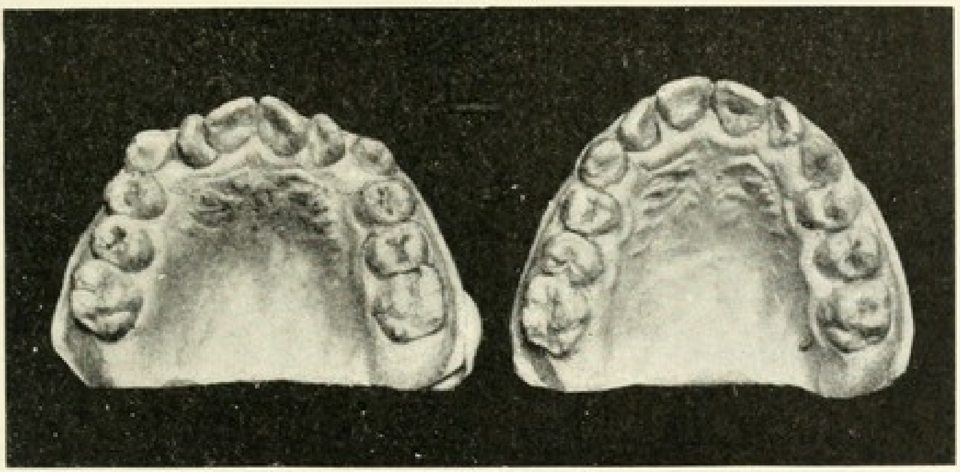
Patient aged thirteen years. When presented the upper incisors were fully the width of a tooth posterior to a normal position, and so badly inlocked, in occlusion, that the crowns were nearly hidden behind the lower. (See Fig. 838.) With the exception of the upper canines, which were forced slightly out of alignment, all the other teeth in both jaws were in proper position and occlusion. (See Fig. 839.) The posterior position of the inlocked incisors was not due, in the slightest degree, to a lingual inclination of their crowns, but the retrusion extended to the roots as well and seemed to involve the intermaxillary process, producing a decided depression of the overlying features. (See Fig. 840.)

Fig. 840.



The probable history of the cause of this condition is as follows: The lower incisors erupted much earlier than the upper, and there being a short-bite occlusion, as soon as the upper incisors began to erupt they became inlocked with the lower incisors. At this time the roots and surrounding processes were in an immature condition. As the crowns continued to erupt they slid down the posterior faces of the lower incisors, where they were retained during the continued development of the roots in the opposite direction, the force being sufficient to prevent the natural growth and development of the entire intermaxillary process, which normally would have carried them bodily forward to an harmo-

Fig. 841.



(Before.) (After.)

nious position. As the other teeth came into place the lateral portions of the jaw were allowed to normally develop in harmony with the natural growth of the other parts. Thus the canines and bicuspids were found in their proper relative positions as regards the lower.

Fig. 842.

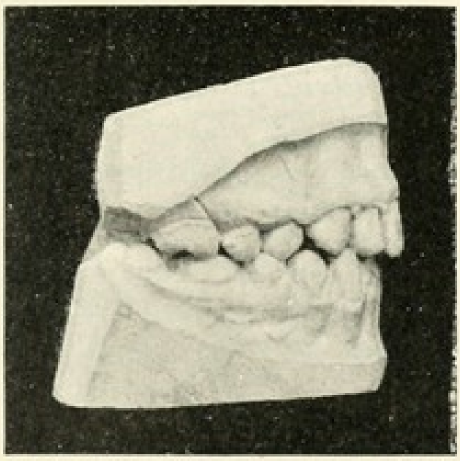


Fig. 843.

Force was applied with the contouring apparatus described in section VI. of this chapter. In less than six months the incisors were carried bodily forward in an upright position, together with the entire surrounding alveolar ridge and intermaxillary process (see Figs. 841 and 842), with a perfect correction of a very unhappy facial deformity. (See Fig. 843.) Fig. 844 is from a photograph taken three years after the completion of the operation.

In dental orthopedia we possess the great advantage over general orthopedia of applying force directly to the bone itself, through the medium of the teeth, without the intervention of the soft and sensitive tissues.

Fig. 844.

The teeth imbedded in the alveolar process, that in turn is firmly united to the true bone, may be considered, when in the grasp of a regulating machine, as an integral part of it, firmly and directly attached to that part of the bone we desire to move, and capable of exerting the quality and direction of force the machine gives to them.

This force being applied unitedly to a number of teeth standing side by side, the surrounding and contiguous bone—which is largely a cancellated structure—is carried bodily in the direction of the force; not by the fracture of its substance or to any great extent by a metamorphosis of tissue, but by the bending, condensation and elongation of its cellular structure; the whole adapting itself to a new form, in which position the immediate interstitial tension of its particles is soon relieved and brought to equilibrium by Nature—though it may require to be held in that position for many months before there is an entire relief from the inherent tendency to return to the primary position.

In contemplating the treatment of a dental irregularity a careful study of the physiognomy in different attitudes of expression should be made, with the view of determining the relative position of teeth and facial contours. The value of a careful preliminary facial examination and comparison cannot be overestimated, for it is often the only guide to correct treatment.

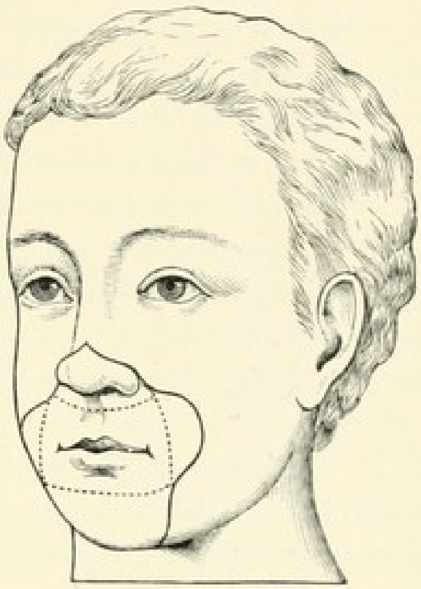
For instance, since it has become possible to expand or retract the anterior portion of the upper apical arch with the surrounding bone in which the moving roots are imbedded, we are no longer confined to the possibility, and frequent questionable propriety, of permanently moving the lower jaw forward or backward to correct a facial deformity which pertains exclusively to the upper maxillæ and middle features of the face.

II. Principles of Facial Orthopedia.

The portion of the human face that it is possible to change with a dental regulating apparatus may be said to lie between two diverging lines which arise at a point below the ridge of the nose and curve downward to inclose the alæ and depressions on either side; thence laterally to encircle a portion of the cheek, and downward to inclose the entire chin. (See Fig. 845.)

Within this ovoidal area are the main features of expression. Within this space the slightest change of contour will often produce a marked effect upon the entire physiognomy and give a different expression to the countenance. It is here that an inherited or an acquired lack of symmetry in the size, shape, or position of the teeth and jaws produces those marked changes of facial contour which characterize different physiognomies. This area may be termed the "changeable area" in contradistinction to the more stable features, or "unchangeable area."

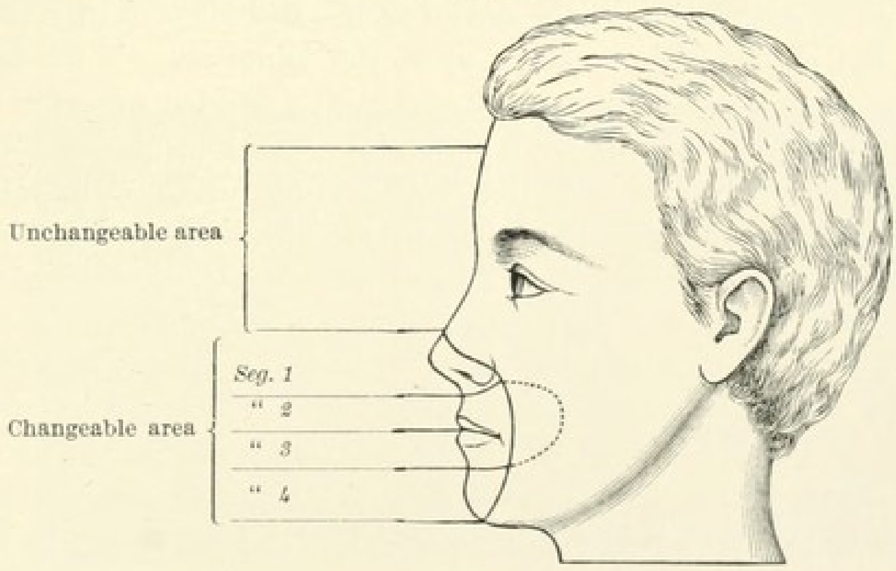
Fig. 845.



For convenience of ready reference, the features in that portion of the changeable area which are bounded laterally by the naso-labial lines may be divided into four segments as follows:

Segment 1.—The end of the nose and the upper portion of the upper lip, including the naso-labial depressions.

Fig. 846.



Segment 2.—The lower portion of the upper lip.

Segment 3.—The lower lip.

Segment 4.—The chin.

In the preliminary examination of the physiognomy from a purely esthetic standpoint with a view of correcting a dento-facial deformity or imperfection by applying force to the teeth, there are certain prominent features to be especially observed and their relative position carefully noted. These may be divided into two classes: first, those which lie in the unchangeable area, as the forehead, bridge of the nose, and malar prominences; second, those in the changeable area.

The four segments in the latter class shown in Fig. 846 are changeable in their relations to each other, and also in their individual relation to features in the unchangeable area. For instance, it is possible to protrude or retrude the upper portion of the upper lip with the depressions on each side of the nose, the nasal septum, and the end of the nose, without changing the lower portion of the upper lip in its relation to other parts. (See Fig. 855.) The same is true of the other segments—in fact, a retrusion of the second segment and a protrusion of the first may be accomplished at the same time. (See Figs. 853 and 854.)

If the lower jaw be mechanically protruded or retruded bodily, the lower lip will of necessity be carried forward or backward with the chin, unless a special operation is performed on the lower teeth to prevent it from changing its relations to the upper lip.

Those portions of the changeable area which lie over the bicuspids and first molars—shown in Figs. 845 and 846—and separated from the lips by the naso-labial lines, may be considered as separate segments, as the causes which influence a change in the contour of the cheeks differ so decidedly from those which change the more anterior areas. The lateral expansion or contraction of the dental arches will often change the contour of the cheeks with no effect upon the labial area, if the anterior teeth remain unchanged in position. Again, a decided retrusion of the anterior teeth and process with no lateral expansion of the arch will invariably result in giving to the cheeks a fuller contour, by relieving the tension of muscular tissues. The same result will often be obtained in closing the characteristic open bite of a mouth-breather by grinding the posterior teeth, and also by retracting a prognathous lower jaw.

In a study of profiles we frequently observe a lack of perfect harmony in the position of the chin. The lower jaw is apparently protruded, or retruded, so as to mar the esthetic perfection of the physiognomy, and yet were these same faces examined by a trained observer he would find in a large proportion the lower jaw in perfect harmony with the unchangeable area, and that the appearance of its malposition was an effect due wholly to a protrusion or retrusion of the upper jaw and teeth. In other words, it is a common error to imagine the chin imperfectly posed because it is not in harmonious relations to the other features of the changeable area, instead of comparing it, as we should do, to the more stable or unchangeable features of the physiognomy.

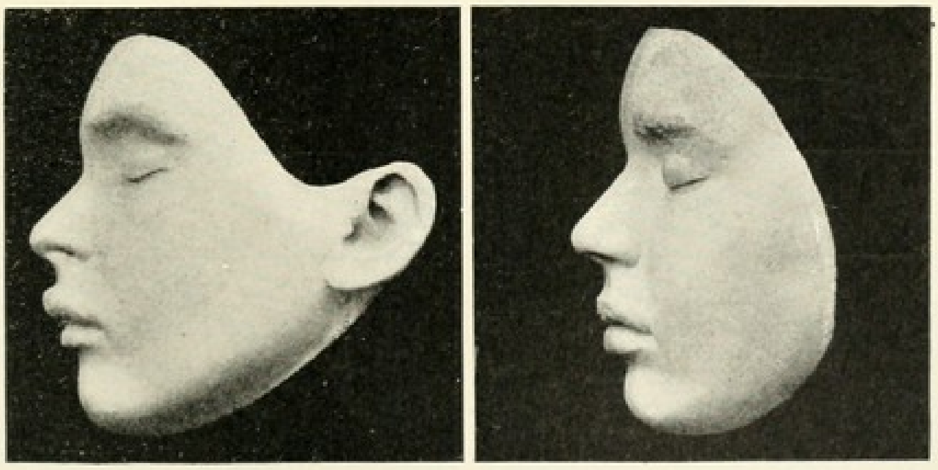
In examining the physiognomy of a patient, the head should be in an upright position, on a line with that of the observer, and the face studied from different angles while in repose and in action.

While looking at the profile in repose the most important thing to determine is the relative position of the chin with the forehead, malar prominences, and bridge of the nose. If its position is harmonious with the unchangeable area and the lower lip is well posed, it indicates that the operation of facial contouring should be performed—if anywhere—upon the upper jaw and teeth. For if the first and second segments are abnormally protruded it will cause a chin to appear retruded that is perfectly harmonious in its relations to the principal features of the face. (See Fig. 847.) Again, a retruded or contruded upper arch with a depression of those features which are supported by the upper maxillæ will cause a perfectly posed lower jaw and chin to appear protruded or prognathous; as instanced by the cases illustrated in sections I. and IV. in which the facial effect, before treatment, was that of protruded lower jaw, but which were perfectly corrected by an anterior movement of the upper incisors and intermaxillary processes.

III. Upper Dental and Maxillary Protrusions.

Figs. 847 and 848 will serve to illustrate the class of facial deformities known as abnormal upper protrusions, and the advantage of retruding the upper anterior teeth and surrounding process.

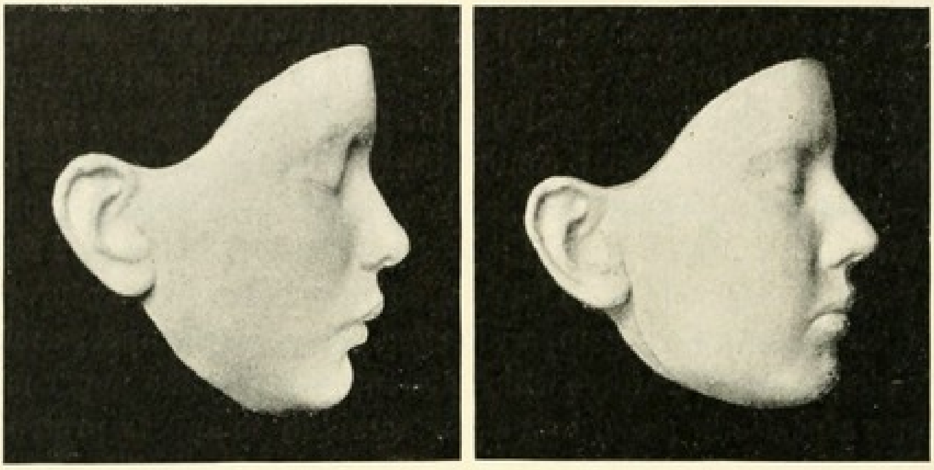
Fig. 847.



In Fig. 847 wide interdental spaces between the upper teeth permitted the reduction without extracting. In Fig. 848 the upper first bicuspids were extracted.

If the operation of "jumping the bite" were performed in these cases, there would no doubt be an improvement of the original appearance of the physiognomy, by the bringing of the chin and lower lip into more perfect harmony with the upper; but this would not be correct treatment, because, as will be observed, the chin is in not far

FIG. 848.



from perfect position when compared with other features of the unchangeable area.

The principles involved in the correction of this class of facial deformities may be diagrammatically illustrated as follows:

FIG. 849.

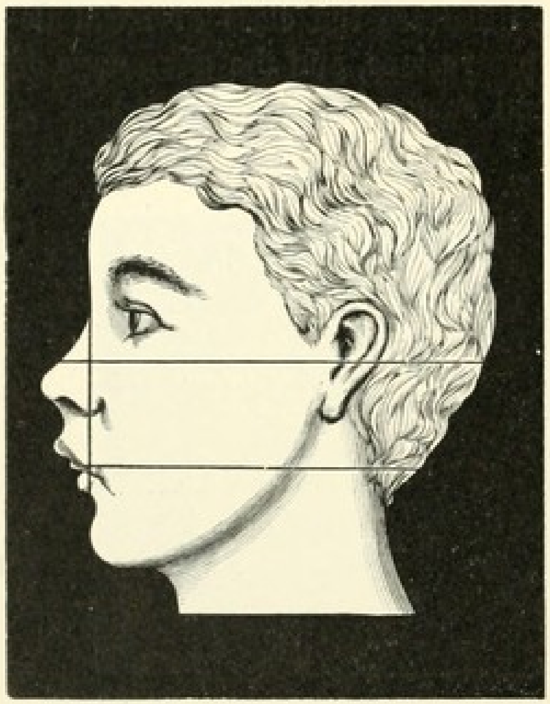


FIG. 850.

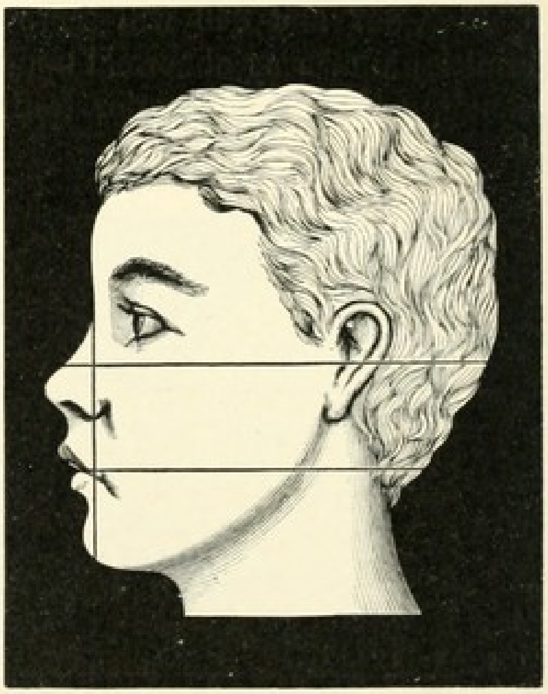


Fig. 849 is a profile view of a typical case of abnormally protruded upper jaw. It will be observed that the chin appears retracted.

Fig. 850 shows the improved effect that would be produced by "jumping the bite" in bringing segments 3 and 4 into more perfect harmony with segments 1 and 2; yet not to be compared with that perfection of symmetrical contour shown by Fig. 851, where the chin and lower lip are permitted to remain in their original harmonious position while the end of the nose and upper lip are retruded into harmony with the whole.

The three faces have been made exactly alike with the exception—as shown by the cross lines—of certain mechanical movements of the profile outlines in the changeable area. In Fig. 850 the outlines of segments 3 and 4 are forced farther forward, and in Fig. 851 segments

Fig. 851.

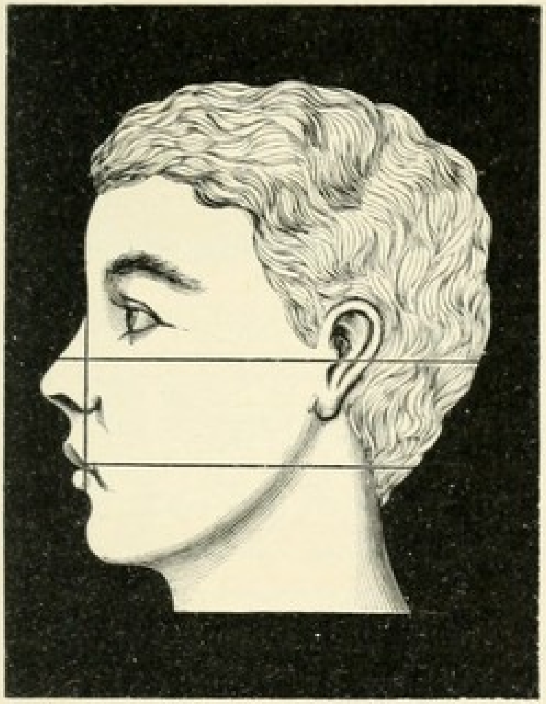
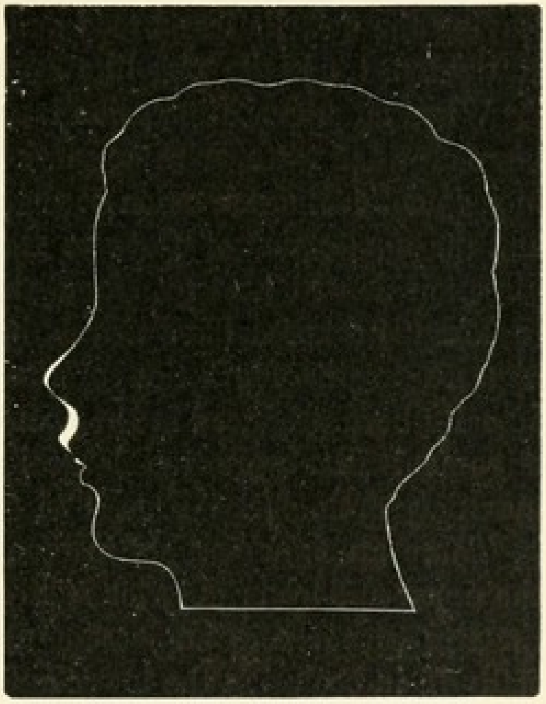


Fig. 852.



1 and 2 are carried back as they would be by a retruding apparatus attached to the teeth.

In comparing Figs. 849 and 851 the difference in esthetic effect is quite striking, and it is one also which would seem to be hardly possible with so little change in the outlines of a comparatively small area. By cutting a piece of black paper to the exact outlines of Fig. 851 and placing it upon Fig. 849 the real and only difference in the two figures can be plainly seen—as in Fig. 852.

When such a change is produced in the features of a human face the difference is greatly enhanced because of the harmonious perfection of other contours not shown by the figures.

It is a noteworthy fact that a very little change in the peripheral shape or position of certain bones of the face on which the features are dependent for their character and form—a change so trifling that it could hardly be measured—resulting in a slight filling out or depression of certain contours, will often beautify to a remarkable degree the appearance of a face that would otherwise be quite plain and unattractive.

This is true of all the more common cases of upper protrusion and retrusion which show an abnormal prominence or depression along the upper as well as the lower portion of the upper lip, and especially of those which seem to involve the entire intermaxillary process, influencing the antero-posterior position of the wings and end of the nose.

In cases of protrusion, by applying a retracting force especially directed to the roots and crowns of the anterior teeth, the surrounding alveolar process and anterior portion of the maxillæ will be forced back, allowing the upper lip to fall into a more graceful and easy pose, leaving the nostrils less broad and open, the upward curve of the nose straightened, and its pug-like appearance removed.

When an upper protrusion is due alone to a labial inclination of large crowded teeth, with no marked protrusion over the apical zone, or in segment 1, the extraction of the first or second bicuspids is indicated, and the application of force to the crowns at such points and in such direction as will best overcome the malposition.

Many instances have arisen, in the practice of dentists who were opposed to the extraction of teeth, where the above condition has actually been produced in the operation of crowding irregular teeth into alignment that were too large for an already perfectly harmonious maxillary arch. (See Figs. 875 to 878 inclusive, in section V.)

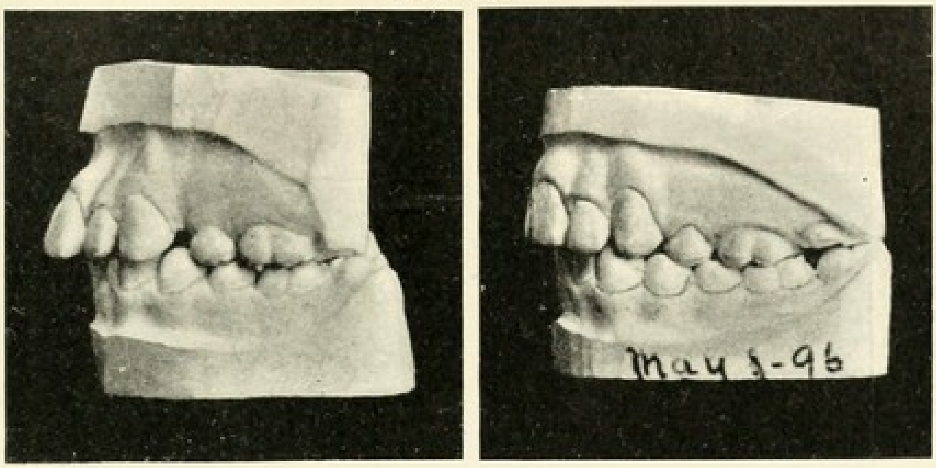
There are innumerable instances where a labial inclination of both the upper and lower anterior teeth produces a pronounced protrusion of the lips with a very unpleasant expression in their management, especially if in occlusion the lower anterior teeth are even with, or in front of, the uppers. The fact that the most natural occluding position of the lower front teeth is somewhat posterior to the upper teeth permits the graceful curve of the lower lip which is so necessary to the esthetic perfection of the chin.

In order to correct a pronounced facial deformity of this character produced by large teeth crowded into arches that are too small for them, but otherwise harmonious in size, it will often be necessary to extract a bicuspid from each side from both the upper and lower jaws. Sometimes the extraction from the lower of a central incisor will be sufficient.

Instances frequently arise where the position and labial inclination of the upper anterior teeth produce a relative protrusion of the incisal zone and a contrusion of the apical, with a protrusion of the lower portion of the upper lip and a slight depression of the upper portion, deepening the naso-labial depressions. If the depression of segment 1 be not too pronounced, it may be restored by a slight forward movement of the anterior apical zone, accomplished in the retrusion of the incisal zone—by force applied at the incisal ends of the teeth alone, with the view of producing, as far as possible, a fulcrum force at the lingual margins of the alveoli.

If the malformation is produced by an inharmonious union of

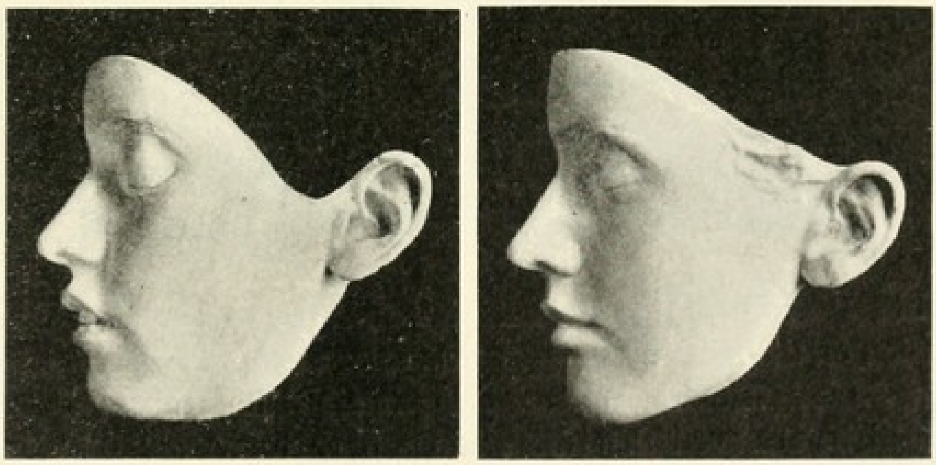
Fig. 853.



maxillæ and teeth, as in the former case, the extraction of an upper bicuspid from each side will be indicated. Figs. 853 and 854 were made from the models of a case of this character, before and after treatment. The upper first bicuspids had been extracted some time before the patient presented for treatment.

In contradistinction to this class of deformities, there is another

Fig. 854.



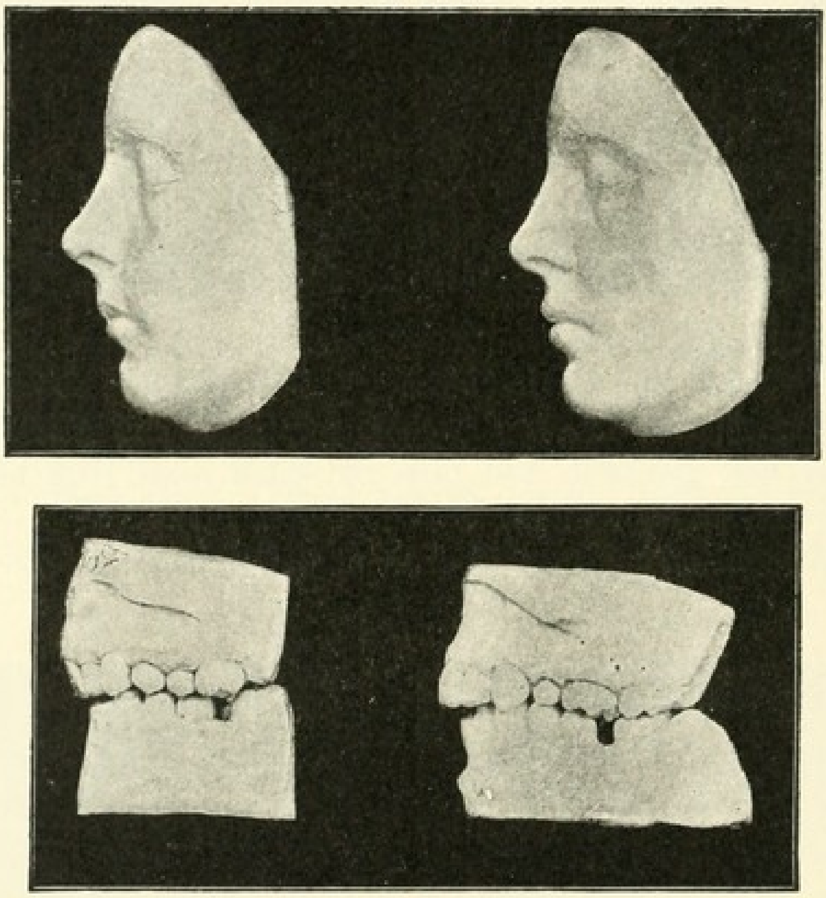
quite as common—though not so frequently recognized as an abnormality—in which all the conditions are reversed, in that the teeth have a lingual inclination with protrusion of the apical zone and maxillæ.

The teeth of these cases are commonly regular in alignment, and owing to their lingual inclination the occlusal zone may be in proper relative position. (See Fig. 855.)

The facial imperfection which consists principally in a prominence or bulging along the higher portions of the upper lip and in the region of the nasal alæ is often quite pronounced. When this is caused partly by the canine roots the difficulties are much increased in the case of patients older than thirteen. The fact that the roots of the canines are surrounded by the most dense portion of the alveolar process, and their movement bodily in a posterior direction requiring the resorption of a large portion of bone, makes this operation one of the most difficult in dental orthopedia.

Fig. 855 is from the models of a patient over twenty years of age,

Fig. 855.



and will serve to illustrate a case before and after treatment of abnormal protrusion of the roots of the upper anterior teeth, alveolar process and maxillæ—the axis of the incisors being inclined lingually.

It will be observed that the canines have been moved bodily in a posterior direction notwithstanding the advanced age of the patient.

If regulating appliances are properly constructed that will permit the production of an independent static fulcrum at the occlusal ends of the teeth, so that the entire power of the machine may be directed and maintained upon the roots (see Figs. 896 and 897, in section VI.) perfect contrusion of the prominence will slowly but surely result.

If the teeth are crowded, overlapping, or turned on their axes, a correction of alignment may require the extraction of a bicuspid on each side in order to regulate them without an abnormal protrusion of their crowns. This is especially indicated when much retrusion of the canine roots is desired.

IV. Upper Dental and Maxillary Retrusions.

Facial imperfections which are due to insufficient fulness of contour in the central features of the physiognomy are quite common, and vary in degree from conditions that are hardly noticeable to those which may well be classed among the most unhappy of facial deformities.

There are two distinct classes of this type of facial irregularity—one being due to a lack of development of the intermaxillary portion of an otherwise harmonious upper jaw; the other to the fact that the entire upper jaw itself is too small and too posteriorly placed, in its relations to other parts.

The teeth and alveolar process of the retracted parts are prevented from assuming harmonious relations, and consequently the overlying features are more or less depressed in proportion to the contruded or retruded frame upon which they depend for their contour.

The primary cause of these conditions may be often very obscure and admit of nothing more tangible than conjecture, and, not unlike many of the causes of irregular teeth, be really immaterial to the work of correction.

It may have been caused by the exertion of local physical forces during the early years of immaturity (as, for instance, the mal-eruption and occlusion of the teeth); or a local disturbance and interruption of nutrition from prenatal or postnatal causes; and lastly, but by no means rarely, by inherent physical tendency.

Class 1: *Retruded Upper Incisors and Intermaxillary Process.*—In the more pronounced deformities of this class the physiognomy will often appear flattened, with prominent cheek bones and protruding chin and lower lip; the upper incisors occlude evenly with or posterior to the lower incisors, and at times are extensively inlocked in this position, as instanced by the case fully described and illustrated in section I.

The upper incisors, which alone have their origin in the intermaxillary process, are in their entirety posterior to a normal relative position. The labial inclination of the crowns, together with the deepened incisive fossæ, will show at once the contruded position of the roots and their maxillary surroundings.

The upper lip resting upon the retruded teeth and the overlying process is proportionately depressed. Nor does the facial defect end here. The entire lower portion of the nose, supported as it is by the nasal cartilages which spring from the anterior nasal spine and lateral borders of the nasal orifice, is often decidedly affected in shape by the retracting influence of its supports.

When there is a decided retrusion of the entire upper lip and lower portion of the nose, with alæ resting in deep depressions caused by the unusual prominence of the naso-labial folds, the effect is that of an abnormal protrusion of surrounding parts, producing at times a startling expression of maturity that is only common to persons of advanced age. This expression can be seen in Fig. 856, which is that of a girl only twelve years of age, and will serve as a type of cases commonly met with in practice.

Fig. 856.

Class 2: *Retruded and Contracted Dental and Maxillary Arch.*—In this class of deformities the physiognomy, in the more pronounced cases, has much the same characteristics as those described above, but presenting a more general retraction of the central features, with less pronounced naso-labial folds. The nose is often thin and the nostrils pinched; and though the end of the nose may be depressed, the distance from the tip to the more depressed lip is often lengthened. If the patient is a "mouth-breather" with the

Fig. 857.

Fig. 858.

typical "open bite," the deformity and the difficulties attending its reduction will be greatly increased.

Fig. 857 is from a profile model of a face of this class. Fig. 858 is from the same model photographed at a slightly different angle to show the angularity of the features.

Fig. 859 is a view of the teeth in natural occlusion. The first lower bicuspids have been removed preliminary to retruding the anterior teeth to reduce the abnormal protrusion of the lower lip and esthetically deepen the curve between the border of the lip and the chin. The figure has the appearance of a perfect occlusion of all the molars, whereas, on account of the very great narrowness of the upper jaw, the buccal cusps of the second molars only, occluded with the lingual cusps of the lowers.

Fig. 859.

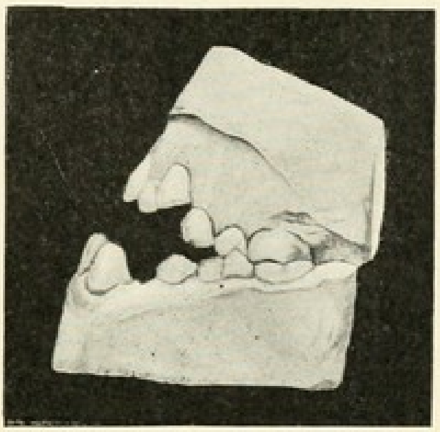
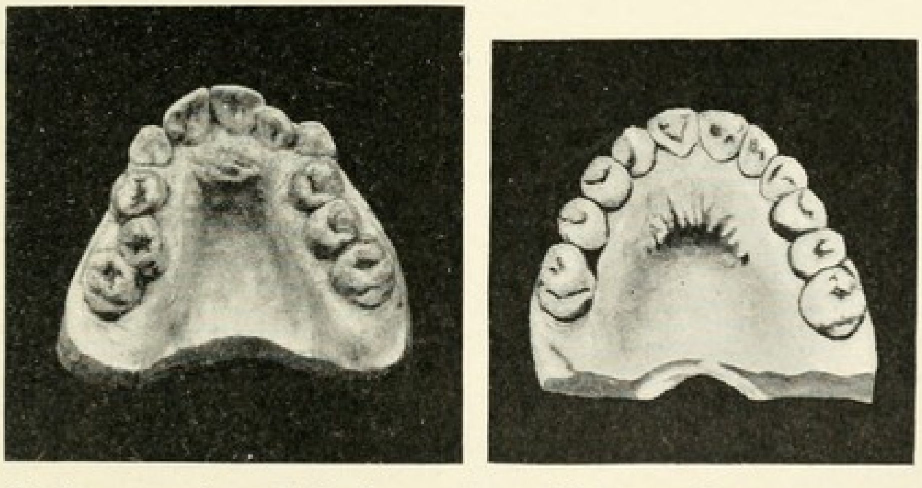


Fig. 860 shows palatal views of the upper arch before and after treatment.

Fig. 861 is a view of teeth in natural occlusion after treatment. The entire upper dental arch, especially at the apical zone, was considerably enlarged. The "open bite" was partially closed by grinding the molars and partly by extruding the teeth anterior to the molars with small rubber bands extending from the upper to the lower teeth. Fig. 862 is from a model of the face after treatment.

As mentioned in section II., a depression of the central features such as described is often mistaken for a prognathous jaw, and treated accordingly.

Fig. 860.



A slight retraction of the lower jaw will in nearly every case of this character produce an improvement in the facial aspect, because the chin and lower lip are brought into more perfect harmony with the depressed central features. Such a change, however, when it is not demanded, can never cause the beautifying effect produced by forcing the depressed facial features—in segments 1 and 2—forward, thus bringing into perfect harmony the entire physiognomy.

This can be verified with any profile view of a typical case—as Fig.

863. Fig. 864 is the same face, except that the chin and lower lip have been retruded, producing a certain improvement, but not to be compared with Fig. 865, where the chin and lower lip retain the same relative position to the unchangeable area as in Fig. 863, while segments

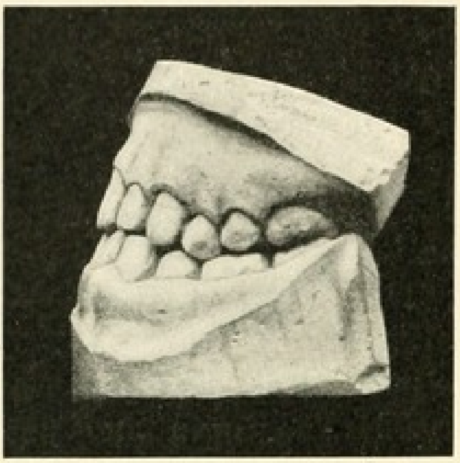


Fig. 861.

Fig. 862.

1 and 2 have been carried forward, with a result which proves (not alone in theory, but in practice) this to be the only true course to bring about an harmonious and esthetic adjustment of all the features of the

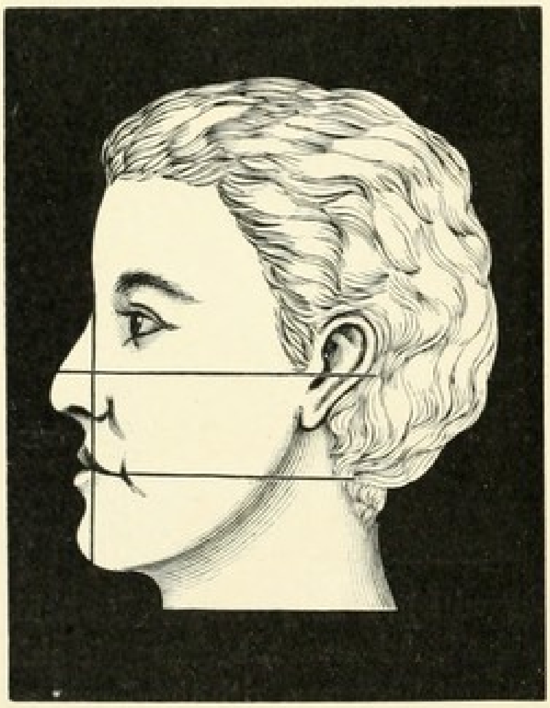


Fig. 863.

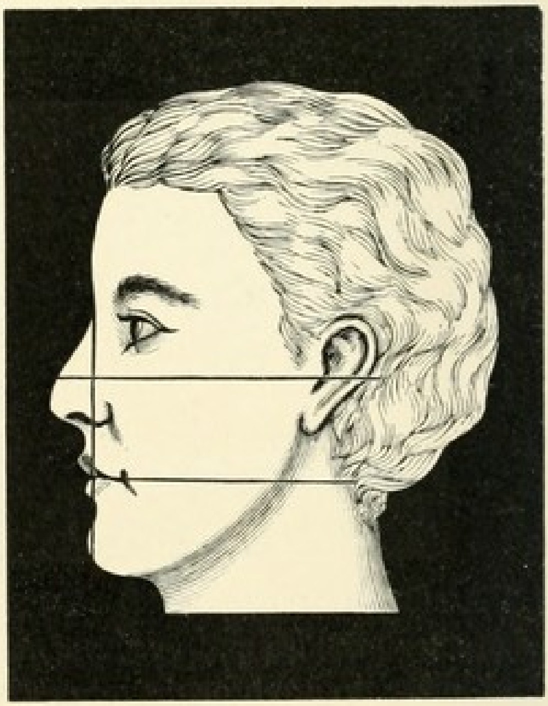


Fig. 864.

physiognomy. Fig. 866 shows the actual difference, which may be verified upon trial, between Figs. 863 and 865.

Fig. 867 will serve to illustrate the common result in practical operations of this character.

The contouring apparatus (Fig. 895) that is used to accomplish these

Fig. 865.

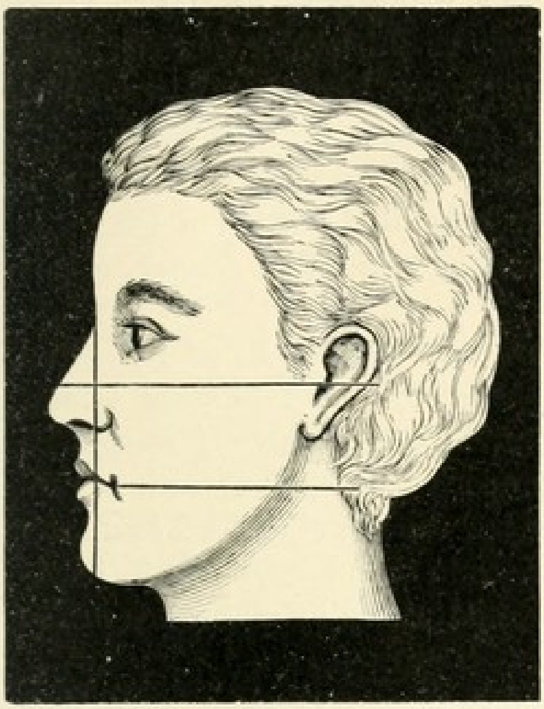
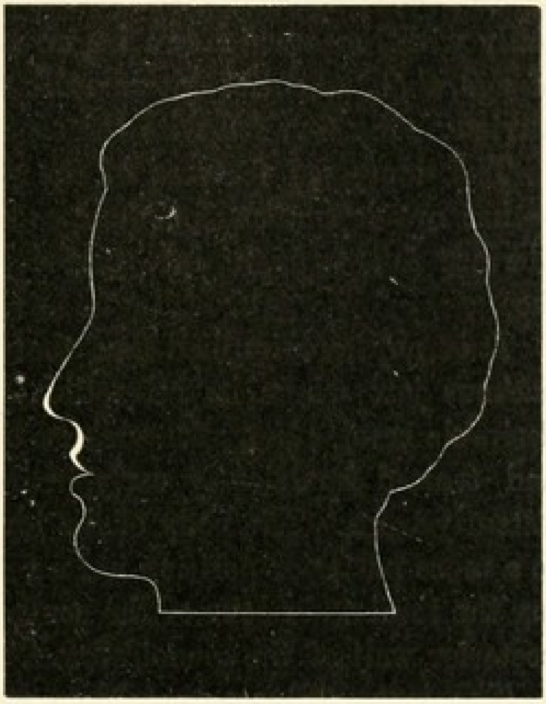
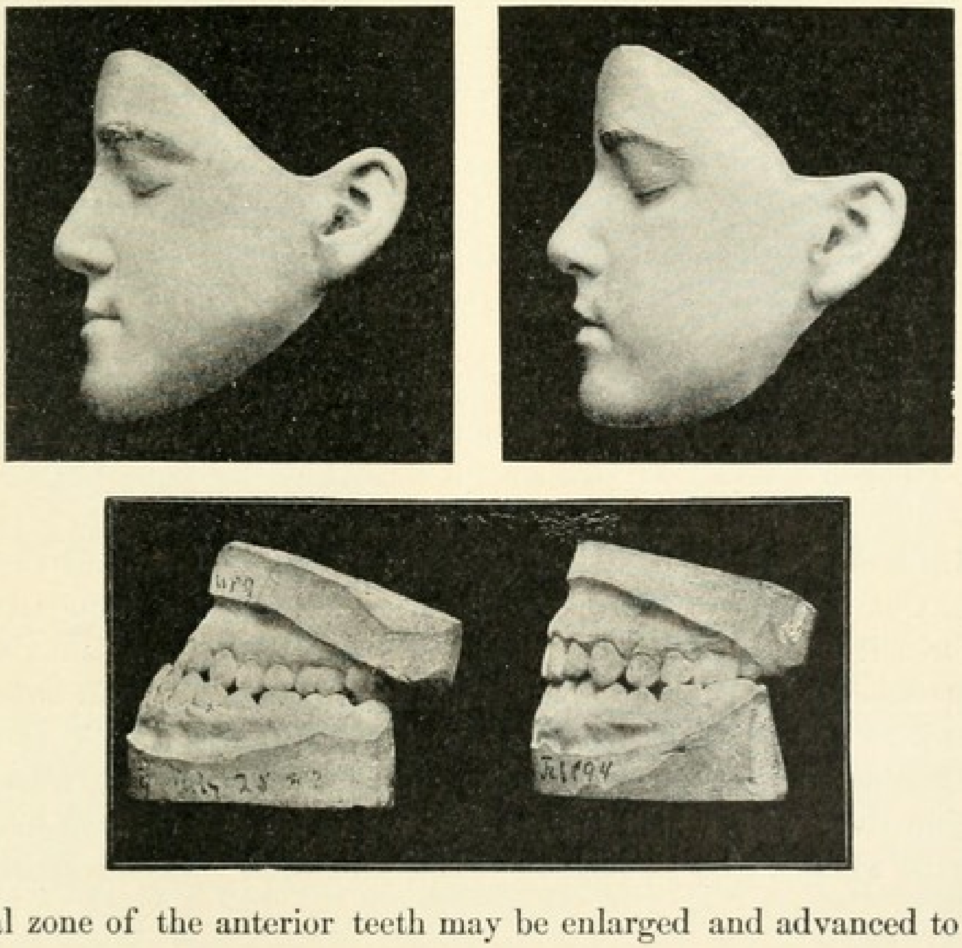


Fig. 866.



results is fully described in section VI. of this chapter. With it the

Fig. 867.



apical zone of the anterior teeth may be enlarged and advanced to any desired degree; while the movement and inclination of the crowns are under the perfect control of the operator.

In this operation it will be found in a majority of cases, and especially with those which are begun as early as thirteen or fourteen years of age, that the entire intermaxillary portion of the upper jaw may be carried bodily forward with the roots of the incisors.

The depressed features of the physiognomy—in segments 1 and 2—that are dependent for their contour upon that portion of the maxillæ are thus brought into perfect harmony with other features of the face.

It is not here implied that there are not many cases of real prognathous jaw where its retraction, if possible, would produce a most desirable result; nor that such an operation is impossible if recognized and treated sufficiently early with properly adjusted apparatus persistently worn. The body of the lower jaw can certainly be forced back to a more posterior position in its relations to the upper, partly by bending the rami and necks of the condyles, and partly by absorption of the posterior wall of the glenoid fossæ.

The many failures that have attended these operations have been largely due to the advanced age of the patients and much to the fact that the apparatus is dependent upon the will or caprice of the patient for its persistent application.

On account of the early maturity and ossification of the lower maxilla, these operations should be undertaken as early as from five to ten years of age.

The caps fitted to the head and chin should be made to exert a uniform pressure over the surfaces upon which they rest, admit of free ventilation, and the whole apparatus when in place should have no projecting parts which will interfere with the comfort of the patient at night.

Fine wire gauze answers admirably for the body of caps. It can be cut and readily shaped to any contour. First cut a narrow pattern of thick paper to accurately fit the zone indicated by the desired border of the skull-cap. Duplicate this in thin tin; solder the free ends together and fit to the head to see that it takes the proper position and desired flare. Cut the pieces of gauze a little in excess of the required size and force it into the rim, where it should be tacked at one point only, with soft solder. The adjustment is finally perfected by again fitting it to the head and a line drawn along the borders where it is to be completely soldered. In constructing the chinpiece, first make a frame of German-silver wire, which is then soldered to gauze as shown in Fig. 868—the whole to be shaped to produce an even pressure upon the chin.

The projecting ends of the wire are bent so as to lie close to the face, and with sufficient extension to prevent the rubber bands pressing into the cheeks. The ends are doubled toward each other at the proper angle to receive the bands.

Fig. 868.

Small wire triangles serve to attach the rubber bands to the skull-cap, by means of flat buttons sewed to the gauze. Finally, cover the rim of the cap with padded silk ribbon and line the chinpiece with some loosely woven material, binding the edges with silk.

The skull-cap is admirably adapted also for applying a retruding force to the upper anterior teeth, by means of a bar which engages with an encircling wire attached to molar anchorages.

V. The Relations of the Physiognomy to the Saving and Extraction of Teeth.

In its widest scope this subject includes the propriety of saving, and on the other hand, the propriety of extracting certain teeth of the deciduous as well as the permanent dental arches which in any way influence the prevention, the production, or the correction of dento-facial

Fig. 869.

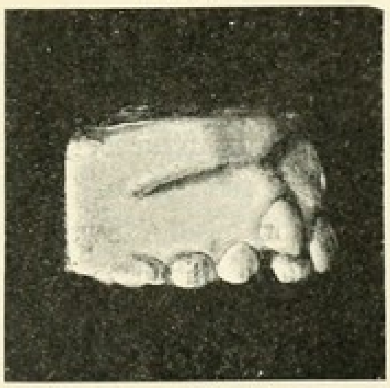
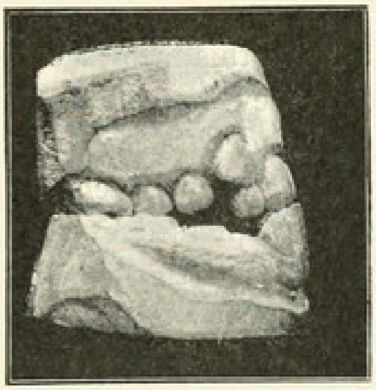


Fig. 870.

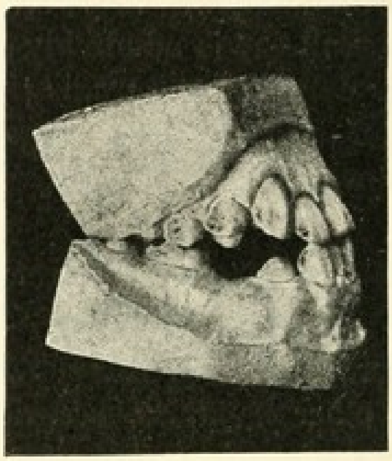


irregularities. Two phases of this subject will be here presented. The first will be in regard to the saving or the extraction of the upper bicuspids for patients older than fourteen, to correct a dental irregularity; the second will deal with the early extraction of the bicuspids to prevent an abnormal upper protrusion.

In the common form of dental irregularity shown by Fig. 869, especially if only the model of the upper jaw were the subject of study, it would in all probability be decided to extract the first bicuspids as the best course to pursue as a first step toward securing a perfect alignment of the dental arch; and the proceeding would probably be correct as far as the upper teeth alone were concerned. And again, if both upper and lower models were studied in occlusion and the irregularity of the lower arch was—as is usually the case—in correspondence with that of the upper, as shown in Fig. 870, the extraction of the lower first bicuspids would doubtless, and correctly, be decided upon. This plan of correction might even be decided upon after a superficial study of the face of the patient, which we may suppose to be similar to that shown in Fig. 871. Certainly the extraction of the lower first bicuspids, which have

Fig. 871.

Fig. 872.



just begun to erupt, and the retraction of the anterior teeth would reduce the apparent protrusion of the lower lip and bring it into more perfect harmony with the depressed upper lip.

Yet when this face is carefully studied from the higher standpoint of esthetic development it becomes evident that the chin and lower lip are not protruded, in their relations to the malar prominences, the bridge of the nose, and the forehead, but that the central features of the physiognomy are depressed even to a decided retraction of the lower portion of the nose; and that which is really demanded in this case is the advancement or forward movement of the entire intermaxillary portion of the jaw and incisor teeth; and further, every tooth in that dental arch is necessary for the ultimate retention of the several parts in their corrected position.

In the correction of malformations which demand the protrusion of the incisors bodily with the roots and intermaxillary process, the position of the canines, as in this case, will frequently prevent the proper attachment and application of apparatus for producing the desired effect; so that it often becomes necessary to first enlarge the dental arch and force the crowns into partial alignment by ordinary means, preparatory to placing the incisors in the grasp of contouring forces. Fig. 872 shows the position of the teeth in this case in the intermediate stage, the anterior teeth crowded into imperfect alignment, and with no special facial improvement. (It may be added that at this stage in the operation, cases of this kind have been considered finished, until it was found possible to enlarge the apical arch.)

Fig. 873.

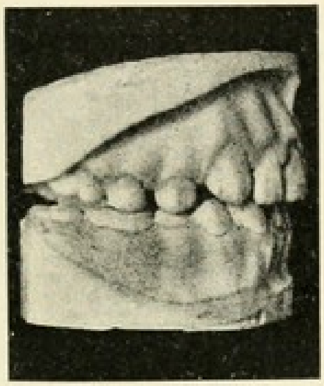


Fig. 874.

Fig. 873 shows correctly the final result, which was accomplished with the contouring apparatus described in section VI. It will be seen that the incisors are in an upright position and there is now ample room for all the teeth, while the remarkable improvement to the physiognomy is poorly shown by the face model Fig. 874.

Another case, that of the upper arch, Fig. 875, if examined alone

Fig. 875.

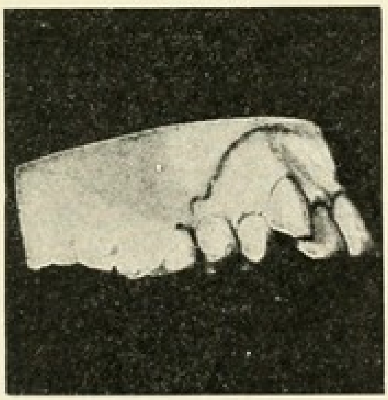
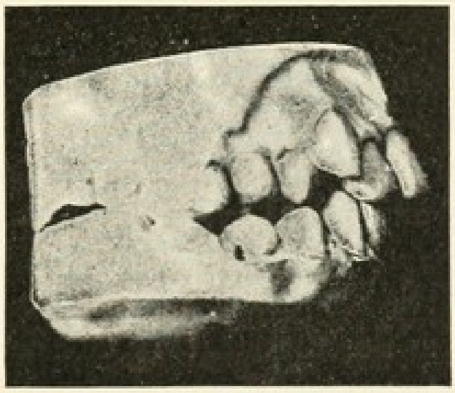


Fig. 876.



and compared with the upper of the former case, or Fig. 869, will be found very similar. The same crowded condition of the teeth, the same lack of sufficient room for the proper eruption of the canines ; and yet this is from the model of a case that absolutely *demanded* the extraction of the bicuspids. At fourteen years of age the irregularity presented the appearance shown in the illustration Fig. 876, showing the models of the case in occlusion. The patient was placed in charge of a dentist who attempted the correction of the irregularity without removal of the first bicuspids: Fig. 877 shows the result two years afterward.

It will be seen that the incisors were forced forward to a decided labial inclination, for the purpose of crowding the canines into alignment; and all the anterior teeth are turned on their axes so as to occupy the least possible space. Fig. 878 is from the model of the face of the patient at that time.

That a mistake was made in the plan of treatment pursued is evidenced by the following considerations: First, the protrusion of the crowns of the upper anterior teeth produces an unhappy expression of the mouth that is equivalent to a deformity, and one that could not be remedied in this particular until certain members of the dental arch were removed. Second, if it were a case in which the maxillary arch was too small, with a depression of the overlying features of the face,

Fig. 877.

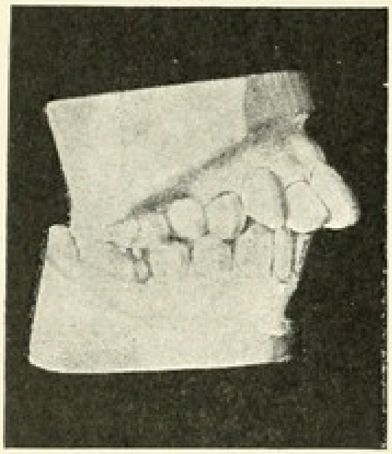


Fig. 878.

the decided labial inclination of the teeth could be overcome by an enlargement of the apical zone, which would have permitted a slight retrusion of the occlusal zone with a partial, if not complete, regulation of the dental and facial deformity. But this was not the condition, and therefore could not be considered. The third and most effective argument is one which should never be overlooked in all cases where the crowns flare outward. The conical shape of the teeth permits them to stand in perfect alignment though with a decided labial inclination, but in this position the interproximal spaces so necessary to the preservation of the teeth are so completely closed as to cut off the union of interproximal gum tissue, which must ultimately result in the resorption of the gum and alveolar process and all the dire consequences that follow.

Had the first bicuspids been extracted, many difficulties in the regulation of the teeth would have been removed; and what is of far greater importance, there would have been a satisfactory result in the dental arch and physiognomy. Or even further, had the upper first bicuspids been extracted as soon as they erupted, together with the deciduous canines, as will be outlined in the second phase of the subject, the case would have required little or no other treatment.

Fig. 879 shows the present position of teeth after regulation, by retruding the anterior teeth to fill spaces caused by the extraction of the bicuspids. Fig. 880 is from a model of the face after treatment. It

Fig. 879.

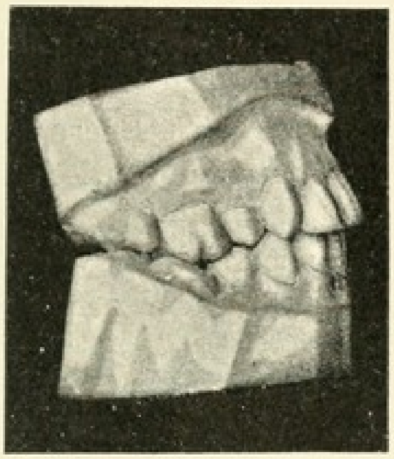


Fig. 880.

will be seen that the interproximal spaces between the teeth are restored, while the retrusion of the anterior teeth allows the lips to fall gracefully into proper position. The improvement in the facial aspect of this and all other cases cannot be fully shown by a plaster model of the face. Fig. 881 was made from a photograph of this patient, taken a few months after the completion of treatment.

Fig. 881.

There are many instances where the early extraction of the bicuspids, as soon as they can be reached with the forceps, is demanded.

For example, adult faces with abnormal protruding upper jaws and teeth, and with a bulged appearance about the lower portion of the nose should have been thus treated. The teeth are commonly large, prominent, and crowded, though not always labially inclined.

The ordinary upper protrusions which come under this head are so common they will require no further explanation or illustration.

Upper protrusions where the teeth are not labially inclined are not quite so common.

The alveolar arch is necessarily prominent, though the deformity in the main, as in the more common forms of protrusion, is due to the large size of the upper maxilla proper, far out of proportion to the more delicately chiseled features which it supports and forces into unsymmetrical contours. The depressions in which the wings of the nose rest are more or less obliterated, as would be occasioned by the sting of a bee or an alveolar abscess. The nostrils are broad and open, and the end of the nose forced forward and upward (*retroussé*) by the protrusion of the spinous process and cartilaginous septum. The upper lip being stretched over its inharmonious frame is shortened so as to cover the teeth with difficulty, and in action readily rises to an unpleasant exposure of the teeth and gums.

This is an extreme, though not uncommon, condition. Every stage from this to perfect harmony characterizes the innumerable varieties of a certain type of physiognomy.

Fig. 882 is from the face model of a young man, eighteen years of age, and may be taken as a type of this character of facial deformity.

Fig. 882.

Fig. 883.

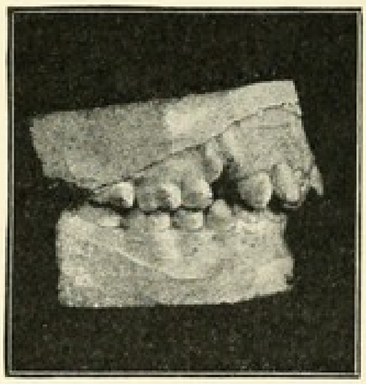


Fig 883 shows the teeth in occlusion. The canines and canine eminences are very prominent, and extend high up under the wings of the nose.

Had this case received the early treatment here advocated, the deformity would have been prevented and the almost insurmountable difficulties attending its reduction during nearly three years of constant treatment altogether avoided.

Any one who has never attempted to move the roots of the canines in a posterior direction for patients older than sixteen cannot begin to appreciate the difficulties of such an operation.

And while the result is quite satisfactory under the circumstances, as will be seen by Figs. 884 and 885, the physiognomy is not nearly so perfect esthetically as it would have been had the case received proper early treatment.

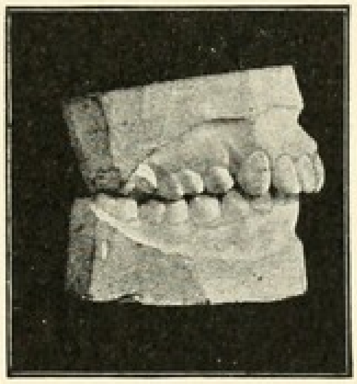
The important consideration from a surgical and artistic standpoint in nearly all cases of abnormal upper protrusion is: Has not Nature been forced to produce these conditions, wholly or in part, to accommodate teeth that were too large for the natural or inherent frame and overlying features? And could we have helped Nature in the early years of development, by making it unnecessary for her to produce this excessive growth of bone for the development and sustenance of all these large teeth?

The same is true where the protrusion seems to have been caused by the inheritance of an inharmoniously large jaw crowded full of teeth.

We certainly cannot reduce the size of the teeth, but we can reduce their number, and in so doing reduce the size of the destined maxillary

FIG. 884.

FIG. 885.



and dental arch. But we must make no mistake. The danger of advocating such a principle to those who have given this branch of dentistry little thought is that teeth will be extracted to accommodate an overcrowded condition in the arch, with little or no thought of the physiognomy, when a careful and properly pursued study of the features and their comparison with the parental types will show that in reality the dental and maxillary arch should be enlarged, and every tooth remain to induce its natural growth and development. If this has not been attained by natural processes, every tooth should certainly remain to hold the artificially developed arch in place.

How are we to study the undeveloped face of a child, every lineament of which is passing through rapid changes of growth, with a view of determining whether or not the dental arch and jaws will be too prominent, or that other features will not enlarge to a harmonizing proportion?

A most wonderful provision of Nature in dentition causes the full-sized crowns of teeth to erupt, as regards time, somewhat in proportion to the natural growth and enlargement of the jaws. And even when they do not erupt earlier than is normal, or when their natural eruption is not interfered with by the premature extraction of the deciduous teeth, they are usually obliged to take an irregular position or attitude at first, and await the growth of the jaw which permits them to become regular.

It is perhaps a safe general rule to never extract a permanent tooth for the purpose alone of correcting a dental irregularity, unless the jaw has ceased growing; and never then unless it is shown by a careful study of the position of the teeth—their relation and occlusion—that the dental arch should not be expanded; or by a study of the physiognomy, that the alveolo-dental arch should not be enlarged.

In a study of the relations of the teeth, the jaws, and the physiognomy of a child with the view of determining the advisability of extraction to correct or prevent the ultimate production of a facial deformity or marked imperfection of the features, it may become necessary to study the physiognomies of both parents and possibly other members of the family, to correctly determine the influence of inheritance.

In this comparison of temperament, physical frame, features, and teeth, it may require no more than a glance to furnish all the data that will be of practical use.

Usually but one parent accompanies the little patient, and a study of that one physiognomy may be a sufficient guide; if not, other members of the family should be seen.

If there be a marked difference in the parents it may not be difficult to determine from which the child has inherited the teeth, by the peculiar shape and size of the incisors alone. But in regard to the maxillæ in an undeveloped condition there will be more difficulty, though it is well to remember that the deciduous teeth are rarely irregular or disproportionate in size to the frame and facial features. If, therefore, there be a more than natural difference in the size of the permanent and deciduous teeth it will indicate union of inharmonious types.

In this connection it must not be forgotten that the crowns of the permanent incisors are almost invariably far too large for their undeveloped surroundings. The apparently disproportionate size of the central incisors to that of the jaw is a subject of frequent and anxious parental comment. If the occlusion of the incisor teeth be far from a normal type in their anterior relations, and the same condition exists with either parent, it is an indication of what the child will become if unaided by dental skill, especially if a similarity be noted in other particulars.

With differences in temperament, compare general shape and size of the eyes, brows, ears, and teeth.

Other features are so subject to change in the processes of natural growth and development that they cannot be relied upon to furnish legitimate data. For instance, the nose may change in a few years of late youthful development from one originally small and short—and over the nasal bones decidedly depressed—to a form different in every particular.

When neither parent presents the same unsymmetrical relations that promise to prevail in the child, the cause may be a union of the large teeth of one parent with the small jaws of the other.

When the teeth of the parents are decidedly dissimilar in size, it may be possible, as before stated, to determine with certainty from which parent the teeth of the child are inherited, and when the teeth and jaws of the other parent are small and other features are similar to those of the child, it indicates a union of undiluted types.

All these things are of the utmost importance in determining the impropriety of extracting certain teeth to reduce an apparent abnormal protrusion, which may in time become symmetrical in its relation by the natural growth of the jaws and other features ; and also the equally culpable error of saving teeth, or the failure to extract teeth, whose very presence in the arch obliges Nature to reproduce a parental deformity, or produce an acquired deformity, by an effort to sustain the large teeth of one parent in conjunction with the small jaws of the other.

For a child with an abnormal upper protrusion similar to Figs. 886 and 887, with teeth prominent and crowded in an arch which does not

Fig. 886.

Fig. 887.

admit of correcting by a lateral expansion, extract the first bicuspids as early as possible, even before their eruption is completed, together with the deciduous canines—unless it be one of those very rare instances where the first permanent molars cannot be saved.

The same is true of the lower, when there is reason to believe there will be a disproportionate over-development of the lower dental arch.

In the ordinary course of eruption the development and eruption of the permanent canines are doubtless more influential than those of other teeth in emphasizing an anterior protrusion of the central features of the physiognomy.

In the course of their eruption they are obliged to crowd into alignment along the mesial surfaces of the roots and crowns of the first

Fig. 888.

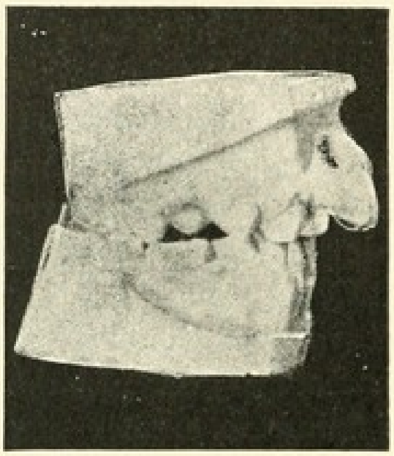
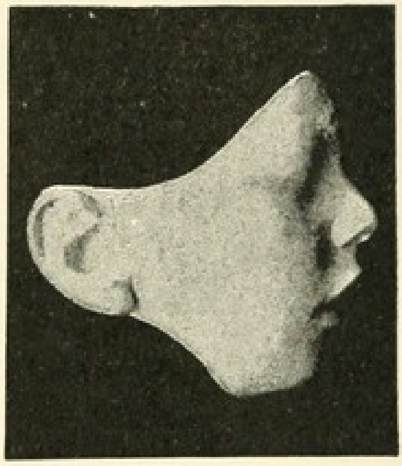


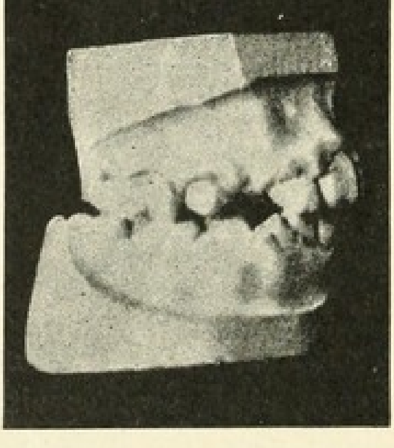
Fig. 889.



bicuspids—which at this time represent the immovable bases of the arch—with the result that the incisive and intermaxillary portion of the arch is forced forward to a more pronounced position. This movement has been shown to be not impossible or difficult of attainment by artificial force, even much later in life.

With the first bicuspids and deciduous canines removed sufficiently early there are numberless instances when the arch, anterior to the second bicuspids, would be diminished the width of a bicuspid, without resort to artificial means.

Fig. 890.



By the exertion of a slight traction force from an occipital base of anchorage the sockets of the temporary canines will be closed by the permanent laterals, and the permanent canines in the course of their eruption will be deflected into the alveoli of the extracted bicuspids.

Figs. 888 and 889 represent one case out of many under treatment by this method, though not all by the occipital method.

Fig. 890 shows the position of the teeth after about two months of traction force from molar anchorages; the protrusion not being so pronounced as to demand the use of the skull-cap.

It will be seen by the canine eminences—though far better shown upon the model itself—that the position of the canine crowns is immediately over the former alveoli of the first bicuspids. As they continue to grow downward in this somewhat open channel, their roots, which are not at present developed, will grow upward, the teeth in their entirety finally taking a position and inclination similar to that of the bicuspids which they replace, and considerably posterior to that which they were otherwise destined to occupy.

The patient, nine years of age, had the teeth, eyes, ears, and general temperament of the father, whose upper arch was abnormally protruded in a similar manner, which was the *raison d'être* for dental aid.

Had the father's teeth been in proper relative and symmetrical position, and similar to the son's in other particulars which could be legitimately used as data, it would have been an argument in favor of non-extraction with the expectation of other treatment later; but it should not have been passed upon without seeing the mother. Had the mother's teeth been found small and the general physical features cast in a more delicate mould than her husband's, investigations along other lines would have been required with the view of determining if the child had not the large teeth of the father and small jaws of the mother; in which case extraction would also have been indicated.

VI. The Contouring Apparatus.

The limited area upon which force can be applied to a tooth, compared with that portion covered by the gum and imbedded in a bony socket, has made it next to impossible, with all ordinary methods, to move the apex of the root in the direction of the applied force; nor could this ever be accomplished with force exerted in the usual way at one point upon the crown, however near the margin of the gum it may be applied, for the opposing margin of the alveolar socket must receive the greater portion of this direct force, and in proportion to its resistance it will become a fulcrum exerting a tendency to move the apex of the root in the opposite direction.

But if in the construction of the apparatus a static fulcrum is created independent of the alveolar process at a point near the occluding portion of the crown, while the power is applied at a point as far upon the root as the mechanical and other opportunities of the case will permit, the apparatus becomes a lever of the third kind, the power being directed to a movement of the entire root in the direction of the applied force.

This proposition is made plain by reference to diagrams. In Fig. 891 let A be a point upon a central incisor at which force is applied in the direction indicated by the arrow, then will the opposing wall, B, of the alveolar socket near its margin receive nearly all of the direct force; and in proportion to its resistance will there be a tendency to move the root in the opposite direction. This will also hold good even if the force be applied at A, Fig. 892, or as far upon the root as may be permitted by attaching a rigid upright bar, C, to the anterior surface of the

FIG. 891.

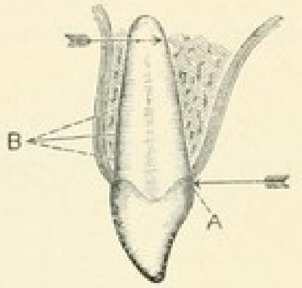
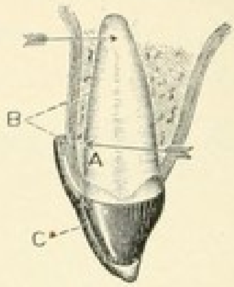
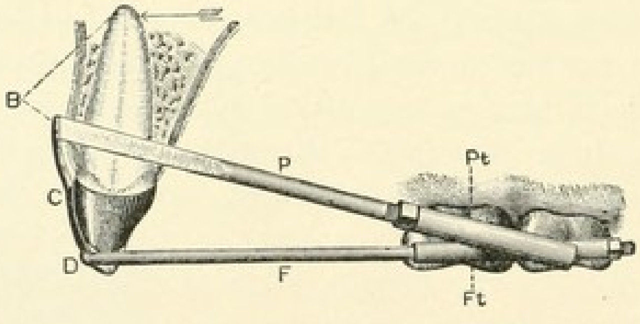


FIG. 892.



crown; the only difference being that the direct force is distributed over a greater area. But if, as in Fig. 893, to the lower end of C a traction wire or bar, F, is attached and if the mechanical principles of the machine be further enforced by uniting its posterior attachment to the anchorage of the power bar, P, the anchorage force will be materially neutralized and an independent static fulcrum at D created. The apparatus now will distribute its force over the entire root, and give complete direction and control of whatever power is put into it. The

FIG. 893.



entire tooth may be carried forward bodily or either end may be made to move the more rapidly. The force thus directed to the ends of the roots will have an increased tendency to move the more or less yielding bone in which they are imbedded.

For practical illustrations of what has been accomplished by an apparatus of this kind see cases described in sections I., IV., and V. of this chapter.

The contouring apparatus is made entirely of German silver, with the exception of the nuts, which are of nickel. German silver is preferred, not because it is cheaper than gold and platinum, but because it possesses certain qualities which render it adapted for the purpose to which it is applied.

In making the banding material for this apparatus, thoroughly anneal a piece of wire No. 13 and pass it through the rollers—with an occasional re-annealing—until it is reduced in thickness to Nos. 35 and 38 (or 0.004 and 0.0056 of an inch).[1] This will give bands about $\frac{1}{4}$ and $\frac{3}{16}$ of an inch wide. Use the thinner material for the anterior teeth and the thicker for the anchorage appliance. Before using, it should be wound into rolls and brought to an even red heat, held there for ten minutes, then allowed to cool slowly. This will ensure perfect softness and adaptability.

In taking the measurements for the bands, cut from the material the proper length, and, holding the ends of the loop between thumb and finger, pass it over the tooth to be fitted. When in place bend the ends sharply at right angles and finally, grasping the two ends in the pliers, draw the band firmly around the tooth. The bands for the anterior teeth should extend at this time sufficiently beneath the approximal borders of the gum to assure complete extension to the labio- and linguo-gingival borders. The approximal extension should be cut down to the gingival border of the enamel in the final finishing of the apparatus.

After the bands are soldered carefully, fit and burnish them to the teeth. In order to obtain perfect adaptation it often becomes necessary to contour them slightly with the proper pliers. The joint which projects on the anterior surface of the bands for the anterior teeth should be placed at one side of the middle to allow the upright bar C, Fig. 893, to rest exactly along the median line.

When the teeth are so crowded together that the banding material cannot be passed freely between them they should first be separated with waxed tape. It is to be preferred to rubber because sufficient space is obtained in twenty-four hours with little or no discomfort to the patient beyond the general soreness of the teeth, which must always follow the preliminary steps of a regulating operation. These tapes are allowed to remain between the teeth—renewing them each day—till the final attachment of the apparatus.

The first appliance to be described is that designed for moving the roots of the upper incisors forward.

Before it is possible to apply the contouring force it is frequently necessary to first move the crowns of very irregular teeth into alignment somewhat—and even to rotate them—so as to bring them into a position to be properly grasped by the power bar of the apparatus. (See Fig. 872, with description.)

[1] In this description it will be understood that German silver is the metal indicated and Brown & Sharp's gauge that by which thicknesses are measured.

When the bands have been fitted as described above, they should be placed upon the four incisors and a plaster impression taken of the labial surfaces of the bands, teeth, and adjoining gum. For a tray to carry the plaster to place use a thin piece of lead cut the proper size.

After the impression is removed, carefully remove the bands and place them in their respective positions on the impression; the joints of the bands will serve to guide them to place. This when filled with Teague's or other investing material will give a model with the bands in position, to which may be fitted and soldered the upright bars.

The upright bars are made of No. 14 wire, bent to fit the anterior face of the band and tooth along the median line of its axis, and also the gum to about $\frac{1}{8}$ of an inch above its margin. In soldering them to the bands, completely fill the V-shaped spaces on either side the upright bars, to give sufficient rigidity and finish to the appliance. After they have been soldered and removed from the model they are further finished by filing the bars flat on the sides which lie next to the gum, tapering them to one-half their diameters at the upper ends. It is against this surface that the power bar, P, is to rest, as shown in Fig. 893. The upright bar may also be flattened somewhat over the face of the tooth, but not at the point where it leaves the band for the gum, as full strength and rigidity are required here. (In Fig. 893 the engraver has made the upright bar appear far too light at this point—marked C—for practical use in sustaining the great force of the power bar at B.)

The bars having been cut off even with the occluding ends of the teeth, and properly rounded and polished, the small transverse grooves, D, may be cut just above the ends to receive the fulcrum wire, F, No. 24 gauge, which is much smaller than shown in Fig. 893.

In constructing the anchorage portion of the apparatus to be attached to the posterior teeth too much care cannot be observed in order that the several parts perform the work assigned to them and the greater portion of force be neutralized at points of anchorage.

When the second molars have fully erupted, band the first and second molars—otherwise the second bicuspids and first molars—and sometimes all three teeth. Where it becomes advisable to apply this particular form of force before the eruption of the second bicuspids, the second deciduous and first permanent molars will answer for the purpose.

The banding material should be as wide as the tooth will permit, and in thickness from Nos. 36 to 35 (or 0.005 to 0.0055 of an inch). When the bands have been made as described and perfectly fitted, place them in the positions they are to occupy and take a plaster impression —one side at a time—allowing the plaster to barely cover the bands, but sufficiently extensive to show on the model the bicuspids and canines, for reasons that will become obvious.

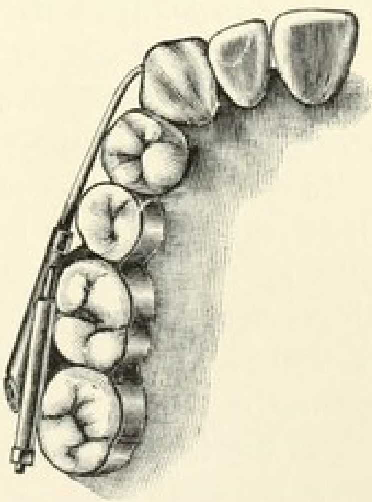
After removal, replace the bands accurately in their positions in the impression, and fill as before with Teague's or any good investing material.

This material will give a model that will hold the bands in exact relative position while they are being soldered, and one also that is sufficiently extensive to enable the placing and soldering of the tubes in proper position and direction—a thing of the utmost importance.

In selecting the tubes the smaller should loosely fit the threaded end of No. 20 wire, which is the size to use for the fulcrum wire, F. The size of the larger tube should be governed by the size of the power bar, *i. e.* when the jaw is large with fully developed teeth, or when the distance is considerable from anchorage appliances to the upright bars on the anterior teeth, the size of the power bar, P, should be No. 14. It should rarely be smaller than No. 15, though when the operation is attempted for very young children No. 16 will answer the purpose. But the ordinary German-silver wire of the shops of these sizes will not do. It must be specially prepared in order to withstand, without bending, the great force exerted upon a bent bow or bar. All wire for power bars should be drawn, without annealing, from No. 6, and be nearly as rigid as tempered steel. In the selection of tubes the larger should loosely fit the threaded end of the power bar, and be $\frac{1}{2}$ to $\frac{3}{4}$ of an inch long.

An important feature is the position of the power-bar tubes. They should be so placed and soldered to the anchorage bands that the power bar—when placed in the tubes—will extend from it in a straight line to the canines, where it bends over to engage with the upright bars, C. (See Fig. 893.) If this precaution be not taken, but instead the power tubes are soldered in the ordinary way, in contact with the buccal surfaces of the bands, the power bow, in most instances, will require to commence its encircling bend immediately upon emerging from the tubes, with a decided weakening of its rigidity and possible failure.

Fig. 894.



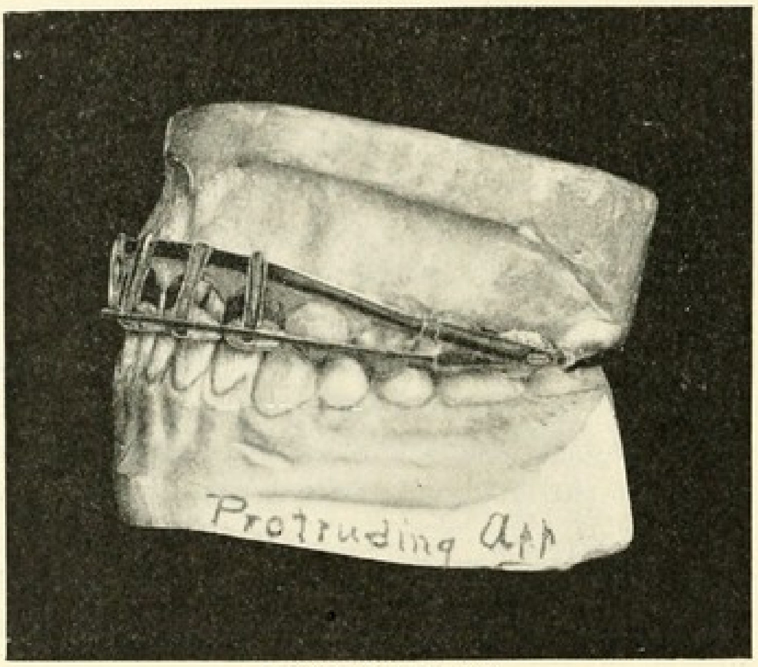
In order to obtain the proper position it will often be advisable to rest the posterior end of the larger tube upon that of the smaller, as shown in Figs. 894 and 895. All projecting portions that are liable to irritate the mouth should be rounded and polished.

In soldering tubes to place use a slightly lower grade of silver solder than that used to join the bands. Use sufficient to thoroughly unite all the joints, and fill all V-shaped spaces, being careful to turn the joints of the tubes toward the bands that they may be closed. Thoroughly unite the approximal surfaces of the bands and reinforce the lingual V with an extra piece. (See Fig. 894.)

In finishing the apparatus, the soldered parts should be boiled in a solution of sulfuric acid to remove the borax and oxids. After being neutralized and brushed they are now ready for the trial fitting to the mouth.

In this operation the bands should be perfectly fitted to the position

Fig. 895.



Protrusion apparatus.

they are to occupy—the upright bars readjusted, if necessary, and all surplus material cut away—sharp and rough surfaces smoothed and polished, and the gingival and occluding edges of the bands carefully burnished to the teeth.

In constructing the power bar the anchorage attachments should be placed upon a plaster model of the teeth, in order to accurately determine its length and the lengths of its threaded ends, then properly shaped to the gum over which it is to rest. It should be flattened in the rollers to about one-half its diameter along that portion which lies in front of the bicuspids. In this operation it may become necessary to roll the bar so that the bent bow is flaring, to fit the gums against which it nearly rests, and to engage perfectly with the upright bars—especially if the incisors are labially inclined.

When the apparatus is polished and heavily gold-plated it is ready for the final cementing to the teeth. Brush the teeth with pumice stone, place a napkin in the mouth, and dry the teeth and surrounding gum with spunk. Pack it around the teeth, where it is held firmly in position while the cement is being prepared and placed in the bands by an assistant. See that all material used in polishing is removed from the inner surface of the bands, and the surface scraped or scratched with a sharp excavator.

The cement should be mixed thoroughly, but rapidly, to the consistence of thick cream, and scraped from the spatula along the upper and inner edges of the bands.

When each part of the appliance is ready, force it quickly and firmly to its position; its final adjustment being perfected by the use of the mallet on a large oval plugger resting upon the soldered parts.

After the anchorage attachments have been cemented in place, make an appointment for the next day to attach the remainder of the apparatus, in order to allow the cement to become perfectly hardened, that the bands may not be dislodged, or even slightly started, by the strain to which they are subjected in the final adjustment of the power bar.

Another way is to adjust the anchorage attachments to the ends of the power bar—out of the mouth—after the parts have been perfected, shaped, and fitted—and cement the whole to place in this condition. By this method the whole apparatus can be attached to the teeth at one sitting.

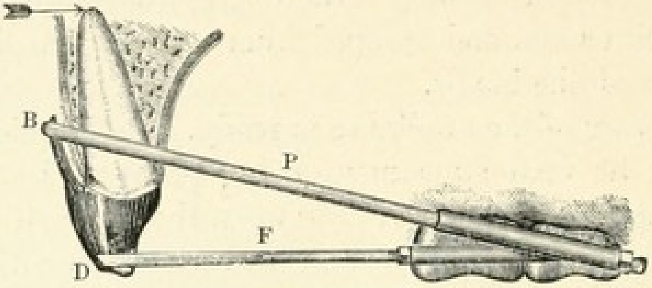
On account of the intense rigidity of the power bar it is important that when it is in place on the teeth the threaded ends should lie within their respective anchorage tubes without exerting the slightest force in any direction until it is applied, as intended, by the power of the screws; therefore great care should be observed in giving to it the proper shape, by bending as accurately as possible upon the plaster model, and afterward by a trial fitting in the mouth before cementing the anchorage bands.

With the anchorage attachments and power bar in position the bands are to be cemented to the anterior teeth. As each band is carried to its place, it should be seen that the flattened surface of the upright bar is pressed down firmly upon the power bar, so that an even force will be given to each of the teeth when power is applied—it being presupposed that in the trial fitting of the parts the power bar was shaped so as to engage perfectly with the upright bars—the free ends of the latter extending slightly above it.

The same kind of apparatus may be employed upon the lower incisors with perfect success, though there will not be the same tendency to carry the entire alveolar ridge forward with the roots as on the upper; the change being largely by a metamorphosis of alveolar tissue.

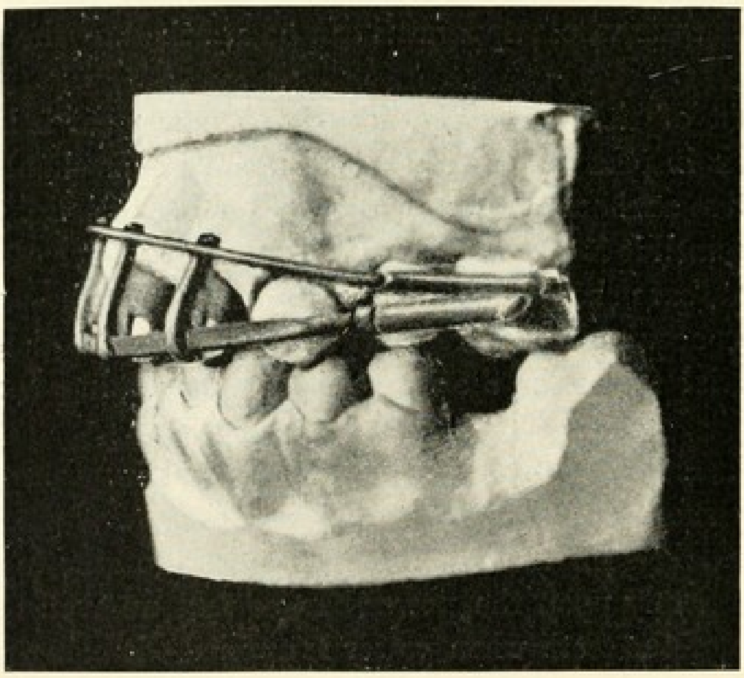
An apparatus for contruding the roots of the anterior teeth is constructed in a very similar manner. The direction of the two forces being reversed, it becomes necessary, however, to make certain important variations. The power bar (P, Fig. 896) now exerting a traction force, No. 16 will be found sufficiently large for all purposes. It is not flattened, but rests in grooves cut in the anterior surfaces of the

Fig. 896.



upright bars, B. The power-bar tubes should be soldered closely to the anchorage bands so that the nuts which now work at the posterior ends of the bar will not irritate the mucous membrane of the cheek. The fulcrum bar, F, exerting in this apparatus a jack-screw force, should be

Fig. 897.



No. 16. It is flattened along its middle portion to engage with the occluding ends of the upright bars at D, provision being made for the purpose in the construction.

The power of the two forces being so great upon the upright bars, with a tendency to lift the occluding ends from their attachments, and thus allow the free ends to press into the gum, it is important with this apparatus that the occluding end attachments be reinforced by soldering to the bands an extra piece of banding material that shall extend from the labial face over the occluding end of the tooth to the lingual portion (shown in Fig. 897).

After the joint of the band has been soldered, the reinforcing piece, of sufficient length for the purpose, should first be soldered to the labial face alongside of the joint; then the band is perfectly fitted to the natural tooth—the extra piece being bent over and burnished to its position on the labial surface, and the position of its end distinctly marked upon the band, to serve as a guide to soldering.

When the hoods are completed in this way and finally all placed on the tooth and perfectly fitted, an impression should be taken for fitting and soldering the upright bars as described for the protrusion apparatus.

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