PUBLICATIONS

BY

ROY G. ELLIS

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PREFACE TO SECTION I

Electrodeposition and its Application to Dentistry

In the early decades of the twentieth century considerable interest was shown in the adaptation of the principles governing electrodeposition, to dental procedures. Prior to this numerous attempts to apply it to the dental field had been tried and discarded. The papers which are attached hereto, culminated in the publication of a monograph on the subject, issued by the Canadian Dental Research Foundation in October 1943.

During the 1940's and 1950's the fabrication of dental models, electrolytically, for the production of inlays and crowns (particularly porcelain jacket), was common practice. The apparatus required was simple and inexpensive to assemble. It provided the most accurate method known for the reproduction of an impression. The surface of the model produced was hard and clean.

The introduction of new, hard surfaced, accurate model materials in the last decade, which match all the advantages of the electrodeposition process and which by comparison, are superior timewise, has resulted in the virtual elimination of a once useful technique.

The Electrodeposition of Indirect Inlay Models*

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DURING the last half century dentistry has witnessed many great advances, so that it is now well established in the forefront of the important professions. To achieve this end much valuable original work has been done by individual members of the profession and much has been learned from the experience of others. We have turned repeatedly to the allied arts and sciences and the knowledge gained we have adapted to our own specific needs.

The principles governing the procedures outlined herein apply to the dental application as well as to the trades in question. The results obtained in either case are dependent upon the principles of electrolysis. It is known that during the conduction of electricity through a solution, chemical decomposition takes place and the metal contained therein is deposited in its pure form. By this means it is possible, firstly, to deposit a thin veneer of one metal upon another, namely to electroplate it, and secondly, it is possible to lay a metallic deposit upon an object, whether that object be metallic or non-metallic, without actual union taking place and thus to build a counterpart to the object. This latter process is known as Electroforming.

Electroplating

In the electroplating trade the article to be plated is of a metallic nature and therefore a conductor of electricity. It is attached to the negative terminal (cathode) of a battery or suitable source of current and is placed in a tank containing a solution of a salt of the metal to be deposited. A piece of the same metal is attached to the positive terminal (anode) and placed in the tank, but not in contact with the cathode. When the current passes, the metal in solution is deposited upon the cathode, which is the article to be plated. The anode, on the other hand, gradually goes into solution.

Electroforming

In the electroforming process the deposition may take place upon a surface which is not metallic, i.e., a non-conducting surface. Two outstanding examples of the use of electroforming in the manufacturing world are the production of phonograph records and electrotype. In the phonograph record industry we see the process of the formation of a "negative" by electrodeposition, from a wax positive. Electrotype, on the other hand, involves the formation of a "positive" from a wax negative or impression. A brief description of the process of making a record is outlined here from the work of "Blum and Hogaboom" (1). "The original wax record is first coated with graphite upon which copper is deposited to form a "master plate" which is a negative. From this plate one or more "mother plates" are made by electrodeposition. The mother plates are positives, and serve as the forms on which the final matrices or "stamping plates" are deposited. The fact that satisfactory results can be obtained even after several

* Presented at the Ottawa Dental Society Monthly Meeting, October 18, 1937.

"generations" of plates have been made is good evidence of the accuracy of reproduction." According to the same authors, "It is the most accurate method of reproducing a metallic surface." Perhaps it is not assuming too much to accept this statement as being true for the reproduction of non-metallic surfaces also. The production of electrotype is carried out as follows. The original type, after being set up and corrected, is prepared and pressed into a block of wax. The impression so obtained is a "negative," into which metal is to be deposited by electrodeposition. Closer examination reveals the fact that the production of electrotype and the dental application of electrodeposition to be discussed herein are similar processes. In each case an impression of wax or equivalent material is obtained of the article to be reproduced. By electrodeposition a positive is formed. Thus we may study the electrotyping industry and collect much valuable data for the operation of our own electroforming apparatus even though it is on a very much reduced scale.

Requirements

From the study suggested above we find that the first and most obvious requirement is some source of direct current at a constant, relatively low voltage (6-12 V.). Batteries would be suitable but they are in need of continual care and recharging. To generate the current by means of a low voltage dynamo would require the installation of expensive equipment. It is possible, however, to adapt the alternating current as supplied to our office by a simple and inexpensive arrangement. The outline and the apparatus suggested below is found equally as satisfactory on the 110-120 volt 60 cycle circuit, as on the 110-120 volt 25 cycle circuit. By means of a small transformer, such as the Lionel toy transformer (type WX, 50 W, 25 cycle) secondary voltages ranging from 3 to 17 volts are available. Converting the alternating current to direct current is accomplished very simply by means of a dryplate rectifier (such as Rectox Unit S. 695622 made by Westinghouse). Finally, a simple resistance to reduce the amperage to within the limits required (for copper 10-15 amp. per square foot) is a 50 or 60 watt lamp, which is connected in the circuit in series. (See Fig. 1.) Thus, very inexpensively, probably not exceeding eight dollars, the current is adapted to meet our requirements. It is not suggested for one minute that the above method is the only way to accomplish this, but a desire to make the set-up simple and inexpensive has been kept foremost in mind.

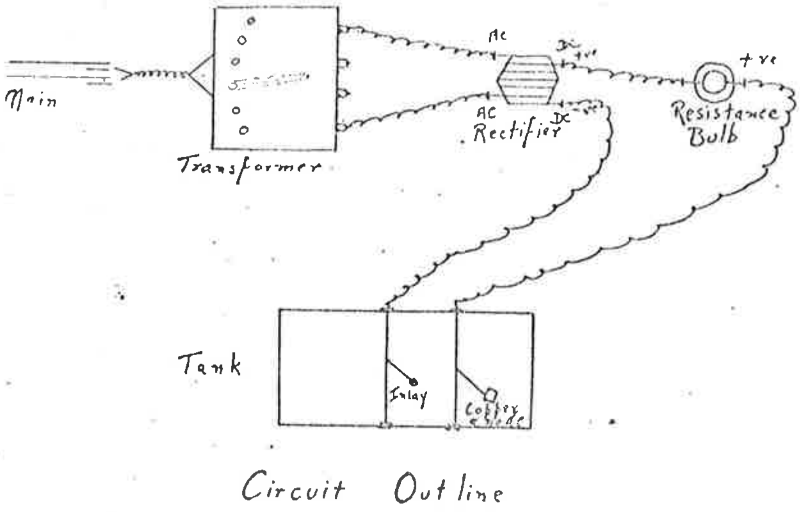

Figure 1.
The circuit outline as suggested.

In order that the voltage and amperage across the tank might be recorded, a voltmeter and ammeter may be very readily connected in the circuit. The voltmeter is connected in parallel and the ammeter in series. However these figures have been tabulated for the circuit as seen in Figure 1, and the results are given in the following table.

RELATIONSHIP OF SECONDARY VOLTAGES TO AMPERAGE IN THE CIRCUIT SHOWN*

	Secondary Voltage: Volts	Equivalent Amperage: 50-Watt Resistance Bulb Milliamperes	60-Watt Resistance Bulb Milliamperes
Primary Voltage 110-120	3.7	28	63
	4.8	36	79
	5.0	37	85
	5.8	42	95
	6.6	47	105
	7.4	52	121
	8.2	56	123
	8.5	57	124
	9.0	60	126
	9.8	64	132
	10.6	67	137
	11.4	71	142
	12.2	75	147
	13.0	78	151
	13.8	81	152
	13.5	79	153
	14.3	83	155
	15.1	86	159
	15.9	90	162
	16.7	93	166
	17.5	96	170

The first column of figures represents the range of secondary voltages possible with the transformer suggested. The second and third columns represent the respective number of milliamperes available with this range of voltage readings when using the 50 or 60 watt resistance bulb.

The solution, acting as the conducting medium and source of metal supply, in which the deposition takes place, is called the electrolyte. It will consist of a salt of the metal to be deposited. In the case of copper, copper sulphate is used extensively. According to Freeman and Hoppe [2], 24 to 32 ounces to the gallon of water provides the most favourable limits of concentration of crystallized copper sulphate. It is known that acid solutions are better conductors than ordinary solutions, and since the whole process depends on the degree of conductivity through the electrolyte, it is expedient to use an acid solution of copper sulphate.

* It is found that the same circuit, using the same equipment on the 110 V., 60 cycle line, gives the same readings as set out in the above table.

Experts agree that 8 to 10 ounces of commercial sulphuric acid are required to the gallon. As the acid concentration increases, the solubility of the copper sulphate decreases, so that there is a balance between these two in solution, which must not be overlooked.

The electrolyte formula would be as follows:

Crystal copper sulphate........... 24 to 32 ozs.
Commercial sulphuric acid...... 8 to 10 ozs.
Water .... 1 gallon

The tank which is employed in the process should be of a non-corrosive material, such as lead or glass. In general it is desirable to have it as large and deep as conditions justify. A large volume of the electrolyte is advantageous in reducing the effect of changes in concentration which may occur as electrolysis takes place.

All parts of the circuit should be constructed of a material which is a good conductor, such as copper, and all contacts, wherever possible, should be made permanent, either by soldering or bolting. The resistance of a single poor contact is very great, and may affect the efficiency of the apparatus seriously.

The anode of copper may be of electrolytic, drawn or rolled copper—the latter is best and should have an area which is larger than the cathode area.

The cathode will be the object on which or into which the electrodeposition is to take place. If it is metallic merely a separating medium is necessary so that a union between the two will not take place. Graphite is satisfactory. If the object on which the deposit is to take place is a non-conductor, then the surface must be rendered conductive by special treatment. If it is porous as in the case of wood or plaster of paris, it must first be rendered impervious to the electrolyte by means of a coat of wax or varnish (shellac) and then conductive by means of graphite or copper bronze. If the surface is impervious such as we have with wax, or dental compound, then it need only be treated to render it conductive, that is, apply the graphite or copper bronze.

Characteristics of Deposition

Our study of the general electroforming and electroplating trades now turns to the factors which influence the characteristics of the deposited metal. The finer the crystals of the deposited metal the smoother, stronger and harder will be the deposit. There are still many unknown factors which influence the character of the deposits but some of the known factors are to be considered. The first known factor is the current density. Current density, according to Freeman and Hoppe, may be defined as "the number of amperes per unit area of cathode," and is given usually as so many amperes per square foot. While opinions vary as to the optimum amperage per square foot for copper deposition, for general purposes 10 to 15 amperes per square foot is accepted. The effect of increasing the current density, according to Bancroft and other authors, is to decrease the size of the crystals which are formed. However, there is a definite limit to the rate at which metal can be deposited and still produce dense deposits. This limit is called the "critical" current density and if it is increased above this limit the deposit produced is soft, loose, spongy and reddish in colour, and is spoken of as a "burnt" deposit. The burnt deposit is highly unsatisfactory and is to be avoided. As the "critical" current density is approached the evolution of hydrogen at the cathode is seen to increase.

The conductivity of the electrolyte has an important bearing on the characteristics of the deposit. The conductivity of the solution governs the potential drop through it. A high potential drop through the solution as the result of a lowering of sulphuric acid, favours the formation of large crystals and this results in the appearance of "trees" on the surface of the deposit. Unfortunately, during the process of electrolysis it is found that there is a gradual decrease in the acidity and a corresponding increase in the copper sulphate concentration—owing to the fact that more copper is dissolved from the anode than is used at the cathode. The excess copper takes up the sulphuric acid to form copper sulphate, therefore weakens the acidity of the electrolyte, reducing its conductivity and increasing the tendency to form rough deposits and "trees."

Agitation of the electrolyte is employed for the purpose of insuring uniformity of concentration of the solution which in turn maintains a high cathode efficiency and therefore a lessened tendency to produce hydrogen and hence a dense, hard, copper deposit. "However whatever method is used for agitation, whether it be by the introduction of air or by mechanical means, there is danger of particles from the anodes being kept in suspension and giving rise to a roughness on the cathodes." [1]

The temperature of the electrolyte will also affect the characteristics of the deposit. The crystals deposited at higher temperatures are coarser than those deposited at lower temperatures and hence the deposit will be coarser. Therefore the tank should be in a relatively cool place, i.e., away from radiators or other sources of heat.

Dental Technique

The equipment necessary to prepare an impression for insertion into the electrodepositing tank is simple and inexpensive. It consists of:

1. Bunsen burner
2. Glass slab
3. Camel's hair brush
4. Sticky wax—pink base wax
5. Copper wire (24 G. and 14 G.)
6. Spatula
7. Pair of scissors
8. Graphite

The impression taken in compound or wax in a copper band presents a non-conducting surface, similar to the impression taken of the set-up type in the electrotype process. It presents a surface impervious to the electrolyte and therefore needs no treatment in this respect. For the purpose of rendering the surface a conductor there are two mediums available, namely graphite and copper bronze powder. The important properties of such a medium are that it be (1) a good conductor, (2) of an extreme degree of fineness, (3) that it possess colloidal properties. Of the two mediums mentioned graphite seems to possess these to a greater degree than copper bronze powder. The graphite may be used as a dry powder and dusted onto the surface or it may be used in the wet state. In the electrotype industry in former years it was employed in the dry state but in recent years wet graphite has been used almost universally, because of better conductivity and because the dust was injurious to the health of the workers. Place on a small glass slab enough graphite (Aqua Dag-Acheson Colloids Corporation) to cover a pin's head and mix with about one drop of water. A watery suspension of graphite is obtained which can be painted over the entire wax or compound impression surface, by means of a fine camel's hair brush. (Fig. 2.)

It must be remembered that the copper deposition will extend to the limits of the graphite, so that the extent covered can be controlled by the careful placement of the graphite. Now subject the wet painted impression to a gentle draught of air to dry the surface. Examine it for patches that might have been missed and touch these with the wet graphite and dry. The

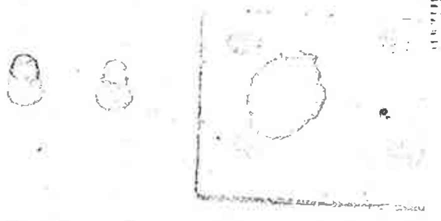

Figure 2.
The graphite mixed on a slab and painted into the impression surface.

use of copper bronze in the author's hands has not been very satisfactory because of the difficulty of rendering the entire area of the impression conducting to the same extent. The result was a model with patches missed invariably.

The second stage in the procedure is that of making arrangements for the inclusion of the impression surface, now a conductor of electricity, in the electrical circuit. The graphited impression surface is to all intents and purposes insulated by the compound impression, unless some part of the copper band around the gingival region of the impression is left exposed and the graphite carried out to meet it. This happens in many cases but for the case in which it does not, provision must be made for directly bringing the impression surface into the circuit.

A piece of fine 24 gauge (B. & S.) copper wire, about two inches long, is taken and at one end about one-eighth to one-quarter of an inch of the wire is bent on itself, thus forming a shepherd's crook. (Fig. 3.) The loop formed is now straddled over the gingival portion of the band so that the short end contacts some part of the graphited impression surface, a point preferably which is not a part of the area of the inlay preparation. The remaining long section of the wire is now wrapped around the outside of the copper band and stuck to it at one spot with sticky wax, leaving about three-quarters of an inch free. A carrier is now made which serves two purposes; firstly, that of completing the circuit, and secondly, that of carrying the impression into the electrolyte in the tank and at the same time ensuring that all parts of the cathode, other than that small section to be deposited on, are insulated from the electrolyte. (See Fig. 4.)

A piece of 14 gauge copper wire about 5 to 6 inches long is used. At one end a section about 1 to 1½ inches long is bent at right angles to the remainder and two-thirds of this section is flattened. Through

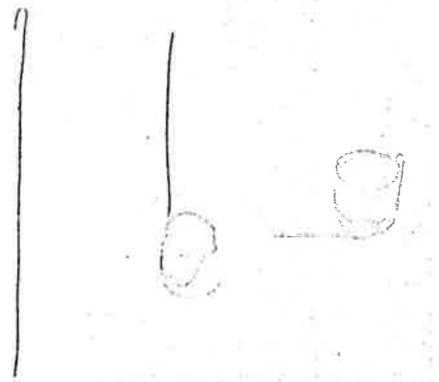

Figure 3.
The first step in wiring the graphited impression.

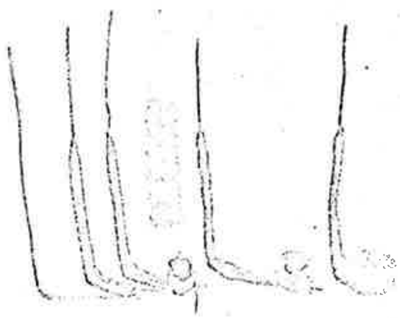

Figure 4.
Attaching the wired impression to the carrier.

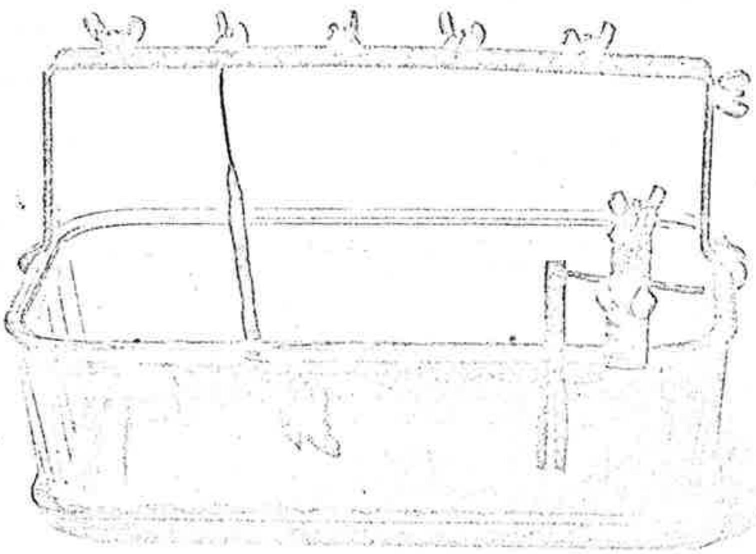

Figure 5.
Tank showing connections and supporting bars.

this flat platform a 22 gauge hole is drilled—about one-eighth of an inch from the end. Now all but the flattened portion and about 1½ inches of the opposite end are covered with one-sixteenth inch of vulcanite to insulate it. The wired impression is now seated on the flattened platform on the carrier and the free end of wire which was left is passed down through the hole on the platform and wound around the end of it. This ensures a good contact at this point in the circuit. A strip of ordinary wax about 2 inches by ¾ inch is cut and warmed very slightly (enough to make the wax bend readily) and wrapped around the band. Every portion of metal exposed is now covered with wax and sealed so that the electrolyte cannot possibly come into contact with it. This is the cathode terminal.

The impression now prepared is ready for insertion into the electrolyte in the tank. The electrolyte formula has been given previously. A pickle jar or fish bowl makes a suitable tank. The two supporting bars across the tank should be good conductors, such as copper (½″ x ⅛″) with suitable connections soldered onto these bars, to which the cathode and anode may be attached, respectively. A simple and yet strong contact is obtained by using screws and thumb nuts for this purpose. (Fig. 5.)

The anode is simply a bar or block of copper which has a short 12 gauge copper wire soldered to it for the purpose of attaching it to the anode supporting bar over the tank. Care should be taken to see that the soldered joint does not enter the solution.

The anode and cathode terminals are now ready to be placed in the tank. The distance they are apart and the relationship between them in so small a tank seems to have little effect on the deposit or rate of deposition. The current density required for the piece must now be estimated. It was previously stated that 10 to 15 amperes per square foot for copper and acid copper sulphate electrolyte was satisfactory. We must therefore calculate roughly the area of the graphited surface. For the bicuspid impression 1/4 inch diameter and a band 1/2 inch deep we have .44 square inches area. In the case of a current density at the rate of 15 amperes per square foot, this small area would require 46 milliamperes. Adjust the current accordingly and switch it on. For a molar three-eighths of an inch diameter and one-half inch deep, 75 milliamperes would be required. A full mouth impression would require approximately 100 milliamperes per square inch of surface.

The time factor is an important consideration at this stage. Enough copper will be deposited at the above current density rate to form a shell which may be used satisfactorily after four hours in the tank. However 10 to 12 hours will produce a shell over 1/2 mm. thick. Thus if the impression is put in the tank at 6 p.m. or even later and left overnight, by the next morning ample copper will be deposited to ensure a very strong model.

The shell is now quickly backed up with a household cement, stone or a low fusing metal, such as Mellottes. The model will now be complete when the compound impression is removed, being careful not to overheat the compound when doing so. The dark graphite surface may be cleaned off with a brush.

Precautions During Operation

A few precautions might be mentioned which it would be well to observe during the operation of the process.

(1) As the electrolyte is strongly acid a bath of sodium bicarbonate should be kept near at hand into which the finished piece is placed for a minute or two immediately after removing from the tank. This prevents the acid solution coming into contact with the clothes.

(2) The excessive formation of bubbles at the cathode will be accompanied by a "burnt" deposit and is due generally to the current density being too high. During normal deposition little or no hydrogen is formed at the cathode.

(3) The tendency for the acid concentration of the electrolyte to become decreased and the copper sulphate concentration increased during normal operation, eventually results in the deposition of copper sulphate crystals on the anode which interferes with normal deposition of copper. Discard the solution and make some new. As no method of agitation is employed in the tank it is recommended that the electrolyte be stirred up once or twice a week to help maintain uniformity in concentration throughout different parts of the tank.

(4) Be extremely careful that the impression is always attached to the negative terminal. If it is attached to the positive terminal by mistake and the source of copper is attached to the negative terminal, the impression will be ruined and the copper band disintegrated. This can happen very easily.

Conclusion

We may well ask the question, "What claims are made for electrolytic copper as a model material?" I think the answer will be found partly in the table of comparisons, on the following page.

The cost factor of approximately ten dollars, mentioned in this table, includes the apparatus, i.e., rectifier, transformer, tank, wire connections, etc., amounting to a little less than nine dollars and enough supplies of copper sulphate, copper, sodium bicarbonate, commercial sulphuric acid and graphite to last for a considerable period of time. The cost of operation, i.e., for the electricity, has been estimated roughly to be about one cent per 1,000 hours of operation, and even if this were exaggerating the case greatly, it would still be a small item.

Copper	*Factor*	*Amalgam*
Electrolytic copper 40	Hardness (in Brinell numbers)	40-65
Most accurate method known	Accuracy of reproduction of impression	Dependent on manipulation and control of volume changes
Simplicity of deposition No packing	Manipulation	Short-comings in mixing and packing
Pure metal	Contamination	Mercury present. Effect on Gold
Apparatus and supplies to last a year or more approx. $10.00. Current (fraction of a cent per model).	Cost	Silver alloy .20 Mercury .03 — per model .23 Copper amalgam .10 per model (using it over again)

In conclusion it is perhaps unnecessary to point out that this method of making models may be used for all types of gold inlays, porcelain inlays and jacket crowns. The simplicity of manipulation, and the inexpensiveness of the apparatus and production, commend this practical method to greater use.

The writer wishes to express sincere appreciation to Dr. S. M. Richardson of the Department of Radiography and Photography of the Faculty of Dentistry for the photographs included within this article.

REFERENCES

(1) Bloom, W., Hogaboom, G. B., Principles of Electroplating and Electroforming. McGraw-Hill, 1929, p.141.

(2) Freeman, B., Hoppe, F. G., Electroplating with Chromium, Copper and Nickel. Prentice-Hall, 1930, p.101.

The Hidden Treasure

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(Reprint from North-West Dentistry)

WITHIN the dental profession, there lies concealed a hidden treasure! It is a treasure indeed for it involves inestimable wealth, and it is unquestionably hidden, for thus far it is virtually lost. To elucidate this mysterious calamity better, it may be well to cite the story of the Lost Artist who lived in Paris a few centuries ago. He was a real master, yet no one was aware of it, not even himself. He had no conception of the monetary value of his collection, nor had he any buyers, for he was too reticent about displaying his art in the Public Court. He died a pauper, and after his death his paintings were sold for millions.

We have a parallel situation in our profession: the goods are there to sell but the buyers are limited. Have we, too, failed to display our wares in the Public Court? Has the dental profession failed in any way in its efforts to keep the avenue between it and the public open? Is the profession itself responsible for the hidden treasure or is the answer just "The Depression"?

Perhaps there is no better way of answering this question than by citing a coincidence that took place in a certain cemetery. On one monument was found the following inscription:

"Here lies Dr. John Smith, a dentist, famous among his colleagues for his great ability and professional skill. He died at the age of 55, discouraged and penniless. He was buried by the City. May he rest in peace."

Within a few feet of the grave of Dr.

A Simple Electrodeposition Apparatus for Use in Dentistry

by ROY G. ELLIS, B.D.S.(Adel.), D.D.S., M.Sc.(Dent.), Toronto, Ontario

ELECTRODEPOSITION has been defined as the process of making an electrodeposit. An electrodeposit on the other hand has been defined as that which is deposited by an electric current or "a deposit made by electrical action." Thus the process of electrodeposition is the process of depositing a metal from one substance on to another by means of electrical action.

The industrial art of electrodepositing has been advanced greatly since it was first applied over 100 years ago. In the dental field however, it has been investigated and tried and discarded repeatedly for reasons which are quite obscure to one who reads the limited reports of its use in this field. There appear to be several places where its application in dentistry is indicated.

Historical

Soon after the recognition of the process of decomposition of water into oxygen and hydrogen by the passage of an electric current through it, very early in the 19th century, there followed rapid developments which have led to the present scientific industrial arts of electroplating and electroforming. Among these early developments one phase is of particular interest. About 1838 the discovery of the galvanoplastic process, (electriforming), was announced by Professor Jacobi to the Academy of Sciences of St. Petersburg. He is therefore, credited with being the father of galvanoplasty.

Within a few years (between 1845-50), European dentists were investigating this new art of reproduction (of a solid form), using the electrolytic process. According to W. Pfannhauser[1], Dr. Vajna of Budapest was the first to succeed in making a copper model to be used in the construction of artificial dentures. St. Schulhof of Bohemia extended Vajna's work which is described by Pfannhauser as "a mèthod of making artificial dentures by the electrolytic deposition of silver and points out that mechanical methods are complicated and do not reproduce details as accurately as one would like."[2]

In 1856, John Newell of New York, sought and obtained a patent on the electroforming process and presented the idea to the dental profession on this continent.

Since these first attempts to apply the principles of electrodeposition to dental procedures, numerous efforts have been made both on this continent and elsewhere to popularize the use of the principles of electrodeposition to its applications in dentistry.

There are two phases of electrodeposition which though fundamentally the same, differ in some respects.

Firstly, it is possible to deposit a thin veneer of one metal upon another. This is called electroplating. The process is well known to us in its almost universal use in the jewelry, silverware and general trades.

Secondly, it is possible to deposit a metal upon an object, whether that object be metallic or non-metallic, and thus to build a counterpart of the object. Such a process is known as electroforming and the art of electroforming is the art of galvanoplasty.

Two outstanding examples of the use of galvanoplasty in the industrial world are the production of the plates for the manufacture of gramophone records and electrotype. In the former case we see

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the formation of a "negative" by electrodeposition, from a wax positive.

Electrotype, on the other hand, involves the formation of a "positive" from a wax negative or a wax impression of the original object.

From the above examples given, we note two important facts. (1) In the latter example we recognize the similarity of the procedure to that of many dental procedures wherein a positive is formed from a wax or compound impression of the original object. (2) In the case of the gramophone record, we recognize the extreme degree of accuracy of this method of reproduction.

The adaptation of the art of galvanoplasty to certain dental procedures is therefore indicated: e.g. the formation of dies for the indirect inlay technique, jacket crown technique and acrylic restorations.

We must recognize the fact that the dental field differs from the commercial field, principally because we are dealing with comparatively small areas upon which the deposition is to be made. The equipment therefore is built on a comparatively small scale.

For convenience sake we will discuss the details of this equipment under the following headings.

(a) Source of electrical energy.
(b) Control of current.
(c) Measurement of current.
(d) Distribution of the current.
(e) Receptacle in which the electrolytic process is to take place.
(f) Operation and maintenance of the apparatus.

Source of Electrical Energy

The general requirements of the electrical energy supplied for the process, are direct current of low amperage and relatively low voltage. An inexpensive source of direct current at a relatively low voltage (6-12 volts) is available in the form of a dry cell, or wet plate battery. These however, require continual care and recharging. To generate the current by means of a low voltage dynamo for the small current requirements in our limited field is out of the question, both because of space available in a dental office and also because of the cost of installation of such equipment.

There are available today four or five commercial instruments designed for use

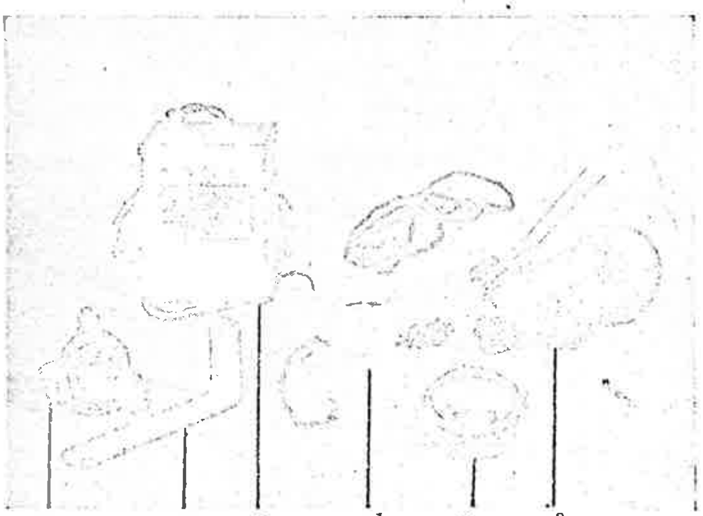


Figure 1
r—rectifier; r. s.—rectifier stand; t—transformer; o^1—electric socket; o^2—light bulbs.

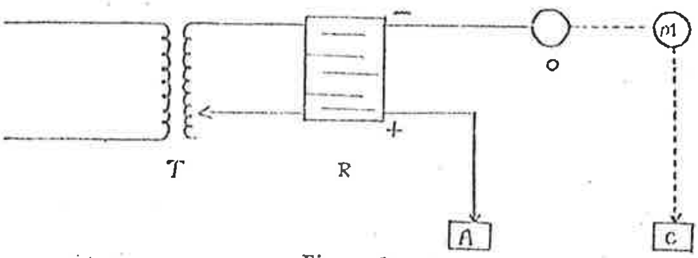
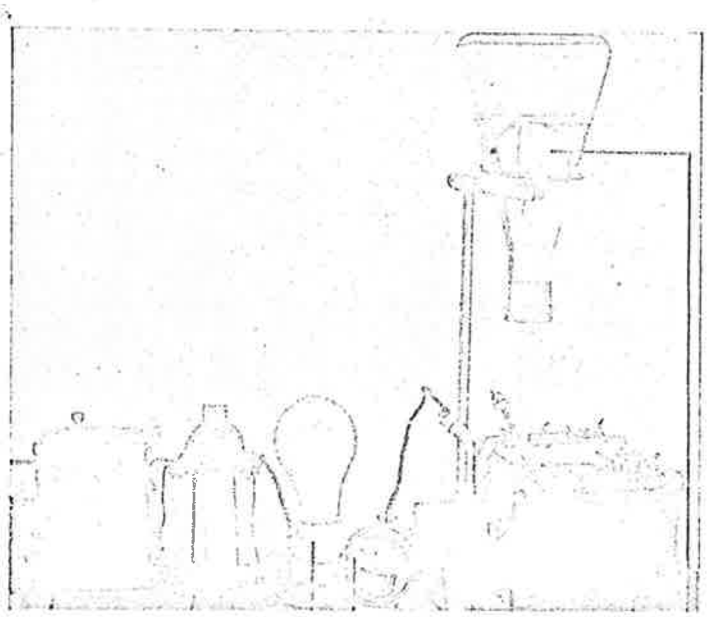


Figure 2
t—transformer; r—rectifier; o—electric socket and light bulb; m—milliameter; a—anode; c—cathode.



t r o m c a v y

Figure 3
t—transformer; r—rectifier; o—electric socket and light bulb; m—milliameter; c—cathode terminal; a—anode terminal; v—tank or vat; y—reservoir.

in the dental office for electrodeposition of metals, but in each case the cost of such an apparatus has limited the extent to which they have been used. The operating principle of these is much the same in each case; namely a method of supplying unidirectional current with a means of controlling it so that the current may be varied from 50 milliamperes to 1 ampere.

The apparatus which the writer has made from parts readily available in any radio trade supply depot, (Figure 1), has been set up with the thought in mind of having it simple and inexpensive. By means of this apparatus the current as supplied to a dental office can be adapted to meet the requirements. This apparatus has been used almost constantly since 1937 and has proven itself highly efficient and easy to control.

The primary source of current, is that which is supplied for general domestic use, namely 25 or 60 cycle alternating current. A transformer capable of reducing 110 volts to 3—15 volts is required and shown at t in the diagram, (Figure 2). The terminals from the transformer then pass to the alternating current terminals of a dry plate rectifier (r in diagram). The purpose of the rectifier is to reverse the half cycle of the A.C. and thus supply direct current, or as it may be referred to, "a unidirectional current."

There are many satisfactory makes of transformers; the one which has been used and is seen in Figures 1 and 3, is a Lionel transformer (such as is used on a toy train set) Type WX. 50 W. 25 cycle. If the circuit is 60 cycle then the transformer must be rated accordingly.

Similarly there are several suitable makes of rectifiers. The one seen in Figures 1 and 3 is a Westinghouse, Rectox Unit, S 695622. The capacity of this unit is less than one ampere and is therefore limited in this respect. Seldom, however, do we require a current greater than ½ an ampere.

A Mallory dry plate rectifier No. F 12.C.1 has also been used, where a current of greater amperage (up to 2 amps.) is required.

Control of Current

A variable resistance might be added to the circuit in series for the purpose of regulating the current supply. The simplest method of supplying such a resistance was considered to be the inclusion of a single electric light socket into which could be inserted an electric light bulb of any size, from 50 to 200 watts. (Figures 2 and 3 at 0.) This limited form of variable resistance combined with the adjustment of the transformer within narrow limits, allows a relatively simple, elastic, and inexpensive method of controlling the supply of current.

Measurement of Current

For dental purposes the strength of the current used is very small (somewhat less than one ampere in most procedures) and therefore a milliameter would be required

Figure 4
a—anode terminal; b¹, b²—bus bars; an—anode of copper; ca—cathode; c—cathode terminal; l—level mark on tank; f—fahnstock clip soldered to bus-bar.

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for measuring such a current. This instrument is connected in the circuit in series, as shown in the diagram. Figure 2 at M.

If the voltage across the tank is to be recorded, a voltmeter may be readily included in the circuit, in parallel. In the dental field we are seldom interested in the voltage in such detail and therefore have omitted the voltmeter from the circuit.

Distribution of the Current

The electrical energy now available across the terminals must be distributed to the receptacle in which the electrolytic process is to take place. In the commercial field the metal used and the size of the conductors for distributing the current some distance to the large tanks was seen to be important. In the dental apparatus the tanks are small and the problem of distribution of the current is proportionately small. The bus-bars may be made of ½″ x ⅛″ copper bar as seen in Figure 4 at B^1 & B^2. Loss of electrical energy in the small dental apparatus may however be encountered through the increased resistance of faulty contacts. Therefore it is well that all possible connections which can be fixed permanently should be soldered.

Tank

The receptacle in which the electrolytic process takes place may be referred to as "the tank" or "the vat."

In the small field, a glass tank is quite satisfactory. The deeper the tank the better the results, owing to the decrease in effect produced by variation of the concentration of the electrolyte at the terminals. An inexpensive form of glass tank is seen in Figure 4. This tank has a capacity of approximately 600 c.c. The ideal tank should be about 8″ x 6″ with a capacity of 1000 c.c. (1 litre).

To the equipment described above might be added (without great expense) a means of automatically replenishing the electrolyte, to compensate for loss by evaporation.

In Figure 3, we see an inverted flask half filled with water and two glass tubes extending through the rubber cork downwards into the tank. The underlying principle of the operation of this automatic replenishing device is that of the syphon and is further explained in the diagram in Figure 5.

As the level of the electrolyte in the tank falls and air enters at A the pressure in the glass flask is equalized with that outside the flask and a syphon action permits the liquid in the reservoir flask to

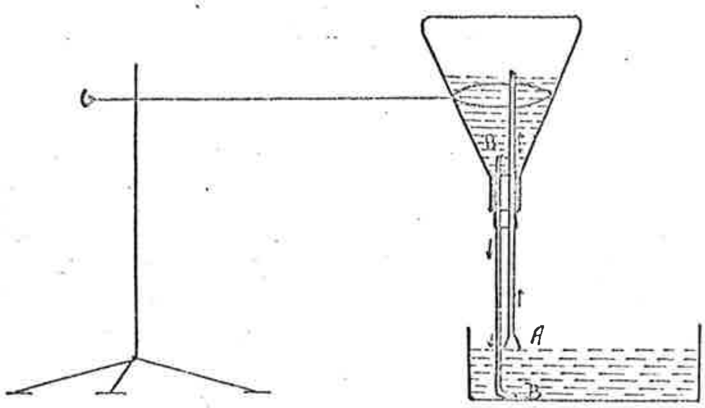

Figure 5
Sketch of reservoir at y in Fig. 3.

flow into the tank. As soon as the level rises again and cuts off the open end of the glass tube at A, the pressure in the flask becomes less than the pressure outside and the syphon effect ceases and the fluid in the flask ceases to flow out through B. Thus the loss of electrolyte by evaporation, actually only water, starts the process of replacement of the water from the overhead reservoir.

However the addition of the equipment described above to compensate for the loss of water from the electrolyte by evaporation, is not essential. To simplify the apparatus, loss by evaporation may be controlled by placing a mark on the tank at the height of the original level of the solution in the tank (Figure 4), and adding water once or twice a week, as required, to restore the solution to the original level.

In arranging this apparatus the writer's prime consideration has been to suggest the use of a piece of apparatus which the dentist himself can put together. It is simple, efficient and the total expenditure involved prior to the war, was less than ten dollars.

BIBLIOGRAPHY

1. Pfannhauser, W. Die Electrolytische Metallniederschlage 1928.
2. Viverito, J. A. Electrodeposition in Dentistry. Dental Cosmos; Volume 77, December, 1935.

Report Prepared by the Research Committee of the Canadian Dental Association on Research in a National Health Insurance Program

FOREWORD

RESEARCH will play a most important part in any plan for the control of dental disease. The expenditure of funds involved in the dental aspect of the scheme may be drastically reduced in proportion to the effort directed in the research field.

At the request of the committee on Health Insurance of the Canadian Dental Association, the C.D.A. Committee on Research has produced the enclosed research outline as an adjunct to the role dentistry is to take in a health insurance plan for Canada. The importance of this integral complement cannot be overemphasized. While the cause of dental disease is not definitely known, there is an ever-increasing knowledge developing regarding the control of the diseases of the mouth.

Intensive study of the subject has been in the past handicapped by lack of financial support and also due to the fact that sufficiently large control groups for study have not existed. The adoption of the plan advocated at the present time, would furnish an abundance of clinical matter for study.

A truly preventive aspect of the plan would be established through the adoption of a research department as a definite part of the arrangement. The efforts of such a department would be directed toward the reduction of the incidence of dental disease, lowering the cost of operation and furnishing a source of information for the guidance of the dental practi-

The Journal OF THE CANADIAN DENTAL ASSOCIATION

VOL. 9 TORONTO, APRIL, 1943 NO. 4

The Application of the Electrodeposition Process to the Construction of Small Acrylic Restorations

By ROY G. ELLIS, B.D.S.(Adel.), D.D.S., M.Sc.(Dent.), Toronto, Ontario

It is generally agreed that acrylic resin, whether it be for dentures or small restorations in natural teeth, is most ideally processed against a non-porous metallic surface. In the case of the small gingival inlay or the jacket crown, and all the intervening possibilities in restorations of this type it is virtually impossible to burnish tin foil, either to the wax pattern or the mould in the flask. It is a relatively simple and inexpensive procedure however to deposit a thin layer of copper on the wax pattern which when the coated wax pattern is invested and the wax is boiled out will leave a clean, hard, bubble-free metallic surfaced mould in which the acrylic resin may be processed. The results obtained by the author during the past year with this procedure, have been extremely encouraging.

It is not the intention of the writer to discuss the pro's and con's of acrylic as a suitable material for operative restorations; suffice it to say, that this material at the moment does seem to lend itself to use for gingival inlays and semi-permanent crowns for protecting fractured anterior teeth in the young patient.

From these two standpoints the technique of processing acrylic resin will be discussed.

The Jacket Crown and Semi-Permanent Acrylic Crown

After the preparation for the jacket crown or shoulder less acrylic cap has been completed a suitable celluloid crown form is chosen and contoured to fit accurately at the gingival margin. (See Fig. 1).

Perforate the celluloid form at both the mesiolingual — and disto-lingual angles, approximately 2 mm. from the incisal edge. Fill the crown form with ivory shade inlay wax and soften uniformly in water at 140° F. Carry the crown form to place and seat it over the prepared tooth, allowing the excess wax to escape through the holes provided on the lingual surface. If further adjustment is considered to be necessary remove the crown form and reheat the partially seated form and wax impression and re-

CORRECTION

The title of the paper by Dr. Ellis which appeared in the March issue of the Journal should have read "The Application of the Electrodeposition Process to Dental Procedures".

Fig. I
Celluloid crown form adapted and contoured to fit the prepared tooth.

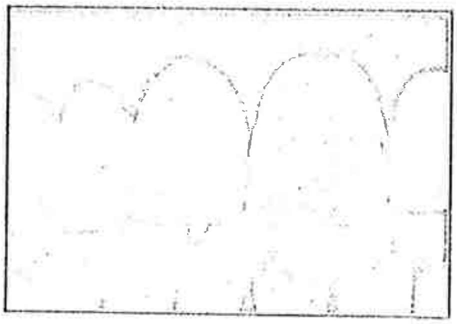

Fig. II
The upper left central with celluloid form and ivory wax in place.

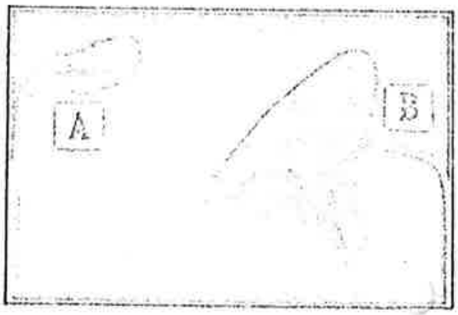

Fig. III
A. Gingival inlay pattern mounted. B. Crown pattern mounted.

place on the prepared tooth. If the contour of the crown form does not fulfil the requirements aesthetically, add wax to the outside of the celluloid form and thus contour the crown form as desired. (N.B. Add a thin film of wax to the lingual surface of the form to aid in boiling out later.)

Figure 2 shows the contoured form in place on the tooth. The wax inside the form gives an accurate impression of the tooth. Thus, at one sitting the preparation is made, the impression is taken, the shape of the finished crown is determined, and the shade is recorded. Establishment of the shape of the finished crown by the means just outlined renders further steps for this purpose unnecessary, thus eliminating a try in, or taking registrations for mounting a die on an articulator as required in the indirect technique.

The crown pattern prepared thus far is removed to the laboratory. A small piece of ivory wax (about the size of a pin head) is fused on to the lingual surface and to this is attached one end of a 4″ length of 24G. copper wire. (See Fig. 3B).

The Gingival Inlay

The gingival inlay pattern seen in figure 3A was made by the direct method in the cavity and removed from the mouth on a similar piece of wire to that used for the crown.

Metallization

Both the inlay and crown patterns so mounted, on copper wires are ready for metallization. The technique used in the metallization of wax or compound, using graphite, has been described by the writer in the preceding issue of this journal. However, graphite in this case will leave a blackened surface on the deposited copper and the shade of acrylic which is processed against such a surface, cannot be controlled. To replace graphite metallization we turn to metallization by means of silver. This process depends on the familiar experiment of the reduction of a silver salt, with the resultant silver mirror formation.

The wax inlay pattern and jacket crown pattern as seen in Figure 3 are first washed in a solution of Stannous Chloride, the formula of which is:

Stannous Chloride—1 gram
Hydrochloric acid (Conc.)—1.5 c.c.
Distilled Water—100. c.c.
Mix.

This solution is easily made up, and may be stored for a reasonable length of time without deterioration. It is kept in a wide mouth bottle so that the inlay pattern or jacket crown pattern may be immersed in the solution in the bottle for one to two minutes, following which they should be washed off in room temperature water. The mounted impressions are then lowered into a small receptacle, such as a baseplate wax box (1½" x 1" x ¾"), a dappen glass for a small inlay, or better still an empty 1 oz. porcelain powder jar. Do not let them touch the sides of the receptacle.

Over the impression or impressions so arranged pour first the following silver solution and then the accompanying reducing solution, leaving the impressions completely immersed in the mixture for 4 or 5 minutes—agitating them at frequent intervals during that time. The result of this procedure will be the formation of a silver film over the entire surface area of the wax, celluloid form and everything in contact with the mixture, including the receptacle.

The two solutions must be freshly made just prior to using them because of their unstable nature.

The formula for each is as follows.

Silver Solution

Silver Nitrate Crystals—420 milligrams
Distilled Water—9 c.c.

Reducing Solution

Pyrogallol crystals—100 milligrams
Citric acid crystals—21 milligrams
Distilled Water—3 c.c.

For the sake of convenience these formulae have been transposed into more convenient terms, and are used as follows:

Silver Solution

Silver nitrate (fine crystals)—1 large end of Caulk silicate measuring spoon.
Distilled water—9 c.c.

Reducing Solution

Pyrogallol (fine crystals)—1 large end of Caulk measuring spoon.
Citric acid (fine crystals)—½ small end of Caulk silicate measuring spoon.
Distilled water—3 c.c.

As all of these substances dissolve rapidly in cold water, it takes but a minute to make these solutions each time they are required. The cost of this method of metallization may be questioned but is actually less than 2 cents per piece.

Figure 4 shows the small inlay pattern and the jacket crown pattern after silver metallization. If these pieces were now attached to the cathode terminal of the electrodeposition apparatus, copper would be deposited over the entire surface of

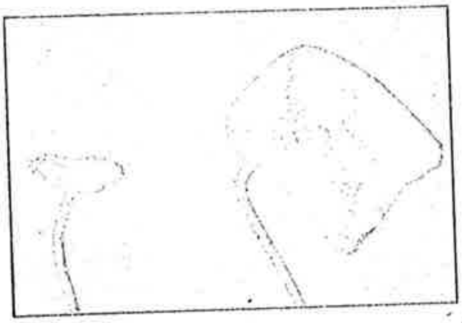

Fig. IV
Inlay pattern and crown pattern coated on every surface with a film of silver. This is called metallization.

both, thus completely encasing them in a copper matrix, making it impossible to remove the wax and celluloid form in the case of the crown, and also making it impossible to pack the plastic acrylic into the matrix to form the acrylic inlay or crown.

It is desirable therefore to make provision for having the labial face of the crown not covered by the copper deposition, and in the case of the inlay to have the buccal or labial surface of it left exposed. Sandarac varnish is therefore painted on the labial face of the metallized crown pattern and on the surface of the metallized inlay matrix, with a fine camel's hair brush. (N.B. After the wax pattern is metallized it must not be allowed to dry off at any stage or else the silver film will crack and chip off). Therefore do not attempt to dry the surface onto which the varnish is to be painted or to dry it after it has been applied. Such steps are unnecessary and dangerous.

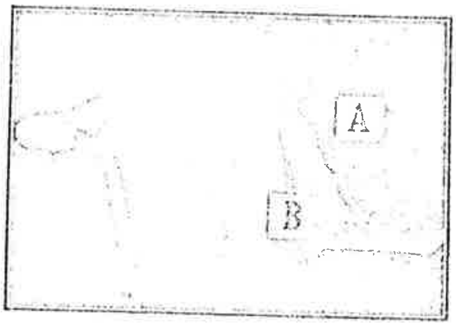

Fig. V

A. The area covered by varnish which insulates the region and prevents the deposition of copper on it. B. The unvarnished silver film.

The metallized, varnished patterns are now ready to be immersed in the copper electrolyte for the purpose of checking the area varnished and the efficiency of the metallization process. Figure 5 shows the line of demarcation between the varnished area (A) and that which is not varnished (B). Copper will be deposited on the unvarnished area. Attach the prepared pattern or patterns to the cathode, and insert into the electrolyte.

The Electro-deposit

The amount of current required depends on the area to be covered as explained in a previous article. The time required should be limited to a 3 — 4 hour deposit. A heavy deposit will add to the difficulties in removing it from the processed acrylic resin.

The area of the pattern covered by copper, when the copper deposition is complete, is the same as that outlined in Figure 5. The labial face will be left uncovered.

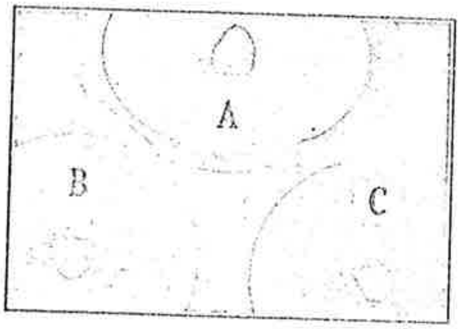

Fig. VI

A. The pattern mould in the lower section of the flask after boiling out the wax and removing celluloid form.

B. The first top section of the flask.

C. The relief top section of the flask.

The crown pattern is now invested in a triple section flask as shown in Figure 6. The wax is boiled out and the celluloid crown form is lifted out with pliers. This will be easy to accomplish if the lingual surface was coated with a thin film of wax as suggested earlier in this paper. The full top of the flask is shown at "B", the relief section at "C", and the copper matrix in the lower half at "A". Note the metallic model and metallic lingual and proximal surfaces against which the acrylic can be processed safely.

When the plastic acrylic is packed and the flask is ready to close for processing, apply tin foil to protect the labial face.

The inlay pattern is treated similarly to the crown, except that in the case of the simple gingival inlay, the relief section of the flask is not used.

When the acrylic is processed and the inlay or crown are removed from the flask but still encased in copper, the copper is easily and quickly removed by placing it in a bath of concentrated nitric acid for a few seconds only; a 3 to 4 hour deposit of copper will be removed in a few seconds. Prolonged exposure to the acid might result in disintegration of fine margins. The copper may also be removed by peeling it off, as platinum is removed from porcelain.

Experiments are proceeding which indicate from early results, that the shade of acrylic resin will be more uniform when processed against a metallic surface, than when processed against a treated stone or plaster surface. These same experiments also support the view that greater accuracy is obtained when a metallic matrix is used.

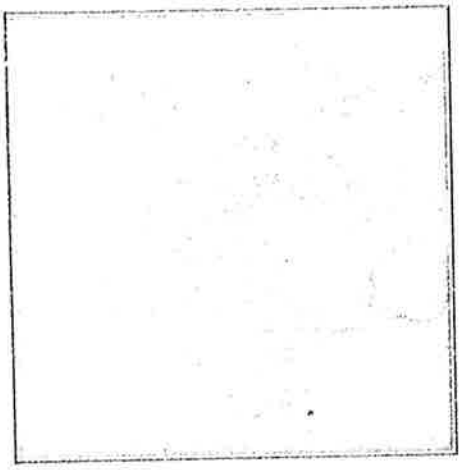

Fig. VII
Upper left central with acrylic cap in place. Upper right central with temporary crown in place.

Figure 7 shows a completed acrylic cap on the upper left central, made by the method described herein.

The writer wishes to express sincere appreciation to Dr. I. H. Ante for the time and care given in obtaining the photographs included herein.

230 College Street.

An Appreciation of Dr. J. S. Bagnall

By A. W. FAULKNER, D.D.S., F.A.C.D., Halifax, Nova Scotia

NINETEEN years ago the Canadian Dental Association in session at Vancouver, on motion of Dr. F. W. Ryan then Dean of the Faculty of Dentistry of Dalhousie University, elected Dr. J. Stanley Bagnall of Halifax as its Secretary. The thought apparently motivating the selection was to give assistance to the recently chosen President—Dr. G. K. Thomson of the same city. Having both President and Secretary from the same locality would expedite the business of the organization and improve its efficiency.

For two years he worked with Dr. Thomson preparing for the 1926 session of the Association in Halifax. During this year plans for reorganization were discussed out of which, two years later, a National Body still bearing the name "The Canadian Dental Association" started its growth. It was no easy matter for the Secretary—who was continued in office—to adjust himself from the change-over from the old routine of a weak voluntary organization, whose chief business was transacted at biennial meetings, to that of the new set-up formed and

SECTION I

Electrodeposition and its Applications in Dentistry
Bulletin # 26. Toronto. Canadian Dental Research
Foundation, 1943.

~~See separate enclosure.~~

Electrodeposition and its Applications in Dentistry

BY

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Faculty of Dentistry, University of Toronto

BULLETIN NUMBER TWENTY-SIX

ISSUED BY
THE CANADIAN DENTAL RESEARCH FOUNDATION
October, 1943

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October, 1943

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BULLETIN NUMBER TWENTY SIX

July, 1943.

ACKNOWLEDGMENT

RESEARCH workers are invariably dependent upon the efforts of others and in the case of the work recorded herein it is no exception. Grateful acknowledgment is made here to Dr. S. M. Richardson, for his willingness to oblige at all times when photographic assistance was needed;

to Dr. T. Cowling for his suggestions and the loan of equipment from his department;

to Miss D. Berry for the time she devoted in conducting p.H. tests on various solutions used;

to Dean A. D. Mason for his encouragement given and buoyant enthusiasm which supported the efforts of the writer, and finally to Miss M. Jackson for her faithful and excellent work in compiling this material.

Some sections of this bulletin have appeared previously as articles in the Journal of the Canadian Dental Association.

CHAPTER 1

ELECTRODEPOSITION AND ITS APPLICATIONS IN DENTISTRY

Introduction

ELECTRODEPOSITION has been defined as the process of making an electrodeposit. An electrodeposit is defined as that which is deposited by an electric current or "a deposit made by electrical action." Thus the process of electrodeposition is the process of depositing a metal from one substance on to another by means of electrical action.

The industrial art of electrodepositing has been advanced greatly since it was first applied over 100 years ago. In the dental field however, it has been investigated and tried and discarded repeatedly for reasons which are quite obscure to one who reads the limited reports of its use in this field. There appear numerous indications where its application in dentistry can result only in improvement in that particular phase of technique to which it is applied.

Therefore, it is the hope of the writer of this thesis to draw the attention of the dental profession to the fundamentals accepted in the general art of electrodeposition and to outline wherein these may be applied to specific techniques commonly used in dentistry.

Historical

Soon after the recognition of the process of decomposition of water into oxygen and hydrogen by the passage of an electric current through it, very early in the 19th century, there followed rapid developments which have lead to the present highly developed industrial art of electroplating and electroforming; among these early developments one phase is of particular interest. About 1838 the discovery of the galvanoplastic process, (electroforming), was announced by Professor Jacobi to the Academy of Sciences of St. Petersburg. He is therefore, credited with being the father of galvanoplasty.

Within a few years (between 1845-50), European dentists were investigating this new art of reproduction (of a solid form), using the electrolytic process. According to W. Pfannhauser,[1] Dr. Vajna of Budapest was the first to succeed in making a copper model to be used in the construction of artificial dentures. St. Schulhof of Bohemia extended Vajna's work which is described by Pfannhauser as "a method of making artificial dentures by the electrolytic deposition of silver and points out that mechanical methods are complicated and do not reproduce details as accurately as one would like."[2]

In 1856, John Newell of New York, sought and obtained a patent on the electroforming process and presented the idea to the dental profession on this continent.

Since these first attempts to apply the principles of electrodeposition to dental procedures, numerous efforts have been made both on this continent and elsewhere to popularize the use of the principles of electrodeposition to its applications in dentistry. The basic principles underlying electrodeposition are those for electro chemistry.

CHAPTER 2

GENERAL ELECTRODEPOSITION

Fundamental Principles of Electrochemistry

ELECTROCHEMISTRY is defined by an eminent authority as "The science which treats of the relation of electricity to chemical changes."

"The phenomenon of the chemical decomposition of substances or compounds (chiefly aqueous solutions of metallic salts) by means of an electric current is called Electrolysis."[3] The conducting solutions, namely those that contain acids, bases or salts which undergo this process of decomposition are called Electrolytes. The two metallic leads along which the current is introduced into and passes out of the solution are termed Electrodes. The former, the afferent terminal is positive and is called the Anode, while the latter, the efferent terminal, is the Cathode and is negative.

Within the electrolyte a certain degree of dissociation takes place resulting in the formation of particles called ions. "These ions are electrically charged regardless of whether a current is passed through the solution or not. When a current is passed through, the charged ions are carried by the current and discharged at the electrodes."[4] The positively charged ions migrate to the negative electrode (the cathode) while those negatively charged are attracted to the positive electrode (the anode).

When the ions yield their charge they lose the characteristics of the ion and become atoms of the element so released. For an example, let us turn to the acid copper sulphate solution and examine the electrochemical reaction which results in the deposition of copper at the cathode.

We might consider the copper sulphate as being dissociated into Cu^{++} (cupric) ions and So_4^{--} ions. The former are discharged at the cathode resulting in the formation of metallic copper on the cathode. The So_4^{--} ions are discharged at the anode combining with the copper of the anode to form copper sulphate. If this process were uniformly continuous copper sulphate would be formed just as fast as copper is deposited from the solution and hence the balance of copper sulphate and sulphuric acid in solution would be maintained indefinitely. However this is not exactly the case in actual practice.

Further elaboration of this point will be taken up at a suitable time later.

From this example the general principle of the method of deposition of a metal from an electrolyte is established. It may be applied to many metals.

Electrodeposition—Two Phases

With this brief statement of the process whereby a metal may be deposited upon the negative terminal, the cathode, we now turn to the two phases of electrodeposition which are fundamentally the same and yet differ in some respects.

Firstly, it is possible to deposit a thin veneer of one metal upon another. This is called electroplating. The process is well known to us in its almost universal use in the jewelry, silverware and general trades.

Secondly, it is possible to deposit a metal upon an object, whether that object be metallic or non-metallic, and thus to build a counterpart of the object. Such a process is known as electroforming and the art of electroforming is the art of Galvanoplasty.

Electroplating—In the electroplating trade the article to be plated is of a metallic nature and therefore a conductor of electricity. It is attached to the cathode upon which the metal in solution is deposited and the article is thereby covered or plated. The adaptation to the dental field of this phase of electrodeposition is limited but will be referred to in a subsequent chapter.

Electroforming (Galvanoplasty)—In the electroforming process the deposition of a metal may be made upon a non-metallic surface, i.e. a non-conducting surface.

Two outstanding examples of the use of galvanoplasty in the industrial world are the production of the plates for the manufacture of gramophone records and electrotype. In the former case we see the formation of a "negative" by electrodeposition, from a wax positive.

A brief description of the process of making a record is outlined here from the work of Blum and Hogaboom for the purpose of drawing to the attention of the dentist the accuracy of this method of reproduction. "The original wax record is first coated with graphite upon which copper is deposited to form a 'master matrix.'

This matrix is a negative. From this plate one or more master records are made by electrodeposition. The plates are positives and serve as the forms on which the final or 'pressing matrices' or 'working masters' are deposited. The fact that satisfactory results can be obtained even after several 'generations' of plates have been made is good evidence of the accuracy of reproduction".[6]

Electrotype, on the other hand, involves the formation of a "positive" from a wax negative or a wax impression of the original object, in this case, type.

From the above examples given, we note two important facts. (1) In the latter example we recognise the similarity of the procedure to that of many dental procedures wherein we form a positive from a negative impression of the original object. (2) In the case of the gramophone record, we recognise the extreme degree of accuracy of this method of reproduction.

The adaptation of the art of galvanoplasty to certain dental procedures is therefore indicated.

The Characteristics of the Deposits

For a moment let us direct our study to the general electroforming and electroplating trades and learn of the factors which influence the characteristics of the deposits. The finer the crystals of the deposited metal, the smoother, stronger and harder will be the deposit. While there are still many unknown factors which influence the character of the deposits, some of the known factors must be considered.

Current Density according to Freeman and Hoppe[7] may be defined as "The number of amperes per unit of area of the cathode", and is given usually as so many amperes per square foot. The optimum amperage per square foot for each metal differs, and even for the same metal, opinions vary as to a current density required; for example, copper may be stated as 10 to 15 amperes per square foot; for nickel, somewhat less.

The effect of increasing the current density, according to Bancroft and other authors, is to decrease the size of the crystals which are formed. However, there is a definite limit to the rate at which a metal can be deposited and still produce dense deposits. This limit is called the "critical" current density and if it is increased above this limit the deposit produced is soft, loose, spongy, and in the case of copper, reddish in colour and is spoken of as a "burnt" deposit. As the critical current density is approached the evolution of hydrogen at the cathode is seen to increase.

Agitation refers to the production of continuous movement of the electrolyte so that stasis does not occur. The effect of agitation of the solution is to increase the metal supply at the cathode—and hence the ease with which metal is thrown out of the solution. This means that a higher current density might be used and good deposits expected in a bath where agitation is used, whereas a similar current density in a bath not agitated would result in "burnt" deposits. Agitation, furthermore tends to clear away gas bubbles from the cathode in certain situations.

As a disadvantage, on the other hand, agitation introduces the factor of the continual suspension of any sediment which might be in the tank. Small particles drift onto the cathode and lodge there to cause roughness of the deposit. In the applications in dentistry wherein the back of the deposit is to be reinforced with stone, plaster, cement or a low fusing metal, (as in the case also of electrotype) this cannot be raised as an objection.

Agitation is effected by means of compressed air bubbling through the solution, mechanical means, and other ways, all of which add to the expense and complication and cumbersomeness of the apparatus set up. This is a disadvantage in its application in the dental office. Considerable experience with still solutions for dental purposes makes us realize that there is little to be desired or added by the inclusion of the features of agitation. Occasional stirring of the solution is all that seems necessary.

Temperature—the temperature of the electrolyte will also affect the characteristics of the deposit. The crystals deposited at higher temperatures are coarser than those deposited at lower temperatures and hence the effect upon the surface of the deposit. The use of cold solution aids in the simplicity of the construction of the dental apparatus.

Conductivity—the conductivity of the electrolyte has an important bearing on the characteristics of the deposit. The conductivity of the solution governs the potential drop through it. A high potential drop through the solution as the result of a lowering of conductivity favors the formation of large crystals and this results in the appearance of "trees" on the surface of the deposit.

Throwing power—The degree to which a metal is deposited evenly upon a cathode is determined by the "throwing power" of the solution. In the case of cathodes of irregular shape, this factor is important, generally speaking. In the dental applications however, even though we are concerned with irregular shaped cathodes, uneven distribution of the deposited metal is not serious. This particular aspect will be discussed later.

In the general field of electrodeposition throwing power is influenced among other factors by the conductivity of the solution, and the polarisation of the cathode.

Briefly, in a practical way, the more even distribution of metal upon the cathode may be expected to result from making the anode as nearly as possible the same shape as the cathode; and increasing the distance between the cathodes and anode. In the latter case the near parts of the cathode are relatively little nearer to the anode than the far parts and therefore will not be subject to a greater concentration of current density with the consequent greater deposition of metal.

Shielding the prominent parts of the cathode by means of glass, or some insulating material has been suggested by some authors as a means of obtaining more even distribution of metal upon the cathode. Supplementary inside anodes have been suggested by others.

The Electrodeposition Industry and its General Requirements

From a study of the electrodeposition industry we find that the first and most obvious requirement is some constant source of direct current, at relatively low voltage (6-12 volts). Such a current may be supplied by means of a "low voltage generator" or from storage batteries.

To control the current, rheostats to regulate the voltage are used, although it is more expedient to regulate the generator, i.e. the source of the current.

"A very simple form of parallel rheostat for experimental work, with commercial current of 110 or 220 volts, can be made by arranging a "bank" of incandescent lamps in parallel."[8] If it is desirable to measure the current flowing in the circuit, an ammeter may be connected in the circuit in series, and a voltmeter may be connected in parallel to measure the voltage.

The distribution of a current of high amperage, such as is used in the general electroplating industry requires care as to the size of the conductors used and the nature of the conducting material. When the current is of small amperage, conducting wires of a suitable metal may be used without being concerned too much with their size. Copper is the metal that is considered best by reason of the fact that it is a good conductor of electricity, relatively resistant chemically, and is of moderate cost.

Of equal importance with the nature of the conductors of the current is the nature of the connections made between one part with another. To eliminate loss of current, as the result of the increased resistance offered by a single poor contact, all connections should be made permanent, where possible, either by soldering or bolting.

After brief consideration of the source of the current, its control, measurement and distribution to the field of operation, namely the tank or vat, let us turn to the requirements of this part of the equipment.

The tank must be of convenient size, strong, cheap, and resistant to the solutions to be used in it. The larger and deeper the tank, the better, for reasons of overcoming changes in concentration of the electrolyte during operation. Wood, stoneware, concrete, iron, and in the case of small tanks glass, have all been used and found satisfactory materials for tanks in the electrodepositing industry.

Some means of agitation of the solution is generally provided for, whether it be by mechanical means, or compressed air. The need for occasional filtration introduces the problem of the location of the tanks, the type of filters to be used with the various solutions, such as acid solutions, neutral solutions or alkaline solutions.

Finally, in large establishments consideration is given to the protection of the electrical and mechanical equipment from fumes of the solutions. Care in the ventilation of the rooms will aid in reducing this factor to a minimum.

The above considerations will be discussed later with special reference to their application to the dental field and their importance in the dental office.

The Metals Used In General Industry

The metals chosen for use in the general electrodeposition industry are selected primarily for their value in electroplating.

Such factors as the color of the metal and the lustre which it produces on the finished (plated) object are of vital importance.

The capabilities of the metal to resist corrosion and tarnish are factors to be considered also. This latter property is influenced by the relative position of the metal in the Electromotive Series. The Electromotive Series table appears below as taken from Freeman & Hoppe.[9] Gold is best and platinum next. They are at the positive end of the series.

ELECTROMOTIVE SERIES

Potassium	2.92
Sodium	2.72
Aluminum	1.34
Zinc	0.77
Chromium	0.47
Cadmium	0.42
Iron	0.34
Cobalt	0.23
Nickel	0.20
Tin	0.15
Lead	0.13
Hydrogen	.0
Copper	0.35
Silver	0.80
Platinum	0.86
Gold	0.99

Certain specific properties for the metals often determine their choice for use.

For example, gold is sometimes selected for its resistance to corrosion and tarnish and because of its appearance. Nickel and chromium on the other hand because of hardness, find their place in industry. Tin and silver are chosen because of their resistance to certain foods, while silver is used sometimes because of its high reflecting power. Copper is chosen because of the comparative ease in the deposition of it.

The above considerations are based on the requirements for the electroplating industry. The electroforming industry (galvanoplasty) is fraught with added difficulties, and the choice of the metal to be used is determined very largely by the ease of deposition.

Copper is accepted as the most suitable metal for galvanoplastic processes—and is applied to an enormous field. The production of electrotype is one important branch of this field. Gramophone record moulds are also included; reproduction of metallic surfaces, and plastic objects, (such as in plaster of paris) are lesser phases of its application. Besides all the places where copper is employed commonly in the galvanoplastic art there are many small fields of special application such as in the formation of plates for the fashioning of imitations of (alligator skin) leather, producing inlaid work by galvanoplasty, and many other highly specialized fields of galvanoplasty.

Copper is readily deposited either from acid copper solutions or alkaline cyanide solutions, with few difficulties presenting in the operation of the process and its maintenance with a high degree of efficiency.

Nickel has been used as a substitute for copper in many of the fields noted because of the greater degree of hardness of the metal. However, difficulties with impurities in the solutions and the maintenance of the p.H. of the solutions and many others have reduced the extent to which nickel has replaced the use of copper.

The use of silver and gold in the galvanoplastic field has been limited still further not only because of the cost of these precious metals, but also because of the extreme difficulty of depositing them satisfactorily.

Chromium, too, and most other metals have proven too difficult to control in galvanoplastic processes; the slightest variations in the electrolytes or working conditions, affecting the deposits to a marked degree.

Turning now from considerations of the choice of metals to be used in the general field of electrodeposition, let us focus our attention on the choice of metals to be used in the application of the principles of electrodeposition to the dental field.

CHAPTER 3

DENTAL ELECTRODEPOSITION

Choice of Metals Available and Their Suitability

WHEN consideration is given to the selection of the metals which might be used for purposes of electrodeposition in dentistry we think of both the electroforming and electroplating fields. The logical subdivisions of each of these fields are determined by the fact as to whether the metal so deposited is to be used for laboratory technique purposes only or for use in the oral cavity.

e.g.

Electroforming	A.	Laboratory technique	—Models, etc.
			—Indirect Inlay model
	B.	Oral cavity use	—Denture base
Electroplating	C.	Laboratory technique	—Plating a copper model against which vulcanite is to be processed.
	D.	Oral cavity use	—Denture base

A.—For laboratory technique purposes the factors governing the choice of the metal to be used would include: ease of deposition, economic considerations, hardness and color to a limited extent. Copper fulfils these requirements more nearly than any other metal and is our first choice. Nickel, on the other hand, is used to a limited extent for the same purposes. Therefore when we consider special technical procedures of model or die construction we will select copper as the metal to be used.

B.—Where the metal deposited is to be placed in the oral cavity and remains in contact with the oral fluids, new factors enter into the consideration of the choice of the metal to be used. Not only must the color, hardness, economic aspects and adaptability be acceptable, but also the metal must be resistant to corrosion and tarnish in the mouth, and tolerated well by the tissues. Tissue tolerance is perhaps limited to those metals high up in the Electromotive series such as gold and silver, and to a lesser extent rhodium, nickel and chromium. Nickel and chromium are relatively low down in the Electromotive series, but under most conditions they are both "passive" and their potentials are much more positive than would appear in the table.

On the other hand silver, and nickel and gold in some mouths are readily tarnished. According to one author, "few, if any, of the common denture base materials do not stimulate the mouth tissues. Tissues reacted so well to chemically pure silver, however, that there is no evidence of stimulated tissues under such a metal, and even in some cases badly inflamed and irritated mouths were freed from these evidences of irritation."[10] A similar experience was noted in one case by the writer where a nickel denture base was used.

C.—Occasionally in the laboratory procedures the need for electroplating a metallic model arises. The factor of the resistance of the metal used, to corrosion, is the important consideration in choosing the metal. e.g. A copper model on which a vulcanite denture is to be processed, must be tinned or cadmium plated to resist the action of the vulcanite on the copper during the process of vulcanization.

D.—When the need arises for plating a metallic object which is to be worn in the mouth, similar considerations arise which have been discussed above, viz. those concerning tissue tolerance. e.g. A partial denture cast in a silver base alloy might be rhodium plated to resist tarnishing. A metallic splint cast of Victoria metal might also be rhodium plated.

Equipment for Electrodeposition as Applied to the Dental Field

When we examined the requirements which are necessary in the broad field of the electrodeposition industry we became acquainted with certain facts. With the information gathered in this way we are now able to approach the dental field and to apply the basic principles. At the outset we must recognize the fact that the dental field differs from the commercial field, principally because we are dealing with small areas upon which the deposition is to be made. The equipment therefore is built on a comparatively small scale.

For convenience sake we will discuss the details of this equipment under the following headings:

(a) Source of electrical energy.

(b) Control of current.
(c) Measurement of current.
(d) Distribution of the current.
(e) Receptacle in which the electrolytic process is to take place.
(f) Operation and maintenance of the apparatus.

(a) *Source of Electrical Energy*—An inexpensive source of direct current at a relatively low voltage (6-12 volts) is available in the form of a dry cell, or wet plate battery. These, however, require continual care and recharging. To generate the current by means of a low voltage dynamo for the small current requirements in our limited field is out of the question, both because of space available in a dental office and also because of the cost of installation of such equipment.

There are available today four or five commercial instruments designed for use in the dental office for electrodeposition of metals—but in each case the cost of such an apparatus has limited the extent to which they have been used. The principle of these is much the same in each case; namely a method of supplying unidirectional current with a means of controlling it so that the current may be varied from 50 m.a. to 1 amp.

The apparatus which the writer has made from parts readily available in any radio trade supply depot has been set up with the thought in mind of having it simple and inexpensive. By means of this apparatus the current as supplied to a dental office can be adapted to meet the requirements. This apparatus has been used almost constantly since 1937 and has proven itself highly efficient and easy to control.

The primary source of current is that which is supplied for general domestic use, namely, 25 or 60 cycle alternating current. A transformer capable of reducing 110 volts to 3-15 volts is required and shown at T in Figure 1. The terminals from the transformer pass to the alternating current terminals of a dry plate rectifier (R in diagram). The purpose of the rectifier is to reverse the half cycle of the A.C. and thus supply direct current or as it may be referred to "a unidirectional current."

There are many satisfactory makes of transformers; the one which has been used and is seen in subsequent photographs is a Lionel transformer (such as is used on a toy train set) Type WX. 50 W. 25 cycle. If the circuit is 60 cycle A.C. then the transformer must be rated accordingly.

Similarly there are several suitable makes of rectifiers. The one seen in the photographs of the complete apparatus is a Westinghouse, Rectox Unit, S 695622. The capacity of this unit is less than one ampere and is therefore limited in this respect. Seldom, however, do we require a current greater than ½ an ampere.

A Mallory dry plate rectifier No. F 12.C.1 has also been used, where a current of greater amperage (up to 2 amps) is required.

(b) *Control of the Current*—A variable resistance might be added to the circuit in series for the purpose of regulating the current supply. The simplest method of adding such a resistance was considered to be the inclusion of a single electric light socket into which could be inserted an electric light bulb of any size (from 50 to 200 w). This limited form of variable resistance combined with the adjustment of the transformer within narrow limits, allows a relatively simple, elastic, and inexpensive method of controlling the supply of current.

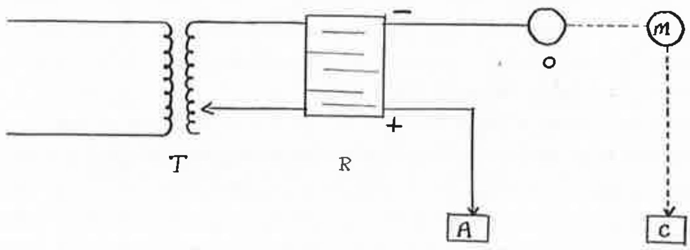


FIGURE 1

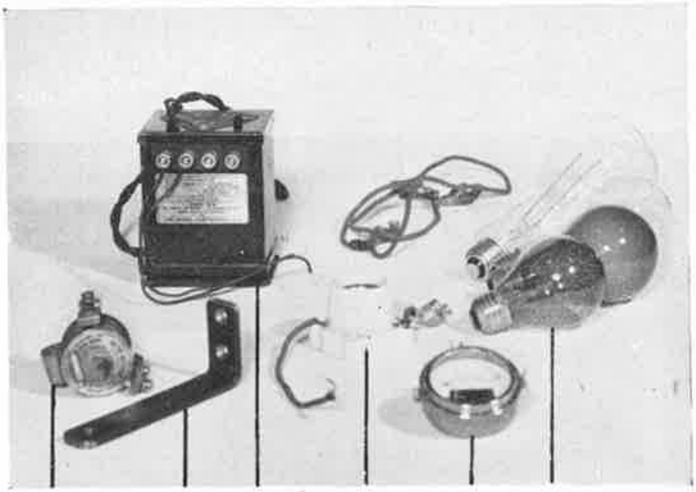
t—transformer; r—rectifier; o—electric socket and light bulb; m—milliameter; a—anode; c—cathode.

(c) *Measurement of the Current*—For dental purposes the strength of the current used is very small (somewhat less than one ampere in most procedures) and therefore a milliammeter would be required for measuring such a current. This instrument is connected in the circuit in series, as shown in the accompanying diagram. (See Fig. 1.)

If the voltage across the tank is to be recorded, a voltmeter may be readily included in the circuit, in parallel. In the dental field we are seldom interested in the voltage in such detail and therefore have omitted the voltmeter from the circuit.

(d) *Distribution of the Current*—The electrical energy now available across the terminals must be distributed to the receptacle in which the electrolytic process is to take place. In the commercial field the metal used and the size of the conductors for distributing the current some distance to the large tanks was seen to be important. In the dental apparatus the tanks are small and the problem of distribution of the current is proportionately small.

The bus-bars may be made of ½″ × $^1/_8$″ copper bar as seen in Figure 3 at $B.^1$ & $B.^2$ Loss of electrical energy in the small dental apparatus may, however, be encountered through the increased resistance of faulty contacts. Therefore it is well that all possible connections which can be fixed permanently should be soldered.



r r.s. t o^1 m o^2

FIGURE 2

r—rectifier; r.s.—rectifier stand; t—transformer; o^1—electric socket; o^2—light bulbs.

(e) *Receptacle in which the Electrolytic Process is to Take Place.*—The receptacle in which the electrolytic process takes place may be referred to as "the tank" or "the vat."

In the small field, a glass tank is quite satisfactory. The deeper the tank the better the results, owing to the decrease in effect produced by variation of the concentration of the electrolyte at the terminals. An inexpensive form of glass tank is seen in the photo-

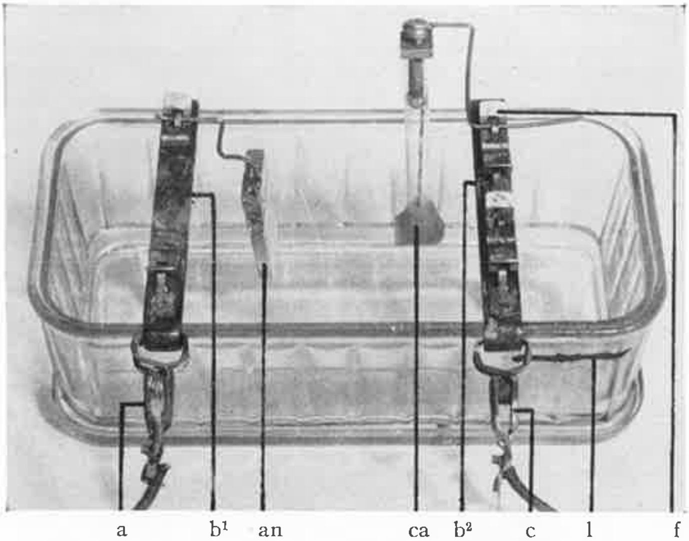


FIGURE 3

a—anode terminal; b^1, b^2—bus bars; an—anode of copper; ca—cathode; c—cathode terminal; l—level mark on tank; f—fahnstock clip soldered to bus-bar.

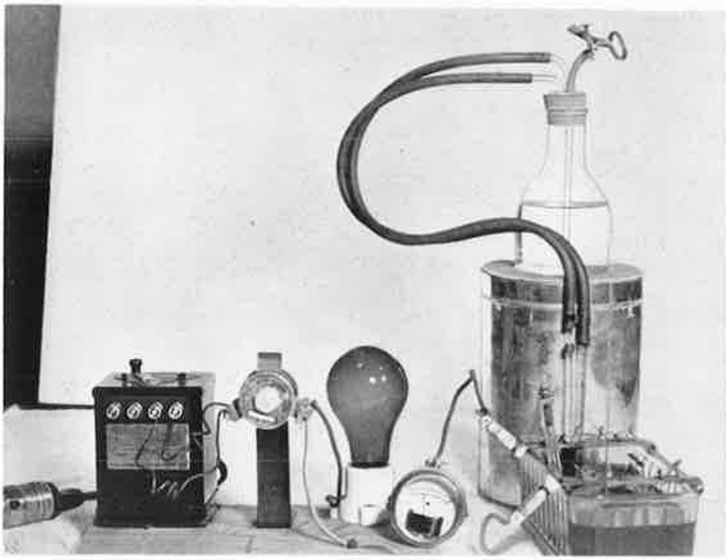
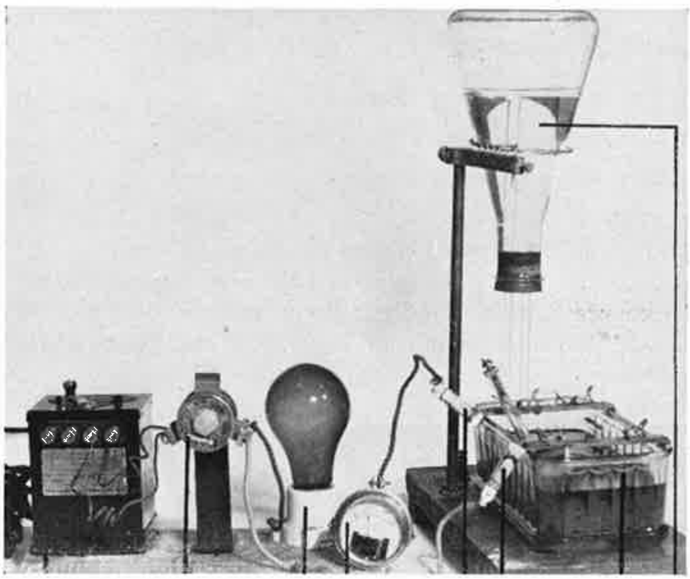


FIGURE 4

graph Figure 3. This tank has a capacity of approximately 600 c.c. The ideal tank should be about 8″ × 6″ × 6″ with a capacity of 1000 c.c. (1 litre).

(f) *Operation and Maintenance of the Apparatus*—To the equipment described above might be added (without great expense) one of two methods of automatically replenishing the electrolyte, to compensate for loss by evaporation. The first method is by the use of a flask, placed above the level of the tank and connected to it with two rubber tubes as seen in Figure 4.



t r o m c a v y

FIGURE 5

t—transformer; r—rectifier; o—electric socket and light bulb; m—milliameter; c—cathode terminal; a—anode terminal; v—tank or vat; y—reservoir.

The second method and the most efficient of the two is shown in Figure 5. In this we see an inverted flask half filled with solution and two glass tubes extending through the rubber cork downwards into the tank.

Diagrammatically the principle of this reservoir is as follows.

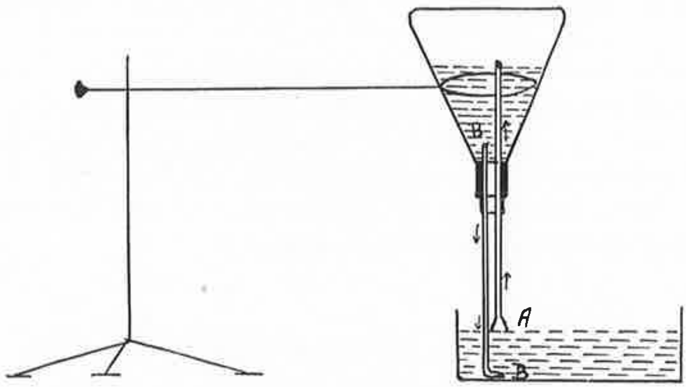


FIGURE 6
Sketch of reservoir at y in Figure 5.

As the level of the electrolyte in the tank falls and air enters at A, the pressure in the glass flask is equalized with that outside the flask and a syphon action permits the liquid in the reservoir flask to flow into the tank. As soon as the level rises again and cuts off A—the pressure in the flask becomes less than the pressure outside and the syphon effect ceases and the fluid in the flask ceases to flow out through B. Thus the loss of electrolyte (actually only water) by evaporation starts the process of replacement of the fluid in the tank.

However, the addition of the equipment described above to compensate for the loss of water from the electrolyte by evaporation, is not essential. To simplify the apparatus, another method of compensating for the loss of water from the electrolyte will be suggested later.

As has been said before, the writers' prime consideration has been to advise the use of a piece of apparatus which the dentist himself can put together. It is simple, efficient and the total expenditure involved prior to the war, was less than ten dollars.

Applications to Dentistry

For convenience of discussion of the application of the electro-depositing art to specific dental procedures the following classification of these procedures has been drawn up.

Electroforming	Technique	—Models for inlays, crowns, etc.
		—Bite appliances
		—Records—Pre-extraction; special and Orthodontia casts
		—Acrylic Inlays
		—Teaching models
	Oral	—Denture Bases—nickel & silver
		—Obturator
		—Artificial Nose
Electroplating	Technique	—Teaching models
		—Copper model for Vulcanite
	Oral	—Crowns
		—Copper bands for use in mouth
		—Partial Dentures
		—Bite Appliances
		—Splints
		—Silver Denture Bases

CHAPTER 4

ELECTROFORMING FOR TECHNIQUE PURPOSES

IN a previous section we considered briefly, the suitability of certain metals for dental purposes. It was suggested that copper fulfilled the requirements desirable in a metal to be used in technique processes. Copper is hard, its color is good; from the economic standpoint it is satisfactory and it is perhaps the most easily manipulated.

For copper, the electrolyte in which the action is brought about, may be either the acid copper sulphate solution or the alkaline copper cyanide. Up to the present time the acid solution has proven to be the most efficient and is the medium of our choice.

The Copper Electrolyte

The formula for the copper electrolyte is satisfactory within certain limits. Most authors agree that 24-32 ounces of the crystallized copper sulphate to the gallon of water, provides the most favorable limits of concentration of this salt. It is known that acid solutions are better conductors than ordinary solutions, and since the whole process depends on the degree of conductivity through the electrolyte, it is expedient to use an acid solution of copper sulphate.

Commercial sulphuric acid is used to acidify the solution of copper sulphate and is required in limits of 8-12 ounces to the gallon of water. As the acid concentration increases, the solubility of the copper sulphate decreases, so that the balance between the two must be kept within certain limits, or else copper sulphate crystals will be deposited out of the solution.

The Electrolyte formula.

Crystal copper sulphate.......24-32 ounces
Commercial sulphuric acid..... 8-12 ounces
Water.......................One gallon

Mix.

N.B. Considerable heat will be developed when the sulphuric acid is added and therefore caution should be observed. The acid should be added slowly, while stirring continuously.

The above formula using the metric system would be approximately:

Crystal copper sulphate.......800-900 grams
Commercial sulphuric acid.....300-325 c.c.
Water.......................3800 c.c.
Mix

However, with the idea of strict economy in mind, it would be well to recall that perhaps only 600-800 c.c. of solution are going to be required for the tank to be used in the dental office. Furthermore, the writers' experience and tests have shown that the solution may be kept in use, with reasonable care, for a year at least and may be longer. Therefore the formula for the electrolyte might be broken down to supply 600-800 c.c. as follows:

Crystal copper sulphate.......130 grams
Commercial sulphuric acid..... 50 c.c.
Water.......................620 c.c.
Mix.

The copper electrolyte made on the basis of the above formula has been used and found extremely satisfactory in the work done by the writer.

Four factors concerning the electrolyte should be considered if its efficiency is to be maintained.

Firstly, if the copper, which is deposited on the cathode, were taken out of the solution at exactly the same rate as it was dissolved from the anode, a condition of balance would exist in the solution indefinitely. Unfortunately, this is not the case. Theoretically, there is a gradual decrease in the acidity and a corresponding increase in the copper sulphate concentration, which is explained in the following way. Some of the copper goes into solution at the anode as Cu^{+} (Cuprous ions) and not all as Cu^{++} (Cupric ions). "As the electrochemical equivalent of cuprous copper is twice as great as that of cupric copper it follows that just to the extent that cuprous ions are formed more copper will pass into the solution from the anode than if only cupric ions were formed. The net result is an increase in the content of copper sulphate and a decrease in that of the free sulphuric acid."[5] The effect of this is to interfere with the efficiency of the rate of deposition of copper at the cathode.

Secondly, there is the factor of evaporation of water from the surface of the tank, which also has the tendency to disturb the balance between acid and copper sulphate and results in deposition of the copper sulphate crystals on the anode and in the bottom of the tank. See Figure 7.

The efficiency of the process is rendered negative by this situation and the deposition of copper at the cathode ceases.

Thirdly, there is the process of "drag out" which occurs each time the cathode (the impression) is removed from the electrolyte. The cathode "drags out" with it some of the solution, in which is some acid and some copper sulphate.

Hence, a gradual tendency to weaken the solution of both.

Fourthly, there is sure to be the accumulation of a certain amount of sludge in the bottom of the tank. This comes from the atmosphere, and from impurities in the anode.

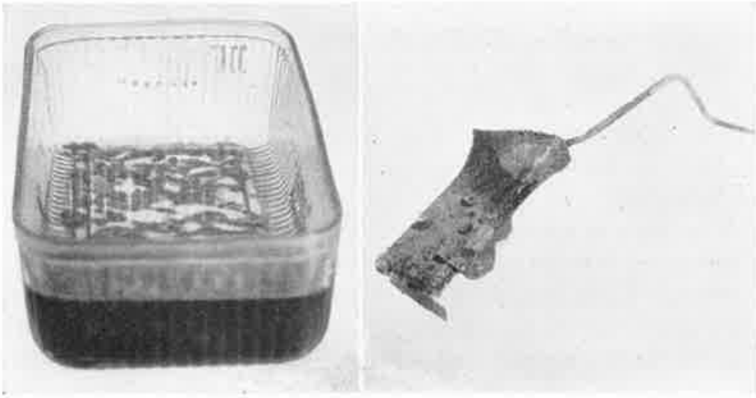


FIGURE 7

Photograph showing copper sulphate crystals deposited in the tank and on the anode

Maintenance of the solution as an efficient electrolyte depends on the control of the above mentioned four factors. While nothing has been done directly to control the decreasing acidity, it will be aided by control of the second, and third factors. Perhaps, too, the addition of a small amount of sulphuric acid to the solution from time to time is warranted. Tests for p.H. concentration conducted on various solutions—and one in particular, which was in continuous operation for a year, illustrate the gradually decreasing acidity. See table below.

Solution No. 1	Solution No. 2	Solution No. 3
Constant Use	Not Used	Not Used
Vat not covered Reservoir Used	Vat not covered Reservoir Used	Vat not covered No Reservoir
p.H. .40 p.H. .62 p.H. .69 p.H. .88 p.H. 1.00	p.H. .40 p.H. .56 p.H. .41 p.H. .28 p.H. .38	p.H. .40 p.H. .50 p.H. .46 p.H. .59 p.H. .49 p.H. .56

N.B. All three solutions were portions of same original mix.
N.B. As the value increases the acidity decreases.

It will be seen from this table showing the results obtained for p.H. tests done at intervals with the Beckman p.H. meter, that the solution represented by the figures in the first column, gradually became less acid. This solution was in constant use for a year.

The figures in columns 2 and 3 are those for two solutions (similar in formula to the solution in column 1), one of which was open to the atmosphere, but never used. The other (column 3) was in a well-stoppered jar. The results in the case of 2nd. and 3rd. solutions show that the acidity remained fairly constant. Use must be a contributory factor therefore, for the decrease in acidity in the first solution.

Control of the evaporation of water from the solution can be easily accomplished in several ways. The simplest method and the one involving no extra equipment is to place a mark on the tank at the height of the original level of the solution in the tank.

Add water as required by the drop in the level. Should crystallisation occur as the result of evaporation, restoration of the level by the addition of water will quickly result in the solution of all the crystallised copper sulphate, and a return to normal. The amount of evaporation might be reduced by covering the tank with a glass cover.

Instead of a glass cover, a cover made out of a half car battery casing with the terminals going through it, might be used. However, the cover, of whatever type, will only limit the loss by evaporation and additions of water will be required from time to time. The third method of controlling loss by evaporation involves additional inexpensive equipment. The principle involved in the method of operation of the reservoir is explained by the diagram Figure 6.

The solution which has been referred to previously as having been in operation for one year was carefully recorded for volume lost by evaporation. After the original 600 c.c. of solution had been placed in the tank, 7,200 c.c. of water were added during the year, through the reservoir. This amounted to about 300 c.c. every 15 days, or 20 c.c. a day. However, this was for a tank with a solution surface area of 26 square inches, and another tank of different area would result in more or less evaporation.

Control of the "drag out" factor was not practised with the solution tested for the year in actual operation. No doubt this contributed to some extent for the loss in p.H. of this same solution referred to before. But besides the loss of acid, some copper sulphate was also lost. A series of tests were carried out to determine, comparatively only, the extent of this loss of copper sulphate.

By adding 10 c.c. of electrolyte to 15 c.c. of concentrated sodium nitrate and diluting with 100 c.c. of distilled water, and then using a clean, weighed, copper gauze cathode and platinum anode, all the copper content of that small amount of solution could be removed and deposited on the cathode. The increased weight on the cathode represented the amount of copper in the 10 c.c. of solution. This test could be accomplished in 4 hours with a current of 300 m.a. Proof of all the copper being removed was furnished by adding to a few drops of the diluted solution, a few drops of H_2s water. No discoloration meant that no copper sulphate remained.

From the table it will be seen that all solutions tested were made originally from the same formula, and all received the same treatment. Solution No. 1 and No. 2 were new: Solution No. 3 one year old and had been in continuous use, and Solution No. 4, one year old, but it had never been used, and had been in a well-stoppered jar, from which no doubt a slight amount of evaporation had taken place, and no compensation for it had been made.

The results are interesting. Numbers 1, 2 and 4 had virtually the same copper content but No. 3, the much used solution, in which the "drag out" factor had not been compensated for, contained less than half its original copper content. The loss must be attributed to the "drag out."

To compensate for this factor it is suggested that immediately the anode or cathode is removed from the tank at any time, whether it be for inspection or after completion, that it be washed in a jar kept available alongside the tank for this purpose. By so doing, the solution "dragged out" is washed off. This rinsing water might then be used to refill the reservoir or for the additions which are to be made from time to time, to compensate for the evaporation. The "drag out" solution is therefore returned to the tank.

The results obtained are shown in the table below.

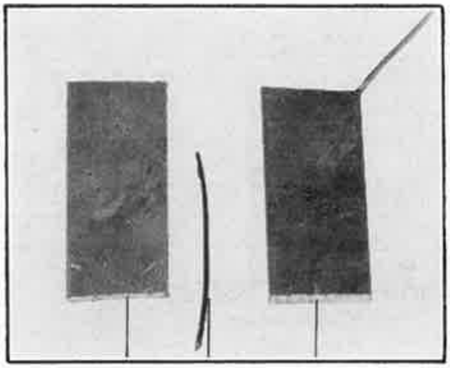
Solution No.	Solution Formula	Grams of Copper contained in 10 c.c. of solution
1..........	Copper Sulphate... 130 gr. Sulphuric Acid..... 50 c.c. Tap Water........ 620 c.c. New Solution Not used	.470 grams
2..........	Copper Sulphate... 130 gr. Sulphuric Acid..... 50 c.c. Distilled Water.... 620 c.c. New Solution Not used	.465 grams
3..........	Copper Sulphate... 130 gr. Sulphuric Acid..... 50 c.c. Tap Water........ 620 c.c. Solution 1 year old Used continuously	.200 grams
4..........	Copper Sulphate... 130 gr. Sulphuric Acid..... 50 c.c. Tap Water........ 620 c.c. Solution 1 year old Not used	.480 grams

As far as the accumulation of sludge in the tank is concerned, the solution should be filtered once a month to free it of the sediment.

Before leaving the subject of the maintenance of the copper electrolyte it should be said that the solution referred to several times above, as having been kept in operation for one year; which had 12 times its original volume of water added; whose p.H. increased from .40 to 1.00 and the copper content of which was reduced to less than half of its original content, nevertheless at the end of one year it was still functioning well, but not quite as efficiently as a new solution.

The Copper Anode

The anode may be of electrolytic, drawn or rolled copper—the latter being considered best. It should have an area which is larger than the cathode area. It is also advantageous for the anode to be similar in shape to the cathode surface upon which the metal



a b c

Figure 8
a—Copper bar, 2″ × 1″ × ¼″. b—24 ga. copper wire. c—completed anode.

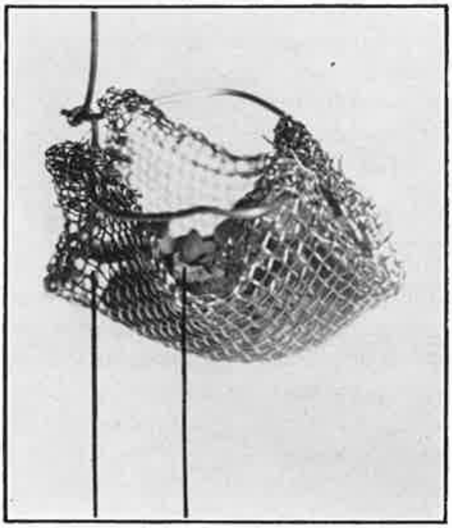
is to be deposited. However, with small objects such as impressions of individual teeth with their cavity preparations, the surface is very irregular and different in every case. It is impracticable, therefore, to meet the ideal in respect to having the anode and cathode surfaces similar.

The anode used by the writer is simply constructed from rolled bar copper. A piece 2″ × 1″ × ¼″ as seen at (a) in the Figure 8 is suitable for the small tank used. If the tank is 6″ deep then the measurements could be increased to 6″ × 1″ × ¼″.

A piece of 14 G. copper wire is soft soldered to one corner of the copper bar to complete the anode, see Figure 8 (c). The anode should be long enough so that the soldered join will not enter the solution when the anode is in place.

The 2″ long anode seen in the photograph weighed 70.690 grams. Approximately ¾ of one gram of copper will be used for each small unit to be electroformed, so that we might expect to make 80-90 models out of each anode of these dimensions. The cost of this item in the whole process will be mentioned later.

As a practical measure of economy, the copper shells—after they are discarded, might be used over again at the anode. The



a b

FIGURE 9

a—Stainless steel gauze basket. b—copper scrap in basket to form anode.

backing material used must first be removed. If this has been low fusing metal, it also will be recovered to be used over again. If it was stone or plaster or cement it will be destroyed in removing. The copper shells might be further cleaned of impurities by a nitric acid dip. A basket of stainless steel gauze with a stainless steel lead wire is constructed very simply and very inexpensively as shown in Figure 9.

This basket may be of varying size according to the requirements. The one shown is about 1″ × 1″, and holds about 10 grams of scrap copper. After numerous tests in actual operation the stainless steel does not appear to be affected by the electrolyte or have any effect on the electrolyte.

The Small Cathode—In a Metallic Band

The cathode will be the object on which or into which, the deposition is to be made. The small cathode in dental laboratory procedures will include the impression of a cavity preparation for a gold inlay to be made by the indirect method, a porcelain jacket crown, a gold crown, or a porcelain inlay. The materials commonly used for taking such an impression are wax and compound, contained in a metallic (copper, brass, aluminum) band. The wax or compound is a non-conductor of electricity. Any treatment of the surface to render it a conductor must not in any way deface it or change the shape of it.

Metallizing the Cathode

The process of rendering the wax surface a conductor of electricity is called metallizing the surface. Failure to be thorough in this phase of the process has, in the past, been responsible for many disappointments. The various methods available for metallizing a non-conductive surface may be classified as dry or wet processes. For the dry process we return to study briefly the electrotyper's work. He takes an impression of the type with a specially compounded wax, and on it he brushes dry graphite. This surface is well burnished and it is then covered with wet graphite. Further treatment of this graphited surface is proceeded with by wetting the surface with some dilute copper electrolyte and dusting on iron filings. The copper and iron in the presence of the acid solution sets up a number of individual minute cells, each of which precipitates metallic copper onto the graphited area. The metallized surface is now washed off. In recent years wet graphite has been used almost universally, because of better conductivity, and because the dust of dry graphite was injurious to the health of the workers. For dental purposes the electrotyper's process is not highly satisfactory. Copper bronze powder might be substituted for the dry graphite in the previously outlined method. In the writers hands this has not been very efficient.

The wet methods of metallizing a wax impression include two suitable procedures which are applicable to the dental field.

The first method is based upon the use of graphite in a colloidal form. Aqua Dag—a product of the Acheson Colloids Corporation—has been the graphite of choice. Very minute quantities are used so that it is therefore a relatively inconsequential item when considering the production costs.

On a glass slab (set aside for this use only) or a suitable receptacle, as seen in Figure 10, place a small portion of the colloidal graphite. Enough to cover the head of a pin per impression should be sufficient.

When ready, mix the graphite with a drop of water. The mixture should be thin and watery, not creamy in consistency. See Figure 10—right.

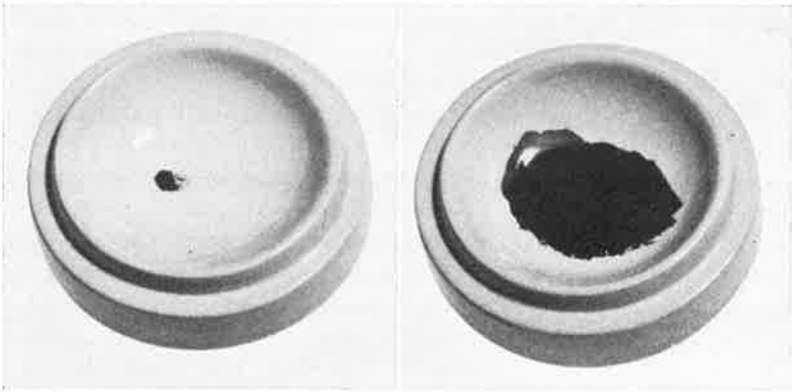


FIGURE 10

With a small camel's hair brush the watery suspension of graphite is painted onto the dry surface of the impression and over the edge to contact the metallic band containing the impression material. The graphite is now dried by means of a few puffs of air from a chip blower. This automatically effects an even distribution of the graphite over the impression surface, blows out any excess, and also blows some out to contact the band, as mentioned above. Examine the surface carefully for any areas which were missed in the graphiting process and retouch any such areas before proceeding. The copper deposition will extend to the limits of the graphite so that the extent of the impression covered can be controlled by the careful placement of the graphite.

A few drops of dilute copper electrolyte are now dropped into the graphited impression with a medicine dropper and iron filings are dusted in with the solution. A suitable shaker for the iron filings is a discarded mercury dispenser. After three or four minutes the contents of the impression are washed out gently and with the aid of a camel's hair brush, any particles may be removed. Upon inspection it will be seen that the graphite is completely covered with a deposit of copper. If the copper deposit is not complete, dust iron filings on the areas missed and add a drop or two of solution again. Wash off after three or four minutes.

While the above wet process for metallizing an impression is perhaps the most efficient, relatively simple in its application and inexpensive, there is always the unclean nature of graphite to contend with, both in its application and on the finished model. In the case of porcelain work and especially in the case of acrylic restorations, a cleaner metallizing process is desirable.

A second wet process, that fulfils the latter requirement, is described below.

It is based on the chemical precipitation of silver upon the wax surface of the impression. Two solutions are required in this process and as both are comparatively unstable they should be made up fresh just before using. Such a limitation at the outset might be discouraging but it can be met rather simply.

The two solutions are silver nitrate and a reducing solution. When brought together, silver is deposited, which on glass will form a shining silver mirror. On wax or compound the same effect is produced. Silver is a splendid conductor of electricity and therefore excellent for metallizing the wax of the cathode. Silver nitrate is of course bad from the standpoint of the stains it produces if it gets on the hands or linen, but its antidote, common salt, is cheap, and should be readily available both for cleaning up utensils in which the silver nitrate has been used and for preventing stains.

Prior to the application of the silver metallizing solutions to the surface of the wax impression the surface is treated with a preparatory solution. The preparatory solution is poured into the box which is formed around the impression and left for three or four minutes. The impression is then washed off.

The formula for the preparatory solution is as follows:

Stannous Chloride....1 gram = 4 large ends of Caulk silicate measuring spoon.

Hydrochloric acid.....1½ c.c.

Distilled water........100 c.c.

Mix and allow sediment to settle.

The formula of the silver solution (A) and the reducing solution (B) which have been found effective appear below.

			Approximate Cost
(A)	Silver nitrate crystals........	2.1 grams	4½ cents
	Distilled water..............	45.0 c.c.	
(B)	Pyrogallic acid (Pyrogallol)...	.480 grams	1 cent
	Citric acid..................	.105 grams	1/10 cent
	Distilled water..............	15.0 c.c.	

These quantities given above would be satisfactory for a full edentulous impression.

For small impressions, or a number of small impressions one-fifth of these quantities would be suitable i.e.:

			Approximate Cost
(A)	Silver nitrate crystals........	.420 grams	1 cent
	Distilled water..............	9.0 c.c.	
(B)	Pyrogallic acid (Pyrogallol)...	.096 i.e. .100 grams	1/5 cent
	Citric acid..................	.021 grams	1/50 cent
	Distilled water..............	3.00 c.c.	

These quantities might be weighed up and placed in suitable capsules or glass vials ready for mixing. However, this calls for a pair of relatively accurate scales weighing in milligrams.

Thinking again in terms of the general practitioner, our object is to make all suggestions and procedures as relatively easy and adaptable as possible. Therefore these small quantities have been related to measuring devices which are no doubt readily available in the office of any general practititioner. A Caulk's silicate powder measuring spoon, a 25 c.c. glass measure, and an ordinary teaspoon, will serve as all the equipment required.

After weighing many times, measured quantities of the chemicals referred to in the above formula, these formula have been translated into terms of the measuring devices mentioned. For example, for sufficient solutions suitable for metallizing an edentulous upper impression take:

(A) Silver nitrate crystals (2.1 grams)	= 5 large ends of silicate measure—level
Distilled water	= 45.0 c.c.
(B) Pyrogallol (.480 grams)	= 1 level teaspoonful
Citric acid finely powdered (.105 grams)	=2 small ends of silicate measure—level
Distilled water	= 15.0 c.c.

Or for a small quantity:

(A) Silver nitrate crystals (.420 grams)	= 1 large end of silicate measure—level
Distilled water	= 9.0 c.c.
(B) Pyrogallol Crystals (.100 grams)	= 1 large end of silicate measure—level
Citric acid (finely powdered) (.021 grams)	= ½ small end of silicate measure
Distilled water	= 3.00 c.c.

These chemicals are readily soluble in cold distilled water. Hence with the method of measuring the required quantities as outlined above, the task of making up a fresh quantity of solution when needed is greatly simplified. The writer has kept the solutions made up in well-stoppered, dark bottles, in a cool dark place for several days and found them still quite efficient after such treatment.

When the solutions are ready for use, the impression, whether it be large or small, should be "boxed in" (none is necessary for most small impressions in a metallic band) and into the boxed impression the solutions are poured. Immediately the mixture turns dark but it should be left for from five to ten minutes. After this time has elapsed, wash off the impression thoroughly. Care should be observed in this step. Nitric acid will clean any containers in which the solutions have been prepared.

The impression is now metallized with silver and ready for immersion in the tank.

To obviate the necessity for the need of metallizing an impression, Thompson has suggested the use of an impression material which is conductive in itself. He writes, "An impression material which I have found satisfactory for this technique consists of a mixture of very fine graphites, such as Dixon's Microfyne 60% and ordinary paraffin 40% by weight."[11]

The reaction of the material under various tests were studied and an abstract of the results appears by the same author in the Journal of Dental Research.[12]

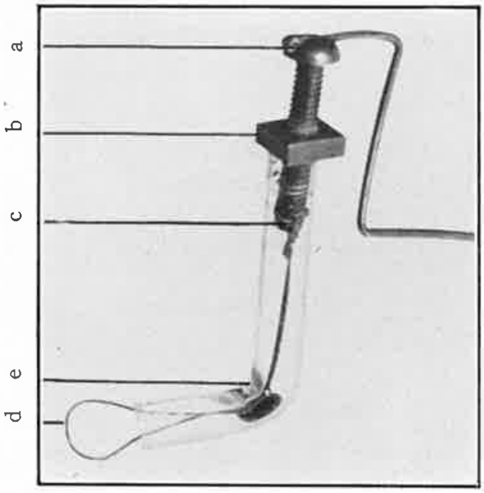


FIGURE 11

a—14 ga. copper wire soldered to stove bolt. b—adjusting nut of stove bolt. c—24 ga. copper wire attached to stove bolt. d—wire loop of carrier. e—glass carpule tube.

ATTACHMENT OF THE CATHODE

After metallizing the impression by one of the wet process methods described above, there is placed around the band, at the open impression end, a collar of ¼″ cellulose tape (Durex). This collar should be extended 2 to 3 millimetres beyond the end of the metal band. See fig. 12.

The purpose of this cellulose collar will be mentioned at a later point in this discussion.

Arrangements must now be made whereby the impression surface, now metallized and therefore a conductor of electricity, may be attached to the cathode terminal. A carrier or holder is required. A very simple holder can be made as follows: (See Fig. 11.)

The 14 G. wire is soldered into the slot in the rounded head of the stove bolt. The 24 G. wire is bent to form a loop and the ends are soldered to the end of the threaded portion of the stove bolt. The 24 G. wire loop is now threaded through the glass carpule tube—so that the extreme end of the loop is projecting beyond the end of the carpule tube. The size of the loop beyond the glass can be adjusted very simply by adjusting the square nut on the stove bolt.

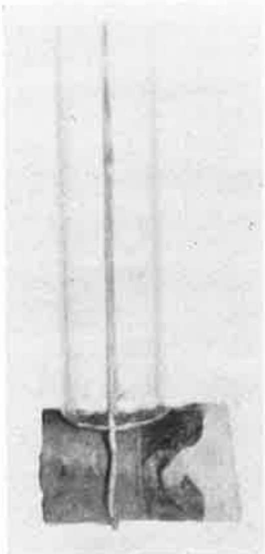


FIGURE 12

The glass carpule tube might be bent as seen in the Figure 11. This type of carrier will be referred to later as the bent carrier.

The metallized impression is placed in the loop of the carrier so that the wire loop snares the exposed portion of the metal band. The loop is then made tight around the band by adjustment of the square nut on the stove bolt. See Figure 12. It is now necessary to insulate the metal band by covering its surface with wax.

With the electrolyte prepared and in the tank, and a knowledge of certain factors which have to be observed for maintaining the efficiency of it, the anode bar and cathode might now be attached to their respective bus-bars. The importance of being sure that the impression (cathode) is attached to the negative terminal and the anode to the positive terminal cannot be overemphasized at this stage. The attachment of each piece to the wrong terminal will not only result in no copper being deposited in the impression, but it may also result in disintegration of the impression material.

Several factors are now of importance before the current is turned on and the deposition commenced. What shall be the relative position of the cathode to the anode? How much current is needed and how long will it be before sufficient copper is deposited to form a shell thick enough to be serviceable?

The position of the cathode in relation to the anode does not seem to be of great importance. Generally, a cathode of irregular form is better, the further away it is from the anode. Under such circumstances the nearest parts of the cathode will receive only relatively little more concentration of current than the sections farthest away. If on the other hand such a cathode were very near to the anode the nearest portions will have focussed on them a greater concentration of the current.

In the many tests carried out by the writer very good results have been obtained by using a 3″ distance between the cathode and anode.

The current required for the optimum deposition is dependent upon the area to be covered. Current density, we learnt earlier in the discussion of this subject, was defined as "The number of amperes per unit of area of the cathode." The current density varies with each metal. For copper it is stated to be 10 to 15 amperes per square foot. Therefore the amount of the current required to deposit copper on a small dental impression will have to bear the same relationship. We must calculate roughly the area of the metallized surface or surfaces. e.g. An impression of a bicuspid tooth ¼″ in diameter, and ½″ deep—has an area of .44 square inches. In the case of a current density of 15 amperes per square foot, this small area would require approximately 46 milliamperes. For all impressions the rate would be approximately

100 milliamperes per square inch of surface. There is considerable leeway on either side of this figure so that it is unnecessary to waste much time in figuring out for each impression how much area is involved. Very little experience is necessary to judge by observation, whether there be only one or several impressions to be considered, how much current will be required. Too high a current density will result in "burning" the copper deposit (loose, reddish, granular copper) particularly at the edges, and too low a current density will result in slow deposition. The capacity of the unit seen in Figure 3 is about eight small impressions; the current required will be for the sum total of all the areas or perhaps we might say approximately 350-400 milliamperes. Adjustment of the apparatus to meet the requirements was provided for in the set up. For the convenience of those who would operate the apparatus without a milliammetre in the circuit, the following table has been drawn up, showing the relationship of the secondary voltages, the resistance bulbs and the ampere readings, using the apparatus as seen in Figure 3. These figures are for the acid copper electrolyte only.

Time and Rate of Deposition

The time required for the deposition is an important consideration in most dental offices. A satisfactory deposit of copper will depend on what is considered to be a satisfactory thickness. The weakest point in this respect will be the deepest section in the cathode. Numerous measurements were made with a micrometre, of the thickness of the copper shell on what was considered to be a satisfactory model. At the weakest point, i.e. the most prominent point, the copper was found to be only .003″ to .004″ thick, which is approximately 1/10 of one millimetre. The time required to obtain this thickness was found to be approximately 4 hours under ordinary circumstances. However, it is usually found expedient to place impressions in the electrolyte for deposition at 5 or 6 p.m. and remove them at 9 a.m. the following morning. After this length of time of 12-15 hours, the thinnest section of copper will measure approximately .005″ to .006″.

In an attempt to determine how the time of deposition could be reduced to a minimum many experiments have been conducted by the writer. Many suggestions made by various people were tested. For example, Levy,[13] says, "It has hitherto been believed necessary

Table Showing the Milliampere Readings for the Secondary Voltages Indicated with Varying Resistance Bulbs

Secondary Volts	40 W. Resistance Bulb	60 W. Resistance Bulb	100 W. Resistance Bulb	200 W. Resistance Bulb
3.7	38	94	140	238
4.8	50	114	175	280
5.0	50	117	179	300
5.8	53	128	193	...
6.6	58	136	209	350
7.4	63	145	220	...
8.2	68	151	228	...
9.0	72	157	238	400
9.8	78	162	245	410
10.6	81	166	251	...
11.4	85	171	259	440
12.2	90	176	265	...
13.0	95	179	270	...
13.5	96	180	272	490
13.8	99	183	276	490
14.3	100	184	277	...
15.1	103	187	281	500
15.9	107	190	288	...
16.7	109	192	292	...
17.5	112	195	296	530

N.B. The above milliampere readings were obtained with the Westinghouse rectifier in the circuit.

Table Showing the Milliampere Readings for the Secondary Voltages Indicated with Varying Resistance Bulbs

Secondary Volts	40 W. Resistance Bulb	60 W. Resistance Bulb	100 W. Resistance Bulb	200 W. Resistance Bulb
3.7	12	40	65	120
4.8	22	65	110	200
5.0	25	75	115	210
5.8	28	95	142	255
6.6	33	105	160	310
7.4	40	115	185	330
8.2	45	123	195	350
9.0	48	130	210	380
9.8	52	135	220	390
10.6	55	142	225	400
11.4	62	150	235	410
12.2	65	152	240	420
13.0	68	155	245	440
13.8	71	160	250	450
13.5	70	158	250	450
14.3	75	162	255	450
15.1	78	166	260	465
15.9	80	170	260	470
16.7	85	172	...	490
17.5	85	175	...	500

N.B. The above milliampere readings were obtained with the Mallory rectifier F.12 C.1 in the circuit.

Table Showing the Milliampere Readings for the Secondary Voltages Indicated—Without a Resistance Control in the Circuit

Volts	Milliamperes
3.7	400- 450
4.8	700- 720
5.0	750
5.8	910
6.6	1.150
7.4	1.350
8.2	1.520
9.0	1.850
9.8	2.150-2.100
10.6	2.320
11.4	2.400- .500
12.2	2.600- .700
13.0	2.850
13.8	2.900
13.5	
14.3	
15.1	
15.9	
16.7	
17.5	

N.B. The above milliampere readings were obtained with the Mallory Rectifier F.12 C.1 in the circuit but with no resistance bulbs in the circuit to control the output.

to use a low current density for dental electroforming, because the band and its contained impression are so small in comparison to the anode that a high current density burns them. This necessitated a lengthy exposure to the current." He then goes on to say that an auxiliary cathode permits one to use higher current densities. His words are, "I use as an auxiliary cathode, a copper bar equal in size to the anode, and hang the object to be plated directly in front of this auxiliary cathode. Because of this, a current density of from 3 to 4 amperes can be used, thus completing a copper shell die in from 2 to 2½ hours if desired."

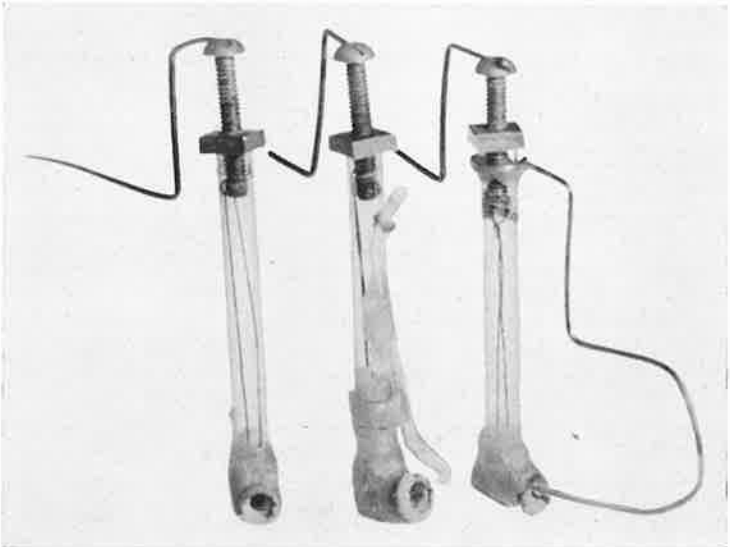


FIGURE 13

(a) Impression mounted in straight carrier.
(b) Impression mounted in straight carrier with glass tube attached to provide a continuous supply of fresh electrolyte in the depth of the impression (cathode).
(c) Impression mounted in straight carrier with auxiliary anode wire attached: it is not connected in the circuit.

The results of the tests conducted on the above suggestion of using an auxiliary cathode will be discussed later, but the writer could not demonstrate any improvement. See p. 56.

The use of an auxiliary anode as seen at C in Figure 13 was also tried.

The auxiliary anode consisted of a 14 G. copper wire—adjusted to the glass carier, but not connected in the circuit at any point. The free end of the wire entered the open end of the impression but did not contact it at any point. Large and small loopings of the wire toward the anode were tried, but the results were approximately the same in each case.

The free end of the wire inside the impression was reduced in diameter, showing that it had acted as an anode. That portion of the wire which looped farthest away from the impression and nearest to the anode proper, was built up on, hence it had acted as a cathode. See Figure 14.

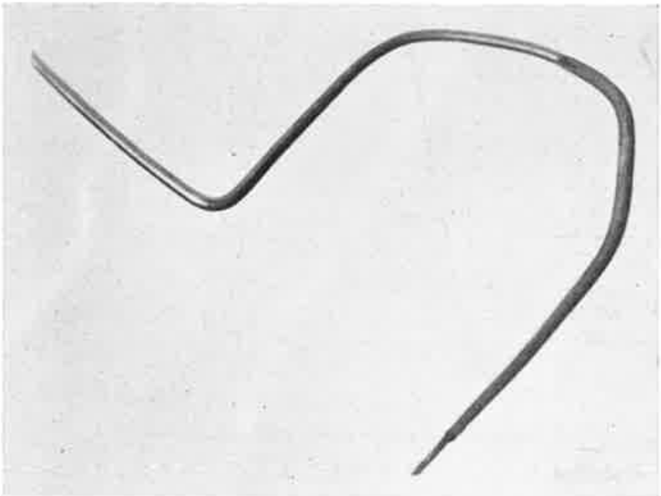


FIGURE 14

Another suggestion made was that a continual supply of fresh electrolyte delivered to the inside of the impression (cathode) would replenish the depleted electrolyte within the impression and result in faster deposition. A glass tube was bent so that it could be adapted to the carrier. It was arranged so that a fine delivery tube could be placed inside and to the depth of the impression (cathode) and this tube then could be connected to a source of supply of electrolyte. See Figure 13 (b). The source of supply was delivered at the rate of 4 drops per minute; at this rate it took 4 hours to run in 25 c.c. of copper electrolyte.

Other experiments were conducted as well, with the results shown in the table on pages 51, 52, and 53.

The numbers of hours each test piece was given is recorded in the second column; the voltage and milliamperage used, are recorded in the third and fourth columns respectively. While in the fifth column the weight of copper deposited is tabulated and in the seventh column, micrometer measurements of the thickness of the shell at four standard points are denoted. The four points at which these measurements were made for the jacket crown copper shell are shown in the diagram below. See Figure 15.

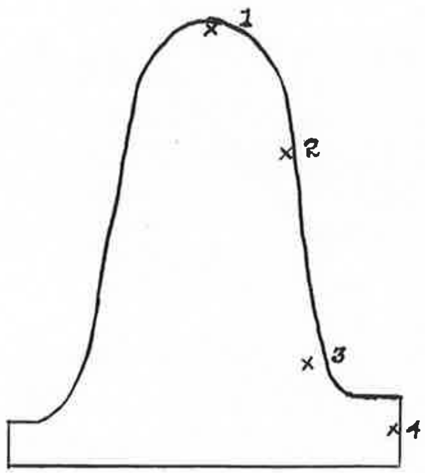


FIGURE 15

The figures given for thickness represent an average of four measurements taken at each of the four positions on each shell. The last column defines the important variations used for each of the tests.

NOTES OF EXPLANATION REGARDING TERMS USED IN TABLE SHOWN

By the *straight carrier* we mean—the impression mounted on a straight carrier as seen in Figure 13, 13A, with a 2 m.m. collar of durex tape, and metallized with graphite.

By *edges heaped*—we refer to the excessive deposit of copper which is laid down at the periphery of the impression (unless the tape collar is sufficient to control it).

Results of Experiments Conducted on Rate and Time of Deposition of Copper

No. of test piece	Time hours	Voltage	Milli-amps	Weight added in grams	No. of cathodes	Average measurements No. 1, 2, 3, 4 position	Variations in conditions and Results.
A	4	7.4	140	.230	one of 3	(1) .002″ (2) .002 (3) .004 (4) .004	Straight carrier. Edges heaped up. Silver metallization.
B	4	7.4	140	.180	one of 3	(1) .003″ (2) .003 (3) .0063 (4) .0065	Straight carrier. Edges not heaped up.
C	4	7.4	140	.170	one of 3	(1) .002″ (2) .003 (3) .005 (4) .0065	Straight carrier. Individual electrolyte supply.
D	10	7.4	210	.890	one of 3	(1) .0025″ (2) .004 (3) .007 (4) .0115	Straight carrier. Individual electrolyte supply. Heavy deposit all around edge of impression.
E	10	7.4	210	.710	one of 3	(1) .005″ (2) .0065 (2) .0090 (4) .0100	Straight carrier. Heavy deposit on lower half of edge only.

Results of Experiments Conducted on Rate and Time of Deposition of Copper—*continued*

No. of test piece	Time hours	Voltage	Milli-amps	Weight added in grams	No. of cathodes	Average measurements No. 1, 2, 3, 4 position	Variations in conditions and Results
F	10	7.4	210	.720	one of 3	(1) .0045″ (2) .0051 (3) .0079 (4) .0090	Supplementary wide anode, using a large loop. Heavy deposit on lower half of edge only.
G	16	7.4	65	1.160	alone	(1) .0038″ (2) .0069 (3) .0136 (4) .0296	Bent carrier. Heavy excess on edge nearest to anode.
J	2	3.7	500	.100	alone	(1) .0010″ (2) .0011 (3) .0017 (4) .0020	Straight carrier. Supplementary cathode.
K	4	3.7	500	.080 some lost from edge	alone	(1) .0016″ (2) .0015 (3) .0023 (4) .0025	Straight carrier. Supplementary cathode.
M	3	5.8	50	.160	alone	(1) .0021″ (2) .0022 (3) .0026 (4) .0040	Bent carrier. Edges—good.

N	3	5.8	50	.130	alone	(1) .0013″ (2) .0014 (3) .0026 (4) .0038	Straight carrier. Heaping along lower edge. Copper gauze screen.
O	4	6.6	88	.200	one of 2	(1) .0035″ (2) .0044 (3) .0054 (4) .0074	Bent carrier. Not much heaping of edge.
P	4	6.6	88	.260	one of 2	(1) .0027″ (2) .0026 (3) .0044 (4) .0063	Straight carrier. Edge heavily heaped.
Q	4	5.8	88	.130	one of 2	(1) .0019″ (2) .0020 (3) .0033 (4) .0048	Straight carrier. Long collar of Durex tape. 6m.m. instead of 2 (normal)
R	4	5.8	88	.210	one of 2	(1) .0021″ (2) .0029 (3) .0039 (4) .0047	Bent carrier. Long collar of Durex tape. 6 m.m. instead of 2 (normal).
S	14	5.0	88	.570	one of 2	(1) .0046″ (2) .0051 (3) .0104 (4) .0119	Bent carrier. Very little excess or heaping at edge.
T	14	5.0	88	.840	one of 2	(1) .0040″ (2) .0042 (3) .0070 (4) .0094	Straight carrier. Very heavy excess around lower edge.

By *individual electrolyte supply*—we refer to the case where a separate source of supply of electrolyte direct to the cathode is provided for as explained and shown in Figure 13 (b).

By *supplementary wire anode*—we refer to the use of the wire loop as shown in Figure 13 (c).

The *bent carrier* is similar to the straight carrier but as seen in Figure 11, the insulating glass tube is bent. The impression is mounted looking upward, rather than facing the anode.

The *supplementary cathode* was composed of a large sheet of copper $2'' \times 2''$, attached to the cathode terminal. The small cathode—the dental impression, was placed in front of the larger supplementary cathode.

The *copper gauze screen* was a $2'' \times 2''$ piece of copper gauze hung in front of the impression upon which the deposition is to take place, but without connection to the circuit. These are the variations referred to in the last column of the tabulated results of the experiments.

To interpret the results it is essential that we try to compare the tests done when a single variation is introduced, but when the general conditions otherwise are the same.

We might take the straight carrier as being the normal and the bent carrier as being next and compare one with the other. Then the results of the tests done with certain variations introduced could be compared with these, more or less normal conditions.

For example, tests O and P are comparable as far as conditions are concerned, except that O was mounted in a bent carrier and P was in a straight carrier. O is thicker than P in each of the four positions measured. Tests Q and R being conducted under similar conditions are comparable, and show a slightly thicker deposit for R, which was also mounted in a bent carrier. Tests S and T are again in the favor of the bent carrier. For the results of these experiments see the table immediately below.

Measurements Bent Carrier		Conditions	Measurements Straight Carrier	
Test O	.0035″ .0044 .0054 .0074	4 hours—normal tape collar (2m.m.) —otherwise similar.	.0027″ .0026 .0044 .0063	Test P
Test R	.0021″ .0029 .0039 .0042	4 hours—long tape collar (6 m.m.) —otherwise similar.	.0019″ .0020 .0038 .0048	Test Q
Test S	.0046″ .0051 .0104 .0117	14 hours—normal collar —otherwise similar.	.0040″ .0042 .0070 .0094	Test T

Therefore from the results of the tests made it is assumed that the bent carrier is the better of the two. After considering the three tests O, R, and S, we must come to two conclusions; firstly, a long (6 m.m.) tape collar impedes the deposition to some extent. See the results below where a 6 m.m. tape collar was used and a 2 m.m. tape collar was used.

Long 6 m.m. collar			Short 2 m.m. tape collar	
Test R	.0021″ .0029 .0039 .0042	4 Hours	.0035″ .0044 .0054 .0074	Test O

Secondly, prolonged deposition adds very little to the thickness of the deposited copper shell and we might justifiably conclude that the additional time is unnecessary. See table below which compares a 4-hour deposit with a 14-hour deposit.

4 Hours			14 Hours	
Test O	.0035″ .0044 .0054 .0074	Bent Carrier	.0046″ .0051 .0104 .0110	Test S

The results of further tests where other variations are introduced might now be compared with those of either the straight carrier or the bent carrier.

The Individual Electrolyte Supply

Compare the results of test C with B.

Individual Electrolyte Supply			Straight Carrier	
Test C	.002″ .003 .005 .0065	Similar conditions 4 Hours	.003″ .003 .006 .0065	Test B

And under the same heading compare test D with E.

Individual Electrolyte Supply			Straight Carrier	
Test D	.0025″ .004 .007 .0115	Similar conditions 10 Hours	.005″ .0065 .0090 .0100	Test E

Comparison of the result in these two instances leads us to the conclusion that the individual electrolyte supply arrangement is detrimental to the rate of deposition rather than a benefit.

Supplementary Anode

Compare the results of test F with E.

Supplementary Wire Anode			Straight Carrier	
Test F	.0045″ .0051 .0079 .0090	Similar conditions 10 Hours	.005″ .0065 .0090 .0100	Test E

Here again we might assume that nothing was gained by the use of a supplementary wire anode in improving the distribution of or rate of deposition.

Supplementary Cathode

Compare the results of tests K with B.

Supplementary Cathode			Straight Carrier	
Test K	.0016″ .0015 .0023 .0025	4 Hours	.003″ .003 .006 .0065	Test B

The results of this test and several others with a supplementary cathode were always the same. The supplementary cathode was detrimental rather than an advantage.

Based on the above work we come to several obvious conclusions. They are:

1. The best method of mounting the impression for the most rapid deposition is in a bent carrier, so that the impression mouth is facing upwards and not towards the anode.

2. Prolonged time of deposition adds little, because after four hours or thereabouts, the metal is deposited on the edge of the impression nearest to the anode and not in the deepest portions, where it is needed.

3. Too long a collar of cellulose tape around the mouth of the impression impedes the deposition.

The Efficiency of the Process of Deposition

While the amount or weight of copper deposited in a certain length of time is not of great importance when considering the usefulness of the finished model, it is an indication of the efficiency of the apparatus. It is known that for copper, one ampere-hour would deposit 1.1858 grams of copper. The table which follows shows the results of tests conducted on several copper solutions and the estimated percentage of efficiency.

Completion of the Model

Following the deposition of a satisfactory thickness of copper in the impression, the final stages in the formation of a model are described below. We must always remember the fact that we are dealing with a strong acid solution which will quickly ruin clothes if it makes contact with them. Therefore after removing the cathode (impression) it should be washed in a receptacle of water to take up the solution dragged out with it. Any solution which has seeped in around the insulating wax and is now inside the glass insulator, as seen plainly from without, must be released and washed out too.

The carrier and impression should be immersed in a bath of soda bicarbonate to neutralize the remaining traces of acid.

The impression may then be dismounted from the carrier and dried off.

The importance of the effect of the Durex tape collar around the impression mouth will now be realized. Where no tape is used, the copper will have heaped up around the edges and extended considerably beyond the limits of the metallic band. See Figure 16.

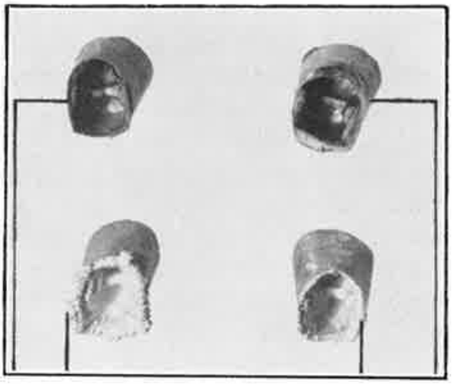
TABLE SHOWING TESTS OF EFFICIENCY OF ELECTROLYTE

Solution No.	Formula	Voltage M A.	Rate per hour—average	Ampere hour rate	Efficiency considering 1.1858 as 100%
A	130 grams Cu_2So_4 50 c.c. H_2So_4 620 (Tap) H_2o Old: used 1 year.	5.0 112 M.A.	.127 grams	1.134	95.6%
B	130 grams Cu_2So_4 50 c.c. H_2So_4 620 (Tap) H_2o Never used: 1 year old.	5.0 112 M.A.	.131 grams	1.170	98.7%
C	130 grams Cu_2So_4 50 c.c. H_2So_4 620 (Tap) H_2o (New)	5.0 115 M.A.	.130 grams	1.130	95%
D	130 grams Cu_2So_4 50 c.c. H_2So_4 620 (Distilled H_4o) (New)	5.0 118 M.A.	.130 grams	1.102	92.9%
E	130 grams Cu_2So_4 40 c.c. H_2So_4 620 (Tap) H_2o	5.0 115 M.A.	.130 grams	1.130	95%

This condition as seen at c in Figure 16 is bad for two reasons. Firstly, the heaped up edge will have taken up most of the current density going to the cathode and therefore less copper will have been deposited in the depth of the impression than is the situation at d, Figure 16, where no heaping occurred. Secondly, the heaping at the edge is bad when we continue with the procedure and attempt to back up the shell of copper with stone, or a low-fusing metal. The heaping up of the metal has been prevented at d by the presence of the Durex tape.

To back up the copper deposited in the impression we require some heavy brown gummed paper. This is readily wrapped around the band and a box is formed into which a low fusing alloy, stone or ordinary household cement, can be packed.

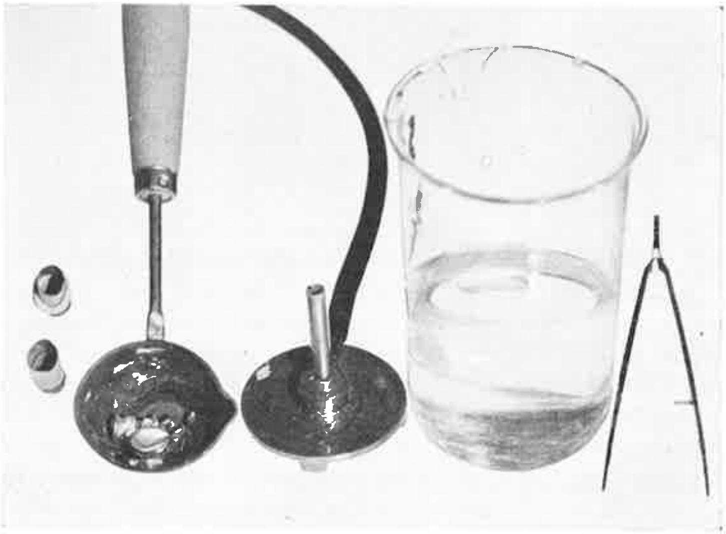
If a low fusing alloy is used to back up the copper shell, then the equipment in Figure 17 is suggested.



a c d b

FIGURE 16

a—Graphited impression without tape collar. b—graphited impression with tape collar. c—excessive peripheral deposit resulting from lack of tape collar. d—result when deposition controlled by tape collar.



a[1] a[2] b c d e

FIGURE 17

(a[1]) Impression boxed—where a heavy deposit existed on the edge.
(a[2]) Impression boxed—with paper—no excess.
(b) Lowfusing metal in ladle.
(c) Burner.
(d) Beaker (or glass) of water to cool off metal.
(e) Pliers to immerse poured impression into beaker.

The metal is poured into the boxed copper deposited impression and chilled quickly. Slow cooling allows the heat to be transmitted to the impression material which causes it to soften and adhere more firmly to the copper surface and hence render separation later, more difficult.

Figure 18 shows the two electrodeposited impressions, backed up with low fusing metal and the paper boxing, stripped off.

In order to separate the impression material and metallic band containing it, from the model, a limited amount of heat should be used. Too much heat results in the impression material adhering too well to the model surface; on the other hand, too little will

FIGURE 18

(a) The one with heavy deposit at edge (no tape was used).
(b) The one where tape was used; no excess at edge.

endanger pulling the deposited copper away with the impression material, especially if a limited deposit was made. After the model and impression material have been separated, the model may be cleaned up with carbon tetrachloride, on a tooth polishing brush used in the hand. The junction between the copper and low fusing metal should be trimmed with a suitably mounted carborundum point and the root stump with a Halls Abrasive Wheel. See Figure 19.

The finished models are seen in Figure 20.

THE ADVANTAGES OF AN ELECTROFORMED MODEL

For indirect inlay work, porcelain work and acrylic restorations, this type of a model has many advantages over other materials

a b c d e

FIGURE 19

(a) Backed up copper shells.
(b) Carbon Tetrachloride.
(c) Tooth polishing brush in mandrel.
(d) Mounted carborundum point.
(e) Hall's abrasive wheel.

FIGURE 20

Two completed models.

used for the same purpose. Amalgam is extensively used and a table of comparisons between the amalgam model and copper electroformed model suggests some of the advantages which might be claimed for the latter.

Copper	*Factor*	*Amalgam*
40	Hardness (Brinell).	40-65
Most accurate.	Accuracy.	Dependent on manipulation and control of volume changes.
Simplicity of metallizing, mounting, deposition, finishing.	Time in manipulation.	Boxing, mixing, packing—personal equation.
No danger.	Contamination.	Mercury is present and in finishing may be a serious factor.
Each model costs but a cent or two.	Cost.	Silver amalgam jacket crown model costs approximately 40c., an inlay model averages 25c.

The factor of accuracy might be discussed a little further. On page 13 we referred to "several generations of plates" being made satisfactorily in the production of gramophone records and the degree of accuracy in evidence in this process. To test out this factor of accuracy in indirect inlay model construction several generations of models were made as seen in Figure 21.

The top row of copper surfaced models shown represents:

(a) the son of the original three-quarter crown preparation,

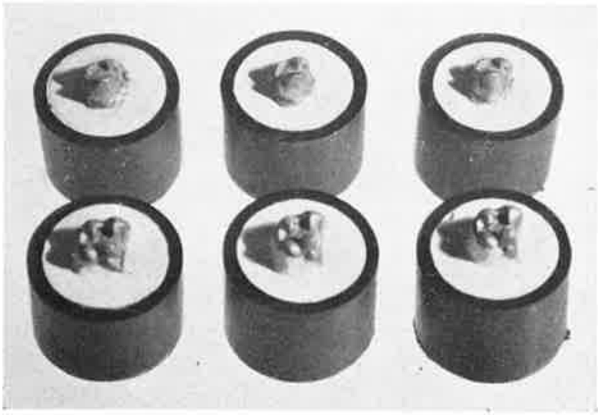
(b) the grand-son,

(c) the great-grand-son.

In other words (a) is from an impression of the original cavity preparation in the mouth: (b) is from an impression taken from (a) and (c) is from an impression taken from (b). A gold inlay cast for one of a, b, or c—fits all three accurately. The lower row of copper surfaced models in Figure 21 were produced in the same way as the top row of models, but for a proximo-occlusal preparation. Again an inlay cast for one, fits all three accurately.

Further elaboration on the cost factor may be in order. The initial cost of the equipment amounts to perhaps a little over ten dollars (war time prices). The cost of the electrolyte—when considering that 700 c.c. will last a year, is a very small item. The copper used for the anode is also a small item—the 2″ × 1″ × ¼″ anode cost approximately 5c., and will be sufficient for 80-90 models and with the new type of steel basket anode it can be used over and over again. The low fusing alloy to back up the copper shell can also be used over and over again.

The cost of the current at domestic rates will be 1 cent for 1 ampere for 10 hours. If 50 milliamperes are used for each im-



a b c

FIGURE 21

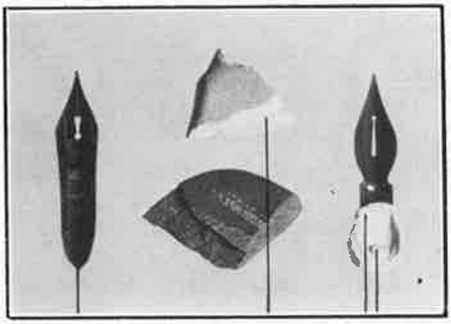
pression, we could run the apparatus at this current density for 200 hours for 1 cent. Thus we would run 12-13 models through for 15-16 hours each for 1 cent, or about 1/12th cent per model.

Finally, it is perhaps not too far from the truth to say that each model made in this way represents a saving over silver amalgam of very nearly 25c. a model, when we consider the average for jacket crown models, inlays, etc. In the past 15 months, the records for the Infirmary, Faculty of Dentistry, show that over 600 models have been electroformed for students. If each one averages a saving of 25c. a model, the total savings represented here is approximately $150.00. What is perhaps more important, it represents a large saving in mercury, an important war commodity.

The Small Cathode—Not in Metallic Band

There are occasions in the dental field when the impression taken in wax or similar material, is not contained in a metallic band as heretofore described. An impression of a gingival cavity for instance, may be taken in the concave side of the rounded end of a pen-nib. See Figure 22.

As a substitute for the pen-nib, a concave piece of metal may be used. In either case the resultant impression is not altogether suitable for mounting in the holder described and illustrated previously. A simplified method of bringing the metallized surface of this type of impression into the circuit is shown in Figure 23.



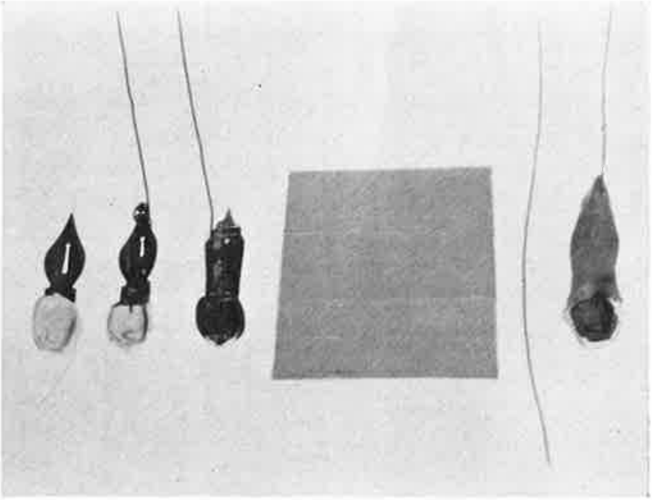
a c x b

FIGURE 22

a—Pen-nib. b—cavity impression. c—compound. x—point of contact of carrier wire with impression.

The impression is shown at (a), and a 6″ piece of 24 G. copper wire at (e). The wire is threaded through the slit in the nib from the convex side of it, and the end of the wire is made to contact the impression material about 3 millimetres from the cavity impression (b). The free end of the wire is wound around the point of the nib two or three times and held with sticky wax at suitable points to prevent it from changing position. The impression is then metallized by whatever method is chosen (c) and with wax (d) the non-essential metallic surfaces exposed are insulated. We see the mounted, metallized and completed impression at (f).

The prepared impression is now attached to the cathode terminal and the deposit made. See Figure 24.



a b c d e f

FIGURE 23

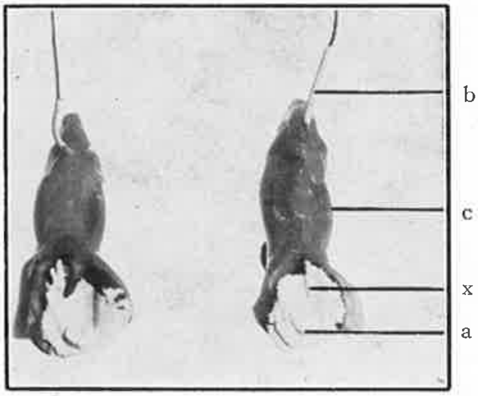


FIGURE 24

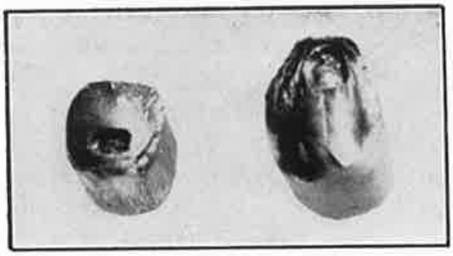
Two impressions on which the deposition has been made.

a—Impression outline in copper deposit. x—outline of wire contact in copper deposit. b—wire carrier. c—wax covering metallic surfaces.

All factors discussed previously under the heading relating to the operation of the electrodeposition process for copper, must be observed.

After copper (or the required metal) has been deposited, the shell formed is backed up or supported by low-fusing alloy, soft solder, or artificial stone. A box might be made with plasticene to limit the amount of the supporting material to be used.

In Figure 25 we see two finished models, one of which is backed up with stone, (a), and the other, (b), with low-fusing alloy.



a b

FIGURE 25

Two completed gingival impression models.

CHAPTER 5

APPLICATION OF THE ELECTRODEPOSITION PROCESS TO THE TECHNIQUE OF CONSTRUCTING AN APPLIANCE TO RAISE THE BITE

A bite may be raised or opened artificially by means of fixed restorations (crown, bridges, onlays) or removable restorations. Whichever method is chosen, one of the essentials to the success of the completed case is that in all functional movements there should be no cusp interference. To obtain such a condition, it has been the experience of the writer on several occasions, to have to spend a great deal of time making final adjustments to the occlusal surfaces of the artificial restorations in order that complete freedom may be established in all functional positions. There is no articulator made which can be adjusted so that it will reproduce exactly all the jaw movements of any one case. The mouth is the best articulator there is and the suggestion made below is based on that principle.

In the case described it is assumed that some form of removable restoration is to be made for the lower arch. Any discussion of the type of restoration to be used, does not concern us in this thesis. What does concern us is the establishment, and recording of, all the paths of movement of the occlusal surfaces of the teeth of one arch when in function with the other. By so recording this occlusal pattern and reproducing it accurately in our finished restoration, we should have a restoration, the occlusal surface of which will allow complete freedom of function in all directions, and hence save a great deal of tedious adjustment which is so often necessary.

Briefly, the procedure is as follows. An impression is taken and a cast made of the arch with which we are concerned. The opposing arch is not included.

On this cast a baseplate is adapted to the lingual side and a pad of compound adapted over the occlusal area. The thickness of the compound should equal approximately the extent to which the bite is to be raised. The lingual flange should be reinforced with wire. A thin coating of wax is now added to the surface of the occlusal compound pads. On this bite block is to be recorded

FIGURE 26

the movements of the jaw in all directions during function. It is placed in the mouth for this purpose and the patient is instructed to grind or chew on the wax-compound pads. The pattern of the paths of free jaw movements will be established on the surface of the compound and in the wax. In other words the case is quickly ground in, in the wax stage—by the patient.

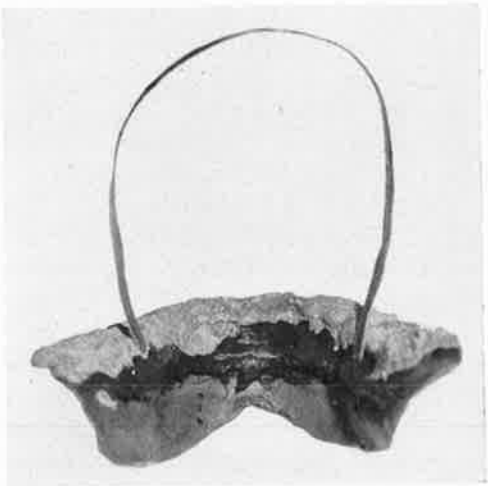


FIGURE 27

If the finished restoration can be made to conform to such a pattern, it too will be ground in, before being processed.

In Figure 26 we see the bite block in place on the cast. On it are recorded not only the centric bite, but also all positions of the functional bite. The surface has been graphited, and will then be metallized chemically with some dilute copper electrolyte and iron

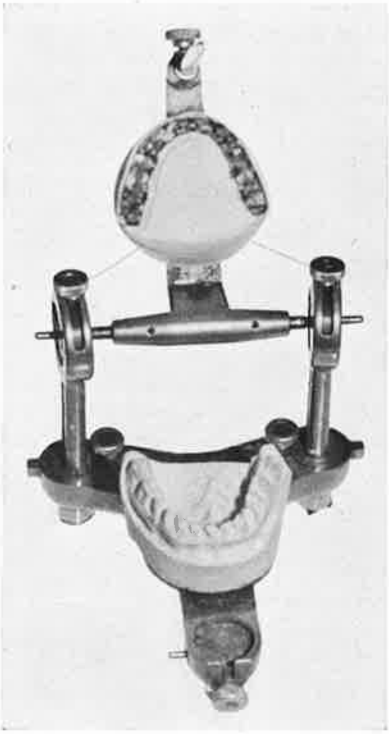


FIGURE 28

filings. Copper is then deposited on the metallized surface, as shown in Figure 27.

The loop seen is for the connection of the piece to the cathode terminal. Before separating the wax bite block and the copper deposition, the block is returned to the cast and sealed on it. The lower cast is attached now to the corresponding bow of the articulator (a plane line articulator would do for this purpose) and the upper bow is attached to the exposed copper surface—after the attachment loop has been removed. The incisal pin is fixed. When the material used for luting the case to the articulator is set, the articulator may be opened by separating the copper deposit from the wax bite recordings.

The copper surface on the upper bow of the articulator is now cleaned. This copper surface represents an accurate reproduction of the recordings made of the bite in all functional positions. It will now be seen that the occlusal surfaces of the lower bite-raising

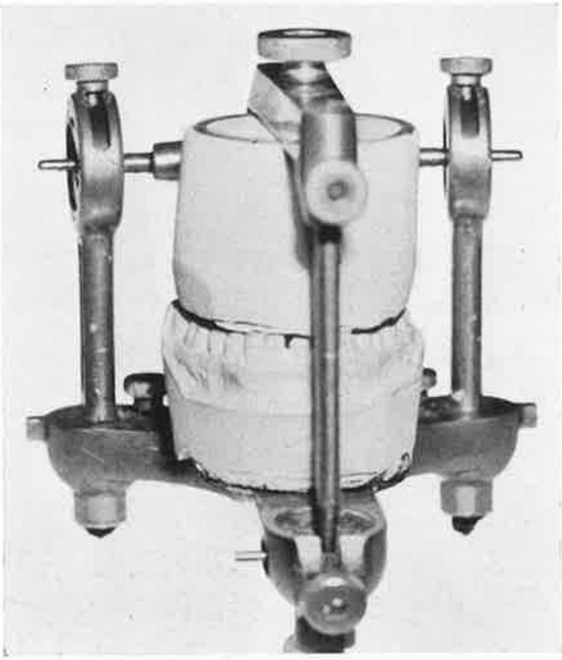


FIGURE 29

appliance (of whatever type is to be made), will not be articulated to a cast made from the impression of the opposing natural upper teeth, but to the copper record of the paths established by them, in function.

On the lower cast, seen in Figure 28, we can now construct the framework for the restoration to be made.

Following completion of this framework, the occlusal portion of the restoration is added. The amount the bite is to be raised in this case is represented by the space seen in Figure 29.

The only carving which will be necessary on the occlusal portion of the appliance will be to form the buccal and lingual limits of the occlusal surfaces.

The acrylic resins have a definite application in these cases and when the method outlined above is followed the copper surface is found to be excellent against which to process the acrylic resin.

After the acrylic resin has been processed there is practically no finishing necessary on the occlusal surface, and furthermore, if the various stages in this procedure have been followed with any degree of accuracy, there will be few or no adjustments to be made to establish freedom of cusp movement in functional occlusion.

Pre-Extraction Records: Special Case Records: Orthodontia Casts

Where we have special reasons for wanting to preserve record casts, such as orthodontia casts, pre-extraction casts, or cases of unusual interest, a metal surfaced cast is ideal. Such a cast can be obtained by either of the two methods described below. One method is to deposit the metal into the original compound impression, and then back it up with stone or plaster of paris: the second method is to pour the cast in stone or plaster and deposit a thin veneer of metal over it. We will confine our remarks to the first method at the moment, and discuss the second method later.

The first method depends on an accurate impression of the arch and teeth, taken in any of the commonly used impression materials, except the hydrocolloids. At the time of writing, complete success has not been attained in metallizing the hydrocolloid materials (the basis of which is agar-agar) but the writer believes that a method can be devised whereby they can be treated and copper deposited into them.

Figure 30 shows two carefully taken compound impressions of the mouth of a boy whose permanent teeth were very late in their eruption. Accurate casts were required of the case for purposes of comparison with future records.

The trays used in taking the impressions have been removed carefully.

As a carrier for an impression of this size, three strands of 24 G. copper wire, each about 7″ long are prepared and one length of

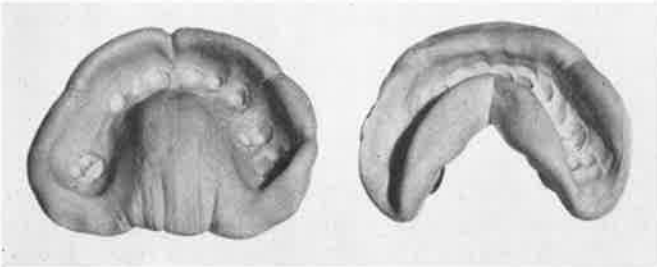
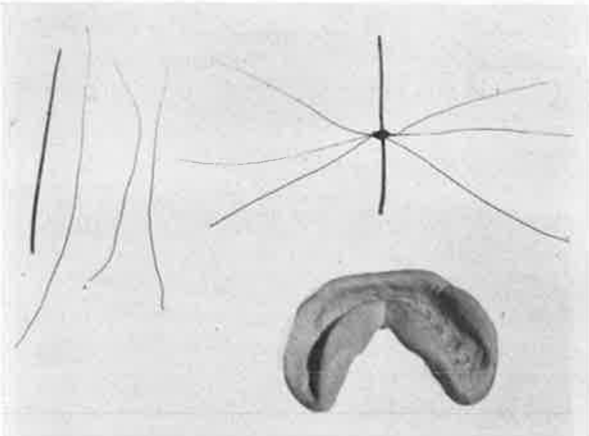


FIGURE 30

14 G. wire approximately the same length. The three 24 G. wires are soft-soldered to the 14 G. wire as seen in the accompanying photograph. See Figure 31 (c).

The spider-like carrier is now ready for use. The impression is centred over the carrier and the six flexible 24 G. free ends of copper wire are brought around to six points at the periphery of the impression and with the aid of sticky wax are held firmly in contact with the periphery of the impression.

All the wires, with the exception of the free ends of the six contact wires, should now be covered with wax or varnish to insulate them.



c

a b

FIGURE 31

The impression surface is next metallized. The method shown in the photographs is with the use of graphite, followed by chemical deposition of copper on the graphited surface. The method of application of these has been explained elsewhere. The only difference now is that the metallizing process is on a much larger scale than heretofore. See Figure 32.

Silver metallization, as described before, might also be used instead of graphite and copper electrolyte with iron filings.

Management of the process for the deposition of copper into such an impression differs only slightly from the process for a small impression. The current density used will be determined by the

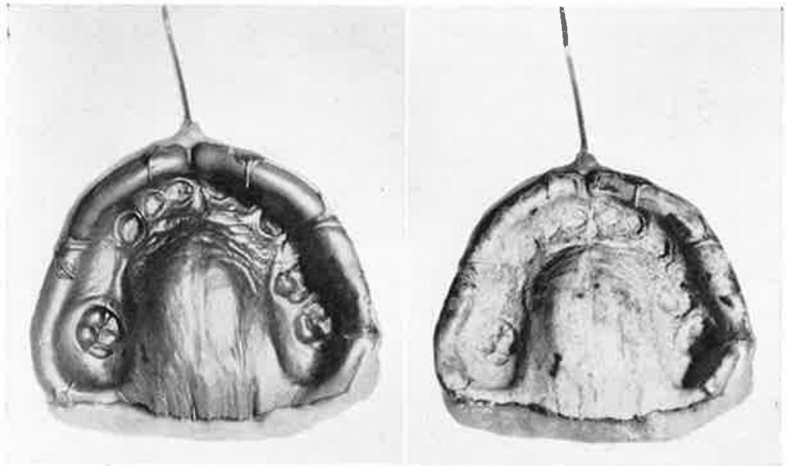


FIGURE 32

area, and on the basis of approximately 100 milliamperes per square inch. Thus for an upper impression, a current of about 500 m.a., i.e. ½ an ampere, will be necessary. The length of time required for the deposition to be carried on will be about 12 hours.

The deposited impressions are then backed up with stone or plaster of paris and the impression material separated from the cast. The cast should be then trimmed and finished. Two pairs of such casts are shown in the Figure 33.

It will be readily seen that there are two important features which can be claimed for casts made in this way, over the average plaster or stone cast. They are, firstly, the feature of permanency against rough usage, accidents, etc. and secondly, the ease with which they are kept dust free. Dust on plaster and stone casts quickly spoils the clean appearance of the cast and is hard to remove. One disadvantage with copper is that it will tarnish readily, over a period of time. A thin plate of nickel over the copper will overcome this difficulty. Nickel takes a high polish and is not readily tarnished.

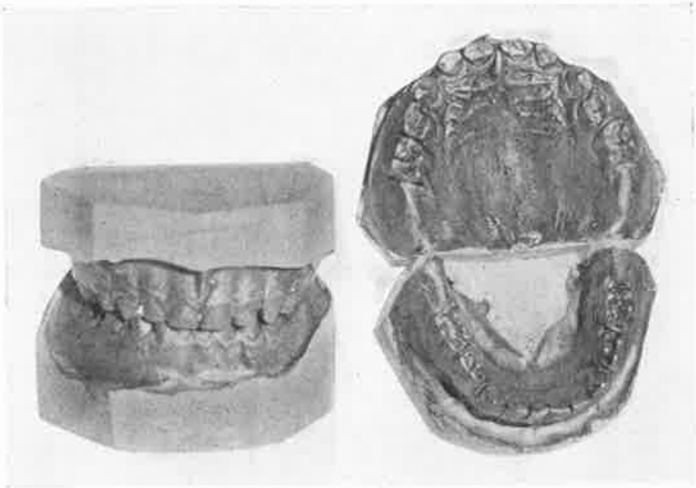


FIGURE 33

THE APPLICATION OF THE ELECTRODEPOSITION PROCESS TO THE CONSTRUCTION OF SMALL ACRYLIC RESTORATIONS

It is generally agreed that acrylic resin, whether it be for dentures or small restorations in natural teeth, is most ideally processed against a non-porous metallic surface. In the case of the small gingival inlay or the jacket crown, and all the intervening possibilities in restorations of this type it is virtually impossible to burnish tin foil, either to the wax pattern or the mould in the flask. It is a relatively simple and inexpensive procedure however to deposit a thin layer of copper on the wax pattern which when the coated wax pattern is invested and the wax is boiled out will leave a clean, hard, bubble-free metallic surfaced mould in which the acrylic resin may be processed. The results obtained by the author during the past year with this procedure, have been extremely encouraging.

It is not the intention of the writer to discuss the pro's and con's of acrylic as a suitable material for operative restorations; suffice it to say, that this material at the moment does seem to lend itself to use for gingival inlays and semi-permanent crowns for protecting fractured anterior teeth in the young patient.

From these two standpoints the technique of processing acrylic resin will be discussed.

The Jacket Crown and Semi-Permanent Acrylic Crown

After the preparation for the jacket crown or shoulder less acrylic cap has been completed a suitable celluloid crown form is chosen and contoured to fit accurately at the gingival margin. (See Fig. 34.)

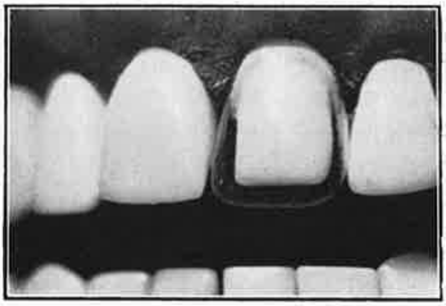


Figure 34

Perforate the celluloid form at both the mesiolingual—and disto-lingual angles, approximately 2 mm. from the incisal edge. Fill the crown form with ivory shade inlay wax and soften uniformly in water at 140° F. Carry the crown form to place and seat it over the prepared tooth, allowing the excess wax to escape through the holes provided on the lingual surface. If further adjustment is considered to be necessary remove the crown form and reheat the partially seated form and wax impression and replace on the prepared tooth. If the contour of the crown form does not fulfil the requirements aesthetically, add wax to the outside of the celluloid form and thus contour the crown form as desired. (N.B. Add a

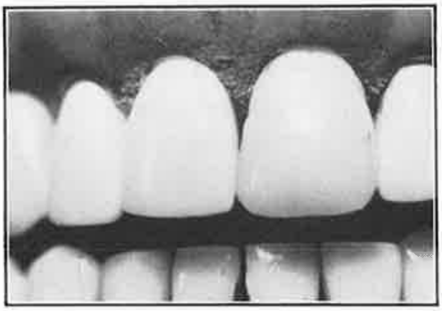


FIGURE 35

thin film of wax to the lingual surface of the form to aid in boiling out later.)

Figure 35 shows the contoured form in place on the tooth. The wax inside the form gives an accurate impression of the tooth. Thus, at one sitting, the preparation is made, the impression is taken, the shape of the finished crown is determined, and the shade is recorded. Establishment of the shape of the finished crown by the means just outlined renders further steps for this purpose unnecessary, thus eliminating a try in, or taking registrations for mounting a die on an articulator as required in the indirect technique.

The crown pattern prepared thus far is removed to the laboratory. A small piece of ivory wax (about the size of a pin head) is fused on to the lingual surface and to this is attached one end of a 4″ length of 24 G. copper wire. (See Fig. 36 B.)

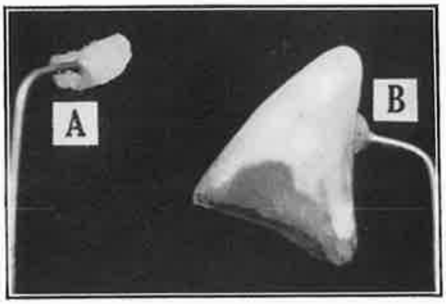


FIGURE 36

The Gingival Inlay

The gingival inlay pattern seen in Figure 36 A. was made by the direct method in the cavity and removed from the mouth on a similar piece of wire to that used for the crown.

Metallization

Both the inlay and crown patterns so mounted, on copper wires, are ready for metallization. The technique used in the metallization of wax or compound, using graphite, has been described elsewhere. However, graphite in this case will leave a blackened surface on the deposited copper and the shade of acrylic which is processed against such a surface, cannot be controlled. To replace graphite metallization we turn to metallization by means of silver. This process depends on the familiar experiment of the reduction of a silver salt, with the resultant silver mirror formation.

The wax inlay pattern and jacket crown pattern as seen in Figure 36 are first washed in a solution of Stannous Chloride, the formula of which is:

Stannous Chloride—1 gram
Hydrochloric acid (Conc.)—1.5 c.c.
Distilled Water—100. c.c.
Mix.

This solution is easily made up, and may be stored for a reasonable length of time without deterioration. It is kept in a wide-mouth bottle so that the inlay pattern or jacket crown pattern may be immersed in the solution in the bottle for one to two minutes, following which they should be washed off in room-temperature water. The mounted impressions are then lowered into a small receptacle, such as a baseplate wax box (1½″ × 1″ × ¾″), a dappen glass for a small inlay, or better still an empty 1 oz. porcelain powder jar. Do not let them touch the sides of the receptacle.

Over the impression or impressions so arranged pour first the following silver solution and then the accompanying reducing solution, leaving the impressions completely immersed in the mixture for 4 or 5 minutes—agitating them at frequent intervals during that time. The result of this procedure will be the formation of a silver film over the entire surface area of the wax, celluloid form and everything in contact with the mixture, including the receptacle.

The two solutions must be freshly made just prior to using them because of their unstable nature.

The formula for each is as follows:

Silver Solution

Silver Nitrate Crystals—420 milligrams
Distilled Water—9 c.c.

Reducing Solution

Pyrogallol Crystals—100 milligrams
Citric Acid Crystals—21 milligrams
Distilled Water—3 c.c.

For the sake of convenience these formulae have been transposed into more convenient terms, and are used as follows:

Silver Solution

Silver Nitrate (fine crystals)—1 large end of Caulk silicate measuring spoon.

Distilled Water—9 c.c.

Reducing Solution

Pyrogallol (fine crystals)—1 large end of Caulk measuring spoon.

Citric Acid (fine crystals)—½ small end of Caulk silicat measuring spoon.

Distilled Water—3 c.c.

As all of these substances dissolve rapidly in cold water, it takes but a minute to make these solutions each time they are required. The cost of this method of metallization may be questioned but is actually less than 2 cents per piece.

Figure 37 shows the small inlay pattern and the jacket crown pattern after silver metallization. If these pieces were now attached to the cathode terminal of the electrodeposition apparatus, copper would be deposited over the entire surface of both, thus completely encasing them in a copper matrix, making it impossible to remove the wax and celluloid form in the case of the crown, and also making it impossible to pack the plastic acrylic into the matrix to form the acrylic inlay or crown.

It is desirable therefore to make provision for having the labial face of the crown not covered by the copper deposition, and in the

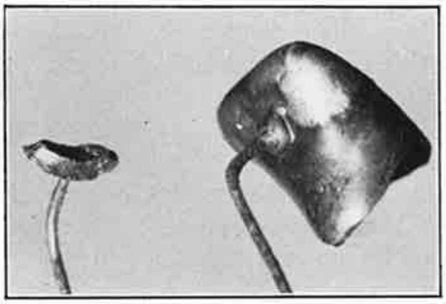


FIGURE 37

case of the inlay to have the buccal or labial surface of it left exposed. Sandarac varnish is therefore painted on the labial face of the metallized crown pattern and on the surface of the metallized inlay matrix, with a fine camel's hair brush. (N.B. After the wax pattern is metallized it must not be allowed to dry off at any stage or else the silver film will crack and chip off). Therefore do not attempt to dry the surface onto which the varnish is to be painted or to dry it after it has been applied. Such steps are unnecessary and dangerous.

The metallized, varnished patterns are now ready to be immersed in the copper electrolyte for the purpose of checking the area varnished and the efficiency of the metallization process. Figure 38 shows the line of demarcation between the varnished area (A) and that which is not varnished (B). Copper will be deposited on the unvarnished area. Attach the prepared pattern or patterns to the cathode, and insert into the electrolyte.

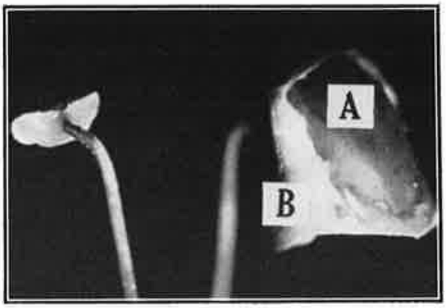


FIGURE 38

The amount of current required depends on the area to be covered as explained previously. The time required should be limited to a 3-4 hour deposit. A heavy deposit will add to the difficulties in removing it from the processed acrylic resin.

The area of the pattern covered by copper, when the copper deposition is complete, is the same as that outlined in Figure 38. The labial face will be left uncovered.

The crown pattern is now invested in a triple section flask as shown in Figure 39. The wax is boiled out and the celluloid crown form is lifted out with pliers. This will be easy to accomplish if the lingual surface was coated with a thin film of wax as suggested earlier. The full top of the flask is shown at B, the relief section at C, and the copper matrix in the lower half at A. Note the metallic model and metallic lingual and proximal surfaces against which the acrylic can be processed safely.

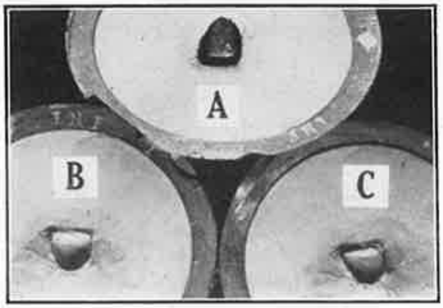


FIGURE 39

When the plastic acrylic is packed and the flask is ready to close for processing, apply tin foil to protect the labial face.

The inlay pattern is treated similarly to the crown, except that in the case of the simple gingival inlay, the relief section of the flask is not used.

When the acrylic is processed and the inlay or crown are removed from the flask but still encased in copper, the copper is easily and quickly removed by placing it in a bath of concentrated nitric acid for a few seconds only; a 3 to 4-hour deposit of copper will be removed in a few seconds. Prolonged exposure to the acid might result in disintegration of fine margins. The copper may also be removed by peeling it off, as platinum is removed from porcelain.

Experiments are proceeding which indicate from early results, that the shade of acrylic resin will be more uniform when processed against a metallic surface, than when processed against a treated stone or plaster surface. These same experiments also support the view that greater accuracy is obtained when a metallic matrix is used.

Figure 40 shows a completed acrylic cap on the upper left central, made by the method described herein.

FIGURE 40

FURTHER APPLICATION OF THE ACCURACY OF THE ELECTROFORMING PROCESS TO GOLD INLAY TECHNIC

For some years the writer has felt convinced that inlays might be formed, or at least the internal shell of the inlay be laid down by the electroforming process. During the course of much experimentation and research the internal shell of an inlay was laid down in an electroformed model or die, and into it gold was cast. In this way the part of the inlay in direct contact with the cavity preparation outline was accurately adapted to the reproduction of the cavity by electrolytic deposition. The remainder or bulk of the inlay was cast in the regular way. Distortion or interference with that portion of the inlay which had already been deposited was considered to be unlikely.

However, the process was exacting and tedious and considered impracticable for general application.

As an alternative to the ideas of first forming a skeleton or shell of the inlay and casting the remainder, the principle of casting directly into an investment model was adapted to the electroforming process. Instead of an investment model, an electroformed model was used and the gold was cast, directly into the metallic-surfaced model.

The metal surface of the model and the gold were then separated very simply and quickly by chemical means.

FIGURE 41

The metal to be used in the model formation was either nickel or silver: copper has too low a fusing point to make it safe for casting gold against it. The result in using copper is merely to cause destruction of the model when the molten gold hits it in the casting process.

The results obtained in the formation of inlays by this method have been very gratifying. In order that we might compare the results of the regular methods of inlay construction with the results of the method suggested above, experiments were conducted as recorded herein. In the surface of a specially constructed steel block there was a simple cavity form, the dimensions of which, recorded by micrometer measurement, were .1638″ long × .0820″ wide × .0460″ deep. See Figure 41.

Inlays of 22 K. gold were made for this cavity by various commonly-used methods and compared with the one suggested. Conditions common to all, such as to type of investment used, consistency of the mix of the investment, heat treatment of the investment, the casting procedure, etc., were maintained as nearly equal as possible.

The table below shows the results of this work. The second column records the technic used; i.e. whether it be direct, semi-direct or indirect. The third column sets forth the impression material used in the formation of a model The next column outlines the model material used. The fifth column is the record of

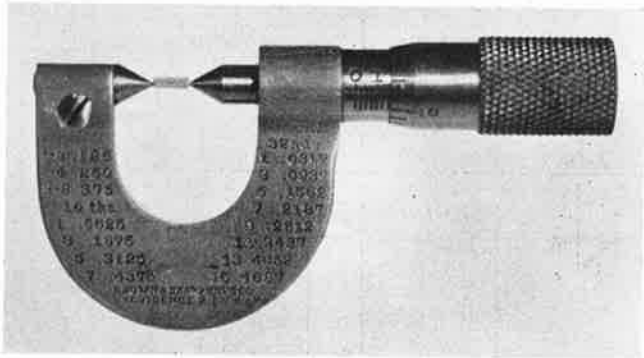


FIGURE 42

the average measurements of the length only, of three castings in 22 K. gold or as otherwise indicated. It may be added also that the measurement obtained for each of the three individual castings in each test was obtained by averaging four measurements recorded for that particular casting. See Figure 42. The last column records the approximate percentage of error.

INTERPRETATION OF RESULTS

From the results shown in the table it will be seen that the most accurate castings were those made by casting directly into the nickel or silver model. The percentage of error with these was from 1/3 to ½ of 1 per cent. The least accurate of the castings

Test No.	Technic Method	Indirect or Semi-indirect: Impression Material used	Indirect or Semi-indirect: Die or Model Material	Average length measurement of at least 3 castings in 22 K gold (.1638″ is die length)	Percentage of error	Remarks
A	Semi-indirect.	Hard blue wax.	Nickel model backed with investment.	.1632″	Approximately 1/3 of 1%	Cast into nickel model.
A[1]	Semi-indirect.	Hard blue wax.	Silver model.	.1629″	Approximately ½ of 1%	Cast into silver model.
B	Direct.			.1622″	1%	
C	Indirect.	Hard blue wax.	Copper model.	.1618″	1.2%	
D	Indirect.	Hard blue wax.	Copper model.	.1618″	1.2%	Acrylic Inlay.
E	Semi-indirect.	Hard blue wax.	Investment model.	.1617″	1.2%	
F	Indirect.	Hard blue wax.	Amalgam model.	.1612″	1.5%	
G	Indirect.	Hard blue wax.	Copper die. Platinum matrix.	.1603″	2%	Porcelain Inlay.

were those made from a silver amalgam model, the percentage of error being 1.5 per cent.

With the castings made using the direct method, i.e. no model, the error was 1 per cent, and with an electroformed copper model it was 1.2 per cent. With the investment model technique, where the casting is made directly into the model, the error was approximately the same as that for the copper model.

It is recognised, of course, that the form used in these tests, namely, that which represents the gingival inlay cavity, was not a compound type. The results of similar experiments done with a compound type cavity might not be the same as those recorded for the simple type cavity. It is reasonable to assume, however, that similar results might be expected.

Arising out of these tests conducted there were other interesting observations made, which are not relevant to a thesis with the above title. They are observations of interest when considering the whole field of gold inlay technique, and must be recorded elsewhere.

The final application of the factor of accuracy of the electroforming process to inlay technique was to be made to the field of porcelain inlays. As will be seen from the table shown above, the porcelain inlay made by the platinum matrix method was accompanied by a 2 per cent error. The writer firmly believes that it is possible to form a metallic model into which porcelain might be fused without the use of a platinum matrix.

The writer has already accomplished this but is not in a position to be certain that the technic developed has been carried far enough to record it herein.

If such a development can be accomplished successfully, then we might expect the same degree of accuracy in the construction of a porcelain inlay as was achieved with the gold inlay, when the gold was cast directly into the model.

Nickel as a Substitute for Copper

The reasons why nickel might be chosen as a substitute for copper in the procedures already described up to this point in this thesis are suggested below.

Firstly, the electrolyte used for nickel is alkaline, unlike that for copper which is strongly acid, and therefore the nickel electrolyte is safer to handle. Secondly, an inlay model made of nickel offers a greater color contrast with gold than copper does. This might be important in the study of the adaptation of the cast inlay on the model. Thirdly, nickel is harder than copper and must on that account be considered a better model-forming material.

Unfortunately, however, the advantages which have been stated are heavily outweighed by the disadvantages in operating nickel electrolytes for galvanoplasty. For plating purposes it is different, but for depositions on wax, compound, or any other material, there are great difficulties. The results are variable. It is always uncertain just how the electrolyte is going to behave. Blum & Hogaboom write concerning nickel, "One of the most exasperating experiences in nickel deposition is that baths prepared even on a large scale from the same or similar materials will yield different results, especially with thick deposits; or perhaps after a few weeks' operation will suddenly improve or deteriorate with no known or measurable change in their composition."[15]

It is known that unless the p.H. value of the electrolyte is kept within definite limits, the deposition is interfered with.

The apparatus and equipment which will be used in the process of depositing nickel will be the same as that described for use with copper. If the reservoir is used to compensate for the evaporation of water from the electrolyte, distilled water will be required instead of tap water.

The electrolyte which will be used for nickel may be made from one of several formulae. Those commonly used will contain nickel sulphate as the source of nickel; sodium sulphate for purposes of increasing the conductivity of the solution; nickel chloride or ammonium chloride to increase the corrosion of the anode, and a little boric acid to act as a buffer, and help maintain a relatively constant p.H. Too much boric acid, however, will lower the p.H.

The formula used by the writer with some degree of success is as follows. To make approximately 500 c.c. of electrolyte:

Nickel Sulphate...........32 grams
Sodium Sulphate..........16 grams
Nickel Chrloride..........16 grams
Boric Acid............... 7 grams

Dissolve in order mentioned in 470 c.c. of distilled water.

The electrolyte should be kept clean by filtering from time to time. Because of the limited use to which the nickel electrolyte is assigned the writer has found it expedient to return it to a well-stoppered bottle after use and maintain the original volume, by addition of distilled water.

The p.H. of the electrolyte must be watched constantly. A simple method of testing the p.H. of the nickel solution is with Squibbs Nitrazene paper. The degree of accuracy attained with these papers was checked recently by the writer, the results of which appear in the table below.

Nickel Solution	Nitrazene Paper Reading	Beckman p.H. Meter
No. 1.........	5.2	5.16
No. 2.........	5.0	5.20
No. 3.........	3.0	2.49
No. 4.........	6.5	6.17
No. 5.........	Too low for chart	2.04
No. 6.........	5.5	5.91
No. 7.........	5.0	5.67
No. 8.........	5.0	5.71

In the first column the solution number is seen.

In the second column the figures represent the p.H. values assigned when using the Nitrazene paper and in column three the accurate p.H. reading as obtained with the aid of the Beckman p.H. meter. A comparison of the figures in columns 2 and 3 reveal the fact that the Nitrazene paper tests are fairly good, and might be safely used as a guide as to the state of the solution.

The best anode to use is somewhat of a problem. A pure nickel anode has a tendency toward "passivity" and on that account it does not corrode or dissolve readily. Cast nickel contains some impurities which may be detrimental, but such an anode is found to dissolve fairly readily and is used on that account.

When considering the care required in operating the nickel electrolyte bath for electrodeposition in the dental field the most important factor is that of maintenance of the p.H. of the electrolyte. The optimum value for the p.H. for the electrolyte for high efficiency is 5.8-6.0. The tendency will be for the p.H. value to fall, i.e. for the electrolyte to become more acid. Seldom does the change occur in the direction of the alkaline side, resulting thus in a higher p.H. value. If it did it is a simple matter to add sufficient sulphuric acid to restore the electrolyte back to the desirable p.H. value.

However, the change most likely will result in the p.H. dropping to a point as low as 4.0 or even further than that on the acid side. To correct this condition nickel carbonate should be added to the electrolyte. When this is done the solution should be allowed to stand to give the undissolved nickel carbonate a chance to settle out. The clear solution is poured off—or it may be filtered off. Even with filtering some of the suspended nickel carbonate will pass through the filter paper.

The exact amount of nickel carbonate required for a measured quantity of the electrolyte will depend somewhat on how low the p.H. is and what quantity of solution is being treated.

A few figures of tests made appear below but further tests in this direction are required if nickel is to be used to any extent.

Solution No.	Quantity of Solution	Original p.H.	Nickel Carbonate added	New p.H.
No. 1	400 c.c.	5.67	7 grams	6.48
No. 2	400 c.c.	5.16	14 grams	5.72

The impressions on which the nickel is to be deposited are metallized in the manner described previously for copper. The current density to be used for each separate piece will be determined by the area to be covered. The basic current density for nickel might be considered to be about 8-12 amperes per square foot, or a little less than that for copper. Too high a current density results in excessive bubbling at the cathode. The milliampere readings for the apparatus described previously, using the nickel electrolyte, appear in the table below.

The length of time required for the deposition of nickel upon or into an impression for model purposes will probably be about the same as that advised for copper. Copper was said to be deposited at the rate of 1.186 grams per amper-hour. Nickel, on the other hand, is deposited at the rate of 1.095, which is about the same as for copper. What little is lost in weight and consequently in probable thickness with nickel is made up for in strength because of the increased hardness of nickel over copper.

However, even when nickel is being deposited seemingly satisfactorily, one of several complications may develop.

Table Showing the Milliampere Readings for the Secondary Voltages Indicated with Varying Resistance Bulbs

Volts	40 Watt Bulb	60 Watt Bulb	100 Watt Bulb	200 Watt Bulb
3.7	28	70	103	150
4.8	42	90	135	200
5.0	37	92	136	210
5.8	43	105	156	250
6.6	50	115	175	290
7.4	55	125	162	310
8.2	60	135	200	330
9.0	64	142	215	360
9.8	69	150	225	380
10.6	72	155	235	400
11.4	78	160	240	420
12.2	82	165	248	430
13.0	86	168	252	440
13.5	90	172	255	450
13.8	90	172	260	460
14.3	92	175	280	470
15.1	96	179	290	490
15.9	100	182	300	495
16.7	103	185	300	500
17.5	108	189	310	510

N.B. The above milliampere readings were obtained with the Westinghouse rectifier in the circuit and compare closely with those for the copper electrolyte shown on Page 45.

Peeling of the nickel due to internal strain may develop. The commonest causes for this may be too high a current density, or because the p.H. of the electrolyte is too low.

Pitting is also a factor which has to be contended with. It is thought to result from many possible causes. Among these are too low a p.H., too high or too low a current density, evolution of too much hydrogen, which accompanies too high a current density, and fine particles of dust in suspension in the solution.

Treeing is also probable in a nickel vat which appears to be working quite efficiently. Such a condition may be due to too cold a solution or a solution whose conductivity is poor! There are a few other minor difficulties.

CHAPTER 6

ELECTROFORMING FOR ORAL ADAPTATION

BEFORE considering the application of the electrodeposition process to the construction of restorations that will be placed in the mouth, we should consider briefly the question of the tolerance of the oral tissues to metals. Electrogalvanic phenomena of the oral cavity caused by dissimilar metallic restorations is the problem which confronts us. Since 1930 a great deal has been written on the subject, much of which is conflicting.

It is admitted by most authors that the human saliva, whether it be acid, alkaline or neutral, constitutes a good electrolyte and that if restorations present in the mouth are constructed of dissimilar metals electropotentially, all the elements are present for the formation of a galvanic battery. The degree to which metals are considered dissimilar electropotentially is dependent on their relative positions in the Standard Electromotive Series of metals table, e.g. zinc and gold in the saliva are favorable to the formation of a galvanic battery.

Lain and Coughran,[16] have conducted numerous experiments relating to this problem and they make this statement: "Considering that every oral cavity containing dissimilar metallic restorations is a constant potential chronic irritant, the percentage or number of persons who seek the aid of a dentist, or physician, is surprisingly small".

While these authors in their early reports assume that a galvanic current is set up in the mouth, between dissimilar metals, after experiments conducted more recently they state: "Reports of recent investigations indicate that the evidence of the existence of electric currents between dissimilar metals in the mouth is not entirely conclusive. Electrical experiments showing that currents do or do not exist have apparently not been reported."[17]

Further studies by Reed and Willman, who grouped the possible combinations of dissimilar metals into those which never come into contact, those which are always in contact, and those which are brought into contact through mastication, conclude that "dissimilar metals which are not in direct contact cannot give rise to galvanic currents".[18] Furthermore, they suggest that where dissimilar metals are in contact, the galvanic current set up is less than one microampere, which previously has been thought too small to be harmful to the oral tissues.

Reinhard Solomon and Galtz believe that there is no electric current flowing normally and after considerable experimentation say: "The diminution of current flow is due in part to polarisation and in part to deposition of an insulatory film".[19]

One of the latest expressions on this controversial problem is that found in an editorial appearing in the New York Journal of Dentistry.[20] Here we find this statement on the subject of Galvanism. "It is well known that authoritative sources in the field of electrochemistry have questioned the reliability of the tests and measuring devices that have been heretofore employed in this work."

The whole subject therefore seems to be in a state of experimentation and some diversity of opinion as to the true situation exists.

What is known definitely is that "positive cases of electrogalvanism will begin to improve at once after removal of prosthesis of either the positive or negative group."[20]

With the little information that is definite we should perhaps follow these general principles, and avoid using dissimilar metals in any one mouth.

The Nickel Denture Base

It is considered highly probable that metal electrolytically deposited would be well tolerated by the tissues providing no other metal is present in the mouth. Nickel, because of its strength, could be made extremely thin, and therefore very light, and serve as an ideal denture base, in those mouths where vulcanite or the denture base materials are not well tolerated. As such, it was tried by the writer and others (McBain)[21] a few years ago with some degree of success.

For example the patient in the case of the denture shown in Figure 43 had been wearing a fairly comfortable vulcanite denture, but the tissue had become inflamed beneath it.

One of the newer denture base materials was tried but a similar experience occurred. A nickel denture base was made on a compound impression taken from the latter denture.

The nickel base, on which the teeth are attached with vulcanite is shown in Figure 43 after it had been worn for three months. At the end of three weeks from the date of the initial insertion of the denture the inflamed condition of the tissue had disappeared, suggesting that the nickel was well tolerated by the tissues and a real benefit to them. Whether it was a coincidence or not that such a result was obtained cannot be stated, but it was very striking.

Today a nickel denture base could be constructed by the following procedure. An impression of the edentulous mouth to be fitted would be poured in stone or plaster of paris. After separation of the impression material from the cast thus formed, the cast is painted with a wax-chloroform solution and the chloroform is allowed to dry off. The wax film left behind is extremely thin, and

FIGURE 43

seals the many minute air spaces on the surface of the cast. It is therefore impervious to moisture. The cast is now wired and metallized with silver as described previously. Better results are obtained if the silver metallization process is repeated a second time. The wired metallized cast is then placed in the copper electrolyte for 5 to 10 minutes at approximately 400 milliamps. By so doing, the metallization process is made very definite and a quick strike with nickel will result when the nickel deposition is commenced. After removal from the copper electrolyte the cast is washed off very carefully to remove the acid solution. Carelessness in this stage will result in loosening the metallization film from the surface of the cast and some of it will float away.

After the washing is complete the cast is attached to the negative terminal (cathode) in the nickel electrolyte.

The anode should be a cast nickel piece approximately the same size as the cathode and the same shape.

The current density is adjusted to approximately 75 milliamps to commence the process. One hour at 75 milliamps is followed by 15 to 20 hours at 200 milliamps.

The nickel base will be rough enough on the surface to which the vulcanite and teeth are to be attached to make it unnecessary to make provision for retainers. It is suggested that a thin film of vulcanite or the denture base material be laid down over the entire palatal surface. Note also in this figure the well-rounded periphery, provided for in the nickel base. If adjustments were needed on the periphery which resulted in perforation of the nickel at some small area, the surface denuded of nickel could be quickly covered by metallizing it; then isolating it and placing it back in the electrolyte for further deposition. Finally polish this region of periphery.

Nickel as a denture base material has a few disadvantages. It is extremely difficult to make a base which is absolutely free from minute perforations. Hence the suggestion that the material used for attaching the teeth be extended over the entire palatal area. Nickel is tarnished in some mouths to a slight extent.

Vulcanite and vulcanization do not affect it. Even when extremely thin it is strong and very light.

During the course of the process of deposition it is well to vibrate the cathode occasionally to shake off any hydrogen bubbles which form and tend to adhere to the cathode. They may cause pitting in the denture base, if they are left undisturbed. As with any other electrolyte the level should be maintained in the tank by adding distilled water when needed.

The nickel electrolyte must be kept filtered and free from organic matter, which is detrimental to good deposits.

Finally it must be admitted that the application of nickel to the field of denture base construction is full of hazards and may result in some disappointments.

The Silver Denture Base

As a substitute for nickel, in the construction of the denture base, silver has been recommended by several authors. The advantages claimed for silver are its germicidal properties, the fact that it is a good conductor of thermal changes, and that the electro-deposition process with silver is comparatively easy to manage.

Silver, on the other hand, tarnishes readily in the presence of sulphides. Therefore, in some mouths, it darkens quickly and vulcanite cannot be adapted to it without plating the silver base with gold, or rhodium, first.

The electrolyte to be used for silver is a silver cyanide solution, which is alkaline, but very poisonous. The composition of the silver electrolyte used by the writer with good results is taken from the writings of Tuckfield,[22] and appears below.

Silver Nitrate	12.31 grams
Potassium Cyanide	23.13 grams
Distilled Water	600.00 c.c.

"The silver nitrate is dissolved in 200 c.c. and the cyanide in 300 c.c. of distilled water. The cyanide solution is added slowly to the silver solution which precipitates the silver as silver cyanide. As the addition of the cyanide solution continues, the resolution of the precipitate will take place to form the double cyanide. Finally, the volume is made up to 600 c.c."

Evaporation of the water from the solution must be watched, as with all electrolytes, and restored as required from time to time. This solution remains fairly stable, and can be used for a long period of time.

The anode should be of pure silver. A rolled sheet $2'' \times 2'' \times \frac{1}{8}''$ is satisfactory. It is fairly pliable in this form and might be swaged into the shape or form of an upper denture base.

The basic current density for silver is about half that required for copper and nickel. Approximately 5-8 amperes per square foot of area is accepted by most authors.

The Silver Base—Method 1

Following the above brief discussion of the requirements for silver deposition we have a basis from which to work. We will proceed to discuss the construction of a silver denture base. Many of the details will be the same as those outlined in the formation of a nickel denture base.

There are two possible methods of procedure. The first method to be described is dependent upon the formation of a copper cast from the original impression. See Figure 44.

The copper shell used in the formation of this cast should not be thick; a 4- to 6-hour deposit will be enough. (With this limited deposit, great care must be exercised in separating the impression and cast.) The wires leading to the periphery of the impression, and used in the deposition of the copper are left long. They are wound together and brought out through the base of the cast.

The wire extension with clip attached will be used later to attach the cast to the cathode terminal. It is already in contact with the copper surfaced cast. The plaster of paris base is then covered with wax to protect it while in the silver electrolyte.

It will be noticed in this photograph that only the copper surface of the cast is left exposed. On this copper surface the silver denture base is to be deposited. An attempt might be made

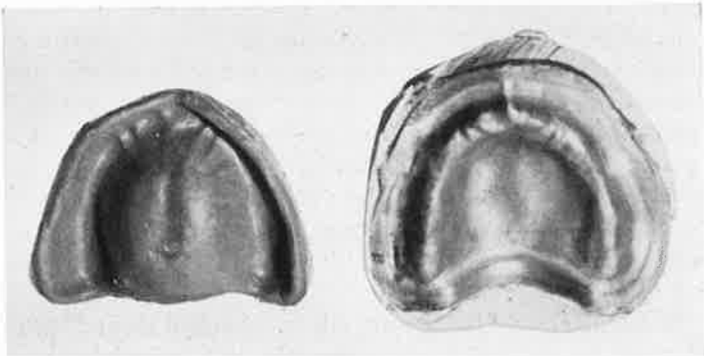


FIGURE 44

by chemical means to coat the copper surface of the cast with silver iodide or silver sulphide which would act as a separating medium. The purpose of this separating medium would be to render separation of the silver denture base from the copper cast possible. On the other hand the writer suggests that if there are any undercuts on the cast, separation of the base from its cast would be difficult, if not impossible. Therefore, no separating medium is used and the silver base is deposited on the unprotected copper cast. To effect a satisfactory deposition the cast is attached to the cathode, the anode is placed in the electrolyte and attached to the anode terminal, and the current is turned on at approximately 150 milliamps. After 24 hours the deposit should be thick enough for a satisfactory base.

It will be noticed that the surface of the deposited silver is rough. The palatal section can be made smooth and polished later; the section over the ridge will be left—the roughness serving well for retention of the material to be used for attachment of the teeth. After removal of the plaster used to form the base of the cast, the copper shell and silver denture base are found joined together.

The copper is readily removed electrolytically by now attaching the piece to the positive terminal, thus making the copper portion of the silver-copper piece, the anode. A block of copper is attached to the cathode and the copper electrolyte is used in the tank. When the current is turned on, the copper portion will be removed and transferred onto the block of copper. The silver denture base will not be in any way defaced.

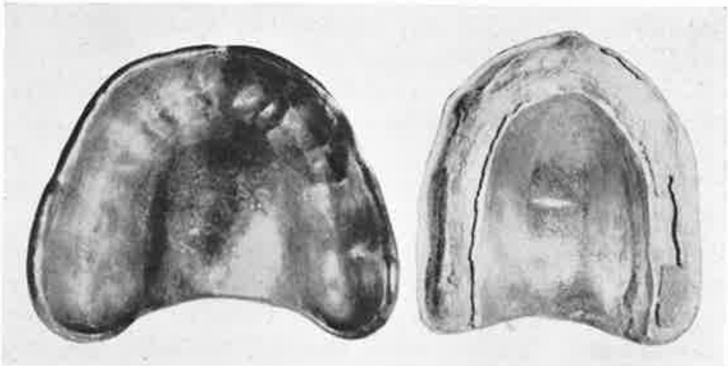


Figure 45

The silver base is now trimmed and polished. It will then be rhodium or gold plated to render it bright and stainless. Without the rhodium or gold protection it would tarnish readily and be unsatisfactory.

In Figure 45 we see the finished denture base at the left. One half of it is gold plated and the other half rhodium plated. The denture base seen at the right will be mentioned in the second method of construction which follows.

The Silver Denture Base—Method 2

The second method to be described for the construction of a silver denture base differs from the first in that a copper-surfaced cast is not required. A stone or plaster of paris cast is used. The importance of this difference is seen at once; where the impression material used was hydrocolloid or if for any other reason it is impossible to form a copper deposit in the impression, the stone or plaster cast formed will be satisfactory in this procedure.

The cast is rendered impervious to moisture, either by treatment in hot stearin until all bubbling ceases or it is painted with a wax-chloroform solution. After this preparation it is allowed to dry. The wire carrier is now adjusted with the contact wires brought to the periphery of the cast at several points and sealed. The cast is then boxed in with wax to facilitate metallization of the surface by means of the silver solutions as described elsewhere. The process of metallization with the silver solutions should be repeated once after the initial treatment, to insure complete coverage of the cast surface. Any minute area missed the first time will be metallized by the repeated treatment.

The wax boxing may next be carefully removed, being sure not to disturb or break the contact wires away from the periphery of the cast.

The metallized cast is then attached to the cathode terminal of the apparatus in the copper electrolyte for 5-10 minutes at 300 milliamps to make the metallization process more positive. After removing it from the copper solution and carefully washing off every trace of acid, it is attached again to the cathode terminal in the silver electrolyte. The anode should be placed so that it is as nearly equidistant from every part of the cathode as possible. The current is turned on and adjusted to approximately 150 milliamps.

At the end of 15 hours the first stage of the deposition is complete. The cast on which the silver is deposited is removed from the electrolyte and washed in a bath of distilled water, which will take up the solution "drag out". This water will be used for replenishment of the water lost by evaporation, as needed. The silver base is dried.

Provision is now to be made for a finishing shoulder for the material to be used for the attachment of the teeth, and also for the retention of the material to the base.

The finishing shoulder and retention undercuts are established by placing wax rims around the crest of the alveolar ridge, slightly to the buccal and the lingual side of the crest. See Figure 46 for a cross section of silver base and wax rim attached.

The buccal and lingual sides of the wax rims are painted with graphite to metallize them as indicated by the letter M in the diagram. After the graphite is dry these areas are treated with copper electrolyte and iron filings as suggested elsewhere.

The final stage of making the silver deposit is now entered upon. The cast is returned to the solution at the same current as before (150 milliamps) for another 15 hours. After this final stage of deposition is complete it is carefully washed again.

It is now trimmed, and polished. The completed denture base made by this method is seen in Figure 45 at the right.

As stated previously the silver denture base must now be rhodium or gold plated.

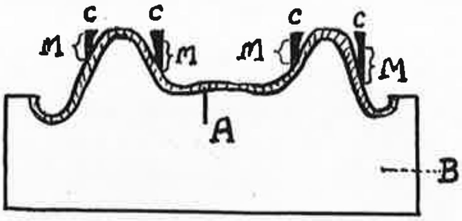


FIGURE 46

(a) Silver base.
(b) Cast.
(c) Wax rims.
(m) The buccal and lingual surfaces of wax rims which are metallized with graphite.

CONSTRUCTION OF A HOLLOW OBTURATOR

A hollow metallic obturator for a cleft palate can be constructed by means of electrodeposition. The advantages which might justifiably be claimed for such a restoration over the usual vulcanite or newer denture base material obturators, are numerous. The metallic obturator is strong, amazingly light, easy to keep very clean, and very accurately adapted. A further advantage which is important is that the original stone cast poured from the impression of the cleft, is not lost, but may be used again to construct a second or third obturator. With either the vulcanite or newer base material obturators, the cast is lost after vulcanisation or processing the new materials. Case[23] went to a great deal of trouble years ago to preserve the original cast. He made a special and somewhat laboriously fabricated split metal mould contained in a special flask for the purpose, so that he could make several vulcanite obturators from the one impression of the cleft. The procedure of the construction of a hollow metal obturator is relatively simple.

From the impression of the cleft a stone or plaster of paris cast is made. On the cast the obturator outline is designed in pencil. See Figure 47.

The section of the surface of the stone cast included in the outline and to a point three millimetres beyond the outline, is now thoroughly impregnated with the wax-chloroform solution referred to previously. A carrier is then adapted to the cast which will also serve to bring the metallized surface of the cast into the electrical circuit later on. This carrier can be made of a narrow strip of 36 G. copper sheet or a 14 G. copper wire—flattened at both ends

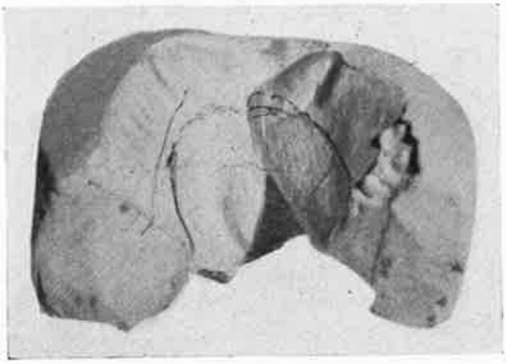


FIGURE 47

where it contacts the cast. Fix the carrier loop firmly at both ends to the cast by means of sticky wax.

The surface of the cast to be contacted by the obturator is now metallized by one of the methods described previously. We prefer the use of graphite followed by the chemical deposition of copper by means of iron filings and copper electrolyte. After the graphite has been applied and dried off, the surface of the cast beyond the limits of the obturator outline is covered over with varnish or wax (preferably wax).

The metallizing process is now completed by treating the graphited area with the iron filings and copper electrolyte. Nickel is now deposited upon the cast. The current density to be used

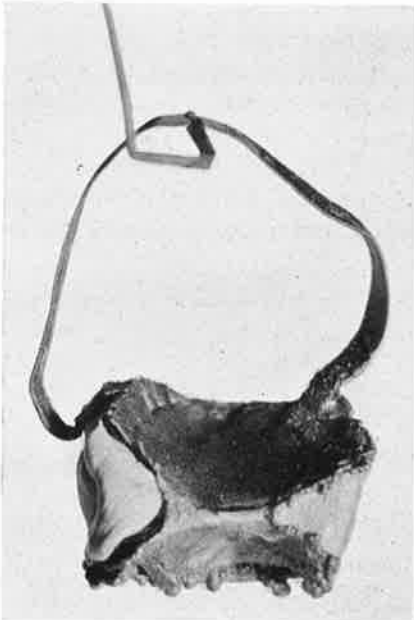


Figure 48

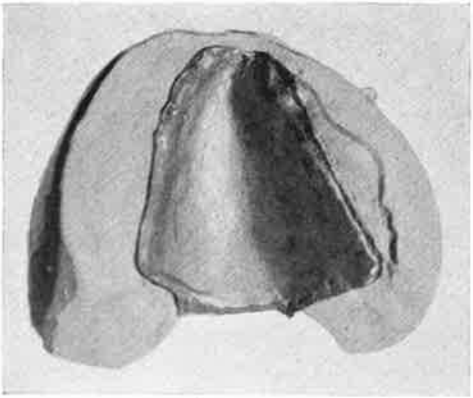


Figure 49

must be determined by the area. The length of time required will be approximately 15 hours.

The palatal and nasal surfaces of the obturator are now laid down on the 30 G. sheet casting wax. The edges of this wax are sealed carefully to keep the electrolyte out of the hollow space. The wax surfaces are now metallized and nickel is deposited upon them. Figure 48 shows the completion of this stage.

The centre of the obturator is now hollow and empty. The

FIGURE 50

walls are metallic—extremely thin but strong. The obturator is now removed from the cast by splitting the cast in the anterior region—but with a clean fracture so that it can be reassembled and used again if necessary. The edges of the obturator are trimmed, excess being removed with a jewellers' saw in which is mounted a fine metal cutting blade. The obturator is polished. The weight of the finished piece seen in Figure 49 is 2.400 grams. The weight of a Canadian dime is 2.300 grams approximately.

Where adjustments are necessary after the obturator has been worn for a few days, and such adjustments result in perforation of the obturator at some point, repair to the perforated areas is effected simply and quickly. The opening is plugged with a small piece of wax, which is made smooth, metallized and closed by further deposition.

An Artificial Nose

The electrodeposition process might be applied to the field of maxillo-facial surgery, a field which is very much to the fore in

Figure 51

wartime. Where an artificial nose is required—the basis for it might well be laid down by the electrolytic process. Nickel would seem to be the ideal metal to use, because of its lightness and strength. The nickel might be rhodium plated at the final stage.

A description of the process of construction of such a restoration is given below.

In Figure 50 we see a skull on which an artificial nose has been built up in plasticene.

An impression is taken of it in plaster of paris.

The deposition of nickel could be made successfully directly into this impression. However, it seems to be better to form a cast of stone from the impression. From this stone cast a sectional impression in compound is made.

It is easier and more satisfactory to make a metallic deposition on a wax or compound impression than on a plaster impression. Therefore, where it is possible to use wax or compound, it is ad-advisable. The compound impression is wired as the obturator was and is ready for metallization. After metallization the nickel deposit is made. Nickel wires suitably placed in the partially completed nickel shell will reinforce the finished piece. The current density required will be determined by the approximate area involved. The length of time to complete a satisfactory deposit will be 24 to 36 hours.

The impression material is now removed and the nickel shell is trimmed to the required outline. It is then silver plated or rhodium plated or both, in the order mentioned.

The completed hollow metallic shell is seen in place on the skull in Figure 51.

The final treatment of the nickel shell to obtain the desired aesthetic effects, does not concern us in this treatise.

CHAPTER 7

ELECTROPLATING

IN general industry the electroplating field is the important aspect of electrodeposition. Therefore, in the texts on electrodeposition, the subject of electroforming or galvanoplasty is given a place of secondary importance.

In dentistry, electroplating is of lesser importance than the galvanoplastic processes and is used to a very limited extent.

We might consider firstly, the application of electroplating to technic procedures and secondly, to phases of the dental field which are dependent on the tolerance of the tissues to the deposited metal.

No matter what the purpose may be, the metal is deposited on a metallic surface in electroplating, and not on a wax or compound surface, or any other type of non-conductive surface.

Therefore, metallizing the surface is not required. The apparatus described above under the electroforming procedures meets the electroplating requirements and the general conditions of operation and maintenance of the solutions will be the same.

The metals which will be useful for plating for dental purposes are copper, nickel, silver, gold, rhodium.

One of the essentials to successful electroplating is cleanliness of the metallic surface to be plated. Conditions which are present on an unclean surface are the presence of oxides and grease.

Oxides may be removed by mechanical and chemical means; grease may be removed by chemical solvents and electrolytic means.

Mechanical methods of cleaning include polishing on the lathe with the available abrasives on linen wheels, brushes and buffs. Scratch brushing is also used.

The chemical methods of removal of oxides include "pickling" in acids. The chemical methods of removal of grease depend on the use of organic solvents, such as benzene, carbon tetrachloride and the like.

The electrolytic method of cleaning requires attachment of the article to the cathode terminal of the apparatus. A bar of iron is used as the anode. The electrolyte is an alkaline cleaning solution, such as Royalite No. 1, obtainable from Canadian Hanson and Van Winkle Company. The solution is used hot. After a short period in the cleaner (a few minutes), the article is rinsed in distilled water. Before being allowed to dry it should be placed directly into the plating solution without touching or being touched by anything, in the meantime.

One or all of the above methods may be used to clean an article in preparation for plating.

ELECTROPLATING—THE METALS APPLIED TO DENTISTRY

Nickel Plating

Prior to the application of the nickel plate to copper or other metals, the surface should be thoroughly polished, using carborundum stones and sandpaper disks on any rough areas, followed by buffs and cotton wheels with pumice, and finally, whiting or rouge. The highly polished surface will be maintained on the nickel deposition.

After polishing the article to be plated, the surface must be made thoroughly clean. Suggestions have been made previously as to the methods available for cleaning.

The nickel electrolyte used for electroforming purposes is found to be satisfactory for plating. Some authors suggest that a special formula should be used for plating purposes, but in the writer's opinion adding to the variety and number of solutions which should be available for dental purposes is not warranted. The p.H. of the solution must be maintained by the means suggested on page 87. Nitrazene paper will be used to test the p.H. of the solution.

The current density required for plating purposes will be approximately 30-40 milliamperes per square inch of area to be plated. The time required will vary with the thickness of plating considered desirable. On a plaster teaching model, first covered with a 3- to 5-hour deposit of copper, a 3-hour deposit of nickel will be ample to protect the model against rough usage. If the article to be plated is not likely to be handled much, a one-hour deposit of nickel should be sufficient.

The deposition of the nickel should be made without interruption; if it must be inspected during the course of deposition it should not be out of the electrolyte for more than a few seconds.

Oxidation occurs quickly if the article is exposed to the air, and this interferes with further plating. Occasionally during the course of the plating, the article should be vibrated to free it from gas bubbles which will form on it. The article should also be rotated once or twice so that the relative position of the anode and cathode change, thereby preventing the plating being thicker on one side of the article than on the other. A series of anodes placed around the cathode would have a similar effect. A warm nickel solution (about 90-100° F.) will result in a brighter deposit of nickel being made.

Finally, when the plating is completed, the article should be washed in hot water and dried quickly to prevent stains forming on the surface of the nickel. The plated surface of the object may now be polished.

Silver Plating

Plating with silver is a relatively simple and rapid procedure. A thick plate of silver is not often required in the dental field. Its use is limited usually to a flash coating of silver over a metallic-surfaced model or article as a basis for, and to control, the color prior to plating with gold or rhodium.

The electrolyte used is the same as that suggested for electroforming with silver. The current density required for a large article such as a full denture cast would be 100-150 milliamperes; for a small article such as a copper band for a single natural tooth, approximately 30-40 milliamperes.

The time required for depositing a flash coating of silver prior to the application of gold or rhodium would be about 15 minutes. If a heavy plate of silver was required, then 2 hours might be necessary.

Cleanliness of the surface on which the silver is to be plated is absolutely essential.

During the process the electrolyte is quite efficient in the cold state.

After the deposit is made the surface may be polished in the ordinary manner.

Gold Plating

During the course of the description of the procedure suggested for making metallic-surfaced teaching models, the gold inlay outline was gold plated to make the model more realistic. The uses of gold plating will be mentioned again later.

Gold is not extremely difficult to handle for plating requirements. The electrolyte is a cyanide solution. Again we are faced with making a choice from several well-recommended formulae:

e.g.: Gold Chloride............1.67 grams
Potassium Cyanide........ .56 grams
Distilled Water........... 600.00 c.c.

The gold solution might well be purchased made up ready for use from a reliable jewellers' supply firm.

The current density required for gold plating will be 100 to 200 milliamperes for a large dental article or 30-50 milliamperes for a small object. The time required for the deposition will be 5-15 minutes.

The operation of the gold plating process is relatively simple and inexpensive. Absolute cleanliness of the article to be plated is essential. The anode should be a 24 K. plate of gold—preferably about 1″ square, and of any convenient gauge.

The temperature of the solution which is best suited for the most efficient deposition, and the best gold color, is from 115-135°F.

The color of the gold deposited from the plating solution will be controlled by the current density used, the temperature of the electrolyte and the background upon which it is deposited.

The higher the current density, the darker and redder will the deposit be. The higher temperature will result in a brighter gold color. A background of copper will give a reddish color, while a background of silver will give a paler gold color, which is preferred for use in dentistry.

Rhodium Plating

A dental restoration which has been carefully polished and then rhodium plated takes on a brilliant lustre without further attention to the finish of it. This lustre is tarnish free and resistant to any influence of the environment into which it may be placed. For those reasons rhodium has several possible applications in the dental field.

The general principles governing the manipulation of rhodium for plating are similar to those which apply for the other metals.

The electrolyte is very expensive. A small quantity should be purchased in the concentrated form from a reliable jewellers' supply house. The concentrated electrolyte can then be broken down to the required dilution by the addition of distilled water. The anode used in the rhodium plating process is platinum. A 1″ × 1″ piece of the .001″ platinum available for the porcelain inlay matrix is satisfactory. Several anodes surrounding the cathode is good practice.

During the process of plating with rhodium, the metal taken out of the solution is not replaced from the anode, with the result that a gradual weakening of the rhodium concentration of the solution takes place. The "drag out" solution must be saved and returned to the original solution. Eventually the old solution must be restored to strength by the addition of some new.

The current density found satisfactory ranges from 150 milliamperes for a large article to 30-50 for a small one. The length of time for the deposition is from 10-15 minutes.

During the course of the plating, the article being plated should be vibrated repeatedly to remove the bubbles of gas which are formed.

The ideal temperature for the electrolyte is 100-115° F.

The original polish of the piece to be plated is of the utmost importance.

The brilliance of the rhodium plate will be directly related to it. The cost of the rhodium plating is generally considered to be about one cent per square inch.

Plating of Restorations Which are to be Inserted in the Mouth

The considerations of the tolerance of the oral tissues to metals have already been discussed, in the section on electroforming for oral adaptation and must be adhered to for electroplating.

Crowns and Inlays

This type of restoration might be made of one of the silver alloys—such as Utiloy or C. I. metal. Any tendency of the metal to discolor or tarnish is eliminated when it is rhodium plated. The writer has followed a few restorations so plated over a period of several years and is convinced that this application of electroplating in dentistry is worthwhile.

Gold Plated Copper Bands

As a temporary restoration for the immediate protection of an anterior tooth in the young patient when it is fractured through trauma, a tightly-fitting copper band may be chosen and adapted quickly. After trimming and adjusting such a band—a flash of silver applied electrolytically to aid the color of the finished piece, and then a reasonable plating with gold, completes a restoration which is satisfactory for the purpose for which it is designed. Such a gold plated band would be cemented to place, after polishing lightly.

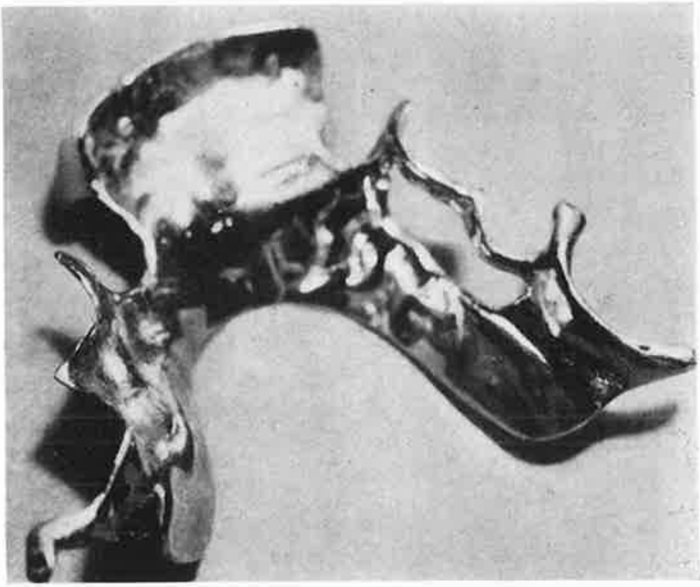


Figure 52. Partial denture—rhodium plated.

Cast Partial Dentures

A partial denture cast in a silver alloy, such as Utiloy, and rhodium or gold plated has also been found satisfactory in the experience of the writer. Figure 52 is a photograph of a partial upper denture, cast in one of the silver alloy metals and polished well, after which a plating of rhodium was applied. The photograph shown was taken without further polishing of this denture, after it had been worn in the mouth for 2½ years. It had maintained a brilliant polish over this period of time.

Bite Opening Appliances

The cast silver alloy bite opening restoration seen in Figure 53 was treated in a similar manner to the partial denture in Figure 52.

The photograph of this appliance was taken without further polishing, after it had given satisfactory service in the mouth for over a year.

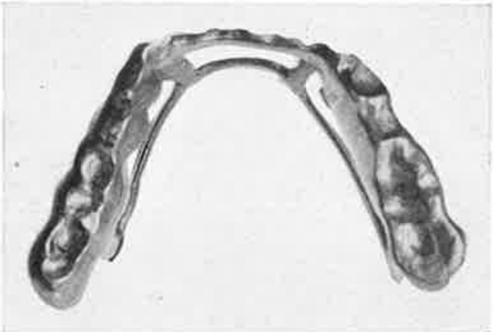


Figure 53
Bite opening appliance—rhodium plated.

Splints for Use in the Treatment of Fractured Jaws

In Figure 54 we see two Victoria metal splints which were used in practical cases. Those who have had experience with such splints realize how readily they are tarnished and corroded in a relatively short time in the mouth. The photographs seen in Figure 54 indicate the existence of such a state.

A very simple, inexpensive, and brief deposition or plating of these appliances would overcome the disadvantage mentioned above.

Figure 54

An initial flash of silver over the highly polished, thoroughly clean, splint surface is followed by 15 minutes in the rhodium or gold plating tank. Rhodium is preferred, because no further polishing is necessary after the plating process is complete.

In Figure 55 we see the same splints seen in Figure 54—but after part of the one splint (upper, right side in photograph), and the entire surface of the other (lower), have been plated.

Following the deposition of rhodium over the areas mentioned on the two splints, further polishing was unnecessary. A brilliant lustre was obtained which would not be affected by the oral fluids.

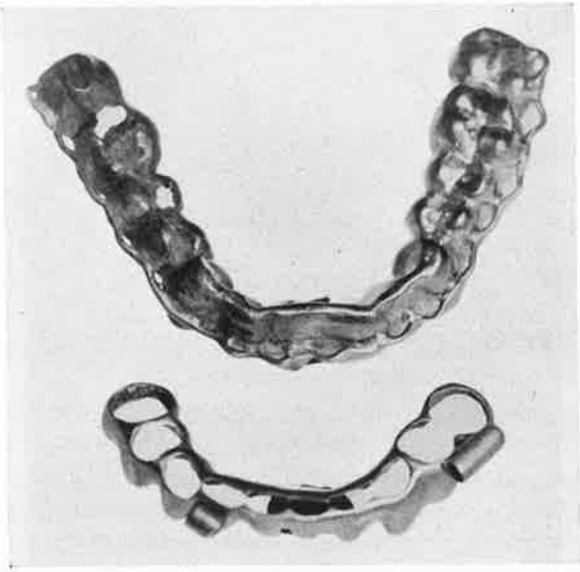


FIGURE 55
Upper figure—right side plated—left not plated.
Lower figure—entire surface plated.

SILVER DENTURE BASE

When we referred to the methods used in the construction of a silver denture base, we concluded with the suggestion that this type of restoration should be gold or rhodium plated. The principles of cleanliness of the metal surfaces to be plated, observance of the optimum current density to be used, temperature of the electrolyte and those factors considered in particular when each metal was discussed, must be rigidly adhered to.

BIBLIOGRAPHY

[1]Pfannhauser, W.: "Die Electrolytische Metallniederschlage",—1928.

[2]Viverito, J. A.: "Electrodeposition in Dentistry"—Application to Inlay Dies—Dental Cosmos, Volume 77, December, 1935.

[3]Langbein, G. Brant, W. T.: "Electrodeposition of Metals"—Baird & Co., 1924, Page 49.

[4]Blum, W. Hogaboom, G. B.: "Principles of Electroplating and Electroforming", McGraw-Hill, 1930, Page 22.

[5]Blum, W. Hogaboom, G.B.: "Principles of Electroplating and Electroforming", McGraw-Hill, 1930, Page 211.

[6]Blum, W. Hogaboom, G.B.: "Principles of Electroplating and Electroforming", McGraw-Hill, 1930, Page 156.

[7]Freeman, B. Hoppe, F. G.: "Electroplating with Chromium, Copper and Nickel", Prentice-Hall, Inc., 1930, Page 17.

[8]Blum, W. Hogaboom, G. B.: "Principles of Electroplating and Electroforming", McGraw-Hill, 1930, Page 183.

[9]Freeman, B. Hoppe, F. G.: "Electroplating with Chromium, Copper and Nickel", Prentice-Hall, Inc., 1930, Page 200.

[10]Charles Lane: "Application of Electrodeposition of Metals to Laboratory procedures".—The Illinois Dental Journal, January, 1936, Page 2.

[11]G. Earl Thompson: "Technic of Electroforming Dies". The Appollonian 16, April, 1941, Page 66.

[12]G. Earl Thompson: Journal of Dental Research, August, 1938, Page 307.

[13]I. R. Levy: "Dental Electroforming". Dental Digest, Volume 43, November, 1937, Page 540.

[14]La Mar W. Harris: "Additional developments in the Use of Acrylic Restorations". Dental Digest, 46, December, 1940, Page 419.

[15]Blum, W. Hogaboom, G. B.: "Principles of Electroplating and Electroforming", Mc-Graw-Hill, 1930, Page 253.

[16]E. S. Lain and G. S. Caughran: "Electrogalvanic phenomena of the oral cavity caused by dissimilar metallic restorations". Journal A.D.A., Volume 23, September, 1936, Page 1649.

[17]E. S. Lain, W. Schriever, G. S. Caughran: "Problem of Electrogalvanism in the oral cavity caused by dissimilar dental metals." J.A.D.A., Volume 27, November, 1940, Page 1769.

[18]G. J. Reed and W. Willman: "Galvanism in the Oral Cavity". J.A.D.A., Volume 27, September, 1940, Page 1471.

[19]Mc. Reinhard, H. A. Soloman, H. L. Galtz: "Further experiments in oral galvanism". J.A.D.A., Volume 26, November, 1939, Page 1848.

[20]Editorial: New York J.D., Volume 11, January, 1941, Page 7.

[21]W. W. McBain: "Electrodeposition of Nickel Denture Bases and dental models". Oral Health, Volume 28, March, 1938, Page 107.

[22]W. J. Tuckfield: "The Principles and technique of electrodeposition as applied to dental practice". Proceedings of the 9th Australian Dental Congress, 1937, Page 228.

[23]Calvin C. Case: "A Practical Treatise on the Technics and Principles of Dental Orthopedia and Prosthetic Correction of Cleft Palate". C. S. Case Co., Chicago, 1921, Page 456-465.

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No. 10.—Treatment of the Periodontal Pocket (issued in conjunction with the Faculty of Dentistry, University of Toronto, September, 1928, H. K. Box. (124 Pages, 120 Illustrations.)

No. 11.—Impressions in Partial Denture Service (presented at the Ontario and Canadian Dental Associations, 1926, and reprinted, with additions, from "Dental Cosmos", September, 1926; December, 1927; January, 1928; March, 1928; and January, 1929), October, 1929, W. E. Cummer, R. J. Reade. (70 Pages, 76 Illustrations.)

No. 12.—Special Cavity Preparations and Castings Processes for Gold Inlays, Including Some of the Physical Phenomena Taking Place in the Materials Used, and Methods of Compensating for the Shrinkage of Gold, January, 1929, H. E. Bulyea.

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No. 24.—A Liquefying Amylase in Human Saliva, Amylopectin, and Dental Caries, 1938, Harold Keith Box, D.D.S., Ph.D., F.R.M.S.

No. 25.—Necrotic Gingivitis, January, 1943, Harold Keith Box, D.D.S., Ph.D., and Arthur W. Ham, M.B.

No. 26.—Electrodeposition and its Applications in Dentistry, October, 1943, Roy G. Ellis, B.D.S., (Adelaide), D.D.S., M.Sc., (Dent.).

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PREFACE TO SECTION II

Dental Education and General Topics

In the 1940's a number of articles were published which called attention to the need for intensification of efforts to promote dental health education and the institution of preventive measures focused on children.

In his book entitled "A History of Dentistry in Canada", published by the University of Toronto Press, 1971, Dr. D. W. Gullett includes for the historical record, the following statement: "In his address to the Annual meeting of the Ontario Dental Association in 1952, Dean R. G. Ellis, enumerated the limitations besetting the development and assimilation of preventive procedures. He referred to the existing accumulation of treatment required by the population; the increased demands arising from the social equalizing process, which was creating a much larger group of persons potentially able to bear the cost of needed treatment; the worsening ratio of dentists to overall population; the slow acceptance by the dental profession of auxiliary personnel; the tendency toward the establishment of an all-embracing welfare state; the lag in communication of research findings throughout the profession and in the dental health education of the public; and the low proportion of the dentists' time devoted to the child patient."

A challenging facet of this general theme, was the importance of developing a scientific approach to the problem of management of traumatized anterior teeth in children. The writing and publication of "The Classification and Treatment of Injuries to the Teeth of Children" (referred to Section III) was a concerted effort to extend both restorative and preventive service to children.

Acceptance of the Deanship of the Faculty of Dentistry in the late 1940's led inevitably to serious consideration of the existing prospects for dental education, including locally, the planning of a new and greatly enlarged dental school (occupied in 1959) and the subsequent expansion of the undergraduate, postgraduate and research programs. Therefore, my published papers and unpublished addresses during the 1950's and 1960's, have been related almost entirely to the general theme of dental education.

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The Journal OF THE CANADIAN DENTAL ASSOCIATION

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YOUR TEETH — YOUR HEALTH†

by R. G. ELLIS, B.D.S. (Adel.) D.D.S., M.Sc. (Dent)
Professor of Operative Dentistry, University of Toronto.

THE members of the human family have been conscious of their teeth for many centuries. This consciousness is increasing with the passage of time. My hope is that tonight I might be instrumental in bringing to you a glimpse of the life cycle of a tooth and the struggle that is being waged between nature's efforts to maintain our teeth and oral structures as a well-balanced functioning biological unit and the forces of destruction which accompany our modern highly civilized form of life.

The extreme degree of refinement of our foods reduces the need for function of teeth in mastication. Furthermore, the high-speed nervous state which we are prone to adopt in life, changes the general systemic conditions and indirectly, the local environment in which our teeth are to be maintained in a state of normal function and preservation.

You—and Your Teeth

"At birth[1] your baby gums and jaws are crowded with potential teeth, for at birth there is considerable development of the crowns of the 20 deciduous* teeth and the jaws also contain the germs of 32 permanent* teeth." The crowns of the 20 foundation teeth which are already forming at birth[2] were initiated many weeks before you were born; the foundations for these foundation teeth were dependent upon the diet and health of your mother which must be well cared for by your family physician. Another factor which influences the formation of these teeth at this stage is the hereditary pattern which is imparted to you by your mother. We have no control over this factor.

The foundation teeth begin to erupt six to nine months after birth[3] and the root formation of these teeth is complete at approximately three years of age[4]. At six, the first tooth of the second dentition appears behind the last foundation tooth[5]. It erupts and takes its rightful place, often unheralded and unsung. Perhaps, this is an unfortunate turn of events and if a mere mortal may be so bold as to say it, Nature's one error in the amazing program of the development and arrangement of the teeth; as one lad of nine said to me recently, when I pointed out

†A lecture delivered in Convocation Hall, University of Toronto, on March 10, 1945, under the auspices of the Royal Canadian Institute.
This is a dental health lecture suggested for use before Adult Education Groups; Home and School Clubs; High School Groups; Red Cross Nurses and others.
Foot notes describe the slide used in illustration of paragraph in text.
*The deciduous teeth, or baby teeth are hereafter referred to as "foundation teeth."
The permanent teeth, are hereafter referred to as "teeth of the second dentition".

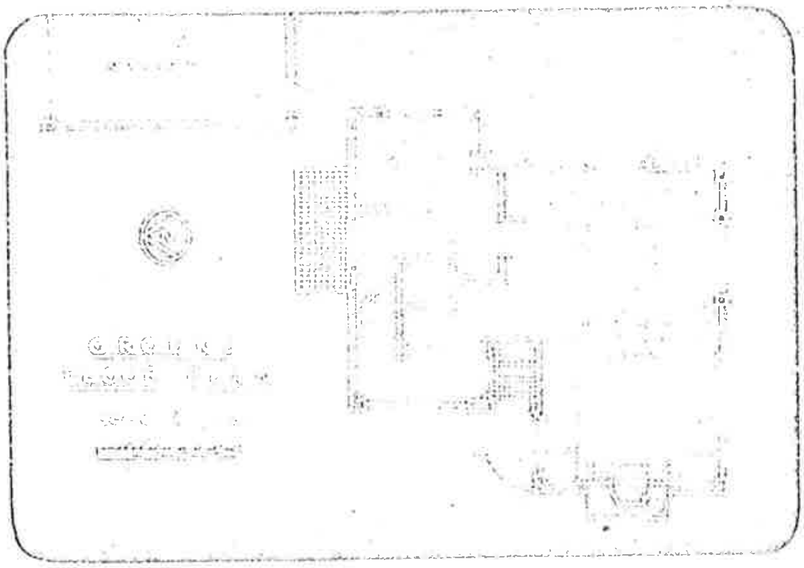

Fig. 1
Blueprint of a House

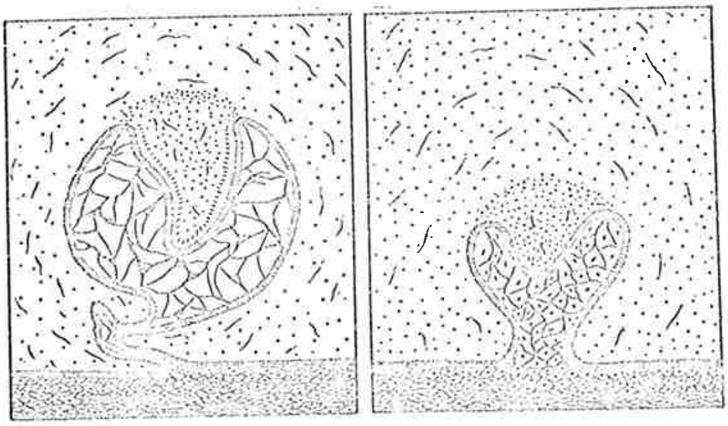

Fig. 2
Proliferation and Histodifferentiation (Schour)

a badly broken down first molar of the second dentition, "I didn't lose any baby tooth back there so you must be wrong, that's only a baby tooth." This tragedy occurs too often[6].

Development

Let us turn for a few minutes and delve into the fascinating story of the development of a tooth. For purposes of comparison, we are going to consider some of the stages in the construction of a house with similar stages in the development of a tooth.

The blueprint for the house represents the plan to be followed, (Fig. 1). The specifications which accompany the blueprint determine the types of

1. Slide-Baby soon after birth.
2. Slide-Diagram of teeth at birth (Schour).
3. Slide-Child, age two.
4. Slide-Diagram of teeth at three (Schour).
5. Slide-Diagram of teeth at six (Schour).
6. Slide-Child's mouth at seven.

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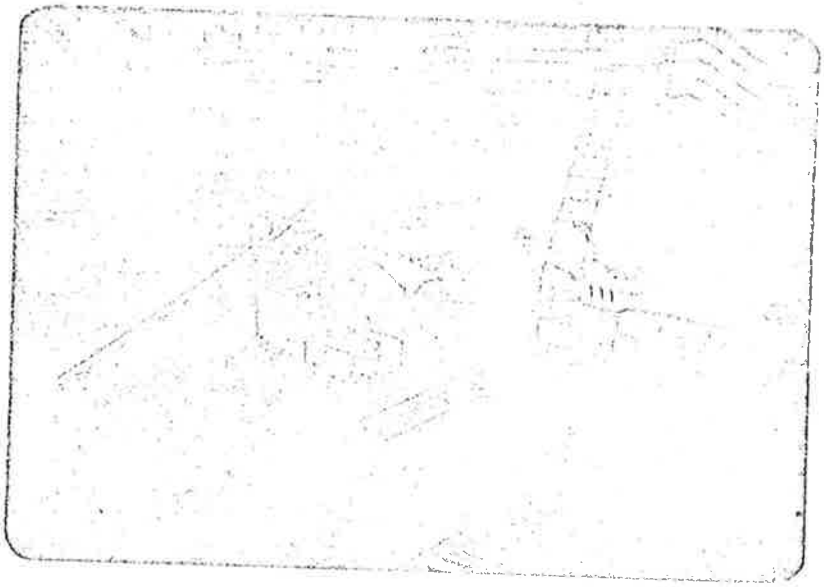

Fig. 3
Foundation of a House

materials to be used. The contract is let and the builders and carpenters and other trades are arranged for. The tooth develops according to similar detailed arrangements. We see proliferation (of the lining of the baby mouth (the epithelium), (Fig. 2), then the shaping of that epithelial proliferation) to correspond with the shape and size of the crown to be formed. This is the blueprint stage. The specifications call for the best materials (dentine, enamel), which can be obtained. The builders and carpenters line up for their task in the stage known as Histodifferentiation. The line on which they form is known as the dento-enamel line, and just as the exact location for the foundation for the house must be pegged out before one shovelful of concrete is laid down, so the dento-enamel line must be determined before enamel or dentine may be deposited by the ameloblasts (enamel) and odontoblasts (dentine).

The foundations may now be laid when these details have been cared for (Fig. 3). In the case of the tooth, the enamel forming cells and the dentine forming cells, if supplied with adequate materials, will deposit a predetermined amount of enamel and dentine each day (Fig. 4). If the calcium, phosphorous and vitamin supply is inadequate, then the type of structure laid down will be interfered with.

When the foundations are complete, the builders proceed with the walls and superstructure which rise from ground level and erupt sky-wards into full view[7]. So with the tooth. It becomes calcified and erupts into view[8].

In the final stages when the exterior of the building is completed, (Fig. 5), the interior decorators move in to make the house comfortable for the future occupants. With the tooth, the interior decorating must be taken care of also. The root development goes on to completion and the internal space is reduced in size by the odontoblasts building onto the walls both for the purpose of insulation and protection (Fig. 6). This is analogous with the insulation and finishing of the walls of the house.

If we compare the length of time

7. Slide-Walls of the house.

8. Slide-Partial eruption (Schour).

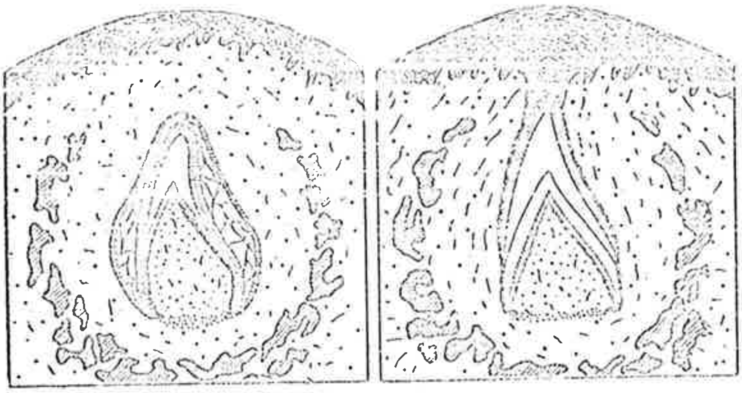

Fig. 4
Apposition and Calcification (Schour)

Fig. 5
Complete Exterior of a House

which elapses between the blueprint stage and the time of occupancy of the house, with the stage of proliferation through to completion of the tooth, it will be found that the difference is enormous; perhaps in the ratio of one year to ten years. During the ten year interval which elapses in the case of the tooth, the materials used in the development of the tooth will be subject to changes controlled by the health of the patient and the diet over that ten year interval; therefore it is of considerable interest that the tooth structure laid down is so uniform. But occasionally, disturbances do occur and they will be reflected in the developing tooth. Let us consider a few of the possibilities which occur during the four stages in the development of the tooth.

Disturbances in Development

1. *At the blueprint stage.*

In the case of the house, if the blueprints were destroyed and not repeated, or were never drawn up, there would likely be no building. In the case of

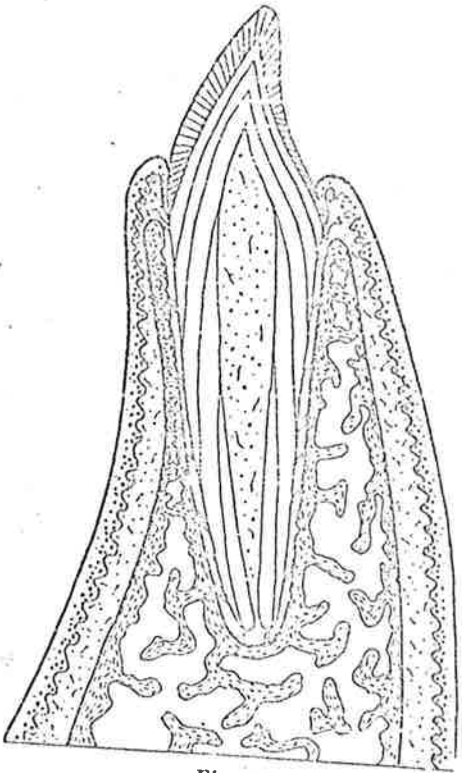

Fig. 6

Complete Eruption and Root Formation

the tooth, if there were no proliferation of the epithelium there would be no tooth. The result of this anomaly is congenital absence of the tooth. It is possible in one mouth to find the absence of a single tooth[9] or even complete absence of all teeth[10]. The cause for this disturbance is as yet unknown, but heredity probably plays an important role.

2. *At the foundation stage.*

If the foundations for the house were constructed of weak materials, sooner or later, erosion of those foundations would take place. In the case of the tooth, if poor materials were used in the foundation stage, it is probable that the enamel of the tooth which is laid down at this stage would be eroded and pit marked resulting in a condition known as hypoplasia of the enamel, (Fig. 7). The exciting cause of this disturbance may be dietary, or some general systemic disturbance, particularly, when associated with fever. For example, measles, and other exanthematous fevers.

3. *At the walls and superstructure stage.*

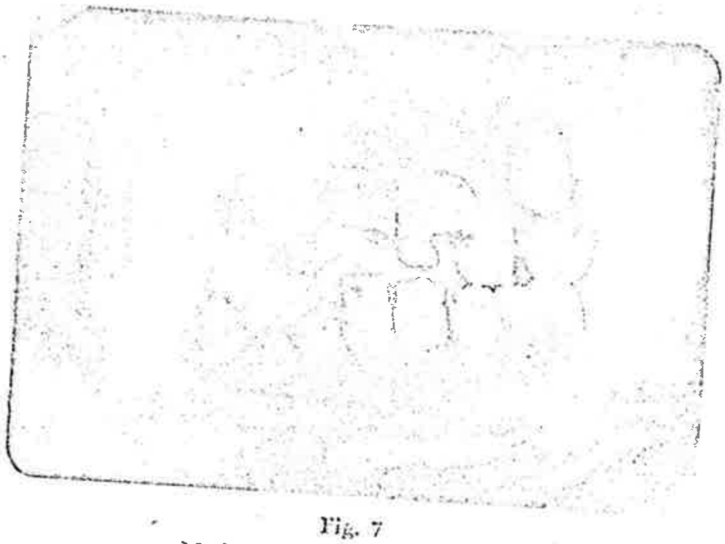

Fig. 7

Moderate Hypoplasia of Enamel

9. Slide-Congenital absence of a few teeth.

10. Slide-Congenital absence of many teeth.

If the walls of a house were constructed of weak materials or by slipshod methods, it is likely that they will quickly become weather-beaten and eroded. Defective deposition of the walls of the teeth may result in similar conditions[11]. The cause again may be dietary, systemic and even based on some hereditary factor.

4. *At the interior decorating stage.*

A violent earthquake may destroy the continuity of the house at the interior decorating stage. A sudden accidental blow on the tooth[12] after it is erupted and during the stage when completion of the root and the interior of the tooth is taking place, may cause the nerve of the injured tooth to become non-vital[13]. As the result, the complete development of the root ceases, and the interior decorating ends abruptly.

These are but a few examples of the possibility of disturbances to the developing tooth at various stages. Such disturbances are common in the mouth of the modern individual, but they seldom occur in the mouths of primitive peoples. Such disturbances are dependent on your health.

Eruption of Teeth

The amazing process of the development of the tooth is followed by an equally amazing process of eruption of the tooth into its rightful place in the mouth. Normal eruption is dependent upon a balance of numerous forces. These forces include the growth of bones, lip pressure, tongue pressure, cheek muscle pressure, endocrine balance, guidance of deciduous teeth, besides the force of eruption latent within each tooth[14].

A disturbance of these forces will result in a disturbance of the time of the eruption of the tooth and the position which it will take in the mouth. For example, mouth breathing, lip biting, thumb sucking, endocrine disturbances, etc.[15]

The vital importance of the foundation tooth as the keeper of the allotted space for a tooth of the second dentition cannot be overemphasized. If these foundation teeth are lost prematurely, normal mastication of food is interfered with and this allotted space is lost, and crowding of the second teeth will result[16].

Maintenance of Normal Diet

Two aspects of diet must be considered to have a considerable influence on the teeth. Firstly, a well-balanced diet, supplying the required minerals and vitamins is essential during the stages of development of the teeth and thereafter. The need for reinforcement of the diet with mineral or vitamin concentrates is strictly limited, and definitely less satisfactory than meeting the requirements through the natural sources[17].

Secondly, the physical nature of the foods is equally important in the growth and development of teeth and the human jaws. The modern civilized diet of prepared and higly refined foods, which deprive the teeth of their much needed function, is bringing about an inevitable slow degeneration of the teeth and jaws[18]. It is reflected in the narrowing of the arches and the increasing degree to which the third molar is absent. Perhaps we may look ahead a few centuries when the third molar will be missing entirely, and the lateral incisor, which now, to an ever increasing degree, is congenitally missing, may also be considered an anomaly when it is present. These changes are necessary if the diminished size of the jaws is to house the teeth which develop.

The coarse fibrous food of the primitive Eskimo and Indian gives needed function for the growth of the jaws and provides ample room for well formed

11. Slide-Severe Hypoplasia of enamel.
12. Slide-Non-vital fractured tooth.
13. Slide-X-ray of non-vital tooth.
14. Slide-Forces of eruption.
15. Slide-Thumb sucker
16. Slide-Premature loss of foundation teeth.
17. Slide-Good foods.
18. Slide-Poor foods.

teeth.[19, 20] Not only have we eliminated coarse foods from our modern civilized diet, but where foods are used which might necessitate the functions of prehension and incision, the knife and fork have been introduced to meet the demands of etiquette, and the front teeth have been deprived of their rightful use. There is a deep social and health significance in the "Chicken in the rough" idea. If our teeth are to serve as they are intended, the slogan might well be extended to include, "Bovine on the T-Bone", even if it does mean a few greasy fingers. The front teeth were meant for function as well as beauty, but by depriving them of this function, they may well eventually lose their beauty.

Oral Hygiene

The natural methods of cleaning teeth are also dependent on tough fibrous foods. However, with the disappearance of tough fibrous foods, we are more and more dependent on the artificial substitute, namely, the tooth brush. The correct method of using the tooth brush is important because much damage can be occasioned to the teeth if the tooth brush is used as though we were scrubbing floors[21].

Stabilizing Forces

Normal muscles, tongue, cheek and lip forces are essential to the maintenance of normal teeth and arches. It would seem that the acquisition of habits results in serious disturbances in growth and development[22].

General Health

To maintain normal oral conditions, the general health must provide a favourable oral environment. Fundamental disturbances such as general fatigue, disturbances of the nervous system, of the basal metabolism, and nutritional disturbances, besides many specific diseases, are reflected in the difficulty of maintaining the oral structures in normal health[23]. Oral health is dependent on the general health and resistance of the host.

Functions of the Teeth

1. *Mastication.*

The primary function of the teeth is that of prehension, incision, and mastication of food; and indirectly for the food to be held in the mouth long enough so that the first enzymes of the digestive process which are contained in the saliva can be thoroughly mixed in with the food bolus. What chance have you got to achieve these ends if a number of teeth are missing or if the teeth do not occlude properly? Too many of us are dental cripples very early in life as the result of the loss of teeth[24]. If you were asked the question, "How old is your mouth?", the answer would probably be at least ten to twenty years older than your chronological age.

The end result of the improper preparation of the food for the stomach can only be, that the whole digestive tract is overloaded and your general health eventually is affected.

2. *Speech.*

The importance of the teeth in speech is obvious[25]. The teeth aid in the formation of the sides of the box in which the sounds are formed. If teeth are missing or are badly misplaced in the arch, the sound box is defective and only by abnormal use of the lips and tongue, can this abnormality be compensated for, and the sounds be formed.

3. *Aesthetics.*

If we are to believe the stress placed by the advertisements for tooth pastes, the teeth are "A thing of beauty and a joy forever". Any anomaly which detracts from the beauty of the teeth may well cause a disturbance of the mental health of the host. For example, how

19. Slide-Comparison-Eskimo and civilized mouths.
20. Slide-Eskimo mouth after contact with civilization.
21. Slide-Tooth brush technique.
22. Slide-Thumb sucking.
23. Slide-Anaemia-effect on mouth.
24. Slide—Dental Cripple.
25. Slide—Speech formation.

could you face your friends with a smile if when you did so, you showed front teeth which were all jumbled up or badly decayed[26]. Would you not attempt to hide the ugly appearance of your teeth and in doing so, be in danger of developing some inferiority complex or other mental aberration.

Dental Diseases

In spite of our efforts to establish normal growth and development, normal eruption, and maintain the teeth and oral structures in a normal condition, according to the statistics, 98% of you in this hall tonight suffer from dental diseases. Too great a percentage of you are dental cripples, and as was stated previously, your mouth is anywhere from ten to twenty years older than your actual age.

The most common dental diseases of which you are victims are dental caries (decay), diseases of the supporting structures (gingivitis and pyorrhea, and malocclusion.

Dental Caries (Decay)

To have decayed teeth has been the unhappy experience of nearly every one of you[27]. The primitive peoples in their native haunts, on the other hand, are practically immune. The aetiology of this disease has been wrestled with by research workers for generations and millions of dollars have been spent in the work. Great progress is being made, and one of the amazing results which would come from the actual control of this disease, would be that the dental profession would find itself without decayed teeth to take care of, and yet I believe I am correct in saying that there isn't a member of the dental profession who is not sincerely interested in seeing dental decay brought under control. I heard recently that in the dental faculty of one of the great universities in the United States that as the result of research work which has been in progress there for a number of years, they have been successful in reducing dental decay by 90%. The results are so startling that the research worker responsible for this development does not believe his own results, and will not release them until further extensive clinical tests have been made.

There have been numerous theories enunciated from time to time concerning the aetiology of dental caries and the concept which is accepted almost universally is that it is a chemico-parasitic process. The enamel is first decalcified by lactic acid formed by the lacto bacillus acidophilus odontolyticus when it breaks down carbohydrate debri which collects about the teeth.

The enamel is built up of a number of columns or prisms which are set at right angles to the surface of the tooth[28]. These prisms are united together by an interprismatic cementing substance which is much weaker than the prisms themselves. The dentine is made up of a series of tubules which might be compared with the tubes in a boiler[29]. The significance of this architectural arrangement is important from the standpoint of the development of dental caries. When the enamel becomes decalcified, it is the interprismatic cementing substance which breaks down first and leaves the prisms unsupported which then are easily broken. The enamel may therefore be penetrated through a narrow opening and the dentine, which is much less resistant because it contains only 72% of minerals as compared with 96% in the enamel, and the carious process extends more rapidly in the dentine. The bacteria enter the dentinal tubes and crowd up these tubes which run toward the nerve in the tooth, breaking down the organic content by enzyme action and decalcifying the mineral content as well[29]. The base of the carious area situated on the dento-enamel junction may therefore be

26. Slide—Jumbled teeth.
27. Slide—Decayed teeth.
28. Slide—Enamel prisms.
29. Slide—Dentine tubules.

much wider than the point of entrance of the carious process through the enamel and it is not uncommon to have a very large cavity in the tooth before it is ever suspected[31]. An x-ray will show this development much earlier than it can be found by simple inspection[32].

Diseases of the Supporting Structures

Gingivitis—Pyorrhea

The most flagrant type of disease to soft tissue is inflammation of the gum margins, called "gingivitis". There is usually a great deal of redness but it is of a superficial nature. The cause is commonly of local origin such as, irritation caused by the accumulation of calculus around the teeth. Mouth breathing is also a common cause[33]. Besides the local factors, some general systemic disturbance, nutritional or otherwise, may cause gingivitis.

The more serious type of soft tissue disease is less alarming in appearance, more insidious in onset but much more deeply rooted. This condition is commonly known as pyorrhea[34]. The gum tissues become stripped from the tooth surface and the bone margins disappear and a pocket develops between the tooth and the gum tissues. These pockets vary in depth and are usually lined by a mass of inflamed tissue capable of absorbing, or allowing entrance for bacteria to the blood stream.

The predisposing causes of the development of pyorrhea may be traumatogenic occlusion, systemic disease and nutritional deficiencies. Traumatogenic occlusion results from badly interdigitated teeth cusps. For example: in a piece of machinery, if one of two cog wheels which were supposed to be working in harmony with each other, had one long tooth, (Fig. 8), then each time that long tooth passed over the second wheel, the whole mechanism would receive a severe jolt, and eventually the piece of machinery would be shaken to pieces. Where long cusped teeth are interlocking irregularly, then during the process of mastication it is possible for the long cusps to jolt the dental mechanism each time the chewing functions are undertaken. It is unlikely that traumatogenic occlusion could develop with the well worn teeth of the primitive people but in the modern individual with long cusped teeth showing little wear there are great possibilities for the development of traumatogenic occlusion, and hence this condition is one of the prominent predisposing factors[35].

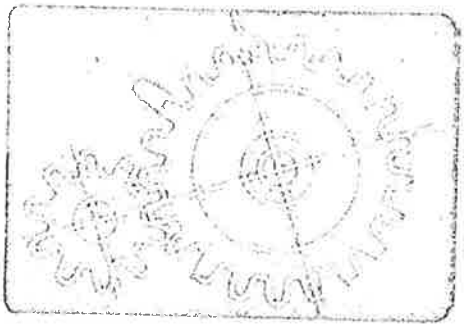

Fig. 8
Cog Wheel with long Tooth

As an exciting cause of pocket formation, there has been no specific organism proven to be the causative factor of the condition. Recently however, our research workers under the guidance of Dr. H. K. Box have considered the organism shown in the slide, a fungus-like growth, as being the possible specific causative factor in the development of the pocket[36]. Much work has yet to be done on this new thought before it can be assigned definite clinical significance.

Malocclusion

The prevalence of malocclusion among your children and mine, is

30. Slide—Tubules in cross section.
31. Slide—Cavity formation.
32. Slide—Bite-wing x-rays for cavities.
33. Slide—Mouth breather.

34. Slide—Pyorrhea.
35. Slide—Comparison, Primitive Eskimo and civilized man.
36. Slide—Fungus like growth.

33

alarming. Irregular teeth predispose the individual to increase in caries susceptibility, to traumatogenic occlusion, and other disturbances[37].

The causes of malocclusion which are recognized, are numerous. For example: Habits, such as lip biting, tongue sucking, finger sucking, endocrine disturbances and premature loss of foundation teeth.

The part which heredity plays in the development of malocclusion must also be recognized.

Whatever the nature of the cause may be in the development of malocclusion, the potential results are far reaching.

Your Teeth, Your Health

Repeated reference has been made to the importance of your health during the growth, development, eruption, and maintenance of your teeth and oral structures. But the teeth must be considered as the cause as well as the effect.

Practically every ailment the human body is heir to has at one time or another been attributed to bad teeth. Focal infection and toxaemia arising from diseased teeth and the oral tissues might develop from periodontal pockets or from non-vital infected teeth. On the other hand many teeth have been sacrificed without benefit to the individual. It is impossible to pre-determine exactly when teeth are responsible for ill health and when they only contribute to it.[38 39 40]

Let us consider the following analogy. The chemical formula shown is that of Niacin (Fig. 9). Niacin (one of the Vitamin B complex) is a valuable adjunct in the diet. If the Co. OH radical were changed to CH. the formula becomes that of Pyridine, which is a motor nerve and heart depressant. The result of that substitution changes the end result from something constructive to something destructive. So with the Health formula suggested (Fig. 10). The various stages of development, eruption, maintenance of the teeth, etc., are dependent on the health and at the same time the health is dependent on the contribution good teeth can make. If one of these well integrated parts becomes distorted greatly then the process is no longer working in favour of a normal functioning biological unit. Health and good teeth are interdependent.

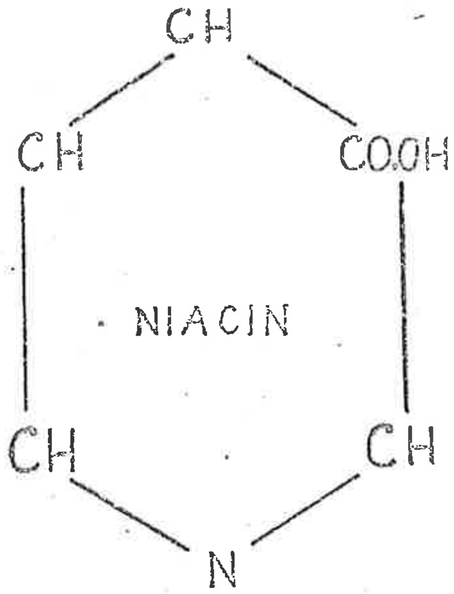

Fig. 9
Niacin Formula

Treatment

What can we say about the treatment for dental diseases? Dental diseases seem to be inevitable. Like the darkey preacher, we are advised to "cooperate with the inevitable". Unfortunately, with dental treatment there is associated the idea of pain, and because of pain, fear. Cartoonists and irresponsible people have added coals to the fire. The great hope for dental treatment lies in the prevention and

37. Slide—Malocclusion—Before and after.
38. Slide—Tooth, non-vital, non-infected.
39. Slide—Tooth, non-vital, infected.
40. Slide—Pyorrhea.

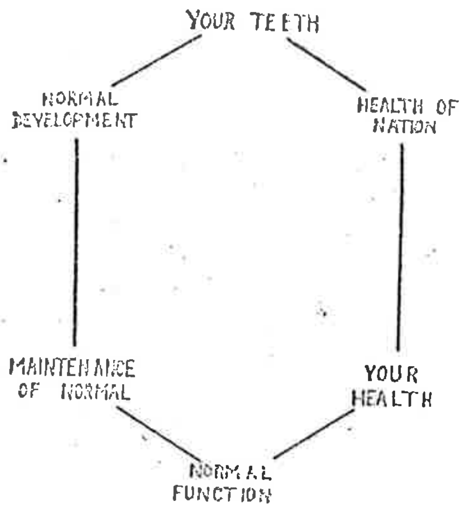

Fig. 10
Health Formula

control of dental diseases. What child today of three years of age, has not had toxoid treatment for diphtheria, etc. It is accepted by most responsible parents as "a must" in the care of the child. The same attitude toward the care of the foundation teeth, would eliminate for the child unpleasant experiences associated with the treatment of advanced dental disease. An initial visit with the dentist at three and at intervals of six months thereafter is the practical expression of such a program.

What greater living memorial could the citizens of this city, nay the whole Dominion, contemplate to honour those Canadian heroes who are fighting and dying to make Canada free and safe for the generations to come, than to build centres wherein the pre-school child, of any race or creed, no matter what his circumstances, could receive the necessary dental preventive measures, analogous to the toxoid treatments.

(The writer wishes to acknowledge the suggestions made by his confrères and the ideas obtained from the dental literature, which have been of great assistance in the compilation of this material).

CHANGE OF ADDRESS

Notice of change of address should reach the Secretary's office before the first of the month in which the change is to take effect. Please furnish old as well as new address.

Members in the Military Services are requested to notify respecting change of address as quickly as possible so that the *Journal* will be received at new address.

In all cases, the former address should be given.

Address all communications to:

The Secretary,
Canadian Dental Association, 211 Huron Street, Toronto 5.

ANNOUNCEMENT

Joint C.D.A. and O.D.A. Meeting

The joint meeting of the Canadian Dental Association and the Ontario Dental Association will be held at the Royal York Hotel, Toronto, May 27-30, 1946.

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ARE DENTAL CRIPPLES INEVITABLE?*

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I. Definition of a Dental Cripple

(a) *Definitions*: "Dental"—according to a reliable dictionary—means "pertaining to the teeth or to dentistry".

"A cripple"—according to the same source is—"a lame person—one who is partially disabled—one who is deprived of the proper use of a limb".

"A Dental Cripple"—therefore—is one who is partially disabled as it relates to the teeth, or one who is deprived of the proper use of the teeth.

(b) *Examples*: Let me give you some obvious examples with illustrations.

(i) The case of premature loss of permanent teeth without their restoration by artificial means. (Fig. 1).

One author[1] has stated that for the majority of us 'our mouths are 10-20 years older than the rest of the human body'. The illustration (Fig. 1) shown must convey to you this idea. Function, speech formation and aesthetics are interfered with considerably. If this individual's limbs were in relatively the same state of debility as his dental apparatus he would be designated a cripple. Hence, we believe the application of the term "dental cripple" to this individual is justifiable.

But you will say, this is an extreme case which you have used to illustrate the point. That may be so in terms of your practice, but you have heard it stated many times, that not more than 25%-30% of the population receive adequate dental care such as you render to the patients in your practice. Among the remainder, dental cripples are very numerous.

Consider for a moment the statement of a U.S. writer[2] when he refers to the men inducted into the U.S. armed forces; "In the recent world conflict when men were first inducted into our armed forces, out of 900,000 selectees, 186,000 were rejected because of dental defects. The requirements were that a man should have 3 upper anterior and 3 lower anterior teeth in contact and 3 upper posterior and 3 lower posterior teeth in contact to pass the dental examination." That is 20.9% or almost ¼ were rejected because they were dental cripples. "This group represented the flower of our young manhood of the nation."

(ii) *Dental Cripples—through premature loss and over retention of deciduous teeth.* (Fig. II).

The loss of the deciduous molars at the early age of seven means loss of function, loss of vertical support, (for the bite is now held open by the erupting first molars) and more seriously

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FIGURE 1
A Dental Cripple (adult)

the deciduous centrals have been over-retained, through failure of normal root resorption. The result of this condition is invariably eruption of the permanent central and laterals too, in linguo-version.

(iii) *Dental Cripples—through malocclusion and irregularity of teeth.*

It is the considered opinion of many outstanding students of dentistry that probably "50% of all malocclusions and facial deformities arise from simple, minor and environmental causes."[3] Premature loss of the deciduous

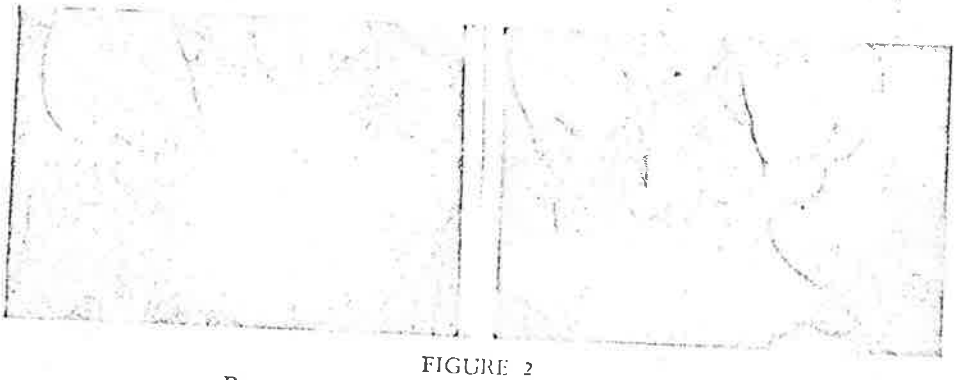

FIGURE 2
Premature Loss of Deciduous Molars at age of 7

a collapsing of the arches through drifting and tipping of the erupting teeth and closure of the space into which the bicuspids are to erupt 2-3 years later. Just what the case will look like when all the developmental forces have ceased to function and all the permanent teeth are in place it is impossible to say; at present the child cannot possibly masticate its food properly, the food therefore cannot possibly be mixed with saliva to initiate the digestion of the carbohydrates because it isn't held in the mouth long enough; furthermore, thinking of the future, the present indications are that this child must be considered a potential dental cripple for the future, through malocclusion.

Over retention of deciduous teeth may have a profound influence in the creation of malocclusion. As an illustration, you may recall cases where teeth and failure to use space maintenance when necessary are reported by Dr. Don. C. Lyons of Jackson, Mich., to be responsible for 65% of instances of malocclusion. In other words, we can assume that if we could control dental diseases responsible for the premature loss of deciduous teeth we could eliminate the development of a large group of potential dental cripples at the outset.

Some of the factors which interfere with the normal growth and development of the teeth and jaws are minor at the outset and even temporary, but once the complicated process of dental development has been interfered with, recovery is difficult and the very forces of nature which normally are constructive, may become destructive, because the initial minor disturbance having once become established develops into a major factor for malocclusion. It is possible that we let many incipient cases of malocclusion develop unrecognized in our practices.

Premature loss of deciduous teeth is but one factor in the development of malocclusion. "The aetiology and prognosis of many malocclusions is unknown."[3] Constitutional disturbances, nutritional deficiencies and inherited characteristics are among the more complicated aetiological factors involved in the development of malocclusion.

An interesting contribution has been made by geneticists relative to heredity as a factor in the cause of malocclusion.[4] "Hellman has shown, in the case of the permanent dentition, that there is a striking difference in the sequence of eruption between normal occlusion groups and malocclusion groups. For example, children with malocclusion begin to erupt their permanent teeth earlier and finish the process later than do those with normal occlusion. Moreover, the first tooth of the permanent set to erupt in the malocclusion group is on an average the lower central incisor, while in the normal group it is the lower first molar. Besides in the malocclusion group the upper first molar precedes its lower partner."

Doctors Norma Ford and A. D. A. Mason[4] studied the Dionne Quintuplets tooth eruption pattern and report as follows: "That the first permanent teeth of the quintuplets to erupt were consistently the lower central incisors."

"That the upper first molars preceded the lower first molars."

"The fact that a common pattern in the order of eruption of the teeth can be traced among the Dionne quintuplets suggests that this pattern may be an inherited one."

Finally, "The inherited characteristics were traced back to the deciduous dentition."

Is it not likely that within a few years with the enlargement of the knowledge already gained in this field of heredity it will be possible to predict with some degree of accuracy the probability of the development of malocclusion, for each child, if the eruption pattern is known, not only of the permanent teeth but of the deciduous teeth.

(iv) *Dental Cripples—through aberrations in the number of teeth which develop.* (Fig. III).

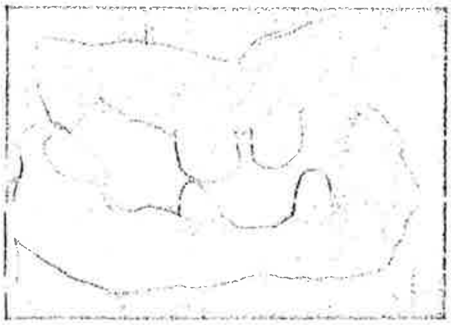

FIGURE 3
Congenital Absence of Teeth

As the result of a disturbance within the early stages of the developmental process of tooth formation this child is missing 24 teeth congenitally. Function, aesthetics and speech formation are grossly interfered with:—the child is a dental cripple without question.

Thus we have considered the four examples of the development of dental cripples namely:

(i) Through premature loss of permanent teeth without their restoration (adult).

(ii) Through premature loss and over-retention of deciduous teeth.

(iii) Through malocclusion and irregularity of teeth.

(iv) Through aberrations in the number of teeth formed.

Thinking now in terms of the child, you might well ask the question;

II. What Evidence is there of the Development of Dental Cripples among present day Children?

In your practice you see children whose dental development is normal and you strive to maintain the normal, by systematic attention. Let me remind you, however, that the number of children who receive adequate attention in this way (which includes more than merely filling holes,) is but a small fraction of the total. To answer the question asked, let me cite two surveys.

Recently, 12 children whose ages averaged 9½ years, were selected at random from the membership of the K. Club of Toronto, and were examined in the presence of two prominent members of this Academy. These children were not likely to have been privileged to have received dental service in dental offices, but on the other hand, they were not from the most underprivileged homes in the city of Toronto. They had received some dental treatment through the school dental services. Eleven of these twelve children had gross disturbances (apart from dental caries) in their dental development, which would place the majority of them in the category of potential dental cripples of the future.

Here is what we would like to see at the age of 7½ (years). (Fig. IV).

Unless something is done soon for the child seen in Fig. V he is a potential cripple in the future through malocclusion.

The second survey I wish to cite is that which was made among the Primary School children in the Porcupine District of Northern Ontario, Canada. This survey was conducted by the Dental Public Health Committee of the O.D.A. in collaboration with the R.C.D.S. Board of Ontario and is reported by Dr. T. R. Marshall in J.C.D.A. May, 1945. I had the privilege of being present in Timmins when this survey was begun and of seeing the mouths of many children who were examined.

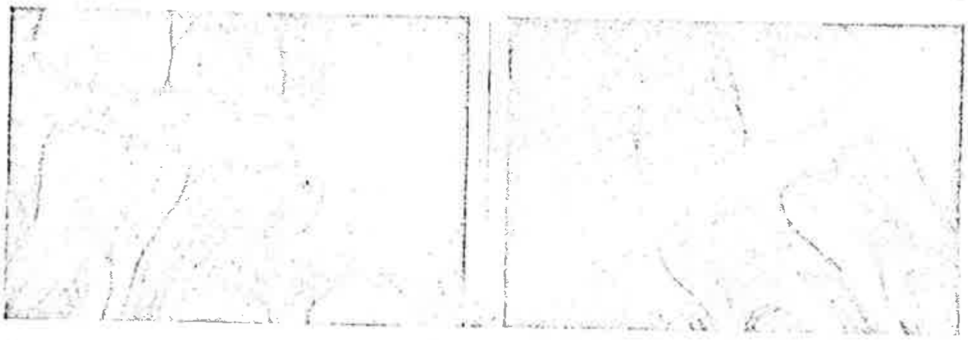

FIGURE 4
Healthy Mouth at 7½ years of age

FIGURE 5
Potential Dental Cripple at 7½ years of age

PORCUPINE DISTRICT SURVEY—1945 SPACE MAINTAINERS REQUIRED

72 Five Yr. Olds — 144 Space Maintainers.
42% of the Total but they need 130 foundation teeth extracted also.
100 Six Yr. Olds — 138 Space Maintainers
61% of the Total but they need 217 foundation teeth extracted also.
71 Seven Yr. Olds — 170 Space Maintainers
43% of the Total but they need 261 foundation teeth extracted also.
61 Eight Yr. Olds — 140 Space Maintainers
40% of the Total but they need 201 foundation teeth extracted also.

There are potential dental cripples in that district by the hundreds.

Perhaps you will protest, that this is not representative of all large cities or many other areas you could name, and I will hasten to agree with you. It does indicate the responsibilities which we as a dental profession accept as custodians of the dental health of our people. Oliver has aptly stated,[4] 'The majority of children with dental diseases if untreated, not only become dental cripples, but worse, have their general health penalized and often seriously impaired."

We have not yet reached the stage when we can prevent dental diseases, so that our program necessarily becomes one of "protection" against the ravages of dental diseases. In a survey of the Guggenheim Clinic in New York City,[5] it was revealed that the following conditions existed among new, very young patients.

GUGGENHEIM CLINIC—1941

Age	3	4	5
No. of Patients	116	212	385
Per cent with Cavities	60	75	80
Aver. No. of Cavities	2.3	3.5	4.2

Therefore, if our program is to be "fully protective', it must commence with the very young child. Furthermore, if our program, is to be successful we, as members of the dental profession, must recognize the importance of not only the environmental influences within the mouth, but also the nutritional, constitutional, and factors of heredity. Many cases require the most sincere cooperation between the dentist and the paediatrician, before treatment is instituted. "The well being of the whole child is the basic consideration." [6]

III. PROGRAM FOR THE FUTURE

If we are to make any progress in our struggle for the elimination of "dental cripples" the program devised must be founded on the development of preventive measures and in the meantime, action of a 'protective type'.

(a) *Protective Dentistry*

As I see it, an active program of "protective dentistry" commences very soon after the birth of the child. While ante-natal care of the mother and child is the responsibility of the physician, the oral health of the mother is important. Every expectant mother should be made dentally fit and recalled for re-examination at 4-6 monthly intervals during the pregnancy and nursing period. The dentist should be included in ante-natal clinics wherever possible.

During the first few months of the child's life active participation of the dentist in the health program for the child, may appear superfluous. However, discussion with the parent on the care of her own teeth and those which the child will soon have, would be of great value. Education, relative to the teeth and oral structures, made a somewhat individual matter in this way and at a time when the mother is most concerned about the welfare of her child, would have a profound effect. Is it not possible that many of the new children and their mothers could be contacted through the city-wide "Well Baby Clinics"?

Again let me refer to the 12 Kiwanis children who were examined. We requested that each child bring his or her toothbrush along and demonstrate how it was used. I wish you could have seen the motley collection which were presented and how they used them. Oh, we can talk all we like on how to use a toothbrush, but a good practical demonstration would go a lot further. The initiation of this practical instruction should be given to the mother in the "Well Baby Clinic," and then to the preschool child as the time came due.

Let me suggest then five phases in the program I foresee.

(1) The child pays his first visit to the dentist in the "Well Baby Clinic" or preferably in the dentist's office. At this time the visit is an educational one for the parent. It is devoted to an examination of the mother's oral condition and instruction on the importance of the child's first teeth, and the care of them. Discussion of nutrition, in collaboration with the paediatrician is also covered at this time, both as it relates to the mother and to the child.

(2) Through the medium of an accurate recall system the child and parent are recalled for re-examination and further education at regular intervals, possibly every six months and more often if it is found necessary.

(3) The child grows up with regular periodic visits to the dentist, having his teeth cleaned at intervals. In this way his first visit is not one demanded by toothache, which is all too frequent, and often a disastrous initiation to the dental office. To the parent of the child, the regular periodic visit to the dentist is a well established habit by the time the child reaches the age of marked susceptibility and certain fundamental dental education has been given on a very practical individual basis.

(4) If we recall the table showing the figures from the Guggenheim Clinic, dental caries is a profound reality with the preschool child, long before he reaches the school era and the benefits he might derive from the school dental service. Therefore, in conjunction with the "Well Baby Clinics," for the older preschool children of parents who cannot afford to seek the services of the family dentist, provision should be made for complete "protective" dental service required by the 3, 4, 5 or 6 year olds. If all parents of these children could be persuaded to go to the family dentist, so much the better. However, wherever the service is given, success for the scheme is based primarily on two factors:
   (a) Getting started early enough.
   (b) Following a rigid recall system, so that the service is complete.

(5) The natural extension of this program to the school era should be relatively simple. Success would still be dependent on giving a complete protective dental service (not just one of filling holes and extracting teeth).

Now I can almost hear some of you thinking out loud and saying that the idealistic program outlined is utterly impractical and the dream of a theorist. Maybe you are right, but let me think out loud too, and add my thought that the present scheme we are following, with no dentist attached to the "Well Baby Clinics" and insufficient preschool dental attention for those children who do not find their way into your office and a dental service in the schools which is definitely better than none at all but is not complete and too extensive to make it complete because of the backlog of accumulated work, is far more impractical than the program I have suggested.

The program may have to be limited to certain ages at the outset, but once it is established it could be extended to older children. At all times where possible, the service should be given by the family dentist, but failing that, it should be provided for.

In the present program it would

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appear that there is no hope of overtaking the accumulated needs; there is little educational value unless it is being repeated at regular intervals; the service is not complete in all phases, and what is even more disastrous, in many instances it is relied upon by some parents, but because of the backlog of work on hand, long waiting periods elapse before cavities are taken care of and teeth are often hopelessly involved by that time.

If, on the other hand, the program is commenced very early on a "protective basis" in conjunction with the paediatrician (before the backlog of repair work has accumulated to prodigious proportions) and it is extended into the school system on a regular interval and complete service basis, potential dental cripples among children could be reduced in number considerably. Smug satisfaction with the "Status quo" inevitably condemns some children to the status of dental cripples.

The importance of cooperation with the paediatrician in this program cannot be overstated, because I believe that the systemic factors are of the utmost importance in the aetiology of dental diseases. Such seemingly unimportant factors as fatigue, the mental outlook of the child and his way of life are probably closely related to his dental conditions.

'Therefore any measures that promote the health of the child increase the likelihood of the teeth remaining sound." [7]

Conclusion

If all the difficulties which lie in the way of putting this ideal program into effect were to be dissipated tomorrow, I wonder whether we as dentists would be ready to fulfil our obligations in it. If the answer is "yes" then we are in a better position than I judge we are. If the answer is "yes" and "no", then I respectfully submit that we could not perform a greater service to humanity, than to initiate and foster a study group on the subject of "Protective Dentistry', which embraces the whole problem that is, both medical and dental in its aspects. If, as the result of our deliberations and constructive planning we became as influential in the prevention of dental cripples as the Ferrier Study Club's of the West have become in the realm of gold foil restorations, the health professions would have reason to be thankful.

Bibliography

1. James Robinson: Address over Radio Station W-I-R-E, Indianapolis, Indiana, May 17th, 1943. Reprinted from Texas Dental Journal in J.C.D.A. "How Old is Your Mouth." 77: Feb. 1945.
2. J. H. Gonders: Personal Communication: In paper about to be published.
3. A. A. Oliver & F. P. Bowyer: "The Dentist's Responsibility to Child Patients." J.O.D.A.: 347: Aug. 1945.
4. Norma Ford and A. D. A. Mason: "Heredity as an Aetiological Factor in Malocclusion:" Journal of Heredity, Washington, D.C. 35: p. 58: Feb. 1943.
5. Annual Report of the Murray and Leonie Guggenheim Dental Clinic, New York City, 1941.
6. W. Hyde: "The Paediatrician and Orthodontist." American College of Dentists Journal: 9-10: 300-308: 1942-3.
7. G. B. Hopkins: A Maternity and Child Welfare Dental Service: British Dental Journal: 79: 1-8: July 6, 1945.

230 College Street.

RESPECTING ADVERTISEMENT IN DECEMBER ISSUE

An advertisement appeared on the inside of the back cover of the Journal of the Canadian Dental Association, Vol. 11, Number 12, December 1945, with the heading "War Surplus Stock at Reduced Prices".

After inquiry, official statement has now been made that this advertisement has no connection with the surplus stock of dental supplies accumulated by the Canadian Dental Corps.

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Vol. 34, No. 5, Pages 411-417, May, 1948. (Printed in the U .S. A.)

THE NO MAN'S LAND OF DENTISTRY

A Challenge

Roy G. Ellis, D.D.S., M.Sc. (dent),* Toronto, Canada

PERHAPS it would be unfair to say that there is but one "no man's land of dentistry." Indeed there may be many, but there is one in my opinion which stands out above all others in importance to the dental profession today.

In May, 1945, Dr. Oren A. Oliver read a paper entitled "The Dentist's Responsibility to Child Patients," which was subsequently published in the *Journal of the Ontario Dental Association,* August, 1945. In that paper, Dr. Oliver issued a challenging statement which has concerned me greatly since I heard it. Dr. Oliver said, "It is my opinion that at least 50 per cent of all malocclusions and facial deformities arise from simple, minor or environmental causes." If this is true, or nearly true, we do not have to wait until the dawn of the caries-free era to make an important preventive service available to mankind; it is our responsibility to accept this challenge and make the most of our present opportunities.

When we consider the significance of Dr. Oliver's statement, the title chosen for this address focuses our shortcomings on a vital problem. I should like to ask the following questions concerning the existence of a "no man's land":

a. Where is this "no man's land"?
b. How serious are the implications of the existence of this "no man's land"?
c. Whose responsibility is it for attacking this "no man's land"?
d. Is the attacker adequately prepared for the task?

In attempting to answer these questions, my purpose is merely to define the area involved and to place the responsibility for future action. The first question may be answered by stating that the "no man's land" under consideration lies astride the fields of the operative dentist (a general practitioner) and the orthodontist. I realize that a no man's land is a dangerous area to step into, and I am fully cognizant of the old saying that "fools rush in where angels fear to tread," but, nevertheless, I have defined the area and I shall state my convictions with respect to it.

The dental care of the child is the responsibility of the general practitioner, and it is to him that the child presents. Early changes from the normal should be observed and understood by the general practitioner. But the general practitioner does not often recognize changes in their incipiency, and even if he does

Presented at the meeting of the Great Lakes Society of Orthodontists, Toronto, Canada, October, 1947.

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he is liable to accept the stand that factors which relate even remotely to malocclusion, whether of etiology or treatment, are the responsibility of the orthodontist. On the other hand, the orthodontist sees comparatively few of these incipient cases of malocclusion. Furthermore, many causative factors which perhaps are simple at the outset have been considered very trivial, and by the time interception is undertaken, complications have arisen. These and many other considerations contribute to the existence of this "no man's land," which results in failure to recognize many incipient cases of malocclusion at a time when simple preventive measures might be very effective.

The responsibility, therefore, for the attack on this "no man's land" lies with the general practitioner, in his capacity as guardian of the child's dentition. His responsibility on behalf of the child does not cease with the filling of cavities in teeth.

The fourth question asked above concerns the adequacy of preparation of the general practitioner for the broad task in hand. The task is one of maintaining a continuity of normal arch development through the early recognition of changes from normal and prevention of the effects possibly arising from abnormal conditions, by intercepting those early changes. This does not involve orthodontic treatment. Malocclusion does not exist as yet. The education of the student of today must be such that the graduate of tomorrow; as a general practitioner, will be capable of fulfilling his obligations to his young patients in a complete preventive program. Herein lies the necessity for a cooperative effort by teachers in orthodontics and pedodontia in the training of the general practitioner.

THE GENERAL PRACTITIONER

The general practitioner is a much-abused and harried professional man. He is expected to be a good general diagnostician, conservative operative dentist, prosthodontist, periodontist, endodontist, pedodontist, exodontist, preventive dentist, to have some knowledge of orthodontics, and be an economist of sorts, at least that he may make adequate returns to the income tax authorities. All this the general practitioner is expected to accomplish in spite of the fact that his education has been a bit lopsided in favor of restorative technique. Indeed, he is truly one who knows "less and less about more and more."

To the previous formidable list of accomplishments, we now add the necessity for the general practitioner to be very observant, and conquer a "no man's land." Let us call it the field of "*prophylactodontia.*" Prophylactodontia according to my dictionary is the art and science of "advance guarding of the mouth and teeth by preventing disease, malpositions and deleterious influences" (Ottofy).

I am not in favor of the terms which have been commonly used, namely, "interceptive orthodontics" and "preventive orthodontics," because they immediately, psychologically at least, suggest the field of orthodontics, and relieve the general practitioner of his responsibility.

Prophylactodontia covers a very broad field including any or all prophylactic measures necessary to the safeguarding of oral tissues against disease and other disturbing influences. Therefore, it includes:

a. Dental caries
b. Diseases of soft tissues
c. Incipient changes which may lead to malocclusion, e.g., habits, etc.

Broadly speaking it involves *observation* of conditions and influences affecting the oral structures and *interpretation* of the effect of these conditions in terms of future developments.

Observation of conditions present will best be made by a careful examination of the oral cavity and its environment. The examination of the mouth of the child by the general practitioner is not always adequate. It should be systematic and all-inclusive.

In logical order, the following phases should be completed:

1. Physical status and general appearance of the child
2. Vestibule of the mouth
3. Oral cavity proper
4. Miscellaneous factors

Some of the points or conditions which are most important if the general practitioner is to intercept incipient changes from the normal include recognition of: premature loss of deciduous teeth, over-retained teeth, congenitally missing teeth, supernumerary teeth, impacted teeth, habits, uneven absorption of roots of teeth, effect of poor operative restorations, nutritional disturbances, metabolic disturbances, tonsil and adenoid enlargements, occlusion of posterior teeth and cusp relationship, overbite, retained deciduous roots, the eruption pattern and its influences, and many others.

The *interpretation* assigned to any abnormalities found will be dependent upon the education and experience of the dentist.

EDUCATION

The objective of dental education of the general practitioner in the field of prophylactodontia is that he may fulfill completely his obligation to his child patients. Does dental education as presently accepted completely satisfy the requirements in this field?

It is logical that the dental student should be educated, firstly, to know and understand fundamentals of growth and development of normal structures in the dental field. This includes embryology, anatomy, and histology, both general and dental, not as individual subjects, but as integrated phases of the study of the living organism as a whole.

The second phase in dental education should be directed toward the maintenance of normal structures in physiologic health. This includes biochemistry, physiology, and preventive dentistry, again not as individual subjects, but as they relate to one and the same living organism, with all its individual units.

When a knowledge of growth and development is mastered by the student and the processes of function are understood, it is more likely that early changes from the normal will be recognized, either as the change affects one minute part or the whole, and preventive measures will be possible.

The field of prophylactodontia is dependent upon this broad foundation outlined above and not upon the individual efforts of prevention of the various groups working separately. The responsibility for the field of prophylactodontia rests with the general practitioner, who is the guardian of the child's dentition. He is dependent upon his own powers of observation and upon the combined efforts of all groups for his education which he must apply in the interpretation of his findings.

CONCLUSION

When this rather idealistic objective is attained for the general practitioner, a significant new era will have dawned for the dental profession, an era of true prevention, an era that will establish the position of the dental profession as a true health service.

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A Report to the Dental Profession on Dental Education

By Roy G. Ellis, *Dean, Faculty of Dentistry, University of Toronto*

IN a recent issue[1] of the *New Zealand Dental Journal* there appears an editorial entitled, "Progress and Dentistry." The Editor draws an interesting comparison between human progress and the progress of the dental profession. I quote from this editorial because it presents a fitting introduction to my remarks.

"Human progress is determined largely by the changes which occur in two fundamentally different worlds. On the one hand is the abstract world of ideas, the changes taking place in our mental outlook, our methods of thinking; on the other hand is the material world, the advances in technology and the science of materials. One of the great problems of the present age is the failure of our mental outlook to keep pace with the great materialistic changes which have taken place over the last hundred years.

"The history of dentistry over this period is in many ways the history of the world in miniature. Many of the changes that have taken place in dental practice have been due to the discovery of new materials and new techniques, but it is doubtful if our ideas have kept pace with the ever-widening frontiers of medical and dental knowledge."

History of Our Progress

Let us review very briefly the remarkable progress of the dental profession and dental education. In a relatively short span of time the dental profession has moved forward to the present highly-developed professional status; this progress is to the credit of our far-sighted, high-purposed predecessors. It is generally recognized that there have been a series of well-defined stages[2] in the progress of the profession through the past century. The first stage, up to and including the 1840's, was concerned with the relief of pain. It is significant that in this period dentists were closely associated with the development and use of anaesthetics. Education, at the professional level, was almost non-existent in the first stage, but became more positive during the rather long second stage through the period 1840 - 1900. This second period has been referred to as the era when apprenticeship flourished, and the practice of a craft was the prime objective.

Great strides in the development of dental education at the professional level took place in the third stage, from 1900-1920. In no small measure the concept of focal sepsis introduced by William Hunter in this period contributed to the demand for knowledge in the medical sciences (Anatomy, Bacteriology, Physiology, etc.) in the dental educational curriculum.

A fourth period, from 1920 to the present time, has witnessed the development of a broadening concept of early recognition and treatment of dental disease. Throughout this development the skill of the profession in restorative dentistry has been continually advanced. Perhaps it is safe to say that to-day this skill and proficiency at the technical level has outdistanced our knowledge of the cause of dental disease. The dawn of a fifth stage appears to be at hand, in which increasing knowledge of dental disease will lead to the development of means of prevention; this in turn will result in the practice of dentistry and dental education changing more in the next twenty-five years than it has during the past hundred.

Dental Education Must Give Leadership in the Extension of Preventive Trends

The leadership given by those responsible for dental education during the present transition stage must be positive and perhaps bold, but at the same time always aware of the fact that preparation of dentists to fulfil *the ever-increasing needs of service is also of equal importance.* Within this transition period, and during the expansion of the preventive trend, there appear many special projects for dental education, each important to the ultimate composite pattern, and each to be co-ordinated with the other. Foremost among these projects are:

(1) Revision of the undergraduate curriculum.

(2) Preparation of dental teachers.

(3) Further collaboration between dental and medical teachers in the field of oral medicine.

(4) Expansion of the graduate program.

(5) Greater awareness for the need and development of reresearch.

Revision of the Undergraduate Curriculum

If we examine, critically, the curriculum of the majority of dental schools to-day, we are impressed by the fact that techniques overbalance the biological sciences. This unbalance is not so much in evidence in the number of hours devoted to each subject, but rather in the relationship of one subject to another.

At the outset, it seems logical that the dental student should be educated first to know and understand the fundamentals of growth and development of the normal human structures within his field. An understanding of the abnormal must be prefaced by a thorough knowledge of the normal, and how the normal developed. This includes a study of the subjects of Anatomy, Embryology, and Histology, both general and dental.

The second phase in dental education must be directed towards maintenance of normal structures in physiological health. The subjects relative to this phase are: Biochemistry, Physiology and Pharmacology.

A third phase follows, in logical order, namely, when failure to maintain structures in normal health results in lowered resistance and disease, causing a breakdown. The subjects pertaining to this phase are: Bacteriology, Pathology, and the allied clinical sciences of Medicine, Surgery, etc.

A fourth and final phase involves repair and restoration, so essential to health and happiness.

In reviewing the present outline of the dental curriculum superficially, it might, perhaps, be said that the foregoing is basically the order followed at present, and that, relatively speaking, the number of hours spent in each subject is satisfactory. On the other hand, there exists a preponderance of techniques in the early years (essentially a repair process), at a time when instruction in "normal" and maintenance of "normal" is of prime importance. Furthermore, the relationship of the physical and medical sciences in the early years to clinical teaching of later years needs critical examination if maximum correlation between these sciences and clinical practice is to be achieved. How best to accomplish this desirable end is a major problem, and one involving the selection and preparation of teachers.

Selection and Preparation of Teachers

What special qualifications should be possessed by a dental teacher? Who should teach dentistry? These questions have been asked over and over again. There are those who advocate that the dental teacher should have proven his clinical ability in practice, and then again there are those who believe that "being a good dentist is not a sufficient qualification alone for a teacher in dentistry." Perhaps we can agree that we are "beginning to realize that the dental teacher must keep in mind not only the achievement of the student in requisite skill, but also his achievement in fundamental knowledge of his subject and the development of desirable attitudes towards his profession and society in general."

Our professional status is bound inevitably to our education, and not merely to our skill in techniques. An instructor must demonstrate well-developed skill, and be equally capable of correlating the preclinical sciences with clinical practice. He is required to stimulate students to develop desirable scientific, professional, and social attitudes. Such a man, you may say, is a superman; he does not exist, and even if he did, he could not be attracted to the less remunerative field of teaching.

It is my belief that there are many men who possess these qualifications, and that an effort to help

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them better prepare themselves for teaching will pay handsome dividends. Dental teachers, particularly in the clinical subjects, should be encouraged to devote enough time (approximately half-time) to teaching and research, so that the maximum continuity in their teaching is possible, but at the same time maintain a contact with private practice.

The preparation of instructors along the lines suggested must be supported by a vigorous programme of fellowships, providing the necessary financial assistance for prolonged study (one or two years) at the graduate level. A new environment in which graduate study is undertaken is most desirable. Furthermore, the experience gained in practice for a year or two after graduation, prior to the period of graduate study, provides the right perspective for continued study. You may say that such a programme of teacher preparation is most difficult to arrange, and yet to-day we have three young teachers from the Dental Faculty away on a one or two year graduate programme, two of whom have left fine practices in the hands of capable recent graduates, who themselves may later proceed with graduate study when they relinquish their present responsibilities and junior teaching posts. This programme of teacher advancement is being aided at present by the Kellogg Foundation, and is vital not only to undergraduate teaching, but also to graduate education and research within the Faculty.

One of the objectives envisaged for this teacher-training programme is better correlation of preclinical and clinical instruction in the undergraduate course. For example: an instructor with a dental background who is well trained in one or more of the fundamental sciences (medical or physical), e.g., Anatomy, might assist those responsible for teaching anatomy to dental students, suggesting occasional illustrations which would give the dental student a keener appreciation of the subject and its importance to dentistry, at a time when the student has little awareness of the relationship of that subject to clinical dental practice. Thus, if during the course of the anatomical structure of the retromolar triangle area and the internal surface of the ramus of the mandible, the student were given some explanation of the mandibular injection, his interest in these structures would surely be stimulated.

Many other examples of the application of the knowledge of anatomy could be cited; however, lest a false interpretation should be assigned to the purpose of correlating the preclinical teaching with the clinical, let me hasten to state that it is not desirable that applied anatomy should replace fundamental anatomy.

The effort to correlate the preclinical instruction with the clinical must not end at this point. The same instructor is important in the clinical department, applying the knowledge which the student has obtained in the preclinical years to clinical practice. Anatomy is but one of the many essential basic sciences in the dental curriculum which must receive similar attention. When the time comes in which the preclinical teaching of Anatomy, Histology, Bacteriology, Biochemistry, Pathology, Pharmacology, Physiology, etc., is more

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closely correlated with clinical practice, a great step forward will have been made in dental education. This development will inevitably contribute to the general preventive trend of the fifth stage in the history of dentistry.

The Development of Oral Medicine

Closely associated with the preventive trend is the ever-increasing consciousness on the part of the dental profession and other groups that we are part of a great health service, and that our responsibility in this regard is well defined.

The late Dr. C. Mayo alluded to the importance of the mouth in its relationship to general physical well-being when he said, "Human life might well be extended ten full years through dentistry alone."

If we accept the challenge issued in these words of Dr. Mayo, then there must be developed closer collaboration between dentistry and medicine in teaching oral medicine to both groups of students.

Another authority has stated, "The mouth is often the barometer of general health conditions." The wisdom contained therein is supported by unmistakable clinical evidence. The early manifestations of various vitamin deficiencies, blood dyscrasias, and other general systemic conditions appear in the oral cavity. The dentist must be broadly trained in oral medicine, and therefore capable of recognizing disease of the mouth in its incipiency. This grave responsibility of dental educators can only be met if the clinical and laboratory facilities of teaching hospitals are readily available.

During the past few months the Dental Service at the Toronto General Hospital has been established as a teaching service, on a similar basis to the other services in the hospital. The Faculty of Dentistry has at its disposal the facilities of a great teaching hospital, and dental students may receive instruction in the hospital, through the dental service. The integration of this new set-up into the undergraduate curriculum is an important step in the general plan for dental education.

Graduate and Post-Graduate Education

The Faculty faces two real problems when we turn to dental education at the graduate level. These are, firstly, lack of trained teaching personnel, and secondly, physical accommodation. Teaching personnel at the graduate level must be experienced and capable of giving advanced instruction, as well as stimulating the students to search out knowledge for themselves. The same programme for teacher-training for the undergraduate will indirectly aid in graduate instruction.

The problem which is most serious within the Faculty at the present time, when considering the graduate programme, is the physical accommodation available. It is extremely unsatisfactory to superimpose graduate or post-graduate instruction on the undergraduate course, because it causes serious disruption of the latter, and failure to reach the objectives set for graduate attainment. Graduate and post-graduate instruction in practically all departments has become increasingly difficult, while present undergraduate classes are overcrowded. However, there is hope that the personnel situation will improve as the teacher-preparation programme is expanded, and it is not without reason that we look for some slight improvement in the matter of accommodation in the near future.

When conditions are slightly more favourable it is expected that courses of various types will be offered on a schedule planned and announced far in advance.

Expansion of Research

Any department within the Faculty of Dentistry which is not conducting original investigation is spiritually dead. We teach to-morrow what is investigated to-day. All members of the staff who are devoting one-third to one-half of their time to teaching should be provided with some (approximately 20%) free time, during which they may conduct and direct original investigations. The strength of our academic institution depends largely upon the staff and the calibre of the teaching personnel, and to a lesser extent on the physical facilities. However, if the physical facilities are woefully lacking, the most determined investigators are frustrated, and men of promise cannot be attracted to an institution which is so handicapped.

The bottlenecks hindering original investigation to-day are personnel and accommodation. Again we look to the teacher-training programme to aid in the matter of personnel, but the matter of accommodation is more serious. There is evidence of increasing financial support being available for the support of research projects, once men and accommodation are available, and in the meantime we must do the best we can under the circumstances.

The Physical Needs of the Faculty of Dentistry

The building occupied at present by the Faculty was built in 1909.

Dental education is looking ahead, and will perhaps change more in the next twenty-five years than it has in the past 100 years. Those institutions with vision and initiative, and which are unfettered by the limitations of the past, will lead the way in this forward movement.

The Faculty of Dentistry of this University must give leadership in dental research, specialist training, dental public health training, and graduate and undergraduate education.

The Faculty has established an international reputation, as evidenced by the presence of students from the following countries in the 1946-1947 session: Australia, 24; England, 3; Scotland, 3; and one each from the British West Indies, China, Norway, and South Africa.

For this high calling the present dental building is not only physically inadequate, but outmoded in view of present trends.

A new building of 100,000 square feet of floor space in close proximity to the teaching hospitals is imperative.

In conclusion, let me quote again from the writings of Dr. T. C. Blegen, Dean of Graduate Studies of the University of Manitoba, who expresses for me the thought I would like to leave with you, in these words,[2] "One of the paramounts needs in dental education, as in every other kind of professional and advanced education, is for the faculties and the practitioners to align themselves courageously with the forward march of their profession, to co-operate with the leaders of vision who carry heavy responsibility to insist upon and not retard the reforms and advances that link the profession with the future."

1. Editorial: "New Zealand Dental Journal," July, 1947.
2. T. C. Blegen: Fundamentals of Graduate Education, "J. D. Education," 10:182: April, 1946.

NIAGARA PENINSULA DENTAL ASSOCIATION

The Niagara Peninsula Dental Association is enjoying a very fine programme for the 1947-48 season, with two Dinner Meetings and a Ladies' Night having been held so far.

The first Dinner Meeting was held on October 10th, 1947, at the Hotel General Brock, in Niagara Falls, with the President, Dr. Don Johnstone, of Niagara Falls, in the chair. At this meeting Dr. C. H. M. Williams, of Toronto, gave an excellent address on "Gum Recession—Its Causes and Treatment," which was well illustrated with lantern slides. There were forty-five regular members present and many guests, including several from Hamilton, Ontario, Niagara Falls, and Buffalo, New York.

On December 6th, 1947, an informal Ladies' Night was held in conjunction with the Supper Dance at the General Brock Hotel in Niagara Falls. This was the first attempt at anything of its kind in the history of the Association, and though the attendance could have been better, it was sufficient to warrant a repeat performance for next year, and certainly those attending did have a good time.

The second regular Dinner Meeting was held on Friday evening, January 16th, at the Welland House in St. Catharines. We had as our clinician at this meeting Dr. Ralph Peterson, of Minneapolis, Minnesota, whose subject, "Acute Infections of the Face and Jaws," was excellently presented and very clearly illustrated with first-rate slides. Fifty members were present from all parts of the Peninsula, and their efforts were repaid by an extremely fine Clinic.

Also at this meeting tribute was paid to Dr. William Alexander MacLean, of St. Catharines, who has completed over fifty years in the practice of dentistry. Dr. MacLean graduated in 1897, practised for several years in Hamilton, then moved to St. Catharines in 1902, where he resided and practised ever since. He was presented with a leather card case containing a silver plaque inscribed with an Honorary Life Membership in the Association.

With the season so far such a decided success, we have every reason to believe that our next three meetings will prove to be just as instructive and enjoyable.

W. B. Smeaton, *Secretary.*

DENTAL EDUCATION AND THE PROFESSION*

by ROY G. ELLIS, D.D.S., M.Sc. (Dent.), F.D.S.R.C.S. (Eng.), Toronto, Ontario

I AM deeply grateful for being given the opportunity of sharing in the festivities as you celebrate another important milepost in the short, but progressive history of the Faculty of Dentistry, University of Alberta. I bring you official greetings and felicitations from a sister school, and a sincere expression of goodwill and good wishes for the future. The Dental Faculty is indeed fortunate to have the sympathetic understanding and the support of President Newton, the Board of Governors of the University and the Provincial Government. There is a tangible evidence of the magnitude of this support in the elaborate new facilities which have been placed at your disposal. The University in turn, is fortunate in having a Dental Faculty staffed by such well trained, virile, ambitious young men. It has been a great pleasure and privilege to hear their clinics and see them in action. I am confident that the dental profession in the Province of Alberta will continue to witness a full measure of success for this school in the years to come, under the very capable leadership of Dean Scott Hamilton. Your ever increasing strength has been and will continue to be a stimulus not only to the practitioners of this province and Western Canada, but also, to dental education across the Dominion. Indeed, your Dean, as Chairman of the Council of Dental Education of the Canadian Dental Association is giving leadership in dental education on a national front.

As this is a gathering of dental practitioners and members of the Faculty, my remarks tonight might be addressed to both groups. We have reason to rejoice over the rapid progress which dentistry has made toward the attainment of full professional status. But lest we become complacent and self-satisfied with our attainments, it is appropriate that we should take cognizance of the opinion expressed recently by a mutual friend and colleague from the East coast, namely, Dr. W. Woodbury[1] (formerly Dean Woodbury) who expressed the view that, "Perhaps the best that can be said for dentistry today is that it is a learning profession. If it is determined to keep on learning it may become a learned profession in time." Some concern and apprehension is in evidence lest we are not ascribed our rightful place among the health professions. Further progress toward the attainment of this objective depends on the willingness and eagerness shown by practitioners and dental educators alike, to accept new responsibilities and new challenges which lie before us in the health field. It would not be healthy for either group to lead the way alone. As T. C. Blegen,[2] Dean of the Graduate School of the University of Minnesota said,

*Presented at the Opening Ceremonies of the new Dental School, University of Alberta, September 21, 1948.

"One of the paramount needs in dental education as in every other kind of professional and advanced education is for the faculties and practitioners to align themselves courageously with the forward march of their profession, to cooperate with the leaders who carry heavy responsibility, to insist upon and not retard, the reforms and advances that link the profession with the future."

Perhaps we, in dental education have not always kept you informed regarding trends in education. This meeting and the activities of the past few days provide substantial assurance of continuing cooperation between organized dentistry and the dental Faculty. I am convinced that you regard the Dental School at the University as a friendly, hospitable home for you to visit; a place interested in its graduates and ready and eager to make a contribution toward the advancement of the profession. I am also confident that your interest and concern for its well being are vital to its future. "It is almost axiomatic that a dental or medical school must have the support of the alumni and the profession if it is to survive."[3]

If the spirit moves you, you will find many worthwhile opportunities to be of assistance to your "Alma Mater". To mention even a few of these opportunities to this audience would be presumptuous on my part.

The history of dentistry during the past 100 years has been sketched by Dean Willard C. Fleming[4] of California, as having advanced through four eras; namely

(1) relief of pain
(2) restoration of teeth
(3) the elimination of infection, and
(4) the control of disease.

Dental education has been to the forefront in the last two stages and will perhaps, to an increasing degree guide the course of the profession into the future. As knowledge of the secrets of "good health" and the causes of incipient dental disease is made available by research, the development of effective preventive measures, will result in radical changes being necessary in dental education, and the practice of dentistry. Therefore, future advancement of the profession toward more active participation as a health profession depends not on increasing trends towards specialization; and not on the development of more refined technical and clinical procedures, (admirable and necessary though they may be), but rather on the degree to which true preventive procedures become routine practice. Such a trend would introduce a fifth era of dentistry, directed towards the preservation of "Positive Dental Health."

On examination, the structures of the oral cavity may give evidence of "positive health" or "negative health". "Positive health" might be defined very simply as *good health*, which implies normal anatomic form, adequate reserve resistance and vitality, and general functional well being. "Negative health", on the other hand, embraces oral disease and dental deficiencies, in varying degrees. The educational preparation for the "negative health" program includes a study of structure (anatomy, and histology); the aetiology and diagnosis of disease, (bacteriology and pathology); the eradication of disease and restoration of affected parts. If we examine critically the curriculum of the majority of the dental schools today, we must realize that the student is educated primarily to cope adequately with "negative dental health". This is a worthy objective, but I venture to say that it cannot remain as the complete objective in the future. It is little wonder then that a very well known lay writer, who was engaged recently to portray the scope of dentistry and dental education, commenced his article with this cryptic, meaningful sentence, "Dentistry is all surgery". Perhaps the term "dental surgeon" which was once so acceptable to the dental profession may yet embarrass us in the future.

When the late Charles H. Mayo said, "Life might well be prolonged ten full years through dentistry alone." I am reasonably sure he was not thinking in terms of restorative service or other palliative measures designed to alleviate pain and the elimination of infection and disease which is already well established. I believe he envisaged a day when the dental student would be engaged in the study of the biological sciences, primarily to enable him to understand the secrets of good health in the oral tissues (both teeth and supporting structures); and when the graduate would be actively engaged in the practice of safeguarding "positive dental health."

When an oral examination is made of a mouth which appears superficially to be in good health, perhaps we are tempted to be very reassuring about the future prognosis. All too frequently time and hidden forces are unkind to us and rapid retrogression from positive health to negative health occurs. The factors which disturb the delicate balance determining the one state or the other, may be minor, environmental or systemic; they may be local or general. Local influences include such simple changes as the loss of a contact point between teeth; the accumulation of a small piece of calculus in the gingival sulcus and many others.

More complex local disturbances such as general occlusal derangement may result in trauma of the whole dental mechanism.

General influences are associated with changes in general physical health. Perhaps there is a great deal of truth in the statement that "The mouth is often the barometer of general health conditions." The wisdom contained therein is supported by unmistakable clinical evidence, e.g. the early manifestations of various vitamin deficiencies, blood dyscrasias and other general systemic conditions often appear very early in the mouth.

If the mouth tissues do reflect, like a sensitive mirror, the general physical well-being, then the physician's interest in the tongue as an indicator of disturbed health, should be paralleled by the dentist's consciousness and understanding of incipient changes in the hard and soft tissues of the mouth. The whole field of "oral medicine" presents a great challenge to the dental profession and a great opportunity in the public health field. No longer should we accept the term "dental surgeon," we must become "dental physicians" as well.

While it is acknowledged that dental deficiencies and oral disease are seldom alone responsible for death and it is equally true that it is impossible to evaluate the contribution which dental infection may make towards systemic disease, nevertheless the prevention of oral disease is the dental professions positive approach to its obligations in public health services.

The greatest contribution which dentistry can make as a health profession must come through action directed towards safeguarding "positive health." On this contribution our status as one of the important public health professions, may well rest.

"Positive health" of the oral tissues makes possible normal masticatory function, good eating habits, good nutritional status, and the initiation of normal digestive processes, besides the absence of oral infection.

Preventive Dentistry in its broadest sense, which has "positive health" as its supreme objective, might be termed the field of Prophylactodontia. It embraces all aspects of our present knowledge relative to the preservation of good health and must ultimately include presently hidden truths which will be added to our knowledge as they are revealed to us, through biological research. If more of this research were devoted to the positive approach, i.e. seeking an answer to the factors which constitute immunity in the immune, rather than studying disease itself, perhaps more progress might be made.

An adequate training for the dental undergraduate student sufficient to enable him upon graduation to practise Prophylactodontia with confidence, must be founded on a revised approach to the teaching of such biological sciences as Biochemistry and Oral Physiology. Do not misunderstand me—I am not suggesting for a moment that we discard the teaching of fundamental Biochemistry and Physiology. These subjects and others are essential biological sciences in the dental curriculum. My opinion and that of many of my associates in dental education is that the applied aspects of these subjects must be taught in such a way by dental teachers, that they become living truths, essential to service. I hope to see the day when a dental teacher with the necessary fundamental knowledge and clinical ability, will teach applied biochemistry, applied physiology, applied anatomy, etc., and correlate these subjects with clinical practice. This at once places new demands on dental teachers. There are those who advocate that the dental teacher should have proven his clinical ability in practice, but there are those who believe that "being a good dentist is not sufficient qualification alone for a teacher in dentistry." I believe that the dental teacher must have established his ability as a dental practitioner and should have more than average knowledge of the fundamental sciences, (whether they be biological or basic sciences) upon which the subject he teaches is dependent, so that he may apply the science of dentistry to the art of his profession.

In addition to possessing a command of the Science and Art of his subject, the teacher should be devoted to those he teaches and imbued with the spirit of research. Through his teaching, his personality, his sincerity, he must nurture in his students good judgement and professional skill; a love for truth for the sake of truth; a measure of self-discipline; the ability to think and the development of desirable attitudes towards the profession and society.

If the education of dental students is directed overwhelmingly in terms of the "art" of dentistry, we fail to maintain dental education at the University level.

As we reflect upon some of the thoughts which I have expressed thus far, we might truly join with Dean Fleming[3] when he asks the question, "How can we hold on to all that has been accomplished in the past, and at the same time prepare our students for the future."

The curriculum in most dental schools is now overcrowded. It is unthinkable to attempt to superimpose new requirements on top of the curriculum of today. Furthermore, it is doubtful whether the addition of another year to the course is feasible for social and economic reasons.

Perhaps we have reached the place where we must revise the curriculum so that the undergraduate student would get a sound basic course, both didactically and clinically, leaving some of the professional skill (as in medicine) to be obtained after graduation, perhaps through a year of internship, prior to entering practice. Such an experience would broaden the young graduate's viewpoint of dental public health concepts and enlarge his knowledge of "oral medicine". This thought is not new, and has been given some consideration in recent years by those who are most alert to the future responsibilities of the dental profession.

Already two large and well known dental schools have sought to meet the situation by closer association with the medical school. I fully expect that there will be other Harvard's and Columbia's, as other groups work out the destiny of dental education as they see it.

There is a glorious opportunity for the development of a distinctive Canadian pattern in this field. Perhaps the Council on Dental Education of the Canadian Dental Association will give the leadership and with the cooperation of all Canadian dental schools, evolve a program to meet the challenge presented by a changing social order.

What greater cooperative enterprise could the profession of dentistry through its National organization, and education at the University level, through the Dental Faculties across the Dominion, embark upon, working together in the true spirit of research, which is that spirit which strives to make things better than they are, for the sake of all humanity.

REFERENCES:

1. Woodbury, W. W. "A talk on Dental Education." Journal Canadian Dental Association: 13. 522, November 1947.
2. "Fundamentals of Graduate Education." Journal of Dental Education: 10: 182, April 1946.
3. 5. Fleming, W. C. "The Place of Dental Education in the Dental Profession." Proceedings of the Convocation celebrating the fiftieth Anniversary of the College of Dentistry, November 1947.
4. Fleming, W. C. "Presidential Address." Journal of Dental Education: 11: 10., October, 1947.

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The Limitations of a Transition Period*

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THE ROOTS of modern dentistry grew strong during the 18th century. The ingenuity, knowledge and skill of one man were in no small measure responsible for the course those roots were to follow in the future. In many respects the season was favourable for their nourishment, but it required the creative genius and professional integrity of Pierre Fauchard to shape the roots from which dentistry has sprung during the 19th and 20th centuries.

A review of the progress which dentistry has made since the end of the 18th century reveals four transition periods. From each of these four periods there emerged significant contributions which have been enlarged and perfected by the research and labour of devoted scientists and professional men. Today these contributions are embodied in the practice of dentistry for the benefit of mankind.

It is obvious that we cannot be too arbitrary in defining the boundaries of a transition period. History proves that a new development often takes decades and even centuries to evolve, although a distinct era may be noted during which the results of the evolutionary process are most significant. History also establishes that advancements are often restricted by limitations during the formative stages.

The first Transition Period

The first of these transition periods was concerned with the elimination of pain. From the writings[1] of the 17th, 18th and the early decades of the 19th centuries it is evident that there was increasing awareness of the suffering associated with dental disease and its treatment. For illustration of this fact we need only recall the artists' caricatures and prints coming down from the past. The long record of strange remedies that were offered to relieve suffering, reveals the effort that was made toward the elimination of pain, but the discovery of anaesthesia by Horace Wells in 1844 marked the first success of this effort. This brilliant achievement established a landmark, the first in a series of notable advances toward the elimination of pain in the practice of dentistry.

Scepticism and superstition had surrounded the use of sleep-producing drugs. Therefore, Horace Wells' success was all the more remarkable because of the discouragements he had suffered at the hands of scientists and members of his profession. Just a few years before Wells introduced nitrous oxide as a general anaesthetic, a well-recognized surgeon of the day had written: "The escape from pain in surgical operations is a chimera which is idle to follow up today." While it may be said that the first transition period ended triumphantly, the animosity and bitterness of the period, and Wells' untimely suicide, focus only too clearly

*Presented as a Luncheon address at the Ontario Dental Association Convention, May, 1952.
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the constraints which bedevil the process of evolution.

The Second Transition Period

Developments in the second half of the 19th century warrant the historian's description of this period as the "era of technological developments." Many factors influenced the surge forward in the adaptation and discovery of materials, instruments and techniques in restorative dentistry. It suffices to relate briefly a few of the most significant contributions of the period. There was the introduction of cohesive gold foil in 1855; the use of the rubber dam in 1864; and in the same year the use of vulcanite for denture construction; the invention of the dental engine followed in 1871; and the long turbulent course of the introduction of silver amalgam which ended in its recognition as a restorative filling material in 1885 following G. V. Black's memorable scientific work. Wm. H. Taggart's introduction of the casting technique came at the end of the second period.

Again, many limitations delayed progress during the 50-year technological transition period. The "amalgam war" which emanated from the undesirable properties of the early silver amalgam and the unscrupulous exploitation of this material by some members of the profession of that day delayed for nearly 50 years the use of this valuable restorative material. The use of vulcanite material was delayed for two decades because of restrictions over patent rights. These two incidents are good examples of the "modus operandi" of limiting factors during a transition period.

The Third Transition Period

Just before the end of the 19th century (1895 to be exact) a German professor at the University of Wurtzburg gave to the world the x-ray tube. Within a few months of Conrad Roentgen's amazing discovery the first roentgenograms of the teeth and jaw were made. It was thus made possible to record shadow pictures of the varying densities of teeth and bone, and it was recognized that variations in density could be caused by disease.

About the same time, the possibility to which others had alluded previously, that disease in the mouth might have an effect on the general health of the individual, was the subject of an address by an English physician, William Hunter, at McGill University, in which he referred to the ingenious metallic restorations used to preserve teeth as being "mausoleums of gold over a mass of sepsis."

These two developments contributed, during the first two decades of the 20th century, to the intensification of efforts to eliminate infection from the mouth.

Unfortunately, a great controversy developed which soon involved both the medical and dental professions and the elimination of infection ran wild. Before this transition period settled down, many teeth were removed indiscriminately by order of physician and dentist, frequently without evidence that they were infected or were contributing to ill health.

The Fourth Transition Period

The fourth era, the one in which we are now living and which is so close at hand that perhaps we are not in a position to evaluate it at this stage, has been directed toward "early recognition and early treatment" of dental disease. This transition period received new impetus immediately following World War I, when socially-minded individuals placed great emphasis on child welfare. In November 1930 President Hoover called a conference in Washington which became known as the White House Conference on Child Health and Protection. President Hoover[2] announced that the conference had been called "To study the present status of the health and well being of the children of the United States and its possessions; to report what is being done; to recommend what ought to be done and how to do it." A few years later the economic depression of the

Thirties found some dental practitioners with free time which they were willing to devote to children. Other factors have probably contributed to the movement which emphasized "early recognition and early treatment" of dental disease.

But there were restraints during this fourth transition period. Important among these was the limited coverage of dentistry for children in dental schools of the day. Wm. Gies in his report[8] (1926) stated that only four dental schools offered dentistry for children in the curriculum. In 1928 seven schools listed courses in pedodontics, and by 1936 the number had risen to 42. And although education in dentistry for children has received increased recognition in dental schools, apathy on the part of too many dentists toward the child patient has continued to restrict the treatment so urgently required by them. One further limitation may be cited in the fourth transition period. It is the enormous backlog of need for dental service by all groups of people, but especially for children.

If we have learned anything from this brief review of the development of dentistry it must surely be that most of the important contributions to the practice of dentistry as we know them today emanated from the past after withstanding many and varied trials and limitations which took a heavy toll from those who were in the vanguard. You might well ask if there is a lesson in all this for the future.

With ever increasing frequency we are being admonished by speakers and writers on every hand that members of the dental profession must become more "prevention minded." Willard Fleming,[4] Dean of the Faculty of Dentistry, University of California, and in my opinion one of dentistry's keenest contemporary observers, expressed the view recently that our new responsibility "is the prevention of dental disease, and this is located along the road to the future." Dr. Gerald Franklin in a paper[5] published in the February 1952 issue of the Journal of the Canadian Dental Association stated in the opening paragraph: "Prevention of disease is the aim of all health services and dentistry is increasingly concerned with the prevention of dental disease." In an editorial[6] in the December 1951 issue of the Journal of the American College of Dentists we read the opinion expressed that "we are now securely within the field of 'control' (of dental disease) with no small proportion of 'repair' waiting to be done. At the same time we know about preventive measures beckoning to us."

These are but a few of the host of such statements that pervade our current literature. However, lest you are misled into thinking that interest and concern about preventive measures are recent developments I would remind you that Hurlock[1] in 1742 observed that "havoc wrought by caries in the deciduous teeth was undoubtedly due to diet." John Baker[1] of Philadelphia in 1779 advised all his patients "Never suffer any of the aliment of food to remain between your teeth after eating, especially if you have any carious teeth; rinse the mouth with milk warm water after every meal." How up-to-date!

Perhaps we may take the liberty of expressing the hope that future events may prove that we have entered an active transition period from which the profession will ultimately emerge with more effective preventive measures. Some of these measures are probably already known to us. When the pages of history are complete in relation to this era, perhaps 20, 30 or 50 years from now, some of the following factors may appear in the record as the limitations which beset the development and assimilation of the preventive procedures:

Limiting Factors

(1) The first limiting factor may well be the accumulation of treatment required by the total population. Many excellent attempts have been made to present realistically the magnitude of the problem associated with service

need. The backlog plus the annual increment being added by new disease presents a staggering potential need for service. Even if totally effective preventive measures were to be adopted tomorrow, many decades would follow during which the profession would continue to meet its responsibility in providing a "repair service" and at the same time assume its new responsibility for a preventive service. This shift in responsibility will take place gradually and it will be determined by the introduction of effective preventive measures. At the beginning of this century the medical profession gave little time and attention to the healthy baby, but today it is routine for mothers to take their babies to the physician, to the pediatrician or to the child health centre, not always because the babies are sick and need the services of the physician, but to keep them well. A similar well baby service aimed at keeping the child's mouth healthy can be just as worthwhile economically to parents as the preventive service provided by the physician, but we must first believe in it, ourselves. It is so easy for us to become overwhelmed by the demands for treatment service at the expense of employment of preventive measures. Recognition of this limitation is our immediate responsibility — it is the responsibility of every dentist registered in this country.

(2) There is another factor which augments the treatment load and which may some day be regarded as one of the important limitations operating in this period. A vast social and economic levelling off process has been taking shape in our civilization during the last two decades. This equalizing process has resulted in the so-called middle class passing from a minority to a vast majority. It has created a new demand for service from a larger group of the population who are potentially able to bear the cost of their dental treatment needs. Will the increased demand for reparative dentistry created by this levelling off process further delay the evolution of the preventive program?

(3) The effect of the limitations of the accumulated backlog and increasing demand for treatment service may be augmented by a third factor, namely the worsening ratio of dentists to the population. Figures released recently by the Canadian Dental Association indicate that while there was an increase of 886 dentists in Canada during the years 1938-1952, nevertheless, this was offset by an increase in the population which was proportionately greater. It could well be that the shortage of graduate dentists will be listed among the restrictions operating during this period. Increased facilities for the education and graduation of a larger annual class of dentists and for the training of dental hygienists are urgently needed. This need can only be met in a new building, located in the vicinity of the teaching hospitals and planned for the integration of training of dentists with ancillary personnel.

(4) The acceptance by the dental profession of ancillary personnel such as the dental hygienist is vitally related to the preventive program. Much time and thought has been given to the employment of ancillary personnel in the dental office. Every study which has been made indicates that the dentist's capacity to provide the health service for which he is specially trained is doubled or trebled when he employs competent ancillary personnel. It is incumbent upon dental schools to provide training for ancillary personnel and an opportunity for graduates to learn to utilize the services of the dental assistant, the dental hygienist and the technician. Our success or failure to accept ancillary personnel into the practice of dentistry in the future is not unrelated to the discussion at hand.

(5) A fifth limitation that has made its appearance already in the world is the tendency to regard favourably the establishment of an all-embracing welfare state such as the National Health

Service of Great Britain. Under this type of all-inclusive plan the child patient has been virtually abandoned and it is easy to see the effect upon the adoption of preventive measures.

(6) What research is to the development of new knowledge, dental health education is to an era of prevention. If the knowledge we have available today could be more effectively communicated to every citizen of this country, through dental health education, the results from the preventive standpoint would be most significant. Indeed, this possibility may not be fully appreciated by every dentist and therefore we state emphatically that education of the public and education of the dentist should go hand in hand. Failure to recognize this fact may introduce a further limitation.

(7) It is logical that the child patient must command a position of first priority in the office of the general practitioner in an era of prevention. It is interesting to note that the interest in dentistry for children is becoming increasingly apparent as was evidenced by the encouraging attendance at the meeting of the Canadian Society of Dentistry for Children held on Saturday, May 10, 1952. This trend is the outcome of the inspirational leadership of a few men who are making a supreme effort on behalf of the child patient.

But as a profession we cannot afford to become complacent about the progress already made. The child patient must receive a still greater proportion of the dentist's time before we can claim that apathy toward the child patient has vanished and the preventive era can move forward without hindrance.

(8) There are many other factors which might be considered among the potential limitations to the transition period ahead. Our present interpretation of a preventive program places the responsibility for it on the general practitioner. Therefore the multiplication of the specialties in dentistry should give cause for consideration if not concern. We give due recognition to the important contribution the specialists make in the practice of dentistry today and we also recognize that a limited number of specialties will be essential in a so-called preventive era, but there is danger in segmentation of the profession into more and more specialty groups at the present time. How easy it would be to misinterpret the following statement which appeared in a very recent issue of the Journal of the Canadian Dental Association: "Prevention of malocclusion is not exclusively the responsibility of the orthodontist. It is much more the responsibility of the dentist." We are convinced that the author did not intend to imply that the dental profession now has a sister profession of orthodontics. Knowing the author of the above statement and his views we are further convinced that he would endorse the following definition: "The obligation of the profession to the public is to help children grow up with healthy mouths which will stay healthy." Surely, this is the responsibility of the general practitioner of dentistry and this is the interpretation we would give to the orthodontist's statement quoted above.

But we cannot leave the general practitioner to assume such a dominant role in the new age without considering one further aspect of this subject. The knowledge and procedures relating to practical preventive measures must be well defined and readily understood if they are to be applied in general practice. This knowledge and these procedures are today scattered through the literature, "in bits and pieces," as it were. At times it becomes confusing as we stop to sift out opinions from statements supported by facts. There is need for organization of this knowledge in simplified form and clarification of practical preventive procedures. Opportunities have been provided for members of the profession to keep abreast of new knowledge and procedures through continuation courses in dental schools, study groups in local societies, and other means. But the response to these opportunities, particularly in dentistry for children and preventive measures, has not been encouraging and calls for study of the whole question. Perhaps decentralization of these courses, by taking them into the field, may stimulate more interest. A great responsibility for the integration, correlation and dissemination of this knowledge rests with the educators in dentistry. Failure at this point could be a hindrance to progress during the present period.

These are some of the limitations that we as a profession should recognize and be prepared to meet. Equally significant impediments delayed the development of the four eras preceding the one we now face. In this enlightened period of evolution, providing all members of the dental profession encourage an attitude of tolerance and understanding, I believe it is possible to promote a dental welfare state which will be directed by the profession toward the prevention of dental disease and which will serve the best interests of the people of Canada.

BIBLIOGRAPHY

1. Bremner, M. D.: Story of Dentistry (2nd ed.; Brooklyn: Dental Items of Interest Pub. Co., 1946).
2. White House Conference: (New York, The Century Company, 1930). Foreword V.
3. Gies, William J.: Dental Education in the United States and Canada (New York: Carnegie Foundation for the Advancement of Teaching, 1926).
4. Fleming, Willard C.: The Place of Dental Education in the Dental Profession, Proceedings of the Convocation Celebrating the 50th Anniversary of the College of Dentistry, University of Southern California, 1947.
5. Franklin, Gerald: Prevention and Interception of Malocclusion, J. Canad. D. A. 18:63, February, 1952.
6. Editorial, J. A. College Dentists 18:207-208, December, 1951.

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in which surveys are usually made. I suggest that in the next dental school survey we ask ourselves first, "What happens to students in the dental schools of America?"

HOW SHOULD THE CURRICULA OF THE VARIOUS SCHOOLS BE EVALUATED?[1]

The title assigned to me invites careful study. I find curriculum defined as "a prescribed course of study in a College or University." Therefore, my topic becomes "How Should the Prescribed Course of Study (in dentistry) in the Various Schools Be Evaluated?" The word "How" suggests 2 avenues of approach. If we interpret "How" to mean "in what way or by what means" then the discussion should be limited to the mechanics of evaluating the curricula of the various dental schools. If, on the other hand, "How" is interpreted to mean "to what extent," the topic then becomes "To What Extent Should the Prescribed Courses of Study of the Various Schools Be Evaluated?" This title presents a real challenge, and is, therefore, chosen for discussion.

At first glance, certain aspects of the curriculum seem to fall naturally within the scope of this interpretation: the content of courses; the hours allocated to each course; the integration and coordination of the various parts of the total curriculum; the facilities provided for the teaching of the individual courses; and the ratio of staff to students. If we reflect further on the phase "To What Extent," we venture beyond the details concerned with hours, subject matter, and facilities. What the teacher *does with* the course of study, the time allotted, and the available facilities are of paramount significance and may be included as intimate parts of the curriculum. Likewise, the students response to and experience with the curriculum must not be overlooked in the process of evaluation of the curriculum. The full scope of my topic then embraces a study of both quantitative and qualitative criteria related to the teaching of dental students. In the final analysis, an evaluation of the curriculum should be made in terms of its success or failure to fulfill the objectives of dental education.

If we asked the members of this panel, this association, or the profession at large to express their concepts of the objectives of dental education, we would likely get a wide range of replies, but I am sure, all would embrace certain fundamental points: (1) To prepare, in both theory and practice, the student so that upon graduation he can take his place in the practice of dentistry as it is known today; (2) To prepare the student to comprehend and appreciate new concepts of oral health and dental diseases and

[1] Presented by Roy G. Ellis, Dean, Faculty of Dentistry, University of Toronto.

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stimulate him to continue his studies either informally on his own or formally through postgraduate and graduate instruction; and (3) To provide a basic university liberal education from which he may grow and become a useful citizen and leader in his community.

These "objectives" cause an evaluation of the curriculum of the various schools to be a complicated undertaking, because it must give equal attention to the criteria which relate to curriculum content and to the criteria which are a measure of the establishment of desirable behavior patterns in dental students and young graduates. Perhaps, we are satisfied with what new dental graduates *can do* in and what *they know* about the professional field. If we are, the belief is predicated upon a well-rounded series of courses, in which each course provide the fundamental principles important to that area of study. In support of this course work there are adequate preclinical and clinical practice which provide the background for the graduate's ability "to do." A good balance between the theory and practice complete this picture. The evaluation of these aspects of the curriculum is straightforward and relatively simple.

The first point enunciated in the objectives of dental education states that we are to prepare graduates for the "practice of dentistry as *it is known today*." "As it is known today," implies change and it provides for development, advancement, and leadership through dental education. If this point is considered, the evaluation of the curriculum should be made, not alone for evidence of the inclusion of the standard basic courses, but for evidence of continuous review and revision by the staff. The evaluation should be sensitive to evidence which reveals (1) whether revision is hampered by vested interest in a particular course or by the capacity or special interests of the staff, and (2) whether revision merely consists of adding new courses or new material without revising existing courses, and hence overloading the whole curriculum. It is just as important to discover in the evaluation of the total program of a school whether these detrimental influences exist as it is to discover that fundamental courses of instruction have been omitted.

Evidence of the failure of dental education to carry students beyond "facts and skills" is all to easy to find. The content of the courses is adequate, but *the methods we use* in presenting the information may create in the graduating student a complacent attitude, an attitude of "content with what he has got," and a feeling that the principles taught "will endure unchanged for all time." Is it not true that our present educational methods subject students in their final years to dull lectures, which repeat instruction given in earlier years? Do not these and other weaknesses in our teaching methods create behavior patterns in the new graduates which are reflected ultimately by the limited reading undertaken by the majority of the members of the dental profession, and even create lethargy in keeping up with advances in the professional field, to say nothing of their obligation in the broader fields of service?

Fortunately, we are all acquainted with the dynamic teacher, whose methods stimulate students to think, to question, and to explore, creating in them a vital pattern from which they continue to grow long after graduation. The ability of the teacher is an important criterion in the success or failure of the curriculum. It should be carefully weighed in the process of total evaluation of the curriculum.

Evidence of the effectiveness of the teacher will be reflected in an evaluation of the progress made by the student in the development of desirable "attitudes." The kind of person the student has become, is just as important as are the kind and quantity of knowledge he has learned during the course. An evaluation of the curriculum should include an appraisal of the student's reaction early in the course, and then later in the course. Finally, to be sure that a change is not just due to cramming, a third appraisal should be made some time after graduation to ascertain to what extent the development is related to well-established behavior patterns. These behavior patterns are responsible for the ultimate attainment of desirable professional attitudes in the dental graduate. Serious consideration should be given to the comments made by Ralph W. Tyler in *Judgment on Teaching* that "the posssibility of improving College instruction is tremendous," and that "some evidence obtained from studies in learning would suggest that much of our instruction is less than 50% efficient."

I will conclude this paper by asking questions, the answers to which are related directly to an evaluation of the dental curriculum:

1. Are the courses of study included in the curriculum directed toward the end that the objectives of dental education will be fulfilled?

2. Is there sufficient evidence that the curriculum is dynamic and under continuous review and evaluation by the staff members individually and collectively, and without prejudice?

3. Is there evidence that the teachers are contributing effectively to the motivation of students?

4. Is there evidence that the teachers have a clear conception of their task and are using positive methods which are likely to guide the behavior patterns of students toward desirable professional "attitudes"?

5. Is there evidence of well-planned experimentation with the curriculum aimed at giving leadership to the dental profession and recognition of trends in the health fields?

A review of dental education suggests a fertile field for research

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The development of dental education during the past century has been inextricably bound up with the evolution of dentistry. A brief historical review of modern Northern American dentistry will indicate the influences which each have brought to bear on the other.

Historical review of dentistry

The first era of modern dentistry ended about 1850. It was noteworthy for the many and varied efforts made to relieve and control pain of dental origin. Events of great significance for both the medical and dental professions culminated with the adaptation of ether anaesthesia for a surgical procedure in 1842 by Dr. Crawford W. Long. This event was unknown to Dr. Horace Wells, a dentist of Hartford, Conn., when in 1844 he first used nitrous oxide as a general anaesthetic.

The second era (1850-1900) was replete with significant technological developments. The introduction of vulcanite for denture construction, silver amalgam and gold foil for fillings, dental cements, fused porcelain and the dental engine were to raise dentistry in the future to the status of a highly skilled technical art. The influence of this era was profound.

By the turn of the century restorative dentistry in North America had achieved a world-wide reputation. Some questions, however, were being raised, both in North America and abroad regarding the relationship of focal infection, including that of dental origin, to the general health. The climax came in 1911 when Dr. William Hunter of London, England, while lecturing in Montreal, told of his experiences with the well-to-do patients in his practice who had debilitating diseases. These patients were greatly benefitted by the removal of teeth (often non-vital) supporting fine fixed prostheses. He concluded by condemning a lot of these restorations as "mausoleums of gold over a mass of sepsis." After the cries of indignation, consternation and bewilderment subsided, there developed a period, notable for the consciousness of members of both the medical and dental professions toward focal infection of dental origin. For this reason, the third era, which began soon after 1900 and terminated about a quarter of a century later, has been called "the era of elimination of infection."

Dental education in North America was influenced greatly by both the second and third eras as we shall see shortly.

While we are too close to the period from 1925 to the present time, there is sufficient evidence to suggest that the historian may assign to the present era the title of "early recognition and early treatment of dental disease." In this period there has developed full recognition for the field of dentistry for children, with dental education giving active leadership in this movement.

Perhaps in the next era, the fifth, the dominant theme will be the prevention of dental disease. If events in the future prove this to be the case, research and dental education, will lead the way.

But can dental education give dynamic leadership in the development of an era of prevention through its present curriculm?

Historical Trends in dental education

In the light of the foregoing it is interesting to search out the trends in dental education in North America. With the establishment of the first dental school in 1840 in Baltimore, quite indepently of the University of Maryland Medical School, a pattern was introduced for North America. Subsequently, other independent dental schools were established during the second era traced above, when rapid technological advances were being made. Not only were the majority of the early dental schools independent, but they also operated as private schools, dependent on private means of support and students fees. In many instances they resembled trade schools, influenced by the profit motive and therefore bound to concentrate on the new and most advanced techniques in order to attract students and indeed, to survive.

It must be emphasised, however, that many of the early dental schools were owned and or directed by very capable, honorable men who played a leading role at the turn of the century, and in the transition period that followed, in turning the tide of dental education away from the low ebb reached under the influence of the technological developments and the private dental school.

In addition, the events recorded briefly above, in the third era of the history of dentistry, influenced dental educators to turn their attention toward the necessity of including in the formal education of the dentist, not only the most up-to-date techniques but also instruction in the biological sciences. This phase of the curriculm could best be provided in the University, in association with the medical departments. But in turning to the Universities, dental educators in North America were anxious to retain their independence and their instruction in the technical field rather than adopt the well established European educational system, in which the dentist first received his training in the biological sciences, perhaps through a medical training, and then engaged for a limited amount of time in the techniques and practice of restorative dentistry. The close association of the dental student with the medical school in the European system contributed no doubt to the association of the dental student with a hospital department where he gained his technical and clinical training in dentistry .

On the other hand the independent status of the dental school in the North American system resulted in the establishment of the University dental clinic with little or no direct affiliation with a teaching hospital. No attempts will be made to compare the advantages or disadvantages of the clinical facilities provided by each system. They each have strength and weakness and they have no doubt greatly influenced the viewpoint of the graduates from the two systems.

On closer observation there appears to be a third system of dental education, combining aspects of both the European and American systems.

Three systems of dental education

The strength of the graduates trained under the European system in Oral Pathology, Oral Medicine and Oral Surgery, may be attributed to the influence of and association with the medical school, medical teachers, and the hospital dental clinic. Frequently under this system instruction in the biological sciences is taken with medical students; then the dental student receives extensive training in the medical and surgical department of the hospital and his clinical dental training is provided in the hospital dental service.

Some details respecting the North American system have been given above. Separated at the outset from medical education, then coming under the strong influence of the technological era in the early developmental stages and finally seeking instruction in the medical sciences and University affiliation, throughout its history the schools maintained their independence. Therefore it is little wonder that the emphasis in the North American schools has been on conservative aspects of dentistry.

What has evolved as a third system of dental education combines certain aspects of both the European and North American systems. This has been possible by virtue of the geographical isolation of the countries in which this system has developed.

It combines the autonomy of the North American school as an independent faculty with the University and yet maintains a close relationship with medicine through the teaching of the biological sciences and hospital practice, first in general medicine and surgery and secondly through its dental clinic functioning in close association with a hospital dental service.

While examples of this system could be drawn from a number of countries around the world, the dental schools of Australia will be cited in this instance. It is not the wish nor intention of the author to create the impression that any one of these three systems of dental education is best. It is the author's belief that during the past 25 years, the interchange of ideas, made possible in many ways, has brought about a greater degree of uniformity than existed previously.

Dental education under each system has its problems. These problems are intimately associated with the future of dentistry and should be the concern of the practising dentist as well as the dental educator.

The chief objective of dental education is to produce well trained general practitioners. With the shortage of dental personnel an acute problem in many parts of the world the dental schools must maintain a full roster of dental students who upon graduation will meet the demand for general dental service.

Certain problems tend to complicate the efforts of the dental schools to fulfil this objective.

Problems in dental education

(1) *Pressure on the curriculum.* The rapidly expanding volume of knowledge in the professional field has led to increasing pressure on the curriculum of the dental school. The time assigned to essential instruction in each of the four professional years of the course is already so overwhelming that it leaves little or no time for the student to do any independent reading, thinking, or studying, either in his own field or in general education. And yet the professional man is conversing daily with men and women in all walks of life, and is in a position to give leadership in community affairs. The University in turn, looks to its graduates to be more than highly skilled technicians in a specialised field. This type of restricted vocational training does not measure up to the status of University education.

(2) *The influence of specialisation.* In dentistry and medicine the trend toward speciali-

sation has been marked during the past 25 years. There are many who have become justifiably alarmed at the degree of segmentation of the profession, and the patient, into speciality fields. The American Dental Association now recognises seven dental specialties and several others are clamoring for recognition.

While recognition of the specialties by the profession and by the public has stimulated better advanced educational programmes for the graduate dentist, its affect on dental education for the undergraduate is less desirable. For obvious reasons the practising specialist is likely to be the man with the best training and experience in that field. He is therefore invariably sought after as a teacher in the undergraduate course. Assuming that his teaching ability is adequate, he is almost certain to be enthusiastic about his subject and will transfer that enthusiasm to his students. He will strive to encourage students to excel in his field. Under these circumstances several things may happen. The student may decide even before graduation that he will become a specialist in that field and his interests in the final stages of his course will be directed toward that field to the detriment of his overall interest in dentistry. The teacher in this enthusiasm (and this enthusiasm is not unworthy) will demand increased curriculum hours to cover his subject adequately. There is then a continuous struggle going on to hold the line and maintain a well balanced curriculum designed to produce general practitioners.

There are dental schools in North America which permit and encourage students in their final year of training to elect special fields for study and practice. There are also dental schools and licence boards which hold to the requirements that the graduate dentist before embarking upon advanced training leading to a specialty certificate must have completed some years of general practice experience. These and many other aspects of specialisation concern both the dental profession and the dental school.

(3) *Need for correlation of the basic sciences with clinical practice.* There is general agreement that the need still exists for better correlation of the fundamental sciences with clinical practice. Failure to integrate these aspects of the curriculum more efficiently, will impede the progress of the development of practical preventive measures in the future.

The Challenge

The pressures referred to above and others of lesser importance, not mentioned, have led inevitably, to a timetable that will not give to a student, frustrated and uncertain in the early stages of his course, positive motivation; and a staff convinced that changes are needed.

What of the future

To rush in and add a year to the course is a great temptation. However, it is generally agreed that such action does not provide the solution. Observations by dental educationists the world over during the past decade lead one to believe that some bold research on the curriculum is overdue.

It is envisaged that a curriculum could be prepared which would save time, and yet provide justifiable expansion in some areas. The curriculum should be effective in insuring early positive motivation of the student and provide better correlation of the fundamental sciences with clinical practice. It must give emphasis to the early introduction to the principles of preventive dentistry.

Coupled with revision of the curriculum a year as an externe after graduation might be considered. The successful completion of one year as an externe could be a further requirement of the legal boards before granting the licence to private practice.

Reorientation of the Curriculum

Perhaps we can best define the present curriculum as being set up on a horizontal basis. The subjects are introduced in strata. First in the strata are subjects presenting normal structures; then follow courses essentially related to function; the study of disease processes, bacteriology and pathology, are next in line and finally restorative dentistry, including clinical practice.

The more inquisitive student views this pattern critically and considers the first two years work in the basic physical and biological sciences as presenting certain hurdles which must be crossed, but once behind, soon to be forgotten. Even the patient thinkers among the student body understand with difficulty the relationship between these fundamental subjects and clinical practice, because they are often so far removed from each other in the curriculum.

It has even been rumored that many of the clinical teachers assume the attitude that after the students have completed their studies in the medical sciences during the first two years of the course, they (the clinical teachers) will teach them, in the clinic, all they really need to know to practise dentistry.

While these attitudes on the part of student and teacher are not the rule, there is enough resemblance to the truth, that they cannot be ignored. There is indeed good reason for research aimed at changes which will lead to positive motivation of students, early in the course.

Evidence is at hand that many schools recognise this problem and isolated moves have been initiated to cope with the problem. There is unfortunately apathy and even opposition from some areas to major changes. Heroic methods will be required if changes are to be effective.

While holding tenaciously to the original premise that the dental school objective is to produce general practitioners, the following principles should guide curriculum reformers.

1. *The vertical pattern of the present curriculum should be replaced with a pattern which might be defined as "horizontal".*

As an example let us consider teaching the technique of taking x-rays. If the background sciences and steps in technique followed in orderly succession and were appropriately integrated the interest of the student would be quickened, time could be saved and the science and art of this phrase of dental education would be better correlated.

At once the cry will arise "but you can't segment and disintegrate presently accepted course outlines in physiology, biochemistry, anatomy and other similar subjects. It is true that a great deal of study of this process would be required. It is also true that the rigid departmentalisation and teaching of these subjects as separate units is open to question.

2. *The quick transfer of fundamental knowledge to preclinical techniques and into clinical practice is then our second principle.*

Why should we delay for two to three years the introduction of the student to clinical practice. By so doing, the fundamental anatomy, histology, physiology and other sciences are a year or two behind him before he looks into the mouth of his first patient. It is possible that the chief reason is associated with the accepted practice over the years or the reorganisation which would undoubtedly be involved in the assignment of clinical facilities for the patients. However, if motivation of the student is accelerated through early introduction of the student to the patient then it is imperative that this change be made. We find it safe and reasonable to introduce the dental hygienist to clinical practice late in the first year or at the beginning of the second year. It is true that the hygienist is limited to prophylaxis and radiology technique, but she develops skill rapidly. It is reasonable then to assume that dental students could be introduced to the clinic at the end of their first year or early in the second year and proceed with the same operations.

3. *The latter suggestion points to the third principle, namely, to establish in the curriculum a more logical sequence to clinical practice.*

It seems illogical to the author to attempt to introduce the student to the patient with the construction of artificial dentures to replace lost teeth. There is good reason to argue that the students clinical experience should commence with the recognition of normal healthy tissues in the mouth, then to follow with the preservation of these tissues in a healthy state, then to the recognition and treatment of the very early changes caused by dental disease and finally restoration of lost structures. This sequence would be logical in an era devoted increasingly to the practice of positive preventive measures.

The implementation of the curriculum envisaged above will involve some reassessment of the use of the physical accommodation of the dental school. Perhaps even a greater problem will be the chapges required in the dental staffs' philosophy of dental education. The assistance and indulgence of the teachers of the biological science departments will also be of primary importance.

A year of externeship

The addition of a year of further experience after completion of the degree course, but before being granted a licence to practise privately would serve as a useful accompaniment to the revision of the curriculum.

The term "externeship" as used above must not be confused with the hospital interneship, nor is it meant to be confined to hospital routine and hospitalised patients. It could be set up as a service provided by the profession, under the control of the profession, and as the profession's contribution in the "welfare state". Provision of service through municipal school dental services, rural dental services, hospital dental services and dental services operated by philanthropic agencies. A nominal stipend might be paid to the externe to offset the cost of living. The service thus renedered in gaining further experience would in a small measure compensate for the assistance the young graduate received out of University funds in financing the cost of his education.

Before such an externe service can be introduced however, adequate facilities of this type must be available to accommodate all new graduates. Furthermore, a system of supervision and evaluation of the work done by the externe, must be organised.

By rotating the externe through several different types of services, including hospital practice, he would receive general experience and further education.

Conclusion

It now becomes quite apparent that implementation of the changes suggested above must be preceded by extensive study and research. Few research projects in the dental field hold opportunities of far-reaching importance for the entire dental profession.

…nk Balance, December 31, 1956	3,897.39
…nk Balance, November 30, 1957	$ 1,903.33
…ngs Account	
…nk Balance, December 31, 1956	$ 5,000.00
Add: Interest Earned to June 30, 1957	75.00
…nk Balance, November 30, 1957	$ 5,075.00

PRESIDENT'S ADDRESS

Custom and not the Constitution and Bylaws of this Association …crees that the President deliver an address at the Annual Meeting. …ere have been many occasions during the past when, as a less …tive member of the Association, I looked forward with keen …erest to the President's message. Now that the shoe is on the …er foot, I have difficulty in justifying, in my own mind, the …e allotted to the President on this busy agendum, except that …far as I can recollect this occasion is the first on which I have …d the privilege of preparing and delivering a Presidential address, …d, who knows, I may not soon again assume the mantle of a …esident. Therefore, this is my maiden voyage in these hallowed …ters, and, at the same time, it could be my last.

During the past few months my thoughts have alternated be…een these contradictory propositions, first stimulated by the …allenge associated with a maiden voyage, and then quickly brought …k to reality by the sobering thought of *singing* a swan song. …erein lies the explanation, should I, during the next few minutes …ver between the provocative attitude and the old adage which …ds "discretion is the better part of valor."

At an early stage in the preparation of these remarks, I decided …turn to the PROCEEDINGS of recent Annual Meetings, read the …e addresses delivered by my predecessors, and follow their lead. …owever, just as this idea became crystallized I recalled the …monition of a member of the staff of the University of Toronto, … Warden of Hart House, "you should recognize the obligation …e different, disturbing, and if necessary, even rebellious." It …s this challenge that led me from the section of the PROCEEDINGS …ying the President's message to the section usually found …ard the *end* of the PROCEEDINGS where the Constitution and …laws of this Association appear, year after year, always the …e. I read them over and over again, of course in succeeding …es of the PROCEEDINGS, in the hope that there would be some…g different. Frankly, during the years I have been in office …this organization, I have had more trouble with the Constitution …n with any other aspect of the Association's business. It was …ical that while in a provocative mood I should eye with some misgivings the Constitution and Bylaws, even to the point of recommending that they should be reviewed, revised, and rewritten.

It was perhaps no coincidence that about the time this decision was made so to recommend, Raymond J. Nagle and his *Ad Hoc* Committee, appointed by the Executive Committee to study ways and means of establishing a Central Office, also came to the conclusion that the present Constitution and Bylaws would have to be rewritten in order to facilitate the establishment of a permanent office for the Association with a full-time Executive Secretary and give the incumbent of that new office a reasonable degree of security.

In order to expedite matters an Advisory Committee to the President was named several months ago to study these documents and one member of that Advisory Committee, namely, Gerald D. Timmons, undertook to do some homework one week-end. The result was a draft of a revised Constitution and Bylaws. As you are now aware, this proposed revision has been studied since by the Executive Committee and distributed to the member organizations for consideration. We are deeply indebted to Dr. Timmons for his many valuable contributions to this Association and now, once again, for his help and advice. We are also indebted to Harry Lyons, who has also assisted by giving his counsel in this undertaking.

For a number of years the desirability of, and latterly the urgent need for, the establishment of a Central Office for the Association have featured prominently in the President's address. A step of this magnitude and importance involves a great deal of careful study and planning. Unforeseen difficulties have been known before to delay similar projects. We have already alluded to the limitations of the present Constitution and Bylaws. We are encouraged, however, by the strong support given by the member organizations and we are confident that without much further delay you will be given an opportunity to ratify the final phase of the project. On behalf of the Association, I want to pay tribute to Raymond J. Nagle and his Committee who have painstakingly explored the many ramifications of this undertaking.

During the past few days the International Association for Dental Research has held its Annual Meeting. The current program of the International Association for Dental Research presents conspicuous evidence of the comprehensive field in which research workers are now engaged. The growth of this organization has been remarkable. The American Association of Dental Schools and the International Association for Dental Research have prospered side by side. It is axiomatic that men and women engaged in dental education should be vitally concerned with the activities and accomplishments of the research worker, and for the same

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reasons the reverse is true. From time to time in recent years, and for various reasons, none of which seem to me to be well-founded, there has arisen the suggestion that the International Association for Dental Research and the American Association of Dental Schools might go their separate ways and meet at different times and in different places. It is unrealistic even to consider such a development affecting two organizations whose interests are directed primarily toward the same objective—providing an effective health service to the public. It would be unfortunate, to say the least, if the relentless trend toward segmentation of the professions into specialty groups were permitted to separate these two organizations whose interests are inseparable. It was logical that a General Session sponsored jointly by the International Association for Dental Research and the American Association of Dental Schools should be arranged for this meeting on the general theme, "The Interrelationship between Research and Education in Modern Dentistry."

If the interest of the practicing dentist in research activities has been discouraging, perhaps we can apportion some of the blame to the dental school. Failure to provide the dentist with an awareness of research in his student days introduces the possibility that his practice experience will fall short of rendering a broad health service. On the other hand, the student who is nurtured in an atmosphere where the scientific spirit prevails, is more likely to graduate imbued with the spirit of inquiry, and in turn to have concern for the total patient. The knowledge that active research is in progress in a dental school should not be restricted to graduate students and staff. The undergraduate students should be exposed to this activity, even if only briefly. In some schools, summer opportunities in the research laboratories are sponsored with the aid of studentships. Such institutions report remarkable interest by the student body in the over-all program, the effect of which may be far-reaching from the standpoint of teaching, research, and the practice of dentistry.

We are honored to number among our distinguished visitors at this meeting, Byron S. Hollinshead, formerly President of Coe College in Cedar Rapids, Iowa, and lately Director of the Technical Assistance Department of UNESCO in Paris. As you are aware, Dr. Hollinshead has been appointed Director of the Survey of Dentistry. This Association has previously indicated its desire to be helpful in the study of dental education. Population trends, the development of a new social order, and public interest in comprehensive health services have provided a new backdrop for the professional education scene since the publication of *A Course of Study in Dentistry* by this Association in the early 1930's.

Perhaps we should heed the observation of Ward Darley who spoke on the subject of "The Implications of Population Trends to Health." He concluded his thought-provoking address with this challenge:

> As we look into the future, I think that two things are going to happen, both predicated upon the continued increase in effectiveness of health service—particularly in the area of prevention—and upon the increasing awareness and interest of the public in health service. The first of these is that the needs of our people for expanded health services are going to be more and more appreciated. The second is, that as that happens, the demand for better and more health service is going to approach more closely the need. In other words, the gap between health needs and demand for health service is going to become narrower and narrower. (PROCEEDINGS: W. K. Kellogg Foundation Conference, June 21-22, 1956.)

To meet this situation so far as dental health service is concerned, either the research workers must provide us with more positive preventive measures and so reduce the need, or the number of new dentists graduating each year must be greatly augmented, a prospect which is alarming and probably unrealistic. As an alternative to increasing the number of dentists, the dentist's "hands" might be increased through the greater use and better integration of auxiliary personnel in the dental office. The Survey of Dental Education could find here a most fertile field for study. Isolated efforts have been reported where dental schools have sought to guide the undergraduate dental student in ways to make the most effective use of auxiliary personnel. It could be that multiple benefits would accrue from a well-integrated plan in the dental school for training the office team. The overloaded undergraduate schedule might be relieved at the clinical level; within certain limitations a significant source of trained auxiliary personnel would become available and the new graduate would develop a practical understanding of the value of teamwork in the dental office. It is conceivable that the dental manpower problem might be alleviated partially if a full-scale program of integration were to become a reality.

It is anticipated that the new study of dental education will give consideration to the effectiveness of teachers. We talk freely about teacher training, but we cannot guarantee that the individual so trained will become a gifted teacher capable of guiding students over and around mounds of detail, without becoming sidetracked en route to the core of the subject. Is it possible that the apparently overloaded curriculum in the dental school is a reflection of the tendency of some teachers to overload the student with masses of detail, instead of presenting a carefully prepared synthesis of the important facts pertaining to his subject?

Then again, it may be that the preprofessional training is responsible for the tendency of students to indulge in memorizing facts and details of lesser importance, rather than being educated to seek out principles. This tendency on the part of the student is not unrelated to the effectiveness of the teaching, both past and present.

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and may be responsible, in a measure, for the student overloading his own curriculum. This situation raises the all-important topic of "Who should study for a professional career—in our case, dentistry?" The admission of young men and women who have the potential to mature into responsible professional citizens when exposed to a thorough indoctrination in ethical conduct and professional attitudes may be more important than what we teach them. The difficulty of predetermining this quality is admitted, but until it is proven impossible to measure, it requires our earnest attention.

The Fourteenth Congress on Dental Education and Licensure held in Chicago on February 1, 1958, under the auspices of the Council on Dental Education of the American Dental Association brought into focus several unique experiments in dental education. These and similar efforts, designed firstly to improve the skill and scholarship of graduates, secondly to offset the dental manpower problem which in some areas has become critical, and thirdly to assure the development of the highest ethical standards among future members of the profession, should be encouraged. Slavish adherence to a rigid curriculum pattern must never become the chief concern of dental education.

It is my opinion that one of the major shortcomings of the present dental curriculum is the limited degree of flexibility permitted individual students in relation to their rate of progress in a class. There is a wide variation in the capabilities, the interests and motivating factors among the members of a large class of students. Under our present system, it is considered uneconomical and impossible to treat each student in a large class as an individual and without reference to the progress of the total class. And yet, perhaps the limitations we fear in providing freedom for the bright minds and skillful hands to forge ahead are more academic than real. A study of motivation of students and some rearrangement of courses in keeping with the findings, would, I believe, be a revelation to most of us. All education is a dynamic process and dental education must be no exception.

In conclusion let me add that I am deeply conscious of the privilege that has been mine in serving this Association, first on the Executive Committee, and then during the past 12 months as President. I have profited in many ways throughout this experience, not the least of which has been the fine fellowship enjoyed with the members of several Executive Committees with which I have served. I have always been full of admiration for the magnificent job done by our efficient Secretary, Marion W. McCrea. To see him in action at close range is almost mystifying. All the details for which he is responsible throughout the year seem to fall into their proper places without effort—as though he were doing what comes naturally. But he gives me no assurance that

I have been in office as President. A President, I am told, is a man who goes about with a worried look—on the face of the Secretary. I've never seen him look worried yet—so draw your own conclusions.

I want to pay a particular tribute to our genial Editor of the *Journal of Dental Education,* Charles W. Craig, and to the Business Manager, Charles A. Scrivener. For personal reasons, Dr. Craig was anxious a year or more ago to relinquish the post as Editor, but because of the pending establishment of a Central Office and changes which might be expected then, he agreed, after much persuasion by the Executive Committee, to carry on. I do not have to emphasize the fine job he has done—you receive ample evidence of that fact in each quarterly issue of the *Journal.*

The Association has a deep interest in several projects now in progress. The Fund for Dental Education is making slow, but sound progress. This Fund will become a vital force in the field of dental educational research.

The establishment of the Central Office will provide a much-needed focal point for the business of the Association and for the integration of our efforts on behalf of dental education.

The educational aspects of the Survey of Dentistry to be completed during the next two years will serve as a stimulus to the members of the Association. The recommendations forthcoming from the Survey will merit our serious study and consideration.

I thank you again for affording me the privilege of serving the Association as its President. And now on with the program. Many people have worked hard to make it a good one. I commend it to you.

[Vice-President Robert W. McNulty, who had assumed the chair while President Ellis gave his Address, appointed a reference committee consisting of Harry Lyons, Gerald D. Timmons, and Harold J. Noyes, Chairman, to consider the Address.]

REPORT OF THE BOARD OF DIRECTORS FUND FOR DENTAL EDUCATION, INCORPORATED

Gradual development of the Fund for Dental Education, Incorporated, can be reported at this time, but progress has been slow because of the desire of the members of the Board of Directors to make no mistakes. The Board, consisting of John E. Buhler, William R. Mann, Marion W. McCrea, Harold J. Noyes, Wendell D. Postle, Raymond J. Nagle, *Vice-President,* and Maynard K. Hine, *President,* has met on several occasions and has discussed methods by which the Fund can become more active and useful.

The following resolution urging support of the Fund for Dental Education was approved by the Executive Committee of the

Will today's plans satisfy tomorrow's needs?

Roy G. Ellis, D.D.S., M.Sc.D., F.D.S., R.C.S.

During the past few years I have appeared in a number of unfamiliar roles, not altogether by choice, but by the force of circumstances. These roles have included: *'money grabber'* in the eyes of the Government and Governors of the University; *'bete noir'* to an architect; *thorn in the flesh* of the University of Toronto Building Construction Department, and *slave-driver* to the senior staff members who, at one and the same time, have been carrying on a full administrative and teaching load while planning for their departments in a new dental building.

We are no longer haunted at night by the filmy apparition of something that might be, for by day we see, in reality, a new home for dental education and research now nearing completion. I am not going to burden you with a mass of building detail, even though I have learnt a new language and could recite figures respecting the *number of 'mullions' and 'muntins'* which are included in the plan, or the *size of the 'ceiling soffits' and 'branch breakers'*.

Throughout the seemingly endless planning that has gone on in relation to the physical plant, those of us closest to the project have come to realize that our chief concern must be whether 'today's plans for dental education will satisfy tomorrow's needs'. But first a word about the present.

The building at 230 College Street, occupied by the Faculty of Dentistry, is just fifty years old. It has served the profession well. Within its walls a host of students have been instructed by loyal teachers, so that upon graduation these students were ready to assume their professional responsibilities. The old building bears mute testimony to the many changes that have taken place in order that improvements in the curriculum and new technical procedures might be taught to dental students.

I am sure many of you can recall your own student days, but for the sake of those who have graduated within comparatively recent times — the last fifteen to twenty years — let me record a few of the changes that I have seen in the past thirty-five years. Denture aesthetics (dentogenics today) was achieved by laboriously grinding to an accurate fit the joints between porcelain 'gum blocks' each carrying two or three teeth. The joint had to be accurate so that the vulcanite forming the denture base and holding the pink gum sections in place would not get through between the blocks and form a dark line. It literally took hours.

In case you are not familiar with vulcanite, let me remind you that it was the great denture material until about twenty years ago. Today, the average dental student does not see vulcanite or know the joys of working with it.

Then there was the foot engine. Sometimes we managed to speed it up to several hundred r.p.m.'s. It sounds foolish now in terms of today's speeds. The electric dental drill at a few thousand r.p.m. was occasionally available to students.

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...airotor is today. But tomorrow the ...or may become standard equipment ...students. Learning to operate in the ...clinical technique course with the ...er-like touch — the *paint-brush* ...nique — required with the airotor ...dpiece may introduce a new approach ...the practice of operative dentistry.

...We could recall some other advances ...de over the past few decades which ...e affected the life of the dental stu...nt and the practitioner, but those men...ed above have taken place during the ...f century that 230 College Street has ...n the home of dental students.

The 'family dentist teaching plan' has ...n the basis for our programme in the ...t — and it will continue with increas... emphasis in the future.

By way of contrast, one school intro...ced many years ago a special curricu...n known as the 'undergraduate ortho...ntic major' with the objective of train... a limited number of specialists in ...hodontics in the regular undergraduate ...rse. There is no denying that this ...thod may be productive of graduates ...ose training in this specialty field is as ...ed as those who proceed, years after ...duation in dentistry, through graduate ... postgraduate orthodontic courses. ...wever, the objective of an undergrad...te course is to train general practition..., not specialists.

If we permit specialization in the ...dergraduate dental course, and if we ...cept it as sound procedure for ortho...ntics, we must accept it for all the other ...cialties. With the flood gates open in ... direction — where are the general ...ctitioners coming from, where are the ...mily dentists coming from, in the ...ture? The 'family doctor' is disappear... — let's be different — and hold on ...aciously to the family dentist.

I have no quarrel with the specialties ... and indeed, in certain areas they are ...ential and the dental schools must provide courses for the training of specialists in their graduate programmes, in the interests of providing the maximum specialist services to the public.

However, so long as the initials E. and F are represented quantitatively by sizeable figures in the D.E.F. rate, as they are today, then the general practitioner — the family dentist — will be the main stream of the practice of dentistry for many years to come.

Our plans for tomorrow are therefore based on the needs of the public, and the students, who upon graduation must be equipped to become the 'family dentists' of the future.

Yes, we are fashioning a building, but it is not the building that I wish to speak about during the next few minutes. I should like to discuss a few of the important facets of our plans in so far as they concern Students — Staff — and the Profession.

Through the years, the significance of positive 'motivation' of students has claimed increasing attention. Undeniably, many students in the freshman and sophomore years fail to appreciate the true significance of the biological science courses. Too many of them look upon these courses as a necessary and barely tolerable part of the 'rat race'. They have difficulty relating the courses in physiology, biochemistry, pathology and anatomy to the practice of dentistry — even though examples illustrating their application are provided at intervals by the basic science teachers.

It has been our contention that the introduction of the student to the oral cavity, during the first and second years, while these fundamental courses are being taught, could stimulate the student's interest in these courses. We have introduced such a programme in first and second years, calling it, for want of a better name, 'orientation to clinical practice'. Our experience with this plan emphasizes that it has great possibilities and it is our intention to expand the programme.

The following example — one of which could be recited — will suffice. The students are paired off in the clinic in the freshman year. They give each other a a prophylaxis and in turn they have a good look around in the mouth. The normal appearance of the gingivae is discussed and examined. Contour, texture, stippling, inflamation, are observed, then a suitable normal case is chosen and also one of inflammation — these can be observed by the class, using closed circuit television. Biopsy specimens are removed from each case for study. At the second meeting of the class the anatomical and histological features of the sections are discussed in relation to the clinical appearance. By this means, anatomy, histology and the other biological science subjects can be made to live, and the student 'motivated' to their fundamental clinical value. The comments of students who have participated in this programme of orientation have been a revelation. The time and effort spent by staff in integrating these facets of the dental course, which at times have appeared to some students so remote, will be justified in terms of positive motivation of all students.

In the pre-clinical operative technique laboratory, the student in the past has learnt cavity preparation on an inanimate dentoform. Many months later he is then required to make the transition to the live patient in the clinic. You will recall the hazards encountered in your own student days in making this transition from model to man. In our plans for tomorrow we will transfer the conventional operative technique course from the laboratory bench to the actual clinical facilities to be used in the clinic years. The headrest of the dental chair will support an aluminum phantom head provided with extracted teeth arranged in reasonably good anatomical order. Under these conditions the student's first ca... preparation will be carried out at th... dental chair, using the same equipme... and viewing arrangements as he will ha... use on the patient — and this inclu... the airotor. He may not produce th... ideal textbook preparations and restora... tions at the outset, but the gap betwee... the laboratory bench operation and th... clinical patient will be closed.

Turning now to the supply of new den... tists to meet future needs, there is ev... dence that the population is increasin... more rapidly than we can increase th... number of dental graduates. We kno... that less than fifty percent of the popula... tion seeks total dental care and we be... lieve that the public appreciation o... dental care is increasing. The statistici... could make the figures look grim but ... scarcely requires a mathematician t... sound the alert to the danger sign... ahead. To meet the danger, we mu... either reduce the need for service or in... crease the supply of hands available to... provide the service. The first points t... research activities from which will co... preventive measures designed to red... the public's need for service and simil... effective dental health education wh... will contribute substantially in reduc... the incidence of dental disease.

The alternative involves personnel. ... increase of hands can be provided ... either graduating more dentists or fa... tating the integration of auxiliary pe... sonnel. The secretary of the A.D... Council on Dental Education, Dr... Peterson, in a paper read in Milwa... Wisconsin, referred to the graduatio... more dentists in these words: 'We k... that we would have to increase inst... the size of all forty-seven dental sc... (U. S.) by one-third in order to ... enough dentists in 1975 to maintai... same ratio of dentists that we have to...

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...of giving guidance and leadership to ...xiliary personnel, becomes a dominant ...ect of today's plans in relation to satis...ing tomorrow's dental health needs. ...nd yet the solution is not simple when ...comes to the undergraduate educational ...ogramme.

In the learning process, students waste ...considerable amount of time, which is ...obably inevitable, until they have ...ined a little experience and can clearly ...scern their objective. The presence of ...xiliary personnel at this stage may ...ly serve to confuse them. Careful ...ning is therefore the key to the intro...ction of auxiliary personnel in the stu...nt regime. Nevertheless, a carefully ...ganized plan to integrate the dental ...sistant, the dental hygienist and the ...ntal laboratory technician, within the ...udent's education, is essential. Several ...udies have now been completed which ...rove conclusively that the dentist can ...ender a greater amount of service, to ...ore patients, in a given unit of time, ...hen he employs auxiliary personnel. We ...ave a long way to go in improving the ...otential output of the dentist by improv...ng the ratio of existing auxiliary person...el to the members of the dental profes...ion. If we don't succeed in this direc...ion, we may have to accept new types ...f auxiliary personnel into the dental ...ealth team.

And this brings us to the considera...on of another matter — perhaps the ...ost vital and important issue of all, ...oth in the education of the undergrad...ate student and in his ability after grad...ation to continue his growth in profes...ional stature. It is the development ...f the professional attitude. The dental ...chool staff is responsible for the indoc...rination of students in professional con...uct, good human relations, and profes...ional and public relations.

Irrespective of how well we teach tech...iques, or impress the student with the ...ignificance of the oral cavity in relation to the total well-being of the patient, if he fails to develop personal qualities which will be translated into the practice of ethical and professional behaviour we fail in our obligation to the profession, both past and present. The present stature of the profession is the heritage bestowed upon us by the efforts of many generations of dentists who have exemplified professional ethics, and placed service above self. Albert Schweitzer said of the professional man: 'He belongs no more to himself alone; he has become the brother of all who suffer'.

You may well enquire now about our plans for developing in the graduates of tomorrow the highest qualities associated with professional ethics. They will not be the natural outcome of the adequacy of a new building or the effectiveness of new equipment; nor will they be developed in proportion to the efficiency of the latest techniques or materials. The attainment of these qualities will be a measure of the example set by the instructors, both individually and collectively.

The selection of staff, then, assumes maximum importance. We would like to think that we are building a staff whose stature will be even more impressive than the building. This programme is already well established, and we are proud of the men and women who comprise the teaching team. Scholarship and skill may be prerequisite for a good teacher; but dedication to professional ethics and service is indispensible in a professional faculty.

You can all recall, perhaps vividly, from your own student days those instructors who impressed you with their inherent personal honesty, kindliness, integrity and sympathy; teachers who placed service above self — men who would not accept 'good enough' as satisfactory but demand your best. They exemplified the qualities which are now and will be in the future the profession's greatest assets. A single member of the staff will not accomplish much alone. It requires the collective effort of all staff members, working all the time, from the beginning of the freshman year to the end of the senior year, to imprint the hallmark of professional man on the new graduate.

And now for the participation of the dental profession in our future plans. If you, the members of the profession, believe wholeheartedly in the profession, you will be concerned about its future. This is inevitably tied to the recruitment of suitable young men and women who will enter the dental schools of Canada and subsequently graduate and take their places among you. If we are unsuccessful in obtaining a sufficient number of good students, then the number of graduates provided each year will drop and the ratio of dentists to the population will deteriorate further. This is a vicious circle, and can only lead, if it continues, to increasing pressure from laymen, business men, and politicians for the services of dentists in their communities. During the past few months I have received in my office in the neighbourhood of 100 letters pleading for the provision of a dentist in a community. Some of these are repeat letters, and the concern of the people involved is quite evident. Under these circumstances our public relations suffer and in due course these laymen and politicians turn away from the dental profession and seek service elsewhere.

From time to time I am confronted by members of the profession who say that they do not feel justified in persuading their sons or High School students into taking up dentistry as a career, and the reasons given are usually: firstly, the uncertainty of the future of the profession, and secondly, the cost. In so far as the uncertainty of the future is concerned, we, the dental profession, are contributing to it if we do not believe in the profession and are not prepared to encourage potential students to take up dentistry. In so far as the cost is concerned, a business friend recently pointed out to me that there were few areas in which a man could make an investment in his future and expect to receive a return so quickly as within dentistry. You, the members of the dental profession, also participate in another way in the student's education as a professional man. Your example, your adherence to professional concepts, your attitude toward public relations, does not escape the scrutiny of either the undergraduate student or the new graduates.

There are probably times when you feel that you aren't given much opportunity to contribute to the education of the dental students. Some of you may have the urge to try your hand at teaching. Many of you, no doubt, have ideas of how much more effective you could make the educational programme.

Apart from doing the actual teaching, there are many important ways in which you may contribute to dental education.

I have always maintained that a dental school must have behind it a strong dental alumni association. The active participation of the membership of the alumni association in the support of a dental school provide's a stimulus to both staff and students.

Remember, your education was subsidized, in part, by someone, whether it was the state or the university. Now you have the opportunity to see that loan funds and scholarships are available to today's generation of students. One of the distinguishing characteristics of a profession is that knowledge is handed down from one generation to another — free — and our obligation is to add to the sum total of that knowledge and hand it all to the next generation. Support of student aid funds by members of the profession is part of the same principle work.

Again, let me repeat that your exam

...nportant in the development of the ...ng men and women who, upon gradu-...n, take their place beside you in the ...tice of dentistry.

The young graduate has a lot to learn ...n he finally makes the transition from ...al school to dental practice. Your ...rest and friendship in him at this ...e will help to make him a better ...tist and stimulate him to a finer ...reciation of his responsibility to his ...ents and fellow practitioners.

You see there are many ways you can contribute to dental education. You are partners with us in dental education, and in the plans we are formulating to meet tomorrow's needs.

And so we move on to 124 Edward Street fully aware of the challenge and the responsibility which lies ahead. The building is important — but what the staff accomplish for the students will be of greater importance to the public and the dental profession of the future.

ENDODONTICS

One-step Reproduction of Radiographs

John Philpot, Toronto, Ontario

...e are many occasions when endodon-...s and other specialists require a slide ...a periapical or an extraoral radiograph ...ich, in itself, is either too dense or of ... irregular size for projection by stand-...d apparatus. This incurs added expense ...d the inconvenience of having copies ...de commercially. This article is in-...ded, therefore, to enlighten the prac-...oner on how this may be undertaken ... himself with the aid of the circle-flash.

Many dental practitioners appreciate ...d probably use the circle-flash in con-...ction with a 35 mm. camera but do ...t realize that this apparatus, with very ...le outlay, can be adapted for produc-...g high-quality reproductions of intra-...l and even larger originals when re-...red.

The sensitive material used for this ...rk is Daylight Kodachrome or an ...ivalent film, and the apparatus is ...structed from the following:

1. A sheet of opal glass, 2 inches greater than the largest film to be copied. (Check for complete opalescence; the type used in an x-ray viewbox is usually satisfactory.)
2. One porcelain or plastic lampholder and one 100 watt lamp.
3. One feed-through switch.
4. A 5 foot length of light cord (5 amperes).
5. A small supply of lumber and hardware.
6. A series of x-ray mounts set in opaque masks, the size of which should match the opal glass (Fig. 2).

The apparatus should be assembled as shown in Fig. 1. No detail of construction has been given, as this apparatus will be used for different-sized radiographs and to suit varying space limitations. However, Fig. 1 shows the basic design which can be adapted to suit specific requirements.

When the apparatus has been assembled, a series of test exposures are made in the following manner:

1. The mask holding the radiograph to be copied is placed on the opal glass.
2. The 100 watt lamp is turned on and the room lights are dimmed (one 40 watt lamp at not less than ten feet from apparatus).

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Out of the Past and into the Future

ROY G. ELLIS, D.D.S., M.Sc.D.,* Toronto, Ontario

Editor's Note:

The Journal of the Canadian Dental Association is privileged to publish the following words written by Dean Roy G. Ellis. Dean Ellis has modestly refrained from mentioning his personal tireless efforts, often in the face of extreme adversity, to bring this colossal Dental achievement to fruition. The past and the future of dentistry will remain indebted to him and to his committee members who cheerfully maintained their full teaching, administrative and research schedules in spite of the tremendous additional responsibilities associated with planning the building.

Fifty years ago the Royal College of Dental Surgeons of the Province of Ontario had a moving day. The dental school took over new quarters at 230 College Street. During the half century since, the school became a full Faculty of the University of Toronto (1925) and has bulged at the seams with overcrowded classes following two world wars.

Fifteen years ago a six-man Committee of the Dental Faculty staff made a detailed report respecting the future needs of the Faculty. This study was financed by the Royal College of Dental Surgeons,

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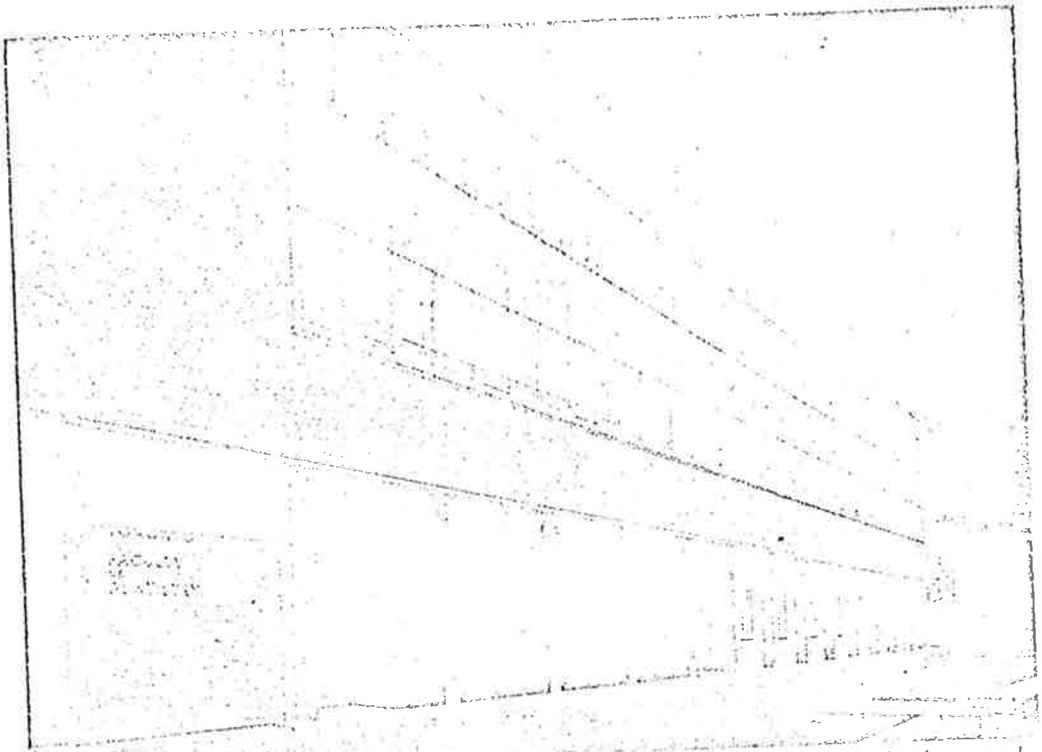

New Faculty of Dentistry, University of Toronto. *Pando Photography.*

and included funds for the visitation of a dozen or more of the most up-to-date dental schools on this continent. Sketch plans were drawn up by the Committee for a four storey building with a total floor space of 84,000 square feet. This was considered adequate then for classes of 80 students. The projected site was the city block on University Avenue, immediately south of the new Hospital for Sick Children, which today is occupied in part by a commercial skyscraper.

Following the release of the 1944 report, a series of events took place which have had an important bearing upon the activities of the past three years.

Firstly, the development of an active, integrated program of graduate and post-graduate education was stimulated by generous financial assistance from the W. K. Kellogg Foundation during the period 1947-49. However, the solution to the problems created by space limitations, was not to be found in the old building.

Secondly, in 1951, the Ontario Government concluded a survey of the health needs of the Province. In respect to dentistry the recommendation was that 120 new graduates were required annually. Only 75 could be accommodated in the existing facilities.

Thirdly, the establishment of the Division of Dental Research in 1951, and the magnificent response of the members of the dental profession a year later to the appeal for financial support of research, triggered further demands for greatly increased space for dental education and research.

Fourthly, and again with assistance from the Kellogg Foundation in 1951, the training of dental hygienists was inaugurated, and again space was the limiting factor.

Therefore, with all these compelling reasons pointing to the need for new and larger quarters for research, and the education of dental personnel, it is not sur-

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prising that in March 1954, the Ontario Government announced in its annual budget the inclusion of the sum of one million dollars as a "special capital grant to the University of Toronto for the expansion of its College of Dentistry". This set in motion the second study during the decade 1944-54 of the feasibility of modernizing and expanding the building at 230 College Street. One year later it was demonstrated that the expenditure of two million dollars in this way would make possible the addition of only 9 dental students, and 6 dental hygienists to each class. More disturbing still, this plan would eliminate any possibility of introducing new concepts into undergraduate dental education or provide adequately for the other needs.

Thus, early in 1955, five* of the original 1944 Committee of six men, found themselves participating as members of an enlarged building Committee. However, the green 'go ahead' light had already shown amber as further visits to dental schools and preparations of plans for a new building were authorized.

It soon became evident that the 1944 concept was inadequate and required radical revision for the reasons outlined above. The 1944 plans for 84,000 square feet of space on four floors mushroomed to six floors covering an area of approximately 184,000 square feet. Similarly, the cost of the 1944 site had increased tenfold, representing over one million dollars, and it was reluctantly abandoned in favour of more building on a less costly site just to the east.

From early in 1956 to the present date the Building Committee has held approximately 100 meetings. They prepared and studied dozens of detailed memoranda on such subjects as "traffic flow in the building"; wall, floor and ceiling finishes; lighting requirements; lecture room requirements; parking space; locker rooms; common rooms; heavy equipment; student instrument kits; sterilizing equipment; closed circuit television equipment, and many others. Throughout the hot summer months of 1956 the Committee met on several occasions with the architect and University authorities to press claims for the inclusion of air-conditioning in the building, but without avail.

However, in spite of some disappointment along the way, the new building is modern, contemporary in design, and colorful. By way of contrast, the overcrowded conditions of the former building have given way to roominess; poorly lighted laboratories, once relieved only by students bringing desk lamps, are now cheerfully bright under fluorescent lighting; dusty wooden floors in the main clinic are now attractive linoleum tile; finger marked painted walls in corridors, student and patient areas have been transformed with colorful mottled ceramic tiles, and frustrating acoustic problems have been eliminated with the use of acoustic tile on the ceilings throughout the new building.

Features of the building, which will be formally opened on November 25th, include: closed circuit television; one clinic room equipped with 124 dental units (all with airotors installed); ramps for patients as they proceed to any one of the seven clinical areas located on the ground floor and the one above; three lecture rooms, each complete with instrument panels on the podium for the control of two types of room lights, motorized screens, and projection equipment; a quiet, pleasant room for 120 readers as the focal point in a well-planned library, and many others.

Research quarters occupy most of the fourth and all of the fifth floors, with excellent laboratories for almost any aspect of research in the biological fields related to dentistry. This includes separate and carefully controlled space for experimental isotope work.

In the clinical areas special aspects of cleanliness control are featured. Two huge combination sterilizers have been installed, each capable of being operated by steam or gas (ethylene oxide). The latter

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* (P. G. Anderson, R. J. Godfrey, J. H. Johnson, C. H. M. Williams, and R. G. Ellis)

is used not for heating purposes but to sterilize perishable equipment with a safe gas, for example, handpieces, endodontic instruments, rubber gloves, and so on.

Closed circuit television equipment has been installed after experimenting with its use and application during the past three years. In some areas a clinical demonstration can be seen equally well by a whole class of 124 students, instead of repeating the operation many times to groups of 8 or 10. A dozen pick-up points for programs have been provided in the building, with 21" screen plug-in points scattered throughout. The main programs will likely originate in the television studio on the third floor, and be received in the 350 seat lecture room where more than one class can be accommodated at a time. Television as a teaching medium will not replace the present conventional methods, but will serve as a useful adjunct.

The new and very modern features will be tempered by a stained glass window, honouring J. Branston Willmott, one of the founders of the school in 1875, which was a feature of the main stairway at 230 College Street. This window, residing now in a suitable place in the new building, along with several bronze plaques, a number of oil portraits and a pair of beautifully carved crests of the University of Toronto and the Royal College of Dental Surgeons will preserve our traditions and ties with the past.

The dental profession should be aware of the fact that the physical plant alone will not make for success in dental education. Most important of all is a well-prepared, dedicated staff. We are confident that we have a staff whose stature is just as impressive as the building.

124 Edward St.

The Tragedy of the Traumatized Anterior Tooth

GEORGE C. HARE, D.D.S., *Toronto, Ontario*

I suppose that there is no time in the practice of dentistry when one feels so helpless and heartsick as when a youngster is brought to the office with a badly traumatized anterior tooth. How often we have heard it said that if only she had broken an arm or leg it would not have been so bad. An arm or leg will repair but when a tooth is fractured it will never be the same again. For all too many years the problem has been solved by the removal of the damaged tooth, but when you look back upon situations which you have met in this manner was the problem really solved? If we are honest with ourselves we know that rather than solving the problem we simply made more difficult problems. Let us consider a child of ten years of age who fractures an anterior tooth. If the tooth is removed it is true that the immediate problem is solved but what of the future? Fixed bridgework cannot be inserted at this time without endangering the pulps of adjacent teeth. The space must be maintained and therefore a partial denture is placed in the

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Manpower in Dentistry — The Dentist

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"Manpower in Canadian Dentistry" is the general topic for consideration by the panel. I suppose some of you would applaud if I could provide you with a concise, accurate statement regarding the dental personnel needs of Canada during the next twenty to twenty-five years. Perhaps the majority of you would not be prepared to accept the stark reality respecting the next two or three decades if I got close to portraying an accurate picture and I might even be burned at the stake for attempting to assume the role of a prophet. I remain calm in the face of this dire consequence knowing full well I probably won't get remotely close to reality. In fact, I have to admit that in my first serious attempt to do some "crystal ball gazing" I found myself rapidly becoming part of the problem, rather than contributing to the solution. Discouraging, to say the least.

Suffice it to say, I believe there will be a need for more and more dentists—come fluoridation, more public health education, or positive preventive measures. But — How many! That is the question.

Present Resources

A convenient place to start from, and possibly the safest, is to recall some known facts regarding the present ratio of dentists to the population. At the beginning of 1960 the ratio for all Canada, according to the Canadian Dental Association was 1 dentist to 3,018 people, and in the U.S.A., 1 to 1697. Why the difference?

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Before attempting to answer that question let us look at a few more detailed figures for Canada. The provincial figures range all the way from 1 to 10,441 in Newfoundland, to 1 to 2,403 for Ontario. The County of York in Ontario, with 1 to 1,638, compares favourably with the ratio for the whole of the U.S.A. Are these wide variations significant from the standpoint of the future — do they mean anything to us at the present time?

An important factor to consider in arriving at a reasonable ratio of dentists to the population in any country, province or community is the concentration of the population in the area. Other factors affecting this ratio include the economic status of the people in the area, the level of general education of the people and particularly health education.

To suggest that Canada might require a ratio of dentists to the population, similar to that for the U.S.A., would be unrealistic because of the great difference in concentration of the population. There is an average of 58 people to the square mile in the U.S.A., while only 14 in Canada (excluding the Northwest Territories and Labrador). To arrive at a formula based on the integration of all the divergent facets of this problem would require the work of a mathematical genius.

The figures for Canada do point up the special problem, peculiar to a large country with a scattered population — with some areas enjoying a higher economic level than others and with variations in general education. Under these circumstances wide differences in the ratio of dentists to the population are inevitable. Therefore, our problem is not alone one of a shortage of dentists, it is one of distribution. I hear members of the profession say we don't need any more dentists in our area. However, there are a great many isolated communities which indicate that a dentist is urgently needed. We should not forget that these communities have the ear of the politician and the seriousness of this question of distribution should not be overlooked.

Projected Resources and Objectives

In the remaining time allotted to me, I should like to draw your attention to three aspects of this topic. First of all, let us project through to 1980 what the dentist-population ratio will be if there are no new dental schools established in this period and if the existing dental school facilities in Canada are by 1965 producing new dentists at full capacity rate. This involves the study and integration of the growth of population through to 1980, of the number of active dentists who will be on the provincial registers during this entire period, and the effect on the overall numbers in practice by the addition of new graduates.

This year, 1960, the population of Canada is well over 17 million. From the Gordon Royal Commission Report on Economic Expansion you see in Table I the forecast of Canadian population growth through to 1980. It is to be noted that the actual 1960 figures are running a little ahead of the high estimate contained in Table I.

Table II shows the estimated number of dentists through to 1980 assuming that the present six Canadian schools will be graduating full capacity classes (317) by 1965 and thereafter.

Based on the population figures just examined in Table I and the estimated number of dentists shown in Table II, in Table III it will be seen that the ratio of dentists to the population may improve slightly through to 1980.

However, the improvement is slight and failure to maintain the existing dental schools at full capacity could mean that the ratio would remain static. A fall-off of 15 percent to 20 percent below full capacity would result in a gradual further deterioration from the present ratio. As a matter of fact, the 1960-1961 freshman classes in the Canadian dental schools are 15 percent below capacity and this means that in all probability the graduating class in 1964 will be reduced by the same percentage. The importance of the recruitment effort for dental students is vital to this program. Each member of the dental profession should consider that he is on the front line of the recruitment effort.

TABLE I

Canadian Population Estimates from the Gordon Royal Commission

Date	Low Estimate	High Estimate
1960	17,370,000	17,650,000*
1965	19,220,000	19,820,000
1970	21,160,000	22,130,000
1975	23,310,000	24,670,000
1980	25,770,000	27,530,000

* Dominion Bureau of Statistics gives population for 1960 as 17,814,000.

TABLE II

Estimated Number of Canadian Dentists assuming graduating classes equal total capacity of schools (317) after 1965

Year	69 Years of Age or Under	70 Years of Age or Over	Total
1960	5524.9	330.0	5854.9
1965	6117.6	457.0	6574.6
1970	6851.6	668.2	7519.8
1975	7740.2	662.2	8402.4
1980	8664.2	560.5	9224.5

Source: Division of Dental Research, Faculty of Dentistry, University of Toronto.

Survival rates computed using Commissioner's 1941 Standard Ordinary Mortality Table.

TABLE III

Projected Ratios of Population per Dentist in Canada based on Gordon Royal Commission Population Estimates and Dental Manpower age 69 years or under from Table II

Date	Low Population Estimate	High Population Estimate
1960*	3143.9	3194.6
1965	3141.8	3239.8
1970	3088.3	3229.9
1975	3011.6	3187.3
1980	2974.4	3177.5

* Based on Dominion Bureau of Statistics 1960 population, the 1960 ratio is 3224.8.

Under these circumstances it is imperative that we deal separately with the distribution problem. Provision of adequate bursaries for carefully selected students, which would assure them of their expenses throughout their course, in return for a reasonable term of service in selected rural communities, would work toward rectifying some of the present discrepancies. The law of supply and demand is irrefutable. While the supply of dentists is below the requirements to meet the demands for all areas, the majority will gravitate to the regions of maximum demand, namely, the communities where the population is most heavily concentrated.

The second observation I would like to make is based on the assumption that the slight improvement shown in Table III is not satisfactory and that we must aim at improving the dentist-population ratio by 1980.

Table IV shows what will be required to reach various objectives by 1980.

Suppose we aim at 1 to 2,500. This requires graduation of 317 new dentists each year from 1965 to 1968 and thereafter to 1980 an additional 133 each year, for a total of 450 per year.

To set our sights on a ratio of 1 to 2,000-2,200 would involve doubling the output by 1968 and continuing with 650 new graduates a year to 1980.

Returning to the objective of 1 to 2,500 by 1980 which seems to be more realistic and involves an additional 133 graduates a year, commencing in 1968, the additional facilities, probably two or three

TABLE IV

Estimated Dental Manpower 69 years or younger in 1980 according to varying number of new graduates from 1968 until 1980

	Increase over present capacity	Total Graduates per year	Estimate of Total Dentists in 1980	Population per Dentist 25,770,000	Population per Dentist 27,530,000
Decrease	67	250	7,871	3,274	3,498
"	17	300	8,463	3,045	3,253
Increase	33	350	9,055	2,845	3,040
"	83	400	9,646	2,672	2,854
"	133	450	10,238	2,517	2,687
"	233	550	11,423	2,256	2,410
"	283	600	12,014	2,145	2,291
"	333	650	12,606	2,044	2,184
"	383	700	13,197	1,953	2,086

Source: Division of Dental Research, Faculty of Dentistry, University of Toronto.

moderate sized schools, will have to be built and register their first classes by 1964. Planning for these schools should be underway now.

Occasionally, members of the profession will ask why it is that the output of the dental schools could not be increased by accelerating the curriculum or by greatly increased registration. Acceleration of the course would involve reduction of the summer vacation period and a shortening of the total length of the course. Such a program was advantageous in the emergency war years but our experience and that of the majority of dental educators leads us to believe that this is not the answer. Students must have time to relax mentally between sessions in order to be able to survive during the very concentrated effort they put forth in any academic year. This is very steadfastly maintained by educators generally. Greatly increased registration is dependent on the availability of sufficient candidates and even if they were available, there is a serious danger involved in mass education.

Practical Objectives

For my third and concluding observation I must return to the "crystal ball". I see in it the necessity for improving the ratio of dentists to the population, as the concentration of people in this country increases, with an increasing population. But I sense also tremendous difficulties in reaching the objective of even 450 new graduates a year by 1968.

The more practical approach to the figure 1 to 2,500 would be to increase training facilities on a gradual basis—with one new school accommodating 60-75 students in a class, and functioning by 1968, another of similar size by 1973 and another by 1978: I would couple with this the student bursary program designed to bring aid to the more isolated communities. During the gradual build-up period, ample opportunity would be afforded for assessing the influence of future preventive measures, health education and improvement in equipment (e.g. high speed) and office procedures, on the dentist-population ratios.

Coupled with these factors will be the integration of auxiliary personnel into the practice of dentistry and their effect on the manpower situation. I am thinking particularly of the dental hygienist, and the more effective use of the dental assistant. In my opinion, our future is dependent upon our ability to graduate new dentists in ever increasing numbers along the lines I have suggested and at the same time to integrate more effectively than we have done in the past auxiliary personnel into the dental team.

Résumé

Notre pays, malgré la fluoration, malgré une éducation plus grande du public en matière d'hygiène dentaire, malgré des mesures de prévention, aura besoin de plus en plus de dentistes.

La population du Canada qui se chiffre présentement à 17,814,000 va dépasser les prévisions de la Commission Royale Gordon pour l'année 1960.

Les prévisions pour 1980 sont de 27,530,000 âmes. Les disponibilités actuelles pour former des dentistes, même fonctionnant à plein rendement ne pourront pas améliorer dans l'avenir la proportion des dentistes en rapport à la population. On croit, pour être réaliste, qu'une proportion d'un dentiste pour 2,500 personnes constituerait un objectif souhaitable pour les prochaines vingt années. Cela veut dire une moyenne de 133 diplômés additionnels à partir de 1968. On pourrait atteindre ce but en établissant deux ou trois facultés dentaires moyennes, une en 1968, une en 1973 et une en 1978. On devrait aussi ajouter à ces disponibilités supplémentaires pour l'enseignement un système de bourses pour les étudiants, organisé pour aider les municipalités éloignées qui n'ont pas de dentistes en nombre suffisant pour leurs besoins.

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PREFACE TO SECTION III

Traumatized Anterior Teeth in Children

Injuries to the teeth of children were identified as one of the most distressing problems with which the general practitioner of dentistry had to cope, on a day to day basis. From both the restorative and preventive standpoints, injuries presented a challenge which had to be met, invariably as emergencies. Management of such emergencies and even subsequent treatment of traumatized teeth, prior to the 1940's was haphazard and it was fortuitous if treatment of such teeth, terminated with a favourable result. It was recognised that a scientific basis for treatment was essential, if dentists were to approach these problems with confidence and some assurance of success.

Extensive study and clinical research resulted in the publication in 1945 of the first edition of the "Classification and Treatment of Injuries to the Teeth of Children". It was reprinted several times and revised at intervals with the Fifth Edition, coming off the press in 1970. The author invited participation of a co-author, in the revision for the Fifth Edition. A copy of the Fourth Edition, 1960, forms part of this submission.

Reviewers of the Fourth Edition, as with previous editions, have been generally very complimentary. Elsie Gerlach, writing in the Journal of the American Dental Association in October 1961 observed: "This excellent manual should be on the reference book shelf in every dental office. It provides information in a concise and lucid form for the dentist confronted with the problem of caring for an accidentally injured incisor".

In 1963, Editorial Mundi of Buenos Aires, printed it in Spanish, for the profession in South America and the next year permission was sought to have it translated into Japanese, for distribution in that country.

There is a good deal of evidence that this publication is the reference text used and recommended by many dental schools in the U.S.A. and Canada.

Perhaps this publication has provided a scientific basis for coping with some of the complex situations attendant upon accidental injuries to the teeth of children.

Traumatized Anterior Teeth*

By

ROY G. ELLIS, D.D.S., M.Sc. (Dent.) (Tor.), F.D.S.R.C.S. (Eng.).

The child with a traumatized anterior tooth presents the dentist with an emergency problem of frustrating dimensions. I have said frequently that I would rather my own child break an arm than an anterior tooth. The arm, in most instances, will yield to treatment, without subsequent deformity. No amount of knowledge or skill can induce reunion of enamel or dentine of the injured tooth. It remains the privilege and responsibility of the dentist to help the child with the broken tooth.

Of first importance when reviewing this subject is the role of the anterior tooth to the beauty of the face. A distorted or broken front tooth can be a disfiguring anomaly leading to sensitiveness and in some children to the development of a mental complex, the implications of which cannot be measured in terms of teeth alone.

While the effect of shock on the pulp of a traumatised tooth is unpredictable, it must be recognized as a complicating factor. The numerous thin-walled vessels of the pulp rupture easily. The confinement of the pulp within unyielding dentine walls endangers its life during a period of inflammation. The prognosis for the young tooth with a large apical foramen is more favourable. Similarly the tooth with a root fracture usually survives inflammation and congestion. The end result of traumatic injury to the pulp may be: firstly, return of the pulp to normal physiological state; secondly, it may undergo chronic degeneration with ultimate calcific obliteration of the pulp space; thirdly, necrosis may result. Our clinical observations indicate that if early necrosis results, it will likely occur within ten weeks from the time of injury. This period has been termed the "critical recovery period" and it influences treatment-planning.

The original problem of emergency associated with traumatic injury has now taken on new facets, namely, a possible indirect effect on the child's mental well-being and uncertainty as to the life of the pulp. What proportions does this complex problem assume for the general practitioner? In 1944 a survey was undertaken to determine the incidence of fractured teeth among Toronto school-children. It was found that 178 or 4.2% of a group of 4,251 children in 7 city schools had fractured teeth. The incidence is comparatively small, and yet I am sure your experience would lead you to report that the number is significantly large. Perhaps you will agree with those who claim these accidents to be on the increase. It is appropriate that we recall the opinion expressed by one author who said that protruding front teeth are among the "hallmarks of modern civilization." Protruding front teeth with little or no lip coverage are vulnerable to accidental trauma.

Diagnosis and treatment-planning should be systematic and positive. Delay and procrastination may result in irreparable damage to irreplaceable vital tissues. A large percentage of those cases, if given immediate, well-directed emergency treatment, will respond favourably.

Three requirements must be fulfilled before proceeding with treatment: firstly, a brief history of the case and the patient's complaint; secondly, a careful clinical examination; thirdly, a roentgenological examination for immediate use and also for comparison with subsequent roentgenograms. The importance of the latter point cannot be overemphasized.

In an attempt to simplify treatment-planning, a classification of injuries to teeth has been suggested as outlined below.

- Class I: Simple fracture of the crown—involving little or no dentine.
- Class II: Extensive fracture of the crown—involving considerable dentine, but not the dental pulp.
- Class III: Extensive fracture of the crown—involving considerable dentine and exposing the pulp.
- Class IV: The traumatized tooth which becomes non-vital—with or without loss of crown structure.
- Class V: Tooth lost as result of trauma.
- Class VI: Fracture of the root—with or without loss of crown structure.
- Class VII: Displacement of a tooth—without fracture of crown or root.
- Class VIII: Fracture of the crown and its replacement.
- Class IX: Traumatic injuries to deciduous teeth.

Great caution should be exercised when discussing with the parent the prognosis of an injured tooth. Despite evidence of only a minor injury, the most unexpected complications develop.

Remember that the pulp of an injured tooth may be suffering shock, and treatment, particularly during the critical recovery period, must avoid further irritation. An injured tooth should be protected from external traumata for some time after the accident and requires an indefinite period for its recovery.

*Presented at the Twelfth Australian Dental Congress, Sydney, August, 1950.

Treatment may be resolved briefly into three phases: (1) Emergency, (2) Intermediate, (3) Final.

Emergency treatment should be designed to protect the injured tooth from further irritation during the 8-10 week critical recovery period. Place the injured tooth at rest, if possible.

Intermediate treatment embraces restorative procedures. Intermediate restorations must be stable, with some degree of permanence, aesthetically satisfactory, and involving a minimum amount of preparation. This temporary restoration may be in place for several years depending on the age of the child at the time of the accident.

The *final* phase of treatment may be considered when the tooth is more mature. It usually involves more extensive preparation of the tooth. In most cases of fracture the time which elapses from the emergency treatment stage to the final restoration may be a matter of 1-9 years. During that period the tooth in question should be under continual observation with roentgenograms and vitality tests.

In the brief time at my disposal I should like to discuss three of the commonest problems encountered in the treatment of injured teeth. These are:—

1. Protection and treatment of the pulp.
2. Root therapy for the non-vital tooth.
3. Restoration of the fractured tooth.

Protection of the Pulp.

The behaviour of the pulp to irritation is well summarized by Kronfeld[1]: "The pulp is an extremely sensitive organ which reacts very readily to any irritation or injury. A severe injury may even cause immediate death of the pulp while a lesser injury causes a typical inflammation known as pulpitis." Because the pulp is enclosed in an unyielding calcified chamber, there can be no compensation for an increased supply of blood which accompanies inflammation. In the young tooth with an incompletely developed root apex and in the case of the tooth with a root fracture, there is some provision for collateral circulation which compensates for the increased blood supply. From clinical experience, however, we are impressed with the extraordinary recuperative power of the pulp tissue in the young healthy tooth, following accidental injury.

Consideration of pulp protection begins with the simple case of the tooth which is injured but which shows no outward signs of injury. Numerous cases have been seen in which two maxillary centrals have been involved, one suffering a fractured crown and the other remaining intact. Quite commonly the tooth with the fractured crown remains vital while the intact tooth suffers pulp damage which leads to necrosis. We know of no therapeutic measures which can be applied to restore the inflamed pulp in the non-fractured tooth. We would suggest, however, that placement of the injured tooth at rest is desirable if possible.

In the Class II cases where the crown of a tooth is fractured with considerable exposure of the dentine, but not an actual exposure of the pulp, operative procedures for pulp protection may be required. The objective of emergency treatment in these cases is to prevent further irritation to the already inflamed pulp. This treatment includes avoidance of the use of strong irritating drugs on the exposed dentine and placement of the tooth at rest. The steps in protection of the pulp in the Class II case are as follows:—

Clean all debris off the fractured crown of the tooth, using routine methods but observing great care not to injure the tooth further. Select a celluloid or resin crown-form and contour it to fit accurately the entire crown of the fractured tooth. Examine the form for possible tissue impingement and also then for clearance in all functional biting positions. Remember, the tooth must not suffer further traumatic injury through function. Lay the form aside and dry the isolated tooth. Cover the exposed dentine with a suitable mix of a rapid-setting, capping paste. Care should be exercised to avoid pressure on the dentine during this and subsequent procedures. After the capping paste has set so that it will not be readily displaced, seal the fractured end of the tooth with a layer of cement. There are two alternatives in placing the protecting form on the tooth. If a celluloid form has been used, prepare a creamy mix of cement; partly fill the form and seat to place over the tooth. This form will remain in place for a period of eight to ten weeks only if it fits accurately and covers the entire crown of the tooth.

With the introduction of the self-curing resins an alternative for the seating of the crown-form presents. In this procedure a resin-form should be used. A satisfactory shade of the resin filling material is selected and a suitable mix is made and the form partly filled with the mixed resin. The form is placed over the tooth and the resin allowed to polymerize for a period of four minutes. At the end of four minutes, the crown-form with its lining of resin is removed from the tooth and the process of polymerization goes on to completion. This resin cap is then cemented in place on the tooth with oxyphosphate cement. In both cases, just prior to cementation of the celluloid form or the modified resin-form to the fractured tooth, it should be perforated with a No. 3 Round Bur on the lingual side about two millimetres from each of the incisal angles in order to allow for the ready escape of excess cement. The retention and the aesthetics of the second type of restoration are better, but occasionally one is confronted with a greater degree of bulk. The patient should be advised before dismissal to report at once if pain should be experienced in the near future. Otherwise a rest period of eight to ten weeks is allowed, following which the patient is recalled and the injured tooth re-examined carefully.

Protection of the Exposed Pulp.

The pulp exposure may be a minute pinpoint involvement of one or both horns of the pulp, or the entire bulbous coronal portion of the pulp may be exposed. According to the type of exposure, the length of time the pulp has been exposed, the age of the patient, and the general status of the pulp, there are four possible procedures in treatment. These are:—

1. Pulp capping.
2. Pulpotomy (partial removal of the pulp).
3. Pulpectomy (total removal of the pulp).
4. Extraction of the tooth.

The degree of success in treatment will depend, firstly, on the accuracy of the diagnosis made as to the status of the pulp and, secondly, upon the adherence to satisfactory methods in implementing treatment.

Pulp Cutting.

For a minute exposure of short duration in which there is little evidence of haemorrhage and where the root apex of the tooth is almost completely closed, pulp capping may be undertaken with reasonable hopes for success. The technique varies very slightly from that already described for the Class II case. Again we stress that no strong irritating drugs should be used on the pulp and pressure from the capping material must be avoided at all costs. A capping paste of calcium hydroxide and distilled water has been used by many clinicians with considerable success. Other capping materials have been described in the literature from time to time. Where there are complications such as root fracture or displacement of the tooth, pulp capping is contraindicated. In these cases the procedure of choice recommended is either pulpectomy or extraction of the tooth.

A slight variation from the procedure described for the Class II case should be introduced at the stage of cementation of the crown-form placed over the tooth. In order to facilitate removal of the crown-form at the end of the eight to ten-week period without encountering re-exposure of the pulp, the surface of the cement casing covering the capping material should be lubricated just prior to cementation of the crown.

Pulpotomy.

While partial removal of the pulp is an exacting procedure and requires strict adherence to principles of asepsis, nevertheless it has been usefully employed in certain cases. Among the factors indicating the use of the pulpotomy technique are: the case of extensive exposure of the pulp; where the pulp may have been exposed for several days; where the root apex is wide open in the very young patient, but where there is definite evidence of vitality in the pulp. Just as with pulp capping, so with pulpotomy, the cases selected for treatment by this method should be carefully chosen. The chief objective of the pulpotomy technique is to maintain the root portion of the pulp in a vital state until such time as complete formation of the root apex has taken place. Various techniques have been described through the literature, but the one used by the author is briefly as follows:—

The pulp in the exposed tooth is anaesthetized by infiltration or conduction anaesthesia. The tooth should be isolated and all instruments used must be sterile. The field of operation must be rendered aseptic and good access obtained to the coronal portion of the pulp with the use of sterile burs. With sharp instruments, preferably not burs, the pulp is severed at the level corresponding to the junction of the cementum and enamel. Haemorrhage may be controlled with campho-phenique. Bleeding will only be serious in cases where the pulp is lacerated. After the haemorrhage is controlled, a waiting period of five to ten minutes is allowed for serum seepage to take place. The pulp stump is then capped with a suitable capping paste such as calcium hydroxide and distilled water. Pressure on the pulp stump must be avoided in this process. Success in the pulpotomy technique is dependent upon sterility in every stage, careful severance of the pulp, and the avoidance of pressure in the capping procedure. Following completion of the operation, the tooth should be given a rest period of six to eight weeks. Within three to six months, evidence of a bridge of dentine at the line of severance of the pulp should be seen in an X-ray. In addition, the radiogram may be used to follow the normal progression of completion of the root apex. If there is no evidence of root apex development within a reasonable period of time (say one year), then it is possible that failure has resulted. The use of the vitality test in these cases is not satisfactory. Detection of failure at an early stage, particularly before periapical breakdown occurs, permits one to proceed with root therapy for these cases. This brings us to the second common problem to be considered in relation to injuries to the teeth of children.

Root Therapy.

Coolidge[2] has expressed admirably the objectives of root canal therapy. He writes: "The purpose of pulp treatment and root canal filling is to prolong the usefulness of a tooth so that it may function in mastication after the loss of the pulp, without harm to the host." We might add that in the case of the young patient where root therapy is indicated for a tooth which has been traumatized, the non-vital tooth is useful if only as a space maintainer during the period when growth and development of the arch is taking place. The loss of a tooth during this period presents us with a serious problem in replacement.

The types of cases encountered under the heading of "Root Therapy" may include the following:—

1. The exposed vital tooth in which pulp capping or pulpotomy are contra-indicated.
2. The tooth with a completely formed root apex which has become non-vital during the eight to ten-week rest period following emergency pulp protection outlined previously.
3. The non-vital tooth with a wide open root apex.

You may be called upon to deal with any or all of these types in rendering service for traumatized teeth. As with any form of modern surgery involving bone (at the root apex) the fundamental consideration is maintenance of asepsis not only of the instruments and dressings used, but also of the entire field of operation.

Vital pulp extirpation.

Anaesthetize the pulp by infiltration or conduction anaesthesia; isolate the tooth and sterilize the field of operation. Open the pulp chamber with sterile burs until good access is obtained to the canal. Remove the pulp and control the bleeding with sterile paper points. Enlarge the canals with reamers and files. The exact length of the tooth should be established by radiographic means. The length should be recorded on the chart. Irrigate the canal with chlorinated soda and hydrogen peroxide to remove all debris. (Always end irrigation with chlorinated soda.) Dry the canal with large paper points. Remove the sharp point of a small paper point and moisten the balance of the point with eugenol. Place this point in the canal as a dressing followed by a pledget of dry sterile cotton in the pulp chamber. Cover the cotton with gutta percha and seal the orifice with temporary cement. Dismiss the patient for three to four days. At the second appointment, apply rubber dam and sterilize the field of operation and remove the dressing previously inserted. Proceed and make culture from the canal. With several large paper points absorb any excess medicament which may be left in the canal. Discard these points. Then remove a small paper point and insert it into the root canal, being careful not to traumatize the periapical tissues. Leave this point in the canal for one minute. Remove this point and drop into a tube of sterile culture media and incubate for 48 hours. Irrigate the root canal again with chlorinated soda and hydrogen peroxide. Dry the canal and insert a further dressing on a paper point and seal the canal as previously. The patient is dismissed for two to three days during the period of incubation of the cultured dressing.

If the bacteriological report is negative at the third visit, we may proceed with the obliteration of the root canal. Again all efforts should be made to obtain a sterile field of operation. With the aid of the radiograph measure the length of the canal. Gutta percha cones are selected which will fit snuggly at the apex of the canal and are cut to the desired length. Dry the root canal with hot instruments or with alcohol and blasts of warm air directed toward the root canal. A mix of root canal cement is prepared on a sterile slab with a sterile spatula. Roll one measured gutta percha cone in the cement and use it to coat gently the inner wall of the root canal with cement. Carry the cone into the root canal until it is flush with the incisal edge of the tooth. Additional measured cones are placed in the canal and with the aid of a No. 3 root canal spreader, these cones are condensed in the canal. The average canal will require many such cones before it is completely obliterated. Subsequent radiograms are employed to determine the success of this operation. When the filling is shown to be satisfactory radiographically, cut the gutta percha cones back to the floor of the pulp chamber with a hot instrument. Cleanse the pulp chamber thoroughly with chloroform and fill the canal with temporary cement.

Non-vital tooth with closed apex.

The author has observed on numerous occasions the development of an area of radiolucency about the apex of an injured tooth. These areas usually develop very rapidly and attain considerable proportions in a short time. Careful root therapy and obliteration of the root canal in these teeth usually results in just as rapid disappearance of the area of rarefaction. Therefore, it is well to proceed with the root therapy in these cases and delay subsequent root resection for a period of three to six months observing carefully further changes at the root apex following obliteration of the root canal. The procedure for treatment of the non-vital tooth, whether infected or not, is similar to that described in the previous paragraph for the vital tooth from which the pulp has been extirpated. The chief point of difference is directed toward the infection which may be in the canal. Great care should be exercised at all times to see that none of the infection is forced beyond the apex during instrumentation. The antiseptic dressings placed in the canal between appointments should be stronger and designed to take care of pathogenic organisms. The principle of drug rotation should be applied in root canal therapy, using two or three medicaments if necessary. The adaptation of the antibiotics to root therapy

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has greatly facilitated the establishment of asepsis in root canals.

The non-vital tooth with open apex.

The tooth with the open apex presents two additional problems. In the first instance it is relatively easy to push infection beyond the apex if one is careless with instrumentation. In the second place, completely obliterating the pulp canal to the apex and no further is a very difficult procedure. The detail in treatment is similar for this type of case to the cases already outlined except that great care should be used not to irritate the apical tissues. The filling of the canal is more exacting. Every cone used must be cut to the exact length of the tooth, and no cone must pass above the incisal edge of the tooth. Some of these large canals will require as many as twenty to thirty gutta percha points to obliterate the canal completely. Dr. G. C. Hare[3] recommends a modified lateral condensation technique for use in the tooth with an open apex.

Not infrequently root resection may be employed to eliminate stubborn infection at the apex of the tooth.

A Temporary Restoration for a Fractured Crown.

After a fractured tooth has been made comfortable with emergency treatment, and a period of eight to ten weeks has elapsed from the time of injury, if the pulp is still vital, we are faced with the problem of restoration of the tooth. It is wise to regard the tooth as a sick tooth and not subject it to further irritation, in the process of preparing the tooth for the restoration. Failure to restore the tooth at this stage is to invite complications of serious proportions. Drifting of the fractured tooth, and of the teeth opposing the fractured tooth, may render the restoration of the crown at a subsequent time a very difficult problem. The length of time that this temporary restoration will be in place depends on the age of the child at the time of injury. It will vary from a few months to several years. Its replacement with a permanent restoration is dependent upon the normal physiological development of the tooth. While many other forms of temporary restorations have been used during the years, the gold and acrylic restoration has given the greatest degree of satisfaction.

Preparation of the tooth.

The amount of preparation must be kept to an absolute minimum consistent with the requirements for retention. The preparation of a normal three-quarter crown with grooves or a preparation with accessory pin anchorage may be dangerous at this stage. The limited preparation includes the paralleling of the proximal sides of the tooth, the clearance of the incisal and lingual surfaces for functional positions and the reduction of excessive contours of the lingual incisal enamel or the labial gingival enamel. The latter step is not usually necessary. Retention in this preparation is dependent upon the parallel proximal sides and the employment of a labial gingival band so that the metallic part of the restoration might be called an open-faced gold crown. An impression of the tooth is necessary and, for this purpose, two alternative techniques may be followed.

Impression of the tooth—compound technique.

This technique is similar to the routine indirect gold inlay technique employing the copper band impression and the preparation of a die seated in a cast. The electrolytically deposited copper die has been used with a great deal of satisfaction by the author for many years.

Impression of the tooth—hydrocolloid technique.

Recently, however, for reasons of greater accuracy, the hydrocolloid impression technique has been employed.

Select a water-cooled tray (either partial or full tray). Adapt two thicknesses of base plate wax over the tooth in question and the two teeth adjacent to it on either side. Place impression compound in the tray and take an impression of the mouth. Remove the impression from the mouth and from it remove the wax which had previously been adapted over the anterior teeth. Trim the compound impression so that it may be reseated in the mouth without impingement on the tissues. Prepare the equipment necessary for heating the hydrocolloid material. A syringe with a 19-gauge needle attached, suitable for heating hydrocolloid, is loaded with inlay hydrocolloid. Three water baths with automatic temperature controls are needed or three receptacles with thermometers to control the temperature manually. The water in these three baths should be kept at the following temperatures: the first at 208° F., the second at 140° to 150° F., and the third 108° to 115° F. Both the general impression hydrocolloid to be used in the tray and the inlay hydrocolloid to be used in the syringe are softened at 208° F. for fifteen minutes. The syringe containing the inlay hydrocolloid is tempered in the bath at 140° to 150° F., while the impression hydrocolloid is placed in the tray and tempered in the bath at 108° to 115° F. for about four minutes. Prior to proceeding with the impression the mouth must be cleansed with a caroid mouth-wash or something similar. Any air bubbles, blood, mucus or other debris on the surface of the tooth from which an impression is required must be removed, as these interfere with the hydrocolloid impression material. It is therefore recommended that the tooth in question should be dried, following which the hydrocolloid is injected from the syringe around the prepared tooth. The

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compound modified water-cooled tray loaded with hydrocolloid is carried to place in the mouth and water-cooled for four to five minutes. In order to get a good hydrocolloid impression, the material must be confined in a closed space and under pressure. After the impression is removed from the mouth, it is placed in a 2% potassium sulphate solution for five minutes, following which it should be poured immediately. The impression of the individual fractured tooth is first poured in hard stone or die stone or some similar material. It is reinforced with a brass dowel pin which is inserted while the die material is soft. The die stone is allowed to set while the impression rests in the potassium sulphate bath. After one and a half hours, remove the stone die from the hydrocolloid impression and trim. The trimmed die is reinserted in the impression and the balance of the impression is poured with stone. When the cast has set, the stone die of the fractured tooth may be separated from the cast. The die should be kept in a vegetable oil bath.

The open-faced gold crown.

Waxing up the restoration may be proceeded with according to standard techniques. The objectives in waxing up this restoration are to provide for strength in the casting, to avoid irritation of the gingival tissues, and to provide for the maximum amount of retention for the plastic veneer restoring the lost labial enamel structure. With the casting complete it is cemented on the fractured tooth and finished with careful attention to the aesthetic requirements. The lost incisal corner may now be restored with acrylic resin. In some instances it will be found more satisfactory to place a thin veneer over the entire labial enamel surface.

Summary.

In this paper I have discussed some of the general problems faced by the practitioner in handling injuries to the teeth of children. The three most common aspects of treatment have been presented. The pulp must always be regarded as being involved until time has proven that it still functions normally. All cases of exposure of dentine must receive protective treatment and cases in which the pulp is directly involved will require immediate attention.

Unfortunately, many of these cases end with the tooth becoming a pulpless tooth and, because of their importance as space maintainers at least, every effort should be made to retain the teeth even in a pulpless state. Prior to the restoration of the injured tooth with a filling that might be regarded as permanent it is very frequently necessary to place a temporary restoration for an indefinite period of time. We have briefly outlined procedures for all these cases.

References.

1. Kronfeld, R.—Histopathology of the teeth and their surrounding structures, Philadelphia, 1933, Lea & Febiger, p. 106.
2. Coolidge, E. D.—Clinical pathology and treatment of dental pulp and periodontal tissues, Philadelphia, 1939, Lea & Febiger, p. 74.
3. Hare, G. C.—Obliteration of the root canal with the open apex, *Journal of Endodontia*, 3: 31-32, 1948.

TREATMENT OF FRACTURED INCISORS*

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RÉSUMÉ

1. Les fractures des incisives font naître des problèmes que le dentiste de famille doit consentir à envisager lorsqu'un enfant se présente pour faire traiter.
2. Les incisives centrales et latérales du maxillaire chez les garçons de 6 à 12 sont les dents les plus exposées au risque de fracture.
3. Le traitement des incisives fracturées implique davantage qu'une sim restauration mécanique de la portion de dent détruite. Entrent également ligne de compte la préservation de la vitalité de la pulpe endommagée l'élimination des anomalies inesthétiques sur le devant de la bouche.
4. Une classification simple et parfaitement complète est présentée par l'aut. classification qui permet d'étudier et d'établir des plans de traitement les cas de lésions traumatiques.
5. L'auteur commente les faits saillants à recueillir au cours de l'interroga du patient et pendant l'examen clinique.
6. Le traitement des incisives fracturées est étudié en trois chapitres:
   Le traitement d'urgence apporte une protection de la pulpe et des ti périodontaux immédiatement après l'accident et pendant une périod repos et de récupération après le choc.
   Description de la nature et de la préparation d'une restauration tempor phase intermédiaire du traitement.
   La troisième phase du traitement qui est entreprise après que la dentine pulpe soient à maturité, constitue la dernière étape de la restitution fonctions, forme et beauté normales de la dent.

ZUSAMMENFASSUNG

1. Frakturierte Schneidezähne stellen den Familienzahnarzt vor Probleme er bereit sein muss zu lösen, im Falle ein Kind sich zur Behandlung vor
2. Die oberen mittleren und seitlichen Schneidezähne bei 6—12 jährigen Kn sind am meisten Verletzungen ausgesetzt.
3. Behandlung des frakturierten Schneidezahnes umfasst mehr als eine mechanische Wiederherstellung verlorener Zahnstruktur. Erhaltung der V lität der beschädigten Pulpa und Vermeidung einer entstellenden Ano vorne im Munde müssen ebenfalls berücksichtigt werden.

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... einfache, allumfassende Klassifizierung ist beschrieben, die sich beim ...n und Behandlungsplan in Fällen traumatischer Beschädigung nützerweisen wird.

...d Erklärungen gegeben über die wesentlichsten Punkte, die für die ...engeschichte und während der klinischen Untersuchung aufgenommen werden.

...dlung frakturierter Schneidezähne ist nach drei Hauptrichtungen hin ...chen worden. Die unmittelbare Notbehandlung sieht Schutz der Pulpa ...es Periodontiums vor unmittelbar nach dem Unfall und während der ...zeit und der Erholungsperiode. Eigenschaften und Vorbereitung eines ...äufigen Ersatzes für die Zwischenzeit werden beschrieben.

...dritte Stufe der Behandlung, die nach Abschluss der Reife von Dentin ...d Pulpa unternommen wird, ist die entgültige Wiederherstellung des ver...ten Zahnes zu normaler Funktion, Form und Schönheit.

RIASSUNTO

... incisivi fratturati presentano spesso problemi che il dentista di famiglia ...e affrontare volonterosamente quando il piccolo malato gli vien presentato.

... incisivi superiori nei ragazzi dai 6 ai 12 anni sono i più suscettibilidi offese.

... trattamento degli incisivi fratturati comporta assai più d'un semplice ...tauro meccanico delle parti perdute. Occorre altresì conservare la vitalità ...a polpa danneggiata ed eliminare le alterazioni anti-estetiche che turbano ...rmonia della parte anteriore della bocca.

... presenta una semplice e completa classificazione che si rivela assai utile ...llo studio e nella progettazione del trattamento in ogni caso di lesioni ...aumatiche.

...i commentano i principali aspetti che occorre registrare nell' anamnesi del ...so e ricordare durante l'esame clinico.

Il trattamento degli incisivi fratturato vien discusso sotto tre titoli: il *trattamento d'emergenza* provvede alla protezione della polpa e dei tessuti periodontali subito dopo l'incidente e per tutto il periodo di riposo e di ripristino dopo l'offesa. Gli aspetti della preparazione d'un *restauro provvisorio* per la fase intermedia vengono poi descritti con cura. Il *terzo periodo*, che sarà intrapreso a seconda del grado di sviluppo della dentina e della polpa, costituisce l'ultimo passo nel restauro del dente traumatizzato onde riportarlo alle normali funzioni, aspetto ed estetica.

RESUMEN

Los incisivos fracturados presentan problemas para los que el dentista debe estar preparado cuando un niño acude a la consulta.

Los incisivos centrales y laterales del maxilar superior de los niños de 6 a 12 años de edad son los dientes más susceptibles.

3. El tratamiento del incisivo fracturado require algo mas que la restauración mecánica de la estructura dental perdida. Debe conservarse la vitalidad de la pulpa herida y eliminar una anomalía desfiguradora en la parte anterior de la boca.
4. Se da una clasificación sencilla y completa útil para estudiar y determinar el tratamiento en los casos de lesiones traumáticas.
5. Se comentan los principales datos que se deben registrat en la historia y durante el examen clínico.
6. Se discute el tratamiento en tres etapas de incisivos fracturados. El tratamiento de urgencia protege la pulpz y tejidos periodontales inmediatamente después del accidente y durante un periodo de descanso y recuperación. Se describen los detalles y la preparación de una restauración interina para la fase intermedia del tratamiento. La tercera fase del tratamiento, se verifica después de haber reaccionado la dentina y la pulpa, y constituye el último paso en la restanración de la función, forma y belleza normales, del diente traumatizado.

SUMMARY

1. Fractured incisors present problems which the family dentist must be willing to meet when a child reports for treatment.
2. The maxillary central and lateral incisors in boys 6—12 years old are the teeth most susceptible to injury.
3. Treatment of the fractured incisor involves more than a mechanical restoration of lost tooth structure. Preservation of the vitality of a damaged pulp and the elimination of a disfiguring anomaly in the front of the mouth are involved as well.
4. A simple, all inclusive classification is presented which is useful in studying and planning treatment for cases of traumatic injury.
5. Comment is made upon the salient features to be recorded in history taking and during the clinical examination.
6. Treatment of fractured incisors is discussed under three headings. Emergency treatment provides protection for the pulp and periodontal tissues immediately after the accident and during a period of rest and recovery from the injury. The features and preparation of a temporary restoration for the intermediate phase of treatment are described.

   The third phase of treatment, which is undertaken, following the development of maturity of the dentine and the pulp, is the final step in restoring the traumatized tooth to normal function, form and beauty.

INTRODUCTION

During the past two decades the dental profession has demonstrated an increasing interest in dentistry for children. This trend has been stimulated by attention being given to the prevention of disease within some current plans and others projected. Dentistry recognises the child patient as being the most hopeful area in which to apply preventive measures.

Under these circumstances it is not surprising to observe all phases of dentistry for children under study, including some highly specialized aspects, such as that embraced by this review.

Fractured incisors provide special problems for the family dentist. They will tax his patience and ingenuity. Easlick (1952) has aptly stated "the variety of forlorn conditions which develop when children's incisors become involved in accidents can be an intriguing challenge or a tremendous worry to the family dentist."

INCIDENCE

Traumatic injuries may involve any teeth, at any age. However, the majority of observers agree that 6—12 years is the period of greatest susceptibility and that the maxillary central and lateral incisors are the most vulnerable teeth. Sheehan (1947) reports that, in 314 cases of traumatic injury to incisors observed during a four year survey, more than one-third occurred in children 6—10 years of age. Ellis (1945) provides figures which indicate that approximately 4.2 per cent of children in his area suffer disfiguring injuries, of which boys were twice as susceptible as girls. Horsnell (1952) like many others attributes the high incidence of injuries to the boisterous playtime habits of children 8—12 and concludes his comment by stating that "the upper age limit, where the incidence starts to fall corresponds with puberty or near puberty when the recreational habits become more mature and less reckless of personal appearance".

AETIOLOGY

Equally important in any consideration of the cause of injuries to young incisors are both predisposing and exciting factors. Protrusion of the maxillary incisors (Angle Class II Division 1) which lack lip coverage, is the number one predisposing factor. "Accident proneness" described by Wilbur (1952) is another predisposing factor with some children. The author recalls a number of cases where the same child had suffered accidental injury to the incisor teeth on two or three different occasions. A long, diverse list of exciting causes of violence could be recited.

GENERAL PROBLEMS

Certain general problems are associated with cases of traumatic injury. First and foremost is the problem of emergency. An anxious parent and a child in pain—the situation is one of urgency for the dentist.

Secondly, it is established that displeasing dental anomalies in the anterior part of the mouth may have possible psychological effects. Lack of treat... or unsatisfactory aesthetic results of restorations for fractured incisors c... be responsible for the development of an inferiority complex.

Thirdly, disturbance of the normal physiology of the pulp tissues, p... cularly the circulation, may result from traumatic injury. The end resul... this disturbance may be *(a)* a return to normal physiologic function; *(b)* ... initiation of a calcific degeneration, which sometimes completely oblite... the pulp chamber; and *(c)* necrosis of the pulp.

Curry (1951) attributes necrosis of the pulp to rupture of the main ap... vessels at the time of trauma. Fish (1948) believes the efferent veins to the p... are damaged by trauma in the apical region, but the arterial supply ma... affected only in the most severe cases. The resultant blood pressure ca... rupture of the minute capillaries, the walls of which are often only one e... thelial cell in thickness.

Fourthly, loss of a tooth due to injury, during the period of growth ... development of the mouth, may be serious. The fractured teeth must be retai... if possible.

Fifthly, after all these problems have been overcome the restoration of ... fractured incisor crown, so that it is permanent, and aesthetically harmoni... is a problem of the first magnitude.

CLASSIFICATION OF CASES

To expedite and simplify the examination procedures, recording case histor... establishing a diagnosis and treatment plan, the adoption of a classifica... of these cases is most helpful.

Classifications limited to cases in which tooth structure (coronal or r... is fractured are suggested by McBride (1932), Hogeboom (1933), Sweet (19... Kronfeld (1949), Herve (1951), Cooke and Rowbotham (1951), and Her... (1952). Classifications inclusive of all types of injuries, including fractures... provided by Adams (1944), Ellis (1945), and Brauer (1950).

There are many points of similarity in the various classifications ref... to above. A simple, all inclusive classification is presented for use in this re...

Class I : Trauma, without coronal or root fracture and without displace...
Class II : Coronal fracture, with dentine exposed but not the pulp.
Class III: Coronal fracture with extensive dentine and pulp exposured.
Class IV: Root fracture, with or without coronal fracture.
Class V : Trauma, without fractures, but with displacement of the tooth.
Class VI: Trauma, resulting in the loss of a tooth or teeht.

Within each of these categories a variety of clinical features will be fo...

THE HISTORY AND CLINICAL EXAMINATION

The desirability of following a systematic procedure in obtaining and reco... the case history and all phases of the clinical examination of the tooth or ... involved is obvious. Besides certain basic information common to all hi...

...ng procedures the following data has special significance in these cases. ... The age of the patient; (2) the time interval which has elapsed since the ...dent: (3) history of any previous accident involving the teeth; (4) how ... accident occurred; (5) presence or absence of pain.

...the clinical examination must be thorough and include both the hard and ... tissues in the area involved remembering that adjacent teeth, not suspected ... the patient are often involved in the accident. Particular attention should ... directed to such detail as (1) coronal fractures; (2) displacement of teeth; ... reactions to percussion; (4) mobility; (5) occlusal relationship with teeth ... the opposite arch; (6) roentgenographic examination. The latter phase of ... examination should be followed through meticulously in every case of ...ry, in order that all possible information may be available respecting the ...size of the pulp and its proximity to the fracture line; (2) the exact stage ...development of the root apex; (3) the presence of root fracture; (4) evidence ...displacement and (5) to provide a record for comparison with future roent...ograms.

Vitality response to tests immediately following injury may not be reliable. ...ack of response within a few hours of the injury may only be temporary, ...ltant from shock to the pulp.

Only after the case history has been fully recorded and a careful clinical ...mination (including roentgenograms) has been completed, is it possible to ...vide a diagnosis for the case and establish a treatment plan. Great caution ...uld be exercised at this stage in respect to providing a prognosis. The most ...cuous situations sometimes have the poorest prognosis.

PREFACE TO TREATMENT

...tment procedures in the field of operative dentistry are usually planned and ...ed out on a single phase basis. Because of the hazards introduced in ...ing extensive preparation in young teeth and the uncertainty, in the initial ...s following injury, concerning the life of the pulp in the traumatized tooth, ...ment plans in such cases which require restoration of lost crown structure ...ably involve multiple phase procedures.

...e first or emergency phase is primarily to provide the traumatized tooth ... protection against further irritation during the initial emergency period. ...e second or intermediate phase involves a restoration of a semipermanent ...re, providing protection, function and aesthetics. However, because of the ...aturity of the histologic structures of the young tooth, it must be designed ... a minimum of cavity preparation.

...e third phase of treatment may be regarded as the final treatment when ...ntional restorative procedures are used.

...will be recognised that common objectives apply in each phase, namely, ...tection of the tooth pulp, and periodontal tissues: (2) restoration of ...n: (3) establishment of harmonious aesthetic results; (4) preservation of ...e in the developing arch; (5) satisfactory retention of the restoration in ...ether it be temporary or permanent.

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In addition the following maxims apply at all times:

1. Retain the child's injured tooth if at all possible.
2. Retain the vitality in all or part of the tooth (radicular part).
3. Lost permanent teeth which are replaced must be in physiologic balance w erupting teeth and the developing arch.

While treatment problems of a special nature are introduced by the age fac in these cases, it must also be recognised that in the young healthy patient, potential for recovery in the traumatized pulp is excellent. The undevelop open root apex provides an additional margin of safety, but even if the ap is fully developed as in the older child, the vascular supply to the pulp is ve good, and this vital tissue is richly supplied with undifferentiated embryo cells and thereby peculiarly protected with a positive defense mechanism.

TREATMENT

Class I: *Trauma, without coronal or root fracture and without displacement*

At first glance it may seem unnecessary to provide a separate category f cases which are restricted within such narrow limitations. The degree of trau involved in the Class I case would appear to be inconsequential. The pati does not often report at the time of injury which further suggests the probl is of a minor nature. Nevertheless, the prognosis for the case, according clinical records, is bad, and the patient seeks treatment when complicatio develop.

If the patient reports at the time of injury, the tooth involved may be tend in function, and it may be a little sensitive to thermal changes. But the symptoms are usually temporary. Some laceration of the soft tissues in t area may cause discomfort.

The routine case history taken at the time may reveal very little of spec importance and the clinical examination nothing of significance, except slig mobility and tenderness to percussion. The vitality tests may be negative a if so, will be attributed to the initial shock to the pulp.

The prognosis for the case should be good, but a premature statement that effect may embarrass the dentist at a later date. The stage of developme of the root of the tooth is important to the future status of the pulp. The aut (1945) and Cooke and Rowbotham (1951) report that the prognosis for all ca of injuries to teeth is better when the root apex is open and the root incompl Under these circumstances, disturbances to the circulation which follow trau are presumably compensated for, by the large apical passageway provided the engorged vessels.

In explanation of why a higher percentage of pulps die in traumatized te when the crowns remain intact, Cooke and Rowbotham (1951) advance thought that the full shock is transmitted to the apex of the tooth with result injury to the vessels of that region.

Treatment for Class I cases is limited. If the gingival tissues are lacerated ..y will heal without treatment, although for psychological reasons a mouth ...: should be prescribed. Saline solution is effective. If mobility is in evidence ..rsnell (1952) advocates the use of a splint—fixed to the adjacent teeth for .. 8—12 week period. Rest to the traumatized tooth is desirable to avoid ..rther irritation and injury during function. Incisal stress may be relieved by ..reful reduction of the opposing teeth.

..ass II: *Coronal fracture, with dentine exposed, but not the pulp*

.. contrast to Class I, the Class II group embraces a wide range of cases. ..om the simplest, with incisal edge enamel fracture of a single tooth to the ..tensive involvement of enamel and dentine in one or more teeth. Hence this ..ategory includes a large percentage, variously estimated to be 60—70 per cent, ..f all cases suffering traumatic injury.

History taking, making a thorough clinical examination and setting up a ..eatment plan, which have been discussed elsewhere, is of first importance.

Treatment for the tooth with only a small chip out of the incisal enamel, ..ay not be requested at the time of the accident. The patient's chief complaint .. such a case will be rough sharp enamel edges, which lacerate the tongue ..d lips. Emergency treatment is limited to reducing the sharp enamel with a ..mond stone and sand paper disks, avoiding overheating the tooth during ..s procedure. As in the Class I cases, the prognosis may seem excellent but .. patient and his parents should be warned to report without delay should ..comfort develop.

During the first 8—10 weeks after injury vitality tests should be made at ..tervals of 7—14 days until they are satisfactory.

Intermediate treatment will seldom be necessary following the expiration of .. emergency period and the final treatment may proceed in accordance with ..rmal conservative measures in the young patient. Where the lost tooth ..ucture is limited to incisal enamel, it is possible to restore the incisal edge ..ntour by judicious grinding. To maintain symmetry the incisal edge of the ..rresponding tooth may have to be reshaped.

The majority of the Class II fractures present with exposure of an extensive ..a of dentine. The tooth is young and the dentinal tubules are large. Suddenly, .. accident, they are exposed to the air, thermal changes, tissue fluids and the ..teria of the oral cavity. The parent is aware of the damage done and the ..d is aware of the tooth's sensitivity. For these reasons they seek the help .. the family dentist soon after the accident.

The importance of positive emergency measures has been emphasized by .. (1945), Horsnell (1952), Easlick (1952), and others. Infection of the pulp ..ugh the large open dentinal tubules may lead to disastrous results. Protection ..nst infection, also provides protection against pain from thermal changes .. masticatory pressures.

Emergency treatment may be the life saver of the pulp in the Class II case. ..hould not be delayed; it must be positive and permanent for a minimum

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of 8—12 weeks (the emergency period). As a preliminary to treatment the dentine surface must be clean. Some writers advocate the use of phenol on the dentine for its bactericidal and cauterizing effects. Dry the dentine surface and apply an obtundent, rapid setting, dressing. The use of zinc oxide and eugenol, mixed thick, is one choice for a dressing; and another, calcium hydroxide mixed to a paste with sterile water or anaesthetic solution (because of sterility); a third suggestion is the following formula to be found in Accepted Dental Remedies (1953) for a fast setting capping paste.

Powder:	Zinc oxide	70.00	gm
	Hydrogenated Rosin	28.50	,,
	Zinc Stearate	1.00	,,
	Zinc Acetate	.50	,,
Liquid:	Eugenol	85.00	ml.
	Olive Oil	15.00	,,

To prepare the cement, mix 10 parts of the powder with 1 part of the liq (the amount of zinc stearate is reduced by one-half for hot dry climate).

When the dentine capping paste has hardened a thin layer of a fast sett cement is manipulated over the protected fractured surface and allowed to This obviates displacement of the capping paste or pressure on the very t dentine wall still intact over the pulp in subsequent stages. Permanence for Class II emergency treatment restoration is provided with a crown form metallic band. The metallic band is recommended by Brauer (1950) and Hor (1952); a celluloid crown form modified with siliceous cement by Cooke Rowbotham (1951), and Easlick (1952), while the author (1952) has rec mended a resin crown form modified with plastic. Whichever form of treatm crown is used, it must have sufficient retention to resist displacement; it m not impede vitality testing during the emergency period; it must not imp on the gingival tissues and it should, if feasible, provide a reasonable deg of aesthetics.

If the emergency phase of treatment is successful the pulp will remain v the tooth will be comfortable and roentgenographically the apex and ap region will show normal shadows.

The next phase of treatment is the provision of an intermediate restora for the fractured tooth. It is to be semi-permanent and yet the preparati the tooth must be very limited. In the young child a modified three-qu inlay of the basket crown type with a plastic or siliceous cement veneer o open face crown with veneer has proved most satisfactory. The preparatio either of these intermediate restorations is limited to parallelization of proximal surfaces of the crown and occasionally reduction of the rem incisal enamel and lingual surface enamel to allow for the metallic cr Retention for the basket inlay is obtained by shaping the labial margin o mesial and distal slices; for the open faced crown a labial gingival bar proximately one to two millimetres wide is used for retention. Many of intermediate restorations have been tried with varying degrees of ... The two referred to briefly above are readily constructed and they ... adequate retention and aesthetic results. They are not dependent upon ...sive cavity preparation.

... function of the intermediate restoration described for the Class II ...ed tooth has been fulfilled when the tooth in question has reached a state ...urity which permits its safe preparation for a conventional type of per- ...nt restoration. The time which elapses from its placement to its removal ... involve 5—10 years, depending on the patient's age at the time of injury ... the rapidity of the process of development of the tooth.

...ere are occasions when circumstances are such that rapid maturity of the ...ne recession of the pulp justify the placement of a final restoration at an ... age. The three pin slipper type of inlay is described by the author (1952) ...se in cases of fractured incisors in children 12 years of age or over, providing ... circumstances warrant. The pins, approximately 1½ millimetres deep, ... size of a 701 tapered fissure bur are placed toward the incisal edge, one ... at the mesial and distal dento-enamel junction line and one at the cingulum ... gingivally as possible. Hartsook (1950) has shown that the enamel and ...ine in fairly young patients have considerable thickness at the cingulum. ...e three phases of treatment for the Class II case (in the classification ...ested herein) have been briefly discussed. Space does not permit a more ...iled outline.

...s III: *Coronal fracture with extensive dentine and pulp exposed*

...y procedure in conservative dentistry which involves an exposed pulp ...ents one of the major problems in the practice of dentistry. The dental ... tissue is highly specialized and extremely vascular. Most workers agree ... the prognosis for and treatment of the pulp exposed through advancing ...es is more hazardous than for the pulp exposed through injury We have ...ady stressed the belief that the potential for recovery of the exposed pulp ...he young healthy child is good.

For reasons given previously the patient with extensive injury of the Class III ...er, will seek treatment immediately. Prompt emergency treatment is required. With the examination data assembled, a diagnosis is made. The treatment ... to be followed will involve the decision in favour of any of the following ...cedures.

(1) Capping the exposed pulp.
(2) Removal of the coronal pulp (pulpotomy; partial pulpectomy).
(3) Removal of entire pulp (pulpectomy).
(4) Extraction of the tooth.

... decision made will be dependent upon:

(a) The extent of the pulp exposure (e.g. minute pulpal horn or extensive exposure).

(2) Stage of development of root apex (open or closed).
(3) Length of time pulp exposed since accident.
(4) Complications, such as displacement or root fracture.

PULP CAPPING. The author has employed the pulp capping procedure w… satisfactory results in carefully selected cases. Few others in this field ma… reference to pulp capping. A minute (pulpal horn) exposure of not more th… 15—18 hours duration is favourable for pulp capping. The technique employ… is simple. Following the emergency treatment procedures for the Class II ca… the pulp exposure is capped with calcium hydroxide. The cardinal princip… to be observed in the procedure include isolation of the tooth under treatme… absolute cleanliness and if possible asepsis; avoidance of the use of stro… drugs and pressure on the exposed pulp. These are chief among possib… irritants.

The emergency treatment crown must have permanence for continuous pr… tection of the pulp during a three to six month period of observation. Follow… a successful waiting period, an intermediate restoration as outlined above … Class II, is prepared. At this stage it is probable that a dentine bridge will… established over the site of injury (Zander and Glass, 1949). Great care sho… be exercised not to re-expose the area of pulp exposure during the preparat… of the intermediate restoration.

PULPOTOMY (partial pulpectomy). Increasing favour and success for this meth… of treatment of Class III injuries is in evidence. Slack (1948), Cooke and R… botham (1951), Horsnell (1951), Herve (1951) and Thoma (1952) descr… the indications, prognosis and technique employed.

In brief, the pulpotomy procedure is useful in retaining vitality in the radic… pulp so that normal apical root development may proceed in cases where … root apex is wide open at the time of injury. However, its use has been exte… to include teeth with fully developed roots although pulpectomy might b… be employed for such cases.

The pulp is amputated at the level of the cemento-enamel junction u… aseptic conditions. The radicular pulp which remains, is capped with calc… hydroxide or zinc oxide—eugenol type of dressing. If calcium hydroxid… used, it is covered with paraffin wax to prevent reaction with the oxyphos… cement base. A rest period of 8—10 weeks is allowed before proceeding … a restoration.

A review of the various techniques employed indicates certain poin… difference. In one technique a large round sharp bur is used to sever the p… while in another, a suitable size sharp spoon excavator is employed. The l… results in a clean cut, and is accompanied by less haemorrhage and less d… of tearing radicular pulp fibres.

Haemorrhage is controlled by means of camphophenique, or epineph… in 1000, or a saturated solution of calcium hydroxide. The chief differe… techniques concerns the desirability of sealing a dressing over the severed p…

-p for 7—10 days prior to capping at a subsequent appointment. Those in ...r of the dressing (usually a sterile cotton pellet moistened with eugenol) ... better healing of the pulp stump. In favour of the immediate and perma- ... covering of the pulp stump is the argument that the danger of infecting ...lp at the second sitting is eliminated.

...spite of these variations the results with the various techniques are reported ...ve been reasonably successful.

...ECTOMY. Complete removal of the pulp is indicated in Class III cases ...re the pulp exposure is extensive or where the pulp has been exposed for ...al days. In cases where the root apex is closed, using present day scientific ...dontic procedures the prognosis is good. Where the root apex is open, the ...dontic procedures may be followed, but great care is required and root ...ction may be necessary.

When the pulp has become non-vital as the result of injury and the contents ... become infected, they can usually be restored to a healthy status by means ...on-irritating germicidal drugs, e.g. camphorated paramonochlorophenol or ... polyantibiotic treatment suggested by Grossman (1951).

The desirability for retaining anterior teeth in the young patient during the ...d of growth and development has been stressed elsewhere and only under ...eptional circumstances need one of these teeth be lost.

...s IV: *Root fracture with or without coronal fracture*

...not common to find an incisor tooth with a fracture of both the crown ... root. It is proposed first to present the case of the simple root fracture. They are more likely to occur in older children, after the crown is fully ...ted and the root fully developed. The prognosis for these teeth is good, ...ding the fracture is situated apically to the gingival third of the root. Other ...rs influencing the prognosis and successful treatment includes, (1) Close ...sition of the apical and coronal fragments; (2) The fragments must be ...bilized; (3) The general health of the patient should favour reparative and ...erative processes.

When the fracture line is in the gingival third of the root, separation of the ...ents is probable and it is more difficult to immobilize them in close ...sition. It is also possible for infection to enter the pulp through the fracture ... from a periodontal pocket or a deep gingival sulcus, when the fracture line ... close proximity to the gingival tissues.

...der favourable circumstances a simple splint will suffice to fix the parts ... repair. Easlick (1952) describes the use of a labial arch wire (at least ... ·028") adapted across the labial surfaces of the combined width of the ...cisors, with the four teeth ligated individually with pliable stainless steel ... ·012") to the labial arch. Acrylic or cast metal splints cemented over the ... more anterior teeth provide splendid rigidity. Bands made for the ...d tooth and the adjacent teeth and soldered together and cemented are ...ry effective.

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Opinions vary as to the length of time a splint should be in place fro minimum of a few weeks up to two years. No arbitrary time can be spec for all cases.

The healing process has been clearly portrayed by Kronfeld (1933). fragment surfaces are first bonded together by a fibrous network, followed deposition of cementum which provides a solid union.

If the case is complicated with a crown fracture as well, both problems n be evaluated individually and jointly, when preparing for treatment.

Class V and VI in the classification set out above are outside the scope review on "Treatment of Fractured Incisors".

BIBLIOGRAPHY

ADAMS, F. R. (1944): "Traumatized and Fractured young teeth," *J. Amer. Dent. Ass.*, 31,

ACCEPTED DENTAL REMEDIES (1953): 18th Ed., *American Dental Association*, Chicago.

BRAUER, J. C. (1950): "The treatment of children's fractured permanent anterior te *J. Amer. Dent. Ass.*, 41, 399.

COOKE, C. and ROWBOTHAM, T. C. (1951): "Treatment of injuries to anterior teeth," *B Dent. J.*, 91, 146.

CURRY, V. L. (1951): "Fractured Incisors," *Dental Practioner*, 1, 341.

EASLICK, K. A. (1952): "Emergency treatment for traumatized young incisors," Texas, *D J.*, 70, 284.

ELLIS, R. G. (1945): "The classification and treatment of injuries to the teeth of child 1st Ed., Year Book Publishers, Chicago.

—— (1952): "The classification and treatment of injuries to the teeth of children," 3rd Year Book Publishers, Chicago.

FISH, W. E. (1948): "Surgical Pathology of the Mouth," Pitman & Sons, London.

GROSSMAN, L. I. (1951): "Polyantibiotic treatment of pulpless teeth," *J. Amer. Dent. Ass.*, 4 265.

HARTSOOK, J. J. (1950): "Treatment considerations for the loss of children's permanent in teeth," *J. Amer. Dent. Ass.*, 40, 414.

HERVE, M. (1951): "Les fractures dentaires, classification et traitement," *Actualites Odon matology*, 14, 157.

HOGEBOOM, F. E. (1933): "Juvenile Operative Dentistry," 2nd Ed., C. V. Mosby, St. Lo

HORSNELL, A. M. (1951): "Treatment of the exposed dental pulp," *Brit. Dent. J.*, 91,

—— (1952): "Trauma to the incisor teeth," *Brit. Dent. J.*, 93, 105.

KRONFELD, R. (1933): "Histo-pathology of the teeth and their surrounding structures," and Febiger, Philadelphia.

—— (1949): "Histo-pathology of the teeth and their surrounding structures," 3rd Ed., and Febiger, Philadelphia.

LIEBAN, E. A. (1947): "Traumatic injuries to children's teeth," New York, *Dent. J.*, 13.

McBRIDE, W. C. (1932): "Juvenile Dentistry," Lea and Febiger, Philadelphia.

SLACK, G. L. (1948): "Vital pulpotomy in the treatment of fractured incisors," *Brit. De* 85, 169.

SWEET, C. A. (1942): "Fractured anterior permanent teeth," *J. Amer. Dent. Ass.*, 29,

THOMA, G. E. (1952): "Vital pulpotomy for fractured anteriors," Fortnightly Rev. Chi *Dent. Soc.*, 24, 7.

WILBUR, H. M. (1952): "Management of injured teeth," *J. Amer. Dent. Ass.*, 44, 1.

ZANDER, H. A. and GLASS, R. L. (1949): "Pulp healing," *J. Dent. Res.*, 28, 97.

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SECTION III

Classification and Treatment of Injuries to the Teeth of Children

Chicago, Yearbook Publishers

1st Ed. 1945; 2nd Ed. 1946; 3rd Ed. 1952;

4th Ed. 1960; 5th Ed. 1970.

See ~~separate enclosure~~.
V.2