Casting to Models, Its Advantages and Technique.

By Weston A. Price, D.D.S., Cleveland, O.

Read before the Second District Society, Brooklyn, N. Y., January 11, 1910.

To judge high standards for both the completed operations and the methods for producing them, we must have clearly in mind both the ideals to be attained and the fixed conditions to which all else must be adapted. For the former, we instinctively use as a high standard the splendid malleted contour gold fillings that have preserved the teeth and done splendid service for decades. Their grand success is due to their excellent margins and contours and compatibility.

Let us take for our standard for judging and constructing inlays, contours that are even more perfectly adapted than those, which, because of their inaccessible positions, were not usually near perfection, and margins that are even stronger and as closely and smoothly adapted to the tooth, and without a visible cement line at any point and without the possibility of the tooth underneath being checked from its insertion. Few of those splendid malleted fillings have perfect contact points, or produce anatomical interproximal spaces; so we can easily appreciate a higher standard for these.

The Ideal Filling.

Owing to the necessity for having a certain mass of gold to have strength with a malleted gold, that kind of filling requires excessive cutting of the tooth structure, frequently at both the step and the angle for extension for prevention. Our ideal will naturally desire more strength with less loss of tooth structure. The surface of an ideal filling must be hard and smooth, but the structure must not be brittle. The margin must be tough and pliable, but not springy; compatible to the tooth structure and not producing thermal shock; and should, to prevent causing pulp stones and secondary deposit of dentine in the pulp chamber, be a non-conductor or be insulated from the dentine by an electrical non-conductor. It must be so rigidly attached as not to allow of its being dislodged by an excessive strain and preferably be so strong as to allow of anchoring one end of a bridge to it when desirable.

Next in importance to the efficiency of the completed filling is the comfort during its insertion, first, of the patient and, second, of the operator; for an operation is not only not a success, but a prodigious failure, which so persecutes the patient as to cause him or her to neglect many other equally important teeth, even though that operation remain in that tooth for a quarter or half a century. Operations claiming to fulfil high standards to-day must be made with so little real discomfort that they will not only be entirely acceptable to our physically strong patients, but entirely so for our physically and nervously weak patients, and without lowering our standards of efficiency for service. If, for example, those splendid large contour malleted fillings could be placed in position without taking an iota from the perfection of their margins or contours, by some method that would relieve the patient and operator of the discomfort and strain incident to malleting, grinding and polishing, we would certainly accept it as a higher standard. If also that filling were entirely homogeneous as is a fused metal, its surface would be much improved, especially if burnished till hardened, and if it be attached to the tooth without strain to the cavity wall, yet hermetically sealed, and also insulated electrically and, if possible, thermally, it will still fulfil a higher standard. The natural dread by our patients of the dental chair of the past is the direct cause of the loss of many times more teeth than ignorance on their part, and this is as important a fixed condition in dentistry for us to meet and correct as the dental lesions themselves.

Having these high standards in mind let us consider how nearly they can be attained by inlay methods and note especially the advantages and disadvantages of particular methods. As we do so, we must have in mind certain fixed physical conditions to which our methods and materials must be adapted. Chief of these are the physical properties of gold and its alloys which as yet have not been definitely and clearly presented. We must, to fulfil the above high standards, either have a means for controlling the contraction of gold, or in some way compensate for or correct that change, else we can not have perfect margins, and an inlay without as perfect margins as the splendid gold-malleted fillings may reach a high standard from other viewpoints, but from that point is much short of ideal.

Conduct of Metals Used for Casting.

The writer has spent much effort for two years determining the fixed physical properties of gold and its alloys, and, while time will not permit of an extended review of them here, some facts or laws are essential for us to have in mind. The general fact that nearly all metals and alloys expand when heated and contract when cooled, is generally appreciated, but the laws governing that physical fact are not appreciated and few, if any, of the arts or sciences should be so concerned to-day to know them as the dental science.

The text-books or encyclopedias on physics mention little more than the fact that contraction occurs on cooling and the practical science of the arts and trades has developed it only for the base-metal, iron. The dental literature and teachings of the past couple of years have presented three essentially different, if not contradictory, phases of the subject. First, and the most general teaching, is to ignore entirely the contraction of gold on cooling, stated to be slightly, if any. The second is, that contraction normally exists, but can be controlled or prevented almost entirely by cooling the gold rapidly after casting. This is based by inference on the casting corrections or long rulers used by cast-iron workers, the pattern-makers for which use longer rules for larger pieces of cast-iron than for small ones: the latter of necessity cool much more rapidly, which reason is taken as the cause for less contraction. This rule is then applied to gold directly, assuming that it obeys the same laws as cast-iron, and the result is said to be accomplished by casting into a nearly cold investment.

Professor Ward, of Ann Arbor, is, I believe, the author and leader of this teaching and practice. The third teaching is that gold does contract on cooling from the melting-point a definite amount, under practically all conditions, and that amount over two per cent. or 1-50 of its dimension in all directions, but that the location of the shrinkage or contraction (not the total amount) can be partially transferred to another part of the cooling mass by pressure on the molten gold while it is in a semi-molten state, and that the distance or range in temperature below the melting or fluid point through which it can be moved from one part of the mass to another to take the place of contraction at that latter place is dependent upon the pressure used. This view was presented by the speaker, together with the reduction of contraction that certain definite pressures would give. The range of control is too short, owing to the conditions, to take care of all the contraction or even half of it. (See Items of Interest, May, 1908.) The behavior of gold as it changes its state, is being studied and will be presented later.

The expansion and contraction shown by + and — in thousandths of an inch of blocks of one-inch cube of the present investment compounds.

Temperature in Degrees F.	Peck's	½ Peck's ½ Plaster	Imperial	½ Imperial ½ Plaster	Fyrite	½ Fyrite ½ Plaster	Dendrolite	½ Dendrolite ½ Plaster	Sump	½ Sump ½ Plaster
Started	0	0	0	0	0	0	0	0	0	0
30-min. setting and expansion	+.7	+.7	+.9	+.8	+1.	+.5	+.9	+.5	+.9	+1.
100	+.9	+.9	+1.2	+1.	+1.	+.8	+1.1	+.9	+1.4	+1.3
200	+3.1	+2.2	+2.2	+2.8	+2.4	+1.9	+2.3	+2.1	+2.9	+2.4
300	+3.7	+3.1	+3.1	+3.	+3.8	+3.3	+3.5	+3.6	+4.	+3.5
400	+4.5	+3.2	+4.	+3.4	+3.8	+3.4	+3.3	+3.6	+4.	+3.4
500	+5.1	+3.	+4.4	+3.4	+3.3	+3.2	+2.8	+3.5	+3.8	+3.
600	+5.7	+3.	+4.4	+3.3	+2.9	+2.8	+2.4	+3.4	+3.5	+2.5
700	+6.4	+2.9	+4.5	+3.	+2.	+2.5	+1.5	+3.2	+2.8	+1.7
800	+6.9	+2.8	+4.6	+2.8	+1.4	+2.1	+.5	+3.	+2.1	+1.
900	+7.2	+2.5	+4.8	+2.5	+.6	+1.3	—.5	+2.9	+1.2	0
1000	+7.8	+2.	+5.	+1.8	—.5	+.3	—1.8	+3.5	+.2	—.9
Total contraction on cooling	—7.	—11.	—10.	—12.	—12.	—15.	—35.	—14.	—15.	—14.

Temperature in Degrees F.	Dr. Taggart's	½ Dr. Taggart's ½ Plaster	Pelton & Crane	½ Pelton & Crane ½ Plaster	Plaster of Paris Medium	Plaster of Paris Thin	L. D. L. Investment Composition	½ L. D. L. ½ Plaster	Plaster of Paris set 15 minutes then heated	Plaster of Paris set 15 hours
Started	0	0	0	0	0	0	0	0	0	0
30-min. setting and expansion	+.7	+1.	+1.8	+1.	+1.3	+1.	+.7	+.8	+.5	0
100	+1.3	+1.3	+1.8	+1.4	+1.4	+1.3	+1.1	+1.2	+.9	+.1
200	+2.3	+2.5	+2.5	+2.5	+2.6	+2.5	+2.	+2.8	+2.4	+.6
300	+5.1	+3.2	+3.2	+4.	+4.5	+3.	+3.2	+3.6	+2.6	+1.5
400	lost	+3.4	+4.	+4.	+4.5	+2.5	+3.8	+3.8	+2.5	+1.9
500	+6.2	+3.2	+4.8	+3.8	+4.3	+1.9	+4.1	+3.5	+2.2	+2.1
600	+6.8	+2.9	+5.2	+3.7	+3.9	+1.	+4.6	+3.4	+1.5	+1.7
700	+7.3	+2.5	+5.7	+3.6	+3.4	—.1	+5.2	+3.	+.8	+1.
800	+7.7	+2.3	+6.3	+3.6	+2.6	—2.	+5.5	+2.9	—.2	+.4
900	+8.3	+.7	+6.7	+3.5	+1.4	—3.8	+6.	+2.5	—1.5	—.3
1000	+8.5	+1.4	+7.1	+3.3	0	—6.5	+6.6	+2.	—3.3	—1.
Total contraction on cooling	—6.	—11.	—5.	—11.	—18.	—24.	—8.	—15.	—18.	—15.

FIG. 1.

We are concerned only for scientific facts and will present the results of our further research only for that end. Dr. Lane, of Philadelphia, in a letter to the speaker, which was an advance synopsis of a paper he was to give before the Susquehanna Dental Society, stated that the only force that could be available to any advantage was simply the amount necessary to change the spheroidal tendency of the gold. Dr. Kabell, of Chicago, in the May, 1909, ITEMS OF INTEREST, in reviewing the recognized contraction, presented an experiment to show that the location of the contraction was not affected by air pressures on the sprue and investment differently between three and twenty-five pounds. Unfortunately, he introduces errors into his experiment which were larger than the unit he desired to measure, viz., the expansion of his instrument and depending on a semi-fluid mass of gold to pull on the head of a pin, for, after it is strong enough to pull the levers, it is too strong to be moved by twenty-

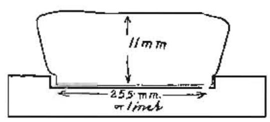

FIG. 2.

five pounds per sq. in. air pressure. It is exceedingly difficult to measure the exact contraction of a unit of gold without introducing errors that may be greater than the measurement we would record, for we will have the contraction or expansion of the wax form or model that we have measured, and the expansion or contraction of the investing material we have cast into. No investing material that the speaker knows of has constant dimensions when heated and cooled again within a wide range of error. The only acceptable substitute for it is fused quartz, which has less than one-fortieth as much expansion and contraction as gold for the same change of temperature. In other words, when an inch column of gold on cooling in a fused quartz chamber contracts (without pressure to change the location of the contraction) over twenty-thousandths of an inch, the quartz chamber will contract less than one-two-thousandths of an inch. Investing compounds, in which these experiments are usually made, including all our commercial investments, vary from a maximum expansion at about 900 to 1000 degrees, of eight-thousandths for the best, to a contraction as much as fifteen- to twenty-thousandths, according to its manipulation. See table of expansions and contractions of investing materials at various temperatures (Fig. 1).

Fig. 2 shows a fused quartz block with a chamber or box one inch long, cut into one side and the actual contraction of the molten gold, in this case over an ounce. I have the original here and the dimensions were secured by projecting the shadow on to a screen and measuring, as well as by direct measurement. The pressure here is the weight of the column of molten pure gold eleven millimeters high, and since the weight or hydrostatic pressure of a column of pure gold 760 millimeters high is about fifteen pounds to the square inch, the pressure on the gold in the quartz box in this experiment is about one-third of a pound per square inch. This is certainly more than enough to control the spheroidal tendency, but has not prevented a contraction of over one-fiftieth of an inch, which would be a great deal in bridge abutment or large compound inlay. I have several quartz chambers into which pure gold was cast at various definite pressures, which show diminishing opening at the end of the bar, or, in other words, an increasing control of the location of the contraction. Those made with low pressures will rattle in their boxes, while those made at high pressures will not. The cylinder of cast-gold in a tube of fused quartz one-fourth inch high contains a casting made with no pressure except the weight of its column, and the gold will drop out.

Effect of Pressure at Various Temperatures.

To determine accurately the effect of definite pressures and the range of temperature at which they would affect or move the freezing or cooling gold, I made an instrument that heated a button of gold, or other metal, in contact with a thermo-electric couple. On the button was placed a quartz plunger about one-eighth inch square surface to correspond with even a very large sprue neck. On heating a two-pennyweight button fine gold it expanded normally about one-thousandth of its diameter for each hundred degrees F. under five-pennyweight load on the quartz, until it reached 1940 degrees F. and then kept sagging until it reached its melting-point at 1960 degrees F.; five pennyweights then could not modify or change the location of the contraction after the gold was cooled twenty degrees below its actual melting or fluid point. This would be about equivalent to one and one-fourth pounds air pressure per square inch on a sprue, or a little over. When the weight was increased to two ounces, equal to a little over ten pounds air pressure per square inch, the mass began moving at 1920 degrees.

Gold Alloyed with Aluminum.

At eight ounces, equivalent to a little over forty pounds air pressure per square inch, it began moving 1900 degrees, and at twenty-four ounces, equal to about 120 pounds air pressure per square inch on a sprue, it began moving at 1760. This will be the range of the cooling process through which pure gold will be moved and the location of its

TABLE OF BEHAVIOR OF GOLD AND ITS ALLOYS UNDER PRESSURE.

NAME OF METALS		24 kt. Gold	24-kt. Gold 99.9% Alum. 1/10 of 1%	Gold 99.8% Alum. 2/10 of 1%	Gold 99.5% Alum. 5/10 of 1%	Gold 99% Alum. 1%	Gold 95% Alum. 5%	Gold 90% Alum. 10%	Aluminum	Alum. 95% 20-kt. Gold 5%	Alum. 90% 20-kt. Gold 10%	22-kt. Gold Solder	20-kt. Gold Solder	18-kt Solder	Silver	Copper	Gold. 20 pts. Nickel. 4 pts.
										(20-kt. Gold= Au. 20 + Cu. 3 + Ag. 1 pts.)							
WEIGHTS 5 dwts.	Sagging commences	1940 F.	1770 F.	1590 F.	1640 F.	1240 F.	1140 F.	1090 F.	1220 F.	1270 F.	1270 F.	1440 F.	1390 F.	1500 F.	1665 F.	1730 F.	1680 F. Softens
	Weight drops	1960	1800	1870	1750	1490	1270	1140	1240	1292	1340	1610	1605	1520	1730	1915	2000
Sagging range to the drop under this weight		20	30	280	110	250	130	50	20	22	70	170	215	20	65	185	320
Sagging range to normal melting point		20	30	280	110	250	130	50	Normal melting point 1292 F. 72	22	70	170	215	20	Melting point 1870 205	Melting point 1996 266	Melting point unknown 320
1 oz.	Sagging commences	1940		1540	1540	1240	1110	1090	1090	1040	1270	1440	1390	1420	1665	1730	
	Weight drops	1960		1870	1710	1470	1140	1140	1165	1240	1310	1610	1490	1500	1720	1900	
Sagging range to the drop under this weight		20		330	170	230	30	50	75	200	40	170	100	80	55	170	
Sagging range to normal melting point		20		330	210	250	160	50	202	252	70	170	215	100	205	266	
8 oz.	Sagging commences	1930		1400	1390	990	1090	1090	1020	1040	890	1340	1270	1270	1650	1620	
	Weight drops	1960		1845	1670	1310	1140	1115	1140	1220	1290	1500	1460	1490	1705	1880	
Sagging range to the drop under this weight		30		445	280	320	50	25	120	180	400	160	190	220	55	260	
Sagging range to normal melting point		30		470	360	500	180	50	272	252	450	270	335	250	220	376	
24 oz.	Sagging commences	1760															
	Weight drops	1960															
Sagging range to the drop under this weight		200															
Sagging range to normal melting point		200															

FIG. 3.

contraction be affected by twenty-four ounces actual pressure per square one-eighth inch. By adding two-tenths of one per cent. of aluminum to the gold its melting-point was materially reduced, viz., to 1870 degrees, and the range of temperature through which it is moved by the various loads increased several fold, or five pennyweights, moved the resulting alloy 280 degrees below its melting or fluid point instead of 20 degrees for pure gold, and an eight-ounce load, 470 degrees instead of 30, and a twenty-four-ounce load 600 degrees instead of 200. This alloy makes fair fillings, and being 998 parts in a thousand pure gold can hardly be detected from pure gold, except for being firmer. The further addition of aluminum does not improve this quality materially, while it produces a brittle gold rapidly; ninety per cent. gold and ten per cent aluminum, has a lower melting-point than pure aluminum, and lower than ninety-five per cent. aluminum and five per cent. gold, and an alloy of about one part gold and two parts of aluminum makes an alloy slowly, under continued heating, that has so high a melting-joint that it can, with difficulty only, be fused with a blowpipe. It is a poor brittle metal, and difficult to produce.

The table of metals and alloys (Fig. 3) shows the temperature at which the various pressures will move the mass.

Another method of establishing the effect of pressure on the control of the location of contraction was to make a chamber of fused quartz 25 cm. (10 inches) long, 1 cm. wide and 2 mm. across. The two opposite sides that were 1 cm. apart, were ground and polished straight from end to end, to within one ten-thousandth of an inch, which made the apparatus very expensive. The fused quartz for constructing it had to be made in Germany. A column of fluid pure gold freezing or cooling in this chamber showed the diameter at various distances from the top of the column, which gave the exact pressure without errors such as are introduced by the wax and investment method, and gave results that corroborated those reported above.

Controling Contraction of Metals.

Since gold does contract and we can, at best, only modify the location of part of the total contraction, we have only two alternatives; either to enlarge the mold as by expanding the investment, or produce an alloy that will not contract, except where we can hold it, making it stretch as a ring or staple over a form. This has been done in an alloy which, however, we can not use, viz.: Invar metal, composed of nickel 35 parts and a special iron 65 parts. This alloy has practically no expansion and contraction as compared either with nickel or iron. The writer has tried to make an alloy of gold that would have this property of nearly zero contraction and expansion on cooling and heating, which could be used in the mouth and also having good casting qualities, but so far has failed. It probably will be accomplished by some one, and metallurgists should try to produce it. Our only methods available at present are to expand the pattern or investment or both and control the shrinkage as far as possible by pressure on the freezing metal, which combined methods will reduce the contraction fully two-thirds, and to hold the contracting gold. There are conditions where, by stretching the gold as it cools, the contraction can nearly all be controlled, as shown by these rings cast for this tapering column. When the gold is allowed its full contraction with a very soft investment, to retain the form of the ring, it will not pass nearer than to within about one inch of the base, while the wax form passed over the base. With an average plaster and silica investment heated to 800 degrees and moderate pressure, it passes to within half an inch of the base, and when cast over a hard model of the artificial stone it will slip over the base, because the pure gold could not contract, or, rather, was stretched as it did so. This will pass over the base, and will be referred to in casting crown bases, double compound inlays, etc.

Advantage of Model Methods.

Another fixed condition to which we must adapt ourselves and our methods, is a very confined, inconvenient space for making exact operations in, and all of the work that we can remove from that confined environment to where we may have freedom will add not only to the comfort of both the patient and operator, but to the exactness of that part of the work that pertains to contour, etc., provided we can readily remove unchanged all the data pertaining to the relations of parts, which we can very readily do with great exactness, as will be shown.

This is the great advantage of all model methods, and the speaker believes that in the near future a very large majority of all the inlay work will be done by some of the model methods. The requirements are that an impression be taken that will faithfully reproduce not only all the cavity surfaces, but the contiguous parts, so that all the involved relations can be faithfully reproduced outside of the mouth. There are two general divisions or kinds of model procedures. One provides for a model that reproduces the tooth and in which a pattern is made in platinum foil or wax, from which, when separated from the model, the inlay is made. The other provides that the filling or inlay be made directly in the model itself, thus eliminating two steps. To the former class belong the fused metal and sulphur and amalgam models which are good as far as they go, but do not allow of casting or fusing the filling directly into them. The other is a hard model that reproduces the teeth and structures with equal faithfulness, but also allows of casting or fusing the gold directly into it, and in which the inlay is polished and practically completed except for the final finishing of the margin when cemented into the cavity. So far as I know, there is only one such hard model as the latter calls for, viz., the artificial stone suggested by the writer. It is a silicate cement and uses phosphoric acid as a liquid. Unlike the silicate cements, it does not have contraction on setting and can be heated to and above the melting-point of gold without contraction on cooling again. It expands to about eight-thousandths at dull red heat and requires some heat to make it become stone hard. I have developed some improvements in the methods for making it since I reported before.

It is a silicate cement with the essential difference that it does not contract on setting nor again on being heated, even to a high temperature. Practically all the silicate cements contract as much as forty thousandths of their dimensions on being heated even dull red and fuse far below the melting-point of gold. It was extremely difficult to produce a substance that would not contract after being heated and that would sustain such a temperature. This is the only substance that is moldable and hard and strong that the speaker knows of that will do it.

Exceeding great exactness of formula and fusing temperature are necessary to produce a constant material that will not contract, when mixed with its acid, more than one-thousandth of its dimension. In any formula the variations in the chemical consistency of the ingredients must be met by varying slightly their proportions. A good kaolin, three parts; calcium hydrate, one part, and aluminum oxid, one part, by weight, thoroughly ground together wet, and burned to about 2750 degrees F., produces, when ground again without contact with iron, a good foundation. This is mixed, when finely ground with best quality potshell, equal parts. The fused mass above has extreme hardness and is very difficult to powder. No two kaolins have exactly the same chemical proportions, which makes careful adjusting of the above formula, to the material used, necessary. This does not make so white a model as a result obtained in a synthetic manner by a formula I have developed of the following contents:

Pure silica	20 parts
Calcium hydrate	19 parts
Aluminum oxid	42 parts

The purity of the calcium oxid will determine the exact amount of it required to produce a stone of zero contracting quality. This is also, when powdered without contact with iron (for the slightest trace produces frothing and gas bubbles), mixed with the finely powdered potshell, and the whole mixed and powdered to go through at least a 200-

mesh sieve. The acid may be prepared most easily by boiling slowly a good quality of ortho-phosphoric till it ceases boiling and fumes cease to be given off, though still syrupy, and not turning either brown or white. It is then diluted after cooling to about 45 3-10 degrees Baum specific gravity and brought again to boiling-point. The addition of modifiers to the acid, in nearly all cases, lowers the fusing-point of the resulting artificial stone.

I will be glad to assist any manufacturer who will provide the materials in good quality to the dental profession. Anyone can make the trays, having a good quality of heavy, hard brass. The wax is made by melting together, dry, a

Pure white gum demar...	110 parts
Tamarack (hackmatack)	10 parts
Beeswax	15 parts
Paraffin	10 parts
Stearic acid	2 parts

In the orders given and without contact with water, which injures the quality.

The making of an inlay by the wax-pattern method and casting involves three transfers of the cavity surfaces, viz., (1) the tooth to the wax, (2) the wax to the investment, and (3) the investment to the gold, and the inlay is thus three steps removed from the tooth. With the fused metal model or sulphur model, or amalgam model methods, the cavity surfaces have been transferred five times, viz., (1) the cavity to the impression, (2) the impression to the fused metal, sulphur or amalgam model, (3) this model to the wax pattern, (4) the wax pattern to the investment, and (5) the investment to the gold.

The stone-model method cuts out two of these steps and transfers of the cavity surfaces, and, like the wax-pattern method, is only three transfers of surface removed, viz., (1) the cavity and tooth surfaces to the impression, (2) the impression to the stone model, (3) the stone model to the gold; but it has many distinct advantages, some of which are as follows:

Advantages of Artificial Stone Models.

(1) The wax which takes the impression of the cavity is supported at every point by more hard wax, which in turn is attached to the tray and its metal septum, passing between the teeth, in case of an involvement of the contact point, thus entirely eliminating the making of exact wax contours and margins in the tooth cavity.

(2) The margins and contours of the filling are made with hot wax on a dry model held in the hand with the approximating tooth removed or replaced at will and besides, with no moisture, blood, gum tissue, cheek or tongue in the way to prevent viewing and forming a normal contour and margin, or to prevent the manipulation of the wax to that ideal.

(3) The septum of the tray and the wax it carries with it presses the gum tissue temporarily away from the gingival margin of the cavity.

(4) The model reproduces the contact point of the approximating tooth and permits of exact and definite adding to the new gold contact point to reproduce a more perfect anatomical interproximal space, secured by slight separation with a temporary filling.

(5) The stone model is very strong and hard, and when the gold is cast against it (for the stone model with its wax filling is invested and thus becomes a part of the investment) the cavity surfaces are not distorted, which occurs in large measure with all plaster and silicate investments with any but an extremely low pressure.

(6) The stone model gives the tooth surfaces and contours beyond the cavity margins, which allow the polishing of all surfaces and contours of the cast or fused gold inlay while in its normal environment, making an extreme exactness of normal contour possible.

(7) The cavity margins can not be bent, spun or distorted in polishing.

(8) The heat of polishing does not hurt either the patient or operator, nor can the inlay fly, as it is held securely by the model.

(9) For simple cavities without much contour to be reproduced, the inlay can be very quickly made by fusing directly into the model (described later).

(10) Several teeth involving several adjoining contact points can be restored at once with great exactness.

(11) It is extremely simple on the stone model to reinforce with iridio-platinum all places where pure gold is not ideally strong.

(12) Inlays hollow to any extent can be simply made by adding new soft stone to the stone cavity before waxing.

(13) The stone model is so strong that any desirable pressure can be used without distorting the cavity surfaces which occurs with the plaster and silica investments materials.

(14) Porcelains, except high-fusing, can be fused into gold or gold and platinum foil while on the stone.

(15) The stone models can be reheated at will even after being thrown hot into water, making it possible to assemble bridges and orthodontia appliances and build them up in sections.

(16) Any skilled assistant can make the models and wax, and articulate, and cast or fuse the inlays and polish them with exceedingly great exactness, as well as the operator.

(17) The patient is saved much time and discomfort, and besides should have a restoration fulfilling very high ideals; higher than by most methods.

(18) The operator increases his ability to serve and, therefore, to earn, besides making more perfect restorations.

Technique of Making Stone Models.

The method of making a stone model is as follows: Mix the powder and liquid to about the consistency required for a silicate cement, filling and insert carefully into the dried wax impression with a small pointed spatula. A steel spatula can not be used for mixing, owing to the formation of gas bubbles; use instead nickel, German silver or bone. As soon as the stone is set enough to hold its own weight without flowing, it is placed over a burner and the wax of the impression melted off, but not pulled off as with compound. By the time the wax is all melted off the stone is strong, but not hard like earthenware, until heated dull red with the blowpipe. The model is black from the carbon of the wax until heated red, which makes it white.

If the mix is too thick when placed in the impression, it will be difficult to prevent entrapping air and will also make a weak model by being laminated instead of homogeneous. It should run very slightly in large quantity on the spatula or slab, but not soft enough to drip, when mixed properly. The impression must be thoroughly dry when the stone is put into it, and small quantities must be placed into very deep parts of the impression first, with the small point of the inserting instrument. The same care must be taken as when painting an investment onto and into a wax pattern for an air-bubble or disc on any cavity surface makes the inlay that much too large and prevents it seating. Any assistant can with a little practise make the models.

If porcelain is to be baked on the model, the wax must be all burned out first, making a white model, otherwise the carbon from the wax will discolor the porcelain.

Cavity Preparation for Inlays.

The preparation of cavities is so important as to determine quite largely, before the impression is taken by any method whatsoever, whether the operation will be a success or a failure. To say that a cavity should be prepared so an impression will draw, only makes it fulfil one of the crudest and simplest requirements of the fixed conditions. The physical properties of the gold and tooth substance: the established fundamental principles of carrying cavity margins to immune areas; the anatomical relations and the physical stresses to be sustained, all unite to establish the fixed conditions which, of necessity, control in general the ideal preparation of each and every cavity.

Beveled Margins.

Since gold contracts to a considerable extent on cooling from the liquid state, which can not be entirely corrected or prevented, and since it is impossible to make cavity surfaces of the gold perfect in smoothness, it becomes necessary for these and the reasons established by the fixed conditions, that we utilize the malleable or moldable quality of gold in order that we may produce margins of the high ideal we have taken for our standard, viz., the gold in close adaption to the tooth without a visible cement line at any point around the margin. Such margins can not be made all around an inlay having butt joints coming at right angles to flat surfaces. We must bevel every margin that does not naturally meet the surface at such an angle as to permit the gold being burnished and finished tightly to the tooth. The strength of the margin makes it imperative that we do not make thin knife edges, but rather like the edge of a chisel. Such a margin can be burnished closely to the tooth while the cement is still soft, provided the metal is pure or nearly pure gold. This method of preparation is particularly indicated at the gingival margins where, of necessity, a butt joint can rarely, if ever, make such a margin as our standard requires. The fulfilment of the requirements of extension for prevention removes enough of the tooth structure to allow of the withdrawal of an impression from approximal surfaces where the contact points are to be reproduced, and very often there will be a decided saving of tooth structure for an ideal inlay preparation as compared with the ideal preparation for a malleted filling.

The strength of the inlay in resisting the stresses of mastication make it essential that we do not depend upon the cement for retention, but rather prepare all cavities with a dovetail locking step, or a locking post, and depend on the cement to prevent the inlay backing out of the locking seat. The detailed application of these fundamental principles of margin preparation, of carrying margins to immune areas and the mechanical locking of all inlays will be demonstrated with illustrations for the various cavities.

Taking Impressions of Cavities.

A first requisite for the taking of impressions with any plastic is that it be supported equally at all points to and beyond all areas to be accurately reproduced. This makes a variety of forms of trays necessary for the large variety of cavities met with. These can best be illustrated in connection with the individual cavities. Great care must be exercised that trays be made of a very stiff material, otherwise the impression wax will spring it when it is pressed over the tooth or teeth, and when removed the spring of the metal will slowly but surely distort the impression. The impression material should be as stiff at the base of the impression as can conveniently be pressed to place, and very soft on the surface to allow it to be pressed into every crevice. For very difficult cavities with margins extending below the tissues, it is often of great advantage to use the first impression as a tray and after drying place a fresh surface of hot impression wax in it by dropping from a heated stick. The first mass, the cold, hard impression carries the second of warm, soft material into every crevice even far under the gum tissue where possible.

The impression material used for making artificial-stone models must be free from inorganic substances and must be such as will melt clean from the stone without injuring the surface.

The ordinary impression compounds are not suitable, and for this reason a proper impression wax is furnished with the stone. A dry heat must be used to remove the wax from the stone, and if it is desired to save the wax a dry water bath can be used and is made very simply by placing a dry cup or tumbler in a basin of boiling water. After the wax has melted off, the model should be hardened by being placed in a large flame which has an excess of oxygen or air. This will burn up the wax without smoke. The warming of the special wax provided to be used with the stone is best accomplished by placing a wafer of proper size in some very warm water and soften to about the toughness of stiff leather; at the same time moisten the fingers so that the wax will not stick to them. Fold the wax over and over, preferably slightly heating the folding surfaces as they come together, in a gas or alcohol flame. Place in the dry tray previously selected, at which time it should be quite resistant to pressure. Heat the surface in the flame and, after drying the excess of water from the cavity with a blast of warm air, press to place. The impression should not extend into needless undercuts. While supporting the tray with one finger place the saliva ejector in the patient's mouth and throw a stream of cold water on to the impression. When it is partially chilled withdraw part way from the cavity to remove extensions that may have protruded into adjoining interproximal spaces and press again to place and chill, and remove. If there is uncertainty as to whether the cavity is free from undercuts, place the impression back into the tooth once or twice to plane off any possible points where it has drawn. Special points in impression taking will be brought out in connection with the different cavities.

Simple Occlusal or Buccal Cavities.

The detailed technique for applying this method to the various cavities will be taken up in detail beginning with the most simple: First, simple occlusal or buccal where there are no difficult contours to replace. Use cross-cut taper, fissure burs for the preparation, cutting out all involving fissures. Bevel all margins, preferably with a small vulcarbo stone such as the hub of a vulcarbo separating disc. The simplest tray for supporting the wax for taking the impression of such cavities to and beyond all surfaces required to be accurately

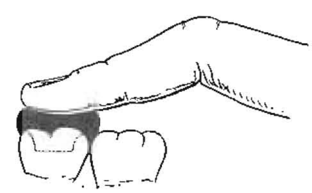

FIG. 4.

reproduced is the finger, as shown in Fig. 4. Heat a piece of wax in the hot water, as directed, and, after folding into a stiff cone, heat the base of the cone just a little to make it sticky; partially dry the forefinger and place the base of the cone upon it, then drive the excess of water from the cavity with a short blast of warm air, and after warming the tip of the cone quite soft press it into the cavity and chill with the stream of cold water after placing the saliva ejector. The part of the wax within the cavity may not be quickly chilled hard enough to prevent it being distorted when the impression is removed, so loosen the impression, and after the cool water has reached the cavity, press it back into the cavity to place once or twice to make sure of no distortion. There are two methods for making the gold inlay for such a cavity, viz., fusing and casting, but for either method the stone model is made in the same way. After mixing the stone on a slab to about the consistency of a thick porridge, place it into the thoroughly dried impression, being careful not to inclose air. If it is desired to make and complete the operation immediately, use the fusing method and place the freshly mixed stone directly on a wire gauze plate over the edge of a bunsen flame and heat, at first slowly, to harden the stone and let the wax drop off into any provided receptacle.

There are bunsen burners supplied by the dental trade provided with a drip dish about the burner. The model should be heated in the direct flame until the wax takes fire, which it will do and burn without smoke in a large flame, having an excess of air. After removing the model from the flame place over it either thin soft platinum or, much better, "Rowan's" gold and platinum foil, shade 2 or 3, and after pressing the center into place with a roll of cotton, use a piece of unvulcanized rubber with a sheet of rubber dam around it and press the foil into close contact with the cavity walls and margins. If the gold and platinum foil is used take a piece twice the size of the top of the tooth and after annealing fold once, which makes a good strong lining for the cavity and adapts very closely. After adapting the lining melt blocks of pure gold into the cavity directly into the stone with a blowpipe. The lining will draw the pure gold up over all margins and no flux is needed.

From the time the impression is taken, the whole operation, making the model, burning off the wax and melting the gold seldom requires over ten or twelve minutes, even when done in a clinic with improvised conveniences. The inlay is trimmed with a stone and polished while on the stone model where it was made and with very great exactness of contours, for the model gives the contours and surfaces beyond the margins, which a simple cavity pattern does not. Usually simple occlusal cavities carry out the normal contours of the natural perfect tooth, and do not require a special contour for the antagonization. This will be almost universally true for all young people and for such cases no bite is required.

The making of an articulation record or occluding model will be described later. If on placing the inlay into the cavity and letting the patient bite, it is too full, the surface will show a mark and the inlay will be placed back in the model and ground, and, in so doing it can not fly or be distorted, or cause discomfort from heating. The locking of the inlay is secured by grinding cross-cuts around the part which goes within the cavity and into which the cement forms an anchor key. In certain cases of excessive strain on inlays, as bridge abutments, similar grooves should be cut into the cavity wall. The inlay should be set with a very slow setting, soft hydraulic cement, ground very fine and the margins should always be finished to the tooth while the cement is still soft. For the reason that the most perfect margins can only be secured by burnishing and spinning a malleable metal to the tooth wall, we should use a pure, or nearly pure, gold for inlays. The hubs of vulcarbo separating discs are especially good quality of stone for finishing the gold to the margins and should be run toward the enamel to drag and flow the gold to the tooth. In some cases a fine gold finishing bur is very efficient. Follow these with a fine cuttlefish disc and finally burnish with a polished steel burnisher;* pear or oval shapes are most convenient. The burnish-

*The new burnishers, made of tungsten, are vastly superior to steel.—Ed.

ing hardens the surface of the gold. Such margins properly finished, as directed, can not be detected from the very best malleted and most exquisitely finished fillings, except that they keep their surfaces better.

The other method for restoring such a simple occlusal or buccal cavity is by casting directly into the stone cavity as follows: After melting and burning off the impression wax, cool the model and proceed to wax up an ideal filling in the dry stone cavity, using any base plate wax, preferably one not colored, for the advantage of transparency. Use a hot instrument and melt and mold the wax to the stone. Attach a pin and sprue gate to the wax at any point and invest the whole model with its waxed filling in a casting ring, using any cheap strong silica and plaster investment. About four parts by weight of a suitable silica to one of plaster is good. Dry and burn out in the ordinary way, except that there can be no damage done to the cavity surfaces by rapid heating since they are very strong, being entirely in the stone model part of the investment. Cast with any method directly into the stone cavity and use as high a pressure as desired. The higher the pressure the less the contraction by the forcing of new gold from the sprue into the cavity as the gold in the cavity recedes by contraction, as explained in detail earlier in this paper. To have the pressure effective the sprue neck must be large and the investment hot. Too small a sprue neck with any method of pressure prevents movement of the congealing gold by the chilling of the gold at that point. When casting with air pressure or suction machines, always mount the inlay on the sprue so that the mass of the inlay is below the point of attachment and trim away any parts of the model that extend outward below the inlay, thus cutting off the pressure on the margins that would otherwise be in pockets in the stone model. With a centrifugal force this is not necessary.

Inlays cast into the stone model with low pressure will be easily removed, and when fused in with a blowpipe, as directed, will drop out, while those cast with high pressure will always be so tight as to necessitate the breaking of the model to get them out. The difference is due to the control of the contraction of the inlay by pressure on the sprue. The hot casting ring containing the stone model is thrown into cold water to chill after casting (water does not affect the stone after it is heated), and after washing off the plaster and silica and cutting off the sprue gate it is ready to polish. This is done as with the fused inlay while it is in the stone model, with stones and discs. To remove the polished inlay from the model when cast with high pressure use a pair of knife-edge cutting pliers, like wire-cutters or wedge-cutters, and split the model in such a way as not to bend the inlay. It will usually shell out clean and bright like the meat of a nut, but if any pieces stick to it use an excavator to dislodge them. Be very careful to look for any possible beads on the back of cavity surface caused by air bubbles caught in the stone when mixing or inserting it. These are easily seen and if not removed would prevent the inlay going to place. Inlays to fit inside dimensions, when cast into the stone, will fit the cavities more tightly than when fused, and vice versa when intended to fit outside dimensions. Grind cross grooves in the cavity surface for the cement to lock into and anchor the inlay and set and finish as directed for the fused inlay. Any ordinary assistant can soon learn to do any or all the work of making the inlay from the time the impression is taken to preparing it for setting.

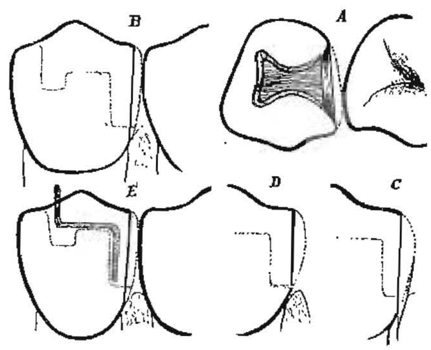

FIG. 5.

Simple Single Approximal Cavities.

We will now consider the restoration of the simple single approximal cavity. The cavity preparation for anchorage and prevention of return of caries requires a seat in the occlusal and removal of the contact or approximal surface sufficient to carry the margins to immune areas. This preparation can, if properly applied, give all surfaces and margins in such relations that if cavity undercuts are filled they can be faithfully reproduced in an impression, provided the impression material is supported properly at all points. The two weak points of approximal fillings are the gingival margin and the anchorage. Both can be made very strong if the cavity is properly prepared. The fixed conditions are established, that to make all margins of every cavity of the high ideal selected, we must use the moldable or bending quality of pure, or nearly pure, gold and burnish the chisel edge or margin into very close adaptation at every point while the cement is soft. To be able to do this we must prepare the cavity accordingly, and with greatest necessity at the gingival margin. When the contact surface is removed sufficiently to carry the buccal and palatal margins to immune areas there is room to pass a thin separating disc between the teeth and prepare that important gingival margin, as will be seen in any of the illustrations of approximal preparation. The bevel at the gingival margin should if possible, for immunity, be carried just under the free margin of the soft tissue. The floor of the cavity does not require to be carried to the edge of the soft tissue as for an ideal preparation for a malleted filling. If the decay does not involve the tissue to be used for the step, much less will need to be removed at that point for a given strength with the inlay than for a malleted filling, provided the reinforcing bars are used in the step

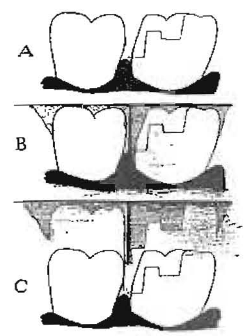

FIG. 6.

when casting, as directed later. If every margin should end in a chisel-shaped edge, that must be provided for in the preparation of the cavity. Figs. 5a and 5b show two views of good bicuspid approximal preparations. Fig. 5d shows the usual inlay butt joint at the gingival margin and is very bad preparation, for it is impossible always, if ever, to make with that preparation a margin there having the high ideal we have adopted. Use crosscut taper fissure burs and small stones for the preparation of the step and its margins. The taking of the impression has one apparently very serious difficulty, viz., the undercut under the contact point of the adjoining tooth, which will distort any mass, being drawn unprotected from the cavity and interproximal space. This can be prevented quite perfectly by means of a septum on the tray, which extends between the teeth to the gingival tissue, as shown in Figs. 6a, 6b and 6c; 6a shows the cavity preparation and the relation of contact point of the adjoining tooth; 6b shows the tray with the wax on both sides of the septum in the tray and pressed to position as when taking the impression, and 6c illustrates how the wax, under the contact point, is drawn off and is not able to distort the impression of the cavity because the surface is completely protected by the septum as the tray is withdrawn straight outward from the cavity. The septum also has the great advantage of pressing the soft tissue out of the way to permit an impression of the otherwise difficult gingival margin.

The distance to the gingival margin varies greatly and accordingly trays have been made with the following different lengths of septums, 3-16 inch, 4-16 inch, 5-16 inch, 7-16 inch, and care should be used in selecting the tray with just the proper length of septum for the case to just press the soft tissue without cutting it. If the cavity is prepared without undercuts, or with the undercuts filled, and if the impression wax is quite stiff next to the tray and quite soft on its surfaces, and after placing in cavity is started a little and replaced before it is hard and then well-chilled with a stream of cold water before removing it, you will make a very faithful reproduction of the cavity and margins. If the impression is carried beyond the gingival bevel, the bevel at that point will show to extend to the end of the impression. Make a record of the width of the bevel below the gingival floor, either by marking it on the impression with a scratch line on the wax to be reproduced on the stone model or by noting the distance below the floor and wax and finish to that record. If this precaution is not taken the contour of the inlay may be waxed and cast, as shown in 5c, where the contour of the approximal surface is carried too far under the gingival tissue and must be removed before setting, otherwise a most irritating and defective gingival margin would result. The impression is filled with the stone and the model made as previously directed.

If a record of the occlusion is required, have the patient bite into a small warmed piece of base-plate wax placed over the cavity. This is placed on the model in the same position and after wiping the surface of the model at each end beyond this wax with vaseline, to prevent sticking, place some freshly mixed stone into the prints of the cusps of the antagonizing tooth, letting it extend on to the vaseline surfaces of the model for contact. Place the whole over the flame and in a few moments it will be hard and the wax bite melted off. This makes a very quickly made model articulator and, particularly in compound or multiple restorations, is of great convenience and accuracy. Almost invariably when the contact point is gone the natural anatomical interproximal space is destroyed by the teeth closing together, which space should be secured again by placing in the prepared cavity a temporary stopping filling for a few days. To preserve the space will necessitate an addition of gold on the contact point of the inlay. To secure this definitely, we will polish a little off the contact-point of the approximating stone tooth which has become a part of our model. We will also polish off a couple of tbousandths of an inch extra to allow for polishing the gold of the inlay. The cavity may now be waxed up with a warm instrument, though usually it is best to divide the model between the teeth, thus giving very perfect access to the gingival margin. To separate the model, use a fine jeweler's saw and start a cut and then with the fingers or a pair of excising forceps fracture through. After waxing up the cavity press the two pieces together in their exact relation, as shown by the fractured surfaces articulating together, and thus produce a very exact contact-point. The normal contours of the tooth

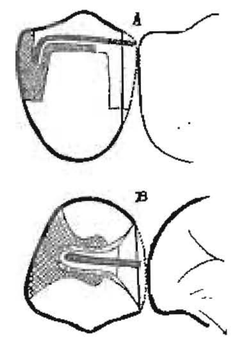

FIG. 7.

are shown by the model and the waxing can be done with extreme accuracy, producing more perfect ideal contours for the anatomical conditions as they exist than can usually be done with a matrix and polishing and shaping contours of malleted fillings in the mouth.

If greater strength is required in the step, run a piece of round iridio-platinum wire through the die-plate and thread it and cut and bend a piece to set in the step, as shown in Fig. 5e. This is placed in the cavity before waxing it and an end is left, as shown, extending about a sixteenth of an inch beyond the model to engage in the investment which will hold it in place when the wax is melted out and the molten gold is going in to chill around it. This makes very little cutting necessary in the step for a very strong anchorage. If there is already a good filling or inlay in the other approximal or the occlusal surface of the same tooth, this method makes a very simple and strong means of locking the two together, as shown in Figs. 7a and 7b. A groove is cut across the occlusal of the fixed filling and a hole drilled into the strong part of the mass. A piece of the threaded iridio-platinum bar is bent to fit into the hole and lie where it will be in the mass of the new inlay. The impression is now taken over this and the bar comes away with it. When the stone is placed in the impression and the model removed from the impression by melting the latter, the bar is in place in the model as it was in the tooth. Wax up the cavity over it and cast around it. It can not move because the end that was in the hole is anchored in the stone model. All inlays are polished on the model in practically the same manner. Be particularly careful with the gingival margin and contour.

The writer usually takes two impressions, which only takes a few moments, and for no other purpose than the advantage to the assistant of having a second model of the cavity before him when polishing the gold inlay in the first model to show where the cavity margins are and to allow of practically complete exact shaping and polishing on the model

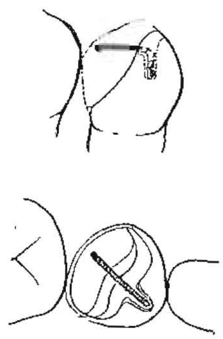

FIG. 8.

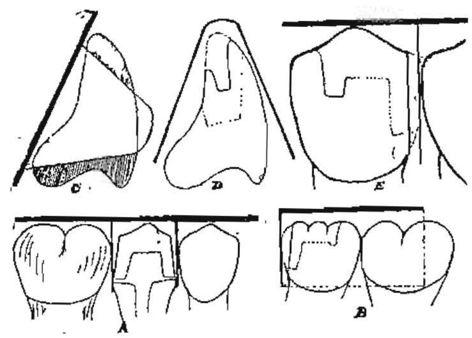

FIG. 9.

before fracturing it. The advantage of the stone model for final shaping and finishing of normal contours is very great.

After removing such normal inlays from the model, by fracturing it with a pair of cutting-pliers or forceps, crosscut the back of the inlay with a thin-edged stone and look for any beads of gold from air-bubbles, and if the mass of gold is large and lies near the pulp, grind off sufficient to give a good cement lining between at that point. Place in the cavity and burnish carefully to all margins and look particularly to see that the gingival margin has not been contoured and extended too far, as shown in Fig. 5c. Cement with a very slow setting cement and finish all margins to the tooth while the cement is still soft. A cement that sets too quickly for doing this makes such margins as we have taken for our ideals impossible. After spinning all the accessible margins to the tooth with the stone and disc, the gingival margin must be finished with hand instruments which, however, can be done very accurately and quickly if the gingival margin is not left extending beyond the gingival bevel which is easily corrected if looked for before cementing. Use fine draw-cut files or finishers and burnishers. The D. D. Smith prophylaxis scalers make excellent inlay trimmers and finishers for the gingival borders if you have no better. The writer has designed simple convenient forms that reach all surfaces and angles easily. They can be obtained through any of the dental supply houses and are made by the Cleveland Dental Mfg. Co. They include file-cut trimmers in pairs so designed as to reach the gingival margins of all teeth from both inside and outside. Also long-taper rotary finishers for the same purpose for use in the handpieces.

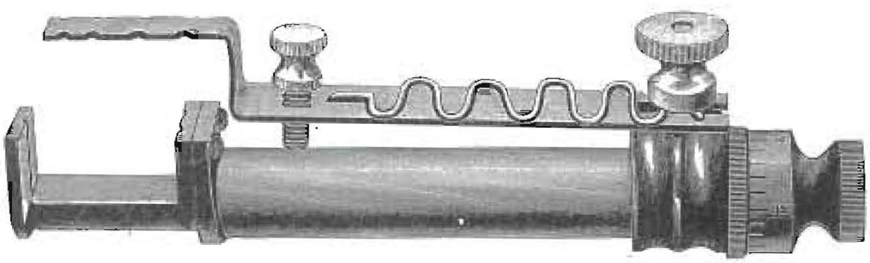

FIG. 10.

Anchorage with Bar.

The principle of anchorage by means of a bar, around which the inlay is cast, is very applicable and with great advantage for badly or partially broken-down teeth, as cuspids, where no retaining walls are left, as shown in Figs. 8a and 8b. In such cases the threaded bar is placed in the hole in the tooth and is allowed to come away with the impression, as in Fig. 7. This makes a very strong anchorage, with exceedingly little loss of tooth structure. Any of the cavity restorations considered so far are very simple compared with the double compound restorations in bicuspids and molars, because the uncontrolled contraction, or that not compensated for by expansion of the investment, does not draw it away from the pulpal walls, but by the shortening mesio-distally makes the inlay, which is the shape of a staple or horseshoe, too short to go over the occlusal surface, and when forced down pries out the gingival borders. Such compound restorations, well adapted, give excellent reinforcement to otherwise frail teeth, and are infinitely better than the abominable mother-hubbard gold crowns so often placed on them. The stone model is of particular advantage in this form of restoration because its strength is sufficient to hold the pure gold when cooling over it, and thereby causes it to stretch mesio-distally, prevents the shortening. A great saving of tooth structure is secured across the occlusal surface if the threaded iridio-platinum bar is used in the form of a staple lying over the pulpal walls. The tray used for such a case is shown in Fig. 9a. It has two septums; they are adjustable in their distance apart so that it can be used for bicuspids or molars of any size. It is made of different lengths of septum, 3-16 to 7-16 of an inch.

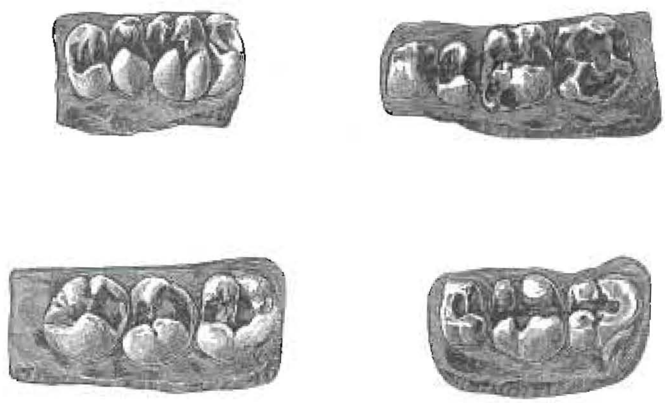

FIG. 11.

Restoring Adjacent Lost Contours.

Where the contact or approximal surfaces of two teeth have to be restored at once a new difficulty is involved. The impression is taken in the same way and by a similar tray as for single approximal restorations. The new difficulty lies in the fact that since both contact points are gone and are to be restored we can not take from either to get the extra space for making the other as we did in the case of the single approximal restoration where we polished from the stone contact-point of the approximating tooth to get the extra gold to make up for the separation secured by the temporary filling and for polishing to get a good finish. This can be done approximately by fracturing the model through between the teeth and waxing up the contact-points with an excess, as shown by articulating the fractured surfaces. It can be done very exactly by means of a micrometer articulator, shown in Fig. 10. In use the soft stone model in the impression is placed between the vaselined jaws to set. When sufficiently set the model is removed and heated and broken through between the teeth. The occlusion is secured by the bite in base-plate wax, as described and in these instruments the antagonizing model is attached, when the stone is setting, to a movable arm which has all the movements of mastication. The micrometer articulator has a micrometer screw that moves the jaws to or from each other with a scale on the revolving head reading directly in thousandths of an inch. The position of the jaws is noted when the separated pieces of the model are in contact. The model is removed and the cavities waxed up normally with a little excess of wax on the contact-points. The two pieces of the model are now placed in the articulator and the micrometer screw turned until the two are within, say, eight-thousandths of their normal relation. That is an allowance of two-thousandths for each surface for gold to polish to get a good finish and two-thousandths for each surface for separation by the temporary filling. The occlusion is then adjusted by pressing the occluding model into the wax filling, it being mounted on the articulator. When these fillings are cast and finished they will usually go to place with good normal pressure at the contact-points. The writer frequently makes several adjoining restorations at once with great accuracy by means of this instrument. Note that where temporary fillings are pressing on both sides of the same tooth as where several contact-points are to be restored at once there will be no movements of that tooth, so in cases of several adjoining restorations being made at once from one impression, only the end teeth can move. Fig. 11 shows several models where several contact-points were restored at once. One case had six contact-points. This can only be done where there are no undercuts to prevent getting accurate impressions.

Disto-Occusal Cavities in Third Molars.

The cavities involving the disto-occlusal surface of the third molars require a tray like a box with three sides, as shown in Fig. 9b. The end of the box acts as the septum of other trays to press the tissue away from the gingival border of the cavity. The cavities in the incisors and cuspids usually require a compound impression, there are some, however, that can be taken in a simple direct impression, as illustrated in Fig. 9d, which also illustrates the form of tray used. The use of the strengthening bar, as directed, will often allow of a saving of tooth structure in the incisal step where the strain is very great and the tooth tissue very limited.

It is only when cavity walls are parallel to the tooth walls that both can be reproduced in one impression. When, however, the approximal cavities of cuspids and incisors are entered from the lingual surface, as they should almost always be (see Fig. 12), and should have good locking form, as described later, the cavity walls are at nearly right angles to the tooth walls, and since the impression of the cavity must be made in the direction of its walls only the lingual surfaces of these teeth can be produced with the cavity impression which leaves the labial surface and margin of the cavity absent. This difficulty is very completely overcome in the following simple manner by a two-section impression. A tray with a very thin septum is used, the shape of which is shown in Fig. 13a, and in position in Fig. 9c, without the impression wax on it,

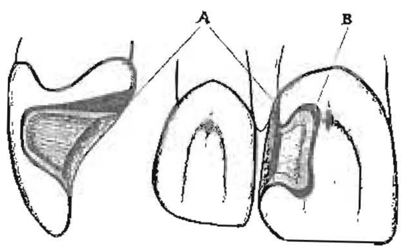

FIG. 12.

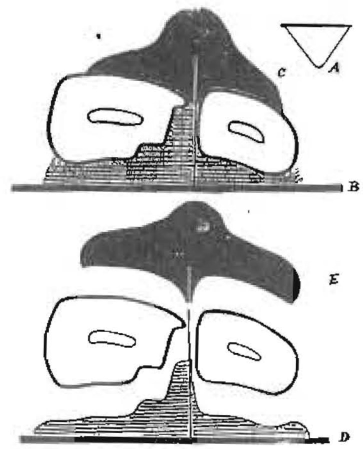

FIG. 13.

and in a cross-section view with the wax on it in Figs. 13b and 13d. The tray, with impression wax on both sides of the septum, is placed in position from the lingual surface and the end of the septum passed through between the teeth and while being held with the finger, the soft wax adhering to the protruding part of the septum is all scraped or pushed off, exposing it and all the labial surfaces of both teeth and particularly the labial margin of the cavity, shown in cross lines Figs. 13b and 13d. The wax is chilled with a stream of cold water and the impression partially removed from the cavity to insure that all the wax has been removed from the labial surface on the septum. It is then pressed to place again in the cavity and chilled with a stream of cold water and a second small cone of wax, quite tough at the base and soft at the point, pressed over the cold, wet septum and the labial surfaces of the teeth and the impression and tray projecting at the end and chilled thoroughly. This is shown in cross section in black, Figs. 13c and 13e. After chilling, the labial piece is removed, and then the tray with the lingual and cavity surfaces, and, after drying, the two pieces are placed together and fastened with a hot instrument or sticky wax and the model made in the usual way. After casting and removing from the model, the short bevel on the labial margin is raised slightly to permit the inlay to pass into place, and after the soft light-colored cement is in place, that margin, with all others, is burnished down and finished to the tooth, as directed. This operation can not be detected from a malleted filling except for the lighter color of the tooth from the cement under the labial wall. The preparation of these cavities requires that the cavity be cut, either dovetail from the lingual entrance or with a step and locking pit or groove on the lingual surface, and special precaution should be taken to bevel well the gingival margin, particularly toward the palatal angle of the proximal surface (see Fig. 12a). The writer believes this to be the strongest filling that can be placed in such cavities as well as the most esthetic. Two approximating cavities can be filled at once as conveniently as one.

Hollow Inlays.

In all the cavities considered and also for the restoration of such broken-down teeth as have only a part of one wall remaining, it is often desirable or essential to make the restoration hollow. With the wax pattern this is accomplished by removing some of the wax from the cavity surface. With this method it is done by painting some freshly mixed soft stone over the surfaces of the stone model that are to be made hollow. This can be done with great exactness on the model and no heat need be applied to this freshly applied stone, since the heat of drying out the investment and melting out the wax is sufficient to harden it. In the compound approximal cavities involving both approximal surfaces and the occlusal of the same tooth it is of especial advantage to place a thin layer of new stone over the pulpal walls extending quite near to the margins which places all the pressure due to the mesio-distal contraction of the gold entirely on the margins, the only place it is necessary in any cavities.

Angles of Incisors.

The very small incisal angles that are not too conspicuous for all gold are very easily and strongly restored by drilling one small post-hole and inserting a small threaded iridio-platinum wire or post and taking the impression directly over it. The post comes away in the impression and is again transferred to the model as it is made. Wax up over the post and cast and polish. If, however, there is considerable of the angle gone, the gold will be too conspicuous and in such cases, whether the anchorage is by a post or by the dovetail and step preparation, as in Fig. 12, wax up the angle with a cavity in the labial face and cast in gold or gold and platinum. The advantages of making these angles on the model are very great, for the operator has the adjoining teeth in place as well as the one involved, and the normal contours can be made very accurately and quickly. After casting and polishing, there are two methods of making a porcelain inlay in the exposed labial face. The simplest way is to bake a low-fusing porcelain directly into the cavity in the gold, or gold and platinum, while the inlay is still on the model. The disadvantages of this method are that the contraction of the gold and porcelain or gold and platinum and the porcelain being different there is great danger of the porcelain checking from the stress, though it may not show for six months after. Another disadvantage is that the yellow color of the gold will show somewhat through the porcelain unless it be a very dark tooth. If the tooth should be light it will be practically an impossibility to match it in this way. The writer has come to setting practically all these cases before making the porcelain inlay for them, and polishes away the gold line next to the enamel margin, and matches the porcelain direct to it, and bakes it in a platinum impression, and then cements it into the gold inlay.

All-porcelain angles for these cases have not proven to have sufficient strength, though they look well. All-gold angles have the strength, but have not a tolerable color. This combination gives the strength of the all-gold and the esthetic effect of the all-porcelain. These are exceedingly satisfactory restorations.

All-porcelain restorations are easily made, either by placing over the prepared cavity and tooth very thin platinum foil about one ten-thousandth thick and taking the impression over it. When the model is made the platinum will cover the cavity surface as it did the cavity of the tooth. The porcelain is baked directly into the platinum foil while it is on the model, and the advantages are that the surrounding surfaces and contours are present to guide in reproducing a normal contour which is extremely difficult if the platinum matrix is removed alone to build the porcelain into. Another way is to take the impression of the cavity and tooth, and after reproducing in the model, burnish the thin platinum foil to the stone model and bake the porcelain in it while it is on the model.

Crowns and Bridge Pieces.

For casting crown bases and bridges, the stone model is extremely useful. First, in the casting of abutments it has the advantages that the normal contraction of root foundations and crown bases is laregly prevented, for the gold cast where it surrounds the stone is held from contracting unless in too large mass, when it will crush the stone. This quality is of particular advantage in casting gold partial or full plates where there is much total error from contraction because of the

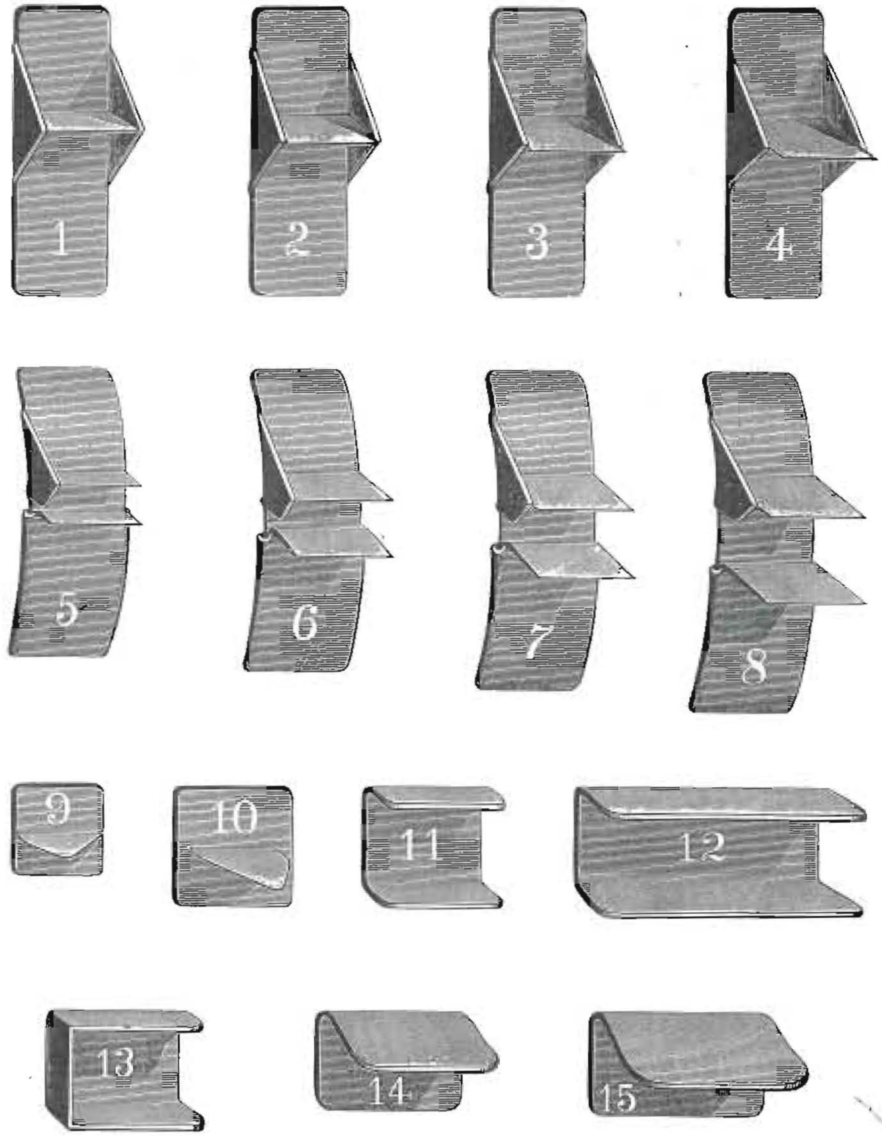

FIG. 14.

dimensions if cast onto a yielding mass. Bridges should be attached to inlays instead of crowns wherever possible, and for this purpose the use of heavy iridio-platinum posts and bars inserted into the tooth and a cast made over them, if of pure gold, makes a foundation that can be burnished to the tooth, making a better joint than a hard alloy of gold can, and with equal strength. In assembling, the section carried is soldered to the bar and surface of the inlay. Because of the impossibility to entirely control the contraction of the gold it is best to cast the foundations and section to be carried separately, and then assemble.

When casting over porcelain bridge teeth, if you will place a piece of iridio-platinum bar tightly between the pins before casting, it will be almost impossible to break the porcelain, provided it is well heated and the porcelain surface is flat and not convex. In orthodontia the stone is used to cast appliances upon. The waxing is done with a small paint brush and the wax is heated hot in a dish and painted to place with great simplicity and ease. In taking the impression it is very desirable to have appliances a trifle larger than the tooth. This is accomplished by placing over the impression, after it has been removed and partially cooled, a piece of rubberdam and then replaced over the teeth and pressed tightly to the teeth. This enlarges every surface the thickness of the rubber.

There are many other uses for the stone, such as making occluding models for setting up teeth, in which case the cusps of the teeth are so strong as to allow of pressing the porcelain into position which can not be done with plaster-occluding models. It is also very useful for record models where its hardness is a great advantage. Fig. 14 shows the trays used for taking impressions of cavities; numbers 1-4, inclusive, are for taking proximal cavities, and differ only in the length of the septums, viz., from 3-16 to 4-16, 5-16 and 7-16; 5 to 8, inclusive, are for taking compound approximal cavities and crown bases, and differ also only in the length of the septums. They are adjustable. Numbers 9 and 10 are for the two-section impressions of the anterior teeth; 11, the short box for occlusal involving buccal or palatal or simple occlusal; 12, a long box for several teeth together, not involving undercuts; 13, the disto-occlusal cavities of the third molars and similar cavities; 14 and 15 the anterior teeth from the incisal edge.

The trays go by the numbers here given and must be made of very strong material, otherwise they will spring and distort the impression, making failure certain.

Discussion on Dr. Price's Paper.

President Van Woert. Dr. Price has finished his lecture. While it was announced to me this afternoon that the gentleman whom I desire to call upon, does not wish to speak this evening, due to physical disability, I think every member present will feel as I do, that there is no one better qualified, and no one we would be more glad to hear from, than our esteemed friend, Dr. J. Leon Williams, of London, England.

Dr. J. Leon Williams, of London, England. Mr. President and Gentlemen: I have but very few words to say on this paper, and those few words are entirely commendatory in character. I think one of the greatest pleasures in life—certainly in our professional life—is to meet a man who is master of the situation. I do not know of any greater pleasure in life than that. It implies everything that is involved in what we call evolution—the conquest of mind over matter—it is all figured in the mind of the man who is master of the situation.

I attended the clinic this afternoon and watched Dr. Price. I heard a great many questions asked—some of them very sharp and clever—that involved the consideration of principles a good deal outside of the practical line of work that he was demonstrating, all of a scientific nature, and it delighted me to see how thorough his investigation had been outside of the practical part of the work; how it rested on the most thorough and complete scientific investigation into all the side issues involved, and every answer to those questions demonstrated that he was master of the situation. I have made a great many experiments in inlay work. I am the fortunate, or unfortunate, possessor of three casting machines. I have not the Taggart, because I could not get it. I tried for a long time to get it, and I saw others were going on with inlay work, and I was falling behind, and I bought the first inlay machine I could get. However, the results were not satisfactory. Then I bought another, and another. My chief difficulties arose largely in deep approximal cavities, where they extended below the gingival margin. I was not able to control the shrinkage so as to get a joint at all satisfactory to me.

Another difficulty was the one to which the doctor referred—of getting the inlay placed after it was finished; but the one that chagrined me most was the lack of a good margin at the cervical border. By accident one day my wax model had a flange, and I saw that that covered the joint, and I said, "Why not do it in that way?" Since then I have made a point of doing it, and from that adopted the method mentioned by Dr. Price to the extent of using beveled margins. While Dr. Van Woert says he gets perfect contact there with a butt joint, I can not do it, and I am going soon to spend the day with Dr. Van Woert, and I hope to get some good points from him.

By having the flange slightly overlapping the bulk of the cavity, I have been able to get better results. I said to Dr. Price—and this will illustrate my appreciation of this lecture and of what I saw this afternoon—that I was not altogether satisfied with what I saw to-day, and I did not think I should be satisfied unless I could make an arrangement to go to Cleveland and spend several days with him; and he has very kindly given me an invitation to do that. I can express my confidence that this is an advance on anything I have ever seen before—a most complete and scientific method for gold inlay work.

President Van Woert, We have one of our own members with us whose name is well known to you in connection with this work, and you will all be glad to hear what Dr. Ottolengui has to say.

Dr. Ottolengui. You all know I have been a lifelong friend of Dr. Van Woert, and of Dr. Rhein, and neither one has been able to convince me that there is any advantage in the model method of making gold inlays. Dr. Price comes nearer to convincing me of it than anybody, and that brings me to the crux of this whole situation. I am not attracted by the advantage of having a tooth in my hand to fill it, because I have been filling teeth in the mouth for a good many years, and I can manage them in the mouth. I can do exactly what Dr. Price says I can not do. I can make a wax inlay for a cavity and remove it with less distortion than I have been able to remove any impression of that cavity which is used afterward for making a model of that cavity. Those facts are the same in connection with this method as any other; but the attractive feature in this method is not in the fact that this stone model may be used to form a wax model of an inlay, but that it may be used to cast the inlay into. I do not think anyone has spent as much time studying the contraction of the materials to be used in this way as Dr. Price has, and he admits the impossibility of absolutely controlling these contractions; but, as he truly says, what does it matter, so long as you can preserve the cavity surface of your inlay, and make it accurate? If you can change the location of the shrinkage of the gold, so that it will affect the surface that you are going to alter anyway with your polishing process, it is a matter of no consequence, because the 1-1000 which represents the shrinkage is of no moment, if it can be made to occupy some other portion of the inlay, rather than that portion which goes into contact with the cavity. That, of course, is exclusive of margins. If you have contraction enough to make it impossible to have perfect margins, that ruins the inlay. I remember when Dr. Taggart gave his demonstration in Jamestown, a gentleman arose and said ,"The day of art in dentistry is about to vanish; fillings are now to be made by machine." It seems to me the day of artistic dentistry has just dawned.

President Van Woert. I understand that at a recent meeting of the New York Institute of Stomatology, Dr. Gillette, of New York, showed some very beautiful specimens of cast-gold work, and read a paper upon the subject. I think he can add something to the discussion of the evening.

Dr. William Gillett, New York. I can say but little, particularly at this late hour. I am very glad indeed to express to Dr. Price my appreciation of the immense amount of hard work he has done. Knowing a little of his capacity for hard work—reaching back to the days of cataphoresis—I can understand something of what he has been doing, and of the way he goes at his work. I have been very much interested from the beginning in Dr. Price's work. I want to say to him I am heartily in accord with him in handling inlay work by the impression or model method. I get a great deal more satisfaction myself by processes of that kind than I do by the direct method, so far as I have tried it; but I am quite ready to admit that the direct method has its advantages, and I am inclined to think many of the differences that men find between the two methods are differences of personal equation—that if the same man will make the same amount of effort and take the same pains with one as with the other, he would do as well. For instance, if Dr. Price would work as diligently on the direct method as with the impression method, he would obtain some very satisfactory results.

I want to plead for that same perfection of ideal in the inlay work that he has spoken of. It is easy enough to obtain in inlay work that same high perfection we fought so hard for in our foil fillings, and it is so much easier for the patient to have us do it in that way. For heaven's sake, gentlemen, let us do that kind of inlay work, and not "sloppy" work.

Dr. Ottolengui. Dr. Price, can you really reproduce the cavity? Is the cavity in your model identical with the cavity in the tooth?

Dr. Price. Very closely, but not absolutely. It is impossible to reproduce anything identically or absolutely. A standard may not mean the same thing to two men.

We can reproduce a cavity within the thousandth of an inch. I would not consider the thousandth of an inch accurate. When I am working with an instrument at home that I can adjust to measure to within a hundred-thousandth of an inch, a thousandth of an inch seems large; but we can ignore a thousandth of an inch in our work if we burnish the margin as directed.

Dr. Gaylord. In heating this compound in which the wax impression still remains you burn out the wax. Is that heat sufficient to harden your stone?

Dr. Price. Yes; but if you want to make a very hard model, heat it dull red, which I generally do. If not, there is some wax and carbon still in the mold which make it black.

Dr. J. Leon Williams. Have you experimented very much with wax?

Dr. Price. Yes, I have. This is not perfect, but it is the best I know of. I have measured its elastic and resistant qualities, and it is the strongest impression material I know of that will burn off the stone and give us a good impression and not injure the stone.

I am going to repeat a statement that I know you will not all agree with. I am sure of it, because one man told me so. To make a cavity of the best form for inlay work, into which we are going to put a cast filling, every margin should be beveled or rounded so we have a chisel-shaped edge to burnish at every point, and not a square butt joint. I fear the man is not born—unless it be your worthy president—who can make, for example, a gold filling to fit flat and flush the neck of this wide-mouthed bottle, and have it only flush with the surface, and close that joint at every point, without carrying the gold by some means as spinning to the wall, which will leave a furrow on the flat surface. He conld spin pure gold there, but he would leave a little trough.

Dr. Ottolengui. Do you mean in the bottle or outside?

Dr. Price. I mean like cutting a cork off square, close to the bottle's mouth. I can not conceive how I could have misunderstood your president from the plain language be used, but I feel sure I must have misunderstood him.

President Van Woert. I am sorry, but as president of this society, I can not answer your remarks in detail.

Dr. Ottolengui. The president of our society is not supposed to take part in our proceedings. Still, as he has taught all of Brooklyn to make "butt" joints, I wish you would make him answer that point.

President Van Woert. I might say it is beyond my prerogative to answer a question of that kind, because it would take more time than I would be allowed, and that would not be fair to the guest of the evening, but when there is time, I can answer the question. [Laughter.]

Dr. Price. I can conceive of one or two points being in contact and hence a tight butt joint at those points, but to hope that all around a filling we can have absolutely perfect butt joints, contradicts the contraction of gold and available means for correcting it, unless you have an investing material that will expand much more than any I have been able to find.

Dr. Ottolengui. You talk as though necessarily all inlays are bound to be a little too small. I have had many so large I could not use them. How does that occur?

Dr. Price. That is not an unreasonable question or strange condition. It happens in daily practice, if you use a very soft investing material. You have probably had a pressure distortion, not a uniform expansion. In certain investments you will get it apparently larger every time; if you have nearly parallel walls it will take but an extremely slight distortion of any inlay surface to prevent it seating, which is the principal cause of an open joint at the gingival margin when using a butt joint preparation at that point.

Dr. Ottolengui. It is not a question of chance, it occurs very much too often. Our president has had that experience, too, because he has invented a way of etching such inlays so that they may be reduced sufficiently to use. [Laughter.]

Dr. Price. You may have found an investing material such as I have never found, if it expands that much. I certainly want to test it, but I am almost certain your enlargement was due to distortion, a yielding of the investment.

Dr. Ottolengui. I will send it to you. It is of no use to me.

Dr. Price. The chances are you have an error there that you are not taking into account. I have tested very accurately and have not found any investing material that expands on heating even half the amount of the contraction of the gold, as you will see by the tables in Fig. 3.

Dr. Ottolengui. Can you not bake porcelain directly into the gold inlay?

Dr. Price. Yes; but there are two serious difficulties. Sometimes, owing to the contraction of gold being greater than porcelain: the contraction of the porcelain being from 8-1000 to 12-000, and the gold 20-1000, the gold will crush the porcelain. Jeweler's porcelain can be baked into gold, and the shrinkage is so great as to be near that of the gold, consequently it will not craze or check. Another difficulty is that if we have the yellow of the gold showing through the porcelain. In a bluish-white tooth, it is almost impossible to match shades. If it is a dark yellow tooth, we can bake the porcelain directly into the gold so far as the color is concerned. The low-fusing porcelains have greatest contraction and, consequently, are less liable to be checked.

Dr. Chayes. What body do you use?

Dr. Price. Jenkins', or Ash's, or Brewster's gold matrix porcelain—any low-fusing porcelain.

Dr. Ottolengui, Method for Fusing Porcelain in Gold Inlays.

I want to say a word on the subject of fusing porcelain into a gold inlay. As soon as Dr. Taggart expounded this doctrine, this idea occurred to me as a possible, very attractive cosmetic opportunity, being able to get the strength of a gold inlay combined with the appearance of a porcelain inlay; but when it is attempted in practice, the difference in the expansion of the two is so different that one is liable to crack the porcelain. In the gold matrix the contraction of the gold is so weak that it is resisted by the porcelain; but where you have a large mass of gold, as in an inlay, checking is apt to occur. I had some time since an inlay which was to occupy the major part of an upper molar, the mesio-buccal angle of which would be exposed when the patient laughed, and I was anxious to have the mesio-buccal surfaces of porcelain, and the morsal surface of gold. I found difficulty in fusing porcelain into the inlay. We made several attempts, and we would find the porcelain checked. We threw the inlay into hydrofluoric acid, removed all the porcelain and started over again. Whilst there is a difference between the coefficients of contraction in gold and porcelain which enables the gold to "pinch," and thus check the porcelain, porcelain has another characteristic of which advantage may be taken; that is, elasticity. To take advantage of this, fuse the porcelain in layers, and as each is fused *cut out the current and allow the piece to cool down completely within the furnace.* This requires a long time, but when doing a beautiful piece it is well to take the time. Let the furnace get completely cold. The contraction of the gold is so slow, and the layer of the porcelain so thin, that there will be sufficient elasticity in the porcelain to yield under the stress of the contracting gold, and not check. By fusing my large porcelain-gold inlay in this way in three or four bakings we obtained an absolutely perfect piece in which I could not find any check under a magnification of about thirty powers, nor has any check developed up to this time over a year later. I have made several since then with the same result.

Dr. Price. In casting on to bridge facings your porcelains are often broken because the gold has a greater contraction on cooling than your porcelain, and, as your gold contracts over the pins, it draws them closer together and crushes the porcelain between them. If you will put between the pins a block of metal that has the same expansion and contraction as the porcelain, viz., platinum or iridio-platinum, the gold will have to stretch, and the pins can not be drawn together, and the porcelain facing will not be broken.

Dr. Babcock. Where can we obtain this material?

Dr. Price. I hope I will not have much more trouble in trying to arrange so that you can easily get the materials, for practically no effort is being made to place it within your reach. It has cost me a great deal in both money and time, extending over several years, to experiment and perfect this material. At one time I used a physical chemist's entire time for six months to assist me. It has also been some trouble to get some one to manufacture it, for I, myself, will not enter the manufacturing business. The big manufacturers do not seem to be anxious to bother with it, not knowing whether there would be a large demand for it. If you will urge them to make it they will. I have had my brother, of the A. M. Price Electric Co., make this for us, but he is doing exclusively pyrometer work for glass and pottery factories, and has not facilities for making it. He is making a little as an accommodation. I wish the cement manufacturers would take it up, which they could most easily do, as it is directly in their line.

There are only two or three other points that I will take time to emphasize in closing the discussion. An important detail of finishing the fillings is this: After putting the filling in the tooth be sure to finish it while the cement is soft. Hold the inlay in place with a strong curved instrument and spin the margin toward the tooth by running toward the margin. The joint will be perfectly closed in that way, provided the cement is soft and very slow setting. Follow that with a fine cuttlefish disc, and then with a polished burnisher. The gingival margins will be done with hand files, gold finishers, hurnishers and strips.

In regard to the casting machines that you may use, I have only to plead for some machine that is better than anything the public has had offered to it yet. With all due deference to Dr. Taggart's machine, and the vacuum machines, they do not provide us the range, and the flexibility, and the control we require for best results. In my office I keep trying to experiment, and I can hardly get my good assistant here to leave that electric centrifugal machine and make an inlay with anything else, even for experimentation. I believe the centrifugal principle is the best, but it must be capable of a high velocity when desired, and be able to carry large casting rings or cups. A hand machine using gears is, in my judgment, the best. With this instrument that I used to-day the gold is melted in an electric muffler and the temperature is shown by a pyrometer.

If you will ask the manufacturer for something of greater range of pressure, and yet simple and positive, I think you can get it.

I appreciate more than I can tell your kind reception and your patience. I thank you.

A very hearty vote of thanks was tendered to the essayist, which was accompanied by long applause.

Adjournment.