THE TREATMENT OF TEETH

NOTES ON THE TREATMENT AND FILLING OF TEETH

BY

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THIRD EDITION

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PREFACE

TO THE THIRD EDITION

During the period which has elapsed since the publication of the second edition the writer's notes have grown in volume, consequently the third edition is larger than its predecessors. The book is more fully illustrated, and has been carefully revised and brought up to date.

The chapter on Porcelain Inlays has been completely rewritten; the chapter on Treatment of the Teeth Preparatory to Filling Them, largely so. A chapter on Gold Inlays has been added, and in various other parts additions have been made to the text.

The writer begs to express his sincere thanks to Mr. Chas. Rippon for contributing "The Technique of Gold Inlays" and the sketches illustrating this; to Mr. Geo. Brunton for the description of his strip matrix, and for the model showing the application of the same; to Messrs. C. Ash, Sons & Co., Ltd., and to the S. S. White Dental Manufacturing Co. for the loan of blocks for illustrations; to the publishers for the blocks specially made for this edition, and to all who, by their published writings or their personal communications, have so greatly assisted him in the production of this work.

WM. CASS GRAYSTON.

August 1909.

PREFACE

TO THE SECOND EDITION

A SECOND edition of these "Notes" having been called for, it has been found necessary to considerably revise and enlarge them in order to keep pace with the march of dental progress.

The scheme of the first edition is adhered to, inasmuch as no attempt is made to write a complete treatise on "The Treatment and Filling of Teeth," but merely to allude to certain points in operative dentistry which have particularly interested the writer.

It would perhaps be better if the title were "Notes on the Filling and Treatment of Teeth," but the original title (which was chosen because the treatment of a diseased tooth comes before the filling) is retained to avoid confusion.

The word occlusal is selected in preference to the more usual term crown, whenever the masticating surface of a bicuspid or molar is indicated, for the word crown really includes the whole of the exposed surfaces, viz., mesial, distal, buccal, and lingual, as well as masticating or occlusal.

WM. CASS GRAYSTON.

February 1904.

INTRODUCTION

TO THE FIRST EDITION

It is not intended in the following notes to enter exhaustively into the subject of treating and filling teeth, but merely to allude to certain practical points in a simple manner. The scientific principles which underlie all practical work are not dealt with, for they are best studied in the works of those who have devoted much time to scientific research. It has been frequently stated, and is very true, that success in any operation depends more on the man who performs it than on the method he employs, and consequently a description of personal work, in which there is little, if anything, that is new or original may be of small interest to the experienced. It is hoped, however, that here and there may be found a hint that will be of service to younger practitioners.

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NOTES ON THE TREATMENT AND FILLING OF TEETH

CHAPTER I

THE RELIEF OF PAIN

As many patients consult a dentist primarily for the relief of toothache, it will be well to briefly consider the usual causes of this most distressing pain, and the remedies which generally relieve it.

Toothache is most frequently caused by irritation and inflammation of the tooth-pulp, by irritation and inflammation of the dental periosteum, or by a combined inflammation of both these parts. In the various text-books accurate and careful descriptions of the pain caused by these different conditions, and also by the various stages of the same condition, are clearly set forth; but it happens in practice that few patients are capable of accurately describing the pain they have suffered, and beyond making a few general inquiries, such as how long the pain has existed, whether or no it keeps them awake at night, and whether it is very severe, the questioning of patients is of very little value, and the diagnosis must always principally depend on the eyes and instruments of the operator. If the tooth to which the patient refers the pain is carious, the decay should be removed sufficiently to admit a temporary filling. If the pulp is not exposed, and external pressure on the tooth in all directions gives no pain, if there is no tenderness on applying pressure to the gum over the roots of the tooth, and if the pain has not been severe, it may be presumed the cause is pulp irritation, and that the case will be readily amenable to treatment. Any of the usual remedies, such as carbolic acid, oil of cloves, or creosote, will generally give prompt relief. A very useful preparation is a paste made of carbolic acid, oil of cloves, and tannin, to which, in all cases of severe pain caused by an inflamed pulp, a little cocaine may be added with advantage. Whenever this paste is allowed to remain in a tooth for from twenty-four hours to a few days, it will be found that the tannin has dried up and hardened the softened dentine; this renders its removal easier and less painful, and frequently does away with the necessity for flooring a cavity with cement or gutta-percha in order to prevent shocks from thermal change. It is important to relieve pain as promptly as possible, and in order to effect this it is occasionally necessary, in cases of non-exposure of the pulp, to apply the rubber dam and thoroughly dry the dentine with applications of absolute alcohol and warm air, in order to promote the absorption of the medicament. It is hardly necessary to mention that if one remedy does not answer, another one should be tried. It will often be found that an alternate application of two or three remedies is better than a continuous application of a single one. It is also hardly necessary to say, that whenever the pain is severe, every effort should be made to relieve it before the patient leaves the chair, and that it is frequently advisable, if the pain has not completely subsided, to tell the patient to return in from half-an-hour to an hour, if necessary. An application of chloroform may "act as a charm" in quickly relieving pain, but it should always be followed by one of the already-mentioned medicaments, owing to its effects rapidly passing off.

Whenever an aching tooth, with a live but unexposed pulp, resists the usual treatment, it becomes a question whether the pulp shall be boldly opened into, so as to enable the remedies to be placed in direct contact with it; whether arsenical paste shall be at once applied, informing the patient that probably severe pain will ensue for some hours; or whether the tooth shall be extracted. The position of the cavity, the value of the tooth, and the temperament of the patient, are all factors in determining the line of treatment. If, on removing the loose débris from the cavity, a portion of the pulp is seen to be exposed, it is well to remove as much of the softened dentine in the neighbourhood of the exposure as can be done without causing pain. An application of one or more of the previously mentioned remedies will usually stop the pain. Whatever application or dressing is used must always be carefully sealed in the cavity before the patient is dismissed; and it is important to do this with as little pressure as possible. Pressure not only causes pain in these cases, but may also force out the greater part of the medicament on which so much depends.

In many cases the dressing may be covered up with a concave metal cap, which protects the pulp from any pressure that might be caused by the temporary filling, and also encloses the dressing, reducing the risk of squeezing some of it out of the cavity. There is every advantage in using these caps whenever they can be readily and accurately applied. But when they are difficult to place in position, they are perhaps more trouble than they are worth. They are quickly punched out of a sheet of tin—or the tinned iron, of which the ordinary tin boxes are made, can be used. The

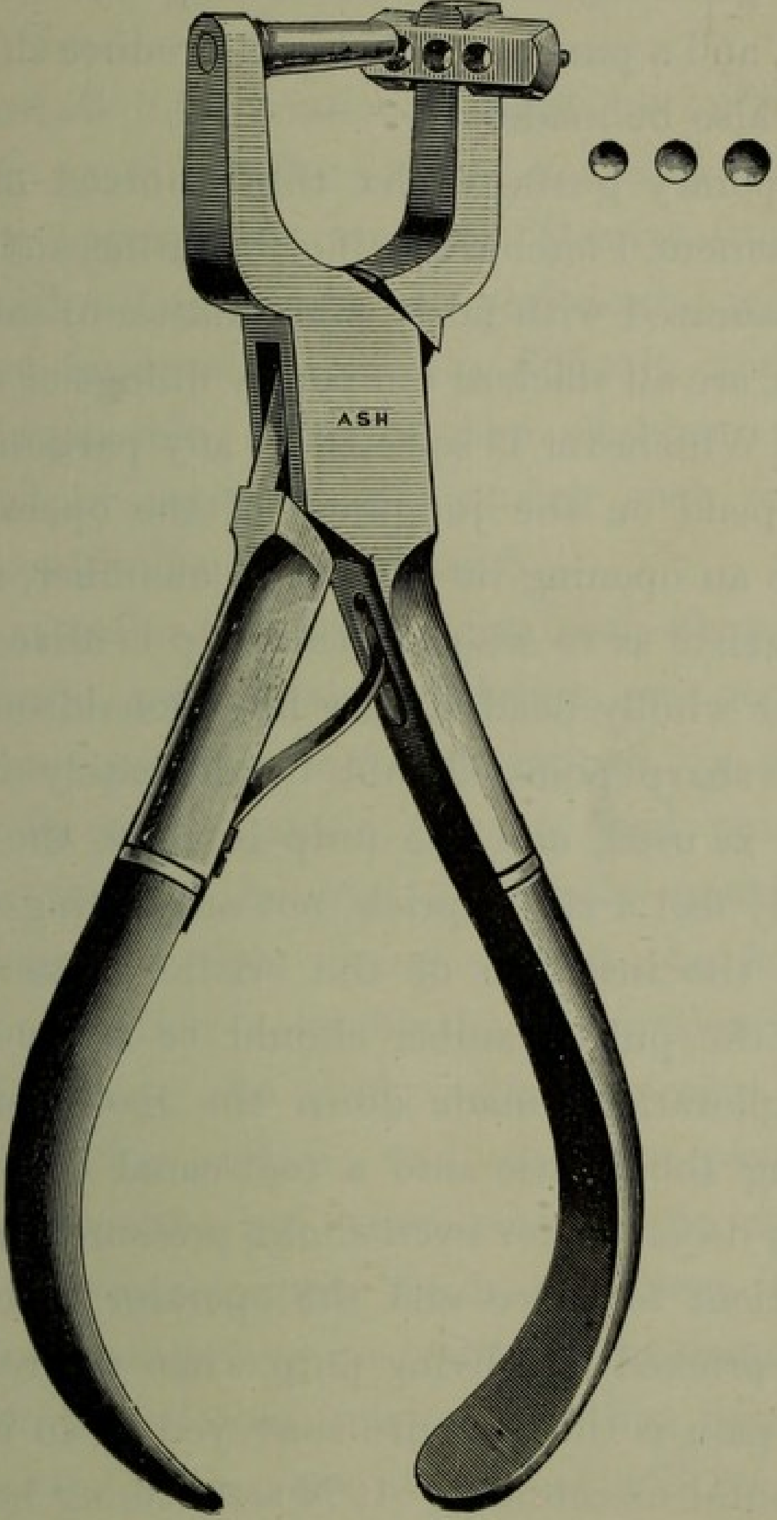


FIG. 1.

instrument designed for this purpose by Mr. Northcroft (Fig. 1) produces *round* caps—the form that is most generally useful, but *oval* caps are sometimes needed, and a punch which would produce this shape should also be made.

Temporary gutta-percha, thinly mixed oxyphosphate cement, Fletcher's artificial dentine, and cotton-wool saturated with fairly thick mastic or sandarach varnish, are all efficient temporary fillings or dressing seals. Whichever is selected in any particular case will depend on the judgment of the operator. If there is an opening into the pulp chamber, and any doubt exists as to whether the pulp is alive, or partially or wholly dead, a very fine Donaldson bristle with a sharp point should be delicately inserted. If care is used, and the pulp is alive, the patient will only feel a slight prick, not amounting to pain. Should the insertion of the bristle cause no sensation, the pulp-chamber should be freely opened, and explorations made down the root-canals. In inserting the bristle into a root-canal one is occasionally deceived, for even slight pressure may cause the patient to wince, and the operator to conclude he has pricked into living pulp, when the real cause of the pain is the pressure conveyed to an inflamed periodontal membrane. It is astonishing how little pressure, even with such a delicate instrument as a Donaldson bristle, will sometimes cause a patient to tell the operator he has "touched the nerve," subsequent examination revealing that the pulp is entirely dead.

Periosteal inflammation, caused by an inflamed pulp, is readily relieved by soothing the pulp with any appropriate remedy. The treatment of a tooth with a highly inflamed periodontal membrane is often rendered extremely difficult, and sometimes impossible, owing to the slightest pressure produced by manipulation causing such pain that the patient will not submit to it.

Inflammation of the alveolar periosteum, dental periosteum, peridental membrane, or periodontal membrane, as it is variously termed, is generally caused by septic poison from a dead pulp. The pain is usually relieved by freely opening the pulp-chamber—thus giving vent to the foul gases of decomposition—and by the application of counter irritants to the gum; iodine liniment is very useful for this purpose, and capsicum plasters are also very good; but some patients do not seem able to properly apply them, and keep them in place sufficiently long, to receive much benefit.

When periodontal inflammation has reached the suppurative stage, very little relief will be obtained until the pus is able to escape. In many cases the fine steel bristle may be passed through the apex of the root, and the pus will at once flow through the root-canal. If there is any difficulty in passing the bristle through the apex, this may often be overcome by applying a 50 per cent. solution of sulphuric acid to the end of the root-canal. In other cases the patient may be directed to poultice the gum with pieces of hot figs, or to apply the more convenient capsicum plasters until the pus is drawn through the alveolus into the gum, whence it is readily evacuated with a lancet. Drilling through gum and alveolus gives speedy relief in many cases, but is too heroic a method for general practice.

Whenever the patient resists the manipulation necessary to vent the canals, it becomes a question of the judgment of the operator, whether he will attempt to get rid of the pain by trusting solely to local applications to the gum, or whether he will at once extract the tooth. An excellent procedure in these cases, where the cavity of decay is very accessible, and also in cases of obstinate pulp inflammation without exposure, is to administer gas and freely open up the pulp-chamber with a large clean bur in the dental engine. After opening into a septic tooth and exposing the orifices of the root-canals, it is advisable to postpone further manipulation until the pain has subsided; and in these cases the cavity may be left open, merely filling it loosely with cotton-wool to prevent it becoming choked up with food; or a rapid-acting and penetrating disinfectant may be at once applied, and the tooth temporarily filled. If a dead pulp is in a sufficiently coherent state to be readily removed, it should usually be taken out of the tooth at once. In all cases of obstinate toothache, no matter what may be the cause, the application of strong tincture of iodine (iodine liniment) to the gum is useful. Another valuable application is a compound of alcohol, 1 oz.; chloroform, 2 oz.; ether, $\frac{3}{4}$ oz.; gum camphor, $\frac{1}{2}$ oz.; laudanum, $\frac{1}{8}$ oz.; oil of cloves, $\frac{1}{2}$ dr. To apply this mixture, saturate a fairly large pellet of cotton-wool, and hold it on the gum for a few minutes, taking care to prevent the liquid running on to the face, as it is apt to irritate and burn the skin.

The diagnosis of toothache is often difficult; frequently the pain is referred by the patient to a tooth that is perfectly sound. An examination of all the teeth in both jaws should be made, and if, as is usually the case, one or more decayed teeth are found on the same side of the face as the tooth to which the pain is referred, the treatment of one or more of these teeth will give relief. Pain caused by one decayed tooth may be referred to any other tooth in either jaw on the same side of the face as the affected one, but it is extremely rare for it to pass the median line; thus the writer has known pain caused by a left lower wisdom tooth to be felt in a left upper central incisor, but has never known a tooth on the left side (either upper or lower) to cause pain on the right side, and *vice versâ*. Frequently the pain is referred to one of the branches of the fifth nerve, and is then termed neuralgia. The pain is usually felt under or over the eye; in the temporal region; in, under, and in front of, the ear; running upwards, to the temporal region, or downwards, to the shoulder and arm.

Pain under or over the eye usually points to upper teeth being affected; while pain in or about the ear, particularly if the pain is at the back of the ear, or shoots downwards, points to lower teeth; "while pain over the parietal eminence, to trouble from either upper or lower teeth."[1] In these cases the condition of the decayed teeth must be ascertained, and suitable remedies applied, when the neuralgic pain will usually cease.

When several teeth have been filled, and the patient cannot locate the pain in any one tooth in particular, the diagnosis is again often difficult. Tenderness of a tooth to pressure, or tenderness of the

[1] Smale and Colyer.

gum over any particular tooth, or looseness of a tooth, is sufficient evidence for the removal of a filling. In other cases the application of heat and cold must be resorted to. One of the most convenient and efficacious methods of applying heat is to hold a piece of hot gutta-percha against the tooth; a hot steel burnisher, or the copper bulb of the Evans' root-canal drier, or the hot-air syringe may also be used; while cold is conveniently applied by holding a small ball of cotton-wool in the foil carriers, spraying chloride of ethyl on to it until it is covered with particles of ice, and then rapidly applying it. If all the filled teeth are separately tested in this way, one or other of them will usually prove either more or less sensitive than the rest, and the filling of this tooth should be removed, and the conditions ascertained and treated. Tapping the teeth with the handle of a steel instrument is also useful; sometimes a tooth will prove more tender than the others if tested in this manner, and this is often a useful guide.

The above methods of diagnosis apply to cases where none of the teeth are carious, with the exception that if any one tooth responds to the test, it must be drilled into through the sound structure. Before drilling into a tooth that is externally sound, great care must be taken; and if any doubt exists it is better for the patient to wait to see if the pain will finally locate itself in one particular tooth, or symptoms develop which enable a more accurate diagnosis to be made. If an apparently sound tooth is less translucent, or darker in colour than its fellows, it will generally be found to contain a dead pulp, and it may be opened into in these cases without any hesitation.

The electric mouth mirror will be of assistance in some of these cases. The room should be darkened and the light placed behind the teeth. A want of translucency, which is not apparent in daylight, may then be discovered.

Severe toothache, which is often of the referred or reflected kind, is frequently caused by the difficult eruption of a wisdom tooth, particularly a lower wisdom. This possible factor must always be considered. The treatment is to cut away the gum over the erupting tooth, and cauterise the edges with nitrate of silver. If this does not relieve the pain, the wisdom tooth must be extracted. And if this is an uncertain or risky operation, the tooth immediately in front should be sacrificed. This gives room for the wisdom tooth to erupt, and by thus relieving pressure the pain usually ceases. In the majority of cases it is not difficult to recognise the presence of an erupting lower wisdom tooth, but it is sometimes necessary to pass a fine sharp-pointed probe through the gum at the back of the second molar, in order to detect its presence. The writer calls to mind a case where the probe passed through the gum for a quarter of an inch or more before it struck the occlusal surface of the tooth. In this case an incision was made through the gum, nitrate of silver was applied, and the opening packed with cotton-wool saturated with antiseptic varnish. The pain immediately disappeared. The wound was kept open and cauterised until the gum no longer obstructed the eruption of the tooth. It has been stated that the closure of an upper wisdom on to the flap of gum that may partially or completely cover an erupting lower wisdom, is a frequent cause of pain, and that the extraction of the upper wisdom relievés the pain, and enables the lower tooth to erupt. Cases occur in which the gum and peri-odontal membrane become acutely inflamed, causing great pain, either from local or constitutional causes. In some of these cases the cause is unapparent or unascertainable. The application of strong tincture of iodine to the gum and the removal of tartar, is generally the best local treatment. Some of these cases may easily be mistaken—if only one or two adjacent teeth are affected, and these teeth contain fillings—for periodontal inflammation caused by an inflamed or a dead pulp.

Pain after the extraction of a tooth is best relieved by packing the socket with cotton-wool or lint saturated with a paste of orthoform and water, or orthoform and alcohol; or the socket may be filled with either the paste or the dry powder, and the orifice sealed with a ball of cotton-wool saturated with mastic or sandarach varnish. In some cases it will also be necessary to cauterise and stimulate the socket with creosote, carbolic acid, or nitrate of silver. Burring out the socket, especially at the apex, has been recommended in certain cases, but the writer has never found it necessary to resort to this, and the cases in which it is advisable may be considered rare. A frequent cause of pain after extraction is a too rapid healing of the gum at the orifice of the socket. This often causes the gum to curl over the sharp edges, and practically stretch or press itself tightly on to them. In these cases, the gum should be slit in several places with small scissors, cauterised with nitrate of silver, and kept away from the ragged edge of the socket with cotton-wool and sandarach varnish. The relief of pain in teeth which contain either inflamed or dead pulps is often rendered difficult, and sometimes impossible (unless extraction is resorted to), owing to the formation of either secondary dentine or pulp stones. In all cases, therefore, where the pulp does not appear to be exposed, and the application of the usual remedies fails, the pulp-chamber must be drilled into if possible, and if found to be filled up with secondary dentine, it must be cut away until the orifices of the root-canals are exposed. The presence of what are known as pulp stones often causes severe pain which is difficult to relieve, owing to these nodules forming a barrier to the absorption of whatever remedy may be applied. Two distinct causes of pain may exist in a tooth that has more than one root-canal. One canal may contain a highly inflamed pulp, and in the other one the pulp may be dead and in a septic state. These conditions will be still further complicated if there is much formation of secondary dentine. It is always advisable, whenever it is possible to do so, to ascertain the exact conditions by free excavation, for in these cases the pulp in the crown of the tooth (or pulp-chamber) will either be dead or have turned itself into secondary dentine.

Rhizodontrophy is the operation for relieving pain due to a dead pulp, or preventing its recurrence after filling in these cases, by drilling a small hole into the pulp-chamber, just under the free edge of the gum, usually on the buccal or labial surface, and at right angles to the long axis of the tooth, thus forming a vent for the escape of the gases of decomposition, and sometimes pus.

Some operators, instead of cleansing and filling roots, perform rhizodontrophy whenever called upon to fill pulpless teeth, or to save the trouble of drilling out a filling and treating the roots when a pulp has died under a filling. This is a slovenly practice, which cannot be too strongly condemned. Occasionally it may prove of great value, when a patient, for instance, is about to leave the neighbourhood, and there is no time to give relief in any other way; or in cases where, owing to a highly inflamed periodontal membrane, it is impossible to cut out a filling or open into the pulp-chamber through the cavity of decay. In many of these cases the tooth may be supported on the lingual side by the thumb or fingers, and drilling through the neck of the tooth at right angles may be quite bearable. In these cases the vent-hole is not to take the place of root treatment and filling, but is used as a means of enabling it to be subsequently carried out, when, of course, the vent-hole will be filled up.

It is, however, decidedly preferable to open directly and freely into the pulp-chamber through the cavity of decay, or by cutting out a filling when necessary, whenever it is possible to do so. It is often impossible, except by ocular or instrumental proof, to know whether the symptoms are çaused by a dead pulp or by one that is inflamed, and if, as may easily happen, rhizodontrophy is resorted to in a case in which the pulp is alive, or in a case in which the pulp-chamber happens to be filled up with secondary dentine, it will be a worse than useless proceeding. It is therefore an operation only to be resorted to in the extreme cases already mentioned, and also where, owing to exceptional difficulties of manipulation, or extraordinary resistance of a tooth to the usual treatment, it may be the means of preventing the extraction of a valuable tooth. It is not, however, a very nice thing to leave a tooth in such a condition that foul odours escape from it into the mouth, but cases do occur in which it is distinctly advisable to save a tooth even if its retention demands rhizodontrophy. Notwithstanding the fact that toothache, if intelligently diagnosed, generally responds rapidly to local treatment, there are cases in which systemic treatment in addition is necessary if the patient is to be relieved from pain as speedily as possible. Acute periodontal inflammation may also cause constitutional disturbance which should be medically treated.

A dentist, if he thinks good, may advise patients to take one of the ordinary household remedies, such as a simple, innocuous purgative; but for anything beyond this they should be referred if necessary to a medical practitioner.

CHAPTER II

REMOVAL OF TARTAR

After attending to any teeth that have ached, it is always advisable to remove all tartar from the teeth. This is often a tedious and usually an uninteresting operation, and its proper performance is frequently neglected. To remove tartar in a neat and efficient manner, with as little laceration of the gums as possible, demands considerable skill, and often considerable time. No exact rules can be laid down for the performance of this operation, for both the operative technique, as well as the selection of instruments, will greatly depend on individuality.

A very large number of instruments for removing tartar—usually known as scalers—have been devised. These may be separated into five groups—viz. (1) Those which enable either a push-cut or a pull-cut to be given, and which are known as universal scalers; (2) those which are used with the push-cut, and which may be described as either plain chisels or dentate chisels; (3) short-bladed hoes or pull-cut scalers; (4) scrapers or spoons used to perfect the work of the chisels or hoes; and (5) multiple-bladed cutters or scrapers similar to the files or rifflers used in trimming and finishing gold fillings. Fig. 2 shows some useful forms of these types, an almost endless variety of which is to be found in the catalogues of the makers of dental instruments.

For general purposes the removal of tartar may be described as best effected by first breaking up or chipping away the main bulk of the incrustation, and then scraping away the smaller particles that are left adhering to the teeth. To begin with the lower incisors; it will often be found that passing a very thin, chisel-like, scaler between the necks of these teeth from the front, dislodges a good deal of the deposit from the lingual surfaces. If this cannot be easily accomplished, the point of a universal scaler (Nos. 1 and 2, Fig. 2) may be applied to the lingual surface, forcing the sharp point downwards and sideways in the direction of the interproximal spaces. This readily breaks away the tartar that covers the interstices between the teeth, and the mass that remains on the lingual surface of each tooth can be frequently dislodged in one piece by placing the point against the ledge or projection that is left at the sides of the teeth, and lightly levering sideways.

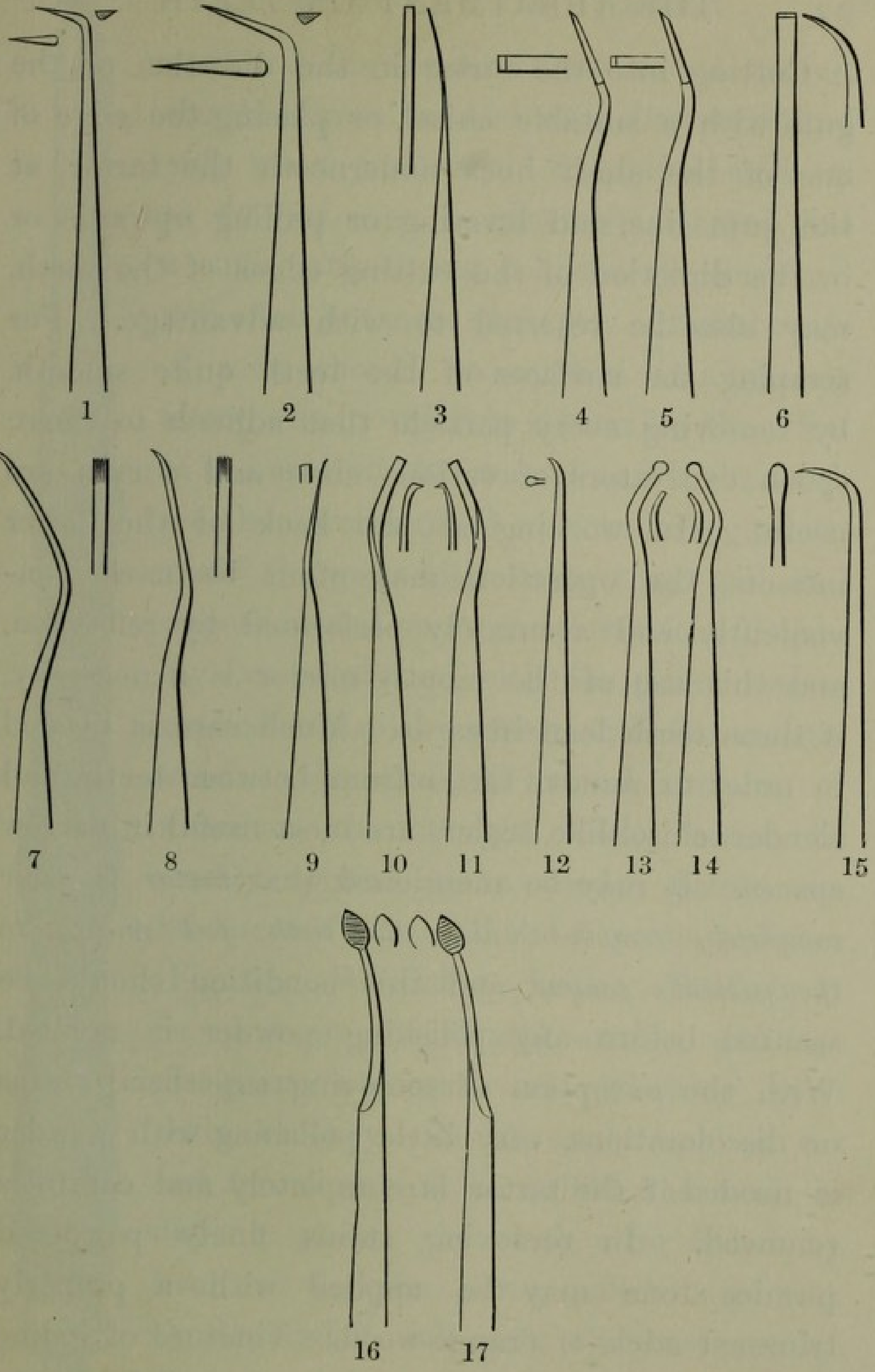


Fig. 2.

Cutting into the tartar in the direction of the gum with a suitable chisel, or placing the edge of one of the short hoes underneath the tartar at the gum line, and levering or pulling upwards, or in the direction of the cutting edges of the teeth, may also be resorted to with advantage. For scraping the surfaces of the teeth quite smooth, by removing every particle that adheres to them, spoon excavators of various sizes and curves are useful. In working at the back of the lower incisors, the operation may often be most conveniently and accurately performed by reflection, and this use of the mouth mirror is a necessity, if these teeth lean inwards. Much care is needed in order to remove tartar from between teeth, and slender, chisel-like, scalers are most useful in narrow spaces. It may be mentioned that *tartar is never completely removed unless the teeth feel smooth to the patient's tongue*, and this condition should be secured before any polishing powder is applied. With the exception of removing superficial stains or discolorations, very little polishing with powder is needed if the tartar is completely and carefully removed. In removing stains, finely powdered pumice-stone may be applied with a properly trimmed stick of orange-wood. Tincture of iodine also assists in removing stains, and may be safely used. Acids are sometimes necessary, but should always be used with discretion, and only when necessary. Sulphuric acid up to 50 per cent. is generally selected, but a sufficiently strong solution of *aqua regia* will often act more promptly. Bicarbonate of soda should be applied immediately afterwards in order to neutralise the effect of the acid on the enamel, and if the teeth are then well rubbed with an orange-wood stick charged with soap, they will feel smoother and more comfortable. Polishing can be effected with fine pumice-stone, applied on labial surfaces with the orange-wood stick; and on lingual surfaces, or wherever the straight stick cannot be readily applied, short wooden points can be successfully used in a porte polisher (Fig. 3). Wooden or leather wheels may be used in the dental engine, and are of great assistance in polishing such parts as they can be easily applied to; but for what may be called fine work in difficult places, the stick used either by itself or in the porte polisher as may be demanded, will give the best results. Finely powdered Hindostan stone, and,

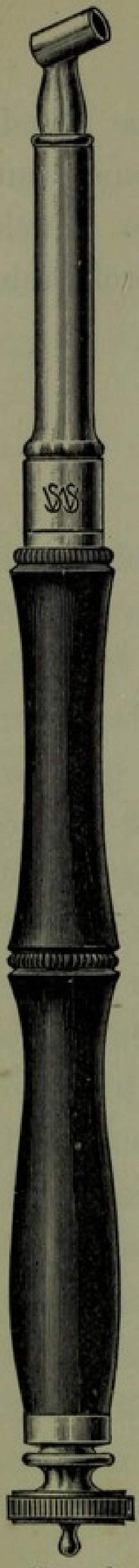


FIG. 3.

finally, precipitated chalk may also be used. Circular brushes are much used by some, but in the writer's opinion they cause too much spattering of the powder to make them preferable to leather discs.

CHAPTER III

PYORRHŒA ALVEOLARIS

It would be out of place in a book of this description to criticise the term Pyorrhœa alveolaris, or to attempt to go into the etiology of the disease. For practical purposes it may be said to consist in a wasting away, or decay, or absorption, of the sockets of the teeth, which proceeds usually in a more or less irregular manner, and then, in consequence of lack of support, the teeth become loose, and if the disease runs its course unchecked, the teeth finally drop out, or need extraction. During the progress of the disease small brown scales of an exceedingly hard and adherent tartar are deposited on the roots, in places where the alveolar process has disappeared. This has been given the name of sanguinary or serumnal tartar, as it appears to be deposited from the exudations of the diseased tissues, and not from the saliva. The destruction of the sockets of the teeth is accompanied by a slow or chronic state of inflammation of the periodontal membrane, and the membrane itself becomes destroyed as the disease progresses.

Every now and then cases occur in which the chronic or painless state becomes acute, and if the tooth is extracted a mass of thickened and inflamed tissue is found at the end or side of the root. There is every reason to believe that the disease originates in an irritated or inflamed periodontal membrane, and that anything that irritates and inflames this membrane may cause the disease. There is also reason to believe that the variations, the progress, and the curability of this condition, do not so much depend on its immediate cause, as on the constitution or state of health of the patient, and the length of time the disease has existed. Its cause may be local or constitutional. Anything that will irritate the membrane sufficiently to prevent its recovering its normal state will always, in the absence of treatment, result in the loosening and loss of the teeth. It is only a question of time.

Local irritation may take the form of tartar, malocclusion, or the presence of any foreign body under the gum. The effect of local irritation on the periodontal membrane, is manifest to any one who has accidentally left a silk ligature on the neck of a single-rooted tooth after removing the rubber dam, and the effect of malocclusion is easily proved by leaving a hard gold filling too high on an occlusal surface. It is well known what a state the mouth and gums are in during a severe illness, and as the gums and the periodontal membrane are intimately connected, it becomes merely a question of the spreading of the local inflammation—or unhealthiness—to this membrane for it in its turn to be affected. It is no uncommon thing for a patient's gums to be red and puffy and bleed easily for some considerable time after recovery from an illness; and there is every probability, in the event of the generally inflamed condition of the mouth spreading to the periodontal membrane, that pyorrhœa will be established, unless the vitality of these tissues is sufficient to enable them readily to resume their normal state with the general improvement of the patient's health. Deposits of crystals of uric acid on the apices of roots have been put down as the sole cause of the disease. That deposits of some kind do take place at the apices of roots in some cases is certain. That absorption and roughening of the apices of roots also sometimes take place is true. But that the disease depends on the periodontal membrane being attacked in a certain way (not necessarily always the same way), and on the kind of resistance (or the want of it) that nature puts forth (or is able to put forth) in any particular case, may be accepted as a common-sense view in the present state of our knowledge in regard to this disease in particular and predisposition in general.

As far as the bacteriology of this disease is concerned, Dr. Harold Simms[1] says: "It has long been in the minds of bacteriological workers that there was in the peculiar course of pyorrhœa much ground for suspecting the existence of a specific micro-organism; so far, however, this must remain a conjecture, for no one has yet, despite much earnest effort, succeeded in proving the existence of such an organism; and latterly the efforts of bacteriologists have been more directed towards finding out what influence those organisms have which we can cultivate. Working on these lines, Mr. Goadby[2] has been able to introduce his method of treatment, based on Professor Wright's opsonic tests and inoculations." Briefly, Mr. Goadby's method consists in testing the resistance of the patient's blood to one or more of the bacteria that are considered to predominate in any particular case. Then if, as usually happens, the general resistance of the body to the organism which is concerned in the local trouble is below normal, a vaccine is made from a pure culture of the

[1] *Transactions*, Odontological Society of Great Britain, April 1907.
[2] Ibid. March 1906.

particular organism it is sought to combat. The injection of this vaccine in accordance with the ascertained conditions raises the general resistance of the body to the organism that is concerned with the local trouble. This treatment does not in itself cure the local disease, but it enables local treatment to be successfully carried out in cases in which it would otherwise prove of no avail. This is a distinct step in advance so far as constitutional diagnosis and treatment are concerned, and still further emphasises the necessity of giving proper attention to any constitutional disease or weakness of the health if pyorrhœa is to be successfully treated.

If the value of the natural teeth were better understood and appreciated, and if the almost hopelessness of satisfactorily treating this disease in an advanced condition were realised, it would be customary for medical men to send their patients to a dentist as soon as they had recovered sufficiently from an illness to be amenable to dental treatment. By this means many cases of pyorrhœa would be either prevented or rapidly checked.

The local treatment consists in eliminating all sources of mechanical irritation by first of all removing the tartar from the roots. This is imperative, as unless it is completely removed success cannot be expected. The bottom of the pockets should be freely scraped or curetted whenever it is possible to do so. Elongated teeth must be shortened in order if possible to free them from the bite, and teeth that are very loose must be firmly held in position by ligaturing them to firm teeth with soft platinum wire, or by means of some firmly fixed mechanical appliance. Nature is thus given a chance to repair lost tissue, and when this is effected, the ligature or appliance should be removed. The removal of tartar from the roots is difficult to accomplish. It must be done almost entirely by the sense of touch, and the scales are often so firmly adherent to the root and project so little that there is the greatest possibility of the instrument slipping over them without the operator being conscious of their presence. This may to a great extent be avoided by using one of the short-bladed hoes shown in Fig. 2. This instrument—or some similar one—should be inserted as deeply as possible into the pocket, and the cutting edge made to bite into the cementum, so that the root itself as well as the tartar is scraped. The root is denuded of periosteum where this tartar is deposited, and the slight scraping of the cementum will do no harm, and is infinitely preferable to leaving particles of tartar, for where any of these are left the parts rarely, if ever, improve.

The small files shown in Fig. 2 are also useful for this purpose. In order to facilitate the removal of the hard deposits, and also to enable the alveolus to be more easily curetted, some more or less heroic procedures have been resorted to. The gum has been slit from the neck of the tooth to the bottom of the pocket and the flaps pressed away so as to expose the root as much as possible. Another method is to obliterate the pocket by burning away the gum with the electric cautery. The writer has no experience of the treatment of pyorrhœa in this way. Its success will no doubt depend on the recuperative power of the gum.

When the deposits are removed, and the teeth, if necessary, are firmly braced by ligatures or an appliance, the pockets and edges of the gum should be treated with escharotics, antiseptics, or astringents as may seem good. Chloride of zinc, in proportionate strength to the requirements of the case, is a most valuable remedy, as it combines all the desired properties, *e.g.*, it is an escharotic, an astringent, and an antiseptic, and can be used full strength or diluted as the circumstances of the case demand. In full strength, or approaching this, it will generally cause some pain. The various remedies that have been used with more or less success are well known, and need not be mentioned. Solutions of sulphuric acid, or aromatic sulphuric acid full strength, have been recommended, and certainly help to clean out the pockets. Tincture of iodine applied to the gums is most useful, and there are few cases where, if it were only applied early enough and frequently enough, it would not check periodontal inflammation sufficiently to either entirely prevent pyorrhœa, or, at any rate, render its subsequent treatment easy and satisfactory.

A solution of ammonium bifluorid has recently been introduced by Dr. Joseph Head of Philadelphia.[1] It is claimed that this preparation readily dissolves tartar without in any way injuring the cementum or the enamel of the teeth, and enables the calcareous deposits to be more easily and more thoroughly removed from the roots.

Success in the treatment of pyorrhœa is often doubtful and sometimes impossible. If the sockets of the teeth are very much destroyed, and the teeth are causing annoyance, it is better in the majority of cases to extract them. If, on the contrary, the destruction is not very extensive, and particularly if only a few teeth are involved, the treatment may be undertaken with every probability of, at any rate, greatly improving the conditions and in some cases effecting a complete cure. In others, although the

[1] *Dental Cosmos*, January 1909 ; *Items of Interest*, March 1909.

lost tissue is not completely restored, the teeth will become firm and useful in mastication, and the disease is for all practical purposes cured. Much, however, will depend on the patient's vitality or health. Very delicate or weakly individuals, and especially those who are suffering from some chronic ailment or disease, are not good subjects. The thorough removal of tartar from the roots, on which so much depends, frequently causes pain. The introduction of cocaine into the pockets will often mitigate this, but sometimes appears to have little or no effect. A great deal depends on the temperament of the patient, and there are nervous, irritable individuals for whom the operation cannot be satisfactorily carried out, and the loss of whose teeth is in consequence only a matter of time. But when one or more teeth are affected and there is no possibility of successfully treating them, the sooner they are extracted the better, for the retention of these teeth in the mouth is likely to seriously impair the general health of the patient. During the treatment and for some time afterwards the patient should be instructed to frequently use an antiseptic and astringent mouth wash. One of the best washes for these conditions is chloride of zinc, used in the proportion of from one to four grains to the ounce of either rose water or orangeflower water. Unfortunately, however, it is so disagreeable that few patients will persist in its use. It is very important, when a good result is obtained, for the teeth afterwards to be carefully scaled at regular intervals.

CHAPTER IV

FILLING TEETH

A DESCRIPTION of the filling of teeth may be divided into a consideration of, firstly, the materials, and, secondly, methods of using them. For many years the materials employed were: gold in the form of foil of various thicknesses, and also as a sponge-like preparation known as crystal gold; tin-foil; amalgams; gutta-percha; and the white cements (oxychloride of zinc, and oxyphosphate of zinc). To the above are now added porcelain inlays; gold inlays; the black cements (oxyphosphate of copper); and the new kind of white cement known as the silicate filling. In order to avoid confusion, inlays will be dealt with in a separate chapter.

Gold.—Gold foil for filling teeth is prepared either as cohesive or as non-cohesive gold. Crystal gold is strictly a cohesive gold and must always be treated and manipulated as such.

Absolutely pure gold possesses the property of welding when cold, provided the surfaces to be united are perfectly clean and dry. The least deposit on the gold, either of moisture or any extraneous substance, interferes with this welding, and, consequently, if this property is to be taken advantage of, it is always necessary to anneal the gold before use, in order to drive off anything that may happen to have collected on its surface. This welding property is made use of by the majority of dentists in making gold fillings.

Non-cohesive gold is so prepared that there is no possibility of one piece sticking to another. Any welding is quite out of the question, and the filling is made by so wedging and interlocking the pieces of gold together in a cavity that it forms a tight, dense plug. This non-cohesive property is probably attained by subjecting the leaves of pure gold-foil to some vapour which deposits something on its surface. If this non-cohesive gold is annealed, it will sometimes be noticed that a vapour is given off, and when brought to a dull red heat it becomes, as a rule, thoroughly cohesive. There are a few makes of non-cohesive gold which become so slightly cohesive on being fully annealed that this does not prevent their being worked non-cohesively. These foils, the character of which is only slightly changed by annealing, are often spoken of as "true, non-cohesive gold." They *can* be worked cohesively, but it demands special care and manipulation. What it is that gives them this particular property is a trade secret. It has been stated that it is due to the addition of a very small quantity of alloy to the gold. These true, non-cohesive foils, however, seem also to have been subjected to the action of some vapour, for, as above mentioned, they are not so absolutely non-cohesive when annealed, and heating them causes a vapour to be given off, just as with other makes of non-cohesive gold. This vapour will only occasionally be noticed with any kind of non-cohesive gold, and no doubt is due to an excess of whatever has been deposited on its surface. Many dentists hold that the non-cohesive gold which becomes thoroughly cohesive when fully annealed is the best cohesive foil to use. They consider that the treatment to which it has been subjected in order to render it non-cohesive protects its surface, and prevents it from absorbing deleterious matter to the detriment of its working properties. Some purchase cohesive foil and at once proceed to protect it by exposing it to the vapour of ammonia. This renders the gold non-cohesive; but as the ammonia is readily dissipated by heat, the cohesive properties of the foil are immediately and completely restored by annealing. The advantages of using what may be called a protected foil will apply more particularly to manufacturing districts, where the air becomes contaminated with the smoke or the fumes from factories. The writer practises in a seaside town where there are no manufactories. This may be the reason—added, perhaps, to keeping his gold apart from the drugs he uses—why he has been unable to notice any difference between the working of a protected and an unprotected foil, no matter how long some of the non-protected or cohesive variety may have been in his office.

Intermediate between the non-cohesive and the cohesive gold is a kind known as semi-cohesive. The name semi-cohesive attached to a make of gold is sometimes misleading, for it will almost always be found necessary to anneal it before use (as it is worked on the cohesive principle), and it usually becomes cohesive when well heated. There are, however, makes of true, semi-cohesive gold, of which the semi-cohesive globe-foil was an excellent example. This kind of gold when fully annealed is still semi-cohesive.

If non-cohesive gold of the kind that becomes cohesive when fully annealed is lightly annealed on a sheet of mica an excellent semi-cohesive gold may be produced, although it demands great experience in order to hit the happy medium between under- and over-annealing it. Non-cohesive gold is often termed soft gold, while cohesive gold is often spoken of as hard gold. Semi-cohesive gold is frequently described as either soft gold or soft cohesive gold.

There is so much confusion of terms and misunderstanding of the properties of gold in its various states or conditions that an attempt at explanation may not be out of place. It has been stated that the softest gold in itself is the cohesive variety. It is also well known that annealing a bar of gold brings it to the softest possible condition, just as it is well known that it can be hardened by hammering. In speaking of soft and hard golds, so far as filling teeth is concerned, we mean the softness or hardness of the metal during its manipulation, and the comparative hardness of the filling when it is completed. There is no doubt that fully annealed gold becomes harder during its manipulation in a tooth, and the resulting filling is harder when completed than one that is made in exactly the same way with slightly annealed gold, and the less the gold is annealed the softer it will work and the softer will be the filling. It is presumed that the gold in these cases is welded into a coherent mass. All this is difficult to account for. The fact that the layers of fully annealed gold in a pellet, cylinder, or strip, stick together very quickly during the process of packing, and that consequently a more resistant and apparently harder pellet is produced, does not account for the greater hardness of the completed filling, and no satisfactory explanation is forthcoming.

Semi-cohesive gold, if manipulated with a mallet, can be condensed into a perfectly coherent mass, the density of which (density and hardness are not synonymous terms) cannot be surpassed with cohesive gold. But if hand pressure is used with both of these kinds of gold, the cohesion produced with the semi-cohesive variety will usually be inferior, although in many cases it may be sufficient for all practical purposes. The advantage of semi-cohesive gold is that it is a little more adaptable than cohesive gold, and consequently excellent adaptation, and an even condensation, may be produced with larger pieces or with broader-ended pluggers.

Crystal Gold.—So much misconception exists concerning crystal gold, and so many misleading statements have been made in the past, and continue to be made at the present day, about this form of gold, that it may not be out of place to quote from an article "On the Value of Crystal Gold in Dentistry," by the late Dr. N. W. Williams.[1] After stating that crystal gold was first brought to the notice of the dental profession in 1855 or 1856, and was the invention of Professors George Watt

[1] *International Dental Journal*, February 1892.

and J. Taft, and describing the process of its manufacture, he (Dr. N. W. Williams) goes on to say:—

"The process being somewhat difficult and complicated, and attended with some danger to health, the inventors were never able to make it in sufficient quantities for sale, and the profession were deprived of a very valuable aid in operative dentistry. Becoming associated with Professor Watt in 1865, we continued to make it for our own use during the seven years of our association, and I have never before or since filled teeth with greater satisfaction to myself and patients. The crystal gold known under the name of A. J. Watts' crystal or sponge gold was brought out about the same time as that of Watt and Taft. At first it was not a success, as complaints were made that it discoloured in the mouth and did not give a perfect filling at the margins. This may have been due in part to bad manipulation, for, being very spongy, one was inclined to use it in too large pieces, and then it would harden under the instrument before it was condensed throughout the mass. The makers of this gold have steadily improved it, until now it is a very valuable gold for saving teeth." It is stated ("Items of Interest," 1901) that Dr. N. W. Williams showed the late Dr. de Trey how the original Watt and Taft's gold was made, "the outcome of which is the Solila gold of to-day."

The writer has made considerable use in his practice of A. J. Watts' crystal gold during the last twenty-two years, and has always found it to be an excellent and reliable preparation. He has also used several of the more modern productions, and some of them appear to be very good preparations. A good make of crystal gold is a fascinating kind of gold to use, and although one who is accustomed to foil may at first fail to satisfy himself, it will be found that a familiarity with the material rapidly causes any difficulties of manipulation to disappear, and one soon forgets that its use was ever attended with difficulty or disappointment. It is very important, however, to realise that it is extremely easy to make bad fillings with crystal gold, and that those preparations which possess the property of "staying in place" in a cavity without rocking or balling up, no matter how large the piece may be, or how carelessly it may be placed in position, lend themselves particularly well to imperfect work. If a crystal gold filling is to be welded into a coherent mass (and the very structure of this gold particularly demands this) and well adapted to the cavity walls, it must be worked with as much care and thoroughness as cohesive foil. All the rules that apply to cohesive foil fillings apply with equal if not greater force to crystal golds, with the exception that with some makes of crystal gold the filling can be easily started either without pits or without resorting to wedging in a base of non-cohesive gold. This very quality may, however, tempt an operator to fill an improperly prepared cavity, often with disastrous results; and the very general temptation to stuff a cavity full of crystal gold, and imagine, because each piece stays in place and the surface finishes up smooth and hard, that the filling is both well condensed and accurately adapted, will, as a rule, result in a disappointment that is often attributed to the gold instead of to its mal-manipulation.

It is amusing to hear crystal gold lauded *because* it can be used successfully with hand pressure, just as if good hand-pressure fillings could not be made with foil. It is appalling to see broad-faced pluggers used exclusively throughout the whole operation of packing and condensing this gold—particularly if hand pressure is resorted to. A few experiments made out of the mouth and a careful examination of the interior surface of the plugs, will convince any one that the principles that govern the making of cohesive fillings with foil apply with equal force to crystal golds, and that the best way to accomplish first-class fillings with crystal gold is first to "serve an apprenticeship" to foil. The reason for this will be made plain by the following quotation from "Principles and Practice of Filling Teeth," by Dr. C. N. Johnson, page 172, first edition: "The chief distinction in this connection between foil and crystal gold is that foil demands care, and so expresses itself at every turn, while the other demands equal or greater care, but seems constantly to give the impression that it does not."

Crystal gold should be carefully torn up or separated into smaller pieces with fine-pointed foil carriers or tweezers, or with needles set in handles; cutting it up, even with a razor, compresses it in an undesirable manner. Within reasonable limits the looser the texture of this gold the better—Watts' crystal gold, for instance, was at one time made only in the form of blocks or cakes of varying density. The No. 1 block was the loosest in structure and was generally preferred to the denser forms. In addition to the large blocks this gold is now prepared in thin slices, in strips, and also in small cubes. This has been done without interfering with its working properties, and adds considerably to the convenience of the operator. Different makes or preparations of crystal gold vary somewhat in their working properties, and admitting that some makes may be better than others, it may easily happen that an operator will prefer a certain preparation merely because its working properties suit his fancy.

Any attempt to institute a comparison between the various forms of crystal gold that are now manufactured would demand a large number of carefully carried out experiments, in the absence of which the writer does not feel justified in expressing an opinion in these "Notes" as to their relative merits. Crystal gold lends itself quite as well to mallet work as foil does, and—just as in the case of foil—the greatest condensation and the best adaptation will be produced with accurately applied mallet force. The structure of crystal gold does not favour the use of the sliding blow, or wiping action, that is so frequently employed when the fast-striking engine or electric mallets are used. The automatic, the pneumatic, and the hand mallet will therefore usually give the best results with crystal gold. But a sliding or rubbing blow may be employed if the gold be first partially condensed either by a direct blow or by hand pressure. The pluggers should be finely serrated, or just sufficiently rough to prevent slipping. Any forms of pluggers that will give good results with cohesive foil may be used with equal satisfaction with crystal gold. If a good make of crystal gold is properly and thoroughly manipulated, quite as good results can be obtained as with foil.

Some operators will doubtless find that crystal gold enables them to work more easily, more rapidly, and quite as efficiently if not more efficiently, than with foil; but there are other operators who can manipulate foil quite as easily, rapidly, and efficiently as the most expert workers with crystal gold. It is the man and the method and not the material that makes for success, although individuality will always play a great part in selection of material and results obtained with it.

Methods of Preparing Gold Foil.—Gold foil is prepared for introduction into teeth in the following ways: By simply tearing small pieces from the sheet with tweezers or foil carriers; by rolling or twisting the sheet, or part of it, into a rope, and then cutting it up into small pieces; by folding the sheet flat upon itself several times, and then cutting it into strips, or tapes, of convenient length and width; by further cutting these strips into small squares; by cutting the sheet into strips and rolling them round a spindle into a cylinder-like form; by tearing small pieces from the sheet and rolling them into little balls; and by cutting strips or squares from a sheet of very thick foil. Different operators use one or more of the above-mentioned methods of preparing the gold, as may seem best to them. The most intimate union of the molecules of the gold, producing the most perfect welding, density, and hardness, is doubtless obtained by the use of small flat squares, providing each one is packed flat without any curling up or doubling of the edges. This is, however, a very tedious and slow method of working, and the majority of operators will find they obtain practically as good results by more rapid methods. The use of these squares for building up or perfecting the surfaces of fillings is a practical proceeding, and no better surface or finish can be obtained than in this way. No. 4 foil, folded up to No. 128, viz., 32 thicknesses, or layers, of the No. 4 foil, and cut into these small squares, can be used for surface work with great satisfaction if properly annealed.

Small pieces of foil torn from the sheet may be used for filling minute cavities, or parts of cavities (especially starting pits and fine grooves) that are difficult of access. Pellets or cylinders have a wide range of usefulness, but balls of gold foil will generally be found too resistant to be accurately adapted and condensed by the cohesive method. In using strips or tapes of gold it is important they should not be too thick. The building up of contours, and the filling up of the middle of large fillings, may be satisfactorily effected by means of strips containing eight thicknesses of No. 4 foil, and ten thicknesses and even sixteen thicknesses may be used for building up, but accurate adaptation and density is best attained by confining oneself to four thicknesses of either No. 4 or No. 5 foil, producing No. 16 with the No. 4 foil and No. 20 with the No. 5 foil. The writer has no desire to speak dogmatically on this subject, but he distinctly deprecates the use of thick tape against cavity walls, and believes that, all things considered, the No. 16 strip is the best form of gold for producing accurate adaptation and great density. Pellets or cylinders in the cohesive or semi-cohesive state should be loosely rolled. The best cylinders for cohesive or semi-cohesive work are those purchased ready-made. As a rule they are made of very thin gold, and the smaller sizes, by reason of their delicacy, should be particularly applicable against cavity walls when hand pressure is used. Cylinders—probably owing to the extremely thin foil of which they are made—are not so reliable as foil, inasmuch as their quality seems to vary. There is very rarely any trouble with foil in this respect, but it is not uncommon to find one bottle of cylinders work perfectly, and the next one prove most unsatisfactory when the gold is annealed. Heavy foil, such as No. 30 or No. 60, is principally useful for surfacing fillings, although some operators use the No. 30 heavy foil in strips of single thickness for filling large cavities. In using heavy tape, such as single strips of heavy foil or the lighter foil folded into a heavy tape, it is usually necessary to pack each layer flat, by attaching one end to the gold already in place, and then carefully folding the strip backwards and forwards on itself, layer by layer, taking care to weld each layer absolutely flat to the already condensed gold. If thin tape, such as four folds of No. 4 foil (producing No. 16), is used, the end of the strip may be attached to the gold that is already in the cavity, without any particular care being taken as to whether it is packed flat or not. The point of the plugger is then placed on a part of the projecting strip in such a manner that one, two, three, or more layers are simultaneously packed down and condensed, the gold being worked on the whole fairly flat. Irregular masses of gold, such as pellets cut from a rope, or little balls, will not, as a rule, produce such hard and evenly condensed fillings as the flatter forms. This is shown by these fillings often becoming pitted or roughened by the force of mastication. This can be avoided by making the surface of tapes or squares.

Gold and platinum is supplied either in the form of foil or of crystal gold. This is used to give a harder surface to a gold filling, and some consider that it gives a better appearance to fillings that are exposed to view.

Manipulation of Gold.—Decidedly the best cohesive gold-work is accomplished by means of a mallet, providing the cavity admits of a mallet plugger being accurately used.

Many operators—particularly in countries where patients consider gold fillings an ornament to their teeth—do not hesitate to cut away part or the whole of labial walls in incisors and canines in order to use a mallet. This is a proceeding that is strongly objected to in the British Isles, and for this reason—as well as for the reason that it is impossible to prepare many posterior cavities in such a manner that a mallet can be used—hand pressure has to be greatly resorted to. A straight plugger with the condensing surface at right angles to the shank enables a dead or direct blow to be given in the most efficient manner. The straight plugger may be inclined at an angle of not more than forty-five degrees to the gold without materially decreasing the efficiency of the work. The condensing or working face of the plugger may be placed at an angle to the shank, providing this angle does not exceed forty-five degrees, and also providing the shank itself is not curved. The foot-pluggers provide the best example of this form.

The shank of the plugger may be slightly curved or twisted, but any curve or twist which brings the working face much out of line with the shank must be avoided. Considerable curve may be given to the shank if this does not throw the working face out of line with the shank. This is brought about by giving the instrument a bayonet shape. Fig. 4

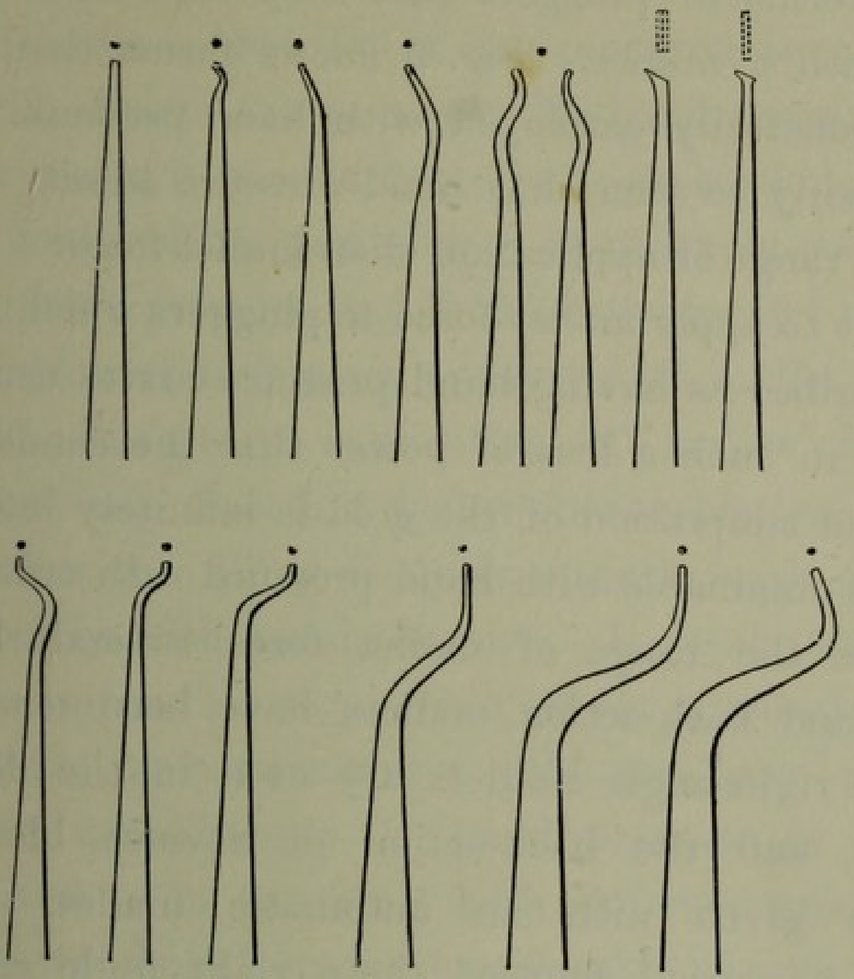


FIG. 4.

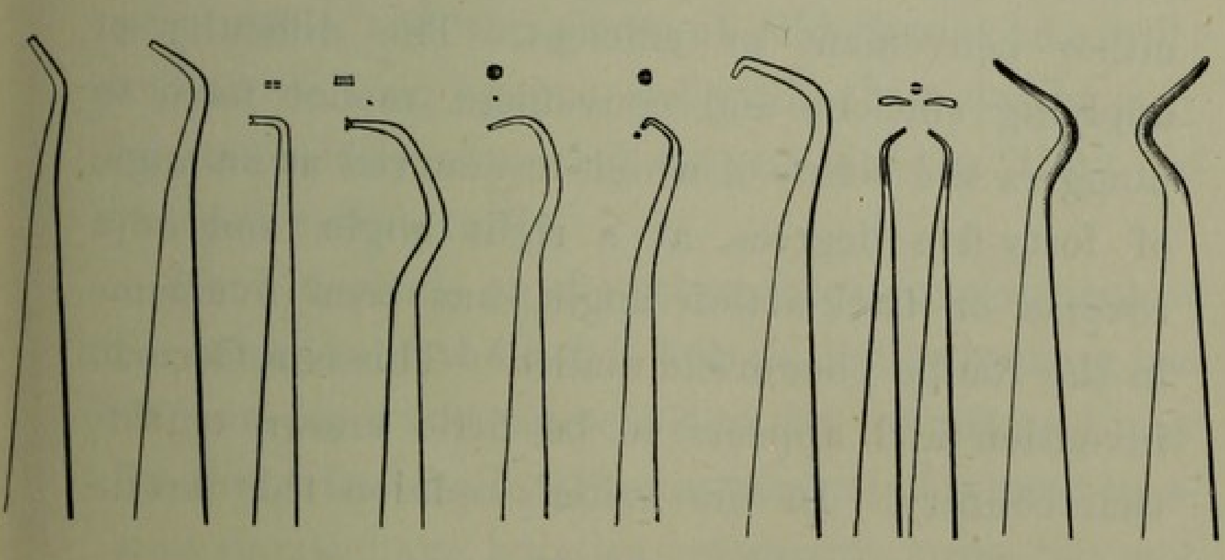


FIG. 5.

shows forms of pluggers that may be successfully used with a mallet. Fig. 5 shows forms that can be satisfactorily employed with hand pressure. It will readily be seen that hand pressure admits of a greater range of application than mallet force. Any attempt to apply mallet force to pluggers which may be described as having hand-pressure curves usually results in such a loss of power that the condensation and adaptation of the gold is infinitely inferior to that obtainable with hand pressure. In order to increase the range of mallet force several right-angle and back-action mallets have been made.

The right-angle mallets are used in the dental engine, and the back-action or reverse blow is usually given with an automatic mallet. The writer has tried four of these right-angle engine mallets and found none of them satisfactory. Nor has he found the back-action of the automatic mallets either convenient or efficient. The difficulty of applying efficient and convenient mallet force to pluggers the points of which are curved at an angle of forty-five degrees, at a right angle, and at a reverse or back-action angle, has been overcome in the Rauhe pneumatic mallet.[1] This is a German invention and appears to be little known outside that country. In the writer's opinion this instru-

[1] For description of which see Appendix.

ment greatly increases the range of practicable mallet force, but he is not prepared to say that it will obviate the necessity for hand pressure. In many cases, it is advantageous to pack and condense the gold—either partially or as much as possible—with hand pressure, and then to supplement the condensation of each piece or layer with mallet force.

A satisfactory application of mallet force in almost any direction is very desirable, no matter whether the filling is made entirely with a mallet or partly with hand pressure. It is almost if not quite impossible to produce *perfect* adaptation with cohesive or semi-cohesive gold and hand pressure alone; consequently, if hand pressure is entirely resorted to in any case, both the instruments and the gold should lend themselves to the production of the greatest possible adaptation and condensation. The plugger points should be as fine as practicable, and the pieces of gold should be small; and in working against the walls they should only be sufficiently annealed to enable the work to proceed satisfactorily.

Much depends on the strength or development of the muscles of the hand, but an indiscriminate use of great force is disagreeable to the patient, and may fracture a frail wall. The instruments for hand pressure should have handles reasonably large, but not too heavy, and the shanks of the pluggers should be short. The wooden handles with short, steel shanks designed by Dr. Barker provide the best form the writer is acquainted with (Fig. 6). In applying the pressure the wrist and fingers should be turned or twisted, in order to sway the handle backwards and forwards. This rotates the point of the plugger and makes it bite into the gold with increased force. If, in addition to this, the point can be made to travel along the gold with a wriggling movement, so much the better; but the extent to which either the swaying or the wriggling movement may be employed will depend on the case.

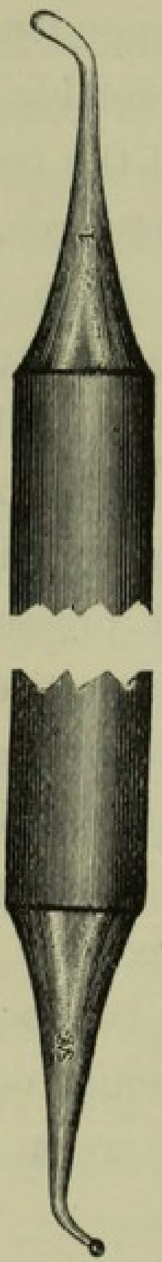


FIG. 6.

In dealing with mallet work we are confronted with several problems which, although in reality easy of solution, have not yet been completely solved. This is doubtless due to the great amount of work that would have to be undertaken by several men before accurate conclusions could be arrived at. So much depends upon an individual's skill, and method of manipulation, that a comparison of similar experiments carried out by a number of operators is needful. The condensation and adaptation of cohesive gold depends on accurately applied force. What we want to know is the exact relationship that the force of the blow, the size of the plugger point, and the form and thickness of the gold bear to one another.

Dr. Black and those who follow his teaching have made experiments with the object of reducing the filling of teeth with gold to an exact system. The amount of force, the method of applying it, the size of the plugger points, and the number of blows necessary to condense and adapt pellets of varying size have been worked out; but there are so many different kinds of mallets, so many ways of preparing the gold, and such a variety of conditions to deal with in the mouth, that, as already mentioned, there is still much ground to be covered in this direction.

The finer the point—in reason—the greater the condensation and the better the adaptation. The heavier the blow, the better is the adaptation and condensation. The more favourably the gold is prepared for ease and accuracy of adaptation and condensation, the more surely will these be obtained. The difficulty is not so much in making fillings sufficiently hard and strong to resist the wear and tear of mastication, as to save teeth by perfectly adapting the gold, and it may be said that any method which will ensure perfect adaptation with cohesive gold will surely produce a well-condensed filling, providing the whole of the filling is made with equal care. Starting with the point that thin strips of gold, or small cylinders, lend themselves particularly well to adaptation, and selecting what is known as a retaining point plugger, viz., one with a condensing surface of $\frac{1}{64}$ inch in diameter, as the point that produces the greatest condensation and adaptation, we must not forget that when the fine plugger is applied to adaptable gold with great force, an altogether unnecessary amount of time and energy may be expended. The comfort of the patient and the well-being of the periodontal membrane render the use of excessive mallet force undesirable, and a light or light medium blow should be used in all ordinary cases. The question to be settled is therefore principally confined to size of plugger and forms of gold. The condensing power of the fine point gives it a fairly wide range as to the form of gold that may be used in connection with it, and the more favourable the form of gold, the greater the latitude in the selection of sizes of pluggers. It has also been pointed out that semi-cohesive gold may be used in slightly larger pieces than the fully cohesive, and it therefore follows that gold in the semi-cohesive state still

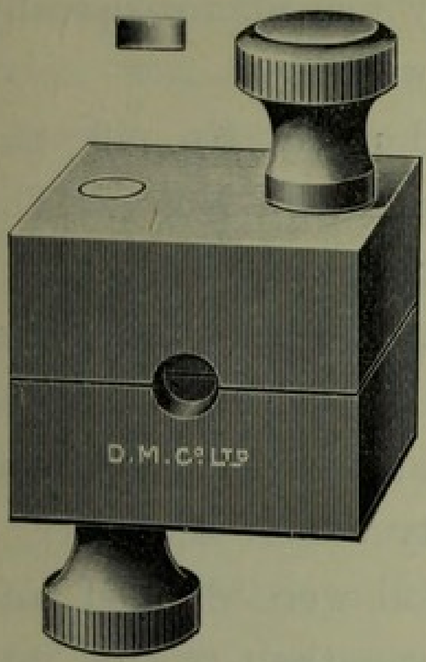


FIG. 7.

further increases the range or latitude of forms of gold and sizes of pluggers.

The writer has made a number of experiments in a steel block (Fig. 7), with the object of ascertaining the adaptation and density of fillings made with various forms of gold. In order that the blow might be the same in every case, an automatic mallet was used (Dr. Southwick's pattern, Fig. 8). This instrument was adjusted to give the light medium blow with which it was used in the mouth. From these experiments the following are selected:—

No. 1.—No. 4 foil folded up to No. 16, cut into strips of convenient length and width. The plugger was straight, non-serrated, with a round, flat face or condensing surface three sixty-fourths of an inch in diameter. The adaptation of the

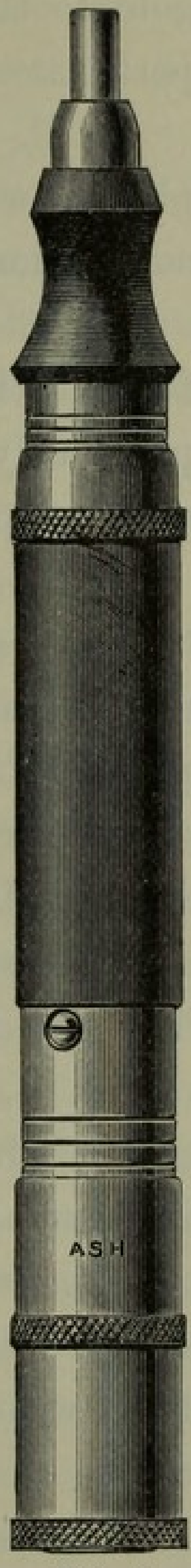


FIG. 8.

gold to the walls of the cavity was microscopically perfect. The specific gravity was 18·9.

No. 2.—The foil was folded up to No. 32; the plugger was the same as in experiment No. 1. The adaptation was bad; the specific gravity 17·5.

No. 3.—The same as No. 2, except that the face of the plugger was half the size of the one previously used. The adaptation was good, but not perfect; the specific gravity was 18·4.

No. 4.—Sheets of No. 4 foil were divided into thirds; each third of a sheet was then twisted into a rope, and cut up into square or short oblong pieces. The plugger with a face diameter of three sixty-fourths of an inch was used. The adaptation was similar to those produced with No. 32 strips and the smaller plugger, viz., good, but not perfect. The specific gravity was 18·1.

No. 5.—The sheets of foil were cut in half; each half was twisted into a rope, and cut up into small pieces as in experiment No. 4. A plugger with a condensing surface one sixty-fourth of an inch in diameter was used; the adaptation was perfect. The specific gravity was not taken.

No. 6.—Hand pressure. Morgan-Hastings extra-pliable cylinders, No. ½ size; the face of the plugger was just over one thirty-second of an inch in diameter; the gold was unannealed. The adaptation was excellent, but not quite perfect; the specific gravity was 17·6.

No. 7.—The same as No. 6, except that the gold was annealed, and the plugger point was one sixty-fourth of an inch in diameter. The adaptation was not quite so good as No. 6; the specific gravity was 17·1.

In these experiments the gold was fully annealed on the electric annealer, except in Nos. 5 and 6. In No. 5 the naked flame of a spirit-lamp was used, and in No. 6 the gold was not annealed at all. The hand-pressure fillings were made with more force than the writer could apply in the mouth. Some experiments made by the professor of chemistry, to whom these and several other experimental fillings were submitted, convinced him that the usually adopted method of obtaining specific gravities by weighing in air and water is inaccurate, as far as testing gold fillings is concerned. Four fillings that had been saved when the rest were consigned to the scrap-gold box, and melted up, were re-tested by a more accurate method.[1] Two of these re-tests apply to experiments which are not mentioned; the other two were the fillings in experiments Nos. 1 and 6. In the former the

[1] For description of which see Appendix.

re-test gives a specific gravity of 18·66, and in the latter 17·54.

One of the objects in making these experiments was to ascertain if the adaptation obtainable with great hand pressure could be compared to that produced with moderate mallet force. The conclusion arrived at—as already explained—is that a very excellent—though rarely, if ever, perfect—adaptation is obtainable with hand pressure in the mouth, *providing* the form of gold, the annealing of the gold, and the size of the pluggers used, are such as lend themselves particularly well to the attainment of the desired result. Two good makes of crystal gold were also tested with mallet force and hand pressure, and were found to be almost if not quite as adaptable as the most favourable forms of foil. Any slight difference in the adaptation was probably due to the pieces used being relatively larger than the pieces of foil.

These experiments are far too limited, and as a dentist is not a machine that works always with mathematical accuracy, it has been pointed out that a very great amount of work is necessary in order to arrive at completely accurate conclusions.

They point out, however, as well as do some other experiments that the writer has not thought necessary to allude to, that certain forms of gold are more favourable than others, that a fine-pointed plugger is in itself better than a larger one, and that unannealed gold (providing it can be made to stick) produces in itself superior adaptation and density whenever the mallet force necessary to obtain a high degree of excellency with fully annealed gold cannot be employed. It has been mentioned, however, that density and hardness of a filling are not synonymous terms, and this also applies to cohesion. There is every advantage in using unannealed or lightly annealed gold against the walls of cavities, particularly if hand-pressure is used, but the writer considers that the bulk of a hand-pressure filling that is made by the cohesive method should usually be made of fully annealed gold.

There is also no doubt that the specific gravities above mentioned can be considerably increased if a favourable form of gold is thoroughly well condensed with a fine point and great mallet force. It must not, however, be forgotten, that the exclusive use of a fine point may reduce density by pitting into the filling, and that the use of a medium point, followed by a fine one, will prevent this, and in many cases give the best result. Such fillings have been made to considerably exceed the density of a button of melted-up pure gold, but it is very doubtful if this extreme density, or even a close approach to it, can be made as a regular thing in the mouth, and a filling made in the mouth that approaches a specific gravity of 18·0 will usually be considered exceptionally dense. The specific gravity of a melted-up piece of S. S. White's gold foil is 19·0.

Some recent experiments made with the object of testing the capability of the Rauhe mallet, convince the writer that either foil or a good make of crystal gold can be perfectly adapted to the walls of a cavity without any particular difficulty, and without using a blow that is unduly disagreeable, providing an adaptable form of gold is used, and providing every part of the cavity is easily accessible. Skill and experience enable many difficulties to be overcome; but just in proportion to the manner in which either the position of the cavity or the way in which it has to be prepared cramps the work of an individual operator, so must a more or less imperfect adaptation be expected. By a perfect adaptation to the walls of the cavity in the steel block is meant not only that no observable spaces or porosity exist, but also that every slight mark or inequality in the steel is even more accurately or clearly reproduced in the gold than if a wax impression were taken. This is a severer test than placing the block in ink or aniline dye.

A filling may be imperfectly adapted at parts and still respond satisfactorily to the leakage test. But as something less than the perfection obtainable in the steel block must be expected in the mouth, it is fair to presume that a method which gives perfect results out of the mouth will produce the greatest number of moisture-tight fillings in the mouth, while a method that is only good enough to produce moisture-tight fillings out of the mouth will probably produce a large number of leaky fillings in the mouth. The writer begs to suggest that if dentists in general, and dental students in particular, would test their gold fillings by making experiments out of the mouth in such a manner that the plugs could be properly examined for adaptation and density, this would result in an improvement in their work and bring about a considerable increase in the average durability or tooth-saving properties of gold fillings.

It is often a convenience to pack and condense each piece or layer of gold with a medium-sized plugger, and then to further condense it with a fine point. This, as already mentioned, may prevent pitting, and result in a better and more even condensation and adaptation. When gold is condensed with a fairly broad plugger so thoroughly that the operator feels sure of perfection, it is wonderful how often the gold will still further "go down" when the fine point is applied.

The method of manipulating non-cohesive gold is entirely different from the cohesive method, and the accurate adaptation of non-cohesive gold does not so much depend on the greater adaptability of the gold itself, as upon the fact that it lends itself to the employment of enormous force. The wedge is the greatest force in mechanics, and it is on the power exerted by the wedge that non-cohesive gold fillings mainly depend for their excellence. The force that may be used is only limited by the strength of the cavity walls, for the lateral compression of the gold by means of the wedge does not jar the tooth or hurt the periodontal membrane. It is quite easy to split off one or more of the cavity walls by wedge power, and this demands discretion in regulating the force.

The great difficulty with non-cohesive gold is in obtaining or producing cavities of the right shape and accessibility. An ideal cavity may be said to be one of medium to large medium size on the occlusal surface of a first lower molar. Here strong walls of sufficient height or depth can be secured at right angles to a flat floor. The gold can be readily inserted in layers parallel to the walls, and the wedge-shaped plugger can be driven into the gold at any part parallel to the walls and at right angles to the surface of the filling. The holes made by the wedge can be solidly filled up by driving non-cohesive gold into them, and the most even and thorough condensation of this gold is arrived at, producing a filling that is not only perfectly well adapted, but will stand the wear and tear of mastication.

Just as this freedom and accuracy of manipulation are interfered with in any case, and just as the shape or depth of the cavity and the strength of the walls depart from the ideal condition, so will the difficulty of making well-adapted and solid non-cohesive fillings be increased. Gold foil is prepared for non-cohesive work much in the same way as for the cohesive method. When pellets or cylinders are used, they should be rolled more tightly, and a thicker gold than that usually employed for cohesive cylinders is advisable, No. 4 or No. 5 foil being usually preferred. Cylinders are now generally used for non-cohesive work, but those that are supplied by the depôts for this kind of work are often too stiff to be easily used in approximal cavities. Useful cylinders can be made as follows:—Take a sheet of No. 4 non-cohesive foil, fold it once on itself, cut a strip the length of the sheet, one or two inches broad, double over the end of the strip with straight, fine-pointed, foil-carriers or tweezers; then with the tweezers, supplemented with the fingers, gently roll the gold strip. Keep the tweezers outside the roll; do not wrap the gold round the points. By proceeding in this way, always catching hold of the external part of the roll, and cutting off the superfluous strip as soon as the cylinder or roll is thick enough, various-sized rolls are easily made. Cut the roll into short pieces of the desired lengths with sharp scissors. The scissors will compress the ends somewhat, and produce blocks rather than cylinders. A little gentle squeezing and rolling with the fingers will bring them back to the cylinder form, although as blocks they will work satisfactorily. Some of the best non-cohesive fillings of the past were made by operators who confined themselves solely to tape. For general purposes it will be found that pellets, or short lengths cut from a rope of suitable thickness, answer all requirements, and are perhaps easier to use than other forms of non-cohesive gold. When large pellets are needed, two or three or more sheets of No. 4 or No. 5 foil may be placed on one another, and then rolled or twisted into a rope, and cut up into pellets, or short lengths, as desired.

Some of the details of filling cavities will be considered later.

Annealing Gold.—Annealing can be done either with the naked flame of a spirit-lamp, or by placing the gold on a thin sheet of platinum or mica, and holding it over the flame. The electric annealer, although extremely satisfactory, and theoretically the only perfect annealer, is by no means a necessity, and the statements that have been made, that its use causes the gold to work with an added degree of softness that enables better and more rapid work to be accomplished, do not agree with the writer's experience. It certainly thoroughly anneals the gold without any fear of over-annealing it. The writer has left both foil and crystal gold on it for half-an-hour with the current full on (Custer's electric annealer), and found the gold worked perfectly satisfactorily. It is only necessary, however, to leave the current on till a part of the fireclay slab glows with the heat, and any one who has regard for his own comfort, or the well-being of his bracket-table, will switch off the current as soon as the requisite heat is produced. These annealers would be greatly improved if they were larger. If a dentist works without an assistant at the chair, or if the assistant is employed in malleting the gold, he will have to stop to recharge the annealer with gold several times during the making of a large gold filling. If the naked flame of a spirit-lamp is used, it must give off no carbon. The least trace of carbon deposited on the gold will prevent perfect cohesion and spoil its working properties.

Methylated spirit seems to vary very much in this respect, and it is well to test it by placing a sheet of mica over the flame, and leaving it there for ten minutes. One lot of methylated spirit will be found to thoroughly blacken the mica, and another lot will leave it quite clean. The safest thing to do is to use rectified spirits of wine.[1] Absolute alcohol has been recommended, but does not appear to be any better in this connection than rectified spirit, and is more expensive. It is difficult to anneal gold on a sheet of mica; the mica does not become red-hot except at the edges, and the time necessary to hold the mica over the flame can only be guessed at, although some operators, from great experience, seem instinctively to know when the desired effect is produced. The writer made a few experiments in trying to regulate this by timing with the second-hand of a watch, but gave it up in despair. The gold was always either under, or over, annealed. There is no difficulty in using a thin sheet of platinum, for as soon as the platinum glows with the

[1] 90 per cent. alcohol.

heat, the gold is fully and satisfactorily annealed. It has already been mentioned that skill and experience with the sheet of mica are particularly valuable in the production of semi-cohesive gold.

All gold that is to be used cohesively, whether foil or crystal gold, should be annealed before use. It can be heated to a dull red without injury, and in fact, if the greatest cohesion and hardness of the filling is desired, it is necessary to heat it to this point. The gold will, however, in many cases work more softly and easily if not so highly annealed (particularly if in the pellet form), and as something less than full annealing is often desirable in order to secure ease of working and ready adaptability to cavity walls, many operators find it useful to anneal each piece of gold by passing it over or through the flame just before placing it in the cavity, and by this means to vary the cohesiveness as desired. Others, again, will anneal all the gold necessary for an operation before commencing it. Strips of thin tape are almost impossible to anneal evenly in the naked flame unless the following procedure is adopted, which is very satisfactory:—After folding the sheet of gold, cut it into oblong pieces about half an inch wide, and one or two inches long; take hold of one end of this broad, flat piece of gold with foil-carriers, and hold it over the flame until it becomes just red-hot, then transfer the foil-carriers to the other end, and re-anneal it; by this means the part that was originally held by the point of the carriers, and which would consequently be imperfectly heated, is fully annealed, and if anything like reasonable care is taken, the gold is not in any way over-annealed at any part. A great amount of gold may be annealed in this way before the operation is commenced, and will hold its cohesive properties for a considerable time. If, however, the surface of the filling is approached, and the gold used at this part has been on the pad for some time, it is as well to pass each strip rapidly through the flame just before inserting it. Of course these broad, oblong pieces are cut up into strips after this annealing. It has been stated that this hardens the edges and renders the manipulation difficult and the result uncertain. This is a mistake as far as thin strips are concerned, for cutting them up after annealing makes no difference, either real or apparent. The only difficulty is, that the gold has a tendency to stick to the blades of the scissors; but this is a small matter, and either passing the blades of the scissors between the fingers, or changing the scissors, will greatly prevent this. The same difficulty exists to some extent in cutting up strips of gold before annealing, and some operators, to avoid it, place the gold between sheets of thin paper and cut through both paper and gold.

Before dismissing the subject of annealing, there are two little points that may be mentioned. One is that Watts' crystal gold, if taken from the freshly opened box, will often work unsatisfactorily if it is fully annealed. Very light annealing is all it must be subjected to, but as soon as it has become stale from exposure it can be brought to a full dull red heat without detriment. This peculiarity may apply to other makes, and is worth remembering. Any difficulty in regard to this may be overcome by previously subjecting this gold to the fumes of ammonia. The gold may be placed in a closed box in which a small saucer containing strong liquid ammonia is placed, or a piece of cotton-wool may be saturated with the liquid and placed in the box apart from the gold. Another point is, that the thick small squares that have been alluded to for surfacing fillings can be more satisfactorily annealed on the electric annealer than in any other way.

The balling up of gold that is so often alluded to, simply means that the gold refuses to cohere. This may be due to under, or over, annealing—usually the latter; but given a good make of gold, and an operator of some experience who is careful in little things, it is rarely that a piece of gold will "ball-up." On the other hand, given a careless dentist, whose foil-carriers are smeared with dried varnish or chloropercha, the serrations of whose instruments are rusty or dirty, and who anneals his gold in the naked flame of a spirit-lamp, the wick of which is thoroughly charred, or contaminated with the fumes of the matches used in lighting it, &c., it is not to be wondered at if he finds it difficult to work cohesive gold.

Combination of Cohesive and Non-Cohesive Gold.—Non-cohesive gold is frequently used for starting fillings of cohesive gold, either to facilitate this part of the operation, or to avoid the use of starting pits. The writer has never been able to understand the prejudice that exists in the minds of some against starting pits. A starting pit is drilled in the dentine at a safe distance between the enamel border and the pulp, its direction being away from the pulp. Any idea that a small pin-like piece of gold—that is more remote from the pulp than the large mass of filling that rests on the floor of the cavity—should cause irritation or death of the pulp, when the filling itself is a far more probable cause of this, is difficult of comprehension. It is true that a pin-head or pin-point gold filling that does not extend more than half a millimetre into the dentine *may* cause death of a pulp; but if these cases were seriously considered, no one would ever make a gold filling.

When it comes, however, to considering the difficulty that may every now and then occur in making a satisfactory starting pit, and when any trouble or time that filling the pit and carefully extending the gold over a cervical wall, or other starting wall, is considered, the value and convenience of wedging in a base of non-cohesive gold is manifest. Cohesive gold does not cohere with non-cohesive, and will not usually even stick to it, consequently a mechanical adhesion, produced by driving or locking the cohesive into the non-cohesive, is imperative. This can be effected with sharp, deeply serrated pluggers; or pits may be forced into the non-cohesive gold (in the direction of the cervico-lingual, and cervico-labial, or buccal, angles), and then the cohesive gold is driven into these pits.

It is important to begin attaching the cohesive gold before the non-cohesive is much condensed. As soon as it is wedged to place, and sufficiently firmly pressed to prevent dislodgment, the cohesive should be applied, and the condensation of the cohesive layer will then fully condense the non-cohesive, and drive it into close contact with the wall.

In an occlusal cavity, or in a small round or oblong approximal cavity that can be filled by force applied at right angles to the floor, a base of non-cohesive may be wedged between the walls, and pressed down on to the floor. The deeply serrated plugger, or the forcing of a few pits into the base, will enable the cohesive gold to be easily added. The making of combined fillings of non-cohesive and cohesive gold presupposes the use of much more non-cohesive gold than is employed for merely starting the filling. This method is resorted to mainly for purposes of convenience and rapidity. In approximo-occlusal cavities of molars and bicuspids, the non-cohesive is used up to the knuckle, and the cohesive completion, or top, is securely locked into the rest of the cavity; no question of mechanical attachment of the cohesive to the non-cohesive portion being in these cases relied on for *retention* of the cohesive top. In approximal cavities in incisors and canines, and in occlusal, labial, and buccal cavities, the cohesive portion depends for its anchorage on an interlocking attachment to the non-cohesive gold.

In occlusal cavities the non-cohesive gold is condensed against the side walls with lateral pressure until so much gold is inserted that it can no longer be placed and packed laterally. This leaves a more or less narrow hole near the centre, which is filled up from the bottom with small pieces of cohesive gold. The filling is then tested with a sharp-pointed, wedge-shaped plugger, and if this can be forced into the gold at any part, the hole made by the wedge is filled with cohesive gold. This is repeated at other parts until the sharp point cannot be made to penetrate at any place. Labial and buccal cavities may be treated in the same way if a combination filling is desired; this method may also be adopted in approximal cavities in the incisors and canines, and if the surface of the non-cohesive gold is sufficiently depressed or forced down during the making and filling up of the holes a cohesive surface may be obtained. In this case the cohesive top or surface is firmly attached to the ends of the series of rod or nail-like portions produced by filling up the small holes with cohesive gold. Another method that is very useful in approximal cavities in these teeth is to fill the cavity with non-cohesive gold, and then—instead of making any holes in it with the wedge—to force the mass in the direction of the labial wall if working from the back, and in the direction of the lingual wall if working from the front, in such a way that a sufficiently deep and broad trench-like cavity is formed for the reception of the cohesive portion. The success of this depends on an accurate adaptation of the non-cohesive gold to the cervical, labial or lingual, and cutting edge walls by carefully condensing against these walls as each piece is packed in place, and in giving a retaining shape to the trench that is to be filled with cohesive gold. The engine-bur may be used to cut out some of the non-cohesive gold if necessary. In this method either the lingual or labial wall is left free, and is utilised as a help in retaining the cohesive portion.

In theory, combination fillings of non-cohesive and cohesive golds are inadvisable, because there is a different spring, or resistance, to the stress of mastication in these two kinds of gold, each differing in rigidity or elasticity. In practice it will be found that this combination will in many cases prevent the wearing of the surface of a non-cohesive plug, and may produce a durable filling in place of a readily worn away or disintegrated one. The writer has a distinct prejudice in favour of an all-cohesive filling, or an all-non-cohesive filling, providing either one is sufficiently perfect to serve its purpose ; but he willingly admits that these combination fillings serve a very useful purpose, and are often preferable to any attempt that may be made with either material used singly. He would also beg to suggest that a young dentist, who has not had the time or experience to enable him to become an expert in either the cohesive or the non-cohesive method, may find these combination fillings a very useful bridge at the outset of his career.

Instruments for Filling Teeth with Gold.—The pluggers used for filling teeth with gold are many and various. Such a large number have been designed that it is hard to make a selection. The difficulty is not so much in knowing what to choose, as what to reject, for it is impracticable to regularly use more than a certain number. Some useful forms have already been alluded to (Figs. 4 and 5, page 51).

Two or three sizes of point of each instrument may be used, varying from about one thirty-second to one sixty-fourth part of an inch in diameter, bearing in mind the principles in regard to relationship of plugger-point to form of gold, and force applied, that have been alluded to. Foot-pluggers may have a working face of not more than three thirty-seconds of an inch long by one sixty-fourth of an inch wide, or two thirty-seconds long by one thirty-second wide. Larger condensing surfaces than any of the above-mentioned sizes may be used if desired to place and pack or partially condense the gold preparatory to the employment of a smaller plugger. One or two ball-ended burnishers for exposed surfaces, and one or two thin flat ones for use between the teeth, should be added to one's case of gold-filling instruments.

The pluggers for cohesive gold may be either smooth, or finely serrated. Smooth or non-serrated pluggers may be satisfactorily used, but owing to their greater liability to slip are rather dangerous in the hands of a novice. They are not so likely to damage the margins of a cavity as serrated ones, but owing to the manner in which fine serrations generally facilitate the work, they are preferred by the majority of operators. Instruments with deep, sharp serrations are useful for driving cohesive into non-cohesive gold. They may also be used for tacking down pieces of cohesive gold if it is found that either the form or thickness of the gold or the position of the cavity interferes with the immediate cohesion usually produced with either finely serrated or smooth pluggers. The form of the end, or condensing surface, of the plugger makes little or no difference to the excellence of the work. Flat, or convex, or even ball-ended instruments may be used. A rounded end is not so likely to damage margins, and the smooth convex form admits of a sliding blow being used. This is a favourite method with some operators. There is no such thing as the form of the plugger having anything to do with spreading the gold. Spreading only takes place as the result of extreme condensation, and the shape of the instrument has nothing to do with this.

The manner in which the gold is placed, and the filling built up, will depend on the exigencies of the case. The surface of the gold may be kept flat, or concave, or convex. As a rule it is advantageous to commence the condensation at or near to the centre of the layer and work gradually towards the wall. It is easier to perfectly adapt the gold to the floor of the cavity in the steel block, or to the floor of a cavity on the occlusal surface of a molar, than to the side walls, because the force is delivered at right angles to the floor. An attempt to apply right-angle force to the side walls would result in the production of a gold lining which would spring or curl away. In order to avoid this it is advisable to condense the gold against the side walls in such a manner that it is driven into the angle between the already condensed gold and the wall. A proper condensation of the gold at this part will prevent the filling being built up against the walls much ahead of its base. The angle at which the force is applied will vary according to circumstances. As a rule it will be almost at a right angle to the base, and at about an angle of forty-five degrees to the other walls; but it may be delivered almost parallel to a wall if desired.

Pluggers for packing non-cohesive gold are of much the same forms as those used in the cohesive method. In many cases the points may be larger and the serrations deeper. The wedge-shaped pluggers should taper to an absolutely sharp point. A four-sided instrument that is tapered down to a point is a useful form, and many of the older operators were in the habit of keeping the point and side angles as sharp as possible by rubbing them on an oil-stone. They often used the sides for packing and condensing the gold laterally, then the point for further lateral condensation, and finally the point for making holes in the filling, and for complete consolidation of surface.

Mallets.—It is probable that no better work has ever been accomplished than that which is done by means of the old-fashioned hand mallet. No other percussive instrument enables the dentist to feel so exactly what he is doing, and to vary the force so accurately and delicately. In order to use the hand mallet with ease and precision the operator must be completely ambidextrous, or else be dependent on a skilled assistant. Very few dentists are ambidextrous, and even if the operator is equally skilled in the use of both hands, an assistant is often necessary, in order to hold back the cheeks of a patient, and to throw light into the cavity with the mouth mirror. The hand mallet will therefore never be generally adopted, more especially as some very efficient substitutes have been invented. The steel hand mallet gives a sharp ringing blow, and appears to condense the gold more quickly than the lead mallet. The lead mallet seems to demand a little longer use before the feeling of perfect condensation is arrived at. The sharp blow of the steel mallet is, however, more disagreeable to a patient than the dull dead blow of the lead mallet.

Hand mallets are also made of brass, tin, and composition metals. These, however, are either akin to the steel or the lead mallet, depending on the kind of metal used, and there does not seem to be any particular advantage in attempting a compromise between the sharp blow of the steel and the dull blow of the lead mallet. The improved automatic mallets (of which the old Snow and Lewis mallet is the progenitor) are very efficient instruments, and their convenience and little liability to get out of order make them very popular.

Certain dentists have found that the automatic mallet is disagreeable to patients, because there is a distinct interval between the placing of the plugger on the gold, and the delivery of the blow.

It must not be forgotten that there are several makes of automatic mallets, which vary somewhat in their construction and working properties. Any appreciable interval or hiatus between placing the plugger on the gold and delivering the blow, is due either to using an automatic mallet that is not of the best construction, or to screwing it up to a very heavy blow. The best manner of adjusting the blow will also, no doubt, vary in different mallets. The writer finds as the result of testing fillings (made out of the mouth), for cohesion, that with the Southwick automatic mallet (Fig. 8, p. 57) a long stroke and a light blow give better results than a short stroke and a heavy blow; and for ease of manipulation, comfort of the patient, and general efficiency, he has adopted a medium or light medium blow, and an adjustment of the length of stroke or blow that is exactly midway between the longest and shortest adjustments. He also finds, as the result of trying them on his own teeth, that an automatic mallet is one of the least disagreeable of all the various mallets he has used. The various dental engine and electric mallets are much liked by some operators, and the use of suspension electric dental engines enables the engine mallets to be used with the greatest convenience. The writer finds that these fast-striking mallets greatly interfere with the sense of touch, and it is consequently difficult to know exactly when the gold is condensed. He also finds that the blow of some of these instruments is so indistinct (more a vibration than a blow), that it is necessary either to use them with great pressure —which is disagreeable to the patient—or else spend a very long time in condensing each layer of gold. These instruments, however, vary in their working properties, according to the kind that is used, and great familiarity with an instrument has much to do with the quality of the work produced. It has been mentioned that the hand mallet enables the strength of the blow to be instantaneously varied with the greatest ease and delicacy. Some of the pneumatic mallets enable this to be accomplished with almost equal precision, and the writer has had occasion to speak favourably of the Rauhe mallet.

Preparation of Cavities for Gold Fillings.—To prepare a cavity for the reception of gold it is necessary, in nearly all cases, to cut away part of the tooth, to enable the instruments to be freely used in the removal of the decay, the cutting of the anchorage, and the insertion and packing of the gold.

A certain amount of "opening the cavity," as it is called, is necessary, no matter what material is selected; but the cutting must usually be much more freely done if gold is to be used, for every piece must be placed at once just where it is wanted, and condensed by the direct action of the plugger. There is no possibility of pressing the gold round a corner and squeezing it into position. This cutting away of part of the tooth does no harm. The part removed is replaced with gold, and it can be done in such a manner that the tooth is in no way weakened, or made less useful. To open an occlusal cavity the overhanging edges of enamel are cut away until they are level with the interior walls. It must be remembered that, owing to the body of a tooth being composed of dentine, it usually decays to a greater extent than the enamel, and on the removal of the decay the interior is consequently larger or more hollowed out than the orifice (Fig. 9*a*). The rule in occlusal cavities is to make the orifice as large as the interior diameter, so as to do away with any overhanging ledge under which it would be almost impossible to accurately pack and condense the gold (Fig. 9*b*). This applies also to cavities on the labial, buccal, and lingual surfaces of the teeth, and to a certain extent to all cavities.

To open a mesial or distal cavity in the six upper front teeth, it is usually advantageous to cut away either part or the whole of the lingual wall. Occasionally part of the labial wall may be removed instead, but this should, as a rule, be avoided, for although it makes the whole operation easier, and it can be completed in less time, the gold shows some-

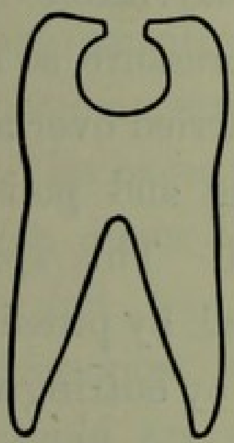


FIG. 9*a*.

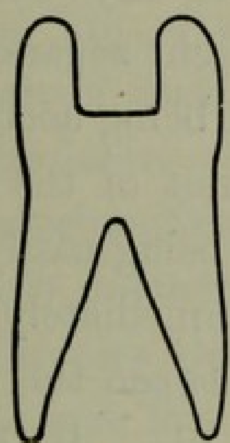


FIG. 9*b*.

what, and this should always be prevented if possible. Some operators, instead of cutting away either the lingual or labial wall, separate the teeth widely by pressure; and beyond trimming the edges to obtain smooth firm margins, do not remove any of the walls for the purpose of obtaining access.

The writer having originally practised this wide separation method with as much preservation of both lateral walls as possible, infinitely prefers a slight separation and the access obtained by cutting away one of the lateral walls. The packing of the gold can be accomplished with greater certainty, the nuisance of obtaining a wide separation is avoided, the patient is not worried with keeping the cotton-wool or tape, or whatever may be used to obtain the desired space, between the teeth for a considerable time, the teeth rarely become painful from the pressure, and the cutting secures free margins at parts of the filling at any rate. It is advisable, however, to obtain a slight separation by pressure, so as to admit of the gold being accurately carried over all margins, and to admit of the trimming and polishing tapes and discs being easily applied. This space can be obtained immediately, if desired, by pressing a wedge of wood between the teeth, or by cutting with a thin separating file. If the separating file is used, the slight division thus made will not spoil the appearance of the teeth, and is decidedly preferable to showing a line of gold; but except for preventing the exposure of gold, it is well to remove no more of a labial wall than is absolutely necessary, and as a rule slight separation by pressure is better than slight separation with a file.

To obtain access to all medium and large-sized cavities on the approximal surfaces of bicuspids and molars, the overhanging enamel at the occlusal part is entirely cut away, and if necessary—particularly in distal cavities—part of the buccal wall may also be removed. In all medium and large-sized cavities the lateral walls should, if possible, be cut away sufficiently to secure free margins, but more than the cutting necessary for this purpose is admissible in certain distal cavities where the access is difficult.

Having opened the cavity, the next step is the removal of the decay. This is easily accomplished (unless very sensitive) by the use of sharp spoon and hatchet excavators of various sizes and curves. Now, with the exception of the labial walls of front teeth, break down all frail overhanging enamel at all parts, and be particularly thorough in this respect at cervical walls. (Cavities that are to be filled with gold are alluded to, not frail shells that can only be filled with a plastic material.) This can usually be easily done by placing a suitable spoon excavator at the edge just outside the cavity, and breaking it down by inward pressure (pressure in the direction of the cavity). The plug-trimming files (Fig. 10, Smith's (*a*) and Rhein's (*b*) trimmers) are also useful for supplementing the spoon excavators, and for trimming margins generally. Chisels and sharp engine-burs should be used for removing overhanging enamel in occlusal cavities, and for freeing and trimming the lateral walls of approximal cavities. In approximo-occlusal cavities in bicuspids and molars a good deal of overhanging enamel can often be removed in a rapid manner by means of a chisel and hand mallet. In suitable cases a very light tap, which causes the patient no pain or even inconvenience, is all that is necessary, providing, of course, the chisel is held at the proper angle, viz. in the line of cleavage of the enamel rods. Margins of

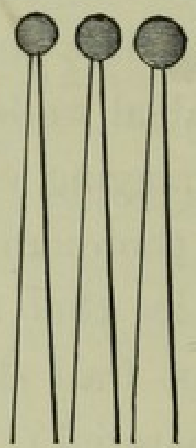


Fig. 10*a*.

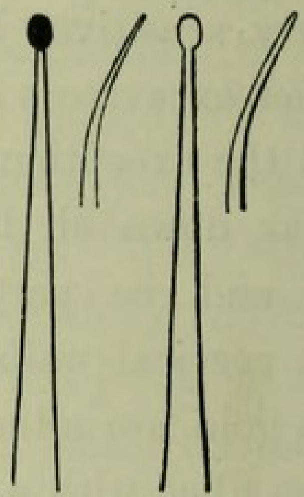


Fig. 10*b*.

cavities should usually be bevelled if gold is to be used. The extent of the bevelling will depend on the case, and the manner in which it will facilitate the carrying of the gold over the margins without damaging them. The greater the bevel, the more difficult it is to finish to a fine clean edge, and the labial margins of front teeth, and the margins of labial cavities in general, admit of very little bevelling if the finest blending of tooth-structure and gold is necessary for appearance' sake. The thickness of the gold over the bevelled margin must also be considered, for it is quite possible to bevel to such an extent that a thin layer of gold over a much-bevelled margin becomes lifted up in time through the stress of mastication, and an imperfect joint results. The main thing to consider is to produce a margin that will not be chipped or broken by the force used in condensing the gold over it, and which is sufficiently cleanly cut to admit of a fine margin when the gold is finished. Having removed decay and trimmed the margins, proceed to shape the cavity for anchorage. The final finishing or smoothing of the margins should be done just before the insertion of the gold.

Anchorage.—The retention of a filling depends on the shaping of the interior of the cavity, and in this connection there are several points that demand careful consideration. The anchorage should be made in such a manner that the tooth is weakened as little as possible; the pulp is not unduly approached; and the accurate condensation of the filling at all parts is not interfered with. All anchorage must be made in accessible places. It is no use making an accessible part of a cavity either inaccessible or difficult of access by undercutting, and it must not be forgotten that to make an undercut takes up time and often causes pain, and that to fill the undercut also takes time. It may therefore be laid down that it is distinctly advisable to make anchorage in places that are easily reached, and can be readily and accurately filled, and that no more undercutting should be done than is absolutely necessary. The operator must, however, be guided by the circumstances of each case, and when necessary, time and convenience must be sacrificed to stability. As an illustration of this, the writer once saw a celebrated dentist, who was renowned for the rapidity with which he could insert gold fillings, demonstrate his method. The skill and manipulative dexterity of this operator were of a very high order, but he so hollowed out the cavity in order to easily and rapidly insert the gold, that it was not surprising to learn that the filling shortly afterwards remained in a perfect state of preservation in the waistcoat pocket of the patient. If this cavity had been prepared with every respect for maintenance of strength of tooth structure, it would have taken far longer to insert the gold, but the filling would have proved more useful.

The question of shaping cavities for retention may be divided into a consideration of the older or more general method, and the newer proceeding perfected and introduced by Dr. Black. In the older method the cervical walls are curved or rounded, and anchorage as well as maintenance of integrity, or absence of rocking of the gold during its condensation, is effected by means of pits, grooves, and undercuts. Dr. Black's method consists in broad, flat cervical walls; cavity walls at right angles to the floor; the formation of sharp angles at the lines of junction of the walls and the floor, and the absence of all pits, grooves, or undercuts. There is no doubt that Dr. Black's method is based on sound mechanical or engineering principles, and that it facilitates the introduction and packing of the gold in many cases, enabling the filling to be made more rapidly. An operator cannot, however, always do exactly what he would like to do. There is not always as much tooth structure left to work upon as is desirable, and patients are not all blocks of wood who will permit their teeth to be excavated on exact mathematical lines. It is often necessary to compromise, and whenever this can be done without any real detriment to the operation, it is advisable to do so. It may also be pointed out that no better work has ever been done, or in all probability ever will be done with gold, than that accomplished by the late Dr. Webb and several others who prepared cavities in the older way. It is more difficult to prepare cavities in the new manner, and the inverted cone bur, which plays such a large part in this preparation, is a much more dangerous instrument than the round bur. Those who practise the new method exclusively are doubtless sufficiently expert in it to be unaware of its ever presenting difficulties. The writer desires to express his appreciation and admiration of this method, but cannot help thinking that it has sometimes been presented with too little regard for, and too great depreciation of, the older way.

In preparing cavities on occlusal surfaces of molars and bicuspids, both the old and new methods are practically "on all-fours." A flat floor and straight walls at right angles to the floor is the preparation that is necessary, whether it takes the form of an ordinary round or oblong cavity, or the cutting out of fissures. To effect this, all overhanging enamel is cut away until the softened dentine is removed, and the cavity generally shaped up, always cutting until hard dentine is reached. The floor is flattened, and the angles made sharp with an inverted cone bur, or suitable excavator, and this bur can be used in these cavities easily and with safety.

In incisors and canines the older method is to remove the decay, and cut to hard dentine with excavators and round burs. A groove is then cut along the cervical wall with a small round bur, taking care to avoid, on the one hand, cutting too close to the enamel margin, and on the other, too close to the pulp. The ends of the groove are then deepened slightly, by drilling upwards and outwards at the cervico-labial, and upwards and backwards at the cervico-palatal parts. One or both of these depressions is deepened into a starting pit, if desired. An opposing anchorage is made by drilling a little pit in the dentine at the cutting edge whenever the cavity will admit of this being done without weakening the cutting edge; and whenever the labial and palatal walls will admit of it, a fine groove is made along them with a fine round bur, or an excavator, at the line of junction of these walls and the floor of the cavity. Whenever, as often happens, the enamel is not supported by a sufficient thickness of dentine to admit of this, the cervical anchorage is deepened and broadened, particularly at the ends of the cervical groove; and whenever the near approach of the cavity to the cutting edge renders the drilling of a pit at this part out of the question, a mere cutting of this wall at right angles to the floor is all that can be done. In many cases, where, owing to breaking down, or frailty, of the lateral walls, the anchorage is rendered doubtful, the cervical cutting may be supplemented by extending the cavity well across the lingual surface, and slightly undercutting the dentine at this part. By this extension a frail or shallow lingual wall may be converted into a strong and most useful one. Care must be taken in doing this, and the extension should be broad and shallow, rather than narrow and deep, so as to avoid cutting too near the pulp.

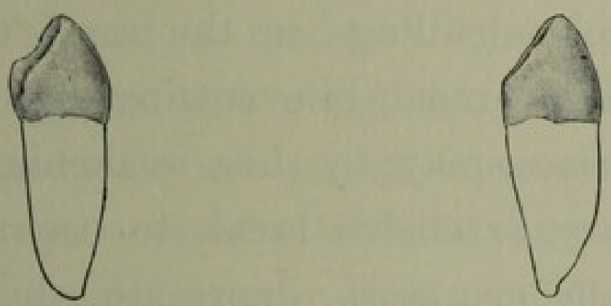
Dr. Black's method in these cavities is to cut the cervical wall flat at right angles to the floor, and to extend it in the region of the cervico-labial and cervico-lingual angles as far as practicable. The cutting edge of the cavity is made at right angles to the floor, and the labial wall is also cut at right angles to the floor. The lingual wall is squared out in the same way, wherever its thickness will admit of this being done. This generally means a squaring out at the cervical portion of this wall, and, if practicable, a little squaring out near the cutting edge. When the cavity involves the cutting edge of the tooth, or approaches it so closely that a break may occur in this part after filling, a step extension is cut across the cutting edge.

Access to these cavities is obtained by separation, and by cutting away part of either the labial or the lingual wall. The methods of access apply equally well to all methods of preparation. Small round or oblong cavities are prepared in a similar way by either the old or the new method, straight walls and a flat floor being usually readily obtained; and the formation of sharp angles, or in the older method the making of a little groove around the cavity, is readily accomplished with an inverted cone bur or suitable excavator.

In cavities on the approximal sides of bicuspids and molars, it is usually necessary to convert them into approximo-occlusal cavities, if gold is to be satisfactorily used. This is effected by cutting away the overhanging enamel and dentine at the occlusal part, and making the cavity into one of three walls. In the older method the absence of the occlusal wall was counterbalanced by cutting a distinct groove, about one sixty-fourth of an inch deep, along the palatal and buccal walls, at the line of junction with the floor, extending from the occlusal enamel to the cervical wall; and if the lateral walls were also slightly concave, or sloping inwards, the anchorage was considered sufficient. The cervical margin was left curved, but was not grooved, as the proximity of the pulp would render this a dangerous proceeding, unless the groove was made too close to the enamel border, leading to its being damaged by condensation of the gold. The lateral grooves were generally deepened into little pits at the cervical wall, and further deepened—if thought good—into starting pits. These depressions, supplemented by the lateral grooves, effectually prevented rocking or displacement of the gold during its manipulation. Many operators found it necessary to produce a fourth wall in these cavities by undercutting the occlusal part, and this could generally be accomplished without this margin being afterwards broken or chipped by the force of mastication; and this undercutting was often made easier by a dipping in of the decay at this part.

It frequently happens, however, that the lateral walls are frail, and will admit of little or no anchorage being made at this part, and they may even slope slightly outwards. In these cases such undercutting at the cervico-buccal and cervico-lingual angles as might be necessary to start the filling and prevent its rocking was resorted to, as well as cutting the juncture of the lateral walls and floor of the cavity into as distinct angles as possible. The cavity was then extended sufficiently across the occlusal surface to produce a step, or arm-like extension, sufficiently broad and deep to counterbalance the want of retention that would otherwise have existed. Many operators adopted this step extension as a general method of practice to prevent weakening the lateral walls by grooving or otherwise undercutting them, and to save the time, trouble, and uncertainty of filling these lateral grooves or undercuts. With the exception that the rounded or curved cervical wall was retained, and that depressions were made at either side of this wall, and that the end of the step was often undercut, it will be seen that this is a near approach to the Black method.

Dr. Black's method is to make a broad, flat, cervical wall well extended laterally; to make the



Lower Bicuspid. Upper Canine.

FIG. 11.

lateral walls parallel to the floor; to cut the line of junction of these walls and the floor into sharp angles; to cut the step extension in every case, and to make it with straight walls, a flat floor, and sharp angles, and to square out, or make as distinct as possible, the angles at the juncture of the lateral and cervical walls. In some lower bicuspids the lingual cusp is so short and the buccal cusp is so long in comparison, that these teeth are very like upper canines in appearance (Fig. 11). Bicuspids of this shape do not lend themselves well to the formation of the usual occlusal-surface step extension. The method of preparation adopted in these cases should usually be similar to that used in the canines. Theoretically, all methods of bicuspid and molar preparations of approximo-occlusal cavities weaken the walls, and may lead to a breakdown. Any grooving or undercutting of the lateral walls may do this; and even if this is avoided, a step extension, which, owing to the presence of two approximo-occlusal fillings in the same tooth, necessarily forms a trench-like cutting right across the occlusal surface, may, by thus weakening the cusps, cause a very extensive break to occur. For this reason some operators deprecate the step, and, while following out Dr. Black's directions at other parts of the cavity, prefer to slightly undercut the occlusal part, but avoid altogether the step extension.

In practice, however, it will be found that accidents of this kind rarely occur with any kind of preparation—providing it is carefully carried out—and that if an accident occurs it is generally due to the filling of a frail tooth. Such accidents may often be prevented by shortening and rounding the cusps of the filled tooth, and also the cusps of the opposing tooth or teeth. This is a proceeding that should always be considered, and practised whenever the circumstances of the case present the possibility of an accident occurring.

A careful preparation of the margin is imperative. All little cracks, chalky patches, or defects, must be cut out; and it is advisable to carefully examine the enamel in the neighbourhood of the margin with a magnifying glass. Many fillings fail because of some small defect in the enamel, close to, but not immediately connected with, the margin. The margin should be made as smooth as possible with chisels, spoon excavators, fine-cut engine-burs, fine files, emery or sandpaper tapes or discs, &c., whichever may be most suitable to the case in hand.

It is considered, however, that a polished margin, or one that is sufficiently smooth to approach this condition, should be avoided, because it has been found practically impossible to perfectly adapt cohesive gold to the smooth, polished, somewhat slippery interior of a glass tube; therefore Arkansas or other extremely fine stones should not be used for perfecting the margins of cavities that are prepared for gold fillings.

Extension for Prevention.—What is known as extension for prevention has provoked much discussion. This method of preparing cavities consists in cutting the cervical margins of approximal cavities well below the gum, and cutting away the lateral walls, until the juncture of the filling and the margins of the cavity are sufficiently exposed to be kept clean and free from food deposits, by the action of the tongue, lips, cheeks, and tooth-brush. The cervical margin is protected by the gum, and it may be conceded that if the margins of a well-made and well-extended gold filling are attacked by decay, it is due to carelessness on the part of the patient in keeping the teeth clean. It is very nice to be able to say to a patient, "Your teeth are now restored in such a manner that their permanent preservation is entirely in your own hands;" but it is no more possible to carry out this method to the complete satisfaction of both operator and patient in every case, or in the majority of cases, than it is possible to fill every cavity with gold with complete satisfaction to all parties. Extension for prevention is more necessary in the bicuspid and molar region, than in the incisors and cuspids, for the simple reason that the margins of non-extended cavities—meaning such as are only extended for access as opposed to prevention—in front teeth are not so prone to decay, and because extension for prevention in front teeth may destroy their appearance. It should also be remembered that the proper extending of a cavity in an incisor or cuspid, as well as in other positions, prolongs the pain of the operation, and unless this extending is absolutely necessary, it is unwise to push the endurance of a good patient to an extreme.

Non-extended cavities in the front teeth, if well filled with gold, usually last sufficiently long to induce an operator to content himself with merely extension for access. The comparatively frequent failure of gold fillings in approximal cavities in bicuspids and molars that are not extended for prevention, makes the question of whether it is worth while to use gold entirely in these cases, depend to a great extent on the production or the non-production of extension for prevention. If it is admitted that non-extended gold fillings frequently fail in a comparatively short time in these places, and extension cannot be properly carried out, it is surely hardly wise to use the material that demands the greatest skill, time, energy, and mental and physical strain to insert. If the filling is likely to fail owing to non-extension, it had better be one that is more easily introduced. If possible let it be one that is supposed, at any rate, to have a preservative effect on the tooth, unless the appearance of the tooth demands the use of gold. An amalgam filling, with or without a cement lining, and with or without a gold top or masticating surface, as the kind of amalgam used and the circumstances of the case suggest, will usually be a more practical and satisfactory operation—all things considered—than any attempt to make an all-gold filling in these cases. Extension for prevention as an "academic principle" is perfectly sound, but the writer all through these notes has endeavoured to point out that "circumstances alter cases."

Insertion of Gold.—To explain methods of packing gold into teeth, a few typical cases will be mentioned. It does not come within the scope of this work to minutely describe the filling of numbers of cavities in all sorts of positions, each of which may present instructive peculiarities. It is intended merely to allude to the filling of certain cavities; for it is presumed that an operator who has once grasped general principles will be able to modify them as circumstances may demand.

Cohesive Gold.—To fill a very small occlusal cavity, or a very small cavity in any exposed position, take a small pellet of gold, and simply press or hammer it in. A cavity of this size may be considered as similar to a starting pit, and filled accordingly. Pack in other very small pellets one by one, attaching them to the previously condensed gold until the cavity is full. To fill a cavity a little larger than this, press in a larger pellet of non-cohesive gold, and hold it down, if necessary, with an instrument held in the left hand, until it is packed just sufficiently to stay in place without rocking. If this is not accomplished, remove the pellet and insert another one, pressing it to one side of the cavity, and insert and wedge in other pellets between the first one and the other walls of the cavity, until a sufficient mass has been introduced to stay firmly in place, when the whole of this gold is pressed directly on to the floor. By the use of two instruments, one to hold the gold and the other to partially condense it, there is usually no difficulty in making the foundation, and the filling is then completed with pellets or tapes, the first one or more of which are driven in and attached to the non-cohesive base as already described. To fill a star-shaped cavity, consisting of a central hole, with fissure-like extensions, wedge non-cohesive pellets towards the ends of each arm, until the centre is reached; then wedge more pellets in the centre, condense down sufficiently to admit of the attachment of cohesive gold, and build up with pellets or strips. If the extension arms and the centre are too shallow to admit of this method of wedging a foundation being satisfactorily carried out, drill a starting pit at the end of each extension, and work cohesive gold from these pits carefully over the whole of the floor, and up to the surface. Fissures must be cut of sufficient depth, and properly squared out to admit of the gold remaining firmly in place, without any lifting of the edges by the force of mastication.

Filling Upper Incisors and Cuspids.—In working from the lingual surface, place a pellet of non-cohesive gold against the cervical wall, and press it well into the angles or undercuts. If one sufficiently large pellet will not stay in place, press a pellet against the cervico-labial angle, another one against the cervico-lingual angle, and then wedge a third one between these two, and press the whole mass of gold up to the cervical wall. Force a fine-pointed plugger into the gold at one angle of the cervical wall, and fill in with small pieces of cohesive gold. Pack the non-cohesive gold well into the angle or undercut, and add cohesive gold while doing so. Treat the other angle in the same way. This locks the non-cohesive gold firmly in place, and provides a ready and firm attachment for more cohesive gold which can then be easily extended from one angle to the other, driving the non-cohesive base into close contact with the wall as the condensation of the cohesive layer is carried out. In order to drive the gold accurately into sharp or well-defined angles, a very fine-pointed plugger or, better still, one with a flattened almost knife-like edge, with fine single serrations cut on the edge, is needed. The manner in which a cavity is prepared, and the sharpness of the angles will determine the kind of plugger to be used at these parts. If a starting pit is used, it should be drilled at the cervico-labial angle, and carefully filled with cohesive gold; the foundation is then made by carefully working the gold across the cervical wall from the starting pit, until it reaches, and can be packed into, the cervico-lingual angle or undercut. In making a starting pit, it should only be deep enough to readily and securely hold the first few pieces of gold, and should be only of sufficient diameter to easily admit the insertion and withdrawal of the fine plugger. There is no advantage in undercutting a starting pit, although squaring out or flattening the bottom is occasionally useful. It is, on the contrary, advantageous to enlarge its orifice somewhat, so as to enable the rest of the gold to be more easily attached. As soon as the foundation is made, the filling is continued by adding more gold at the cervico-labial angle, taking special care to thoroughly condense it at the labial wall; more gold is then worked across to the lingual wall, and carefully condensed against it, the direction of force being mainly in the direction of the cervical wall. As the filling proceeds in this way, it is useful to turn the overlap over the labial wall with a thin, flat burnisher, and to firmly press or rub it against the margin.

The cervical margin should also have been treated in this way. The surface of the filling is then further condensed, and built up by adding gold to it if necessary, applying the force at right angles, or somewhat at right angles, to the surface. As the filling is built downwards in the direction of the cutting edge, it becomes impossible to apply the force in the direction of the cervical wall with advantage. Right-angle force applied directly to the labial wall, the cutting edge, and the floor of the cavity, is now resorted to, still continuing to turn the gold over the labial wall. Obtuse-angle, right-angle, and corkscrew pluggers will all be found useful at these parts, and hand pressure will be found needful in very many of these cavities that are opened into, and filled from, the lingual surface. Working by reflection in the mouth mirror is usually a convenience, and often a necessity, in these cases. It is also frequently a convenience to force a pellet of non-cohesive gold into the angle or pit at the cutting edge, and this often secures a better adaptation at the bottom of the angle or pit. In filling these cavities from the labial surface, the method of procedure is very similar, except that, if a starting pit is used, it should be drilled at the cervico-lingual angle, and the foundation worked across to the cervico-labial angle. The labial wall becomes what the lingual wall was when filling from the back, and *vice versâ*, and the preparation of the cavity, and the packing of the gold, is regulated accordingly. A mallet can generally be easily and accurately used from the labial surface, and the force applied in any direction, as the exigencies of the case demand. The careful turning over of the gold will take place at the lingual instead of at the labial wall. Unless a very wide separation has been secured, or unless both the lateral walls are freely cut away, it is usually impossible to perfect these margins (labial if working from the back, and lingual if working from the front) after the filling is made; and as slight imperfections are often observable, particularly if the teeth are only sufficiently separated to admit of a polishing tape or sandpaper disc, there is every advantage in securing perfection at this part as the work proceeds, and the thin flat burnisher is a convenient and efficient means of assuring this.

It has been pointed out that conspicuous gold filling should be avoided as much as possible, and the removal of part of a labial wall to facilitate the operation has been deprecated, notwithstanding that filling from the back frequently demands hand pressure. The removal of part of a labial wall on a distal surface does not, however, render the filling nearly so conspicuous as if the same amount, or even less, had been cut from a mesial surface. This is a point worth considering in selecting the opening, but it is better to get into the habit of filling all these cavities from the back whenever it is possible to do so, although it is more difficult and takes up more time.

It has been stated that if the labial side of a filling on the approximal surface of a front tooth shows slightly it looks more disagreeable than if it were more conspicuous, because the light falls on it in such a way that a shadow is cast, giving the gold a dark appearance. It has been laid down that if the filling shows at all, it should be made to show considerably, because a gold filling that looks like gold is more pleasing than one which resembles a black patch of decay. In the writer's experience this applies to the small round or oval fillings of the more or less "pin-head" type; but, as far as those which involve the greater part of the approximal surface are concerned, he begs to differ from the opinion that they should be extended labialwards for purposes of appearance. On the contrary, the less the gold shows in these cases the better. Apart from the gleam of gold which many people object to, these conspicuous fillings often look very disagreeable by artificial light.

The writer once sat opposite to a lady at a dinner-table, and was surprised to notice that one of her upper lateral incisors presented a peg-like appearance owing to a considerable part of one approximal side and the whole of the cutting edge being missing; especially so as her husband was a skilful dentist. Afterwards he was requested to examine her teeth, and was astonished to find that this tooth was most splendidly filled with gold. The approximal side, including a good deal of the labial side and the cutting edge were restored in a manner that could not be surpassed. The lady's husband—though himself an excellent gold-filler—had sent his wife to one of the best operators in the land, and was very proud to show the large quantity of most excellent work that her mouth contained, and yet *this* was the appearance that the most conspicuous filling actually presented when viewed under ordinary circumstances by artificial light. This is a striking example, one of several that have come under the writer's notice, where very well made and finely finished gold fillings, which were well extended on to the labial side, presented the appearance either of unfilled cavities or of dirty, discoloured fillings. So much for the advantage of extension for appearance as a general method of practice. It is one which the writer has never been able to realise the benefit of.

Small round or oblong cavities that are surrounded by strong walls can be filled as if they were occlusal cavities; for, by means of a little extension towards the lingual surface (or the labial surface if necessary) plus a little separation, they can usually be prepared like occlusal cavities, and filled much in the same way, using, of course, instruments sufficiently curved to reach them easily. The first few pellets will generally be packed in the direction of the labial or lingual wall—depending on the opening.

Where both the labial and lingual walls of a cavity are badly broken down, there is usually plenty of room to work the gold partly from the front, and partly from the back. It is impossible to prevent the gold from showing, and cutting for access can usually be freely done. In these cases the gold must first be packed into as deep anchorage, or as broad anchorage, as can safely be made at the cervical wall, and a thick layer of gold made at this part. It is then carried downwards over the floor and to the cutting edge, and the contour built up by working directly on to this mass. It is important in these cases for the gold to be thoroughly cohesive, and worked with great care and solidity into whatever grooves, undercuts, or angles can with safety be made at the sides and cutting edge.

Molars and Bicuspids (approximo-occlusal cavities).—To fill an approximal cavity in a molar or bicuspid opened through the occlusal surface, as already described, a pellet of non-cohesive gold may be placed in the angle formed by the juncture of the cervical and one of the lateral walls, first making a little undercut to deepen this angle if necessary. Another pellet is then placed in the opposing angle, and a third one wedged between them, or a large pellet may be placed directly against the cervical wall, and held in place with an instrument in the left hand, and condensed into the angles with a fine-pointed plugger, or while still holding the first pellet in place, smaller ones may be wedged between it and the lateral walls, and into the angles on both sides. Cohesive gold is then attached to the non-cohesive, and the foundation is well condensed and made solid at all parts, working the gold principally towards the angle formed by the cervical wall and the floor (Figs. 12 and 13). It is important for the gold to be worked in this manner, for if it should extend in a thin layer over the margin, it will be apt to curl up, or be drawn away during the subsequent manipulation, and either a slight space or a depression left at this part, causing, in all probability, failure of the filling. When the cervical margin is thickly covered and the gold well wrapped over it, the filling is built up,

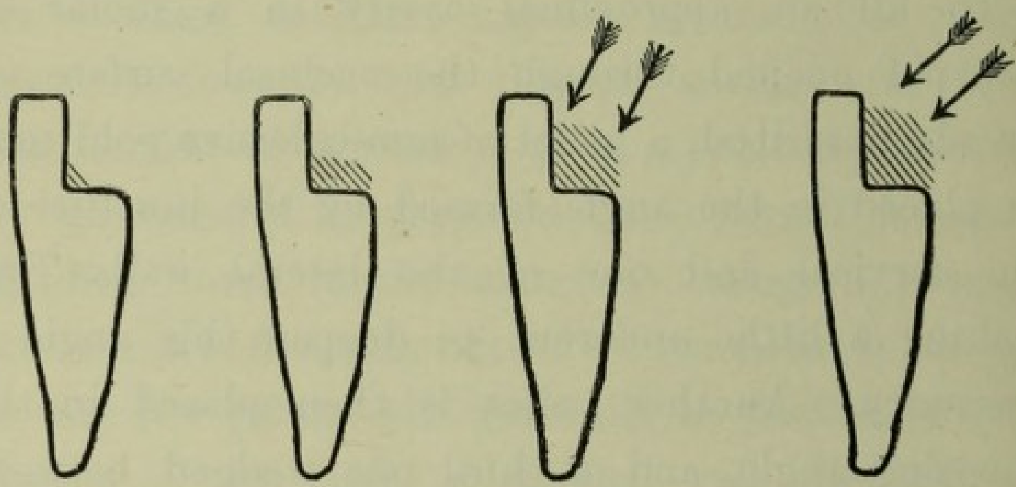


FIG. 12. FIG. 13. FIG. 14. FIG. 15.

The above sketches are not intended to be actual representations of teeth during the process of filling; they are merely diagrams to illustrate the text. The arrows show the directions of force in building the gold.

towards the occlusal surface, preferably with a small foot plugger if thin tape is used, in such a manner that the gold is worked with the point or toe well against the walls, and into any grooves or angles that may have been made here; and then by placing the heel of the plugger in the cavity, and the toe outwards, work the gold carefully up to and over the edges, and build up the external surface convex, so as to restore contour, thoroughly consolidating the gold, including the surface, as the work proceeds (Figs. 14 and 15). If there is any difficulty in wrapping the gold over the margins, use for this purpose either a hand plugger with a broad condensing surface (Fig. 16), or a flat burnisher. When the filling reaches the occlusal surface, carry it well across the floor of the occlusal step cavity, build up the back wall of the step, and complete the filling by working back to the approximal surface. In cases where it is difficult or impossible to start the filling at the cervical wall without undue or undesirable undercutting, one may commence at the occlusal step or undercut, and when this part is sufficiently filled to produce stability of the gold, it may be worked along one of the lateral walls, or over the approximal floor, until the cervical wall is reached and well covered, then the filling may be worked back again towards the occlusal surface until completed. If desired, a starting pit can be made at one or both of the cervical angles, and the filling commenced with cohesive gold, gradually working from one angle to

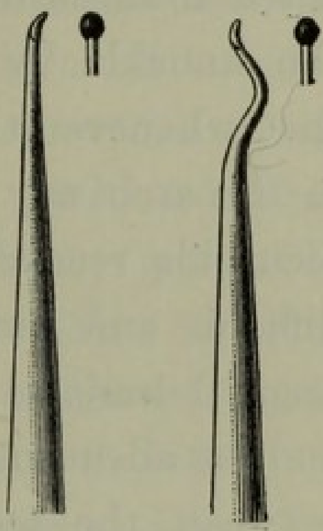


FIG. 16.

the other, across the cervical wall, until a firm foundation is made.

In posterior cavities the use of hand pressure and fine points, and working by reflection in the mouth mirror, is often a necessary proceeding.

Restoring Exact Contour in Bicuspids and Molars without Previous Separation.—Unless the teeth have fallen towards one another, owing to destruction of the knuckle by extensive decay, the writer finds that whenever the teeth are fairly regularly placed in the arch, any previous separation of molars and bicuspids renders the exact restoration of contour difficult and uncertain. In some cases the space secured leads to too great cutting away of the gold, and the all-unsuspected leaving of a permanent space between the teeth. On the other hand, a plus contour may be left which is not only undesirable, but may cause pain through the production of lateral pressure. The following procedure has therefore been adopted with satisfactory results:—

As soon as the cervical margin is well covered with gold, a thin flat burnisher is used to press the overlap on to the root, slightly beyond the margin, and the gold is firmly burnished at this part. The next layers are condensed well on to this gold margin and rubbed over it, and also over the lateral walls. By proceeding in this manner, and carefully and thoroughly rubbing the overlap down on to the exterior surface of the already condensed gold, and over the lateral margins, it is found that the filling gradually swells out to exact contour with little or no surplus to be afterwards removed. As soon as the knuckle is reached, or nearly reached, the gold is well up against the next tooth, and it takes a little force to press the burnisher between the filling and the adjacent tooth in order to wrap down the gold. In a little time, notwithstanding that the burnisher has forced the teeth somewhat apart, it will be found impossible to press the burnisher between them. Where this happens, the filling is packed against the adjacent tooth somewhat as if it were a matrix, and the filling is completed. The occlusal part is trimmed with plug finishing-burs, and the corners rounded with sandpaper discs. The lateral and cervical edges are firmly burnished, and trimmed with the Rhein plug-trimmers. The lateral margins, if sufficiently exposed, may also be trimmed with sandpaper discs. A fine ribbon saw is then passed between the teeth, and a fine polishing strip is forced between them through the space made by the saw; as soon as it slips into the interproximal space, it is freely drawn backwards and forwards in order to perfect the surface of the filling. It may be necessary to soap the polishing strip in order to force it between the teeth. More strips are used until the smoothing is completed, and orange-wood sticks, trimmed to fine flat wedge-shaped ends, may also be passed laterally into the interproximal space, to perfect any depressions at the cervical margins that are not reached with the strips. Finally the burnisher may or may not be applied, as thought good. It is found that the teeth are slightly forced apart by the burnisher during the process of turning down the overlap at the knuckle, and that the small space made by the saw and the polishing tapes merely enables the teeth to drop back again into their normal positions, and teeth filled in this manner are as closely knuckled up a day or two after the operation as any other teeth in the mouth. It is very nice to be able to separate these teeth so widely that the whole of the surface of the filling can be clearly seen during the trimming and polishing. It is very convenient to be able to build out to such an extent that free use may be made of sandpaper and cuttle-fish discs in trimming and smoothing the filling, and the production of a perfectly smooth, polished, mirror-like surface, that will not reveal even a hair-like scratch under magnifying-glass examination, is the highest expression of dental art and excellence; but when the various difficulties that militate against the accomplishment of this result are considered, and the risk of producing either insufficient or plus contour is realised, it becomes a question whether the filling of bicuspids and molars without previous separation is not, as a general rule, the more practical and useful method.

Filling Teeth with Non-Cohesive Gold.—In filling medium or large-sized occlusal cavities in bicuspids and molars, and also on buccal or labial surfaces, or in any exposed position, a pellet or cylinder is placed against one of the walls, in such a manner that one end of the pellet touches the floor, and the other end projects slightly beyond the orifice. The pellet is then pressed fairly firmly against the wall, and should usually be as large as can be conveniently introduced and pressed into place. Another pellet is placed against one of the other walls, and so on, until the walls are covered with gold, each piece of which has been well pressed laterally to place. Other pellets are in like manner introduced and pressed towards the walls, until only a small hole is left at the centre of the filling; one or more pellets are then forced into this hole, taking care that the gold goes well down to the bottom of the hole, and also taking care that the pellet, if a single one is used, will fill up the hole, or the last one, if more than one is used, will completely fill it when pressed in and condensed as much as possible. It should be mentioned that if more than one pellet is used at this part, the hole should be sufficiently deep to admit of the last pellet being sufficiently deeply inserted to remain in place after the filling is completed and finished. When this hole in the centre is filled up, proceed to make a hole in another part of the plug with the sharp-pointed wedge-shaped plugger, enlarge it by lateral pressure, and fill it up by introducing pellets—if the hole is fairly large—with lateral force until a sufficiently small hole is left to be filled with direct pressure. Continue to make holes in the plug, and fill them up, until the sharp-pointed plugger will make no impression on the surface at any part. Then firmly burnish the surface of the gold, and grind it down to a smooth surface with fine edges. Again burnish thoroughly and either leave the filling burnished, or finally perfect it with wooden or leather wheels or buffs and a suitable powder, such as fine pumice-stone or Hindostan stone. Cylinders are used exactly like pellets, and strips are folded and pressed flat against the walls, layer by layer, in such a manner that one end of each fold touches the floor, and the other one extends slightly beyond the orifice. Theoretically the cylinder or the strip produces the best filling, because the layers of gold are exactly parallel to the side walls, and as the wear of mastication comes on the ends of the layers of gold, there is little chance of their flaking off. In practice it will be found that pellets cut from a rope of gold serve their purpose extremely well, and the layers are sufficiently parallel for practical purposes; and even the irregular distribution of the gold, produced by tearing pieces from a sheet and rolling them up into balls, can be to a great extent counteracted by the lateral use of the point, as well as the sides of the wedge, and what may be called a mechanical cohesion of the surface produced by the great compressing power of the absolute point.

It is often a great convenience to use short lengths, or oblong pellets, cut from a rope. One end of the short length is placed against the floor, and pressed up to a side wall. The protruding end is then folded over and carried down to the floor, and laterally packed, leaving the doubled end or loop-like projection protruding slightly beyond the orifice. Each pellet or piece is thus folded once on itself. In filling approximal cavities in incisors and canines the gold is first packed against the cervical wall, and more pellets are introduced and pressed in the direction of the cervical wall, taking care the gold is worked firmly against the lateral walls until the cutting edge is nearly reached. One or more pellets are then packed against this wall, until a small space, or hole, only remains to be filled up between the cutting edge of the gold and the rest of the filling. Fill up this space, by directly driving a pellet into it of sufficient size to completely fill it up when well condensed. Then proceed to make holes in the plug, and fill them up as already described. The presence of the adjacent tooth usually renders the labial part of the plug (in working from the back) difficult to easily reach at this part of the operation, and this illustrates the value of condensing the gold as thoroughly as possible against the labial wall during its introduction. The first few holes made with the wedge should be as close to the labial wall as it is possible to make them, and as a right-angle application of the wedge can rarely be made close to this wall, it loses some of its spreading power at this part, and just in proportion as the form, strength, and accessibility of these cavities preclude the even and complete consolidation of the gold, so will the desirability of using either cohesive gold, or a combination of cohesive and non-cohesive gold, be appreciated, although, of course, great skill in the manipulation of non-cohesive gold will increase the range of its applicability.

In approximo-occlusal cavities in bicuspids and molars, it is inadvisable to attempt more than a combination filling. Some of the earlier dentists, whose experience antedated the discovery and successful use of cohesive gold, claimed to be able to make satisfactory contour operations in these cavities with non-cohesive gold alone. This was probably accomplished by much interlocking of the gold by driving the pieces one into the other with sharp points; but whatever may have been done in this direction in the past, is now a lost art, and the use of non-cohesive gold up to the knuckle, and the building up of the rest of the filling with cohesive gold, is all that is now likely to be attempted. In these cases it is generally impracticable to depend in any way on the spreading power of the wedge, although, if a matrix is used, this procedure may be resorted to. The gold should be packed towards the cervical wall, leaving as much overlap as the presence of the adjacent tooth will admit of. The gold should be thoroughly condensed, and fine points should be used against the walls to ensure adaptation. When the knuckle is reached, cohesive gold is attached to the last layer of the non-cohesive gold before it is completely condensed, either by means of sharp, deeply-serrated pluggers, or by forcing small pieces of cohesive gold into depressions made in the non-cohesive, at the lateral walls. The cohesive top is then built up and securely locked in place by means of a step anchorage, or undercuts, in the occlusal surface. When all the non-cohesive gold is in place, the part still to be filled must be regarded as an independent cavity, with the non-cohesive gold forming the cervical wall. When the cohesive portion is completed, the non-cohesive overlap should be condensed as much as possible. Broad-faced hand-pluggers, with the condensing surface in the same plane as the shanks, foot-pluggers used with a mallet, and thin flat burnishers, are all useful for accomplishing this.

Whenever non-cohesive gold can be successfully used it will be found, in many cases, to effect a saving of time, as far as the insertion and consolidation of the gold are concerned, and the work is accomplished with less eye-strain. As far as the excellence of the work is concerned, it must be admitted that, although in certain cases a perfect adaptation may be accomplished with greater ease and certainty, there is no possible adaptation with non-cohesive gold that cannot be equalled with cohesive gold; the latter has a wider range of employment, and a coherent solidity and hardness, that are essential in many cases.

Finishing Gold Fillings.—When the filling of a cavity is completed, the surface of the gold should be further consolidated and rubbed somewhat smooth with a burnisher, using firm pressure. The gold is then trimmed to the desired shape, the edges brought to fine lines, and the filling generally made fairly smooth with files, fine cut burs, stones, emery or sandpaper strips and discs, &c., using one or more of the above as necessary. The burnisher should again be thoroughly used, and, if desired, the filling may be finally made as smooth as possible with a suitable polishing powder applied in any convenient manner.

Some dentists are opposed to the use of a burnisher; they consider it unnecessary if the filling is of solidly condensed cohesive gold, and that it has a tendency to give the surface a wavy or slightly furrowed appearance, and imparts a lustre to the gold that is undesirable in exposed positions. A burnisher will, however, consolidate and harden the surface of solid metal. The writer was informed by a silversmith, that the burnishing of silver goods hardens the surface, and adds greatly to their durability. In order to obtain a fine finish they are also always polished afterwards. If a burnished gold filling is afterwards carefully polished, the æsthetic objection falls to the ground.

In using sandpaper or similar discs, it is advantageous to smear them over with moist soap. This prevents the discs heating, and adds greatly to the comfort of the patient. The disc also cuts more smoothly. A well-soaped coarse disc will finish up the filling quite as smoothly as a dry fine one. Soap is decidedly better than vaseline, glycerine, or oil. It has often been pointed out that the use of a lubricant on a disc causes the rubbed-off gold to adhere to it, and consequently it is an economical proceeding. Burs should also be prevented from heating, by dipping them in a suitable lubricant. The amount of pain that may be given by the use of dry discs or burs can only be realised by one who has experienced it. It may also be mentioned, that a dentist who has had personal experience as a patient of the free and vigorous use of trimming and polishing strips below gum margins, will use the Rhein plug-trimmers, fine thin chisels, and thin flattened burnishers, as much as possible in this region, especially on bicuspids and molars, when cervical trimming with sandpaper discs is inadvisable. The finishing of gold fillings is often tedious, and takes up much time; there is usually very little space to work in, and freedom in the use of the methods employed is in many cases impossible. It may however be laid down as an axiom, that extra care and time spent in preparing a cavity will facilitate and improve the filling, and that extra care and time spent on the filling will reduce the time and labour necessary to spend on the finishing.

General Considerations of Gold as a Filling Material. —The value of gold as a tooth-saving material depends on an exact preparation of cavities on certain lines, an excellent manipulation of the gold in the cavity, and careful finishing of the filling. If the conditions are favourable for this, it is the best material. Its successful use depends not only on a skilful operator, but on a good and appreciative patient. The dentist must be able to do the work, and the patient must let him do it. The preparation of cavities is comparatively a severe, and often a painful, procedure. Nervous, timid patients, and all whose teeth are excessively sensitive, are generally bad subjects for gold filling. The pain caused by thorough excavation is, in the majority of cases, easily bearable, particularly so if the patient understands the operation, and has a sufficient appreciation of the value of his or her natural teeth to realise the advantage of helping the dentist by exercising self-control. Many patients are intolerant of the slightest pain or inconvenience. Some imagine it is quite unnecessary, and consider it is the correct thing to make as much fuss as possible. There is hardly any dentist who can do this work satisfactorily when the patient is flinching and fidgetting, telling him every few seconds he is "touching the nerve," and asking continually how soon it will be finished. Here and there may be found an operator of iron nerve and calm, unruffled disposition, whom nothing disconcerts, and who can do "good gold work" under all circumstances, but he will probably have the satisfaction (?) of frequently hearing, that, although he is considered a remarkably skilful operator, the severity of his methods causes numbers of patients to forsake him for less thorough but more humane practitioners. The dentine is sometimes excessively sensitive, and even if patients can screw themselves up to bear the operation, its proper performance may cause an amount of suffering and shock that —particularly in the case of delicate patients— it is better to avoid.

Fortunately, these excessively sensitive teeth are not met with every day, and in contradistinction, there are some patients whose teeth can be freely cut into in all directions (avoiding the pulp) without causing them the slightest pain.

An experienced dentist readily ascertains the temperament of his patient, and it is distinctly advisable, and of the greatest benefit to the patient, to work accordingly. It is useless to so worry a patient to fill one tooth, that he or she acquires a dread of the dental chair, and can never be persuaded to submit to another operation, gradually allowing all the teeth to be lost through neglect. Whether a patient's teeth are really very sensitive, or whether he or she is simply intolerant of slight pain, or even inconvenience, has practically the same effect in deciding the wise dentist that gold fillings are inadvisable in these cases. In the former case it is much more humane to use other materials, although they may not last so long, and in the latter there is every risk of the work being imperfectly done, and the result consequently unsatisfactory. Therefore the first consideration, if gold is to be used, is "a good patient." The next consideration is what may be called a fairly healthy mouth. Whenever there are evidences which point to the existence of a period of rampant decay, it is well to resort to more palliative work. It is a curious fact, but one that will have been often observed by dentists of experience, that, under certain conditions, the more temporary materials, such as white cement and guttapercha, will save teeth far better than gold. Decay will readily attack the margins of the gold fillings, whereas the margins of white cement or guttapercha will frequently remain intact until these fillings are considerably worn away. A regular replacement of these temporary materials as soon as necessary, will often succeed in preserving teeth indefinitely, in mouths where, owing to frequent replacement of gold, and continual re-excavation, the teeth soon pass to the crowning stage. It is also as a rule inadvisable to use gold if a tooth has recently ached, and pulp-destruction is not resorted to, or if any diseased condition of the periodontal membrane is suspected or has recently been treated. The force used in inserting the gold may set up irritation in these cases, and it is always well to be cautious. It is very annoying to have spent considerable time on a gold filling, and then to be compelled to remove it, owing to a recurrence of some previously diseased condition.

Then again, the extent to which the tooth has been weakened by decay must be considered. Many teeth are decayed in such a manner that proper excavation for gold would cause them soon to break down, whereas many of these teeth may be successfully restored with a plastic material, such as amalgam, and the attachment of a crown to the root postponed for several years.

The main point to be considered—providing the patient is a good one—is the probability of the tooth lasting a long time if filled with gold. It is no use putting a filling which under favourable circumstances might last twenty years in a tooth that will probably only last two; and even when everything appears favourable, the dentist, if skilled and conscientious, will take every precaution to prevent further decay taking place, for beyond the fact that it will in itself resist the action of all the fluids of the mouth, no matter what their condition may be, and that if skilfully and carefully worked, it will not wear away or chip at the edges, he knows there is nothing in the gold that will help the tooth to resist decay. He will, in many cases, enlarge the cavity, so that the edges where the joints between the gold and the tooth are made, can be kept clean and free from collection of food deposits, which by their fermentation and consequent acid reaction might cause a recurrence of decay at these parts, and by being brought out just to where they can be readily seen and reached, admit of being quickly and easily repaired, should decay again take place. He will be careful to grind out all little roughnesses and defects from the edges of cavities, so that there will be no weakness or imperfection of the joint to invite an attack of the enemy. He will feel in fact that he is using a material that will *last* if the tooth will, and therefore he will take pains to enable the tooth to resist as long as possible. No one can prophesy how long a gold filling will last in any individual case, but if the conditions are favourable, the majority last sufficiently long to fully justify the time, care, and expense entailed in making them; and the dentist who inserts many gold fillings will acquire skill and the habit of taking pains—qualities which ensure his patients getting full justice done to them in all his operations.

Tin.—Tin as a filling material is now considered, because its use dates almost as far back as gold. It is usually prepared in the form of foil, and used on the non-cohesive principle. Cohesive fillings have been made with tin, by using small shavings freshly cut from a block of tin at the time of the operation. It is also possible to make a cohesive filling with tinfoil, but this takes up far more time than working cohesive gold. For all practical purposes tin will be considered a non-cohesive material, and manipulated as such. It is softer than gold, and more easily manipulated and adapted to cavity walls. It is a low conductor of heat, and is therefore tolerated in closer proximity to a pulp than gold or any other metal used for filling teeth. Its value as a filling material *per se* is more than counterbalanced by its defects. It becomes discoloured and dark on the surface, and is not so resistant to the force of mastication as non-cohesive gold. The writer has found that tin fillings rot or disintegrate at the cervical margins of bicuspids and molars. This has frequently happened, no matter if the filling was entirely made of tin, whether it was used up to the knuckle and the operation completed with gold, or whether tin and gold were rolled up together in equal quantities, and used as recommended by the late Dr. Abbott and others. This rotting did not take place in every case, but occurred sufficiently often to compel the writer to discard its use in an approximal cavity, unless it was completely covered up with gold.

Many dentists who have used tin, deny that it rots, and the only means of reconciling these opposed statements, is to suppose that the tinfoil supplied to dentists is not always pure. It is well known that much of the ordinary tinfoil of commerce is lead coated with tin.

A reference to Taft's "Operative Dentistry" (p. 83, 4th edition) will show that the writer's experience with tin is not unique. Tin is useful for flooring deep occlusal cavities that are to be filled with gold, and a base for cohesive gold can often be made more easily and quickly with tin, than with non-cohesive gold in occlusal cavities. It would also be extremely useful for starting gold fillings in posterior cavities in bicuspids and molars, if its maintenance of integrity could be relied on. When used in contact with gold its exposed surface becomes perfectly black, and it is therefore out of place whenever this part of the filling is exposed to view. Its use in incisors and cuspids is also generally contra-indicated, for even if completely covered up with gold, it gives a dark, leaden appearance to a labial wall. Whenever a cavity is floored with tin, or whenever it is used for starting a filling, it is a great convenience to be able to attach the gold to it on the cohesive principle. The sponge or crystal gold, known as Solila gold, coheres fairly readily with tin. Leslie's crystalline gold also coheres with tin, but this gold seems to have dropped out of the market. Dr. Shumway produces cohesion between gold-foil and tin by means of a hot plugger.

The late Dr. Benjamin Lord, in a paper[1] read before the New York Odontological Society, said:—

"A combination in which I find great interest is in the use of soft or non-cohesive gold with tinfoil. This is no novelty in practice; but I think that, for the most part, too great a proportion of tin has been used, and hence has arisen the objection that the tin dissolved in some mouths. I am satisfied that I myself, until recently, employed more tin than was well. I now use from one-tenth to one-twelfth as much tin as gold, and no dis-

[1] *International Dental Journal*, August 1893.

integration or dissolving away of the tin ever occurs. I fold the two metals together, in the usual way of folding gold to form strips, the tin being placed inside the gold. The addition of the tin makes the gold tougher, so that it works more like tinfoil. The packing can be done with more ease and certainty; the filling with the same effort will be harder; and the edges or margins are stronger and more perfect. The two metals should be thoroughly incorporated by manipulation. Then, after a time, there will be more or less of an amalgamation. By using about a sixteenth of tin, the colour of the gold is so neutralised that the filling is far less conspicuous than when it is all gold; and I very often use such a proportion of tin in cavities on the labial surfaces of the front teeth. If too much tin is employed in such cases, there will be some discolouration of the surface of the fillings; but in the proportion that I have named, no discolouration occurs, and the surface of the filling will be an improvement on gold in colour."

The writer has tried this method and made the folds by placing a strip of tin on the edge of a sheet of gold, and then folded the gold over the tin in such a manner that the tin was in the centre of the folded gold. As a rule the folding was loosely done, and the resulting strip twisted into a rope and cut into short lengths. It was found that not more than a strip one-sixteenth of an inch wide, cut from a sheet of No. 4 tinfoil, should be folded up with a whole sheet of No. 4 gold, or else the surface of the filling will show black patches. It is wonderful how a very small quantity of tin seems to work through and into the whole filling. The surface of these fillings becomes in time harder than the surface of a non-cohesive gold filling, but no chemical solidification of the filling itself appears to take place, in a reasonable time at any rate. Fillings that have been removed two years after insertion fell apart just as a non-cohesive gold filling will fall apart; this is to say, that the several pellets or pieces of which the plug is made may be easily separated with a pin either after or during the removal of the filling.[1] But if a whole sheet of gold and a whole sheet of tinfoil are rolled or folded together, and a filling made in the mouth, a chemical action takes place which, in cases where the filling does not disintegrate, converts it into a solid mass that is extremely difficult to cut up and remove with engine burs. The writer sees great disadvantage—owing to rotting of the filling in many cases—in rolling or folding tinfoil and gold together in equal or nearly equal parts; and if the tin is reduced in sufficient proportion to prevent disintegration taking place, the resulting filling is very little better than a good non-cohesive gold filling, and can only be satisfactorily used in cases where

[1] A filling removed seven years after insertion was completely solidified, and very difficult to cut out.

the operator could produce an excellent result with non-cohesive gold.

Amalgam.—An amalgam for filling teeth is produced by mixing one or more metals with mercury. The only single metals that have been used for this purpose are silver, copper, and palladium. For some reason palladium is now rarely if ever used, and will not be further alluded to.

The amalgams that are now generally used, are made by melting together several metals, and pouring them into an ingot mould. The ingot is then reduced to fine filings, or shavings, and mixed with the mercury. Of the various metals that have been used for making these alloys, tin, silver, gold, copper, and zinc, are the ones that are most employed. Platinum is used in some alloys, but is thought of little or no value in this connection. One of the main points that careful investigation has brought out is, that silver is the metal that must be used in the largest proportion in making an alloy, and that at least 60 per cent. of silver is necessary. Tin is necessary in order to enable an alloy to be satisfactorily mixed with mercury, and it has been termed a flux for this reason. Its proportion comes next to silver. A good amalgam alloy can be made with tin and silver alone, and in this case the proportion of silver should be from 65 to 74 per cent., depending on whether the alloy is used fresh cut or annealed. Dr. Black finds that the best formula for a silver-tin alloy pure and simple (fully annealed) is approximately 73 silver and 27 tin.

Silver gives strength, expands, and discolours; tin contracts. Gold has been used to decrease contraction, and improve strength and colour; copper to decrease shrinkage, or control the expansion of other metals, and add to their tooth-saving properties. Zinc expands and improves colour. The late Dr. Flagg states in his well-known book, "Plastics and Plastic Filling," that when zinc is used in an amalgam alloy it must be chemically pure. The writer has seen the dentine seriously affected by an amalgam filling which contained zinc. The alloy was made for him from a formula obtained from a dental journal, and consisted of 65 parts silver, 30 parts tin, 3 parts gold, and 2 parts zinc. The deleterious effect of cadmium when used in an amalgam alloy was described many years ago in some of the text-books, and the result produced with the above amalgam was very similar to the description given of the action of cadmium. Electrically purified mercury was used, and in all probability the zinc in this alloy was impure. All these different metals possess different properties when melted up together, reduced to filings, and mixed with mercury. The aim has always been to use them in such proportion that what may be called a perfectly balanced alloy that will give a perfectly balanced amalgam will result. The one great and final test is the behaviour of the amalgam when placed in teeth in the mouth. After many years' experiment Dr. Flagg has finally come to the conclusion that gold is valueless as a constituent of an amalgam alloy. He also says that copper, as copper, and zinc, as zinc, are diametrically opposed to one another, and for this reason he has never made such a combination. For many years the Contour amalgam alloy made by Dr. Flagg consisted of silver, tin, and gold. His Submarine alloy was composed of silver, tin, and copper. He states[1] that a very gradual increase of copper now gives the formula of Submarine as: silver, 60; tin, 33; copper, 7; and the formula of the Contour alloy is there given as from 60 to 70 silver, from 25 to 35 tin, from 1 to 3 gold, and from 1 to 3 zinc. In "Plastics and Plastic Fillings" (6th edition, revised 1901), Dr. Flagg states that gold is valueless as a component of a dental amalgam alloy, and that this conclusion was not arrived at before July 1900. The pre-

[1] *Dental Cosmos*, February 1900.

sumption therefore is, that Dr. Flagg's Contour amalgam alloy now consists of silver, tin, and zinc. The Fellowship alloy, as well as several others, that have sprung into existence since the publication of Dr. Black's experiments, consist of silver, tin, copper, and zinc. An analysis of Fellowship alloy gives: silver, 67·73; tin, 26·33; copper, 4·71; zinc, 1·23; and some other alloys are almost identical.

The alloy to which the name True Dentalloy has been given by the makers is said to consist of silver 72·5 and tin 27·5. The analysis of an alloy will not give the exact proportions of the metals that are put into the crucible, owing to some slight loss that occurs during the melting. It is also stated that a good formula will not necessarily give a good alloy, owing to loss of metals that may occur during melting, and uneven distribution of the metals in the ingot. It may also be mentioned that brass (copper and zinc), bronze (copper and tin), and white metal (tin and zinc) may be used in making an amalgam alloy; and an alloy in which one or more of these compounds are incorporated may behave differently when made into an amalgam from one in which the separate metals are used, although a chemical analysis may give identical proportions.

Dr. Flagg considers that his Submarine alloy makes—owing to the copper it contains—an eminently tooth-saving amalgam; the Contour alloy is a general purposes alloy, possessing great edge strength, and better colour. Some dentists claim that by mixing together the filings of two or more amalgam alloys, they obtain a better amalgam filling than in any other way. They assert that a melting together of the mixed filings, or the making of an ingot which contains the various metals in the same proportions as the mixed filings, does not give the same results. There is no doubt that amalgam fillings in general have proved disappointing, and how much of this is due to improper proportions of the alloy, and the improper mixing of the amalgam, time alone will show. That many alloys have been extensively advertised and used, which experiments have shown could by no possibility have given good results, is proven; and there is every probability that, thanks to the investigations of Dr. Flagg, Dr. Black, and others, the amalgams of the present and the future will serve a better purpose in saving teeth. The principal defect in amalgam fillings is their great tendency to curl away from the cavity margins. This leads to either the amalgam edge, or the edge of the cavity, or both, becoming chipped or broken by the force of mastication, with a recurrence of decay as a natural consequence.

In many cases, even if no break occurs, the curling up of the amalgam edges produces a trench or cavity for the collection of food particles, with equally disastrous results. This curling up of the edges takes time, and although there is a great deal of difference in the behaviour of different alloys in this respect, three years is generally sufficient to produce these defects. It has been noticed that this curling up of the edges is particularly manifest on occlusal surfaces, and more particularly on the occlusal surfaces of approximo-occlusal cavities. There is no doubt that many amalgam fillings seem to "grow out" of the cavity on buccal surfaces where they are subjected to no force of mastication; but that the force of mastication on an amalgam filling increases this, even if in many cases it does not produce it, will be apparent to any one who has used his powers of observation for a number of years.

Dr. Black explains this as being due to the flow of the metal (amalgam) under force or pressure. It has also been pointed out by Dr. Black that an amalgam filling made of filings, or shavings, varies considerably both in its mixing or working properties, and in its behaviour under tests for shrinkage and flow. The explanation is, that filing or cutting up an ingot hardens or tempers the particles into which it is reduced, and that in course of time, owing principally to increase of atmospheric temperature produced by the heat of summer, or the artificial heating of rooms during cold weather, these filings or shavings become gradually untempered or annealed. In order to prevent this variation in the behaviour of amalgam fillings, Dr. Black set himself to work to produce alloys that would give good results in the untempered state, by annealing the filings or shavings. This is usually accomplished by enclosing them in a bottle or flask, and placing the flask in boiling water for a certain time. From fifteen to eighteen minutes is sufficient to thoroughly anneal an amalgam, although doubtless the time will vary with different alloys, and must be determined by experiment. It is stated that it takes two years for an amalgam alloy to become completely annealed by time ageing. It is also stated that the older the alloy is after a certain age, or the longer it is annealed after a certain annealing, the weaker it will be (Dr. Black).

Many amalgam alloys, when used freshly cut and without annealing, are much more difficult to mix with mercury, and the production of a sufficiently plastic mass to admit of comfortable and satisfactory manipulation, is not only more difficult, but demands a large proportion of mercury. The same alloys, when used some considerable time after they have been reduced to filings, will generally mix into a smooth plastic mass quite readily, and with less mercury. This ageing of alloy filings is considered by Dr. Flagg to be a distinct advantage in all cases; while Dr. Black, on the contrary, considers that with certain formulæ it is a detriment. The advantage of using an untempered alloy consists not only in its superior mixing and working properties, but in the fact that, when once it is untempered, it is likely to behave always in the same way. The advantage of using alloys that give good results in the untempered state is therefore manifest. When experts differ it is hard for an ordinary man to know which line to follow. The difference between Dr. Flagg's conclusion, and that arrived at by Dr. Black in this respect, seems to be, that while the former holds that all alloy filings are improved with age, and slow untempering, the latter considers that the composition or proportions of the alloy should vary according to whether the filings are used in a tempered or untempered state.

Apart from the superior mixing qualities of the majority of untempered alloys, the trouble necessitated in keeping the alloy in the ingot form, and filing off sufficient for the case in hand each time, in order to secure even results, is sure to prevent its general adoption. The use of aged or annealed alloys is therefore of importance. Whether a freshly cut, but fully annealed, alloy will afterwards become unduly annealed by an after-time ageing within a reasonable period, should be known; and in view of a probable deterioration through age, it would be well for the makers to place the date of the annealing on the label, and state for how long a time the alloy will remain in perfect condition. There is still a great deal to be learnt about dental amalgams, for the subject has by no means reached finality. That much progress has been made which will lead to the use of better alloys, and better methods of using them, is something that the dental profession should be thankful for.

The method of mixing an amalgam is of importance, and a good deal of misapprehension exists on this point. The writer gathers from Dr. Flagg's book that the accurate, or fairly accurate, weighing of the alloy, and the mercury before making the mix, does not so much depend on the necessity for securing exact porportions of alloy and mercury in the filling, as on the manner in which the mix can be made. Dr. Flagg states that the mix should be accomplished in definite proportions, with one *admixture*—that is to say, that the weighing of the ingredients enables a mix of the desired consistence or plasticity to be obtained without an alternate adding of mercury and filings. It is this usually adopted practice, of alternately adding first one, and then the other of the ingredients, until a mass of the desired plasticity is obtained, that Dr. Flagg deprecates. He claims that this will ruin the best amalgams, and that under proper tests, there is no comparison between the results obtained by these two methods of mixing. It is also found that an amalgam made with one admixture produces a better plastic mass with less mercury; and the excess of mercury that is often necessary, in order to secure working properties in an amalgam prepared by the haphazard alternate mixing method, will transform an excellent amalgam into a comparatively poor one. (See "Plastics and Plastic Filling," chap. ix.) The proper method of mixing an amalgam filling, is to weigh the mercury and alloy "in such proportions, as have been found upon trial, to make the mass just right for working in any given case." The balance designed by Dr. Wheeler, and made by the S. S. White Company, is a very correct one for this purpose (Fig. 17).

Dr. Flagg says:—After determining the proportions of mercury and filings, they are placed in a mortar, and the filings "*gradually* incorporated with the mercury." "This is done by retaining the mercury in the centre of the bottom of the mortar, and by a circular motion, *occasionally reversed*, drawing in the filings little by little." "The mass is then gathered by the finger from the mortar into the palm of the hand, and is kneaded until it becomes a button." The button is then spread out by careful and thorough rubbing in the palm with the finger, again gathered up into a button, and this process is repeated until a perfectly homogeneous

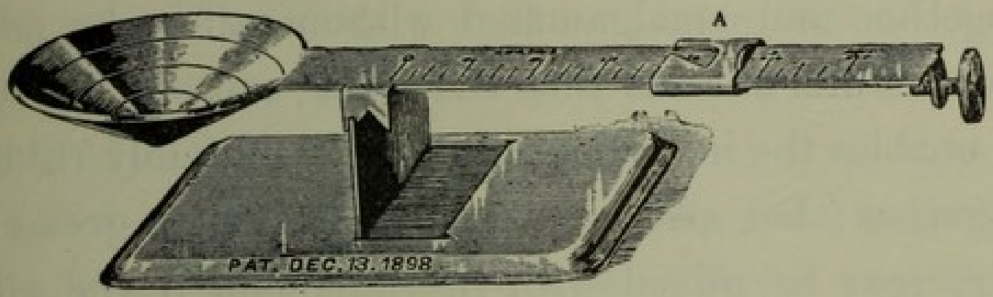


Fig. 17.

plasticity is attained. "It is during this manipulation, oftentimes repeated, that the 'crepitation' of an amalgam is heard."

Dr. Black says that the proper amount of mercury should be mixed with the alloy to begin with, not so much because squeezing out will injure it, but because the mix cannot be properly kneaded if there is too much mercury in it. He also says that the alloy he has found to give the best results works into an amalgam very slowly, and it requires a great deal of kneading to obtain the proper condition of the mass. "To get a smooth-working property, they should be kneaded a considerable time, and you cannot do this kneading properly if there is too much mercury in the mass. They need to be kneaded until the granular appearance has fairly disappeared, and they will work into a plastic state."

The mortar mix is advocated not only because it enables the alloy and the mercury to be placed together and amalgamated without alternate additions of first one and then the other; not only because it enables the ingredients to be more forcibly rubbed together; but also because perspiration or grease or dirt may be mixed with the amalgam if the alloy and mercury are rubbed together in the hand. The writer begs to submit that if the hands are carefully washed and thoroughly dried immediately before the amalgam is mixed, there is no reason to suppose that anything will come off the hands into the amalgam. He finds that mixing the alloy with the right quantity of mercury in a mortar produces a somewhat powdery or friable mass; this is therefore transferred from the mortar to the hand, and rubbed with the forefinger of the other hand until moderate plasticity is produced; the amalgam is then replaced in the mortar and again vigorously ground up. It is then returned to the hand and rubbed until the peculiar squeak or crunching sound known as "crepitation" is produced. It has been stated that a properly mixed amalgam, when pressed on to the palm of the hand, should give a distinct impression of the lines of the palm.

Different alloys will require different proportions of mercury in order to obtain the best results. The proportion of mercury has little effect on shrinkage or expansion, but either too much or too little mercury will produce a weak amalgam that crushes at far less stress than one that has been properly mixed (Dr. Black).

The method of packing amalgams into a cavity is of importance. Because it is a plastic material, it is generally supposed that its perfect adaptation to cavity walls is a simple proceeding. A few experiments made out of the mouth will show that this is not so easy as it seems, and the general method of rubbing it against the walls with ball-ended burnishers is productive of uncertain results. Dr. Flagg says that after each piece is placed in position, it should be crushed by a round-ended or flat-ended plugger, and then tapped with light blows from any appropriate instrument, until it is placed in accurate apposition to the walls of the cavity. The use of a mallet is "not only unnecessary, but really objectionable. It is not needful that the blows should be in any degree *forcible*, but, on the contrary, it is better that they should be such as would more properly come under the signification of 'taps.' The consistency of the amalgam should be such as will permit of perfect adaptation of filling to cavity wall, by tapping with light blows." "This 'tapping' is *not to be done* with mallets, either hand, automatic, or electric, as a different kind of blow from any so given is far preferable. The 'tap' from the filling instrument—the same used for crushing—is a mingled push and blow, which is soon acquired, and is as promptly recognised as very efficient in producing admirable results."

Dr. Black advises the use of a few large pieces of amalgam, in preference to a larger number of smaller ones, and considers that as broad-faced a plugger as can be conveniently used should be selected. The plugger should have a flat, finely serrated face, and the force used in packing amalgam should be as great, if not greater, than the force used in condensing gold with hand pressure. This probably applies more especially to quick-setting amalgams of the "Fellowship" type. Fig. 18 shows Dr. Black's amalgam pluggers, and Fig. 19 Mr. E. J. Ladmore's. Mr. Ladmore informs the writer that these instruments are not always correctly made, inasmuch as Nos. 1, 2, and 3 are sometimes made with ball-ends. This is incorrect; these ends should be pear-shaped. Mr. Ladmore considers that the pear-shaped end packs and adapts the amalgam better than ball-ends.

It is frequently found that during the packing of the amalgams into the cavity, the mercury

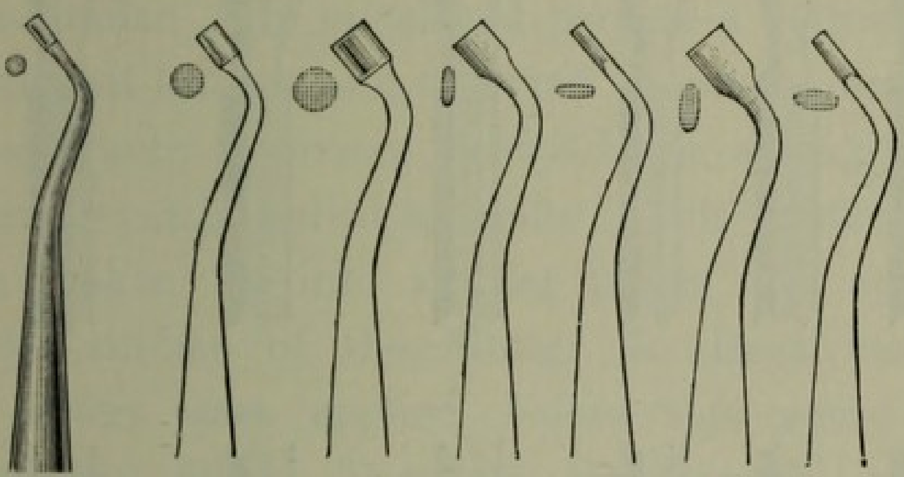


FIG. 18.

works up to the surface. This not only produces an uneven distribution of it throughout the filling, but also prevents the filling being properly contoured, brought to fine margins, and made smooth before it sets. The late Mr. Kirby's experiments showed that it was advantageous to produce equilibrium of the mercury by adding a much drier mix to the surface. This was effected by making two mixes, one of which contained sufficient mercury to produce a mass of the desired plasticity for filling

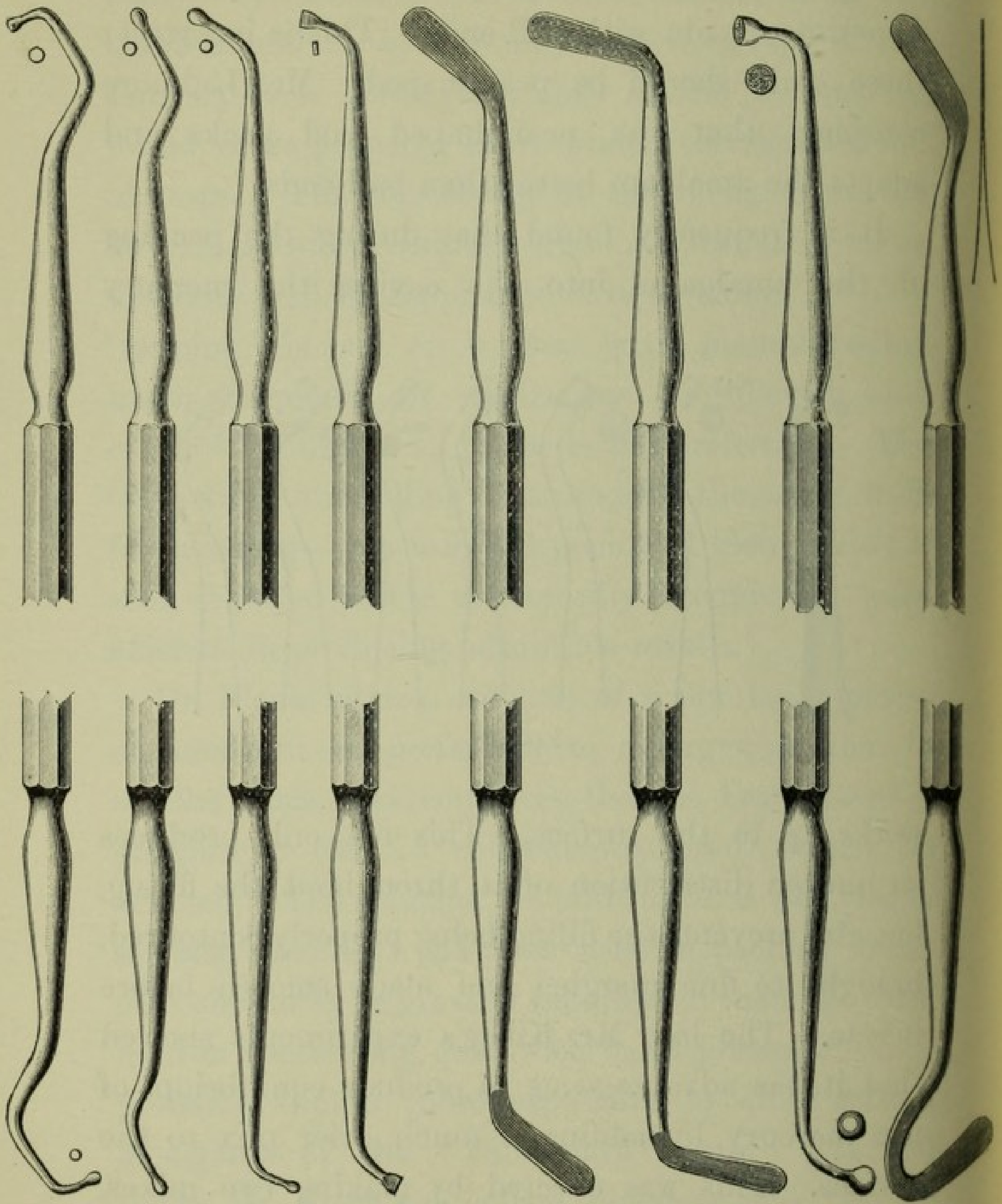


Fig. 19.

the cavity, and the other was made by using less mercury. The correct proportions were obtained by weighing. About two-thirds of the cavity was filled with the more plastic mix, and the filling completed with the drier one. Mr. Kirby considered that this greatly improved the filling, quite apart from any mechanical advantage gained in the finishing process. Dr. Flagg's method was somewhat similar. He enveloped part of a plastic mix in chamois leather, and removed as much mercury as possible by squeezing it with large, strong pliers to form what he called a "wafer"; this "wafer" was then broken up into smaller pieces and applied to the surface of the filling. In large cavities the wafers were applied before the cavity was completely filled. The late Dr. Bonwill packed amalgam into cavities with great pressure, placing a pellet of Japanese bibulous paper between the plugger and the amalgam. His object was to squeeze as much mercury as possible out of the filling, while it was being pressed to place. The mercury that was thus brought up to the surface was wiped away, and when the cavity was filled the surface was hardened if necessary, by placing some of the dry or unmixed alloy on to it, and rubbing or pressing this until it became amalgamated with the filling.

Dr. Flagg says:[1] "The mass should work quite plastic—generally becoming more so as the filling progresses—until the cavity, if it be of ordinary size, is completely filled, when a 'last piece' should be enveloped in a fold of chamois skin and *squeezed hard,* and the wafer thus made laid on the filling. By crushing this wafer into powdery pieces and tapping these into homogeneity with the softer mass, the setting will be hastened, and the edge strength, density, and whiteness of the filling are much increased. This process is called wafering, and will be discussed in the article on 'Technicals of Plastic Filling.' I have said that if the cavity be of ordinary size, the process of wafering should be used after the cavity is completely filled; this is so, because the size of the filling is not so great as to prevent a sufficient effect upon the whole mass from one wafering; but if the cavity is very large, or if it is inaccessible, it is better that two or three mixings be made in small quantities, and that each mix be hardened and set by its own wafer. This will be found particularly advantageous in 'building' crowns, or in making large reparations, as contouring amalgam may be so worked by this treatment as to set almost as

[1] "Plastics and Plastic Filling," p. 106, sixth edition, revised 1901.

fast as it is built on, and to become sufficiently hardened in an hour or two to subserve the purposes of mastication or of clasping."

It will be noticed that there is considerable similarity between the methods of Kirby, Flagg, and Bonwill. The late Mr. Fletcher, who at one time practised dentistry and throughout his career manufactured plastic filling materials, made many experiments, and was strongly of the opinion that no mercury should be removed from the amalgam by squeezing it, or in any other way. The point is, whether or not any appreciable quantity of the other metals is removed with the mercury. If the metals in the alloy are removed in unknown quantities, then a good alloy is converted into a hap-hazard mixture of metals and mercury. The wafering method only differs in degree from squeezing as much mercury as possible out of the whole mass before inserting it; and if this general squeezing is detrimental, the wafering process must also be somewhat disadvantageous, unless it can be proved that the mechanical process of finishing the fillings is so improved by the wafering method, that this more than counterbalances any impairment caused by removal of the mercury. Dr. Flagg had confidence that no harm was caused by squeezing out the mercury. On page 209 of his book[1] he says: "Although alloy metals, in notable quantity, are taken from amalgam when surplus mercury is removed by 'finger squeezing,' it has been positively determined that no change occurs in the relative proportions of metals composing alloys when the surplus mercury is expressed through 'chamois skin.' Following the work of several others, I tested the mercury thus expressed from *one hundred* makes of amalgam, finding only 'a trace' of other metal. This experiment was made three times with like results." A different opinion was expressed by Dr. F. J. Brislee, Lecturer in Dental Metallurgy, University of Liverpool. His various experiments were explained in two papers read before the Liverpool Odontological Society.[2] The subject was approached purely from a metallurgical and physico-chemical standpoint, and Dr. Brislee pointed out that conclusions arrived at in this way may be contradicted by practical experience. But he very truly said that, although he recognised the impossibility of exactly duplicating the conditions of the mouth in the laboratory, "there are certain tests performed outside the mouth which every filling ought to satisfy before they are used in dental practice."

[1] "Plastics and Plastic Filling," sixth edition.

[2] *Dental Record*, February 1906 and June 1907.

The conclusions arrived at as to amalgam fillings by Dr. Brislee were:—

"*First.*—They must be mixed with a definite quantity of mercury, and under no conditions must excess of mercury be used, and the excess removed by squeezing. *Second.*—Pure mercury must be used. *Third.*—The alloy from which the amalgam is prepared should be as homogeneous as possible, and the alloy and mercury should be thoroughly incorporated by rubbing in a mortar. *Fourth.*—Fillings in the same mouth should not have very different compositions, otherwise electrical actions will occur, and result in pain to the patient and disintegration of one of the fillings. This electrical action is brought about by the two fillings of different metals acting as electrodes, the saliva as the electrolyte, and the nerve as the external circuit. The electromotive force of the combination will be greater the greater the distance separating the two metals in the voltaic series, viz.—Zn, Cd, Sn, Cu, Hg, Ag, Au. Thus, suppose two teeth contained a copper amalgam and gold filling respectively, the copper would form the negative pole, and the gold the positive pole, of the combination. The potential difference would be considerable; and since the combination has, in all probability, a low internal resistance, the current strength would be fairly high, giving great possibilities of pain to the patient. On the other hand the copper amalgam would dissolve away, some of the copper being deposited on the surface of the gold filling, and hence neither one filling nor the other would prove as satisfactory as they ought under more favourable circumstances."

The following, which is taken from Dr. Brislee's first paper, shows the value of mixing the alloy with the right amount of mercury:—

"The remaining two slides show the general effect of an excess of mercury. The first shows the 'Fellowship' amalgam, thoroughly amalgamated with just the requisite quantity of mercury, measured by the ratio of one part of filings to one of Hg. The mercury and chips were amalgamated in a mortar, and then packed into a small tube and allowed to set for a month; then ground, polished, and photographed after etching with dilute nitric acid. The microscope revealed a perfectly homogeneous amalgam, dense and without any evidence of liquation. No shrinkage took place, as was evident from the ink test. The *second* shows the same alloy amalgamated with an excess of mercury and the excess squeezed out through wash-leather. The appearance of the finished specimen was totally different from the first. The homogeneous character had disappeared, and there were abundant evidences of liquation having taken place. This was shown by a number of copper-coloured patches covering the surface. Considerable shrinkage had taken place, and the edges of the amalgam showed great evidences of 'spheroiding.' These serious faults, occasioned by the excess of mercury, are probably due to the following reasons:—

"When an alloy is amalgamated and the excess of mercury is removed by squeezing, an unknown quantity of the constituents of the alloy is removed by the mercury, the proportions of the various ingredients removed depending upon the solubility of the metals in mercury. Thus in a silver-copper-tin alloy, tin and silver would be removed to a much greater extent than copper, and hence the resulting amalgam would be of totally unknown composition, and its properties anything but those of the original amalgam. If the amalgam alloy contains gold, this metal is also dissolved out and removed, if excess of mercury is employed, and the excess removed by squeezing. In an actual experiment, an alloy containing Sn 49·00 per cent., Ag 38·8 per cent., Au 12·20 per cent., was amalgamated with excess of mercury and squeezed through wash-leather. The mercury was then removed from the finished amalgam by heating and the remaining alloy analysed, and the result was truly startling—Sn 13·0 per cent., Ag 67·0 per cent., Au 2·0 per cent.—the tin and gold being chiefly dissolved by the excess of mercury squeezed out.

"Another cause of failure is the opposite of that caused by squeezing amalgams, viz., the employment of impure mercury, whereby unknown quantities of unknown metals, such as zinc, copper, cadmium, and lead, common impurities in even commercially 'pure' mercury, are introduced in the amalgams, thereby greatly modifying their properties."

In replying to the discussion which followed the reading of this paper, Dr. Brislee said that electrically purified mercury was the purest form of mercury he had came across. Ordinary "pure" mercury was by no means pure. For the method used by Dr. Brislee to determine the exact proportion of mercury to be mixed with a given alloy, see Appendix.

It was mentioned by Dr. Brislee that there are both quick-setting and slow-setting alloys now made with which equally good results can be obtained. He summed up the description of his experiments by saying: "From these results I should say that, under careful working and selection, the amalgams are capable of giving extremely good results, but there seems to be every necessity to give the amalgam a fair chance to prove its merits."

The principal value of Dr. Brislee's work consists in confirming the experiments of some other investigators, and it may also help to clear up some disputed points. His deduction that different amalgams, when placed in the same mouth, generate an electric current which disintegrates or destroys the fillings, is not borne out by experience as far as the ordinary amalgam alloys are concerned, copper amalgam being the only one which appears to undergo any disintegration in the mouth. The electric current is most marked when the amalgam contains zinc; and the contact of a filling which contains this metal, with gold in the form of a filling, a band, a crown, a bridge, or a plate, is very likely to cause pain. Trouble is rarely caused in this way with the other amalgams, partly because any electric current produced by them is not so strong, and also because the current produces a more or less rapid oxidation of the surface of these amalgams, and this is said to practically insulate them. It is distinctly advisable to line all amalgam fillings which contain zinc with oxyphosphate cement if the presence of other metals in the mouth is likely to cause electrical action.

It is important for an amalgam filling to be completely trimmed and made smooth before the patient leaves the chair. It is very tedious and difficult to trim and smooth an amalgam filling when it is completely set, especially on the approximal sides of bicuspids and molars; and in these positions it is usually a painful process for the patient, owing to the free use of trimming and polishing tapes below the gum, necessitated by maintenance of contour. All that should be done when the filling is set, is to perfect the surface with the finest polishing strips, pumice-stone applied with wet linen or silk tapes, followed, if thought necessary, by tapes charged with chalk or whiting. The occlusal and other equally exposed surfaces can, of course, be easily ground smooth with stones in the engine, and polished with wooden points or leather buffs, and a suitable powder; although the necessity for any grinding is done away with by careful scraping and smoothing at the time the filling is made.

The maintenance of colour in an amalgam filling is very uncertain, and just in proportion to maintenance of colour, so are the tooth-saving properties of the filling reduced. This is to say, that although an amalgam that maintains its colour may save certain teeth remarkably well, there are other teeth in which a filling that readily oxidises and becomes more or less black, is more advantageous. It is difficult to account for this, but that certain amalgams have a hardening effect on the dentine with which they are placed in contact, and also that—all other things being equal—an amalgam that goes black on its exposed surface seems to preserve bad cases better than a non-oxidisable metal filling, is a common belief based on observation.

To again quote from Dr. Flagg's book (p. 76, sixth edition): "It is very important to know that rather *inverse* to the good maintenance of colour is the *real value* of amalgam. In cases where cavities can be nicely 'lined' either with good varnish or good oxychloride of zinc, it is better that an amalgam of good maintenance of colour be used; but *if the preservation of the tooth*, as in a *lone molar* for clasping purposes or for mastication, be the *prime consideration*, all experience indicates that an amalgam *which will discolour*, better accomplishes this end. Therefore, in such cases, and particularly if there are 'submarine' complications, alloys of silver, tin, and copper should be used in preference to those containing gold, platinum, zinc, or—worst of all—cadmium."

Dr. Flagg recommends the use of two amalgams in many cases, viz., one that oxidizes, or "sulphides," for guarding the cervical parts, and one that maintains its colour better for the rest of the filling. It may therefore be said that, just in proportion as the conditions of the mouth, *et cetera*, favour decay, so is the use of an eminently tooth-saving amalgam demanded; and just in proportion as the surrounding conditions are favourable, so may a lighter-coloured amalgam be used with advantage. It is found, however, that any good, light-coloured amalgam will maintain its appearance best on surfaces that are exposed to friction, and that it is a rare experience for any "front tooth alloy" to in any way maintain its colour in incisors. To the writer's eye an exposed amalgam filling in an incisor or canine is by no means a thing of beauty, even if by some chance it should perfectly retain its original colour.

Some years ago he made several fillings in front teeth with the No. 3 platinum-gold-foil, which finishes up platinum colour; and as in every case he found that the teeth would have looked much better if filled with gold, he came to the conclusion that a silver-white filling was far more hideous than a gold filling, and that, for æsthetic reasons alone, amalgam, even if it should maintain its colour, has no place in front tooth cavities that are in any way exposed to view.

The two metals that oxidize the most readily and thoroughly in the mouth are silver and copper, and these are the two metals that, used in combination with mercury, exert a preservative effect on tooth structure. The preservative effect of an amalgam of copper and mercury alone is far more than counterbalanced by its defects, and an amalgam of coin silver alone, which is really a silver amalgam containing about 10 per cent. of copper, has many defects which preclude its general use. Dr. Flagg says: "It turns black, and discolours any kind of tooth dreadfully. It curls up at the margins in an undesirable manner. Its edge strength is not good, but notwithstanding this it saves teeth in a remarkable manner, even in the most desperate cases." Dr. Flagg also says: "In many a cavity where everything else, even copper amalgam, has failed, it has done faithful duty *persistently*."

The method of making coin amalgam described by Dr. Flagg is to reduce a silver coin to fine filings with a "dead smooth" file. The filings are then sifted through a very fine sieve, and a magnet freely and frequently applied to remove all particles of steel that may have come off the file. Dust is removed by careful blowing, and about 55 parts of mercury to 45 of the filings is required to make the amalgam mix; rub into paste in mortar. If amalgamation is not prompt and complete, add a globule of mercury to make a smooth paste; squeeze through chamois; again triturate thoroughly in mortar; squeeze as for wafering; introduce filling as usual; take off soft surplus, and wafer.

Copper Amalgam is made by dissolving pulverised sulphate of copper in warm water, and precipitating the copper by means of either iron or zinc rods or plates. The details of procedure are to be found in several books, and need not be here mentioned. Suffice it to say that the precipitated copper is mixed with mercury, and formed into buttons or discs of convenient size. One or more of these buttons is heated when perfectly set, in a suitable spoon, over a spirit lamp, until globules of mercury appear. The button is then placed in a mortar, crushed up, and thoroughly rubbed with the pestle.

The amalgam is then transferred to the hand, and again carefully rubbed, with the fingers, until it becomes very plastic. It often happens when this amalgam is heated until the globules of mercury appear, that no matter how well it may be rubbed up in the mortar and in the hand, it still remains in a more or less powdery condition. It should then be replaced in the spoon and held over the flame until a slight crackling sound is heard. The spoon is then removed from the flame, and the amalgam allowed to remain in it until the crackling ceases. It is again rubbed up, and, if necessary, the re-heating and rubbing is repeated. By this means any desired degree of plasticity may be produced. The superfluous mercury is then squeezed well out, and it is ready for insertion. It is considered that the iron precipitate produces more even and trustworthy results than the zinc precipitate.

Copper amalgam gives no flow under pressure, and consequently never curls up at the edges. It is also considered to shrink very slightly, or not at all. It can be placed in a tooth in a very plastic condition, and will set very hard. If a *little* soft dentine is left in the cavity it will be permeated by the copper salts, stained a dark colour, and any decay that might otherwise have progressed underneath the filling will be prevented. It will be seen therefore that it possesses certain valuable properties. Its colour, although black, is not of much moment in cavities that are not exposed to view. It will not discolour a live tooth if all the soft dentine has been removed, and the walls are formed of hard, white dentine, but will turn a pulpless tooth very dark. Its merits are, however, more than counterbalanced by its defects. It wastes away on the surface, and in some cases rots, or becomes dissolved away, at the cervical margin. In fact, except that it is somewhat more durable, it behaves in these respects very like a cement filling. The general waste or wear soon causes the contour of approximal fillings to be lost, food to become wedged between the teeth, and recurrence of decay to take place in consequence, while the cervical wasting when it occurs increases the mischief.

Owing to its hardness, it is extremely difficult to cut out, and this is often necessitated for the above reasons. It, can, however, be often used with advantage in occlusal cavities and fissures in bicuspids and molars—particularly for young and fidgety patients—and for cavities on the sides of molars, and sometimes bicuspids, where, owing to the extraction of the adjacent tooth, the filling is perfectly free and can be easily repaired when necessary. A cavity can be very rapidly filled with copper amalgam, and as the surface soon becomes smooth from wasting and wear, there is no necessity to spend much time in finishing the filling. If its use is confined to the above-mentioned cavities, including buccal and palatal surfaces of molars, and occasionally bicuspids, as well as to all cavities in temporary molars that admit of an amalgam filling, and only need to be preserved for a few years, it will be found to give great satisfaction in many cases, particularly if the teeth are sensitive, the anchorage doubtful, the mouth too wet to admit of the use of white cement or an alloy amalgam with a cement lining, and it is desired to dispense with the rubber dam.

Combination (Mixture) of Copper and Alloy Amalgam.—It might naturally be thought that a mixture of copper amalgam and an alloy amalgam would increase the merits and reduce the defects of either used singly. It might be supposed that the admixture of copper would reduce the flow and shrinkage of an alloy amalgam, and that the alloy would reduce the wasting away or rotting of the copper. The writer has made a large number of such fillings during the last twelve years, and finds that his expectations have been fulfilled. It has been stated that this mixture is of no value, inasmuch as the filling acts just like either a copper or an alloy amalgam, depending on the proportions of the mix. Either the filling shows all the wasting and rotting of a copper amalgam, or else it shows all the curling up of margins associated with an alloy.

The writer's experience is that whenever the filling wastes away, this process is very slow compared to copper amalgam; moreover, good edges are maintained, and when no waste takes place, any curling up of edges is very slight, and apparently of little moment. The writer's method is to soften and rub the copper amalgam in the usual way, then to mix the alloy with mercury to the same consistency as the copper amalgam. Equal parts of each amalgam are then rubbed together, first in a mortar, and afterwards in the hand, the surplus mercury being squeezed out in the usual way. It is impossible to obtain perfectly even results, owing to the different amount of mercury that various batches of the same make of copper amalgam contain, and also because the mixing of the alloy to the same consistency as the copper amalgam can be only approximately determined; further, the best alloy for forming the mixture has not yet been ascertained. It may be mentioned, however, that some alloy amalgams mix much more kindly with the copper amalgam than others, and there is also a wide difference in the setting properties, according to the alloy that is used.

Welch's Alloy—tin and silver—is the best the writer has used for this purpose. More recently he has made the mixture by re-heating and re-mixing the copper amalgam until it becomes extremely soft, and then rubbing into it as much of the alloy as it will take up without crumbling, but the fillings made in this way have not been under observation sufficiently long to enable him to express an opinion as to the superiority or inferiority of this method of mixing. These fillings turn perfectly black on the surface, but whenever the writer has removed one of them he has found that the part in contact with the interior of the cavity was a grey colour, showing that no oxidation through leakage had taken place. These fillings are subject to a certain amount of cervical disintegration in some cases, but on the whole they have proved sufficiently satisfactory to convince him that this mixture presents possibilities that are well worthy of investigation.

The Matrix.—There is a difference of opinion as to the value of a matrix in filling certain cavities. Many operators make frequent use of this appliance in mesial and distal cavities in bicuspids and molars, and some find it is also of great assistance to them in filling the incisors and cuspids. It is in filling cavities with amalgam that the largest use is made of a matrix, and it is therefore appropriate to briefly allude to it now.

As far as gold is concerned, the matrix may or may not prove useful. This will depend on what may be termed the individuality, or methods of manipulation, of the operator. Many dentists consider that this appliance interferes with freedom in manipulating the gold, and make little or no use of it; others hold that in certain cases it facilitates the operation and enables the work to be done more easily and with greater accuracy. The writer has at various times obtained different kinds of matrices, but has never taken kindly to them. In filling teeth with gold, the matrix is principally used in connection with posterior approximal cavities in bicuspids and molars, and it may also be satisfactorily employed in the filling of many approximal cavities in the incisors and canines. The late Mr. Lennox showed that a matrix for a bicuspid or molar should be made with a metal strip cut in the form of a segment of a circle or flat ring of a certain size. This shape alone enables the matrix to accurately fit the cervical part of the tooth when it is properly placed in position and tightened up. A straight strip, when passed round the tooth, will invariably stand away from the cervical margin of the cavity, and any attempt to correct this by pressing it to place at this part and holding it there with a wedge of wood or gutta-percha is an unsatisfactory and imperfect proceeding. In addition, however, to producing a matrix of the correct form for accurately fitting the more or less cone-like shape of a tooth, Mr. Lennox recognised that a natural depression or concavity frequently exists on the approximal sides of these teeth at their necks, especially on the upper bicuspids. He therefore made a mandril or shaping tool, which enables the cervical part of the matrix to accurately fit this depression in the root. The shaping tool may be used in every case, because if no depression exists on the root the matrix will assume its original shape during the tightening up of the clamp, and no amount of tightening up will draw the matrix out of or away from the depression if this exists.

Fig. 20 shows the Lennox matrix outfit. The ends of the selected size of matrix should be bent at right angles with pliers; the bent ends or "lugs" are then placed in the slots in the clamp, which is opened wide to receive them. The matrix is then placed on to the ungrooved end of the shaping tool (2, Fig. 20) and tapped with a small riveting hammer into a symmetrical shape. It is then

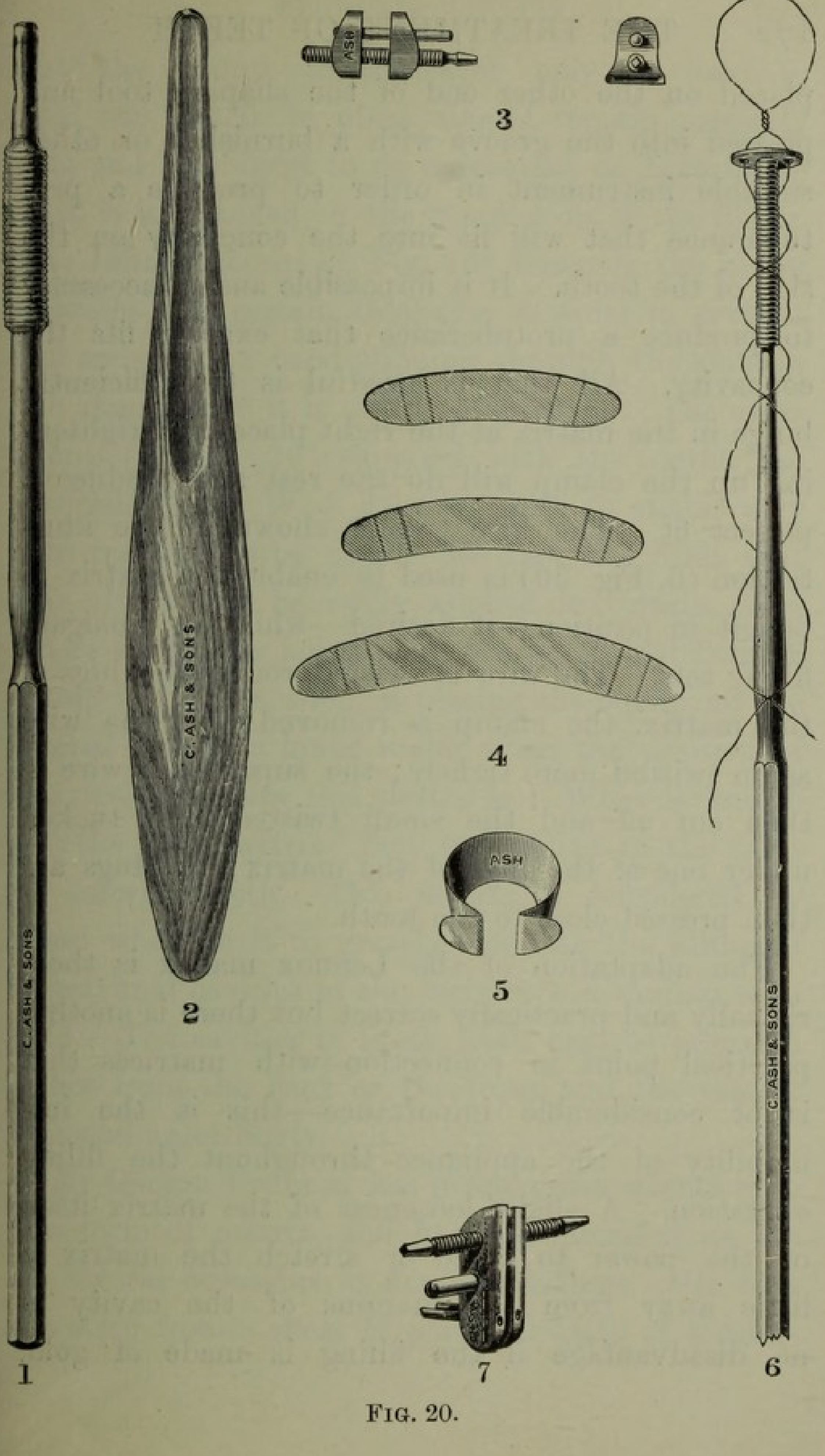


Fig. 20.

placed on the other end of the shaping tool and pressed into the groove with a burnisher or other suitable instrument in order to produce a protuberance that will fit into the concavity on the side of the tooth. It is impossible and unnecessary to produce a protuberance that exactly fits the concavity. All that is needful is to sufficiently bulge in the matrix at the right place, and tightening up the clamp will do the rest and produce a perfect fit. The wire twister shown in the illustration (6, Fig. 20) is used to enable the matrix to be left in position—if desired—while an amalgam filling sets. The wire is twisted round the lugs of the matrix, the clamp is removed, and the wire again twisted more tightly; the superfluous wire is then cut off and the small twisted ends tucked under one of the lugs of the matrix; the lugs are then pressed close to the tooth.

The adaptation of the Lennox matrix is theoretically and practically correct, but there is another practical point in connection with matrices that is of considerable importance—this is the immobility of the appliance throughout the filling operation. A slight looseness of the matrix itself or the power to force or stretch the matrix a little away from the margins of the cavity is no disadvantage if the filling is made of gold, but the clamp, or whatever may be used to hold the matrix in place, should remain perfectly firm and be subject to no movement or disturbance until it is removed on the completion of the filling. The Lennox clamp (3, Fig. 20) demands the use of matrices of a certain thickness in order to prevent the ends of the band slipping through the slots in the clamp when it is tightly screwed up. The extra clamp (7, Fig. 20) supplied with the outfit was devised by Mr. W. J. Law in order to enable very thin matrices to be used. Mr. Law also finds that this clamp can be easily applied in certain cases where the proper adjustment of the original Lennox clamp is difficult, such as placing the clamp on the lingual side of a lower molar when the position of the cavity renders this desirable. What is known as "the strip matrix" may be applied to the front or anterior teeth. This matrix is considered by those who use it to greatly facilitate the filling of approximal cavities in the incisors and canines with gold. The cavities in these teeth may be prepared either from the back or the front, and the matrix adjusted accordingly.

Mr George Brunton has given great attention to this form of matrix, and has demonstrated its use on several occasions at dental meetings. He cuts the strip from a sheet of platinoid $\frac{1}{10}$th of a millimetre thick, and finds it necessary to give it a certain form according to the case in hand.

Fig. 21 shows these matrices. The more irregularly curved one is used in cases where it is necessary to wrap the matrix round a bicuspid.

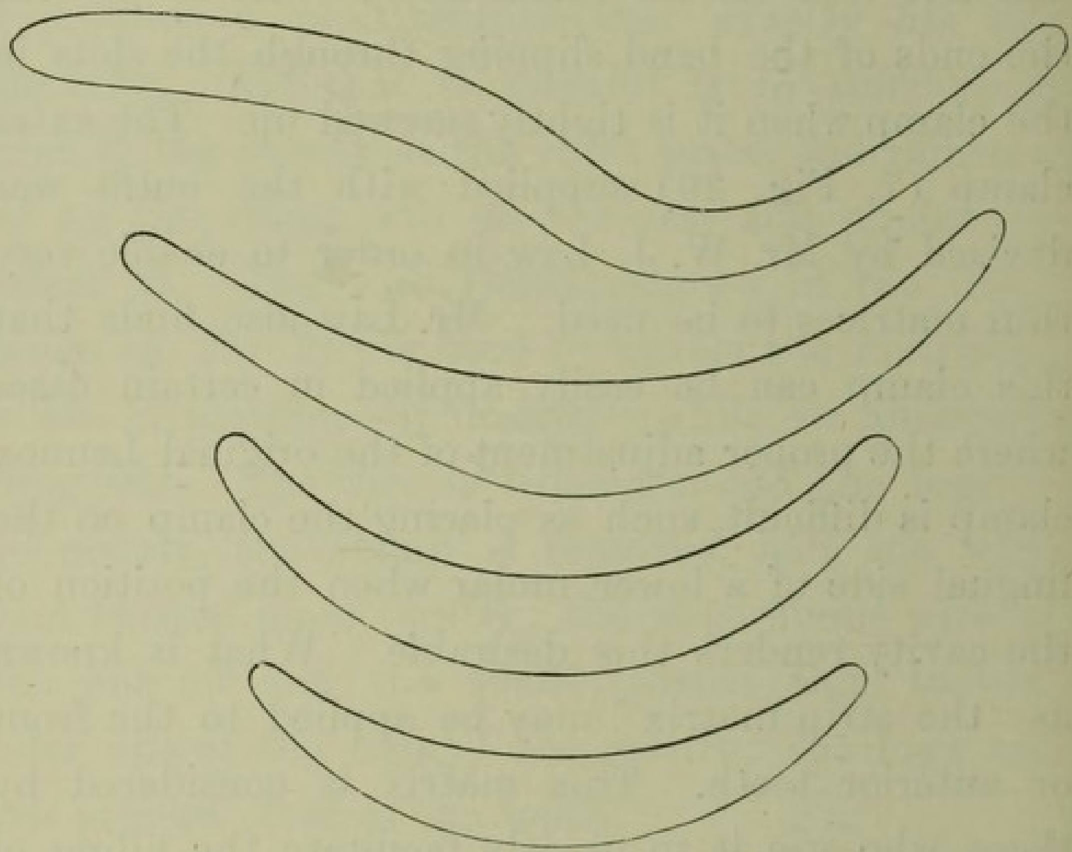


FIG. 21.

The part showing the downward curve is applied to the canine and the forward teeth, and the upward part to bicuspids. Mr. Brunton usually prepares and fills the cavities from the back or palatal side, without any previous separation of the teeth. If the teeth are very close together, a strip of thin steel is passed between them—after the rubber dam is applied—in order to clear off any deposits and smooth the approximal surfaces, and so enable the matrix to be slipped to place. The matrix is then bent and passed from front to back of the tooth to be filled. If the matrix is not close at the cervix a wedge of orange wood is pushed in from the palatal side; marked, removed, and the surplus cut off, it is then replaced. The matrix is bent over the broad end of the wedge and wrapped to and fro between the teeth, thus preventing the wedge from slipping, and keeping the matrix securely wedged to place. The free ends of the matrix are then twisted with long narrow pliers into a tube-like form and rolled tightly against the teeth. This locks or wedges the matrix firmly in position.

Fig. 22 shows the application of the strip. The illustration shows two matrices in position. One extends from between the central incisors to the distal side of the left canine, the ends of which are rolled up at the labial side. The other one extends from between the centrals to the distal side of the right first bicuspid. One end is rolled up between the bicuspids on the buccal side, and the other end is rolled up between the centrals on the palatal side. Strong margins well bevelled on the lingual side are required, and if the cavity is open in front a large cylinder of semi-cohesive gold may be flattened and folded over the margin, half of the cylinder inside

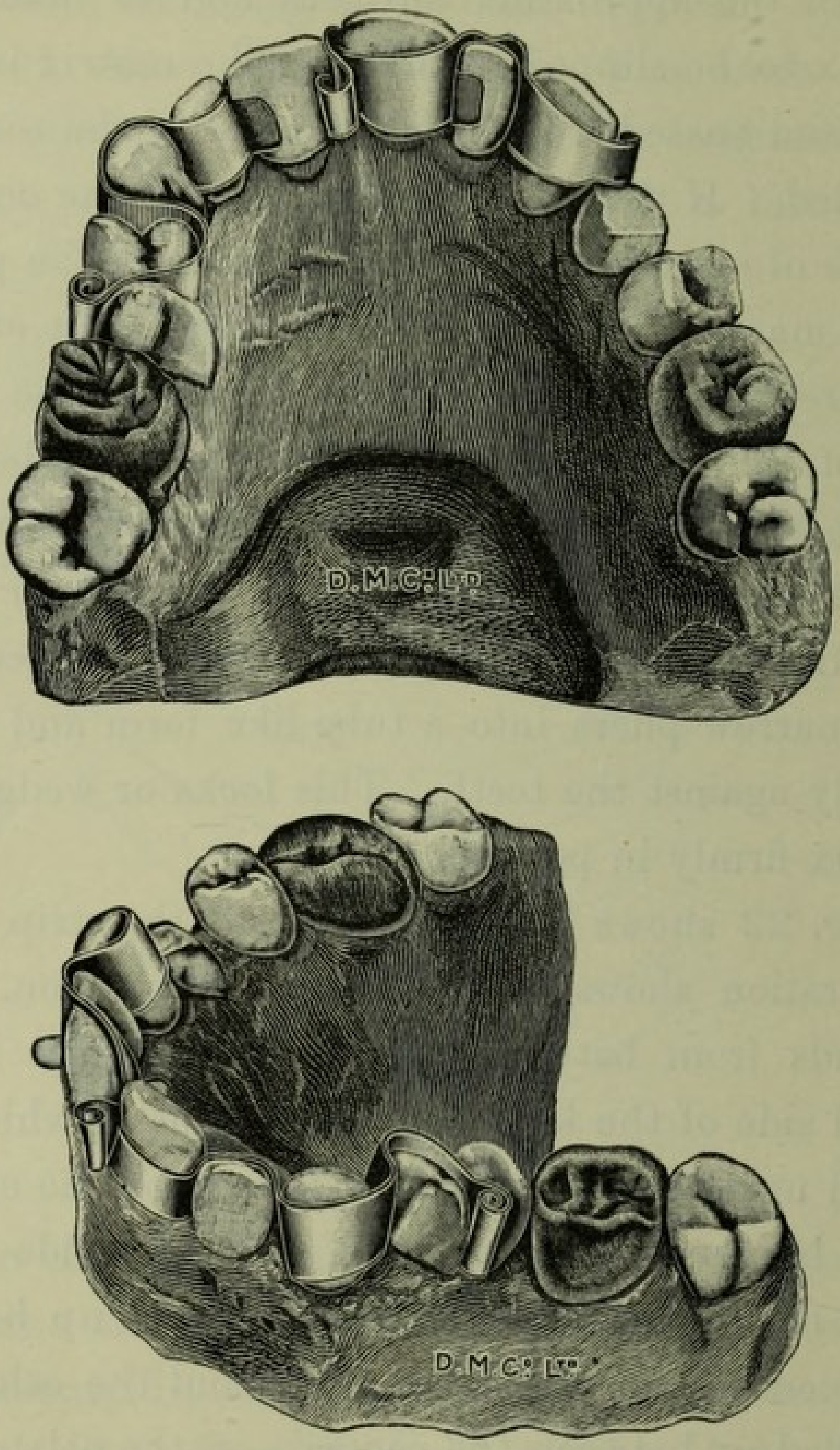


Fig. 22.

and half of it lying on the front of the tooth, *before* sliding the matrix between the teeth; this ensures protection to the margin and forms a good start for the filling. If it is intended that no gold shall show in front when the cavity includes the front wall, the end of the matrix farthest away from the filling may be released, and the strip folded away from the labial side of the filling, and while it is still in position the exposed part of the gold can be cut away and a translucent silicate filling that will match the tooth, introduced, or, if desired, a porcelain inlay may be prepared and inserted at a later sitting. The principal advantages claimed by Mr. Brunton are—first, no previous separation of the teeth is necessary; second, saving of time to both patient and operator; third, perfect fillings can be made from the palatal side without a sufficient sacrifice of a labial wall to cause the gold to show.

Matrices for the front teeth, which are held in place by a clamp, have been invented by Dr. W. Crenshaw. Fig. 23 shows one of these in position.

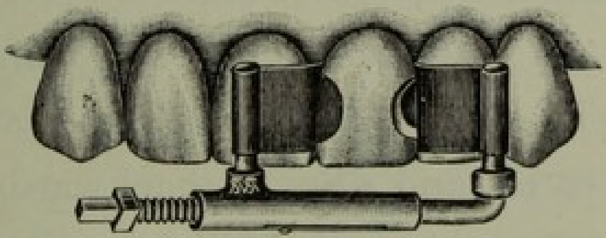
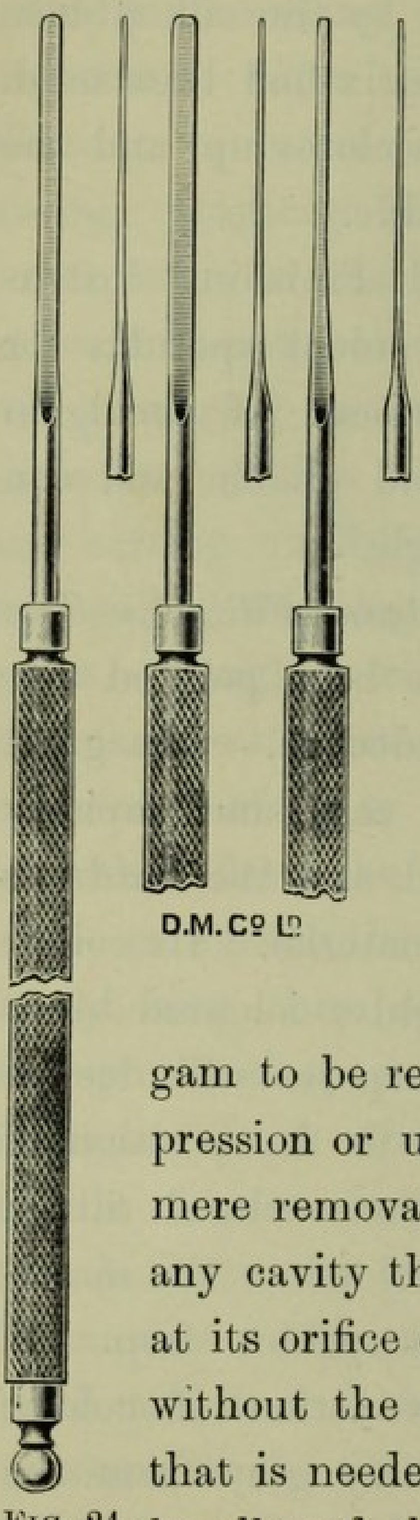


FIG. 23.

In filling approximo-occlusal cavities with amalgam, however, a matrix is considered to be of great value by a large number of dentists. In the opinion of the writer, its principal value is in connection with quick-setting amalgams that demand great pressure in order to bring about the best results. There is no *necessity* to use it if an amalgam of average plasticity and average setting qualities is employed. In making an amalgam filling in an approximo-occlusal cavity, the following method will give good results without a matrix, presuming the amalgam is a suitable one as regards plasticity and setting qualities:—Fill the cavity, and build up against the approximal surface of the adjacent tooth. Roughly trim the sides and occlusal surface, and wafer until sufficiently hard. Trim the occlusal surface to the bite, and make it fairly smooth. Trim the sides and cervical margin, and shape or smooth the filling nearly up to the knuckle by passing thin, spatula-like trimmers into the interproximal space. Clear away any loose bits of amalgam from the interproximal space with a stream of water from a syringe. Pass a fine ribbon saw between the teeth from the occlusal surface. Then pass a strip of thin silk ribbon between the teeth, and draw it backwards and forwards, making pressure on the filling until the amalgam is brought to a smooth and properly shaped contour. If necessary, perfect the cervical margin with a thin spatula. When the filling is completely set, it may be polished if thought good. The space made by the ribbon saw is not increased by the silk ribbon, and is no greater than if a matrix had been used. In a very short time this space closes up, and the teeth are in contact at the knuckle.

Eichentopf's Separating and Finishing instruments (Fig. 24) are very convenient spatulas for trimming the approximal surfaces of amalgam fillings. They are very thin and pliable, and can be easily bent to any desired angle.

General Consideration of Amalgam Fillings.—The disadvantages of amalgam have been pointed out, and some of its advantages alluded to. One great advantage is the comparative ease and rapidity with which it can be introduced, and the hardness and general insolubility of the material. Its colour is not good, and any of the lighter-coloured kinds that are useful for general purposes will deepen or become tarnished according to the position of the filling. A large approximo-occlusal filling, for instance, may maintain its colour on the masticating surface as far as the knuckle; from the knuckle it will often show gradation of colour, varying from a slate-like or dirty grey from the knuckle, to an almost complete black at the cervical margin or gum-line. Owing to its inherent defects of shrinkage and curled-up margins it is not as good a material as gold, where the conditions are favourable for gold, but just in proportion to the presence of unfavourable conditions, so its superiority over the more precious metal is manifest.



D.M. Co Ld

Fig. 24.

With the exception that the margins should not be bevelled if amalgam or any other plastic filling material is used, a cavity that is properly prepared for a gold filling is, strictly speaking, the best cavity for amalgam, but what is essential for gold is by no means essential for amalgam. The very plasticity of the material enables amalgam to be readily pressed into any deep depression or undercut that may exist after a mere removal of the decay is effected; and any cavity that is larger in its interior than at its orifice can be well filled with amalgam without the extensive mathematical cutting that is needed with gold. It must therefore be allowed that amalgam is superior to gold for filling many teeth at the back of the mouth —or in cases where the filling is not exposed to view—for all patients who are sensitive or nervous, or who cannot endure prolonged operations. The question of hard and soft teeth need hardly be considered, for what is known as a soft tooth is generally one that is softened by decay, and the cutting back to sound, hard tooth structure, and the consequent production of a hard tooth becomes usually merely a question of cavity preparation, and it is on the question of the possibility or the advisability of properly preparing a cavity for gold that the use of the precious metal mainly depends.

White Cement.—The white cement fillings are usually oxychloride of zinc (a powder of specially prepared oxide of zinc, and a liquid of chloride of zinc), or what are variously termed oxyphosphate of zinc or phosphate of zinc. These oxyphosphate or phosphate fillings also consist of a powder (some form of specially prepared oxide of zinc), and a liquid, principally, if not entirely, composed of phosphoric acid. The general term osteo, or osteo filling, has also been given to these various white cements, probably because one of the earlier productions was labelled "Os artificiel," or artificial bone. The oxychloride is now comparatively rarely used. It is more troublesome to work than many of the oxyphosphates, and must not only be kept perfectly dry during insertion, but also carefully protected from moisture for some considerable time afterwards by careful varnishing. It appears to be harder than the average oxyphosphate, but is, as a rule, not so durable in the mouth. It often causes pain on insertion, and is said to have a hardening and preservative effect on soft dentine; but this is very doubtful. It is considered to make an excellent root filling—one that will remain moisture-tight and non-absorbent—while the oxyphosphates are considered to make leaky or absorbent root fillings.

As far as filling cavities is concerned, there is no question as to the superiority of the oxyphosphates, notwithstanding the more or less temporary or ephemeral character of any white cement hitherto produced. In mixing these fillings, a little of the liquid and a little of the powder are placed on a glass or porcelain slab, the powder is gradually worked into the liquid, and then more powder is added by firm rubbing with a stiff spatula until a putty-like mass is produced. The mass should then be rapidly inserted and pressed to place in the cavity, and the surface trimmed to shape as it sets.

Whatever may be said as to the value of mixing the liquid and powder in such proportions that an exact chemical compound results, it must be admitted that this can rarely be accomplished; and experience shows that the most durable fillings are those in which the liquid has been made to take up as much of the powder as possible. Too much powder will, however, produce a crumbly mass, and the manipulation should produce a putty-like mix that is, on the one hand, sufficiently stiff, and on the other, sufficiently plastic, to admit of being readily and accurately inserted and packed to place. The mass may be pressed into the cavity with a broad, flat, spatula-like instrument, and then well pressed to the walls with blunt pluggers. The filling should be made "all in one piece," and not added to like an amalgam filling.

Different makes of this cement require different methods of mixing, and the rapidity of the setting varies considerably. A method of mixing that will give good results with one make will render another unworkable; some can be readily brought to the putty-like state, by the gradual addition of powder to the liquid on the slab. With other makes the addition of powder must cease before the putty-like stage is even approached, and this thinner mix must be continually spatulated until it gradually stiffens up to the desired consistency. There is very little difference in the durability of any good make of oxyphosphate cement, and an operator should, as a rule, select one that *he* finds easy to mix and work with. The writer finds, from an observation of the oxyphosphate fillings he has inserted during the last twenty-two years, that the cervical failure so often alluded to, is, in his experience, the exception rather than the rule. In many cases, cervical failure may be due to the use of a cement in either a too stiff, or a too sticky, condition. In the former case, the filling either never goes fully up to the cervical margin, or else it arrives there in a crumbly condition. In the latter case, it probably sticks sufficiently to the plugger to be drawn away from the wall. It has, however, been stated that cervical failure is the rule with some makes of cement, and the exception with others. This probably accounts for the differences of opinion that exist on this point. Oxyphosphate fillings possess the inestimable advantage of adhering somewhat to the dentine (providing it is dry), and consequently in sensitive teeth there is often no necessity to cut anchorage in the sound tooth structure. The decay, if possible, should always be removed; and it should not be forgotten that there are extremely shallow and extremely saucer-like cavities in which even cement will not stay. The modern use of porcelain inlays reduces the number of cavities it was formerly necessary to fill with cement alone, and at the present time cement as a filling material is principally of value as a preparatory filling, or preliminary treatment of certain cavities before using—or in the hope of subsequently using—a more permanent material. It has an average duration of from one to two years, and can be often successfully used to "tide over" a bad time as regards either a period of rampant decay, bad health, or what may be called the foolishness and restlessness of youth. It is surprising how these oxyphosphate cements will save teeth when almost everything else, except gutta-percha, fails—and gutta-percha will not stand long if subjected to the force of mastication. A competent authority has placed small value on cement fillings as savers of the teeth just when the circumstances for saving them are unpropitious; but the experience of the writer is that if the decay can be removed from the walls, the margins moderately well prepared, the cavity sterilized, and the filling kept from moisture until it is properly packed and trimmed, a recurrence of decay will rarely take place at the margins until the filling is considerably worn or dissolved away. The principal use for cement fillings will always be in front teeth, chiefly because the majority of patients will not come up for regular inspection, and recurrences of decay that are solely due to neglect in this respect compel the use of amalgam (with or without a lining of cement, as may be thought good) in many cavities in back teeth, which an operator who was assured of complete control of his patient would have preferred to first fill with cement.

Whenever there is a possibility of a cement filling becoming wet, either during or immediately after insertion, the rubber dam should be used. An oxyphosphate filling will become perfectly hard in water, but it is generally considered advantageous to varnish the surface. The majority of these cements are "hydraulic," *i.e.* as soon as they have become reasonably hard, the absorption of a little moisture tends to improve them. This is probably why those operators who smooth their cement fillings with an instrument dipped in vaseline or oil, and well rub the lubricant over the surface of the filling, find they obtain as good results as if they used varnish. There is no doubt that the majority of oxyphosphate fillings become harder in time: a filling, the surface of which is tested twenty-four hours after insertion, will be found not quite so hard as it would be in a week, and probably not so hard in a week as it would be in a month, and this increase of hardness is taking place in the presence of moisture. There is one practical point that must not be overlooked, namely, that an oxyphosphate filling must usually be cut out and replaced within two years. Some cements are much harder to cut out than others, and the durability of a cement filling by no means depends on its hardness. There are many good cements that may be comparatively easily and rapidly removed, and are therefore to be preferred to those which attain a rock-like hardness.

The writer tested the cements he is in the habit of using as follows: A ball of putty-like consistency was made, immediately dropped into Stephen's ink, and left there for twenty-four hours; a slight permeation of the cement resulted. Experiment No. 2—A similar ball was made, and a pin was inserted into it to hold it while it was varnished; the varnish was partially dried with a chip blower, the pellet was dropped into the ink, and left there for twenty-four hours; in this instance no permeation of the cement resulted. Similar experiments made with the liquid of this cement, and the powder of another cement, produced precisely similar results. Another popular cement was then tried, with the result that it was completely permeated, whether varnished or not, and the unvarnished cement when removed from the ink was found to be considerably reduced in size. These little experiments are mentioned merely to show that a wholesale condemnation of cements because some of them are readily permeated is hardly fair. The writer does not for a moment consider that the cements he tested with such good results as regards permeability are very much better than many other makes. They are good cements with an average durability of eighteen months before needing to be replaced in the mouth—that is all. It is considered that a steel spatula should not be used for making the mix ; it should be heavily nickel-plated, or, better still, made entirely of nickel.

Silicate Cements.—Some thirty years ago the late Mr. Fletcher of Warrington built a special laboratory, and for three years devoted himself exclusively to the task of discovering the "ideal" cement filling. He was unsuccessful, but his experiments enabled him to point out that if ever success were achieved it would probably be on certain lines. The silicate fillings that are now made are akin to, if not actually based on, a filling produced by Mr. Fletcher which did not answer expectations. These fillings, several makes of which have been made during the last three or four years, consist of a liquid which is said to be a modified phosphoric acid, and a powder composed of silicates and alumina. Some of these powders are stated to be composed of silicate of lime and alumina, and such substances as aluminium phosphate, zinc phosphate, zinc silicate, aluminium silicate, and some other materials are used in this connection. The advantage claimed for these silicate cements is greater durability in the mouth than the oxyphosphates, and decidedly better appearance. Some dentists have been annoyed by several of these fillings falling out of the teeth, and, according to some experiments made out of the mouth, the material shrinks considerably. On the other hand, certain dentists have had no trouble with these fillings "coming out," and experiments have been made which show that the material does not shrink. The particular make used, or the manner of mixing and packing it, may account for the variation in results. Some makes of this material possess adhesive properties, others have little or none. Retention should be secured by under-cutting the cavity in preference to relying on the adhesion of the filling to the dentine.

Such experience as the writer has had with the material, inclines him to think that a silicate filling behaves somewhat like an amalgam filling, inasmuch as shrinkage or change of form and curling up of the edges have been observed. It may be that, just as in the case of amalgams, a correct formula, an excellent method of preparing the material, careful mixing of the liquid and powder in definite proportions, and careful packing and finishing will greatly, if not completely, eliminate these defects. The appearance of these fillings is in some cases equal to a good porcelain inlay, although in certain mouths a dark line will collect at the margins just as happens with some inlays. A general discolouration of the surface is by no means uncommon. This is probably due to the fact that a silicate filling cannot be polished to complete smoothness. As a rule the surface is rough, and its good appearance depends on the presence of a film of moisture which hides the roughness and gives these fillings their pleasing appearance. But this very roughness may collect stains, and does so in certain cases.

A point that should be noticed is that all or nearly all the makes that were introduced a few years ago have since been improved by their makers. This shows that dentists have been experimenting with inferior products, and as the only real test of a filling material is its behaviour in the mouth, it behoves one to be careful in selecting cases for the application of a material, the excellence of which has to be taken on trust. The cavity should be undercut, and the margins cleanly cut and not bevelled. The powder and the liquid are separately placed on the mixing-slab, and the powder gradually worked into the liquid until a fairly stiff paste is produced. The paste-like mass should be of the consistency and spreading property of butter. When this is arrived at, no more powder should be added. If the material is quick-setting it may be placed in the cavity at once, if it is slow-setting it should be allowed to remain on the mixing-slab until it stiffens sufficiently to be easily and accurately packed in the tooth. An agate, or bone spatula, is used for making the mix, as rubbing the material with a metal spatula discolours it. Nickel-plated steel instruments may be used to pack the filling providing they are clean and polished, but it is safer to use agate, ivory, or tortoise-shell. Tortoise-shell is recommended because it is stronger than agate or ivory. The filling is packed in piece by piece like an amalgam filling, taking care to work it well into the undercuts. If it is introduced in mass and pressed to place with a flat spatula-like instrument, a hole should be made in the centre, and the mass well pressed to the sides. The central cavity is then filled up. The surplus is removed by pressing it towards the margins and cutting it off there. The contouring and trimming instruments should be lubricated with vaseline, or else they will stick to the filling and disturb its position. When the filling is sufficiently hard, it is trimmed and smoothed with well-lubricated sand-paper and cuttle-fish discs. Excess of the lubricant is then wiped off, and a suitable varnish applied. It is very important for the filling to be protected from moisture until it sets. The rubber dam should usually be applied and kept in position for at least fifteen minutes after the filling is finished.[1]

It has been stated that these fillings should be shaped and finished with a spatula in preference to cutting instruments and discs. There is no doubt that cutting instruments and discs, no matter how fine they may be or how well lubricated they may be, leave a surface that is vastly inferior to that produced by mixing the material, heaping it up into a lump on the slab, tapping it to smoothness and allowing it to set there. It is doubtless a great advantage to so mould the surface of the filling in the mouth, that no after trimming with discs or tapes is necessary. In this respect a good deal will depend

[1] Three or four coats of a suitable varnish should be applied, drying each coat as much as practicable with cold air from a chip blower.

on the material, for some makes are much more easily manipulated in this way than others.

It has been stated that adequate retention can be secured in non-undercut cavities by lining the cavity with oxyphosphate cement and at once inserting the silicate filling. It is, however, difficult to press out one plastic material with another one that is of the same colour, in such a manner that the filling proper has fine close margins. It is very easy for a mistake to be made, and for the finished filling to present a distinct line of oxyphosphate at one or more of the margins. There are probably possibilities in the silicate fillings that have not yet been fathomed. At the present time they are distinctly on their trial, and several years must elapse before a decisive verdict can be given.

The writer begs to suggest that small round or oblong cavities on the approximal sides of incisors and canines, which would show up as dark patches if filled with gold, and which are particularly difficult to fill with porcelain inlays, are very appropriate cases for silicate fillings, and he also suggests that the growing practice of terming these fillings " porcelain fillings " is wrong, inasmuch as it breeds confusion in the minds of patients, and militates against the appreciation of porcelain inlay work.

The Black Cements.—There are not many of these cements on the market. The writer only knows of three. They are usually described as oxyphosphate of copper, and doubtless two of them are oxyphosphate of copper. Of these two he has made trial, with disappointing results. It is stated that this material adheres firmly to cavities that are not completely dry, that it hardens and disinfects any soft dentine that may be left in the cavities, and that it is more durable than oxyphosphate of zinc. The writer has used two makes of this material carefully according to the directions, which, with one make, were to make a very soft mix, and with the other to mix it fairly stiff, like oxyphosphate of zinc. With both makes the result was the same, viz., such a rapid wear or disintegration in the mouth that, in his opinion, they possessed no advantage which justified a con-.inuance of their use. An oxyphosphate of zinc filling would have proved more satisfactory, and as to any effect which these ephemeral oxyphosphate of copper fillings may have on soft dentine, an equally good or better result is obtainable either by a previous treatment of the cavity with tannin and oil of cloves, or tannin and carbolic acid, or an application of nitrate of silver, and the immediate insertion of an oxyphosphate of zinc filling.

The other black cement, which the writer has not used, is largely, if not entirely, made of cobalt. All the writer can say about it is that, whenever he has heard a dentist speak favourably of "oxyphosphate of copper," he has found, on asking what particular make has been used, that the cobalt cement has been employed.

Gutta Percha.—The gutta-percha specially prepared for filling teeth is a very valuable material, but requires judgment in using. The softer kinds are of great general utility as coverings for dressings, and the harder or more permanent preparations, if used in cavities that are not exposed to the force and friction of mastication, probably give better results, taking one case with another, than any other material; a good deal, however, depends on the quality of the material. Gutta-percha deteriorates with age, and dentists would therefore be benefited if manufacturers would put the date of preparation on each packet.

Small cavities in incisors and canines are readily filled with this material, and such fillings will usually last for some years; but a medium or large-sized approximal cavity is better filled with oxyphosphate, when gold or a porcelain inlay is contra-indicated; but when the cavity does not extend either to the lingual or labial surface, gutta-percha will last longer than a white cement, and is easier to replace. Small pin-head holes on the approximal surfaces of bicuspids and molars are particularly suitable cases for gutta-percha—filled with gold, decay will usually attack the margins within a year or two. The writer would always expect a gutta-percha filling to last longer than a gold one in these cases, and, if necessary to replace it, it can be done in a shorter time.

Some authorities explain the rapid failure of these small approximal gold fillings to want of extension for prevention; others put it down to imperfect manipulation. But the most ardent contourist and believer in the necessity for freely exposed margins would not think it right to cut away all the side of a tooth, and hollow out its interior, in order to convert a minute cavity into a magnificent contour filling. And even if the failure of minute gold fillings in these positions is attributable to imperfect manipulation, it must be admitted that not one dentist in a thousand can do perfect gold work in the majority of these cases.

Many labial and buccal cavities may also be satisfactorily filled with gutta-percha. A cavity for this material should have a general retaining shape, and consequently a little more cutting away is usually needed than for a white cement;

but owing to the smallness of the cavities generally filled with gutta-percha the preparation is as a rule rapidly effected.

Gutta-percha shrinks slightly, and in some mouths becomes dark on the surface. This change of colour is often accompanied by a softening and porosity of the surface. It is stated that varnishing the cavity with either copal ether varnish or resin dissolved in chloroform prevents the shrinkage of gutta-percha. Whatever may be the value of this varnishing, the fact remains that the majority of gutta-percha fillings, notwithstanding their leakage, save teeth remarkably well, as long as the filling remains fairly intact. Leaky gold fillings have little effect in saving teeth; why leaky gutta-percha fillings should not be open to this objection to the same extent is not satisfactorily explained. It is true that an explanation is to be found in the electro-chemical theory; but the teachings of the late Dr. S. Palmer in this respect have not been accepted by the profession at large.

For filling cavities (not too much exposed to mastication) where a clasp, or band, or part of a plate will be in contact with the filling and tooth, gutta-percha seems usually to answer better than anything else.

The late Dr. Bonwill partly or completely prepared cavities on the approximal sides of bicuspids and molars, and filled them with the pink base-plate gutta-percha in order to press the gum away from the cervical margins, and separate the teeth sufficiently for contour restorations with gold or amalgam to be subsequently made in the most satisfactory manner. The pink base-plate gutta-percha resists the force of mastication better than other makes, and expands sufficiently to gradually separate the teeth, but this takes a long time to effect, and as a general method of practice should be confined to patients who can be relied upon to present themselves for regular inspection. The writer finds this method particularly useful for young or sensitive patients, for whom it is impossible or inadvisable to properly prepare the cavities. If the cavities be opened up and prepared as fully as circumstances allow, and if they be treated with nitrate of silver before inserting the gutta-percha, it will be found that an average duration of at least a year may be expected of these fillings. In course of time many of these cavities can be thoroughly excavated with little or no pain, and little or no fresh decay will take place during the time that the gutta-percha is resorted to, providing, of course, it it replaced when necessary.

The blackening of the dentine by the nitrate of silver can usually be removed by proper excavation;

and although cases occur in which a small black patch or a fine black line cannot be removed with safety, this will not seriously impair the appearance of the teeth, and shows that the decay has dipped deep into the dentine at places where it cannot be removed, and which, but for the nitrate of silver, would have remained all unsuspected and perhaps caused trouble in the future.

In manipulating gutta-percha, care has to be taken not to overheat and so spoil its durability. A useful method of procedure is to simply warm the shank of the instrument just sufficiently to soften the gutta-percha when pressed on it. If a pellet is picked up with the end of a warm plugger, and at once conveyed to the cavity, a good deal of the softening may be made to take place while the pellet is packed. It is also often useful to hold the pellet in the cavity with an instrument in the left hand, and then further soften it and complete the packing with a warm plugger in the right hand. The idea is to work the gutta-percha satisfactorily with the least heat. It is principally a question of convenience and the size of the cavity whether one or more pieces are used to fill it. If several pieces are used, it is advisable to work them somewhat on the non-cohesive gold principle. Sufficient heat to make one piece intimately cohere with another would in all probability injure the material. Large, medium, and fine-pointed pluggers may be used as desired, and are all useful, the surface being finished by trimming and smoothing with thin flat instruments, heated just sufficiently for the purpose.

Combination of Filling Materials.—The combination of cohesive and non-cohesive gold has been alluded to, as well as combinations of gold and tin. There are also several other combinations that are very useful on occasion.

Gold and Amalgam.—A combined filling of gold and amalgam is of value principally in approximo-occlusal cavities in molars and bicuspids. When the cervical wall is so far below the gum that the rubber dam cannot be carried over this border, or when this would be an inflictive procedure, the filling may be built up to the gum line with amalgam. This enables the dam to be applied, and a gold filling to be made. The amalgam should be trimmed as smoothly as possible, and then further smoothed and polished when it is set. There is no contour knuckle to interfere with the thorough smoothing and polishing of the amalgam, and discs can be freely used to effect this. When the exterior of the amalgam is polished the dam is applied, and the gold filling started by considering the amalgam as forming the cervical wall, and treating it accordingly.

In certain cases, no matter whether the cavity is far below the gum or not, the filling is built up to the knuckle with amalgam, and then completed with gold. A filling of this kind has often advantages over an all-gold or an all-amalgam filling. In difficult cases the tedium and uncertainty of packing the gold into the deeper parts of these cavities is done away with, and the part that is made of gold is as easy of access, and can consequently be as accurately filled as an ordinary occlusal cavity. The gold top, or masticating surface, does away with the curled-up edges and chipping of margins that might take place if the filling were made wholly of amalgam, and the best properties of both materials are thus utilised. In making these fillings the gold may be packed directly on to the amalgam as soon as the latter is inserted; a matrix is generally used in order to prevent the amalgam from being forced out of the cavity or broken by the force used in inserting the gold. It is also a convenience, if not a necessity, to use a gold that will adhere to the unset amalgam; several makes of crystal gold will do this, and whichever is selected is generally used until it ceases to become amalgamated, and a sufficient layer of gold is built up;

then the filling is completed with crystal gold, or foil, as preferred. The filling may also be started at the end of the occlusal step, or occlusal under-cut, remote from the amalgam, and then gradually worked to, and over, the amalgam. It is possible, by proceeding in this way, and directing the force principally at right angles to the long axis of the tooth, to dispense with the matrix. The most convenient and generally satisfactory method is to build up the amalgam to the desired height, and allow it to completely set before inserting the gold. Starting pits and grooves can then be cut in the amalgam, or a little non-cohesive gold worked in, and the filling then completed with cohesive gold. This also admits of the amalgam being so cut away that nothing but gold shows, and this is not so easy to exactly calculate when the filling is made at one sitting. The hard amalgam enables the gold to be more rapidly and freely manipulated, and does away with the delicate—not to say " finicky "—packing that is resorted to, to prevent the gold coming away from the partially set amalgam. As soon as gold is placed on freshly packed amalgam it absorbs the mercury, and this produces an extremely dry but unset and consequently friable amalgam. This necessitates the greatest care being taken in order to prevent the lifting or breaking away from the amalgam base of the first few layers of gold under the pressure used in packing.

When the gold has absorbed all the mercury it can take up, it will show its true colour, but it will then be difficult to make the next layer stick. Then, again, an examination of these fillings a day or two after insertion will sometimes reveal a trench-like, shallow depression at the line of junction of the gold and amalgam, no matter how carefully or with how much force the gold may have been packed into and on to the amalgam. This is probably due to the destruction of the amalgamated gold, for a filling of this kind made immediately really consists of three parts: first, an ordinary amalgam, then an amalgam composed principally, if not entirely, of gold and mercury, and finally a gold filling. In the first edition the writer advocated the "immediate" method of making these fillings, but now much prefers to insert the amalgam, and fill up with temporary gutta-percha, then, at a subsequent sitting, to insert the gold, or to completely fill the cavity with amalgam, and when it is set, cut out sufficient to make room for the gold. When amalgam and gold are used in connection in the same cavity, the surface of the amalgam will become perfectly black, and for appearance' sake it is often advisable to cut out part of the buccal surface of the amalgam, and extend the gold, so as to cover up this part. It is said that an electrical action is set up which is beneficial in saving the tooth; no doubt the rapid oxidizing and blackening of the surface of the amalgam is due to such action, but the action ceases as soon as the surface is oxidized, and beyond the preservative effect that a black amalgam seems to have, the value of these fillings is more mechanical than therapeutic.

It may not be out of place to again allude here to the electrical action that is caused by the presence in the mouth of two dissimilar metals. The generation of a painful electric current may take place when two dissimilar metals are in fairly close, but not absolute, contact; but the presence of moisture between the metals is required to bring it about. A gold clasp which impinges on an amalgam filling in a live tooth may cause pain, and two fillings, one of gold and the other of amalgam, in opposing teeth, may do so whenever the teeth are brought into contact, as the following case will show: the writer made a large contour amalgam filling in a pulpless upper molar, the opposing lower molar having a fairly large gold filling in its occlusal surface. The amalgam filling was trimmed free of the bite, but as soon as, and each time, the patient closed his mouth, he received a shock of pain in his lower molar. To at once remedy this, a small hole was drilled in the centre of the gold filling, and filled up with amalgam before the patient left the chair. He could then immediately close his mouth with perfect comfort. In the same way, if a gold clasp causes pain in a tooth filled with amalgam, a hole may be drilled in the amalgam and filled up with gold. These cases are comparatively rare, but the same experience may happen to any one whose teeth are sensitive, and whose gold fillings should come in contact with the tinfoil wrapping of butter-scotch. The writer has himself more than once experienced it when eating a piece of Roquefort cheese, the tinfoil of which had not been completely removed. There is no fear of electric shocks happening as the result of placing gold and amalgam in *absolute* contact either as fillings or compound gold and amalgam crowns.

Amalgam and White Cement.—It is often advantageous to line a cavity with cement, and then fill with amalgam. Pellets of a tough slow-setting cement may be placed against the walls, pressed to place, and the surplus removed; this forms a complete lining before the amalgam is inserted. The more usual practice is to place a thin mix of cement in the cavity, spread it against the walls, and at once insert the amalgam, using the latter as a buffer to properly form the lining, and press out the surplus cement. To do this is not quite so easy as it seems—the cement must be mixed just right. If too thin it will probably be all but completely pressed out, while, if it is too thick, it will be very difficult to press enough out of the cavity to produce clean, strong, amalgam edges. It may easily happen that at one or more points the cement forms too thick a layer, and the amalgam is merely wrapped over what is practically a cement margin. The operator, finding nothing but amalgam is visible on completion of the filling, thinks everything is right; but in a short time he finds that the force of mastication has broken the thin border of amalgam, and a broad line of cement has become exposed. This necessitates cutting out the cement at the border sufficiently deep to admit of proper repair with amalgam. Also if the cement is too thick it may be impossible to press it out sufficiently to provide adequate retention for the amalgam. Lining cavities is excellent practice, and efficiency is only attained by care and experience. In certain cases the amalgam will be the better retained for the cement lining; shocks to the pulp also, from thermal change, will be to a great extent prevented, and should the amalgam shrink or curl up at the edges, the tooth will be better protected than if no lining were used. When, however, an amalgam is used that has the tooth-hardening, or preservative properties of copper, it is well for it to be in direct contact with the dentine. The use of a cement lining also prevents an amalgam from showing through a thin buccal wall, and consequently distinctly helps to preserve the appearance of the tooth; for this reason it may be useful in certain cases to place the cement only against the buccal wall.

Amalgam and cement are also combined, by mixing together. Some advise the incorporation of the alloy filings with the cement; others prepare the amalgam in the usual way, and then mix it with cement. Neither of these methods has given the writer any better results than the use of white cement alone, and the colour of these mixtures is about the same as an amalgam filling. In certain cases, however, there is great value in making a filling of cement and amalgam, and then covering the surface with the latter. The alloy is mixed with mercury in the usual way, and then part of it is incorporated with the cement during the mixing of the latter. About equal parts of amalgam and cement are used. This mixture is placed in the cavity, the amalgam that has been left over is pressed into the mix, and the surface completely and fairly thickly covered. This method effects the retention of a durable filling in a cavity in which it could be retained by no other means. The mixture adheres to the dentine with great tenacity, and the amalgam adheres to the mixture far better than to cement alone. This method was suggested and described by Mr. F. A. Bellamy.[1] Mr. Bellamy informed the writer that, although he usually presses the amalgam well into the mixture so as to secure its retention, he finds that in cases where it is necessary to simply lay the amalgam on as a veneer, the union is very good, and that, unless the filling has been strained by biting before it is set, the veneer will rarely break away.

Gold and Gutta-Percha.—A layer of gutta-percha may be placed at the cervical margin, and then the filling completed with gold. The writer has occasionally made use of this in cavities that were too far below the gum to admit of the use of the rubber dam until the filling was built up to the gum line. In some cases the result has been satisfactory, in others the gutta-percha has rotted; it is therefore only a method for occasional use: in all cases in which it would not spoil the appearance of the tooth, amalgam should be used in preference.

[1] *British Journal of Dental Science*, February 1887.

Gutta-Percha and White Cement.—This combination is useful in certain cases where a comparatively temporary filling is needed to preserve a tooth for a year or two as a preliminary treatment. It is principally useful in approximo-occlusal cavities in bicuspids and molars where the use of white cement is precluded owing to presence of moisture, and the rubber dam has to be dispensed with. The procedure is to fill up to the knuckle with gutta-percha, and complete with the cement. The better-wearing properties of the cement under mastication protect the gutta-percha, and prevent its being rapidly worn away.

Gold and Cement.—It is a common practice to protect a pulp by flooring a cavity with cement, and then, when it is hard, to complete with gold. With the exception of occlusal cavities in bicuspids and molars, there is usually no room for this in live teeth. In certain large occlusal cavities some operators partly fill with cement, and press pieces of gold into it before it is set; then, at the same sitting, as soon as it is set, condense the projecting pieces and utilise them as so many starting-points on which to build. Care must be taken to have sufficient depth of cavity to retain the gold filling, otherwise it may come out. The writer finds this procedure is more trouble than it is worth, and would prefer to floor the cavity in the usual way, and then insert the gold. Some operators use cement as a help in starting a gold filling. A small quantity is placed against one of the walls of the cavity, and a piece of gold—usually crystal gold—is pressed on to the cement. As soon as the cement is sufficiently set to hold the gold the filling is continued in the usual way. Others smear the entire cavity with cement and then proceed to line it with gold, taking care to press the gold so closely to the walls that only a thin cement lining exists between the gold and the walls of the cavity. By this means a gold basket is produced into which the rest of the filling is packed and condensed. The success of this method largely depends on squeezing the surplus cement out at the margins in such a manner that none of it oozes between the various pieces of gold and becomes mixed up with the surface of the gold basket. It is not easy to prevent this happening, particularly if the cement is mixed so thin that pressing the gold to place causes the cement to part with some of its liquid. It is quite possible for a piece of crystal gold to become saturated in this way. As a rule the retention of the gold filling will depend on the firmness with which it coheres or is attached to the gold basket, and if particles of cement or liquid interfere with this attachment the filling will probably come out during the trimming process or shortly afterwards, leaving the gold basket or lining in place. This difficulty is got rid of by adopting Mr. Madin's method.[1] This consists in placing the cement in the cavity and at once pressing in a piece of No. 30 gold-foil exactly as if making a matrix for an inlay. When the pieces of amadou that are used to press the gold to place are removed, a suitable burnisher is employed to produce close marginal adaptation and work the gold into the retaining angles or undercuts. Pressing the gold into these angles or undercuts generally causes it to split in places, but as nearly all the surplus cement has been squeezed out at the margins, the little that comes through these splits does not matter, and especially so as the cavity, although lined with gold, has a retentive form. Pieces of crystal gold are then packed in with hand-pressure and the filling completed either with crystal gold or foil. There is, however, no method of filling teeth with gold which does not present certain difficulties when applied to the various cases in the mouth. The overlap of the gold matrix obscures the margin of the cavity and

[1] *British Dental Journal*, Nov. 15, 1905.

renders it difficult to know when the right amount of gold is built up to and over this part. Also during the packing of the gold the matrix is apt to lift at one of the margins and the space to be filled up by a little more squeezing out of the cement. The overlap prevents this always being observed, and in any case the cement is becoming stiffer and may cake under the overlap of the gold; the result is that in certain cases a too broad line of cement is discovered when the filling is finished. This usually occurs at the labial margin if an approximal cavity in an upper incisor or canine is filled from the palatal side; or at the palatal margin, if the filling is made from the front, and an attempt to clear the margins by cutting away the overlap as soon as, or shortly after, the matrix is placed in position, usually seriously disturbs it.

There is no difficulty in using the Madin method if all the margins are easy to "get at," but unfortunately, for various reasons, it is practically impossible to prepare all cavities in such a manner that every part is readily accessible. It is easier to clear margins and secure fine margins in difficult places if the older method of packing the gold directly on to cement without an intervening matrix is resorted to; but as already mentioned this has some disadvantages which the matrix method does not possess. Skill and experience will overcome all difficulties, but the writer desires to point out that whatever advantages lining gold fillings with cement may possess, this does not provide "a royal road" to success. The writer sees no advantage in lining a gold filling with cement as far as its retention is concerned. If it is desired to use gold, and the form of the cavity is unfavourable for a gold filling, a gold inlay should be used in preference, but, providing the cavity will hold a gold filling, there are many cases where the manipulation of the gold is so cramped that its perfect adaptation is very doubtful, and in these cases it is certainly good practice to use a cement lining, not for purposes of retention, but simply to fill up spaces between the gold and the cavity walls which might otherwise exist. If the process of lining a gold filling with cement is satisfactorily carried out, and there is no visible line of cement at the margins, such a filling is better calculated to save a tooth than one which leaks. The production of gold fillings which do not leak greatly depends on every part of the cavity being easily accessible to mallet force, and it has just been mentioned that if freedom of manipulation is interfered with the accurate adaptation of the gold is rendered uncertain. These are the cases in which a cement lining can be employed to the best advantage. A thin layer of cement is friable when partially or completely set, therefore the gold should be condensed with hand-pressure until a sufficient quantity has been introduced to protect the cement from the shocks of mallet blows.

Separation of the Teeth.—In filling cavities on approximal surfaces, more especially if gold is to be used, it is necessary—particularly in the incisor and cuspid region—to press the teeth somewhat apart in order to obtain room to work, and to admit of the filling being properly contoured. To separate the incisors make what is known as a "tent" of cotton-wool, using a tough variety of absorbent wool. Roll the fine end very tightly, and force it between the teeth. Keep the fine end outwards, then pull it forward with either the fingers or pliers, until the thicker part is tightly wedged between the teeth; finally cut off the protruding cotton-wool, back and front, with scissors. The small scissors with short slightly curved blades, that are made for trimming the cervical margins of gold crowns, are very convenient for this purpose (Fig. 25). As a rule, the fingers are preferable to pliers for pulling the wool forward. With the latter too great pressure may result, and the teeth will become painful through too rapid movement. Manipulated with discretion, this method of using cotton-wool is convenient, answers all requirements, and rarely causes pain. If a wide separation is desired, this operation may

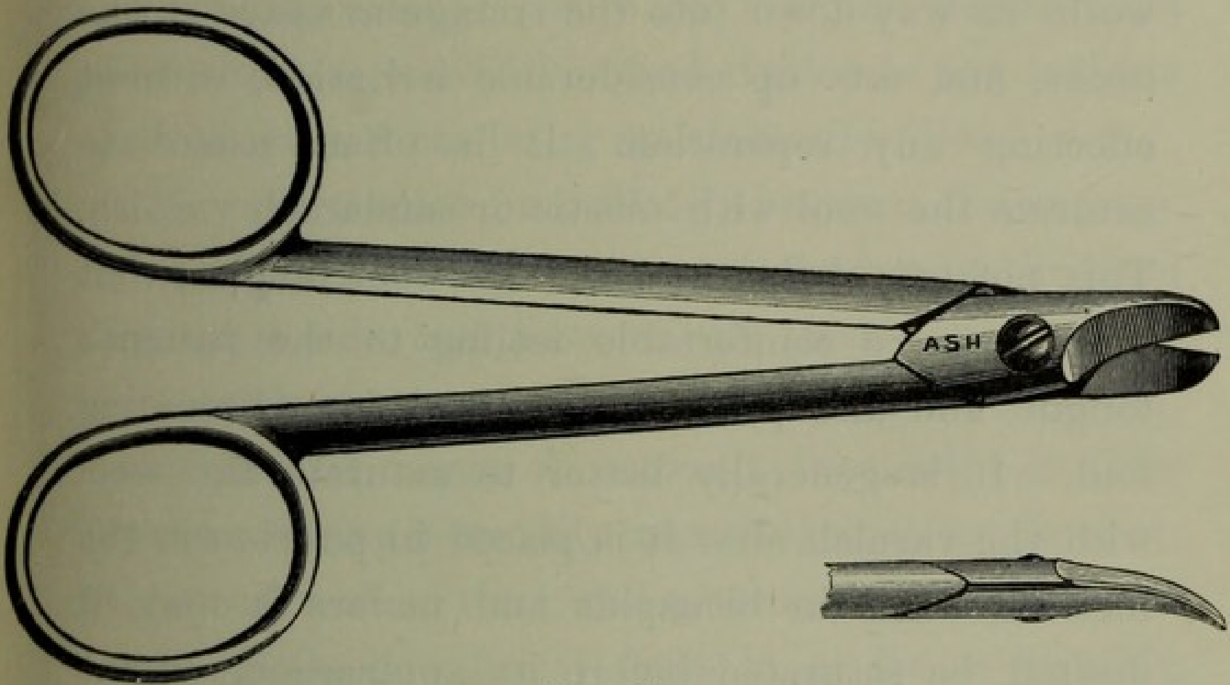


FIG. 25.

be repeated every two or three days until sufficient space has been secured. If the edges of the cavity are ragged and cut the wool, they may be smoothed by passing a fine saw between the teeth. If the teeth are so close together, and so firmly set in the alveolar process that it is impossible to pass the cotton-wool between them, a strip of rubber dam may be used instead, and on the following day the wool can be easily inserted.

In separating molars and bicuspids it is advisable to open, and, partly or wholly, prepare the cavities, and then to wedge one or more balls of cotton into them, and between the teeth. If the wool, instead of being packed into the cavities, is drawn between the teeth as in the incisors, it will be found that it works its way down into the triangular space at the necks, and sets up considerable irritation, without effecting any separation. It is often useful to saturate the wool with mastic or sandarach varnish. This not only helps to stick the wool in place, but gives a more comfortable feeling to the patient's tongue, and also prevents the wool from becoming foul. It is generally better to saturate the wool with the varnish after it is placed in position in the incisors, while in bicuspids and molars it may, if desired, be saturated before its application. Some dentists after partially or wholly preparing cavities in bicuspids and molars, fill them with a gutta-percha—such as the red base plate—which expands somewhat, and by wedging it between the teeth, obtain gradually and conveniently a wide space. The objection to this, speaking generally, is that it takes several months to produce the space, and patients are apt to forget all about it, and as long as they are comfortable, carefully avoid the dentist. Cases in which this method may be employed with advantage have already been mentioned. The Perry separators are very useful instruments for immediately securing space in many cases. Used on the incisors, they are rather in the way, and if the approximal cavities in bicuspids and molars are large, extending down to the cementum, and well cut away at the sides to secure free margins, the points of these instruments will extend right into the cavities, and prevent them being satisfactorily filled.

To secure space immediately between the incisors, first apply a strong solution of cocaine to the gum on either side, and between the teeth; then trim a long stick of orange-wood to a tapering round point; soap it, and insert it between the teeth at their necks, pressing it steadily in until the patient flinches; then wait a short time, and press in still further, and again stop; now firmly press in as far as possible, using considerable force. The object of using a long, and preferably a thick stick, is to admit of its being readily grasped in applying the pressure. Never hammer a wedge of wood between the incisors, the shock of the blow is most disagreeable.

Much greater space is usually needed for porcelain inlays than for any other method of filling teeth, and this can usually be obtained with cotton-wool, applied in the manner already described, and re-applied until the desired separation is effected.

CHAPTER V

PORCELAIN INLAYS

THE various porcelains that are used in dentistry differ considerably in their characteristics. A description of the manufacture of porcelains in general does not come within the scope of these notes. Suffice it to say, that many of the ingredients are natural products which vary somewhat according to the place or quarry from which they are obtained.

The difference between two or more porcelains largely depends on the proportions in which the several ingredients are mixed. Porcelain consists of an infusible substance—aluminium silicate—used in the form of "kaolin" or china clay, one or more ingredients which fuse at a high heat, and certain elements which increase the fusibility of the mass.

For practical purposes it may be said that porcelain consists of infusible particles which are bound together by the fusible elements; the result is a non-homogeneous and somewhat porous substance.

Glass consists of ingredients which are completely fused into a homogeneous and non-porous product. It is difficult to draw a strict line of demarcation between porcelain and glass. If the infusible aluminium silicate is absent, and a porcelain is considered to consist of an unfused element, bound together by fused substances, then the difference between porcelain and glass will be merely one of fusing point.

Certain experiments are now being made with the object of fusing aluminium silicate for a commercial purpose, and if these experiments result in the production of sufficient heat, then, indeed, any porcelain may be turned into a glass. The low-fusing porcelains are akin to glass, inasmuch as the infusible and high-fusing elements are reduced in quantity, and larger proportions of the bases which increase fusibility are added. It has been stated that if a high-fusing porcelain is fused and reduced to powder, and re-fused and again powdered, and this process is repeated a certain number of times, it becomes changed to a low-fusing porcelain.

The manufacturers of dental porcelains carefully guard their products as trade secrets, and it is not to be wondered at that the low-fusing dental porcelains were considered by many to be really glass and discredited accordingly.

The experience of those who used the old glass inlays was disappointing. This apparently non-porous substance discoloured badly in the mouth, while artificial teeth and inlays made of high-fusing porcelain perfectly retained their appearance. The strength of low-fusing porcelain was also questioned, because glass is much more easily fractured than porcelain. Some low-fusing porcelains—or so-called porcelains—were made which also discoloured in the mouth, and it was not until Dr. Jenkins produced his "Porcelain Enamel" that it was realised, after much doubting, that a low-fusing material could be satisfactorily used for making inlays. The Jenkins "Porcelain Enamel" should be strictly confined to this work and used for no other purpose. Porcelain contracts as the result of passing from the unfused to the fused state, and in all probability it still further contracts somewhat in cooling down after it is fused.

The majority of dental porcelains are in sufficient harmony as to whatever changes take place after fusion to enable one porcelain to be fused on to another one that has already been completely or partially fused. This enables an inlay to be made by using materials which fuse at different temperatures. This is to say, that what is known as a foundation body may be used as a base, on to this a porcelain which fuses at less heat may be placed and fused, and finally a still lower fusing porcelain may be applied to complete the work. Also the majority of dental porcelains may be safely fused on to artificial teeth. But this does not apply to the Jenkins "Porcelain Enamel," which appears to behave after fusion in a manner peculiar to itself. This is to say, that if it is fused on to another kind of porcelain, or if it is fused on to an artificial tooth, either the "Porcelain Enamel" or the other porcelain will crack during the cooling down process. This is no doubt due to the Jenkins inlay material contracting or changing its form in a different way or at a different pace to the other porcelains. This does not detract from the value of the "Porcelain Enamel" if it is strictly confined to the purpose for which it was produced, viz., the making of inlays, and no other porcelain is used in connection with it.

The writer also considers there is considerable risk in embedding platinum pins in this material, and if one or more platinum pins are necessary for retaining an inlay in the cavity, it is better for a high-fusing porcelain to be employed. As far as inlays in particular are concerned, the Jenkins "Porcelain Enamel" has stood the test of time, and proved to be satisfactory, but as far as the dental uses of porcelain in general are concerned, the higher-fusing materials have a wider range of application.

Much controversy has taken place respecting the merits and demerits of the various kinds of dental porcelain, and many of these discussions would lead one to suppose that a high-fusing point is synonymous with excellence, and that the quality of the material may be judged by the amount of heat necessary to fuse it. This is not, however, borne out by experience or by the tests which have been made. English artificial teeth are considered to be stronger than American teeth. The English teeth fuse at about 2000° F., and the American at not less than about 2400° F. The tests made by Dr. le Cron show that the Jenkins inlay porcelain fuses at 1588° F., and its crushing strength is 28·305 lbs. per square inch, while the inlay porcelain made by one of the leading American manufacturers, fuses at 2138° F., and its crushing strength is 15·080 lbs. per square inch. This proves that a porcelain is not necessarily strong because it fuses at a comparatively high heat and *vice versâ*. Porcelain has no exact fusing point. That is to say, the temperature at which it fuses varies according to the length of time it is subjected to the heat. A porcelain which fuses at a certain temperature in two minutes will fuse at a lower heat in a quarter of an hour. It has been stated that a high-fusing dental porcelain can be fused at the heat to which a low-fusing porcelain is usually subjected, providing the high-fusing material is kept at this temperature for a sufficiently long time. The best results are attained with a reasonably slow fusion, and, to use a homely simile, porcelain should be slowly baked or roasted rather than rapidly grilled. But a prolonged fusion of such small work as inlays is impracticable as far as the everyday work of a dentist is concerned, and in all ordinary cases few will care to spend more than from two to five minutes on each bake. The application of the heat will also make a difference. Starting with the furnace cold or at a low heat, and increasing the heat until the proper amount of fusion is arrived at, is not quite the same as placing the work in a furnace that is already heated up to a scheduled fusing point. Tests as to fusing points and strength of porcelain will always vary unless the conditions are exactly the same, both in respect to method of fusing and application of force. The strength of the porcelain will vary according to the rate at which it is fused, and its resistance to crushing force will depend on the evenness of the pressure, the rate at which it is applied, and the relationship which exists between the size of the crushing block or plunger and the surface of the porcelain to which it is applied. Also it has been stated that different batches of the same porcelain may vary somewhat, inasmuch as the material taken from one part of a quarry is not always identical with that taken from another part. Therefore tests made by different men are very likely to give different results unless every condition connected with the tests is exactly the same. This doubtless accounts for the difference between Dr. Jenkins' tables and Dr. le Cron's.

A most instructive and interesting paper by Dr. Joseph Head appeared in the *Dental Cosmos*, February 1906, entitled "The Strength of Porcelain when used as a Tip or Corner." The following extracts are taken from it:—

"Dr. Jenkins' tests (*Cosmos*, May 1902, p. 458) proved that pieces of porcelain 1 centimetre square by 2·3 millimetres deep can stand a steady pressure of from one-quarter of a ton for the Whiteley, to a ton for the Jenkins, the other makes falling somewhere within the intervening quarters of a ton. Dr. Jenkins tells us the German laboratory in which these results were obtained and how long it took to make them, but does not tell us how they were made. But I feel that these large figures could only have been obtained under the most perfect conditions, where there was pure compression without the slightest complications of percussion or shear. However, if we approximate these conditions to the mouth, most of us would be satisfied with the Whiteley quarter of a ton resistance, as it is not likely that the human jaw would care to tax itself more than that. So much for steady compression. On this point all porcelains are able to take care of themselves. We must, then, look to shear and percussion for its weak points."

The porcelains tested for shearing strength by Dr. Head gave the following results: The Jenkins inlay material obtained in 1900 stood an average of 26 lbs.; the latest Jenkins inlay material improved, averaged 15 lbs.; the averages of the Whiteley, the Brewster, and the S. S. White's were 21 lbs. for the Whiteley, 19 lbs. for the Brewster, and 26 lbs. for the S. S. White's. "It will be noted that the Jenkins improved material has much less shearing strength than the older material, which is probably due to the fact that Dr. Jenkins has used materials that make it a better filling material, although it cannot stand so great a strain—which is quite possible, as it will be shown that the real danger comes from percussion."

The percussion tests made by Dr. Head showed that the Jenkins material (the older make) broke at an average of 6 oz. The average of the others was: The Jenkins new inlay material 8 oz., the Brewster 5·5 oz., the Whiteley 8 oz., the S. S. White 6 oz. Bars from an old S. S. White's tooth broke at 5·5 oz. In summing up Dr. Head said: "I do not care at this time to make any deductions from these figures, but it is interesting to note that in general the porcelain that stood the least steady shearing force has the greatest percussive strength." Some other experiments were mentioned showing that if the ends of the bars of porcelain that were placed in the cavity or hole in the block were surrounded with rubber dam instead of cement, they broke at from 14 to 16 oz., "showing that with percussive blows the spring of the peridental membrane makes an increased percentage in the force required of about two hundred per cent."

"These facts seem to point to the following conclusions: Any of the standard porcelains in the market are strong enough if they do not receive the full force of mastication, and none of them are strong enough if they do. So the question resolves itself into which porcelain has the best colours, and which is most easily manipulated."

In the discussion which followed the reading of Dr. Head's paper, Dr. Black pointed out that little is known about the stress of blows. He said: "While the ounces which the essayist has given this evening seemed very small, I take it that when he gets at the actual force of his blow he will find it was not small, and that the porcelain stood an equal stress with the one method of using force that it did with the other. A three-ounce weight falling three feet, striking upon an anvil, will give a stress of nearly six hundred pounds. That is a matter of actual measurement." The writer gathers from the above that there is little or no practical difference between the strength of any of the standard porcelains that are used for inlay work, be they high-fusing or be they low-fusing. The by no means infrequent fractures of porcelain teeth on crowns, bridges, and dentures show that when a corner or a cutting edge is restored with a porcelain inlay, the tip should be as thick and as rounded as the circumstances of the case admit of.

In the article on "Porcelain Enamel"[1] Dr. Jenkins says: "In platinum matrices formed on a die that they might be identical, one centimetre square and two and three-tenths millimetres deep, specimens of six high-fusing bodies were fused, by Dr. W. A. Spring of Dresden, who is well known as an expert in high-fusing work. These specimens, together with six similar blocks of porcelain enamel,

[1] *Dental Cosmos*, May 1902.

were sent to Professor Kayser, the distinguished head of the Royal Saxon Institute of Building Technology, to be tested for specific gravity, for resistance to pressure, and for toughness—if, indeed, so brittle a material as porcelain can be said to possess this last quality. The tests occupied ten days' time, extending from January 20 to February 1, 1902. The following is a translation of the official report:—

"RESULTS OBTAINED FROM THE EXAMINATION OF DIVERS PORCELAIN SPECIMENS, AS TO THEIR SPECIFIC GRAVITY, RESISTANCE TO PRESSURE, AND DEGREE OF BRITTLENESS.

(*a*) *Specific Gravity.*

(1)	The brand "Close"	2·223
(2)	" " "Close-Whiteley"	2·249
(3)	" " "Whiteley inlay"	2·225
(4)	" " "Whiteley special"	2·171
(5)	" " "Consolidated inlay"	2·267
(6)	" " "Consolidated continuous-gum"	2·132
(7)	" " "Jenkins porcelain enamel"	2·332

(*b*) *Resistance to Pressure.*

		Kilograms
(1)	The brand "Close": average from two experiments	712·5
(2)	" " "Close Whiteley"	225·0
(3)	" " "Whiteley inlay"	430·0
(4)	" " "Whiteley special": average from two experiments	787·5
(5)	" " "Consolidated inlay": average from two experiments	460·0
(6)	" " "Consolidated continuous-gum"	520·0
(7)	" " "Jenkins porcelain enamel"	924·0

(*c*) *Degree of Brittleness.*

If we consider No. VII. as representing the highest degree of brittleness, and No. I. the lowest, the order of the various brands will be as follows :—

VII.	The brand	"Close-Whiteley."
VI.	" "	"Whiteley inlay."
V.	" "	"Consolidated inlay."
IV.	" "	"Consolidated continuous-gum."
III.	" "	"Close."
II.	" "	"Whiteley special."
I.	" "	"Jenkins porcelain enamel."

(Journ. No. 4251 & 66.) (Signed) PROF. KAYSER.
Royal Saxon Institute of Building Technology—
Testing Department for Materials.
DRESDEN, *February* 3, 1902."

Dr. D. O. M. Le Cron's tests are as follows :—

	Fusing temperature.	Percentages of shrinkage.	Crushing strength, lbs. per. sq. in.
Allen's foundation . . .	2340° F.	22½	26·950
Close's foundation . . .	2288° F.	21¾	45·640
Consolidated Dental Manufacturing Company's foundation	2200° F.	21½	30·390
S. S. White's high-fusing inlay	2254° F.	23½	32·205
Brewster's foundation . .	2218° F.	23¾	20·320
Consolidated inlay . . .	2138° F.	31	15·080
Whiteley's	2138° F.	31	16·000
Brewster's enamel . . .	2084° F.	33	22·990
Ash's high-fusing	2012° F.	33¾	22·810
Jenkins'	1580° F.	38¼	28·305

The tests made by Dr. W. A. Capon as to the fusing points of various dental porcelains were carried out under the following conditions:—

"By repeated experiment I have learned that the fusion in all cases was accomplished at a relatively low heat by giving a long exposure. I, therefore, for the purposes of practical work and to secure a uniform standard of comparison, decided to raise the temperature on each material to such a degree as to admit the use of a uniform time limit of two minutes and adopt as a standard a temperature which, continued during the stipulated time, should fuse the material under test.

"The method of preparing the test-pieces was to mix the powder with water to a stiff, creamy consistency; the mass was then spread to a thickness of about thirty-five seconds of an inch and the excess of moisture absorbed with blotting paper. The edges were then trimmed so that the test pieces were of uniform size of three-eighths of an inch square by thirty-five seconds of an inch thick. Each test piece in succession was then allowed to remain on the furnace platform until dried out, after which it was placed in the furnace under full temperature.

"In opening the furnace door to introduce the test the heat naturally drops a number of degrees, therefore the time record was not taken until the door was closed and the temperature again raised to the full heat the furnace was gauged to develop for the special test in hand.

"Pyrometer tests, November 24, 1902, to determine the fusion-point of porcelain inlay materials, also tooth bodies herein enumerated, are as follows:—

	Temperature.
Downie's	1544
Jenkins'	1544
Ash's low-fusing	1544
Ash's high-fusing	1904

	Temperature.
Moffitt's porcelain	2047
Brewster's enamel	2084
Consolidated high-fusing	2192
Brewster's foundation body	2210
Whiteley's porcelain	2210
Close's foundation body	2300
White's porcelain (inlay)	2300
Parker's body	2586
Ash & Sons' tooth body	2264
Century tooth body	2624
Sibley's tooth body	2408
Dental Protective tooth body	2440
Justi's tooth body	2440
S. S. White's tooth body	2516
Johnson & Lund's tooth body	2586
Luken's tooth body	2606
Consolidated Dental Manufacturing Company's tooth body	2624

"For three reasons these temperatures can be accepted as being absolutely correct, for every detail was given the most minute attention. First, the voltage was controlled to 110 without deviation. Secondly, these figures represent several trials of the same material, and thirdly, the watch was assisted by the eye, which is the only sure way of knowing when porcelain is properly fused."

The porcelain made by the Dental Manufacturing Company, Ltd., London, fuses as follows: The foundation body 2300° F.; the high-fusing 2150° F.; the medium-fusing 2000° F.; the low-fusing, which may also be used for the final baking, 1600° F. The temperature tests made by Dr. Le Cron and

Dr. Capon are sufficiently in accordance—in the majority of instances—to serve as an excellent guide to porcelain workers. But as the conditions of fusing in respect to time and application of heat will vary according to the ideas or requirements of different dentists, as furnaces vary in their size and in the rate at which they heat up, and as different batches of the same material are not always exactly alike, it behoves every one who desires to obtain the best results to make tests for himself, and also to check or test every fresh batch of the material supplied to him, unless he confines himself to a low-fusing porcelain, the fusion of which can be readily observed by the naked eye. A pyrometer will show the heat of the furnace and enable this to be regulated with sufficient exactness, but as time and heat must both be considered a combined time and temperature table is necessary. There is no necessity to use a pyrometer with a porcelain that fuses sufficiently below the melting point of pure gold to enable it to be used with a gold matrix (the melting point of fine gold is 1980° F., and precipitate of gold melts at 1600° F.). The fusion can be observed with the eye and timed with the second hand of a watch sufficiently well to obviate the necessity of continually staring into the furnace. The strength of the electric current varies, however, at different times in accordance with the requirements of its users. In the daytime, when the electric light is not needed, it is weaker than in the evenings. In the winter the current is increased earlier than in the summer. At a certain time of night, when most of the shops are closed, it is reduced. These and other variations in the electric current render it impossible to rely entirely on a watch, and therefore the watch must be considered as an assistant and the eye as the overseer who is responsible for the quality of the work.

Some automatic or so-called pyrometer furnaces have been invented in which the melting of a metal breaks the current, and this is supposed to occur just at the right time to produce the desired degree of fusion. The successful application of this method entirely depends on the use of a metal, or an alloy of metals, which melts at the same rate as the porcelain, no matter whether the electric current be strong and the heat runs up rapidly, or whether it be weak and the heat runs up slowly. The writer does not know if this has been successfully worked out. He tried one of these automatic furnaces with disappointing results. A good substantially made electric furnace in which any of the dental porcelains in the market can be fused, will prove more satisfactory, and in the long run more economical—even to one who confines himself to a low-fusing porcelain—than a cheaper and less substantial make which frequently burns out and has to be continually repaired. The electric furnace is the most popular, the most convenient, and, all things considered, the best furnace for fusing the dental porcelains, but no one need hesitate to take up porcelain inlay work because he practises in a place that is not supplied with the electric current. Gas, gasoline, and alcohol furnaces are procurable, and the Jenkins "Porcelain Enamel" can be fused in the flame of a small spirit-lamp.

Preparation of Cavities.—If the cavity is on the approximal side of a tooth sufficient space must be obtained by pressure to allow the matrix or impression to be withdrawn without distortion, and also to enable the inlay to be easily and quickly placed in position. The cavity must be formed in such a manner that the matrix or impression can be withdrawn without changing its shape. The margins should be cleanly cut and as smooth as possible, and they must not be bevelled at a different angle to the walls. That is to say, that although a general outward slope of the walls is admissible and necessary in the majority of cases, the slope or bevel should be one in which both the dentine and the enamel are on the same plane. If the enamel margin is bevelled at a different angle to the dentine, the margin of the inlay is weakened. It may break as the result of the force of mastication, or even during the setting of the inlay. It is practically impossible to "dead centre" an inlay at once, and even if this were possible it would not be desirable. During the placing of the inlay in position a certain amount of rocking movement is advisable in order to squeeze out as much of the surplus cement as possible. During this movement one edge of the inlay may bear on the margin of the cavity sufficiently to break or chip the porcelain if a bevelled cavity margin, and the consequent over-lapping edge of porcelain exists. Fig. 26*a* shows the correct marginal form; Fig. 26*b* the incorrect form.

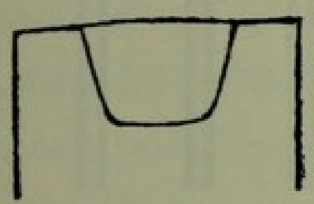


FIG. 26*a*.

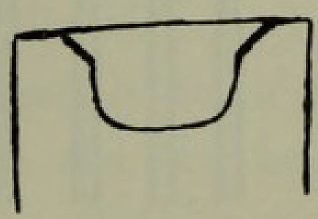


FIG. 26*b*.

In order to shape the walls of the cavity with the greatest ease and accuracy it is advisable to use engine burs with straight sides, such as fissure burs. Special forms of burs have been made for this purpose (Figs. 27, 28), the principal advantage of which consists in the manner in which the blades are cut. The ordinary fissure bur or the cross-cut fissure bur cuts with reasonable rapidity,

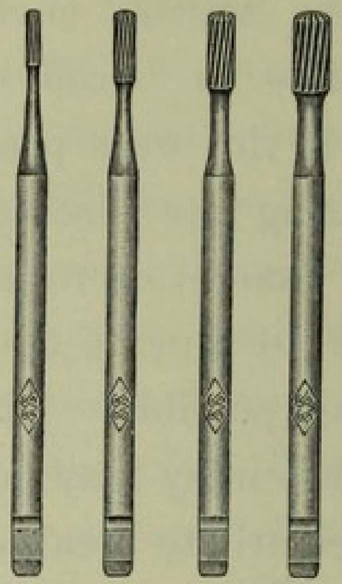


FIG. 27.

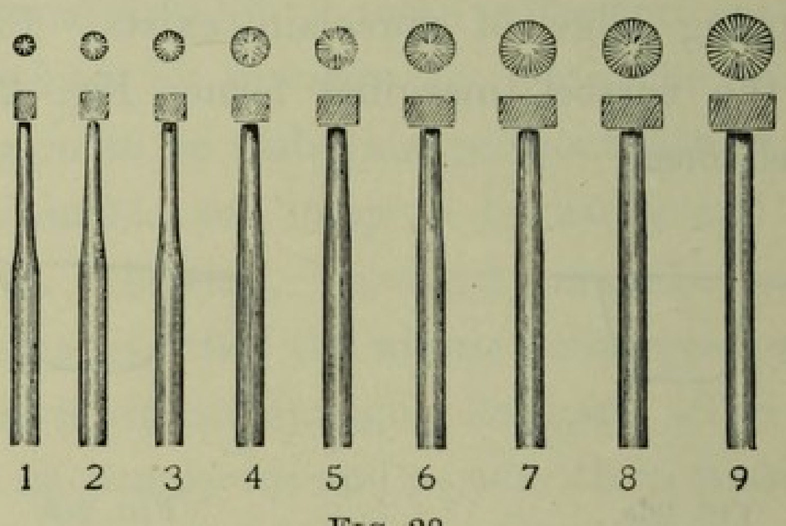


FIG. 28.

but leaves the margins of the cavity too rough. The fine cut or plug finishing fissure bur, or a diamond bur of similar shape will correct this; but the special inlay burs cut with a combination of rapidity and smoothness which is in many cases desirable. Arkansas stones mounted for use in the dental engine (Fig. 29) will produce the smoothest margin, providing they are used carefully and with an understanding that a rounded margin is undesirable.

Cavities that are sufficiently surrounded with walls to be described as round or oblong holes should be given a cup-like form. All undercuts or sharp angles should be obliterated either by cutting

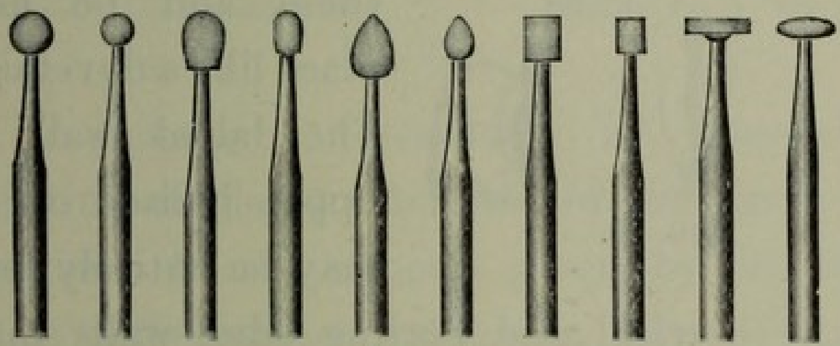


FIG. 29.

them out or filling them up with cement. The outward slope given to the walls will depend on the case, but shallow cavities usually demand the slightest possible outward slope and the broadest possible base. In any case, a distinct saucer-shaped cavity should be avoided. When one or more walls of a cavity are of such little height that they are of little or no value in retaining the inlay, or when one or more walls have been cut away, an undercut may be made without interfering with the withdrawal of the matrix or the placing of the inlay, and this may enable the inlay to be retained in place. As a general rule, where one part of the cavity is undercut, the opposite wall should be given a sufficiently compensating outward slope to enable the matrix to slide out and the inlay to slide in (Fig. 30). The complete removal of one wall may enable two opposite walls to be undercut in such a way that the inlay will slide between them and be held in place like a dovetail joint. The labial wall of an upper incisor or canine may be entirely removed and the cervical and cutting edge walls made to slope slightly from the lingual to the labial side. If these walls are then distinctly grooved or undercut, a dovetail is produced.

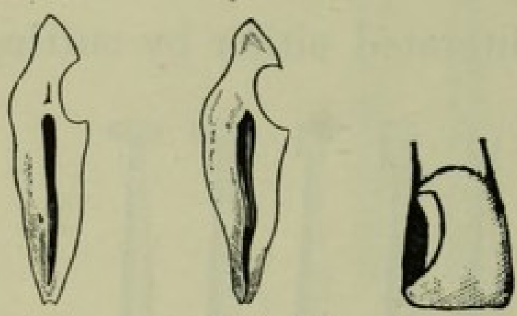


Fig. 30.

The cases in which this method can be properly carried out are comparatively few. As a rule, the tooth is decayed in such a manner that it is impracticable, or else the cavity is so small that one is hardly justified in cutting away as much of the tooth as the dovetail method demands. Also it is a very difficult method, because the proximity of the pulp usually necessitates narrow grooves or undercuts in preference to broad semicircular ones;

and to make an inlay that will fit accurately into a fast-holding dovetailed cavity of this description is an intricate proceeding.

When the corner of an incisor or canine has broken away, or when the near approach of the

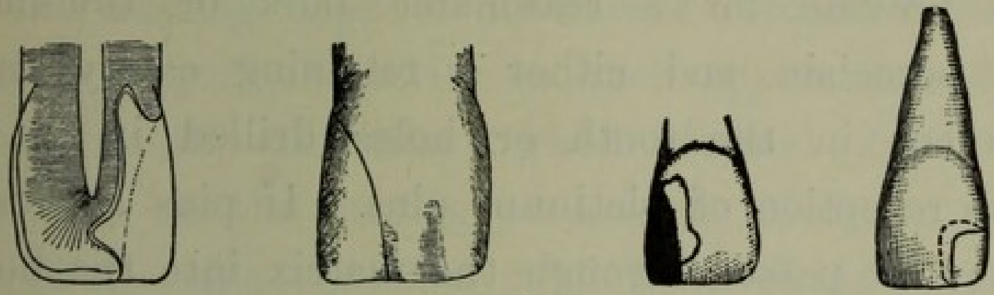


FIG. 31.

decay to this part necessitates its removal, an undercutting of the cervical part of the cavity may —in addition to the support given by the lateral walls—be sufficient to retain the inlay (Fig. 31). But if this is insufficient, a step extension may be made by removing the cutting edge horizontally in the direction of the opposite side of the tooth, and if this step extension is curved cervicalwards (Fig. 32*a*) an adequate retention will be produced. It may be found desirable to cut into the extension in such a way that the palatal side of the inlay appears as in Fig. 32*b*. This provides increased bulk of porcelain and adds to the strength of the tip.

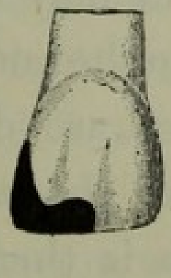


FIG. 32*a*.

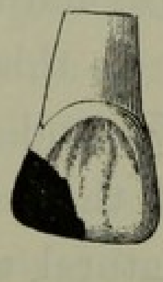


FIG. 32*b*.

The restoration of the whole or part of a cutting edge is rendered more difficult if this is necessitated by the fracture of a sound tooth or is caused by a more or less superficial decay. In these cases the cutting edge must be removed sufficiently to provide for a reasonable bulk or thickness of porcelain, and either a retaining cavity must be cut in the tooth or holes drilled in it for the reception of platinum pins. If pins are used they are passed through the matrix into the holes in the tooth; the ends which project into the matrix are attached to it with wax; the pins and matrix are withdrawn together and invested. The wax is removed and the porcelain placed around the pins and built up to the proper form. If desired, a pin may be bent to the shape of a staple and the loop-like end embedded in the porcelain. If the case admits of it an artificial tooth of suitable size and colour may be fitted and ground to shape.

In this case the end of the natural tooth is ground flat and holes are drilled in it for the reception of the pins of the artificial one. The end of the natural tooth is then ground to accurately fit the back or pin side of the artificial one. When a close joint is obtained, the superfluous part of the artificial tooth is ground away until a properly shaped tip is produced. The ground surfaces of the porcelain are then smoothed and polished, and the tip is cemented to place.

Some very extensive and complicated inlay restorations have been described and illustrated in the dental journals, such as the restoration of the whole of the cutting edge of an incisor combined with a large approximal cavity on each approximal side of the tooth, also inlays which depend for their retention on the cutting of a series of steps, and which necessitate such a cutting up of the tooth-structure that one wonders how this can be successfully done without exposing the pulp. These are interesting as showing what may be possible of accomplishment, but whether this difficult and extensive work is preferable to entire crowns is something that must be left to the judgment of the individual dentist.

The Matrix or Impression.—Matrices or impressions are formed with gold foil or platinum foil, but gold can only be used in connection with a low-fusing porcelain. If gold is selected, No. 30 is the thickness usually employed. No. 60 can be used in many cases with advantage, and when it is difficult or impossible to obtain a good matrix owing to the splitting of a thinner foil, No. 120 may often be used with success. Placing the foil between two sheets of dry goldbeaters' skin, or between

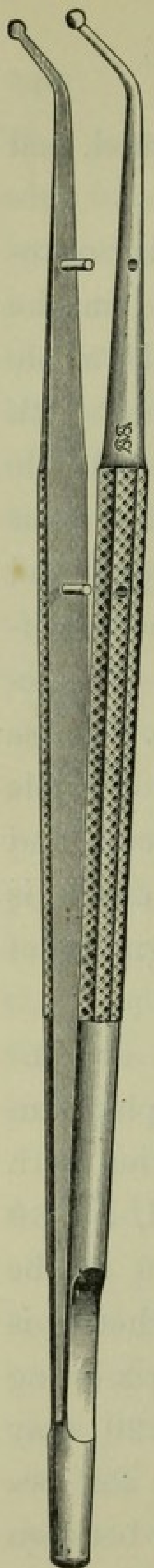


FIG. 33.

two pieces of thin wet silk, reduces the tendency of thin foil to split. The foil covered by the protecting medium is adapted and removed from the cavity. The goldbeaters' skin or the silk is then carefully removed so as not to materially change the shape of the matrix, which is then reapplied and more accurately adapted.

The beaten gold foil is more adaptable than the rolled gold. If desired, No. 60 can be produced by folding No. 30 once on itself; and No. 120 by folding No. 30 twice on itself. If this be done, the gold should be annealed and the layers made to cohere by firm pressure. A second annealing is then necessary in order to restore the softness of the gold. The thickness of the platinum that is usually used for making matrices is $\frac{1}{1000}$ of an inch. A piece of the foil, considerably larger than the orifice of the cavity, is placed over the cavity and gently pressed in with small pieces of amadou or balls of cotton-wool held in fine tweezers or foil-carriers. A special form of ball-ended foil-carrier has been devised for this purpose (Fig. 33). Amadou is usually applied dry and cotton-wool is wetted. More pieces of amadou or cotton-wool are then pressed in until the cavity is full. The overlap of the foil is then pressed closely to the side of the tooth with wool or amadou, or a strip of rubber dam, or a piece of silk ribbon may be used for this purpose. The amadou or wool is removed from the cavity, and the matrix is then more accurately adapted with a burnisher, bestowing great care on the margins.

It has already been said that the margins of the cavity should previously have been given a clean-cut smoothness, and the foil, if properly adapted, will present an equally fine, smooth, and clearly defined edge. A thick foil, such as No. 120, may often be adapted by the burnisher alone. If this method is adopted a ball-ended burnisher is applied to the margin with a circular or all-round movement, gradually sweeping round lower and lower until the bottom of the cavity is arrived at. Some dentists adapt the $\frac{1}{1000}$ of an inch thick platinum in this way, but, as a rule, less splitting of a foil of this thickness will take place if the adaptation is first made with amadou or cotton-wool, and the burnisher is used to complete the operation. The extent to which the burnisher should be used will greatly depend on the thickness of the foil. It requires some practice, and what may be called a tactful manipulation, in order to employ the burnisher to the best advantage. Too much force or manipulation stiffens the foil and makes it lift or leave the margins, and when once this lifting takes place no amount of subsequent manipulation will correct this until the stiffness or spring is removed from the metal by annealing it. This necessitates the withdrawal and re-application of the matrix. The annealing of a gold matrix is best effected by placing it on a sheet of mica or platinum, and holding it over the flame of a spirit lamp. A platinum matrix is best annealed in a hot electric furnace, but holding it in the flame of a spirit lamp will answer the purpose. In finally burnishing the margins, the matrix may be held in place—to prevent rocking—by means of a strip of rubber dam tightly stretched over the side of the tooth, or a piece of wet silk ribbon may be used. It is necessary, however, to clearly see the margins in order to secure the best adaptation, and a little further burnishing will usually be needed after the strip of rubber dam or the silk ribbon is removed. A little splitting of the matrix does not matter unless a split extends to the margin, or unless the foil is so damaged that it cannot be withdrawn without changing its shape. When the adaptation is satisfactory, any overlap which would interfere with the removal of the matrix is cut away, taking care to always leave a little overlap. The matrix is then loosened and carefully teased out of the cavity by gently pressing on the overlap in the direction of the cavity. A sharp probe, a small excavator, or the points of a pair of ordinary foil carriers may be used for this purpose. If the matrix does not come readily away from between the teeth —which may often occur unless the separation is very wide—much patience and gentle manipulation are necessary before the matrix finds the line of least resistance, and can be made to "walk out" from between the teeth without distortion. No force or traction should be used, and if the matrix cannot be removed without this it should be discarded, and the teeth more widely separated, or the cavity more freely opened up. Some operators fill the matrix with wax in order to prevent change of form during removal from the cavity. A specially prepared gum camphor is also used for this purpose, as ordinary camphor crumbles too much when pressed to place. Camphor is preferred to wax because it can be blazed off without leaving any residue, and it is stated that it swages a thin gold matrix to a more perfected fit.

In cases where much patience and careful manipulation are necessary in order to remove a matrix without distorting it, the writer finds that the surface of the wax comes into contact with the adjacent

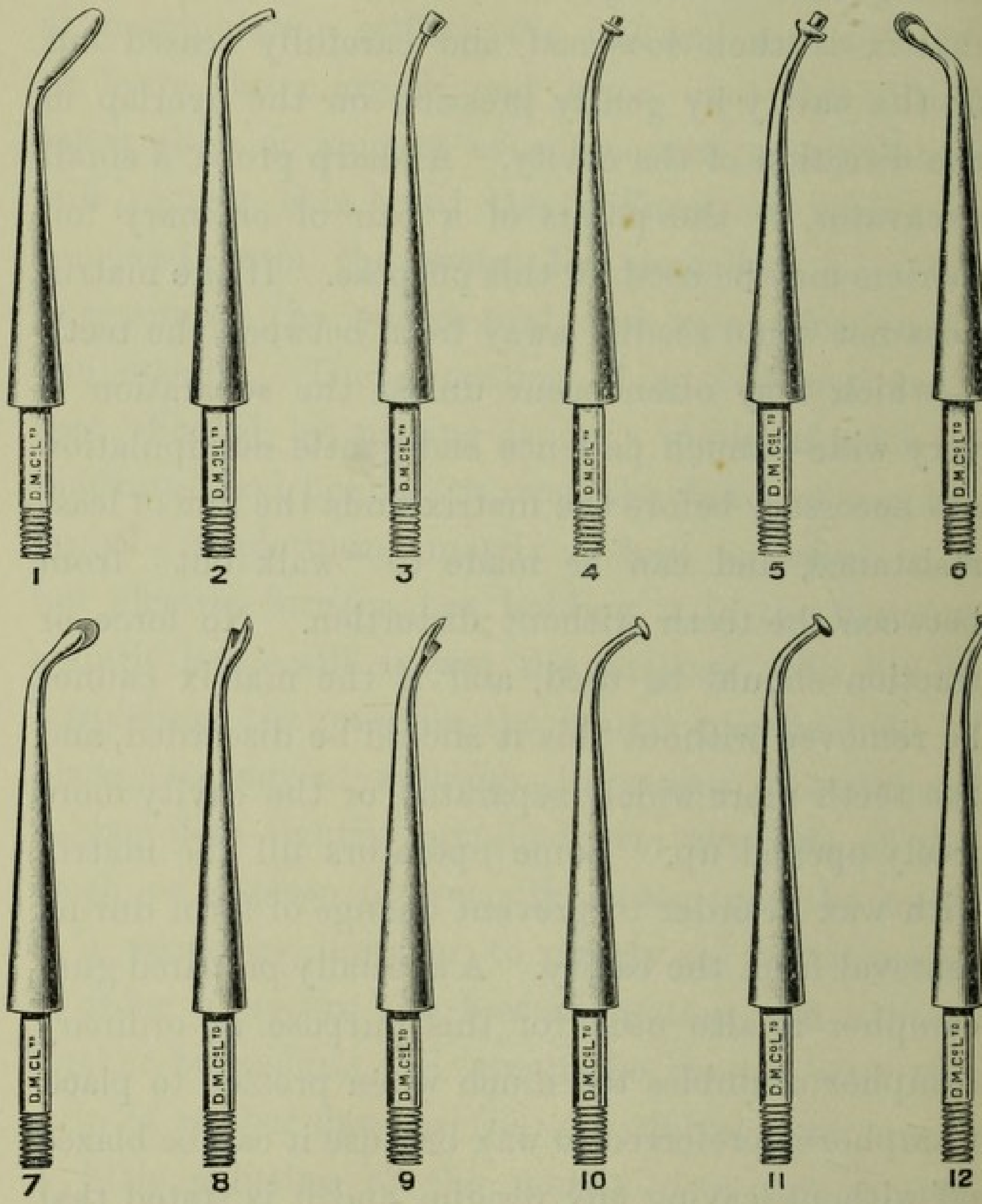


Fig. 34.

tooth and interferes with the removal. When the cervical margin is close to or below the gum, there may be difficulty in passing the foil sufficiently beyond this margin to prevent the edge being drawn into the cavity. A thick foil can be passed between the gum and the margin of the cavity more easily than a thin one. In some cases merely bending the edge of the foil at a right angle will enable it to be carried beyond the margin with a piece of amadou or cotton-wool. In others the edge of the foil may be folded over a piece of floss silk, and carried to place and held in position by means of the silk string. A piece of wire may sometimes be used to better advantage than the string. When the foil is worked into the cavity the string or wire is withdrawn.

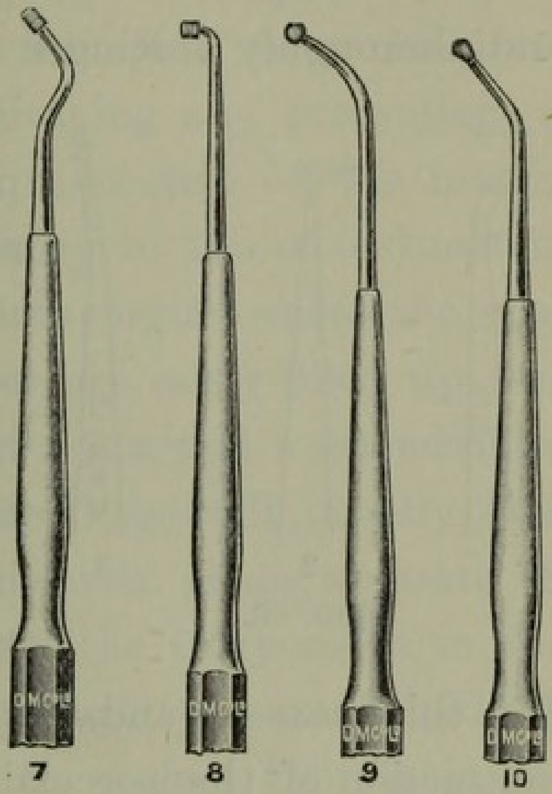


FIG. 35.

Special forms of burnishers have been devised such as the Le Cron burnishers (Fig. 34) and the Pearsall rotary burnishers (Fig. 35). A small and useful set consists of a small ball-ended burnisher, a thin flat one, and the Jenkins model burnisher for cervical margins (Fig. 36). The only advantage that can be claimed for a gold matrix is that it is somewhat easier to adapt than platinum, but, thanks to the soft platinum that is now supplied, there is, as a rule, no great difficulty in obtaining excellent matrices with platinum. Platinum is made as soft as possible by covering it up with unslaked lime and thoroughly heating it in an electric furnace or in the flame of a blow-pipe. Platinum produces a stiffer or more rigid matrix than gold. In cases of difficult removal it is not so likely to be distorted as gold. It can be handled afterwards with less fear of damaging it. For this reason, and also because it resists the contraction of the porcelain better than gold does, it is usually used without an investment, whereas gold is generally invested. Platinum-gold is also used for making matrices, but does not appear to possess any advantage over the soft platinum that is now procurable.

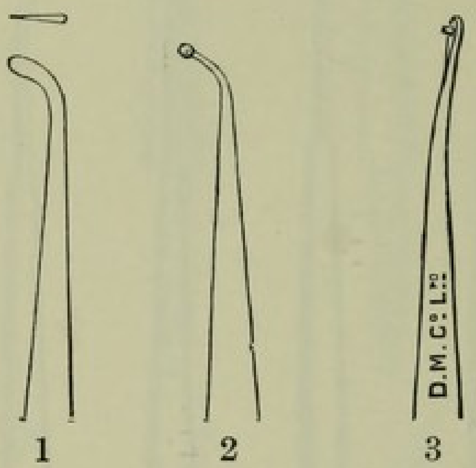


Fig. 36.

Some dentists, instead of taking precautions to prevent the matrix changing its shape during the fusion of the porcelain, prefer to replace the matrix in the cavity after each fusion and re-burnish it to place until it becomes so stiffened or strengthened by the porcelain that it cannot change its form. In addition to this, it may also be replaced as often as necessary during the building up of the contour in order that this may be effected with the greatest exactness. A method which the writer has found useful is to make two matrices, fuse the inlay in one of them without taking any precautions to prevent change of form, then strip off the matrix, and carefully place the inlay in the second matrix. There will be places at the margins where the inlay does not fit; these spaces are easily filled up with a very thin mix of the porcelain, and a second filling up to compensate for shrinkage will usually complete the work. If the matrix is an accurate representation of the cavity, the inlay made in this way will assuredly fit, because the small addition of porcelain necessary to perfect the fit in the second matrix will not in any way cause it to warp. If the second matrix is invested, the inlay can be safely pressed into it, but this may not be necessary, and if the first matrix is invested, the porcelain may be tightly packed in and the number of fusions reduced. It is inadvisable to bring the inlay to the complete state of fusion until it is placed in the second matrix, but it must not be much underfused.

A small point that may as well be mentioned here as in any other place, is that if an inlay is dropped on the floor as soon as it is removed from the furnace and comes up with a blackened surface that cannot be scraped or brushed off, it need not be thrown away. If it is placed back in the furnace the heat will burn it clean.

An impression may be taken of a cavity with some suitable modelling composition such as "dental lac" or "perfection impression material." The matrix is then adapted to a model usually made with a fusible metal, with Spence metal, with amalgam, or with oxyphosphate of zinc. In using a fusible metal, or the Spence metal, care must be taken to pour the melted material at the lowest possible heat consistent with sufficient flow to produce a good cast. An error of judgment as to this may spoil the work, and amalgam or oxyphosphate of zinc is preferable. Copper amalgam is perhaps the best amalgam for this purpose, but it takes a long time to set, and if time presses oxyphosphate of zinc is more desirable. Models made with oxyphosphate of zinc may shrink if they are kept perfectly dry. This can be avoided by allowing them to absorb a little moisture. The matrix is adapted to the model either by the method employed in the mouth, or one of the small swaging machines may be used.

Individual experience disposes some dentists to use the impression method in nearly all cases. It is difficult, however, to remove an impression material from an approximal cavity without distorting it. The thickness of the overlap interferes with the withdrawal to a greater extent than the thin overlap of a gold or platinum matrix. In addition to this, one always knows if a foil matrix comes away in perfect shape, whereas it is often impossible to know if an impression made with a modelling compound is accurate or not until the inlay is made and tried in. In cavities other than approximal ones, or when there is a very large space between the teeth, there is no difficulty in obtaining a good impression.

Mr. Frederick Rose of Liverpool takes two or more impressions of a cavity with "dental lac." In one he makes a model with copper amalgam, in the others with a mixture composed of ten parts plaster of Paris, six parts powdered pumice, and four parts powdered silex. When the models are set the dental lac is removed with hot water. The models made with the investment material are filled about one-third full of Jenkins "Porcelain Enamel," and this is fused in the model. Another portion of the porcelain is then added and fused, and this is repeated until the inlay is completed. The model is then placed in water and the inlay is easily removed. It is now tried in the copper amalgam model, and any rough margins are trimmed off with a very fine stone in the dental engine. If for any reason—such as an accident, or the carelessness of an assistant—the inlay is not satisfactory when completed, an impression is taken of the copper amalgam model, and a fresh model made in which another inlay is fused. Mr. Rose often takes several impressions of a cavity in the mouth, and hands them on to assistants who make the models and the inlays. By this means he has a small number of inlays to try in the tooth and select from. He claims the following advantages for this method: "First, that the work can be done out of the mouth, and that the patient's time and patience are saved, to say nothing of its being easier for the dentist; second, and most important, we have a rough *under surface;* and third, as the inlay is made in *immediate contact* with the model, without any intervening metal matrix, a more accurate fit can be obtained."

The first application of porcelain to the model can be made as soon as the impression material is removed, by softening it in hot water, and the moisture that the model has absorbed facilitates the introduction of the porcelain; but when once the model has been through the furnace, care must be taken not to make it wet or else it will crumble. But the moisture from the mixed porcelain will not be sufficient to affect the integrity of the model. Mr. Rose mixes the porcelain with water, and as the dry model rapidly absorbs the moisture from the mixed porcelain it may be necessary to add a drop or two of water every now and then while the porcelain is being worked to place. The porcelain should not be mixed too thin, and a little practice is necessary in order to place it in position with ease and accuracy, especially against the margins of the mould. Mr. Rose informs the writer that this never gives him the slightest difficulty. One advantage of this method is that the model does not warp or change its shape, and it is therefore unnecessary to take such precautions as may be necessary to prevent the warping of a metal matrix. The success of this method mainly depends on securing perfect impressions of the cavity in the tooth.

Investing the Matrix.—Whether the metal matrix is invested or not depends on the experience or requirements of an individual dentist. An investment may be regarded more as a convenience and a precaution than as an absolute necessity. Gold, by reason of its softness and delicacy, is usually invested, while platinum, owing to its greater rigidity, is rarely protected by an investment. Some dentists rarely or never invest a gold matrix, others are in the habit of always investing a platinum one. An investment enables the matrix to be handled without fear of damaging it. It will to some extent prevent the dragging or warping effect which the contraction of the porcelain may have on it, and in some cases it may enable the porcelain to be more easily placed in the matrix and carved to shape.

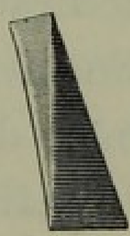
Powdered asbestos mixed with water to a paste of the desired consistency is largely used as an investment for gold matrices. This mixture is placed on a small metal tray, the matrix is placed upon it, and by gentle manipulation with a spatula and by jarring the tray is made to settle down in the investment. This mixture remains soft until it is thoroughly dried with heat. The tray is therefore placed over the flame of a spirit lamp and the contents dried either slowly or quickly. If a rapid drying is effected, it is necessary to make some holes in the investment down to the bottom of the tray to provide vents for the escape of the steam that is generated. It is also necessary to keep the holes open until the investment is partially dried, as the wet asbestos soon flows together and fills up the vents. If this is not done the steam will blow the investment out of the tray, and it will probably break to pieces.

A mixture of asbestos and alcohol has been used to save time. The alcohol is set fire to and blazed off. This produces a more fragile and friable investment than the more slowly dried water mix. An investment of plaster of Paris and pumice stone, or plaster of Paris, pumice stone, and silex takes longer to set, but becomes harder and can be used without a tray. If an investment is used with a high-fusing porcelain, it should not contain any ingredient that fuses at the heat to which it is subjected. This would render the removal of the inlay difficult, and would probably cause the investment to shrink sufficiently to change the shape of the matrix.

Manipulation of the Porcelain.—The high-fusing porcelains are mixed with water or with a solution of gum tragacanth in water. The gum holds the particles more firmly together and enables contours to be more easily carved to shape. It has been stated that this gum acts as a flux and is therefore detrimental, but some manufacturers sell this solution as a special mixing fluid to be used with their porcelains. The low-fusing porcelains are mixed either with alcohol or with water or with the gum tragacanth solution. The method of manipulating the high-fusing and the low-fusing materials differs somewhat. The high-fusing does not melt or flow under the heat as much as the low-fusing, and it is therefore necessary to bring the particles into closer contact in order to prevent undue porosity in the fused mass. This is effected by jarring the material after it is placed in the matrix. The handles of the tweezers, which hold the edge of the matrix, are lightly tapped, or rubbed with a coarse file or other suitably serrated instrument. This brings the moisture up to the surface and causes the powder to settle down more closely in the matrix. The surface moisture is then absorbed with blotting paper, and the jarring is repeated until no more moisture can be removed. If the matrix is invested the porcelain can be plastered in with a small spatula and the moisture brought up by gently rubbing or pressing the material with the spatula. When the matrix is filled to the desired extent, a single or a crucial incision is made down to the bottom of the matrix in order to cause the porcelain to shrink away from the centre. Porcelain on fusion shrinks towards the centre of the mass, and it is usually necessary to divert the centre of shrinkage in order to prevent a drawing in of the walls of the matrix. These incisions will be found to open considerably on fusion, and in places the porcelain may be found to have left the walls of the matrix. When the porcelain has cooled down, these spaces are filled up, and more porcelain is added and treated as before until, as the result of the requisite number of additions and fusions, the inlay is completed. The low-fusing porcelain not only flows more, but shrinks more than the high-fusing. This renders a close packing of the material in mass not only unnecessary but detrimental. The incisions will not be sufficient to prevent the sections of porcelain dragging in the matrix, and not only should less of the material be placed in the matrix at a time, but it should not be tightly packed. This applies more particularly to the first few fusions. The tendency of the low-fusing porcelain to warp the matrix can be counteracted if it is realised that the greatest contraction of the material takes place at its first fusion. That is to say, that when a piece of porcelain is fused it will not again contract if some more porcelain is fused on to it. This is because only the addition, and not the original piece, fuses. If the addition is fused to the same extent as the first piece, the original piece will become just a little more fused; but this will not cause it to contract to an appreciable extent, because the two pieces do not flow into a homogeneous mass with an intercharge of their molecules, as happens if two pieces of pure gold are fused together by bringing them to the melting-point of the metal.

One of the best means of preventing the contraction of the low-fusing porcelain from changing the shape of the matrix, is to reduce the amount of shrinkage by only fusing small quantities at a time, and to distribute the shrinkage in such a manner that it has no dragging force on the matrix. This can be effected by painting such a thin layer all over the interior of the matrix that on fusion it becomes a mere film. If the matrix is carefully lined in this way, adding film to film until a reasonable thickness is produced, it becomes so stiffened and protected that larger additions may be made with safety. In addition to this, if the form of the matrix renders it more likely to warp at one part than another, the weak part may be protected by gradual additions of separately fused small pieces of porcelain at this part. Either a small spatula or a small camel-hair or sable brush may be used to place the porcelain in the matrix. Any air bubbles must be worked out or else porosity will be produced. Care must be taken to clear the material from the margins; and it is a good plan to keep the interior of the edge in view until the last addition, and then to see that the exterior of the edge is just clear. It is well to smooth the surface before each fusion, and at the final fusion, to make it as smooth as possible. The brush should be used to smooth the surface, and the smoothest possible contour for the final bake is produced by having just sufficient moisture in the porcelain to enable it to flow slightly when the tweezers are jarred. If necessary, a drop or two of water may be added to effect this.

Restoration of exact contour is not difficult in ordinary cases. An imaginary straight line drawn from the cervical margin to the cutting edge margin is all that is necessary, unless part of a cutting edge has to be restored. When a corner is missing, the matrix may be filled to the imaginary line from the cervical to the cutting edge margins, and then the cutting edge built up in accordance with a measurement previously taken with a fine pair of dividers; then the imaginary line from the built-up corner to the cervical margin enables the rest of the contour to be reproduced. Other cases will be, as a rule, easily dealt with on similar lines. It is better to build up to exact contour, and re-build up to compensate for reduction of height caused by shrinkage, than to over-build and trust to shrinkage producing the right contour. The low-fusing porcelain flows slightly on complete fusion, but it is inadvisable to depend on this for producing either exact contour or fine margins. The writer has rarely been able to make "Porcelain Enamel" flow to place without over-fusing it. The Jenkins material, when used to restore corners, fuses into a rounded form, while the high-fusing porcelains, as a rule, retain their shape. A high-fusing material, when carved to a sharp line, will stand up under the heat and maintain its form, while a low-fusing porcelain will sink down or flow until sharp angles are lost. This has led to the statement that corner restorations cannot be satisfactorily made with the "Porcelain Enamel." But in the first place, it is usually inadvisable to produce sharp corners. As already mentioned, any kind of porcelain is a brittle material, and corners should be rounded as much as the appearance of the tooth will admit of, and the filling so shaped that it receives glancing blows. In the second place, as sharp a corner as usually exists on the natural teeth can be almost exactly reproduced with the "Porcelain Enamel" if it is built up and fused in the right way. One good method of accomplishing this is to fuse the porcelain until the matrix is filled level with the margins, and to build up a cone at the cutting edge, and rebuild up to compensate for shrinkage until the desired height is arrived at. This acts as a buttress against which the rest of the porcelain is built up until the contour between the cone and the cervical edge of the matrix is completed. Then the porcelain can be placed at the cutting edge side of the cone and moulded or carved to shape. There will be so little fresh porcelain placed at this point that there will not be much shrinkage and rounding of the corner, and one or more slight additions at this part will produce a very well-shaped corner. If an extremely sharp corner is desired the porcelain may be built out beyond the desired contour at this part, and then ground to shape and polished when the porcelain is completely fused. The contour of "Porcelain Enamel" can be ground and polished without the slightest detriment to its appearance or utility. If a glazed surface is preferred the grinding should be done before the matrix is stripped off; and the surface filmed over with a thin mix of the porcelain and again fired.



(Magnified four times.)

FIG. 37.

The Mellersh cores (Fig. 37) provide another means of restoring sharp corners with the low-fusing porcelain. These are thin slabs of high-fusing porcelain made in a suitable form and in sizes and colours to suit all cases. One of these slabs is placed in position when the matrix is nearly filled, and attached with a little of the low-fusing material. The core is a help in building out to exact contour, especially at the cutting edge, and is considered by many not only to enable sharp corners to be easily produced, but also to facilitate the operation.

The writer has pointed out the disadvantage of fusing the "Porcelain Enamel" in contact with any other kind of porcelain, and in order to use these cores without cracking the inlay it is necessary to heat up the furnace very slowly, and also cool down the work slowly. Whether the time that this takes counterbalances any advantages that these cores possess is a question of individual experience.

The writer spent two whole days and one evening in watching a demonstration of the Jenkins materials, given by Mr. Jenkins and Mr. Gow Gregor, and several large corner restorations were accurately and easily made with the "Porcelain Enamel" alone, and as the writer has found no more difficulty in restoring a corner than in making any large or complicated inlay which does not involve the cutting edge, he prefers to run no risks by using the cores. He has no desire to disparage what is doubtless a good method, for he has heard several expert porcelain workers commend it, but his experience with these cores has been somewhat unfortunate—owing to cracking of the porcelain used in connection with them—and therefore limited to a few cases. Those who are young and have keen eyesight will have no difficulty in producing cavities with the requisite fine margins, nor will the accurate placing and manipulation of the porcelain in the matrix or mould give them any anxiety, providing their skill and knowledge are adequate. But those who have arrived at, or have passed middle age, or whose eyesight is not of the best, will find a magnifying glass of great assistance.

The writer has found that the old time-honoured watchmaker's eyeglass is of great value, and, all things considered, the best he has used. In preparing margins of cavities in the mouth it may be held at the right distance with the left hand. In placing the porcelain in the matrix it may be held with the muscles surrounding the eye in the way watchmakers use it. If there is any difficulty in doing this, it is because the rim of the eyeglass is not of suitable diameter for the individual. When fixed "in the eye" both hands are at liberty. The focus of these glasses varies. A No. 3½ or No. 4 glass is a good focus for inlay work.

Several years ago an examination was made of the eyes of watchmakers in Germany in order to ascertain if the habitual use of this lens was harmful to the sight. It was proved that no bad effect had resulted, and the eye with which the glass was used was the better one. This may, however, be due to an instinct which causes the individual to place the glass in the better eye, for few people have eyes of equal strength and capacity. Fig. 38 shows this glass, although every one has doubtless seen a watchmaker at work.

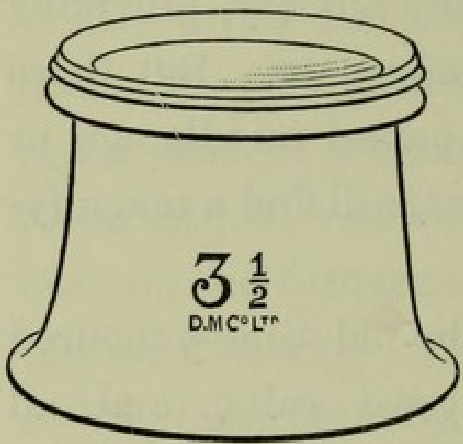


FIG. 38.

Fusing the Porcelain.—A certain amount of moisture remains in the mixed porcelain even after the most careful drying with blotting-paper, and a complete drying with gentle heat is necessary before placing it in the furnace. Many electric furnaces have a metal table or slab projecting just below the orifice of the muffle. This provides a convenient place for drying the material. If the porcelain is mixed with alcohol, a rapid drying is effected by blazing off the spirit; but this may cause an unsettling or slight disturbance of the powdered porcelain, which may be disadvantageous, particularly so at a stage when smoothness of surface and close marginal contact are desirable.

Certain points connected with the fusion of porcelain have already been mentioned. The various stages of the process may be described as the soft biscuit bake, the hard biscuit, the rough or wavy glaze, and the smooth even glaze. In this connection the rough or wavy glaze must not be confounded with the uneven surface, which will result from the complete fusion of a roughly finished piece of unbaked porcelain. Every time a piece of porcelain that has once been through the furnace is again subjected to the same heat for the same length of time, it becomes more fused; therefore, in building up an inlay in several layers, each one of which is fused before the addition of the next one, the first layers should not be allowed to pass beyond the hard biscuit bake. If each layer of the same porcelain is completely fused, the deeper parts will gradually become overfused, to the detriment of the strength and appearance of the finished work. It is not advisable, however, to fuse each layer so slightly that the whole mass shrinks considerably at the final fusion, necessitating the addition of more porcelain to an already completely fused inlay, and producing a sufficient shrinkage in mass to distort the matrix. This applies more particularly to the low-fusing materials, for, as already mentioned, three or more high-fusing porcelains which fuse at different degrees of heat may be used in constructing an inlay.

It has also been mentioned that a slow fusion is better than a rapid one, and although satisfactory work may be accomplished by keeping the furnace at the heat which will completely fuse a particular porcelain in a given time, giving of course less time to the biscuit or under-fused stages, it will be found that turning back the current until the furnace loses its glow, and gradually running it up to the fusing point and holding it there, will give the best results.

It is unnecessary to slowly cool down an inlay after fusion, but a slow cooling after the last fusion adds to the strength of the porcelain. It is not wise to place a partially made inlay in a red-hot furnace immediately the fresh porcelain is completely dry. It is better to allow it to become fairly hot by placing it close to the open door of the furnace. It is quite possible to crack a large inlay if this precaution is not taken. Slight under-fusion is better than slight over-fusion, as very little over-fusion greatly reduces the strength of the material, and it is considered that a porcelain that is slightly under-fused is much stronger than one that is slightly over-fused, although the maximum of quality and strength is arrived at by perfect fusion. A porcelain that is considerably over-fused is a porous and useless substance. When the inlay is completed, the foil matrix is stripped off by catching hold of the overlap with tweezers or foil-carriers, and gently dragging or teasing the foil towards the centre of the base of the porcelain. As a rule it is easy to strip off the matrix, but every now and then small particles are left adhering to the inlay. These may be scratched off with an excavator, and if this instrument fails to completely remove them a diamond drill in the dental engine can be successfully used for this purpose. As a rule a slight feather edge will be found at the margins of the inlay when the foil is stripped off. This is easily removed with a fine stone held in the hand, or a well-worn plug trimmer, such as a Smith approximal trimmer, may be used. Some prefer a sand-paper or cuttle-fish disc in the engine. The writer believes there is less risk of removing any of the true margin if this work is done with the hand.

Matching the Teeth.—One of the best ways of matching a tooth with an inlay is not to try to do it. If the tooth is exactly matched by making the inlay according to a string of shades, or if an artificial tooth is taken as a guide, there is every probability that when the inlay is cemented to place its appearance will be disappointing. The cement underneath the inlay and the angle at which the light falls upon the porcelain must be allowed for in the production of harmony of colour between the inlay and the tooth. No rules can be laid down as to this, with the exception that an inlay on an approximal surface should usually be lighter in colour than the tooth. An inlay on a labial surface should be darker, particularly if it is near the gum, and as the light goes right through an inlay which restores a corner or a cutting edge a considerably darker shade than the tooth should be selected.

The mixing or blending of two or more colours and the graduation of the colour will depend on the requirements of the case. A certain amount of opacity is desirable. The more translucent the inlay the more the "cement problem" and the "shadow problem" come into play. A too great translucency in a high-fusing porcelain is counteracted by the use of a more opaque foundation body. "Porcelain Enamel" is in itself sufficiently opaque. The colours of dental porcelain are developed or brought out by heat, but if the heat is carried beyond the fusing point of the material, or if it is left too long in the furnace, the colours are burnt out.

It has been stated that the colours of the "Porcelain Enamel" are more readily burnt out than those of the high-fusing materials, but over-fusion of either a high or a low-fusing porcelain causes loss of colour, and either kind of porcelain will develop and maintain its colours if correctly fused. A slight over-fusion of the "Porcelain Enamel" increases its translucency to an undesirable extent, and considerable over-fusion renders it dull and too opaque. A porcelain inlay absorbs light and reflects light, and may be considered as a patch which in this respect, as in others, differs from the tooth-structure to which it is attached.

A little experience enables a dentist to ascertain that an inlay of a certain shade or colour matches a tooth of a certain colour when it is cemented to place, although the actual colour or shade of the inlay may differ considerably from the colour or shade of the tooth. The appearance of a natural tooth in the mouth is largely due to absorption of moisture. A dried extracted tooth has a different appearance to one in the mouth. A tooth in the mouth that has been kept from moisture for an hour or two by means of the rubber dam is several shades lighter in colour than it was before the dam was applied, and does not regain its usual colour immediately.

Porcelain, though technically a somewhat porous substance, is not affected as to its colour in any marked degree by absorption of moisture, therefore an inlay should be tried in while the tooth is wet, and if the rubber dam is applied a distinct difference of appearance between the inlay and the tooth may be observed on the removal of the dam, but this will be corrected when the tooth has resumed its usual appearance. It may be mentioned that the painter of a picture expects it to be viewed at the right distance, and the face of a portrait which is life-like at the proper distance may present a very unnatural appearance if closely inspected. In the same way an inlay that is by no means the exact colour of the tooth may defy detection at ordinary speaking distance, and as already mentioned it is often a great mistake to exactly match the tooth.

Those who use the "Porcelain Enamel" are agreed that only a few colours are necessary for all ordinary cases, but they are not agreed as to which are the most useful ones. In the writer's opinion Nos. 22 and 4 of this make of porcelain can be satisfactorily employed in a large number of cases. Light-coloured inlays can often be made with No. 22 alone, and fusing one or more layers of No. 4 on to No. 22 will deepen the colour sufficiently to meet a large number of cases. In the natural teeth the dentine is darker than the enamel, and the use of a dark base and a lighter surface appears to be more akin to nature. The writer has tried both ways, and prefers to use a light-coloured base and a darker surface. Half-a-dozen or more colours may be kept in reserve, and a number of experimental fusings made in order to ascertain the appearance of different blends. It is very easy to make mistakes in selection and blending of colours, especially in cases which demand a variation from the usual routine. With the exception of certain light-coloured inlays, the writer has always found it better to fuse one or more layers of a certain colour or mixture of colours, and then to add one or more layers of another colour or mixture of colours, rather than try to produce the desired result by mixing two or more colours together and making the entire inlay with this one mix. He has also, as a rule, found it better to fuse each different-coloured layer separately, instead of placing a layer of one colour on to the top of another one and fusing them both at the same time. Care must be taken not to change the colour of the porcelain by rubbing it up too vigorously on the mixing slab with a metal spatula.

The writer has produced some blue-black inlays by using a nickel spatula—probably an alloy of nickel and copper—in this way. Platinum, if rubbed off a spatula of this metal, will give a dirty grey colour, and pure gold will produce a pink shade. In some instances advantage has been taken of this in the matching of grey or dirty-looking teeth. An agate slab is recommended by Dr. Jenkins for mixing "Porcelain Enamel" in preference to a glass slab. It is said that the porcelain powder will scratch the glass and cause particles of it to become mixed with the porcelain. There is no need to scratch glass by rubbing the porcelain powder against it. The powder is so fine that a camel-hair or a sable brush can be used to mix it with either water or alcohol. If any of the mixed powder remains over and is returned to the bottle it becomes somewhat lumpy and requires a more vigorous rubbing up. A small agate mortar and pestle may then be used with advantage. It has been stated that any forcible rubbing lightens the colour of the porcelain, but the writer cannot say that he has observed this. A dark stain appears at the margins of some inlays no matter how well they are made and fitted. This spoils their appearance. Fortunately these cases are exceptions. The stain can be removed with a weak acid. Bicarbonate of soda should then be applied to neutralize the effect of the acid on the enamel margin. In some cases the stain may be removed by bicarbonate of soda alone. In all probability the stain will soon reappear.

Anchorage.—The retention of an inlay depends on the cement with which it is fixed in place. The only cement that can be successfully used for this purpose in the mouth is the oxyphosphate of zinc. This material, when used as a cement, has little strength, and its adhesive properties are not great. It is more or less readily dissolved by the fluids of the mouth, and, all things considered, it is astonishing that it has enabled so many inlays to remain in place and save the teeth for a goodly number of years. At one time it was considered that its adhesive properties were considerably increased by the thinness of the mix and the pressure applied to it in setting the inlay. The illustration of the joiner who uses the thinnest possible film of glue in making joints with wood, and who not only squeezes out the surplus with pressure but maintains the pressure until the glue has set, has been so often mentioned that one is apt to forget that oxyphosphate cement is not glue, and that neither dentine nor porcelain are identical with wood. It seems also to have been overlooked that a joiner or cabinet-maker makes frequent use of the dovetail joint in connection with glue.

The manner in which cavities are prepared for inlays has been dealt with in respect to giving them as much retaining form as can be effected with due regard to the withdrawal of the matrix. In many cases this may be increased by undercutting the cavity after the inlay is made, tried in, and found to fit. This undercutting provides extra retention for the cement, but has not much effect on the retention of the inlay unless the inlay itself can also be undercut or grooved in some suitable way. The sides and bottom of the inlay may be grooved or undercut or serrated with a small diamond disc used in the dental engine (Fig. 39). The disc should be kept wet, and its edge should be flat rather than knife-edged. The effectual grooving or undercutting of an inlay greatly depends on its thickness or depth (Fig. 40). Shallow inlays are far more likely to be dislodged than deep ones, and the cases in which a grooved or undercut inlay is most desirable are the very ones in which this method of retention is particularly difficult to produce. In many cases the grooving will weaken the inlay unduly, in others it may be impossible to carry it out. In these cases merely removing the glaze from the underneath parts

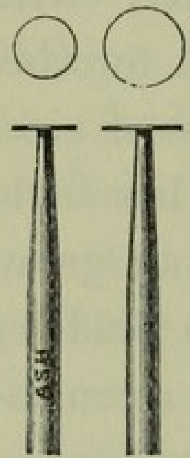


FIG. 39.

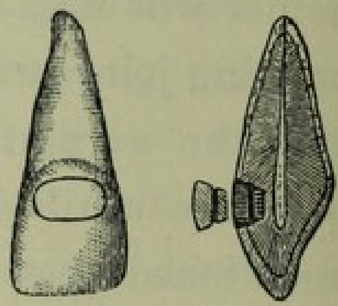


FIG. 40.

of the inlay is resorted to, and the retention depends mainly on the general form of the cavity. The simplest method of removing the glaze is to use a diamond drill in the dental engine. This was recommended by Dr. Evans some years ago. Hydrofluoric acid, sand-paper discs, and small stones are also used, but none of these enable the result to be obtained so easily, so quickly, and so safely as the diamond drill. If a watchmaker's eyeglass is used, this drill can be carried right up to the margins without in any way impairing them. The writer has rarely found any difficulty in holding even a small inlay between the thumb and fingers if they are kept wet during the grooving process, but he prefers to use the diamond drill dry in order to see how the glaze is being removed. The inlay may be fixed to the end of a stick by shellac or sealing-wax if it is found difficult to hold it in the hand. It may be mentioned incidentally that, with the diamond drill, a small mark can be made on the outside surface of an inlay to indicate the position in which it must be placed in the cavity. Some cavities are so formed that it is impossible to know how to insert the inlay unless it is marked in some way or other. The shape of the overlap of the foil is a guide to this, and a mark should be made before the foil is stripped off. An ink mark or a pencil mark is soon accidentally rubbed off, and considerable embarrassment takes place if the inlay goes in the wrong way and cannot be properly adjusted before the cement stiffens. A tiny mark made by the diamond drill can be seen with a magnifying glass, and will not interfere with either the appearance or the utility of the inlay.

One of the best means of undercutting an inlay is to give it the appearance of a stud, presuming that the neck of the stud is sufficiently thick to resist any breaking strain that the force of mastication brings to bear on the inlay. Cement, like porcelain, is only strong in bulk, and unless a reasonable space exists between the grooved or undercut inlay and the grooved or undercut cavity, any dislodging force may cause the cement to break and the inlay to come out. It is no uncommon thing for an inlay to come out with the grooves filled up with cement and a lining of cement to be found adhering to the cavity. The same thing applies to an undercut cavity in the base of an inlay. The basal cavity may be full of cement, the cavity may retain its cement lining, and yet the inlay has been dislodged owing to fracture of the cement. Bulk of cement between an undercut cavity and an undercut inlay not only enables the inlay to be retained in the cement, but, according to Dr. Head's experiments, prevents the cement from being washed out by the dissolving action of the oral fluids, or, at any rate, greatly retards this. This is in contradistinction to the belief that the finer the joint and the thinner the lining of cement the longer the cement would last; but a fine joint at the margins is always necessary. It is true that oxyphosphate fillings have repeatedly failed in certain cavities, and that when they have been replaced by inlays these have lasted almost as many years as the oxyphosphate fillings had lasted months, but the disintegrating effects of the saliva may vary at different periods, and there is no doubt that the untimely loss of some inlays is entirely due to a complete, or almost complete, destruction of the cement. The mechanical retention of an inlay may be said to principally depend on securing one of the following conditions: (1) Depth of cavity; (2) a single or double undercut, made—before the matrix or impression is taken—in such a manner that the matrix will slide out and the inlay will slide in; (3) a double grooving or undercutting of both cavity and inlay, together with sufficient bulk of cement between the opposing undercuts or grooves. There are several methods of producing an undercut cavity in the base or bottom of a porcelain inlay. The centre of the base may be cut out with discs and stones. A more convenient way is to embed some substance in the inlay and remove it afterwards. The selected material is placed at the bottom of the matrix and covered up with the porcelain. The writer does not know who originated this process, but the method is described and illustrated by Dr. N. E. Christensen [1] —a ball of hardened plaster of Paris being embedded in the inlay and afterwards scraped out (Fig. 41).

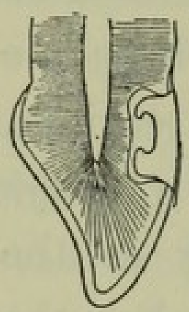


Fig. 41.

Other materials that have been used for this purpose are copper forms, pellets of gold foil, pellets of crystal gold, balls of dried and varnished clay, and powdered silex. With the exception of copper, which is removed by dissolving it in boiling nitric acid, all these substances are scraped out of the completed inlay with a small excavator or a probe. The method of using powdered silex originated with Mr. Charles Rippon, and has been demonstrated by him at several Dental meetings. This method is the outcome of many experiments, made with the object of improving the anchorage of porcelain inlays, and has given the inventor the greatest satisfaction in his practice. The

[1] *Dental Cosmos*, December 1895.

procedure is as follows: A tray filled with dry, finely powdered silex is placed in the furnace, and heated up until some of the particles of the silex are found to have formed themselves into small ball-like masses of various sizes. These little balls are readily picked up with a small sable brush that has been brought to a fine point by twisting it between the lips. The matrix is first thinly painted over with a thin mix of the inlay body, which is fused so that the interior of the matrix is completely covered or lined with a thin glaze of the body. It is then about half filled with a stiffer mix, and a hole is made in the centre with the brush. In making the hole, the body is swept up to the sides in such a manner that it goes up to the margins, and the matrix is thus filled, with the exception of a central round or oblong cavity, which must extend to the floor, and leave the thin glaze produced by the first fusing exposed at the bottom of the hole or cavity. If during the manipulation of the body to make this hole it is found to be too wet, blotting-paper should be applied until sufficient moisture is absorbed to enable the body to be properly and easily manipulated. One or more of the little balls of silex is then picked up with the point of the brush and placed in the cavity that has been made in the inlay body until it is filled up to the right height, care of course being taken not to build up the silex too high. In large inlays that admit of a large central cavity the balls of silex may be gently patted down with an instrument, so that they crush up into a more even mass. In very many cases, merely placing the pieces of silex in exact position with the brush is all that is necessary or advisable. The body is then fused, and this will leave some of the silex projecting, owing to shrinkage of the body. A fairly stiff mix of the body is then carefully placed round the margins of the matrix, and carefully worked from the margins towards the centre and over the silex. The object of this is to fill up the matrix and cover over the silex without disturbing the latter. Another fusing will perhaps still leave the top of the silex exposed; the same procedure is resorted to until it is completely covered or embedded in the fused inlay, then the contour is built up and the inlay completed in the usual way. When the matrix is stripped off, the thin film of porcelain that covers the silex at the bottom of the inlay is readily pierced and broken away with a steel point or an excavator, and the silex is easily removed with a damp brush. Mr. Rippon uses a platinum or platinum-gold matrix without investment. He places the matrix on a tray filled with powdered silex, and consequently the fusing of his inlays produces the little lumps in the silex that are utilised in this process. He mixes the inlay body with distilled water, in which gum-tragacanth is dissolved. This method is by no means difficult if all the various details are grasped, and as its success depends on this, the writer has endeavoured to describe it as fully as possible. It is desirable for the film of porcelain at the base of the inlay to be sufficiently broken away to provide a fairly broad or wide opening, although whether the hole in the inlay is undercut or not greatly depends on the extent to which the base is broken away. A deeply undercut hole is not necessary. It stands to reason that the formation of a good anchorage cavity in the base of an inlay depends on a sufficient depth of cavity to admit of a reasonably thick inlay being made.

It is advisable to broaden or undercut the sides of the cavity in the tooth, and also to deepen the base, if possible, in order to provide space for a fast-holding amount of cement. As a rule it will be found dangerous to deepen the cavity, and therefore the base of the inlay should usually be ground away in order to provide space for the cement. If the layer of cement between the base of the inlay and the bottom of the cavity is thick enough, and if this layer is secured in place by undercutting or broadening the sides of the cavity at its base, it seems hardly possible for an inlay made in this way to be dislodged by the force of mastication or in any other way short of deliberate removal by a dentist, providing that the cement retains its integrity, and it will take a long time for such a basal thickness of cement to be dissolved by the fluids of the mouth even if this should occur.

Cementation.—The cement should be thoroughly mixed to the right consistence, taking care not to rub it up too vigorously with a metal spatula, as this will darken it. The powder of the cement should be very finely ground in order to eliminate all coarse particles which would prevent the inlay going properly to place.

Some experience with the particular cement that is used is necessary to obtain the best results. The heat of the mouth causes the cement to set more rapidly than it does if left on the mixing slab, and this must be allowed for. As a rule, a slow-setting material, such as Harvard cement, is preferred. The Harvard cement possesses the disadvantage of failing to set properly in the presence of moisture;

it is therefore called a non-hydraulic cement. The majority of the oxyphosphates of zinc, if placed in a dry cavity, may be exposed to moisture shortly afterwards with little or no detriment. In fact the absorption of a little moisture before they are completely set is considered to be advantageous.

In the majority of cases Harvard cement can be protected with a varnish until it becomes properly solidified. There are cases in which a cement which sets in the presence of moisture is desirable; such as, labial cavities, the cervical margins of which extend to, or are covered by, the gum. It is often difficult to apply the rubber dam in these cases in such a manner that the gum is well pushed away from the cervical margin, even if gutta-percha has been previously placed in the cavity and allowed to extend and press against the gum. In these and in other cases where the proximity of the gum interferes with the adhesion of a varnish to the joint, a cement which sets well in the presence of moisture will give the best results. In many instances these cavities may be kept dry—without using the rubber dam—until the inlay is cemented to place, particularly if the gum is dried and covered with a film of varnish. Whether the rubber dam should be largely or sparingly used in the setting of inlays is a matter of opinion. There are many cases where there is no difficulty in keeping the parts dry until the inlay is varnished without resorting to the dam. The cement should be mixed sufficiently thin to enable the inlay to go to place, but it should not be thinner than is necessary. A very thin mix of cement has less strength and less resistance to the fluids of the mouth than a thicker mix. A slow-setting cement can be mixed somewhat thicker than one which solidifies more rapidly. The slowness with which it sets gives more time to squeeze out the surplus.

The setting qualities of different makes of cement vary. If two are mixed equally thin, one may become hard in a reasonable time, the other may remain soft. Therefore it is well to make a few experimental mixes, bearing in mind that the material sets more quickly in the mouth than out of it. When the cement is mixed, the sides and bottom of the inlay are covered by rubbing it on the cement; the cavity—previously dried and protected from moisture—is quickly smeared over and the inlay placed in position with as little delay as possible. The inlay may be picked up with foil-carriers, or it may be conveyed to the cavity with a small spatula. If a spatula is used, the inlay should be attached to it before the cement is mixed. A little hard wax may be used for this purpose.

The inlay is then pressed to position with a spatula, or the side of a flattened wooden stick. It is well to place one side of the inlay in the cavity first, and then press down the other side, settling the inlay to place with a gentle rocking movement. This will force as much cement out of the cavity as possible before the inlay is "dead centred" and firmly pressed home. If the only space which exists between the inlay and the cavity is that produced by removal of the foil from the inlay, it is very difficult to make it sink to exact margins.

It is no uncommon thing for an inlay that appeared to fit perfectly when tried in to show raised margins after cementation, and if the margins are ground down the appearance of the joint in regard to closeness of fit may be disappointing. When the inlay is pressed to place the surplus cement should be quickly removed from the margins. This can be effected by rapidly drawing a piece of linen tape over the side of the tooth. Pressure should then be made on the inlay with the spatula or wooden stick in order to force out more cement. The margins may again be cleared with a thin spatula and more pressure applied. Clearing the margins enables the joint to be clearly seen, and may lead to the inlay being more accurately pressed to place. The cement may, however, have stiffened sufficiently to prevent direct pressure accomplishing this; but if a strip of silk ribbon is tightly stretched over the inlay and the side of the tooth, and firmly held in place with the left hand, the inlay may be forced to place by rubbing on the silk with a flat steel burnisher. The silk protects the margins of the porcelain, and enables the slight rocking movement given to the inlay by the burnisher to displace the surplus cement without unseating the inlay.

In all cases it is considered advisable to apply moderate pressure with a wooden stick or a steel instrument for a few minutes, on the assumption that until the cement has partially set it possesses sufficient elasticity or expansion to slightly move the inlay. Some dentists place a wooden wedge between the teeth in order to keep up the pressure for a considerable time, others tie the inlay in place with floss silk. Either proceeding may disturb the position of the inlay, but in certain cases it is well to prevent the inlay being accidentally dislodged before the cement has set, by wrapping floss silk several times round the tooth and inlay and tying it firmly. The inlay and the side of the tooth are varnished before moisture is allowed to come in contact with the tooth. This is imperative if a non-hydraulic cement is used. The varnish and any particles of cement which remain may be removed the next day. The writer considers it is wise to grind down a raised margin in an exposed position. It is quite possible for an inlay to be dislodged by the vigorous use of a tooth-brush if it catches on a raised margin and the anchorage is slight. The side of a small diamond disc followed by an Arkansas stone may be used to grind down the margin. As a general rule a white or a light yellow cement is the best as far as the appearance of the inlay is concerned, although in some cases if the inlay is too light-coloured or the tooth itself is dark, a dark yellow or a grey cement may be used with advantage.

The Strength of Porcelain Inlays.—It has been shown that porcelain is a brittle material which cannot be expected to stand much shearing or percussive force. The resistance of porcelain to a given force increases in proportion to its bulk. The positions in which inlays are most likely to break, are corners and cutting edges of incisors and canines, the palatal sides of upper incisors and canines, the occlusal surfaces of molars and bicuspids, and the approximo-occlusal surfaces of these teeth. With the exception of corners and cutting edge restoration, a reasonable depth of cavity will prevent the porcelain from breaking in two, but there is always some risk of the margins becoming fractured or chipped. The best means of preventing this happening is for the wall of the cavity to have as little outward slope as possible, and for the margin of the inlay to be absolutely flush with the margin of the cavity or slightly below it. Corner and cutting edge restorations should be as thick as the circumstances of the case will admit of, and rounded as much as possible.

In the article already quoted from, Dr. Head says: "The fillings must be rounded so as to receive glancing blows, the edges must be kept as free as possible from strain, and if they chip, as they usually do in an inconspicuous place, the powdered edge should be cut out with a fine inverted cone bur and filled in with gold or amalgam squeezed in on cement, slightly overlapping the porcelain with the metal."

In certain cases the best means of protecting an inlay from either fracture or dislodgment, is to fill the tooth with gold or amalgam, and to insert the inlay in a cavity cut in the part of the metal that is exposed to view.

Tooth-saving Properties of Porcelain Inlays.—Some exaggerated statements have been made to the effect that decay never attacks the margins of well-made porcelain inlays. The preservative effect of these inlays depends on their remaining in place, on the resistance of the cement to the oral fluids, and on such precautions as to "extension for prevention" as apply to other fillings. The closeness of contact with the cavity walls produced by the cement has been compared with the want of perfect contact of many gold fillings, and the shrinkage or change of form of amalgam fillings to the detriment of the older work. But quite apart from the fact that the cement is a more or less perishable material, quite apart from the fact that some dentists hold that the production of perfectly adapted gold fillings is merely a question of technique, and others consider that shrinkage or change of form in amalgam fillings has been practically done away with by improved manufacture and greater care in mixing and manipulation, it must not be forgotten that both gold fillings and amalgam fillings can be satisfactorily lined with cement, and as far as this is concerned, equality of tooth-saving properties secured. In addition to this the strength of either gold or amalgam, and the superior anchorage that is usually obtained when these materials are used, has enabled a far larger proportion of these fillings to remain in place for a longer period of time. However, it has taken a long time to acquire such knowledge as is now possessed about gold and amalgam fillings, and it is only fair to the porcelain inlay system to say that notwithstanding the absurd claims that have been made for it, and notwithstanding the many disappointments that have resulted therefrom, it occupies to-day an important and honoured position, one which it will continue to maintain until the oft-dreamt-of perfect cement filling is discovered. The porcelain inlay enables the appearance of the natural teeth to be restored in a manner which no other filling material at present in existence can equal, and if it is confined—as it should be—to those cases in which appearance is of considerable importance, its average durability will be found amply sufficient not only to justify its use, but to cause both dentists and patients to be thankful that such a method exists.

Some Other Methods.—Several years before the invention of small and convenient furnaces and the production of a variety of dental porcelains popularised inlay work, certain dentists cut pieces from artificial teeth and ground them to fit into cavities. Corner restorations of incisors were made in this way, as well as fillings for labial surfaces. This method was, however, too tedious and difficult for the average dentist to adopt. Cylindrical and tapered porcelain rods were then made to facilitate the filling of round cavities. The end of the rod was fitted to the prepared cavity, and the adaptation perfected, if necessary, by mounting a piece of the rod in a mandril and grinding it in with emery or corundum powder. The surplus part of the rod was then nicked with a disc, broken off, and the surface finally ground smooth after it was cemented to place. Further improvement was made by the production of small round pieces of porcelain, or stoppers, and special burs the exact size of these stoppers. For round cavities on the labial or buccal surfaces, or in any position where this method can be accurately applied, this is to-day the simplest and most accurate procedure. These porcelain stoppers are similar in appearance to the burs shown in Fig. 28, p. 236. The perfecting of this method, and the outfit which enables it to be accurately and easily carried out, are due to Mr. Dall of Glasgow.

A further development of the rod inlay method consists in its more extensive application to approximal cavities. This has been practised for many years by Mr. Dall. Dr. Pierre Robin introduced a similar system, which has been developed by Dr. Guttman and improved as to the outfit by Mr. Macmillan. The following illustration from an article by Dr. Robin gives a general idea of the procedure (Fig. 42). The tapered rod, when pressed home in the cavity, is marked close to the edges of the cavity at each side. The rod is removed and cut in two at the mark on the lingual side—presuming the rod is passed in from the front. At the other mark it is partly cut in two. It is then cemented to place and the projecting part broken off with a light tap with a hammer. The lingual, labial, and approximal sides are then ground to correct form and made smooth when the cement is set. Mr. Frederick Rose's method of restoring the occlusal surface of molars in certain cases is as follows: When the walls of an occlusal cavity are so thin or so ragged that they can be ground down and made level all round with advantage, the cavity is given a cup-like form, and an impression and a bite taken. The models made from the impressions are mounted on an articulator and a flat—or plate—molar tooth selected and its sides ground level

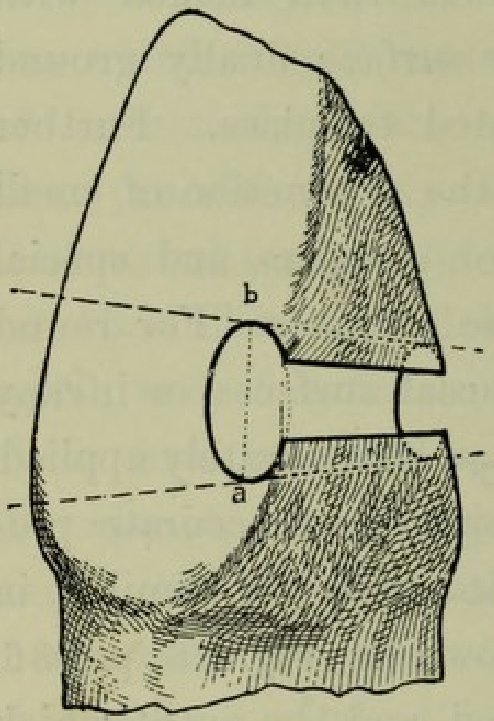


FIG. 42

with the sides of the model of the tooth. It is then placed on the model, with the side containing the pins towards the cavity. By means of the articulator the exposed surface of the porcelain is then ground accurately to the bite and some grooves cut in it to give a better masticating surface. The pins of the artificial tooth are bent, the cavity in the tooth undercut if necessary, and filled with cement. The tooth is then placed in position and pressed close to the margin of the cavity (Fig. 43).

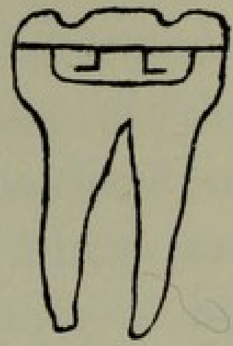


FIG. 43.

CHAPTER VI

GOLD INLAYS

The genesis of the gold inlay is not of so much interest as the modern developments which have so greatly simplified and improved this work. It sometimes happens, even in the practices of careful dentists, that, owing either to frailty of the tooth, or sensitiveness of the dentine, a cavity is not prepared for a gold filling exactly as the operator would like to do it. In a few instances this has led to the filling coming out either during the finishing process or shortly afterwards. Many dentists have then replaced these fillings by smearing the cavity with thinly mixed cement, and pressing them back to place. The probabilities are that this method was original with nearly every one who made use of it.

Few cared to confess that they ever inserted gold into imperfectly prepared cavities. In order to illustrate the retaining property of cement, the writer described a case in which he had cemented a gold filling back to place.[1] This case was mentioned not because there was anything novel in the method, but because a filling re-inserted in this way was in good condition three years afterwards, notwithstanding that one of the walls of the cavity was completely split off by the force of mastication nine months after this filling was fixed in with cement. At various periods of his career the writer has replaced fillings in this way, and although the number (less than a dozen) is too small to draw conclusions from as to the general retention of gold inlays, he has no knowledge that any of these fillings again came out, and those which he has had an opportunity of observing several years afterwards were in good condition, and could not be distinguished from other gold fillings inserted in the ordinary way in the same mouth.

Since the advent of the gold inlay as a general method of practice, it has been ascertained that many dentists have replaced fillings in this way. It is therefore supposed that the modern gold inlay owes its origin to this practice.

A good many years ago, Dr. Ames of Chicago took impressions of certain cavities, made models with copper amalgam, and on these models built

[1] *Items of Interest,* March 1900, p. 174.

up fillings with cohesive gold. The fillings were removed from the models and cemented to place in the mouth. Good results were reported, but this method never became popular.

The late Dr. Atkinson of New York made experiments with the object of melting gold to the exact form of fillings required for the mouth. He failed in his attempts principally because he was unable to prevent the shrinkage of the gold. It is fair to presume that the gold inlay of to-day really owes its existence to the success which has attended the making and insertion of porcelain inlays. Porcelain inlays were hailed as a boon and a blessing, not only because of their superior appearance, but also because they spared the dentist from the tedious labour of hammering gold into teeth, and the patient from sitting still and doing nothing while this was being carried out. Trimming and polishing the cervical margins of gold fillings in approximal cavities in bicuspids and molars is often a trying process, and anything which would add to the peace and comfort of either operator or patient was bound to be given a fair trial. The brittleness of porcelain is, however, a drawback to its extensive use, and it was only natural for the minds of many to turn to gold as the strongest and toughest material, and endeavour to use this metal in the same way that porcelain was employed. Those who began by merely melting gold into platinum matrices were confronted with difficulties in restoring contour except in simple cases. The shrinkage of the metal on cooling also produced many misfits. Then crystal gold was used to restore contour and prevent shrinkage. The matrix was filled and the contour restored with this gold, on the assumption that if the crystal gold was lightly packed, gold of a lower carat could be placed on it and melted, until, as a sponge absorbs moisture, the crystal gold would be permeated by molten metal, and its pores or interstices so filled up that only the surface required flushing over. The unmelted crystal gold was supposed to prevent any appreciable shrinkage of the mass. This was an advance, but there was an element of uncertainty. The crystal gold might not suck up the melted gold sufficiently to produce the desired solidity throughout the mass, and even if it did so, it might not prevent shrinkage. But good results were often obtained in this way.

Another method was to take an impression of the cavity with some suitable material by pressing a small piece to place. This was then carved to represent the contour of the inlay, and models were made in oxyphosphate of zinc, amalgam, or a fusible metal. A thin gold plate was stamped up in a swaging machine to fit the interior of the cavity, and another one to fit the exterior surface. These two plates were then placed in correct contact and soldered together. This produced a hollow inlay. A hole was then made—or it was previously made—through the bottom or base of the plate, which represented the interior of the cavity. Pieces of gold solder of a lower carat than that used for uniting the two plates were then dropped through the hole and melted until the hollow space between the two plates was solidly filled up with the exception of a central cavity, which was allowed to remain in the base to assist in retaining the inlay.

These and any other methods which have been adopted are now largely if not completely displaced by the "Cire perdu" and pressure casting process. The "Cire perdu" (lost wax) method and the casting of metals under pressure are not new; they have been employed in the arts and manufactures for many years. The "lost wax" process has been used in dentistry in connection with a low-fusing alloy for the casting of dentures. Also it is a well-known and much-used method for making special impression trays. But its use in dentistry, as far as casting the precious metal is concerned, and the practical employment of pressure casting in dentistry, are entirely due to Dr. Taggart of Chicago. Like many other processes, when once this method was satisfactorily worked out, it proved to be fairly simple if all the details of procedure are carefully attended to. Pressure may be applied by compressed air, compressed gas, centrifugal force, steam, suction, or wet clay. The writer has used ordinary household bread worked into a paste with water to the consistency of soft putty. The writer's experience in this work is not great, but he has been able to note the following: (1) The investment should be carefully dried or else it may crack; (2) the carefully dried investment should be of such a quality that it will not crack under the flame of a nitrous-oxide blowpipe; (3) borax should be carefully and sparingly applied; (4) the contact of the two parts of the casting apparatus which are brought together when the pressure is applied should be immediate and accurate or else the gold will spatter out; (5) the investment should be as hot as possible or else the gold will become solidified before it flows completely to place; (6) too much pressure applied with a plastic material, such as wet clay, will crack the investment and probably spoil the work.

NOTES ON THE TECHNIQUE OF CAST GOLD INLAYS

By Charles Rippon, L.D.S., *Lecturer on Dental Prosthetics, University of Leeds.*

The preparation of cavities for gold inlays differs from that of cavities where porcelain is to be used. In porcelain inlay work the walls of the cavity must be nearly at right angles to the floor. They should slope outwards only sufficiently to enable the matrix to be withdrawn, and the margins must not be bevelled. In preparing cavities for gold inlays better results are obtained if the margins are bevelled. This produces an inlay with thin margins which can be malleted or burnished to a more perfect adaptation. When the cavity is prepared a piece of special wax—prepared by filtering it several times through fine filter-paper in order to remove every trace of foreign matter—is warmed and pressed into the wet cavity and the patient allowed to bite into the soft wax. This gives an imprint of the cusps of the opposing tooth. The wax is then carefully carved to the exact contour. This may be done while the wax is in the tooth, or it may be removed from the cavity, trimmed up, and then replaced for finally perfecting the margins and any other parts which require a finishing touch. It is very important for the outside surface of the wax to be made as smooth as possible so that this part of the cast inlay can be polished with little or no previous smoothing. If this surface requires any appreciable filing or grinding in order to render it fit for polishing, the contour will be reduced to an undesirable extent. A silk ribbon or a fine linen tape slightly damped with chloroform may be used to finally smooth the approximal contour of the wax while it is in the cavity, and a ball of cotton-wool damped with chloroform may be used at other parts.

Much care is necessary in order to remove the wax from the cavity without distorting it, and it may be chilled with a stream of cold water to make it as hard as possible. The removal may be effected by inserting the warmed end of a small piece of wire into the wax at the most convenient place and using this as a handle. A piece of wire must always be gently pressed into the wax either before or after it is removed from the cavity. The wax inlay is then, by means of the wire, placed upon a stand or support (Fig. 44) and carefully covered with an investment material. Care must be taken to cover it up in such a manner that no air-spaces or bubbles exist in the investment; this is effected by mixing a small quantity of the investment with as little water as possible and painting it over the wax with a small brush. When this has been allowed to set, a section of a metal tube is placed on the stand and filled with the investment material mixed sufficiently soft to flow easily into the tube. The stand and the tube may be held together with an india-rubber ring while the tube is being filled and the investment sets (Fig. 45). As soon as the material is sufficiently hard the india-rubber ring is slipped off and the stand removed. The wire which remains in the investment or mould is now warmed in the flame of a spirit-lamp or a Bunsen-burner and removed. This leaves a fine hole leading from the cup-like depression formed by the stand to the wax in the centre of the mould. The tube containing the mould is now placed on a stand or support over a flame until the investment is

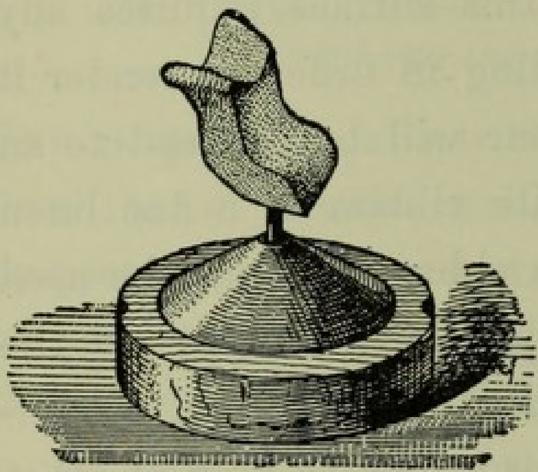


Fig. 44.

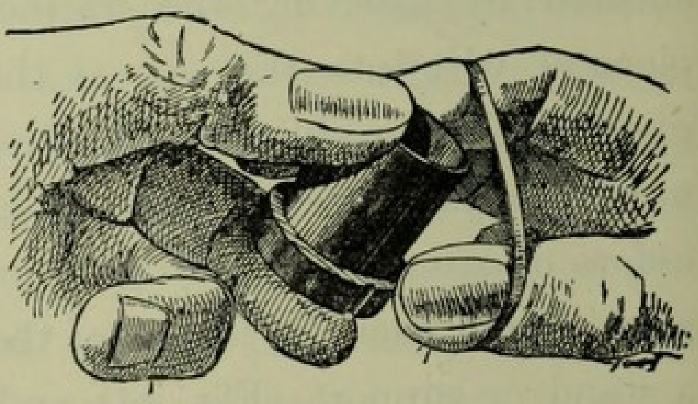


Fig. 45.

thoroughly dried and the wax melted and burned out. The wax completely disappears, leaving a cavity in the investment the exact shape of the wax. The mould is then thoroughly heated, and placed in the casting apparatus with the cup-like depression upwards. Sufficient gold to more than fill the cavity in the interior of the mould is then placed in the depression. The gold should previously have been melted into a button, for if several small pieces are used, one of them may melt first, run into the fine hole and block the entrance. The gold is then melted with a blowpipe—preferably a nitrous-oxide blowpipe—the flame should be applied until the gold is heated many degrees above its melting-point. It should not only be melted but boiled. The gold does not bubble like boiling water, but it should present the appearance of a quivering globule of water. When this stage of fusion is arrived at, the plunger or lid of the casting machine is pressed down, and the contact of the lid with the edges of the mould and the removal of the flame should be simultaneous; the pressure is applied for a few minutes to allow the metal to solidify under pressure. The pressure drives the fluid gold down the fine hole into the underlying cavity, and if the process has been properly carried out, and if sufficient gold has been used to fill the cavity and provide a reasonable surplus, the cavity will be so accurately filled that every fine inequality or mark which the cavity in the tooth has impressed on the wax will be exactly reproduced in the gold. Pressure casting, as at present used in dentistry, drives the molten metal accurately to place in the mould and holds it in position while it solidifies. The pressure has little or no effect in preventing any contraction that may take place during the cooling of the metal.

It is important for the investment to be as hot as possible, for if the deeper parts are much cooler than the molten gold the metal will lose its fluidity before it reaches every part of the cavity, and will consequently fail to completely fill it. The flame of the blowpipe should be allowed to play upon the sides of the metal tube which contains the investment so as to heat it as much as possible before the gold is melted.

Large Inlays and Partial Crowns.—The modern methods of casting gold enable not only ordinary inlays but very large restorations of badly decayed teeth to be satisfactorily made. So much of a decayed tooth may be reproduced by this process that it is difficult to say where inlay work terminates and crown work begins. Large restorations or partial crowns can now be used in cases where it was formerly necessary to make entire gold shell crowns. This does away with the sacrifice of the large amount of tooth-structure that is so frequently necessary in order to telescope a shell crown over the remains of the tooth. The accurate and flush joints producible by the casting method are infinitely better than the overlapping and usually imperfect joints of the shell or the banded crown. While under favourable conditions good results are obtainable, insufficiency of coaptation of band-edge and tooth-neck is of such frequent occurrence that it constitutes a serious defect. The anatomical formation of bicuspids and molars offers a natural and most serious bar to the perfect fitting of a band. It is rare indeed to find a shell or a banded crown with a perfect-fitting joint. With the introduction of pressure casting in its simplest form there is no longer any necessity for these overlapping and badly fitting joints.

Retention of Gold Inlays.—In small inlays sufficient retention is obtained by cutting grooves or slight undercuts in the base of the filling. In large inlays and partial crowns the tooth is built up in the mouth with cement in the form of a cone (Figs. 46, 47, 48, 49). When this is hard an impression is taken and a model cast; on to this model the wax restoration is built to contour, tried in the mouth, and invested for casting. By this

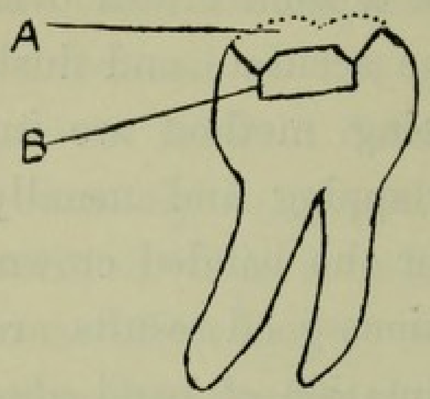


FIG. 46.

A represents the gold inlay; *B*, the cement cone.

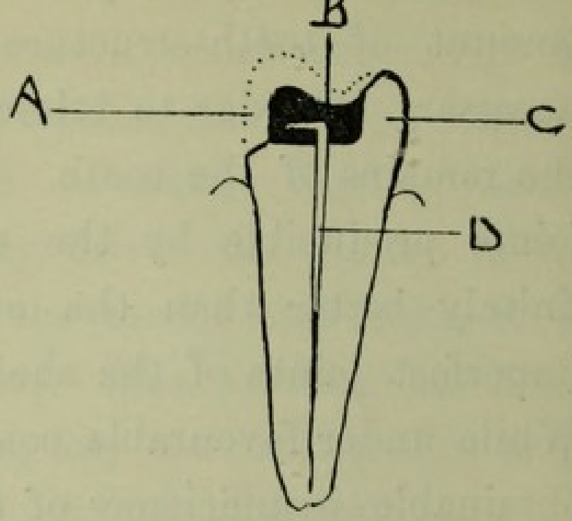


FIG. 47.

A, the gold inlay; *B*, the cement cone; *C*, part of the natural crown; *D*, post by means of which the cement is retained in the tooth.

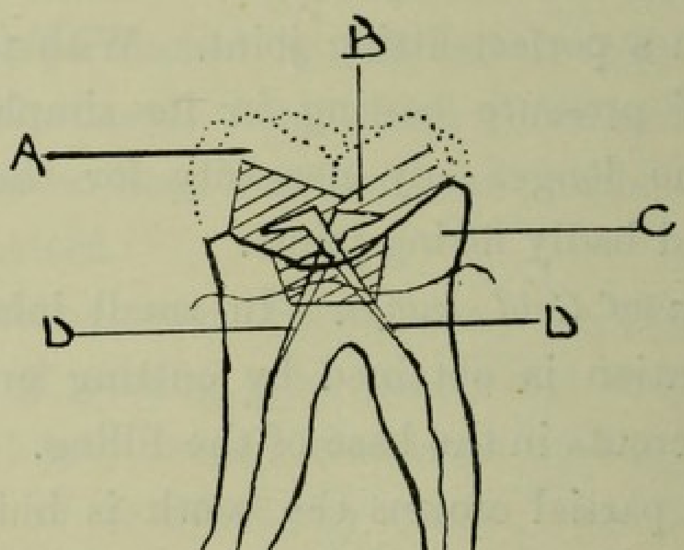


FIG. 48.

A, large inlay or partial crown; *B*, cement cone; *C*, part of the natural crown that remains; *D*, posts by means of which the cement is retained in the tooth.

method considerable time is saved, much of the work being done in the laboratory. There is also a considerable saving in gold. Posts, catches, or tags may be attached to the underneath part of these large hollowed-out inlays. In fact, the re-

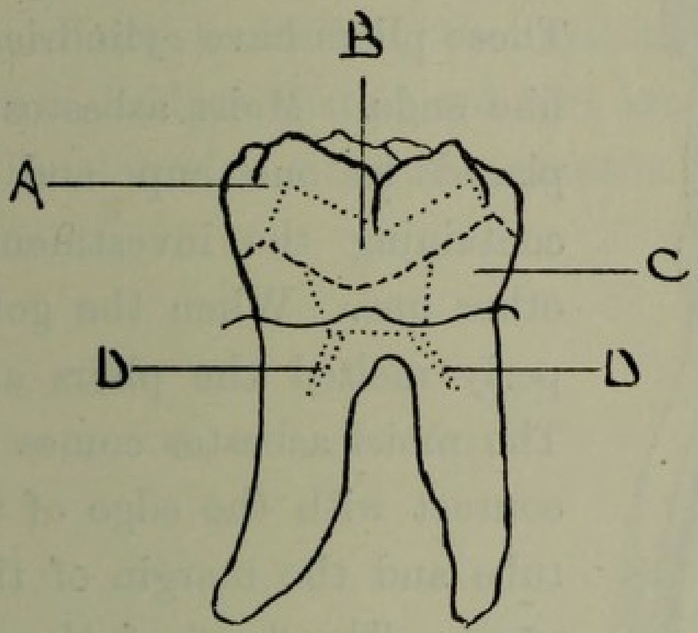


Fig. 49.

This shows the relative bulk and position of *A*, the gold; *B*, the cement; *C*, the tooth structure; *D*, the posts where the case shown as Fig. 48 is completed.

tention of large inlays offers unlimited opportunity for displaying the skill and ingenuity of the dentist. The cone of cement may be supported by posts passing into the roots of pulpless teeth, and it may, if necessary, be cut away sufficiently to provide room for any catches or hooks that may be attached to the base of the inlay. If thought good, the cone may be entirely removed and its place taken by the cement used in fixing the inlay.

The Casting Apparatus.—Amongst the many apparatus which have recently been introduced to the profession, the simplest for inlay work is the Solbrig pliers (Fig. 50). These pliers have cylindrical or cup-like ends. Moist asbestos discs are placed in one cup, and the tube containing the investment in the other one. When the gold is properly melted the pliers are closed. The moist asbestos comes into close contact with the edge of the metal tube and the margin of the investment. The heat of the gold and the investment immediately turns the water in the asbestos into steam, which drives the gold down the fine sprue hole, or gate hole, into the cavity beneath.

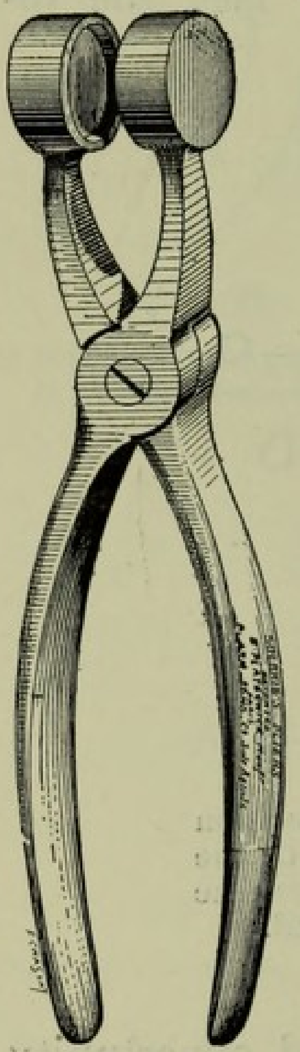


FIG. 50.

The great point to be aimed at is the correct moistness of the asbestos discs. These should just show the moisture on the surface, but any wetness should be removed before the investment is placed in the opposing cup. A good plan is to place the cup with the discs in position in water, and leave it there all the time the wax is being burnt out and the investment heated up. Then a light dab with a cloth removes all wetness from the asbestos, and the discs are in the best condition for producing a good pressure.

The possibilities of pressure casting in dental practice are not limited to the making of inlays and crowns; bridges, plates, and bars are now being successfully cast with a larger apparatus.

CHAPTER VII

TREATMENT OF DISEASED CONDITIONS OF THE TEETH PREPARATORY TO FILLING

Sensitive Dentine.—This is not in itself a diseased condition. The dentine is normally more or less sensitive, although the irritation caused by decay increases this in many cases. Some dentists say they have little or no trouble with sensitive dentine and need no obtundents. What their patients' ideas on this subject are does not transpire. The majority of dentists, and the majority of patients, would welcome a ready, safe, and comfortable method of eliminating the pain—be it much or little—caused by cutting the dentine of live teeth. At the present time no such method, applicable to all cases, exists. It would serve no good purpose to allude to everything that has been tried with more or less success. Cocaine may be driven into the dentine with "a high pressure-syringe." Cocaine or one of its substitutes, such as novocaine, may be injected into the gum. The dentine may be frozen into insensibility; and some drug may be sealed in the cavity with a temporary filling and allowed to remain there for some time.

In order to use "the high-pressure syringe" a small shallow hole must be made in the dentine, either at a convenient part of the cavity of decay or by drilling through the enamel at a sound part of the tooth. The nozzle of the syringe is placed in the hole, and its sharp edges made to bite slightly into the dentine. This can be accomplished by pressing the nozzle against the dentine with a twisting movement. Perfect contact is necessary, otherwise the solution will escape from the hole, and little or none will enter the dentine. If this method is used when the pulp is exposed, or only covered with decayed porous dentine, it is said that the solution, after passing through the dentine, enters the pulp and escapes into the cavity of decay sufficiently rapidly to interfere with the success of the operation. It is therefore considered necessary to avoid this by filling or partly filling the cavity with oxyphosphate of zinc, or some other material which will prevent the leakage.

Those who have become skilled in applying this method speak highly of it, but in certain cases there are difficulties in the way of properly carrying out the technique which may render some other procedure preferable. The injection of cocaine or any of its substitutes into the gum is to be deprecated as a general or routine practice. Some individuals are so susceptible to the toxic effects of cocaine that its indiscriminate use in this way is likely to be followed by some very bad results. Novocaine and some other substitutes are stated to be decidedly less toxic, but at the present time no one can say that any of them are perfectly harmless. Those who inject a drug into the system by way of the gum, in order to obtund the dentine, will use it several times for the same patient in a short period if several teeth require filling; and if, as a result of this, a patient acquires "the drug habit," the dentist will be morally responsible.

The disastrous consequences of "the cocaine habit" are well known. In some instances this has been attributed to the injection of the drug for the extraction of teeth. It is not known whether novocaine, or any other substitute for cocaine, can produce "the drug habit," but this is within the bounds of possibility. Some individuals are very susceptible to local irritation, and the frequent needling of the gums and the pressure of the injection may cause disagreeable results in these cases, even if every aseptic precaution be taken.

In order to successfully obtund the dentine by injecting a drug into the gum, it is necessary for the medicament to be absorbed by the pulp of the tooth. The method introduced by Mr. Arthur H. Parrott[1] enables this to be accomplished with the greatest degree of certainty. The method, briefly described, is as follows:—

"A small quantity of a 2 per cent. solution of novocaine is injected into the gum. The ordinary fine hypodermic needle is then removed from the syringe and replaced with a much stronger, heavier one with an unsharpened square end.

"The syringe being filled with an ordinary sharp needle in position, a preliminary injection is made into the gum, using, perhaps, not more than 5 of the 30 minims which the syringe contains. The *needle* is then withdrawn and *changed* for the heavier one. A clean round *bur*, of a calibre corresponding to that of the heavy needle, is placed in the handpiece, and the head dipped in pure *carbolic*, any excess being shaken off. Tightening the soft tissues, if necessary, over the spot with a finger of the left hand, the bur, revolving fairly rapidly, is passed clean through them and made to penetrate the outer layer of compact bone, the perforation being made as near the level of the apices of the roots as easily practicable, in their direction, and as nearly as possible midway between them where the septum is thickest, to avoid injury of the periodontal membranes. The yielding touch of cancellous bone is easily distinguished and the bur is withdrawn. If the preliminary injection has been effectively made, this small operation will be quite painless. The heavier needle (air being first carefully excluded from the syringe) is then inserted into the perforation in the bone under the soft tissues. The escharotic action of the pure carbolic on the

[1] *British Dental Journal*, August 16, 1909.

bur, apart from its sterilizing action, aids materially in locating the perforation again, by whitening the edges of the puncture made by the bur in the soft tissues; without it there would be little visible sign of the perforation, owing to the automatic closure of the tissue, and the comparative bloodlessness of the part from the preliminary injection. The heavy needle is pressed well home into the pit prepared for it, and a deep injection made with the remaining contents of the syringe, care being taken that the fluid does not leak back. Sometimes strong pressure is still needed, and this must be guarded, as the fluid may find its way into any arterial or neural canal adjacent, and entering with a rush may possibly cause a momentary pang to the patient, or a touch of 'nerves' to the operator. Usually, however, it enters easily and steadily into the vascular bone. As soon as the desired quantity of anæsthetic has disappeared, excavating or burring operations may be commenced upon the tooth itself."

A jet of chloride of ethyl, or the mixture of chloride of ethyl and chloride of methyl known as anestile, is used for freezing the teeth. The application causes pain. This may be mitigated by placing a wad of cotton-wool against the tooth, and at first directing the jet on to the wool. In a short time the wool is removed and the jet thrown into the cavity.

It is astonishing how many patients who will not bear the lightest touch with an excavator, or the most delicate manipulation of a small sharp engine bur, will submit with calmness to what the writer believes to be the far greater pain caused by the freezing process. The pain is, however, of short duration, and re-applications can be painlessly made if the jet is again thrown into the cavity before sensation returns, or as soon as it just begins to return. The obtunding effect is very brief, and the excavation must be rapidly proceeded with. This may lead to too deep cutting and exposing, or nearly exposing, the pulp. It is better to apply the jet three or four times rather than run the risk of this.

In the writer's opinion this method is best suited to what may be called straightforward work. As a rule there are no after effects. In some cases the tooth will ache afterwards for a few hours, and then settle down to its normal state. In one case a patient who was neurotic complained of such severe and long-continued pain that, after several attempts to relieve it proved unavailing, the jet was again applied and the pulp exposed. A considerable thickness of dentine was drilled through before the pulp was reached. The direct application of one of the usual soothing remedies to the pulp stopped the pain.

In another case—also a neurotic—considerable irritation of the gum resulted, causing pain and discomfort for some days. Owing to the sensitiveness of the patient the rubber dam was not used, but the writer has frequently applied anestile without the rubber dam and no irritation of the gum has occurred. Pain or discomfort following the use of this method may be considered exceptional.

During the last two or three years paraform has been used for obtunding sensitive dentine, and good results have been reported. A small quantity, usually made into a paste by the addition of one or more ingredients—such as oil of cloves and oxide of zinc—is sealed in the cavity and allowed to remain there for some time. The writer tried formalin for this purpose several years ago, but found it was not satisfactory, and for this reason he has only recently been induced to try paraform for obtunding dentine. Some nine or ten years ago a paste consisting of one drop of formalin, one drop of oil of cloves, a small quantity of thymol, equal in bulk to one of these drops, and oxide of zinc sufficient to make a stiff paste was successfully used in his practice for mummifying pulps. This preparation was tried for sensitive dentine. In some instances it "worked like a charm." In the majority of cases it caused more or less pain, and the greater the pain the better was the obtunding effect. But an absolutely painless excavation was rarely accomplished. When the pulp was protected by a reasonable thickness of hard dentine the pain disappeared after a few days at the most, and usually subsided before the patient returned. But if the pulp was nearly exposed the pain was more severe, and was only relieved by removing the pulp or extracting the tooth.

It has been stated that paraform is far less irritating than formalin. The writer finds that paraform is a fairly satisfactory obtundent. In some cases it has enabled the excavation to be painlessly accomplished, in others it has reduced but not obliterated the sensibility, even if re-applied. It has been stated that the longer it is left in a tooth the better, and doubtless the length of time will influence the result. Probably a week will be found necessary in many cases. As a rule, in the cases in which the writer has used it no pain has followed, but a certain amount of pain has sometimes occurred. In one case the obtunding effect was produced with no pain, notwithstanding that a complete removal of the decayed dentine showed it had extended to the pulp. The pulp was found to be partially destroyed by the paraform. This agent appears to promise well as an obtundent, but the writer would hesitate to place it in deep cavities without first protecting the pulp. Gutta-percha containing 5 per cent. of paraform is considered by many to be the best preparation. Some dentists consider that it is unwise to completely obtund the dentine because this may lead to too deep cutting and an accidental exposure of the pulp, which may not be noticed if the method is one which also anæsthetises the pulp. There seems to be no reason why insensibility of the dentine should lead to too deep cutting if the anatomy of the teeth is known and the instruments are handled skilfully, unless such a brief effect as that produced by freezing tempts an operator to make haste too quickly.

Sterilization of Cavities.—Microscopic examination shows that even when the whole of the soft dentine is removed there is a certain amount of apparently hard dentine left into which microbes have penetrated. The most thorough preparation of cavities is insufficient to completely eradicate this, except, perhaps, in very small cavities that require considerable enlargement in all directions in order to enable them to be satisfactorily filled. It is considered that these microbes may live under a perfectly tight filling, gradually find their way to the pulp and infect it.

Dr. Choquet, who has made exhaustive investigations in this connection, thoroughly and completely sterilizes the cavity by drying it, removing the decay, drying the dentine with warmed air and 70 per cent. alcohol, followed by absolute alcohol, xylol, geranium essence, and hydronapthol.

By this means not only soft dentine but hard dentine may be completely sterilized.[1]

The writer has been informed that this is a somewhat painful process, and that for all practical purposes an equally good result can be obtained by sealing some suitable germicide—such as oil of cloves—in the cavity and allowing it to remain there for a certain length of time.

The following appears in Evans' "Crown, Bridge, and Porcelain Work," seventh edition: "For the thorough disinfection of dentine and removal of hypersensitive conditions, the author practises the method of previously placing and sealing in the cavity for from two days to a week a mixture of precipitated chalk and carbolic acid and oil of cloves in equal parts. A small quantity of aristol may also be added."

For many years the writer has been in the habit of sealing up a paste of tannin, carbolic acid, and oil of cloves in partially excavated cavities, because this reduces the sensitiveness of soft decayed dentine, renders its removal easier, and dries up and hardens any part that he might not desire to remove from the floor of a cavity. In these cases, and also in others in which it was applied under a temporary filling after complete removal of

[1] *Journal of the British Dental Association*, September 1901.

the decay and proper shaping of the cavity, it was found that the teeth were much more comfortable when permanently filled, sensitiveness to heat and cold being either prevented or greatly reduced.

There has been much discussion as to whether any softened dentine should ever be left in a cavity. Many cases have occurred in the writer's practice where he has considered it advisable to do so, but the decayed part has always been hardened and presumably disinfected by one or more applications of the tannin paste. This has proved extremely useful in working for young, fidgety, or nervous patients. If there is reason to believe that the pulp is merely covered by a mass of decalcified dentine, it should be considered as an exposed pulp and treated accordingly; but there are many cases where the exercise of good judgment will enable cavities to be satisfactorily filled without removing the whole of the decayed part.

The following cases are selected from many in which decayed dentine has been allowed to remain at the bottom of cavities with gratifying results.

In the year 1894 two large cavities were found in the mesial approximal surfaces of the two upper central incisors in the mouth of a school-girl aged about fifteen years. Each cavity contained a mass of very soft decayed dentine, the complete removal of which might have brought about an accidental exposure of one or both of the pulps. The decay was sufficiently removed to admit of temporary fillings, and the tannin paste was sealed in with temporary gutta-percha. The patient was going away to a boarding-school the next day and was instructed to present herself when she returned home for the holidays, which she did. The teeth were then filled with hard gutta-percha and the next year with gold. The thinness of the labial walls rendered it impossible to remove the whole of the discolouration which existed at this part, and consequently the appearance of the teeth was not all that could be desired. For this reason, and also because the enamel at the cutting edge of one of the teeth had become chipped in mastication, the gold fillings were taken out and the discolouration removed with pyrozone. During the removal of the gold from the cavity with the broken cutting edge, part of the labial wall split off. This tooth was then filled with oxyphosphate cement and the other one refilled with gold.

In November 1903 the cement filling was replaced with a contour porcelain inlay. At the present time the fillings are in excellent condition, and the teeth have remained comfortable from the very commencement. The writer considers that the successful preservation of the pulps of these teeth is largely, if not entirely, due to the manner in which the case was originally treated.

In another instance a patient—also a school-girl—consulted a dentist while from home at a boarding-school, and returned in the holidays complaining that the teeth attended to during the school-term had never been comfortable. Two fairly large white cement fillings had been inserted, one on the mesial approximal surface of a first upper molar, and the other on the distal surface of the adjacent second bicuspid. The fillings were removed, and it was found that, owing, doubtless, to the sensitiveness of the patient, a considerable amount of soft decay had been left in the cavities. The decayed part was moist, and had evidently not been treated in any way. The tannin paste was applied until the softened dentine became dry, hard, and shrunken. Such excavation around the side walls as was necessary was then easily accomplished with little or no pain, and the teeth were filled with amalgam. These teeth were then perfectly comfortable, and remained so for the ten following years during which the patient was under observation. Since then she has resided in another part of the country, and been lost sight of.

The writer does not wish to be understood as saying that he invariably leaves decayed dentine in cavities. He merely desires to point out that there are cases where it is advisable to do so, and has endeavoured to explain that this dentine should be treated by some hardening and disinfecting process. The above-mentioned tannin paste has a tendency to discolour front teeth; this can be prevented in the majority of cases by adding oxide of zinc in the proportion of about equal parts of tannin and oxide of zinc.

There is a little point in connection with the treatment of cavities which may be mentioned; this is, that if a tooth be properly excavated for a filling, and temporarily filled with gutta-percha in order that the operation may be completed at the next sitting, it will often be found that the dentine has become so sensitive that merely touching it during the removal of the temporary filling causes more pain than the original cutting. This has led many dentists to believe that gutta-percha causes or increases sensitiveness of dentine. It is the writer's opinion that this increased sensitiveness is entirely caused by the excavation, because if any sensitive part of the body is cut or lacerated it becomes irritated into abnormal sensitiveness. If the precaution is taken to place a dressing of carbolic acid, or creosote, or the tannin paste underneath the temporary filling, a decrease rather than an increase of sensibility will follow.

Exposed Pulp.—If a carious tooth is left unfilled, the decay progresses until sooner or later the pulp-chamber is encroached upon, and a portion of the pulp becomes exposed. In these cases, and also in cases of non-exposure where the pulp has become inflamed (this is usually shown by the amount of pain suffered), it is generally necessary to destroy the pulp. Many cases of successful "pulp capping" may be quoted.

The writer has had two exposed pulps successfully capped in his own mouth, the last one being done twenty years ago; but the proportion of failures to successes is so great that as a general method it is hardly wise to attempt conservative treatment. It is, as a rule (except, perhaps, for young patients with strong teeth and robust constitutions), preferable to waste no time and run no risks of future annoyance, but at once proceed to destroy the pulp. There are two accepted methods of accomplishing this: one is to render the pulp completely insensitive, and at once remove it with an instrument; the other is, to apply arsenic.

The method of rendering an exposed pulp insensitive is known as "pressure anæsthesia." A small quantity of cocaine is placed on the exposure, and, if there is not sufficient moisture present to make it dissolve, a little water is added, or a small ball of absorbent cotton-wool is dipped in a strong solution of cocaine and placed on the exposure. A ball of unvulcanised rubber sufficiently large to overfill the cavity is then introduced and pressed upon with a suitable instrument—such as a small spatula or a ball-ended burnisher—until the cocaine is forced into the pulp. The pressure must at first be very light in order to avoid pain; in a short time the pressure is increased, reducing it if it causes pain, and again gradually increased until it is found that considerable force may be applied without discomfort. Some pulps readily respond to this method and are rendered insensitive in about ten seconds; others require longer time, and it is by no means uncommon for no effect to be produced. From about a quarter of a minute to five minutes is the time necessary to spend in anæsthetising a pulp, with an average of from one to two minutes. Several mixtures of cocaine with other drugs have been recommended for increasing the efficacy and speed of the method—such as cocaine and alcohol; cocaine and chloroform; cocaine, alcohol, and formalin; and cocaine and adrenalin.

The writer found that a saturated solution of cocaine in formalin, made by rubbing up a little cocaine in a few drops of formalin, gave the best results; but he has discarded this in favour of the No. 81 pellets made by Parke, Davis & Co., which consist of cocaine hydrochlor., 1–2 gr.; morph. sulph., 1–8 gr.; atropine sulphate, 1–200 gr. This preparation appears to act more rapidly and to be efficacious in a greater number of cases. But, as already mentioned, "pressure anæsthesia" is not always successful. Irritated and inflamed pulps frequently resist this treatment, and if a five minutes' application fails, it is as well to give it up and apply arsenic. It is inadvisable to use "pressure anæsthesia" if any septic degeneration of the pulp exists. Infectious matter may be forced through the apex and severe periodontal inflammation will follow. It does not seem to matter how small the pulp exposure is so long as it is an exposure.

Molars are, as a rule, more difficult to anæsthetize than the other teeth, and when the uncertainty of being able to completely remove the pulp from the buccal roots of upper molars and the anterior roots of lower molars is considered, it becomes a question whether it is worth while to resort to this method in the molar teeth, except for the purpose of painlessly obtaining a free exposure before applying arsenic. An anæsthetized pulp, or part of a pulp that is left in a root-canal, soon recovers its sensitiveness, and, as a rule, does not forget to make its presence felt. There are means, however, by which these pulp remnants may be safely destroyed and rendered innocuous, providing a fine instrument can be passed to the apex.

The removal of pulps after "pressure anæsthesia" is often followed by profuse hæmorrhage. Cases of more or less severe pain, as the result of the extirpation of the pulp, are by no means uncommon. In some instances this has been attributed to the formation of a blood-clot beyond the apex of the root. In view of this it seems inexpedient to check the hæmorrhage by applying styptics to the root-canal. The barbed instrument —either in the form of an ordinary pulp-extractor or a Donaldson canal-cleanser—which is usually used to remove a pulp, has probably much to answer for as far as these cases are concerned. The pulp is entangled in the barbed instrument and then pulled out. The sensitive tissue beyond the apex is often also rendered insensitive, and it is not always easy to know if the extractor has been pushed too far. If it is passed through the apex and the usual twisting movement made, the soft parts beyond the apex will be lacerated. Also, if the instrument is not passed beyond the apex, the pulp does not always break exactly at the apex. The pulp is continuous with the periodontal tissue, and the break may take place beyond the root-canal itself. It is not unknown for some of the tissue beyond the apex to be withdrawn with the pulp. One of the writer's friends, who is very skilful in using the Gates-Glidden drills, informed him that he always removed pulps with these instruments, and had no trouble either with hæmorrhage or after-pain. Hæmorrhage may be prevented by destroying the anæsthetized pulp with the Evans' root-canal drier. If the copper bulb of this instrument is made very hot, the silver wire will sear the pulp and burn it to pieces. In some cases it will be removed adhering to the wire. This causes no pain unless the wire is allowed to remain too long in the root-canal.

This is a safe and thorough means for removing or carbonizing pulps in cases where the fine wire can be passed to the end of the root-canal; and particularly so if it is desired to reach the canals with as little cutting away of the sound part of the tooth as possible. Care should be taken to pass the wire into the canal before heating it, so as to be assured that it will readily pass right up to the apex, *and not beyond it.* Several sizes of the silver points or wires should be at hand in order that a suitable one may be selected. If necessary, the wire can easily be made finer with a fine-cut file. Hæmorrhage may also be prevented by working a paste or mixture of tannin and carbolic acid into the pulp. If this is carefully and thoroughly introduced as far as the apex, the pulp will be found dead at the next sitting and can be removed with little risk of after trouble. It is sometimes impossible to know at the time if the whole of an anæsthetized pulp has been removed. A fine twig-like portion may be left at the end of a canal and give trouble. It is therefore advisable to work carbolic acid into the canal after extirpating the pulp in order to cauterize and destroy any small piece that may happen to have been left.

In view of the fact that many cases of periodontal inflammation have followed the removal of pulps under "pressure anæsthesia," it is wise to postpone the filling of the root and the completion of the case for a day or two in order to be on the safe side. Of course, if, as the result of personal experience, any dentist finds that this is unnecessary, he will doubtless proceed to complete the case at once. The ball of rubber has proved more satisfactory than the earlier method of injecting cocaine directly into the pulp with a hypodermic syringe, but cases may occur where a syringe can be used with advantage. The writer has no experience of this; but Mr. W. S. Holford mentions its value when a tooth has been accidentally fractured and there is no cavity into which the rubber can be placed. Mr. Holford cuts the needle short, "so that only one-sixteenth of an inch projects beyond a small shoulder, on to which is placed a small piece of unvulcanised rubber. The end of the needle is then placed in the exposure (first having obtunded the exposed part by laying a small crystal of cocaine and eucaine on it and allowing them to dissolve in the moisture or exudation of the pulp), and the cocaine injected into the pulp."[1]

Arsenic effects the destruction of a pulp in a somewhat mysterious manner. The action of this poison on pulps has been often alluded to as cauterization; but pulps that are removed when rendered completely insensitive by this agent do not present the appearance of being cauterized; they appear to be in a highly inflamed state, and it has been supposed that the death of the pulp is caused by an inflammatory strangulation at the apex of the root-canal. This, however, does not

[1] *British Dental Journal*, June 1903.

account for the fact that many pulps become partially destroyed long before the part near the apex has lost its vitality or even its sensitiveness.

The late Dr. Foster Flagg removed a number of pulps which had been destroyed with arsenic. He cut off the small portion to which the arsenic had been directly applied, and submitted the remainder, which consisted of the major part of each pulp, to careful analysis. In no case was any trace of arsenic found in these pulps. Arsenic is an irritant poison, and, as far as its effect on dental pulps is concerned, it is fair to presume that it produces a more or less progressive inflammation which results in stasis, or stoppage of the circulation and consequent death of the part to which the blood no longer flows. Cases have occurred, and doubtless will continue to occur, in which the inflammation produced by the arsenic has not been confined to the pulp itself. It has progressed through the apex to the periodontal membrane. The majority of these cases are easily controlled and the trouble soon subsides. But every now and then no treatment short of extracting the tooth is of any avail. Fortunately these are exceptional cases. Arsenic is a valuable and, in the writer's opinion, still an indispensable drug in the treatment of exposed pulps, but it is not one that can be freely exhibited in regard either to the quantity used or the number of applications.

The method of applying arsenic is to place a very small quantity on the exposed pulp and seal it up with a temporary filling for from one to a few days. It is important for the temporary filling to be inserted in such a manner that no pressure is exerted on the pulp. Pressure causes pain in these cases. The most satisfactory means of avoiding pressure is to place a concave metal cap over the arsenical application and the exposure; but if a cap of suitable size cannot be easily adjusted, the temporary filling should be carefully inserted with lateral pressure—if temporary gutta-percha is used, or if oxyphosphate of zinc or some other cement-like material is selected, it should be mixed sufficiently thin to almost flow to place.

It has been stated that arsenic should never be sealed in a cavity with wool and varnish, because this may easily be displaced; but if a fairly thick solution of either sandarach or gum mastic is used, this can be relied on to remain in place for a few days. The adjacent tooth will help to retain it, and, if necessary, it can be held in place by tying a ligature of floss-silk round the tooth.

The writer uses oxyphosphate of zinc—mixed thin and manipulated with instruments smeared with vaseline—when the cavity is shallow or of such a shape that the retention of anything else would be doubtful. This is not difficult to remove. Many dentists use Fletcher's artificial dentine (oxysulphate of zinc) for this purpose, but the writer prefers oxyphosphate of zinc. When a metal cap can be easily applied and the cavity will retain temporary gutta-percha he usually employs this. In certain cases wool and varnish is found to be the most satisfactory material. It is not necessary for a pulp to be exposed in order to destroy it with arsenic, and in some cases it is advisable to make a preliminary application of this agent in order to expose the pulp with little or no pain.

One of the best means of preventing arsenic causing pain is to freely expose the pulp before applying it. Unless a pulp is successfully obtunded with "pressure anæsthesia," the writer has never been able to freely expose one without causing the patient great pain, even with the lightest manipulation; and unless the patient is suffering severe pain at the time, which cannot be relieved unless this is done, he finds it inadvisable to attempt it.

One of his friends, who practises abroad, once informed him that he had no trouble after applying arsenic, his method being to always freely expose the pulp and then give it a good cut with an excavator to make it bleed well. This is a heroic practice that the writer has never had the hardihood to attempt. For purposes of convenient application the arsenic is usually mixed into a paste with creosote or some other suitable liquid. Other ingredients are often added—such as sulphate of morphia, cocaine, tannin, &c., with the object of preventing or reducing any pain which the arsenic may cause. If the paste contains a large quantity of arsenic, only a small piece can be used; and it is difficult to realise that a minute quantity can contain sufficient of the other drugs for any obtunding or soothing effect to be produced. If a small quantity of arsenic is mixed with a large proportion of the other ingredients, a greater amount of the preparation may be applied; but this is a somewhat risky proceeding, because if any of it becomes squeezed out of the cavity during the insertion of the temporary filling, the arsenic which it contains may irritate the gum and the periodontal membrane to such an extent that the tooth must be extracted.

Cases have occurred in which necrosis of the alveolar process has also resulted. It is better to apply a very small piece of a stiff paste made by mixing arsenic with some suitable liquid, and then to cover it with a ball of cotton-wool saturated with whatever medicaments may be selected to prevent pain. If, as may easily happen, some of the liquid is squeezed out of the cavity, it is not likely to carry any of the arsenic with it if reasonable care is taken. But no method of applying arsenic in connection with any other drugs, and no preparation containing arsenic can be relied on to always prevent pain following the application. The writer has tried many such, and the one which has given him the best results, so far as reducing pain in the aggregate is concerned, is S. S. White's "Nerve Devitalizing Fibre," which is a dry preparation of wool, arsenic, creosote, tannin, and opium. The best results have been obtained by dipping a piece of the fibre in beechwood creosote and covering it up with a metal cap in order not only to prevent pressure but also to retain as much creosote in the cavity as possible. This is a rather slow-acting preparation, and it is often necessary to leave it in the tooth for a week in order to produce the desired result. It must not be thought that arsenic always causes pain; on the contrary, many pulps die without the slightest pain; in others a certain amount of pain or discomfort follows, and in some the suffering is very great. If the patient returns in great pain, the arsenic should be removed and the tooth treated for the relief of pain. In these cases cocaine may be added with advantage to any of the usual remedies.

In certain cases, when the pain persists and the cavity is easy of access, the pulp may be freely exposed with a fairly large sharp engine bur, and if, as usually happens, this is followed by immediate and complete relief, owing, first of all, to the hæmorrhage, and, second, to some soothing application which may also contain some arsenic, the patient will forgive the dentist and perhaps bless him for his thoroughness.

In cases where it is difficult to satisfactorily apply and seal up arsenic in a cavity of decay, a small hole may be drilled in the dentine, either at some convenient part of the original cavity, or through the enamel at a sound part of the tooth. It is only necessary to drill deep enough for a small piece of a stiff arsenical paste to be sealed in with temporary gutta-percha or oxyphosphate of zinc. This leaves the original cavity free for the use of obtundents, and precludes the possibility of the arsenic being displaced or coming into contact with the gum in a case where either of these accidents might happen. If a considerable thickness of dentine intervenes, it will—even in a favourable case—take about a fortnight for the effect of the arsenic to reach the pulp and destroy it.

The opinion is generally held that arsenic has no effect on inflamed pulps, and that the inflammation should always be reduced before it is applied. It is certainly good practice to relieve an aching tooth as promptly as possible by appropriate remedies, and then, at the next sitting, to apply the arsenic; but there are cases when a tooth resists all the usual soothing applications, and the application of arsenic is followed—after usually a period of increased pain—by relief. The writer has often found that relief has occurred long before the pulp is destroyed, or even rendered insensitive to touch.

The resistance of pulps to the action of arsenic varies considerably, and this by no means entirely depends on the existence of inflammation, so far as can be judged by the presence or absence of pain before making the application.

It is often an extremely difficult matter to succeed in destroying a pulp with arsenic in anything like a reasonable time. Time after time a patient may return; the tooth will be re-dressed, and although the superficial sensitiveness may be sufficiently obtunded to admit of the freest exposure, deeper exploration causes pain, and eventually the arsenic is removed, the tooth temporarily filled, and the patient told to return in a few months, or earlier if painful symptoms develop. If a large quantity of arsenic is used, or the dressing frequently repeated, or left in the tooth for a long time, in all probability severe periodontal inflammation of an almost uncontrollable character will be set up, and extraction will usually follow.

In the text-books allusion is made to the occasional resistance of a pulp to arsenic, but that it is of frequent occurrence accords with the experience of many dentists. In the *Journal of the British Dental Association,* April 1894, an article by Mr. Arthur King appeared on this subject, in which the by no means infrequent resistance of pulps to arsenic is alluded to. The use of what are known as mummifying preparations has great value in such cases.

It is a rare thing for a pulp to live after an application of arsenic, and this should therefore never be calculated on. It is the time that may elapse before this happens that so frequently causes embarrassment and trouble. Until mummifying agents were introduced three courses were open: (1) to temporarily fill the tooth and see the patient frequently, removing and replacing the temporary filling at each visit, and keep on doing this until such time as the pulp is found to be dead and can be removed before decomposition takes place; (2) to temporarily fill the tooth and dismiss the patient for a longer period; (3) to heroically remove the pulp. The first is often impracticable; the second frequently results in the death of the pulp before the patient returns, and, as a general rule, he or she arrives suffering either from severe periodontal inflammation or an abscess; the third may be stigmatized as brutal, and only justifiable under exceptional circumstances. Any method by means of which these cases can be more satisfactorily dealt with is worthy of careful consideration.

The Mummification of Pulps.—Much has been written for and against the method known as mummifying pulps. Many adverse opinions have been expressed as to the possibility of satisfactorily accomplishing this. Adverse arguments are based on the assumption that a mummified pulp will not remain in an aseptic condition, and that complete removal of the pulp and accurate filling of the root-canals is the only reliable method.

The success of any dental operation greatly depends on a careful consideration of the circumstances, and it has already been mentioned that the conditions connected with the removal of pulps are not always favourable; on the contrary, they are frequently very unfavourable indeed. The late Professor Miller, whose attainments as a bacteriologist and dental scientist gained for him world-wide renown, recognized the possibility of satisfactorily mummifying dental pulps. He made several experiments in this direction and recommended for this purpose tablets of mercuric chloride 0·003 gramme and thymol 0·005 gramme crushed up in the pulp-chamber after removing the bulbous portion of the pulp. Good results were reported; but as this preparation caused temporary irritation and pain, and discoloured the teeth badly, it was inadmissible as a general method of practice. Since then some useful preparations have been made which penetrate the pulp, dry it up, and render it aseptic without affecting the appearance of the teeth to a greater extent than follows the removal of pulps and filling the roots.

If all pulps could be readily destroyed with safe doses of arsenic, or if all pulps could be quickly rendered completely insensitive, and if, in addition to this, the whole of every pulp could be satisfactorily removed from the root-canals, there would be no advantage in leaving a pulp or part of a pulp in a tooth, and treating it with a mummifying preparation.

In addition to what has already been said about arsenic and "pressure anæsthesia," it may be mentioned that some root-canals are so fine, or so constricted, or so twisted or curved, or so difficult to "get at," that it is impossible to completely remove the whole of the pulp, be that pulp ever so insensitive, or ever so dead. The complete or partial destruction of a pulp with arsenic is a necessary preliminary to the use of a mummifying preparation, because although the remains of a pulp which has been partially removed under "pressure anæsthesia" can be successfully mummified, this usually causes a disagreeable amount of pain which will last for about a fortnight. It is very rare—in the writer's experience—for a mummifying paste to cause any pain when applied to a pulp that has been partially destroyed with arsenic.

It will be gathered from the above, that the cases in which the mummifying process can be employed to the best advantage, are those in which the application of a reasonable amount of arsenic fails to completely destroy the pulp in a reasonable time, and also those in which the position, constriction, or curvature of the canals renders the complete removal of the pulp either impossible or uncertain.

The first satisfactory mummifying preparation was introduced by Mr. Söderberg of Sydney, Australia.[1] This consisted of equal parts of dried alum, thymol, cocaine, and glycerine, to which oxide of zinc was added in sufficient quantity to make a stiff paste. The alum was the drying-up, tanning, or mummifying ingredient; thymol was used for its lasting or permanent antiseptic properties; cocaine to prevent pain while the pulp was being mummified; glycerine to cause penetration of the other ingredients; and oxide of zinc to give consistence to the preparation and prevent discolouration of the teeth.

In the *Dental Cosmos,* May 1899, another preparation was advocated by Professor Boennecken of Prague, Bohemia, who gave a record of a thousand successful applications of his method during the four previous years. He points out that it is necessary to use "some therapeutic agent that will not only perfectly and rapidly devitalize, but also permanently sterilize the fragments of the pulp."

The method as described by Professor Boennecken is as follows:—

"Twenty-four to forty-eight hours after the application of arsenic I remove the crown portion of the pulp (the so-called amputation of the pulp)

[1] *Dental Cosmos*, November 1895.

with a large, sharp bur, using the warm-water syringe for clearing out all the *débris* of the cavity and the pulp-chamber. This little operation is almost in every case quite painless. Then the rubber dam is applied and the pulp-chamber thoroughly washed out with a 10 per cent. solution of formaldehyde (one volume of the 40 per cent. formalin to three volumes of water). I call this the 'formol bath' of the pulp. Then I fill the pulp-chamber with my formaldehyde paste, cover with oxyphosphate, and put in the permanent filling. The tooth is always finished at one sitting."

The formula of the paste is given :—

℞ Cocaine,
Thymoli, āā 1, 0;
Misce exactissime terendo.
Adde Sol Formaldehyde aquos (40 per cent.) gtt. x;
Zinc Oxid, 2, 0.
Fiat pasta.

Professor Boennecken points out that if this paste is exposed to air in an open bottle the formaldehyde soon evaporates, and the paste loses its proper consistence. "It should therefore be kept in small tin tubes which can be hermetically closed." He also mentions that he applies this method to molars and bicuspids, and presumably confines its use to these teeth. "Of course all cases of decomposed pulps, likewise all cases of destruction of the pulp-tissue by pus formation, have decidedly to be excluded from this treatment. In these cases the canals have to be cleaned out and filled with antiseptics."

The writer began to use the alum paste shortly after reading Mr. Söderberg's article in the *Cosmos*, applying it at first in a tentative way in carefully selected cases. The results appeared so satisfactory that a more extensive trial was made with equal success, until a case occurred of a patient returning about ten days after the tooth was filled suffering acute pain. The tooth was an upper bicuspid, and it was found, on removing the filling and probing into the root, that the apical end of the pulp was alive and very sensitive. A mixture of carbolic acid, cocaine, and tannin was then carefully and slowly worked into the canal and pricked into the remnant of the pulp until sensation was lost and the instrument could be freely passed to the apex without causing pain. The pulp was then removed and the root filled. This gave complete and lasting relief.

The writer did not attribute the pain to the alum paste, because he had previously had precisely similar cases while patiently waiting for a pulp to die after an application of arsenic before mummifying preparations were invented. But this caused him to give up the alum paste in favour of one containing formaldehyde, because it was thought that this agent would complete the destruction of the pulp and probably prevent a similar occurrence. The preparation then used was made fresh for each case, and consisted of one drop of formalin, one drop of oil of cloves, thymol equal in bulk to one of these drops, and oxide of zinc sufficient to make a paste of the desired degree of stiffness. After using this preparation for some time with complete satisfaction, it was thought that every time the bottle of formalin was opened some of the formaldehyde would evaporate and the strength of the solution be gradually reduced. For this reason—which may or may not have been a good one—paraform (solid formaldehyde) was substituted for formalin. The preparation which has been used from that time to the present—viz., for eight years—is made fresh for each case, and consists of a small quantity of paraform powder—equal to the amount produced by crushing a cube one thirty-second of an inch in thickness—an equal quantity of thymol, one drop of oil of cloves, and oxide of zinc sufficient to make a paste of the desired consistency. The paraform and thymol are rubbed into the oil of cloves with a spatula on the mixing slab and readily dissolve in the oil. The oxide of zinc is then added, and, if well rubbed in, usually produces a sufficient quantity of paste; if a larger amount is needed to fill the large pulp-chamber of a molar, a little more oil of cloves and more oxide of zinc is used. It is easy to judge the quantity of paraform and thymol by the eye alone with sufficient accuracy for all practical purposes, and preparing this paste each time it is required is no more trouble than mixing an oxyphosphate or an amalgam filling.

The writer has not taken the precaution to wipe out the cavity with a germicide, such as a 10 per cent. solution of formaldehyde, nor has he, as a general rule, applied the rubber dam; but his experiences with mummifying pastes were so satisfactory, that, after a few years' careful trial in selected cases, he has used them since then in all molars to the pulps of which arsenic has been applied, with the exception of those which were gangrenous or in which pus had formed. The same treatment has also followed the use of arsenic in bicuspids in the great majority of cases.

A comparatively very small number of incisors and canines were treated in this manner, and the only patient who has returned with septic roots after the application of mummifying paste to a devitalized or partly devitalized pulp was one for whom this method was used in the two upper central incisors and one lateral incisor. Three years afterwards slight pain was felt in the lateral tooth. The filling was removed, the canal found empty, with slight odour of putrefaction. The root was disinfected and filled with complete satisfaction. Three years later, or six years after the application of the mummifying paste, an abscess formed on one of the centrals, and three months later the same thing happened to the other central. Both these teeth readily responded to treatment, which consisted in disinfecting and filling the roots. It may be that an insufficient quantity of the paste was placed in these teeth, and there is no doubt that the large pulp-chambers of the molar teeth lend themselves particularly well to this treatment, because the whole of the paste that has been mixed can usually be placed there.[1] In about half-a-dozen cases pulps which retained their vitality in the root-canals caused pain after—in some of these instances — a considerable period of quiescence. This necessitated removal of the fillings and destruction of the live part. In about half-a-dozen other cases the teeth never took kindly to the

1 Since the above was written, a first lower molar in the mouth of a boy aged fifteen and a half years has given trouble owing to development of septic conditions. The tooth was treated with mummifying paste five and a half years previously. It rapidly responded to antiseptic treatment, and was then re-filled.

application of arsenic and were never permanently filled. In some of these cases the pulps eventually died and were removed, and the root-canals treated before any decomposition of the pulp took place; but this was of no avail, and these teeth which were considered doubtful cases from the first were extracted. The writer does not attribute the loss of these teeth to the use of a mummifying preparation. All dentists who try to save the natural teeth, and who have been in practice for a number of years, know that cases of this kind occur every now and then.

The above small number of failures, or semi-failures, that have come to the writer's notice during a thirteen years' experience of mummifying pastes justifies him in saying that this method can be relied on to keep a pulp in an aseptic condition for a considerable period of time. This enables those cases in which only a partial destruction of the pulp has been effected to be safely dismissed for the time being, and if notes are made of these cases, the fillings can be removed and the canals cleared and filled when sufficient time has elapsed for this to be satisfactorily accomplished. This should appeal to those who have no belief in this method as a permanent treatment of devitalized pulps.

Treatment of Teeth in which Decomposition of the Pulp has Taken Place.—When a pulp has died a "natural death," it will usually be found in a putrid condition. If it has been long dead the root-canal will be filled with foul *débris*, in a more or less liquefied state, and owing to the irritation caused by the absorption of the products of putrefaction—or the migration of microbes—the periodontal membrane will be usually in a more or less inflamed or diseased condition. The treatment consists in carefully removing the contents of the canals and disinfecting the roots by placing some powerful germicide in the canals. Irritation and inflammation of the periodontal membrane are in these cases produced and kept up by the septic matter in the roots, and, by removing the cause, nature is often enabled to effect a cure; but when there is much degeneration of the periodontal membrane, and when pus has formed, producing alveolar abscess, the removal of the original cause is not always efficacious, and it becomes necessary to cauterize or stimulate the diseased parts to healthy action. This can usually be accomplished by pumping the remedy through the foramen at the apex of the root, using an old "nerve-extractor" wound round with cotton-wool, taking care to sterilize the instrument beforehand. Some operators use a syringe for this purpose; but unless great care is taken the liquid may be forced through the apex with too great pressure, and, unless a fistulous opening exists, this may cause considerable pain.

It is, of course, necessary for the canal to be completely freed from all *débris* before an attempt is made to force anything through the apex. Carbolic acid (full strength) is generally efficient for this purpose. Creosote is equally useful, and is preferred by some. In obstinate cases sulphuric acid (20 to 50 per cent.) may be used. When everything else has failed, the writer has often had happy results with nitrate of silver. This is used in the form of crystals reduced to a fine powder. A little of the powder is introduced into the canal with a steel broach wound with cotton-wool and damped, or a wooden stick may be trimmed to a fine, slender point and damped. The powder will dissolve in the moisture in the canal, or the cotton-wool on the "pumping instrument" may be wetted.

It must be borne in mind that nitrate of silver will probably discolour the tooth. When a fistulous opening exists, the remedy should, if possible, be so forced through the apex of the root that it exudes from the opening in the gum. This can often be readily effected by merely pumping the remedy into the root with the instrument wound with cotton-wool; or the canal may be flooded, a small ball of cotton-wool dipped in the remedy and placed at the orifice, and pressure applied with a ball of rubber as in "pressure anæsthesia." Should a fistulous opening remain unclosed for some time after the roots are filled, the remedy may be applied to the diseased part through this opening, enlarging it if necessary.

Fusing nitrate of silver into a little ball at the end of a fine probe provides a convenient means of applying this agent in these cases. Any fine instrument, such as a Swiss broach, may be heated and the end dipped in the powdered crystals. This causes some of the powder to adhere to the instrument. Then, if it is held over the flame of a small spirit-lamp, the powder melts, and inclining the broach causes it to run to the point and solidify into a little ball. In cases of blind abscess, an opening may be made to the end of the root by cutting or drilling through the alveolar process. This is often a ready and efficacious method of treatment, but is too heroic a proceeding to be recommended as a general method of practice.

In some cases amputation of the ends of roots is recommended, and in others the root and the bone may be scraped with instruments passed through the enlarged fistulous opening. The writer had the roots of a lower molar in his own mouth scraped in this way before the days of local anæsthesia, and found it was so extremely painful that he would not care to subject a patient to this treatment. On a few occasions he has done this after injecting cocaine into the gum and through the fistulous opening, but the result, as far as the absence of pain is concerned, was always unsatisfactory, and for this reason he has never attempted to amputate the end of a root.

It has been stated that in order to make such an operation painless it is necessary to use a saturated solution of cocaine. This would be decidedly unsafe, except in the hands of a specialist who was thoroughly acquainted with the action of the drug and its antidotes, and who was medically qualified to examine the patient beforehand. The suggestion that an operation of this kind should be performed under ether has not been accepted, although these same patients would not refuse to take this general anæsthetic if it were considered necessary in a case of extraction.

Many dentists consider that it is unnecessary to treat a septic root more than once, providing there are no active inflammatory conditions, or no flow of pus through the canal to interfere with the immediate filling of the root. Others are of the opinion that as the dentine absorbs products of putrefaction it is necessary to treat the root several times before it can be completely sterilized. It is quite possible to mechanically clean a canal, flooding it as much as possible with a germicide during this process, and then to fill the root with apparent satisfaction, because if the apex is sealed with the root filling, a barrier is set up which will prevent the passage of anything through the end of the root, and any septic matter that remains in the dentine is corked up.

The writer has always felt that it is necessary to take every precaution to thoroughly sterilize the dentine of the root, because sooner or later whatever it has absorbed in the way of infectious matter will find its way to the periodontal membrane, either by way of an imperfectly sealed apex or through the cementum.

The experiments made by Dr. Kirk of Philadelphia, to prove whether the coagulation of albumen produced by certain remedies (such as chloride of zinc) prevents their absorption, certainly show that the dentine and cementum are more permeable than was generally supposed.[1]

Immediate root filling—which should properly be

[1] *Dental Cosmos*, March 1894.

termed the immediate treatment of a root, or the treatment of a root at one sitting—can only be scientifically and successfully practised if the whole of the dentine of the root is sterilized at one sitting, or if it is sufficiently purified for a root filling of some antiseptic substance to penetrate the dentine and complete this work. One of the most rational and effective methods of producing a rapid sterilization of the root is to clean the canal and disinfect the dentine with peroxide of sodium, or sodium dioxide, as it is also termed. This was introduced to the notice of the dental profession by Dr. Kirk. If it is pure and in good condition it is a yellow-coloured powder, which should be kept from air and light, as it may soon lose its valuable properties. It is necessary to call attention to this, because otherwise disappointment may happen. When it was first introduced the writer procured some and was unable to obtain any good result. The tin, when opened, contained a white powder which was fuzzed up, and caked, on the surface. It is recommended that it should be kept in a dark bottle away from the light, but the writer has found that it keeps very well in an ordinary wide-mouthed stoppered bottle that is kept in his cabinet at the back of a drawer not frequently opened. A small quantity is taken out of the bottle and placed on a glass slab each time of use. If the powder is too coarse, it may be crushed up on the slab. For the successful use of this material the writer is indebted to a paper by Mr. B. J. T. Bennette,[1] in which this agent is dealt with from the chemical as well as the practical standpoint.

The following extracts are taken from this paper:—

"Sodium dioxide was introduced to the dental profession by Dr. E. C. Kirk, who recommends its use as a saturated solution, with asbestos fibre in place of cotton. In my opinion, a better way for ordinary use is to use it in the dry state."

"*Pulpless Tooth—Canal or Canals Putrescent—No Apical Complications.*—Apply rubber dam—and this is most important—tying it with double ligature of well-waxed silk. Clear cavity of carious dentine; dry lightly with cotton. Dip broach in absolute alcohol and then in the powder; insert into the canal. Repeat this till the apex is reached (in fine canals, particularly in the buccal roots of upper molars, use sulphuric acid 50 per cent. for opening them up). Brisk effervescence takes place, the dioxide giving up its loosely combined atom of oxygen, which, acting on all bacteria present, proves a prompt and efficient (*the* most efficient) germicide; the sodium hydrate breaks up and saponifies the pulp *débris*. Wash out canal with syringe and water. When the canal is empty, insert a drop of acetic or sulphuric acid, 30 per cent. and 10 per cent. respectively, to neutralize remaining alkali. Dry the canal with alcohol and hot air; seal the apex, and fill at once."

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[1] *Dental Record*, June 1904.

"*Chronic Abscess with Sinus.*—Proceed as in a simple pulpless tooth; but, before sealing apex, force through it and out at the sinus some stimulating antiseptic; the canal is filled at once. A mixture of creosote and iodine is good but drastic. My favourite is, first, H_2O_2, then a saturated solution of camphor, menthol, and thymol in pure carbolic acid. The abscess is subsequently treated through the sinus, a drop of the agent used being placed in the sac by means of a hypodermic syringe; one treatment generally suffices. This applies to the eight front teeth in both jaws."

Mr. Bennette points out that this agent removes organic matter from the dentine. He also mentions that a mixture of glycerine, water, and sodium dioxide may cause an explosion, and that a mixture of carbolic acid and dioxide of sodium, if slightly heated, causes a violent explosion. A case has been reported of an explosion taking place when sodium dioxide was applied to a root-canal by means of a probe wound round with cotton-wool,[1] and it has been stated that the contact of this agent with water is sufficient to cause this sometimes. The writer has applied it by means of a probe dipped in alcohol, or by means of a probe wrapped with cotton-wool and dipped in alcohol, and no explosion or other inconvenience has occurred.

The writer has taken the precaution to tem-

[1] *Dental Record*, February 1906.

porarily fill the root with cotton-wool moistened with alcohol after using sodium dioxide, and tightly fill the cavity with temporary gutta-percha. On removing the temporary filling and the wool from the root, he has on several occasions found a slight odour of putrefaction on the wool. As a rule, half-an-hour was spent on cleaning and disinfecting the root at the first sitting, and it appeared perfectly sweet when this was done. In some cases little or no effervescence takes place when the sodium dioxide is placed in a canal; effervescence can be produced and the canal more readily cleared, if a little dilute sulphuric or acetic acid is introduced. The writer has sometimes used vinegar for this purpose. Alternate applications of the sodium dioxide and the acid seem to be very useful in these cases.

In the article on pulp-mummification by Professor Boennecken already quoted from, the following occurs as to the treatment of septic roots:—

"For the treatment of septic cases I have recommended for the last two years, to my students and my German colleagues, the sulphuric-acid process of Dr. Callahan of Cincinnati. I consider this method the greatest progress that has ever been made in the treatment of gangræna pulpæ. After a few applications of the acid, the calcific depositions which we find in almost every case of diseased pulps blocking the root-canals are decalcified; the canals get wider, and their sterilization has become an easy thing. Neutralization is done with bicarbonate of sodium, or, better, with peroxide of sodium. When the canals are clean, I fill them with the formaldehyde paste above described. Mix a little piece of the paste with a drop of the 10 per cent. solution of formaldehyde, and fill the canal with the thin cream. The disinfecting power of the formaldehyde gas that is developing after the introduction of the paste is surpassed, according to my experience, by no other antiseptic agent. I always order the patient to come to a second sitting, although, as a rule, the canals are sterilized after the first treatment. Very rarely a third sitting is required. The formaldehyde paste remains in all septic cases as a definitive filling in the canals. It seems to me necessary to fill the roots in septic cases with a soft paste that will never get hard, so that if the tooth should give trouble later on you may at any moment enter the canals again with your nerve instrument. And for this purpose the formaldehyde paste seems to be an ideal material."

Prior to the use of sodium dioxide in dentistry, Dr. Schreier introduced the kalium-natrium or potassium and sodium method of chemically clearing and at the same time disinfecting root-canals. This material is supplied in glass tubes, and covered with a layer of solid paraffin. A small hole is made in the paraffin, through which a roughened broach is passed and removed with some of the potassium and sodium adhering to it. By means of the broach this substance is introduced into the root-canal. Afterwards the hole in the paraffin is closed in order to prevent deterioration of the contents of the tube. For practical purposes this material may be said to act in a similar manner to sodium dioxide, but the writer has had no experience which enables him to compare the two. He obtained some and delayed using it for a considerable time. When he tried it, he found that every time he placed it in the root a small explosion, followed by a little pyrotechnic display, occurred—in all probability the material had deteriorated—but as treating a septic root with fireworks is somewhat disconcerting, this is the one and only time he has used this substance. Some very able and experienced dentists value it highly, and the only reason why the writer has not procured a fresh batch and given it another trial is that he has been satisfied with the sodium dioxide treatment.

The method of applying potassium and sodium and the advantages of this method are clearly explained by Dr. Rhein of New York.[1] Dr. Rhein states that he not only uses this method to remove the putrid contents of a canal, but also to remove any remnants of a pulp that may be left in a fine or tortuous canal after an application of "pressure anæsthesia" to a live pulp.

"There are two chemical compounds that stand preeminent at the present day for the radical accomplishment of this purpose. Both were introduced into this country the same year, and their action is very similar. Sodium

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[1] *Dental Cosmos*, October 1905.

dioxide was introduced by Dr. E. C. Kirk in 1893, and in the same year, at the Columbian Dental Congress, Dr. Emil Schreier of Vienna introduced to the profession the alloy of sodium-potassium (kalium-natrium). Sodium dioxide has the advantage when it is decomposed of combining not only with the putrescent masses in the pulp and disintegrating whatever organic products may be present, but at the same time it also sets free ozonized oxygen, which oxidizes whatever colouring matter may exist. It requires, however, a great deal more care in its use, and is much more difficult to manipulate than the sodium and potassium mixture. This latter preparation was originally introduced by Dr. Schreier with the sole idea of saponifying the fats and other organic tissues and then leaving what is considered this harmless matter in the canals. This is not the form of technique I desire to call your attention to in advocating, as I do, the use of kalium-natrium.

"A barbed Donaldson bristle is passed through the paraffin into the sodium-potassium, and, with a small amount of the latter clinging to the barbs, it is now gently passed into the pulp-canal. The water which is present is at once acted upon, forming sodium and potassium hydroxide, liberating the hydrogen, which gas can be seen escaping. The caustic alkalis in their turn act upon the fats, and the result is a sodium and potassium soap, with glycerine as a by-product. These substances are freely soluble and easily washed out of the canals. The latter process, however, should not be undertaken until all portions either of living organic tissue or decomposed putrescent tissue have been saponified. This stage is determined by the fact that the characteristic bubbling of the sodium and potassium when it comes into contact with either living or putrescent matter has stopped, and the chemical compound rests perfectly inert in the root-canals.

"This alloy not only decomposes and disorganizes the tissue that exists in the canals, but in the act of doing so it bores its own passage through the fine and inaccessible canals, such as the buccal canals of the upper molars and the mesial canals of lower molars. Its ability in this respect for finding the end of the most tortuous canal is limited only by the skill and patience with which it is used by the operator. When it no longer finds any fibrils in the tubuli to act on, it will cease to give forth its peculiar hissing sound.

"The next step is to wash out the soapy mass and any pigments that may be contained therein in order to prevent subsequent discolouration of the tooth-structure. For this purpose I used hydrogen dioxide, which takes the place of the ozonized oxygen set free when sodium dioxide is the agent used. Instead, however, of using simply hydrogen dioxide, I have hit upon the expedient of dissolving in it the most reliable germicide at our command, mercury bichloride. For this purpose I have found the only available hydrogen-dioxide preparation to be that of Marchand. I keep ready prepared for this purpose a solution of 1 part of $HgCl_2$ to 500 of H_2O_2.

"The canals are now thoroughly washed out with this solution, using a glass hypodermic syringe with platinum needles. The oxygen that is set free oxidizes all colouring matter that may remain in the tooth-structure, and on the evaporation of the solution a minute amount of the mercuric chloride residue is left in the dental tubuli, remaining there as a permanent germicide. The canals are now thoroughly dried. A little sterile cotton or paper is placed in the pulp-chamber, the cavity is sealed with gutta-percha, and the patient is dismissed.

"If, on account of lack of time, all the organic tissue has not been saponified at the first sitting, the cavity should be dried and sealed with gutta-percha without washing out the canals with the bichloride solution. This is recommended in order to avoid coagulating any tissue which could later be disintegrated and washed out. Should some sensitive tissue remain in the canals, a dressing of one of the essential oils should be left under the stopping to obtain the benefit of its anodyne effect.

"Upon the patient's return at a subsequent sitting the gutta-percha is removed, and if there be any question as to any organic matter remaining at the ends of the root-canals, the sodium and potassium paste is again applied, and followed with the wash of $HgCl_2$ and H_2O_2."

The use of sodium dioxide or potassium and sodium followed by an antiseptic root-filling seems to the writer to be the only sensible method of immediately completing the operation. The insertion of a solid root-filling, even if this filling is sterilized or aseptic, is, in his opinion, a rather risky proceeding, because the only means of knowing whether the root is completely sterilized or not is to postpone the completion of the case.

There are two "rough and ready" or practical means by which this can be ascertained: one is to fill the canal with sterilized cotton-wool under aseptic conditions, temporarily fill the tooth, and after an interval of one or two days remove the wool from the root and subject it to the "nasal test." The other is to leave the canal unfilled, but seal up the cavity of decay with a temporary filling and wait, for at least three days, to see if the tooth remains perfectly comfortable. It is well for every one to test cases in this way before adopting an immediate treatment and root-filling as a general method of practice.

The Dressing Method.—This designation applies to treating a root-canal two or more times, in order to distinguish it from the immediate or one-treatment method. Any procedure which is employed for the "immediate treatment" becomes a "dressing method" if it is applied more than once before the case is completed, and therefore there is nothing in the "immediate treatment" which may not be applied as a "dressing method" if so desired.

Apart from one or more applications of sodium dioxide or potassium and sodium, or the application of these remedies followed by dressing the canals with something else, the most popular agent now employed for treating a septic root more than once is formaldehyde. This is a powerful, penetrating, rapid-acting, and irritating, germicide and antiseptic. Owing to its irritating properties it can only safely be used in very small quantity or in very weak solution for the treatment of septic roots. The 40 per cent. aqueous solution (which is a saturated solution) known as formalin should be reduced to a 1, or, at the most, a 2 per cent.

solution, or a very small quantity of the solid form known as paraform may be employed.

Confusion has arisen and mistakes have been made because, in alluding to this agent, writers have not always been careful to explain whether a certain percentage means a percentage of formaldehyde or of formalin. To make a 2 per cent. solution of formaldehyde, add 1 part of formalin to 19 parts of water; to make a 1 per cent. solution, add 1 part of formalin to 39 parts of water. A small ball of absorbent cotton-wool, saturated with a 1 per cent. solution of formaldehyde, is placed at the orifice of a septic canal, or in the pulp-chamber, before any attempt is made to remove the contents of the canal or canals. This is tightly sealed in with a temporary filling, and at the next sitting the putrid contents will usually be completely or sufficiently sterilized to admit of being safely removed, and the root may again be treated or filled at once as seems good, or a small quantity of paraform may be used instead of the weak solution. It is better to sterilize the septic matter in a root before attempting to remove it, no matter what germicide or antiseptic may be used, because, even with the most skilful and careful manipulation, some septic matter may be accidentally pushed through the apex—setting up more or less trouble

—and those who are less skilful in this kind of manipulation will frequently do this. The same objection, however, does not apply to sodium dioxide or potassium and sodium, which chemically clear out, and at the same time disinfect, the septic matter. But if the disinfecting vapour given off from the solution of formalin, or from the paraform, passes through the apex in sufficient quantity or strength to irritate the periodontal tissue, and particularly if it acts in such a way that the escape of pus, or the products of inflammation, through the apical foramen is prevented, severe pain, which will probably resist any treatment short of extracting the tooth, is very likely to follow.

Numbers of cases in which formaldehyde has been sealed in a tooth, the periodontal membrane of which is in a more or less acute state of inflammation, have been followed by excellent results. The rapid disinfecting power of this agent has reduced the pain quite as quickly as if the case had been vented in the usual way and any antiseptic treatment postponed. These are cases where the pain is produced by the pressure of the gases of putrefaction on the parts beyond the root. It is a moot point whether the periodontal membrane is irritated and inflamed by the gas itself, whether infection of this part is caused by the gas driving septic matter from the root-canal through the apex, or whether the periodontal membrane is already infected by the migration of microbes from the canal, and the gas merely exercises a mechanical pressure on a part that is already in an irritable condition. It is well known, however, that in many cases what is known as opening up the cavity and leaving it open gives relief, and if equal relief is procured by sealing a germicide in the tooth, this is brought about by such a rapid neutralization of the products of putrefaction that no more of this gas is formed. There is no agent, with the exception of formaldehyde, which can be relied on to accomplish this with such rapidity that it may at once be sealed in the tooth before removing the contents of the canals and disinfecting the roots. But, unless the case is one in which the immediate pain is caused by gas pressure, and unless the formaldehyde vapour which penetrates the canal expends its power on the contents of the canal, and does not pass through the apex in such a state or in sufficient quantity to cause in itself irritation of the periodontal membrane, relief will not follow, and the irritation caused by formaldehyde is very difficult to treat successfully.

In many cases—as already mentioned—a periodontal membrane that is irritated with formaldehyde gives so much trouble that the tooth is extracted. This agent, if used in a case where the canal is vented, and relief follows the escape of pus through the apical foramen, may coagulate the pus in such a manner that it will no longer flow into the canal. The result is a recurrence of pain, and the establishment of a condition that is difficult to treat. If the case is one in which drainage by means of the canal is an important factor in the treatment, the use of formaldehyde may be considered risky. It has been mentioned that only a very weak solution of formaldehyde should be used, and if paraform is employed only a small quantity should be employed. Paraform acts by giving off formaldehyde vapour at the heat of the body.

An extract from the *Dental Headlight* appeared in the *Dental Cosmos,* October 1908, in which Dr. W. L. Mount advocates paraform for treating septic roots. He states that a piece no larger than the head of an ordinary brass pin should be used, and that, for convenience of application, this may be wrapped in a little cotton-wool. This is placed at the orifice of a canal before removing its contents, and tightly sealed in with a temporary filling. In using a 1 per cent. solution of formaldehyde it may be well to measure out a certain number of drops rather than apply an indiscriminate quantity. The writer has used the paste composed of paraform, thymol, oil of cloves, and oxide of zinc, in the treatment of septic roots, and also for filling the canals after cleaning them out, but found that it discoloured front teeth. Glycerine, or glycerine and carbolic, was then substituted for the oil of cloves, and this has caused no discolouration. Creosote, as an ingredient of a formaldehyde paste, has also discoloured the front teeth in the cases in which the writer has tried it.

The following extracts are taken from a paper by Mr. B. J. T. Bennette, published in the *Dental Record*, October 1905 :—

"Formaldehyde approaches more nearly to the ideal antiseptic than any other agent we possess. . . . It has the property of uniting with nitrogenous and sulphuretted products of decay and fermentation, forming products which are in themselves sterile and in the majority of cases antiseptic, all odour being destroyed permanently. Bacteria and micro-organisms generally are albuminoid in nature, and so is their food supply in the main; thus formaldehyde, by uniting with them, destroys both bacteria and also the possibility of their existence. In this is manifest the vast superiority of this drug over mercuric chloride, carbolic acid, and the essential oils, with the possible exception of oil of cinnamon in the back teeth (this is so very good and effective that it will be a long time before its use is abandoned). It must be pointed out that formalin is only a quarter as potent an antiseptic as mercuric chloride—that is to say, in the penetration of soft tissues; but its power of penetrating hard tissue such as dentine renders it really superior in the treatment of teeth, besides which it causes no discolouration as does the mercury salt. There is no doubt that the bichloride of mercury is the most potent antiseptic and also germicide, but in the presence of serum albumen the efficiency of its solution is destroyed."

The addition of tricresol to formalin was introduced by Dr. J. P. Buckley of Chicago, and the treatment with this preparation was described in the *Dental Cosmos*, May 1906. Oil of geranium, or the essence of geranium, and formalin, has been used —principally in France. The following prescription was given in the *Dental Cosmos*, January 1903, as valuable for disinfecting canals from which the whole of the septic matter was not removed:—

℞ Formalin, ♏x.
Oil of Geranium, ℥j.
M.

Sig.—Apply on cotton, and leave in canal for twenty-four hours.

Formaldehyde is, however, such an efficient disinfectant and antiseptic that, as far as the *treatment* of septic roots is concerned, it seems unnecessary to combine anything with it, unless the addition of one or more other agents reduces its irritating properties without materially affecting its germicidal and antiseptic action.

Some of the essential oils are valuable in the treatment of septic roots, and beechwood creosote (which is one of the oldest remedies) has given the writer good results. The oil of cinnamon or the oil of cassia proved, in the writer's experience, to be decidedly better than the best of the other oils, although cassia and cinnamon are far more irritating if accidentally forced through the apex, and far more likely to discolour the teeth. A slight change of colour which is unnoticeable in a molar or a bicuspid is very marked in an incisor or canine, and, except for the treatment of a root preparatory to crowning it, neither cinnamon nor cassia oil should be used in the front teeth.

Careful manipulation will prevent irritation, and —all experiments to the contrary—there are few germicides that can be satisfactorily used in root-canals which will not cause more or less irritation in certain cases if accidentally forced through the end of the root. Oil of cloves, for instance, which is stated to be non-irritating, has caused trouble in this respect in some instances, and although this oil is considered an efficient germicide and antiseptic, the writer has always found that the desired result was only obtained after several more dressings than were needed with oil of cassia. The antiseptic properties of a number of agents were tested by Dr. Black, and an important table of the results obtained was published in the *Dental Cosmos,* April 1889. One in 4000 parts of oil of cassia, and 1 in 2000 of oil of cinnamon proved to be effective. The increased demand for oil of cassia caused it to be adulterated, and later tests made by Dr. A. K. Peck, published in the *Dental Review,* August 1898, showed that its antiseptic value was reduced. Dr. Peck's tests show the smallest quantity of the various agents tested which proved to be antiseptic, viz. in which they will prevent the development of germ life: oil of cassia, 1 in 2233; oil of cinnamon, 1 in 2100; beechwood creosote, 1 in 1280; oil of cloves, 1 in 1150; oil of peppermint, 1 in 875; Dr. Black's 1, 2, 3 (viz. 1 part oil of cassia, 2 parts carbolic acid, 3 parts oil of wintergreen), 1 in 450; eucalyptol, 1 in 116. Eugenol and oil of wintergreen were both useless as dental antiseptics, and oil of eucalyptus only restrained the development of bacteria when a saturated solution was made with the infected bouillon with which the tests were made. Carbolic acid was antiseptic, but not permanently so—1 in 338.

Dr. Harlan pointed out, in a paper read before the Odontological Society of Great Britain in 1887, that when antiseptic essential oils are introduced into a cavity in a live tooth, and sealed therein, they slowly deposit vapourisable camphors which are potent antiseptics. "The same camphors are likewise deposited when the oil is sealed in the root of a tooth. It is on this account that they so readily and certainly disinfect polluted dentine. . . . They are sparingly soluble in water, and on this account are not contaminated by saliva, food, or other foreign substance. The camphors which are deposited, when brought in contact with the slightest quantity of water, saliva, or blood serum, are vapourisable as soon as formed. At a temperature of about 94° F. their extreme volatility permits them to thoroughly impregnate the dentine. The vapourisable camphors are the agents which disinfect the so-called blind abscesses, even where the oil is not introduced into the root of a tooth farther than the pulp-chamber, where it is sealed only moderately tight."

A method of procedure (based on Dr. Harlan's) adopted by the writer for several years, is, at the first sitting, to open up the tooth, clear out the pulp-chamber (or bulbous portion of the dead pulp), place in it a ball of cotton-wool saturated with the oil, and fill with temporary gutta-percha, making two or three small holes through the filling to the cotton-wool for the escape of the gases of putrefaction. At the second sitting, the canals are partially or wholly cleansed, and the oil worked into them, taking great care to avoid forcing anything through the apex. At the third sitting, complete the cleansing of the canals (if this has not been done at the previous sitting), place twists of cotton-wool, saturated (but not dripping) with the oil, loosely in them, or work some oil in with a broach if the canals are too fine for the cotton-wool, and fill as before, only this time make no holes in the filling. If the tooth is perfectly comfortable for three days, the roots may be filled and the case completed.

Should any trouble arise between the third treatment and the completion of the case (which will rarely happen unless some of the oil has been forced through the apex), making one or two holes through the gutta-percha gives relief. This simply means that the tooth is not completely sterilized, and one or two more dressings will be necessary.

Obstinate cases which have resisted the oil of cassia have often been successfully completed with creosote, but all these slow-acting agents require a vent in the temporary filling until such time as the canal appears to be sweet. It seems that until the canal and the dentine are disinfected, or almost disinfected, a gas will form and cause pain by pressure on the tissues beyond the root if the canal is tightly sealed up. Care should be taken to insert the temporary filling with no direct pressure towards the canal or canals, as this may force either the oil or some of the contents of the canal through the apex just as the ball of rubber acts in "pressure anæsthesia," and in opening up a septic tooth it is quite possible for the engine bur to act in the same way, unless this is appreciated and care taken to avoid it.

It would serve no good purpose to mention all the remedies or antiseptics that have been used with more or less success in the treatment of teeth. It is also impossible to say how any particular case should be treated without examining it and perhaps handling it. If time permits and the rubber dam can be applied without discomfort, probably the sodium-dioxide method, opening up the canals, if necessary, with 50 per cent. sulphuric acid, or the potassium and sodium method is the best, followed by such after treatment as may be necessary for periodontal inflammation or abscess. If the circumstances as to time or other conditions do not admit of the application of either of the above-mentioned methods, and there is nothing which appears to contra-indicate the use of formaldehyde, this agent may be at once sealed in the tooth, and in a day or two the canals cleared with instruments and re-treated, or the case completed, as seems good. In other cases the oil of cassia or cinnamon may be used in molars or bicuspids, and an oil that is not likely to cause discolouration—such as oil of peppermint—used in front teeth. If the canals of the front teeth are sufficiently large, and there is no periodontal trouble which renders the manipulation painful, the canal may at once be cleaned with a fine broach wound round with cotton-wool frequently dipped in peroxide of hydrogen, removing the infected wool and re-winding the broach with a fresh supply before dipping it in the agent. When the canal is clean, a dressing of oil of peppermint may be applied; but the tooth should always be loosely filled, or the temporary filling vented, until such time as the temporary root-filling of cotton-wool is found to be perfectly sweet when removed. It is usually unnecessary to vent the temporary filling if a canal is treated with sodium dioxide, potassium and sodium, or formaldehyde.

The mechanical removal of the contents of a root is usually effected with the barbed instruments known as the Donaldson canal-cleansers, or by means of the various forms of drills or reamers that are used for enlarging canals. The writer has always been prejudiced against the use of drills or reamers because they might break in the root-canal. It is often extremely difficult and sometimes impossible to remove the head or end of the reamer if an accident of this kind occurs. A dentist is dependent on the manufacturers for the quality of his instruments, and it is easy for excellent steel to be injured during either the forging or the tempering. On three or four occasions the writer has found such an apparently strong instrument as a Talbot or a Williams reamer break in a root that was being prepared for a crown, notwithstanding that no force was used; on the contrary, they have broken when used with great care and delicacy and there was nothing to cause a sudden catch or jamming of the reamer in the root.

Few if any dentists who habitually ream out canals before filling them can say that they have never broken a delicate flexible reamer in a root. In addition to such an accident as breaking the instrument, the side or the end of the root may be perforated. This can be avoided by using instruments with blunt ends which act as reamers and not as drills. Care must be taken, however, not to use the larger reamers in roots of small diameter, or in roots that are much flattened. In these cases the side of the instrument may cut through the side of the root.

The Beutelrock "nerve-canal" drills are less likely to break than some makes. It is stated that they are not tempered with heat, but hardened, toughened, and rendered elastic, by pulling or twisting the cold steel to shape. The writer has used these instruments during the last two years with considerable satisfaction. The finest size will enter a small canal and reach the apex even more readily than the finest smooth steel bristle. These Beutelrock "nerve-canal" drills are twist-drills, and as supplied they have sharp cutting ends which readily perforate either the side or the end of the root. The ends should therefore be carefully blunted on an oil-stone. In doing this the object to be accomplished is the production of a point or end which will not cut, and which at the same time will not interfere with the free passage of the instrument into the canal. It is well to examine the point while it is being blunted, and to try it on the handle of an old tooth-brush in order to *know* that it will not cut under pressure when revolved in the dental engine. It must not be presumed that a Beutelrock reamer will never break in a root-canal. Like all delicate instruments, they should be handled as lightly and carefully as possible, and as steel is known to break more easily in cold than in warm weather, it is advisable to dip them in warm water on cold days.

In the majority of cases root-canal reamers can be used more delicately and accurately if the right-angle or contra-angle handpiece is attached to the dental engine. It is always advisable to so extend the cavity of decay that the reamer enters the canal as straight as possible. It may be mentioned that it is just as easy to force some of the contents of the canal through the apex with a reamer as with any other instrument that is used for probing or cleaning a canal, and if a fine bristle will pass through the apical foramen, a fine reamer may also do so. It is quite possible for the foramen to be enlarged with a blunt-ended reamer without the operator being aware of it. The length of the canal should be measured with a fine probe and indicated by slipping a small disc of rubber dam on the reamer.

Filling Root-canals.—This is a subject that must be carefully approached, for the differences of opinion that exist are many and various. Some operators go so far as to say that if the whole of the root is thoroughly sterilized it is of little or no moment whether the canals are filled or not, providing the foramen at the apex is of normal size; and that if the orifices of the canals are sealed with the tooth-filling proper, these cases will prove just as satisfactory as if the canals were filled. By way of presenting this subject from various points of view, the following extracts are taken from a paper by Mr. F. Coleman, M.R.C.S., L.R.C.P., L.D.S. Eng., read before the Royal Dental Hospital Students' Society.[1]

"The following reasons seem to contra-indicate such treatment:—

"1. The filling of roots is an impossibility, except perhaps in single straight-rooted teeth, and even then I doubt whether the root is ever filled flush with the apex, an impossibility with the tooth out of the mouth.

"2. Granting that a tooth is filled theoretically flush with the apex, how long will it remain so when the ends of the root become absorbed, as almost invariably occurs in pulpless teeth?

"3. Should subsequent inflammation passing on to suppuration arise at the apex of the tooth, how is one to remove such a root-filling and allow of drainage without a great deal of trouble, and danger in finally pushing the last piece of material through the apex, if it does not already protrude there owing to subsequent absorption?

"4. Filling roots if accomplished requires a large amount of care and time, but this would not be grudged if there were any corresponding benefit to be gained; it adds to the amount of manipulation, and so to the increased chances of introducing sepsis.

"Should an abscess form in connection with a tooth the canals of which have been left open, it is a very simple matter to remove the filling from the cavity and pulp-chamber, which if done early will allow of immediate drain-

[1] *Dental Record*, August 1906.

age, and relief to the patient. A light dressing is then inserted in the canal to act as a wick, and allow any discharge to trickle away, and at the same time prevent the entrance of food. The tooth should on no account be filled until all inflammation has passed off, and should then be only temporarily sealed, and later, if remaining comfortable, a more permanent filling may be inserted, and one is not working in the dark as must be the case when a root-filling of doubtful depth has first to be removed.

"What the final pathological condition is of teeth, the canals of which have not been filled, I am unable to say, as, so far, I have not had to remove any teeth so treated.

"As a pulpless tooth is a pathological, and not a normal structure, it is difficult to say what the final condition would be, there being no similar analogy in surgery.

"Probably the canals remain empty, and, if clean, do not give rise to any further trouble, although absorption of the ends of the roots takes place as when the roots are filled.

"I do not know that there is any disadvantage beyond, perhaps, a theoretical one, in the canals being empty, provided that they remain sweet, and where pulpless teeth give rise to subsequent inflammatory trouble, the advantage in the canals remaining patent will be greatly in their favour for treatment.

"Teeth, the roots of which have been filled, will frequently remain comfortable for many years to the patient, but, unfortunately, they are not so to the tissues, and if the gum around such a tooth be carefully examined, in a large number of cases a small sinus will be detected in the region of the apex of the tooth, often guarded by a minute button-like granulation.

"The sinus frequently has a slit-like appearance, and may only become apparent when the cheek is stretched away from the gum, making the latter taut. Although such a sinus acts as a safety-valve, and may be harmless, and in any case is preferable to the infiltration of exuded material, still, I claim that the tooth itself, through its canal or canals, is the better and more hygienic way of ridding the tissues of any inflammatory trouble.

"Pulpless teeth cannot be restored to healthy organs, whatever sort or kind of root-filling is used, and must be looked upon as foreign bodies, although not of a very irritant nature; if put under the best conditions, they form useful plugs upon which to masticate, and often save the necessity of wearing plates; and if their canals are left open, so that from time to time, should they cause any inflammation and exudation, the latter can easily be got rid of by removal of the central plug, or stopping, which acts as a safety-valve, the irritation they cause is then reduced to a minimum.

"Any elaborate treatment of pulpless teeth is not appreciated by the tissues, and only helps to form an additional foreign body."

Many of the ablest and most experienced dentists hold that the canals should be solidly filled to the apex, and that every effort should be made to enlarge fine canals sufficiently to enable this to be thoroughly done. The theory of solidly filling canals is that moisture will find its way into the root from the tissues surrounding the apex, decompose there, and produce septic conditions. Another very practical point of importance is that if decay should again attack the tooth, or for any reason the tooth-filling proper should fail, a solid root-filling will prevent decomposable or infectious matter finding its way into the canal from the mouth. There is no doubt that solid root-fillings have enabled many roots to be successfully crowned after loss of fillings from subsequent decay that would otherwise have become so infected and decayed that extraction would have been necessary. Theoretically and practically, therefore, root-fillings of a solid nature are useful. As against this, we have to consider the uncertainty of knowing the exact condition of the periodontal membrane, and it is safe to presume that a periodontal membrane that has once been more or less seriously inflamed may at any future time give trouble. It is well known that venting the canals is not only the promptest but often the only means of relieving periodontal trouble, and it is also well known that re-treating a canal will often enable a tooth to be comfortably retained.

Now, the venting and re-treating of a canal depends on the removal of the root-filling ; and just in proportion to the solidity of this filling and the thoroughness with which it has been inserted, so will the difficulties of its removal be increased; indeed, in many cases the safe removal of a solid root-filling is an impossibility. The writer has, on many occasions, removed root-fillings for the relief of pain, and found the canals clean and perfectly sweet. He could attribute the trouble to no imperfection in the root-filling, or to any decomposition in the canals. Venting these canals gave relief, and the teeth were afterwards satisfactorily filled, as far as absence of pain or discomfort were concerned. In some cases the roots had been filled with gutta-percha; in others, with cotton-wool, which, on removal, was found to be impregnated with the odour of an antiseptic. These cases in many instances had been originally treated and filled by other dentists, and the patients consulted him for relief because they were away from home and could not consult their regular dentist.

Personal experience, thus backed up by cases from the hands of others, as well as a perusal of literature on this subject from the pens of some of the most experienced and skilful treaters of teeth and fillers of roots, makes the writer hesitate to use solid root-fillings, especially after experiences of many hours spent in removing them, and many failures to do so. Bearing in mind that the removal of root-fillings is occasionally necessary, no matter how carefully and well the case has been treated, and also bearing in mind that so many of these cases show absolutely sweet canals, when only cotton-wool and an antiseptic have been used, one is forced to the conclusion that the insertion of root-fillings that are troublesome to remove, or, it may be, impossible to remove, is, generally speaking, an unwise practice. Some of the ablest dentists have said that the removal of a solid root-filling need not be considered. If future trouble arises, it should be dealt with from the outside, either by forcing an abscess to form and discharge through the gum, or by drilling or cutting through the alveolar process. The former method is uncertain and subjects the patient to days of suffering; the latter brings dentistry within the region of oral surgery, and no matter how desirable this may be from a dentist's point of view, it is neither desired nor appreciated by the public. There is, however, no good reason why all canals, into which a filling can be introduced, should not be filled in some way. The late Dr. Flagg pointed out that raw cotton-wool (not the absorbent kind) is practically impervious to moisture if carefully packed into a root-canal, and it can be readily removed if necessary. Antiseptic pastes may be used with advantage either alone or in connection with absorbent or non-absorbent cotton-wool. The most popular solid root-filling is gutta-percha. The following very clear description of the technique of applying it is taken from the article by Dr. Rhein in the *Dental Cosmos* that has already been quoted from:—

"The canals are then thoroughly dried with heated air, a few wisps of cotton are wound around a Swiss broach, and this is dipped in the oil of eucalyptus and passed to the ends of the dried canals. The canals are again dried with heated air, which forces this varnish of eucalyptus oil into the tubuli. The Swiss broach wound with its wisp of cotton is now dipped in a solution of base-plate gutta-percha and chloroform, and this in turn is carried to the ends of the respective root-canals.

"From a bath of 10 per cent. formaldehyde, a cone of gutta-percha of suitable diameter is now taken and placed in one of the canals. A root-canal plugger is then dipped in pure alcohol and passed through the flame of the alcohol lamp, which in igniting the alcohol not only warms the plugger but thoroughly disinfects it before it enters the root and presses the gutta-percha cone down to the end of the canal. Sufficient gutta-percha having been placed in the respective canals and the plugger wound with cotton wet in chloroform, it is now used to pack the gutta-percha to the bottom of the canals in one solid homogeneous mass. The object is attained when the patient feels slight pressure at the end of the root, which denotes that the liquid gutta-percha is penetrating the foramen.

"A minute amount of gutta-percha, causing the most imperceptible irritation to the soft tissues, cannot be considered in the light of an irritant if the operation has been attended with due consideration to aseptic surroundings. Its well-known compatibility with the soft tissues renders it the most suitable material for this purpose. The end of the root is now hermetically sealed, and, in order to provide against any infection from without, the gutta-percha is covered with a cement of zinc oxychloride; over this any other operation may be proceeded with."

It has often been proved that gutta-percha does not produce a moisture-tight filling when packed into a cavity in a tooth, and certain experiments have been made which showed that neither gutta-percha nor any other material that was tested produced a root-filling that was moisture-tight, with the exception of oxychloride of zinc. It has been stated that a moisture-tight gutta-percha filling can be made in an ordinary cavity if a varnish of rosin dissolved in chloroform is first applied, and a method of overcoming the shrinkage or permeability of a gutta-percha root-filling was suggested by Dr. Goble in *Items of Interest*, April 1894. Dr. Goble dissolved equal parts of rosin and gutta-percha in chloroform, filled the canal with this, and then introduced a gutta-percha point. He claimed that this produces a moisture-tight and gas-tight filling, and that the rosin is in itself antiseptic. As far as the use of chloro-percha in connection with gutta-percha points is concerned, the writer filled the roots of several extracted teeth with a solution of gutta-percha in chloroform and then inserted gutta-percha points. In nearly every case he was surprised at the amount of chloro-percha that was forced through the apices of the roots.

Oxychloride of zinc makes an excellent solid root-filling, so solid that its removal may be considered practically impossible. The writer has found it to be a difficult material to properly fill canals with, even if it is incorporated with fine twists of cotton-wool. It is necessary to mix it thin, and if the root is filled to the apex some of the material usually passes through the foramen and causes a good deal of pain. This may be prevented by first sealing the apex with a small piece of gutta-percha, or a small ball of cotton-wool; but, unless a canal is very much enlarged, it is extremely difficult to accurately pack either a small piece of gutta-percha or a small piece of cotton-wool against the end of the canal.

Gold is now rarely used for filling roots, although some hold that it is the best material for sealing the apex before inserting a plastic substance such as oxychloride of zinc. One or more small pieces or pellets of non-cohesive gold are generally used if this procedure is adopted. The writer has had the roots of a first lower molar in his own mouth so reamed out (two canals in the anterior root) that several strips of cohesive gold were introduced into each canal and consolidated with a hand-mallet in the manner that an ordinary cavity is filled. The upper part of the canals and the pulp-chamber were then filled with oxyphosphate of zinc. This is, however, exceptional practice, and outside the range of all ordinary and doubtless equally good methods. Points made of wood, lead, and tin, have been forced or driven into root-canals. The adaptation is usually so imperfect that the roots might as well be left unfilled, and the removal of these points is generally difficult, if not impossible. Gold wire has been successfully used in connection with oxychloride of zinc, and the writer does not see why a wooden point should not be satisfactorily used in connection with some plastic material, bearing in mind that this may produce a filling that will be difficult or impossible to remove.

Sixteen years ago the writer treated the septic roots of the left upper central and lateral incisors for a girl aged about thirteen; they were then filled with an antiseptic paste, and orange-wood trimmed to a suitable-sized point was driven into each canal. The cavities were then filled with gold. Some one had previously filled these teeth with amalgam, and they were darker in colour than the other teeth. This worried the patient as she grew older, and she finally decided to have the crowns removed and replaced with artificial ones. This was done two years ago. The roots, which had never given any trouble since they were filled, appeared to be in perfect condition. The wood was dry and sweet. It had evidently been permeated by the paste, and appeared to be accurately filling the canals. It had become decidedly softer, and was easily cut out with a Williams reamer to a sufficient depth for the reception of the posts for the all-porcelain crowns which were then placed on the roots.

"One swallow does not make a summer," and the writer is unable to quote any other cases, for although he may have used this method in a few other instances, he has neither notes nor recollection of them. Successful as this case was, an improvement could probably be effected by keeping ready trimmed sticks of wood in some suitable antiseptic, such as creosote or oil of cloves. This would increase the antiseptic property of the root-filling by adding to the paste the antiseptic already absorbed by the wood. It is hardly necessary to mention the necessity for carefully measuring the canal and marking the stick of wood so that it can be driven up to the apex and jammed against it without passing through. The surplus stick is then readily twisted off, and any part that projects from the orifice of the canal is easily cut away with an engine bur.

Antiseptic Pastes.—For a considerable time iodoform was held to be an indispensable ingredient in any paste that was used for filling root-canals. Laboratory tests have proved that iodoform possesses little or no antiseptic properties. It has been stated that although it has no effect on germs, it possesses the power of neutralizing ptomaines and thereby supplements the employment of a germicide. Clinical experience has proved that if the roots of teeth are properly sterilized, an iodoform root-filling keeps them in good condition for an average length of time that few if any other medicaments can equal. There is every probability that but for its disagreeable and persistent odour, which permeates the operating-room and clings to the hands, and garments of the operator if it accidentally comes in contact with his clothes, this agent would be largely used to-day in the practices of those who have proved its worth. A paste made of iodoform, glycerine, tannin, and oxide of zinc was at one time a well-known preparation. Various mixtures were made with antiseptics, such as creosote. Mr. T. Mansell had a record of eighteen years' very successful use of a paste made by mixing iodoform with oil of cinnamon; the only drawback, which finally caused him to discontinue it in favour of one of the more modern formaldehyde pastes, was its tendency to discolour the teeth. At the present time pastes containing formaldehyde are popular, but, as already pointed out, no antiseptic or other ingredient which possesses the power of discolouring the teeth should enter into the composition of this paste if it is to be used in the front teeth. Formaldehyde in itself does not discolour teeth, but the writer is of the opinion that in some way or other it possesses the power of causing such agents as oil of cloves or creosote to bring about a discolouration which they might not do if used alone. In filling a root with such a plastic substance as an antiseptic paste there is great risk of some of it passing through the foramen at the end of the root, and this is particularly likely to happen if the paste is well forced home with twists of cotton-wool.

No one who desires to fill a canal contents himself with merely smearing its sides, and an antiseptic paste is usually used in connection with cotton-wool and by this means packed into the canal, or else after working it in with a fine probe, the surplus at the orifice is wiped in with a ball of cotton-wool, which produces a sufficient piston-like action to drive the paste into a homogeneous mass in the canal. Any one who has filled the roots of extracted teeth in this way will realise the practical impossibility of filling the canal without some of the paste often passing through the foramen.

Formaldehyde, because of its penetrating and rapid-acting properties, is an excellent ingredient of an antiseptic plastic root-filling, because it will destroy any germs which may have been left alive in the dentine after the supposed complete sterilization of a root. Thymol is a valuable ingredient, because, although it acts very slowly, it is a very persistent or permanent antiseptic which may be relied upon to maintain the root in an antiseptic condition for a long time; but formaldehyde in any form is very irritating to the soft tissues, and thymol is not entirely free from irritating effects unless largely diluted, and therefore, in view of the liability of some of the paste to pass through the apex, it is doubtful if a formaldehyde-thymol paste is an ideal preparation for filling root-canals, notwithstanding the many instances in which it has been successfully used.

The ideal plastic, or readily removable antiseptic root-filling, should possess the following qualities: (1) it should be a good antiseptic; (2) it should be permanent, or so lasting that its antiseptic properties will not become absorbed or disappear for many years; (3) it should be absolutely non-irritating to the soft tissues; (4) it should possess soothing and healing properties so as to exert a beneficial effect on a recently inflamed, or impaired periodontal membrane; (5) it should not discolour the teeth; (6) it should be sufficiently miscible with water to readily pass to the apex of root-canals which after careful drying still contain some moisture.

The writer regrets that he is unable to give a prescription for such a paste, because he does not know of one which answers to all the above requirements, but he begs to suggest that oil of peppermint, boro-glyceride, and oxide of zinc will form a paste that is antiseptic, non-irritating, healing, and easily introduced.

The value of 50 per cent. sulphuric acid for opening up fine, or obstructed, canals has been mentioned. The late Dr. Flagg advised iridium-platinum or platinum-gold probes for applying this agent. It is difficult to apply by means of a probe alone — particularly to upper teeth — unless the cavity in the tooth is flooded with the acid to the detriment of the tooth structure. Asbestos fibre wound round a fine probe has been recommended for conveying the acid to the canal, as absorbent cotton-wool is rapidly destroyed. The use of aqua regia (nitrohydrochloric acid) was advised in preference to sulphuric acid by Dr. F. T. Hayes.[1] Aqua regia does not destroy cotton-wool, and can be carried to place with a steel instrument wrapped round with the wool. In addition to opening up canals, the acids will often remove obstructions which block the apical foramens. This enables a fine steel bristle—which would not otherwise do so—to pass through the foramen in a case of blind abscess and allows the pus to escape to the great relief of the patient.

If much degeneration of the periodontal membrane exists, the use of germicides, cauterants, and the most careful use of any kind of root-filling will fail to restore the diseased part to health; an improvement in the conditions is all that can be hoped for. It is astonishing, however, how long a tooth that was badly diseased at the time its treatment was commenced may be comfortably retained in the mouth and serve as a useful organ of mastication. It has been stated that all pulpless teeth slowly but surely degenerate. Dr. Thomas of Philadelphia, who practises the extraction of teeth as a speciality, finds that sooner or later all "so-called dead teeth" fall a prey to the forceps, but that careful treatment usually postpones this for a long time. Much depends on the health or constitution

[1] *Dental Cosmos*, December 1900.

of the patient. The exact condition of the affected parts cannot be ascertained while the tooth is in the mouth, although some who are expert in using the X-rays and in reading the pictures have obtained great assistance in diagnosing their cases.

All teeth will not respond to treatment, but the careful application of appropriate remedies is usually followed by good results. Those dentists who treat and fill all pulpless teeth that appear to be worth saving, find that a very great majority are by means of the treatment comfortably and usefully retained for a long time, and although it is impossible to accurately gauge the life of any individual pulpless tooth, or to expect that every case will progress favourably, the success and practical value of root treatment and filling is beyond question.

APPENDIX

NOTE BY PROFESSOR SMITHELLS

ON DETERMINING THE SPECIFIC GRAVITY OF GOLD FILLINGS

THE YORKSHIRE COLLEGE, LEEDS.

WE have found it impossible to make any accurate and useful determinations of the "dental" specific gravity of your plugs by simply weighing in air and then in water. The plugs are more or less porous, and as the water gradually enters the pores the apparent weight alters. After a number of different trials, we settled on the following method, which has given satisfactory results:—

The fillings were first made impenetrable to water by heating in vaseline to 100° C. for ten minutes. When the vaseline had cooled to the temperature of the room, the fillings were removed and thoroughly polished with fine linen. The *volume* of each impenetrable filling was calculated from the difference between its weight in air and its apparent weight in water. The vaseline was removed from the fillings by treatment with petroleum ether in a Soxhlet apparatus for three hours. After removal of the petroleum ether by heating to 100° C., the fillings were weighed. Having thus measured the volume of the filling and determined its weight, we get at once the "dental" specific gravity.

ARTHUR SMITHELLS.

December 1903.

DR. BRISLEE'S METHOD (*a*)

FOR DETERMINING THE EXACT PROPORTIONS OF MERCURY AND ALLOY FILINGS FOR MAKING AMALGAM FILLINGS

In connection with amalgams, there is the very important question of the right quantity of mercury to use in order to obtain the best results. A possible method for determining this extremely important factor is based upon the same principle as that used by Müller-Erzbach for determining the composition of certain salt-hydrates —viz. the pressure of the water vapour over salt-hydrate and pure water. Consider the experimental arrangement shown in Fig. 51.

A glass H-shaped vessel, containing pure water in one limb, and a little tube containing the hydrated salt in the other limb. Now supposing the apparatus to be connected to an air-pump at A, pumped out, and then sealed off. The water present in each limb exerts a certain definite pressure, and if the pressure of the water vapour above the hydrated salt is less than that above the pure water, then water will distil from B to

C; if the reverse is the case, from C to B; and finally, if the pressure at B is equal to that at C, then there will be no change. If the water is replaced by pure mercury and the salt by the amalgam chips or amalgam, then we can find in what proportion the fillings must be mixed with mercury in order that the pressure of the mercury vapour above the mercury is equal to that

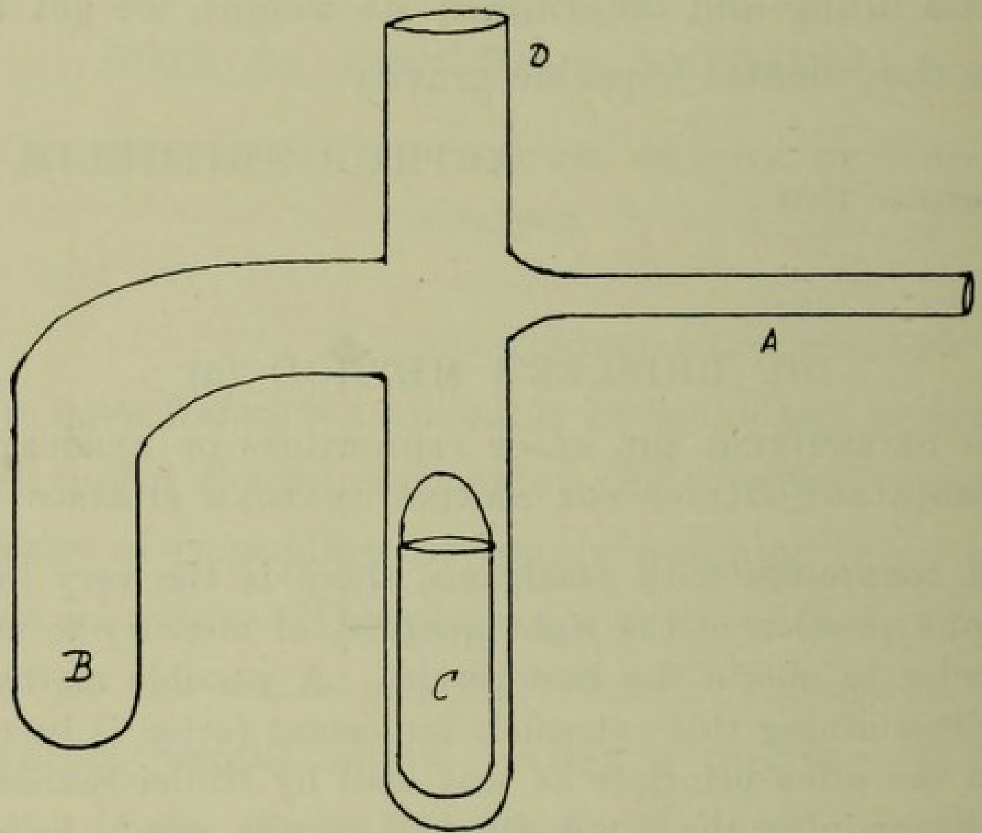

FIG. 51.

above the amalgam at the temperature of the mouth, seeing that the whole apparatus can be immersed in a bath of water maintained at the temperature of the mouth. Now the results of such experiments show the maximum quantity of mercury which can be safely used under the conditions named. Further, the knowledge of the correct amount of mercury requisite to form the compound with alloy would lead to uniformity in results, and fillings placed in the same mouth would have uniform composition, the electrical actions would be minimised. The determination of the correct quantity of mercury, as outlined above, is accompanied by no serious experimental difficulties, the only objection being the length of time which elapses before the equilibrium is established, and this varies from a week to two months, according to composition of the filling. Owing to this I have been unable to determine the mercury factor for many fillings, but I have made a number of experiments

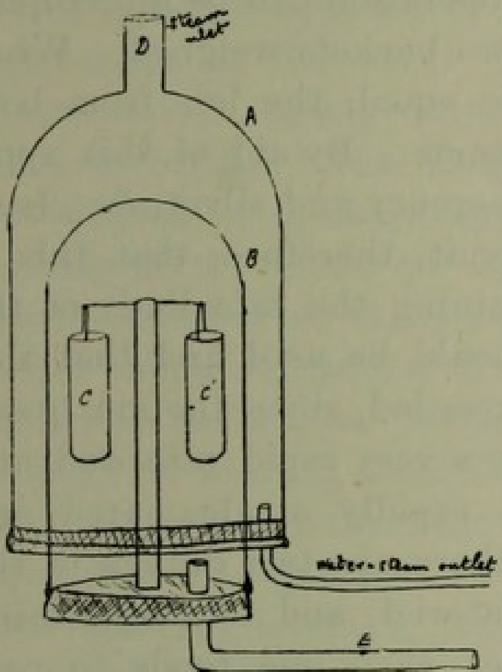

FIG. 52.

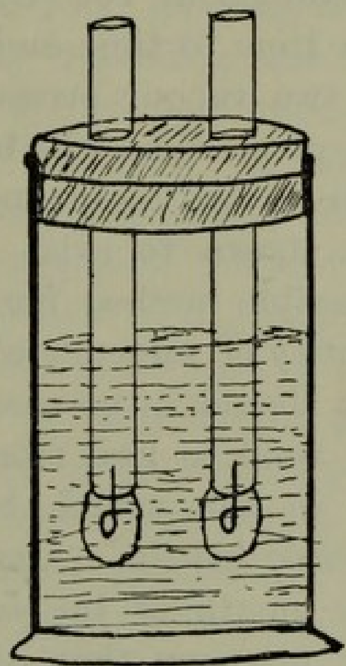

FIG. 53.

in the way just described, only at 100° C. instead of the body temperature. An amalgam which is stable at 100° C. will not tend to give up mercury at the temperature of the mouth. The apparatus which serves even more conveniently than the one described for working at 100° C. is one due to Ogg; who first applied the methods of Müller Erzbach to amalgams. Fig. 52 shows the apparatus designed by Ogg.

The apparatus consists of an outer wide glass tube A, which surrounds the tube B; the tube B passes through a cork, and the space can be kept at a constant temperature of 100° C. by passing in steam through D. The tube B is closed by a well-fitting rubber stopper which carries a glass upright on to which two little glass buckets C and C^1 are hung. The stopper is pierced by another hole through which passes the tube E, which is connected with an air-pump for the purpose of exhausting B. The amalgam is placed in one bucket, the mercury in the other, the apparatus exhausted and steam blown in at D whereby the mercury and amalgam are maintained at 100° C. The operation can be interrupted from time to time and the two buckets weighed. When the two vapour pressures are equal, the loss from both in a given time will be the same. By aid of this apparatus certain compounds of mercury and silver, &c., have been shown to exist. I submit, therefore, that this is a possible method for determining the safe limit of the quantity of mercury which should be used and that this limit should in no case be exceeded, since the amalgams then tend to lose mercury at a very rapid rate and any gold in the mouth becomes rapidly amalgamated and rendered brittle. Again, if there are two fillings in the same mouth of the same material, and one containing more mercury than the other, then one tends to part with mercury and the other to take up some, and hence, neither will behave as it ought in point of stability and durability. The results of the experiments which I have made so far show that for good-class fillings such as Ash's Imperial, best and second qualities, rapid and slow setting, C.A.S. alloy and the D.M. Co.'s alloys, the safe limit is about 40–45 per cent. of mercury, and the amount should be kept as far below this limit as is consistent with the satisfactory working, and this safe limit should be determined for each particular material and marked on the bottle.[1]

[1] *Dental Record*, June 1907, pp. 284–286.

THE RAUHE PNEUMATIC MALLET

Various forms of pneumatic mallets have been invented. The simplest are those in which the blow is produced by applying foot-pressure to an india-rubber ball which rests on the floor and is connected with the instrument by means of an india-rubber tube. The Rauhe mallet is manipulated in this way. Pressing on the ball with the foot drives a metal cylinder or plunger from one end of the instrument to the other one, and releasing the foot-pressure immediately draws back the plunger ready for the next stroke. The strength of the blow depends on the amount of pressure applied with the foot, and the rapidity of the blows on the movements of the foot. A greater number of blows can be struck in a given time with a pneumatic mallet of this description than with an automatic mallet, but not so many as with a light hand-mallet. If desired, from 200 to 250 blows a minute can be given with a pneumatic mallet manipulated with foot pressure. The speed with which a good gold filling can be made does not, however, depend so much on the rapidity of the blows as on their efficiency and accurate application. The efficiency of the blow delivered with the Rauhe mallet —even when light force is used—is in some measure due to the shortness of the pluggers. By reason of this the blow received by the base of the plugger is transmitted to the gold with no appreciable loss of energy. The shape of the base of these pluggers and the manner in which they are pivoted to the mallet-head enable efficient mallet force to be applied to the gold with pluggers bent at an angle of forty-five degrees, at a right angle, and at a reverse or back-action angle. This is effected by pivoting one side of the base of the plugger to the mallet-head, and delivering the blow at the other side. The illustrations (Fig. 54) show some of the most typical plugger-points supplied with this mallet and their positions when placed in the instrument. The manner in which the blow is conveyed to the base of the plugger is also indicated. In order to place the pluggers in the mallet-head the sliding rod, or pivot, is pulled out with the finger-nail as far as it will come. The base of the plugger is then placed in the slot in the mallet-head and the pivot-rod pushed back to place. Care must be taken to see that the projection on

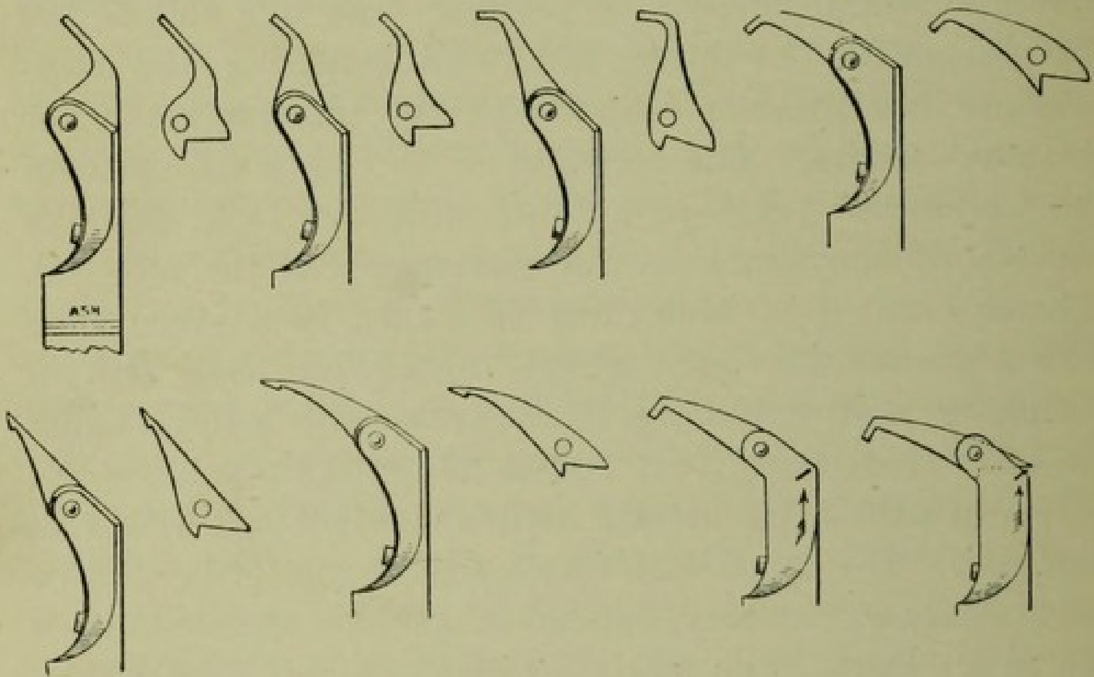

FIG. 54.

the plugger base is placed over the side of the spring in the mallet-head ; if this is not done, the plugger will swing loosely in the slot and cannot be used easily and to the best advantage.

At first it will not be found easy to fix the plugger in the correct position in the slot. There may be a little difficulty in placing the projection over the spring and bringing the hole in the base of the plugger exactly opposite the pivot-rod. Sometimes in sliding the rod into the hole in the plugger it will be found that the projection has slipped over the side of the spring. It is then necessary to try again. This little matter is mentioned in order that the proper adjustment of the plugger may be appreciated. When a new latch lock is placed on a door, it is always more or less difficult at first to easily and quickly adjust the key. In a short time this becomes an automatic proceeding.

Some of the plugger-points supplied with this mallet are too deeply serrated. The writer is informed that this is in response to a demand for deep serrations. Mr. Rauhe himself uses only either smooth or very finely serrated points, and the writer has removed these deep serrations by completely grinding them away. Quite apart from the distinctive features of the Rauhe mallet, which, as above described, enable angle mallet force to be efficiently applied, the writer finds that a pneumatic mallet enables a rubbing or burnishing blow to be applied to the best advantage, inasmuch as this kind of mallet enables the rubbing blow to be given in any direction, viz. forwards, backwards (pull blow), or sideways with equal efficiency. Judging by applying various mallets with varying strengths of blow to his own teeth, the writer finds that the Rauhe mallet is one of the least disagreeable, and particularly so if firm pressure is applied at the moment that the blow is delivered. Experiments made by the writer in the steel block alluded to in the chapter on filling teeth convince him that the Rauhe mallet is a practicable instrument for obtaining good results with angle pluggers used with mallet force, and the use of angle pluggers with mallet force has enabled him to obtain, in the mouth, better results, in the aggregate, than he would have been able to obtain if he had been confined to the more or less straight pluggers demanded by direct mallet force, or to the comparatively less force usually applicable by hand pluggers unsupplemented by such further condensation as, in many cases, can only be satisfactorily accomplished by the application of efficient mallet force applied by angle pluggers.

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