DENTAL PRACTICE

A MONTHLY JOURNAL PUBLISHED IN THE INTERESTS OF THE DENTAL PROFESSION IN CANADA AND THE UNITED STATES

VOL. V. TORONTO, DECEMBER, 1908. No. 6.

W177

Original Articles.

Casting Gold Inlays and Artificial Stone.

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A report of the lecture delivered before the Toronto Dental Society, October 27th, 1908.

Dr. Price began his discourse by saying that an individual's estimate of the perfection of a piece of work would depend upon the height of his ideals. By using the present methods of fashioning inlays there existed a dissatisfaction regarding the constant results of the finished product. The variation in the results is due to a contraction of the metals on cooling, and the contraction of the investment on heating. Even if the operator's work has been perfect in its technique, an error will creep in owing to the contraction of the metal and the contraction of the investment. The object of Dr. Price was to present a method in the construction of inlays whereby this error would be eradicated.

The working out of a method to overcome these difficulties involved an arduous piece of work to determine the extent of the expansion and contraction of the principal metals and investment compounds on the market. The results obtained are as in table I.

The lecturer outlined his difficulty in obtaining the exact shrinkage of a metal. First, he constructed a delicate instrument to record the shrinkage of the metal. The method was to cast from wax models, bars of metals. As the work proceeded it was found that the cast metal bars of the same metal varied as to dimensions. This indicated some error in the process; and it was found that the variation was due to variations in the contraction of the investment material. This difficulty was overcome by finding an investment that would not change its dimensions

Expansion per linear inch for gold and its alloys, and silver, platinum-iridium, aluminum, copper and zinc from 0 to 1,000 degrees F., expressed in thousandths of an inch

Temperature	Gold 24K.	Gold 22K.	Gold 18K. Clasp Metal	Gold and 5% Platinum	Gold and 20% Platinum	Gold Solder 18 pt. Gold 21 " Silver 21 " Copper 21 " Zinc	Silver Pure	Silver Sterling	Platinum Iridium Alloy	Aluminum	Copper	Zinc
Air (75)	0	0	0	0	0	0	0	0	0	0	0	0
100	.2	.3	.1	.3	.1	.1	.3	.3	.2	.5	.3	.3
200	.5	1.2	1.	1.	1.3	.9	1.5	1.5	.4	1.7	1.	1.4
300	1.5	2.3	2	2.	2.2	1.7	3.	2.8	1.	3.	2.1	3.3
400	2.5	3.4	3 1	3.4	3 2	3.	4.4	4.	1.7	4.1	3.2	5.3
500	4.2	4.5	4.5	4 6	4 2	4.3	5.6	5 1	2.3	6 2	4.4	8.
600	5.7	5.7	5.7	5 4	5.2	5 8	7.	6.9	3.	7.5	5.7	10.
700	6 9	6.8	6.8	6.1	6.4	7 2	8.1	8.2	3.7	Metal	3 7	12.
800	8.	8	8.	7.3	7.3	8 3	9.9	9.4	4 3	Softened	7 8	Metal
900	9.	9.2	9 1	8.1	8.1	8 9	11.1	10.5	5.		8.5	Softened
1000	10.	10 3	10.3	9	8.9	9.2	12.8	12.	5.9		10.	

* *Expansion estimated to fusing point from these expansions.*

Gold 24 K.	Gold 22 K.	Gold 18 K. Clasp Meta	Gold and 5% Platinum	Gold and 20% Platinum	Silver Pure	Silver Sterling	Copper	Zinc
22.	22	21.	22.	23.	21.	21.	22.	14.

Total contraction per linear inch of bars of gold and its alloys, and silver, cast under definite pressure, expressed in thousandths of an inch.

Pressure of Molten Gold on Bar	Gold 24 K.	Gold 18 K. Clas Metal.	Gold Solder 18 pt. Gold 21 " Silver 21 " Copper 21 " Zinc	Silver Pure	Gold and 10% Platinum
0.	22.5				
1/50 oz.	20.5		18.		
1/10 oz.	18.				
3 lbs.	14.			20.	
5½ lbs.	13.	15.5	15.		14.

* The fusing points for the alloys are not definitely determined yet.

TABLE I.

by reason of the amount of heat to which it would be subjected. The substance chosen was fused fine quartz.

The work proceeded and the metal was now cast in a substance that would not contract. It was to be expected that now the results would be uniform. But still there appeared a variation in the contraction of the gold, showing that still there was some error entering into the calculations. After much labor and some disappointment, it was at last ascertained that the variation in the different cast gold rods was due to a difference in casting pressure, and that if the results are to be constant, the pressure must be constant. The required pressure is the highest pressure that can be used without distorting the investment.

Dr. Price next considered the results of the pressure obtained from gas or air, and the effective pressure of the centrifugal machine. He said that the pressure obtained by gas is equal to the cross-section area of the mould in fractions of a square inch divided into the pressure per square inch of the gas. That is to say, if the cross-section area of the inlay or mould is 1-8 inch square, it will be the 1-64 of a square inch. If the pressure is 16 pounds per square inch, the actual effective pressure will be 1-64 of 16 pounds, which is 1-4 of a pound. Owing to the pressure leaking away through the investment, and other minor causes, Dr. Price considered the actual effective pressure to be not 1-4 of a pound, but 1-8 of a pound.

In regard to the centrifugal machine, the actual effective pressure is the weight of the mass of moulten gold multiplied by the square of the velocity of the gold in feet per second, divided by the radius in feet of the circle it moves in, divided by 32 to change pounds units to pounds pressure. To illustrate, take 1-2 ounce of gold, which is 1-24 of a pound Troy, revolving at the rate of 10 revolutions per second, or 600 per minute, in a circle which has a diameter of 10 inches, gives an actual pressure on the inlay of 2.14 pounds.

The speaker went on to say that owing to the difference of pressure on the inlay by the casting machine, and the centrifugal, in the case of the former the contraction of the inlay would be twenty thousandths per inch, while in the case of the latter the contraction would be thirteen thousandths per inch. This he pointed out would be a considerable factor in casting a long bridge.

Having dealt with the contraction of the metal, the lecturer then entered upon the second part of his subject, the expansion of the investment on heating. The manipulations of the investment has much to do with the success of the inlay. If the investment material is mixed very soft, and allowed to stand a couple of days, and then heated for a long time, the shrinkage will be considerable, perhaps twenty-five thousandths of an inch. If the

gold now be cast into this mould at a low pressure, there will be a distinct variation in size owing to shrinkage. If, instead of being cast at a low pressure, a high pressure were used to overcome the shrinkage, the result would be a distortion of the investment, and perhaps a production of "beads," which would interfere with the fit of the inlay. These facts point out the importance of a proper manipulation of the investment material. And so it must be admitted that in order to have a relatively perfect inlay there must be an expansion of the investment material to compensate for the contraction of the gold. The lecturer pointed out the necessity of having thick investment walls surrounding the mould; for if the walls are thin, and the investment is heated unevenly, distortion will result. Therefore, do not invest a large piece of work in a small investment cup.

The following table gives the expansion, and the contraction, of various investing materials. First, they are allowed to set thirty minutes and the readings recorded. Next, the records are given for their expansion and contraction in inches from 100 degrees up to 1,000 degrees Farenheit:

From this Chart, Dr. Price pointed out that the greatest expansion at 1,000 degrees was Dr. Taggart's invest, which expanded 8.5, whereas we need an expansion 15 thousandths at 700 degrees. The speaker said he had produced an investment which expands 12 thousandths at 700 degrees.

Another of the difficulties of cast fillings is the necessity of securing a wax impression in the mouth. Much better results would be obtained if a correct impression of the cavities and surrounding structures of the mouth could be taken, and a model reproduced in some hard material resembling stone. This would enable the operator to work under much more favorable circumstances.

The lecturer claims that he has produced such a substance which is named "artificial stone," which has the following advantages. It is almost as hard as the teeth themselves:

It has an expansion on heating that nearly corrects the contraction of the cooling metal. The filling is contoured in warm wax, and the metal is cast directly upon this model, and is not removed until completely polished ready for cementing. It withstands a temperature above that of an alloy of half platinum and half gold, and heat only hardens it. The margins of the frail walls are reproduced as strong almost as the tooth itself. Some of the many advantages are as follows: Reducing to a minimum the work in the mouth; completing the adjustment of the occlusion and contact points outside the mouth; having a dry non-vital structure to design and construct upon with perfectly free access to all sides and aspects, including the gingival margins,

Expansion and contraction shown by + and — in thousandths' of blocks of one-inch cube of the present investment materials.

Temperature degrees F.	Pelton and Crane	½ Pelton and Crane ½ Plaster.	Brophy's Imperial	½ Imperial ½ Plaster	Sump	½ Sump ½ Plaster	Dendrolite	½ Dendrolite ½ Plaster	Fyrite	½ Fyrite ½ Plaster	Peck's	½ Peck's ½ Plaster	Plaster Paris Medium Stiff Mix	Plaster Paris Thin Mix	I. D. L. Investment Composition	½ I. D. L. ½ Plaster	Dr. Taggart's	½ Dr. Taggart's ½ Plaster	Plaster set for 15 minutes	Plaster set for 15 hours
Started	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30-minute set	+1.8	+1.	+ .9	+ .8	+ .9	-1.	+ .9	+ .5	+1.	+ .5	+ .7	+ .7	+1.3	+1.	+ .7	+ .8	+ .7	+1.	+ .5	0
100	+1.8	+1.4	+1.2	+1.	+1.4	-1.3	-1.1	+ .9	+1.	+ .8	+ .9	+ .9	+1.4	-1.3	+1.1	+1.2	+1.3	+1.3	+ .9	- .1
200	+2.5	+2.5	+2.2	+2.8	+2.9	-2.4	-2.3	+2.1	+2.4	-1.9	-3.1	+2.2	+2.6	-2.5	+2.	+2.8	+2.3	+2.5	-2.4	- .6
300	+3.2	+4.	+3.1	+3.	+4.	+3.5	+3.5	+3.6	+3.8	-3.3	+3.7	+3.1	+4.5	+3.	-3.2	+3.6	+5.1	+3.2	-2.6	-1.5
400	+4.	+4.	+4.	+3.4	+4.	+3.4	+3.3	+3.6	-3.8	+3.4	+4.5	+3.2	+4.5	+2.5	+3.8	+3.8	+lost	+3.4	+2.5	-1.9
500	+4.8	+3.8	+4.4	+3.4	+3.8	+3.	+2.8	+3.5	+3.4	-3.2	+5.1	+3.	-4.3	-1.9	-4.1	+3.5	+6.2	+3.2	+2.2	-2.1
600	+5.2	+3.7	+4.4	+3.3	+3.5	-2.5	+2.4	+3.4	+2.9	+2.8	+5.7	+3.	+3.9	+1.	+4.6	+3.4	+6.8	+2.9	+1.5	-1.7
700	+5.7	+3.6	+4.5	+3.	+2.8	+1.7	+1.5	+3.2	+2.	+2.5	+6.4	+2.9	+3.4	— .1	+5.2	+3.	+7.3	+2.5	+ .8	+1.
800	+6.3	+3.6	+4.6	+2.8	+2.1	+1.	+ .5	+3.	+1.4	+2.1	+6.9	+2.8	+2.6	—2.	+5.5	+2.9	+7.7	+2.3	— .2	- .4
900	+6.7	+3.5	+4.8	+2.5	+1.2	0	— .5	+2.9	+ .6	+1.3	+7.2	+2.5	+1.4	—3.8	+6	+2.5	+8.3	+ .7	—1.5	— .3
1000	+7.1	+3.3	+5.	+1.8	+ .2	— .9	-1.8	+3.5	— .5	+.3	+7.8	+2.	0	—6.5	+6.6	+2.	+8.5	+1.4	—3.3	—1.
Tot'l contraction on cooli'g	—5.	—11.	—10.	—12.	—15.	—14.	—35.	—14.	—12.	—15.	—7.	—11.	—18.	—24.	—8.	—15.	—6.	—11.	—18.	—15.

TABLE II.

both for constructing and finishing; a rigid model or mount to hold your piece upon for finishing, eliminating the danger of distortion of margins and discomfort from heat in polishing, or of the inlay being caught upon the polishing disks, etc.; a hard, smooth surface to cast upon that will withstand any pressure desired without possibility of pitting or distorting, allowing of very high pressure in casting; a model so strong as to reduce the contracting tendency of the gold in part by withstanding it, causing the metal to stretch where it is held by the model; a rigid reproduction of the tissues and surrounding parts which are always with the piece being restored and an important aid in designing and finishing; a model upon which porcelain can be designed, formed and fused without removal from its surrounding relations.

Dr. Price next gave the details of the procedure in using this artificial stone. First a simple case was taken, as a buccal or occlusal cavity. An inlay for this class of a cavity is most quickly made by using a platinum, which is first burnished into the cavity; then wax, somewhat chilled, is pressed into the matrix and trimmed to the required shape. The pressure on the wax forces the platinum to all parts of the cavity. The platinum matrix filled with wax is next removed, and the back of the impression is filled with artificial stone. This is then heated and the wax removed. After heating three or four minutes gold can be fused into the platinum, and the inlay is polished and finished before removing it from the artificial stone. The stone is broken in order to remove the inlay.

A more difficult class of cavities to manipulate are those involving approximal surfaces. For example, take approximal cavities in two upper bicuspids. Of course the cavities are formed so that the impression material will readily draw. The next step is to take a piece of wire bent in the form of a shepherd's crook. The wire passes along the buccal surface, then through the cavities to the lingual surface, and either backward or forward along this latter surface. On this wire is now placed a piece of softened impression compound which the patient bites to place. The compound being chilled and removed now forms the impression tray. To obtain a sharp impression of the cavities, some softened, sticky wax is dropped on the cavity side of the tray, which is quickly placed in the mouth again, and the patient once more brings the teeth together pressing the wax into all parts of the cavities. The other side of the tray contains the impression of the opposing teeth, which will give the correct articulation. After chilling the impression is removed. Artificial stone is now poured into both sides of the impression, producing the cavities to be filled on one side, and the articulating teeth on the other.

The models dry in a couple of hours, when the compound and wax is removed. For ease and precision of work, and to obtain correct contact points, the model is fractured with wedge cutters at the two cavities. Each cavity is then filled separately with wax and correctly contoured. The two halves of the model are now placed together to adjust the contact point. After this is done, the two halves of the model, each containing a wax model of the cavity, are separately invested in the ordinary way with investment compound, and the inlay cast in the usual way. The inlays are always finished and polished before removing them from the stone model.

For casting inlays, Dr. Price favors an electric centrifugal machine. The machine should be so constructed so that the pressure and temperature can be readily controlled. That is, the operator should be able to flow the gold into the mould at a certain temperature and under a certain definite pressure which at all times is under perfect control. The lecturer went on to describe such a machine which he had designed.

Dr. Price now reached a most curious part of his discourse. We were told that the foregoing ideal conditions could be attained by the use of this artificial stone. In the next breath we are told that we cannot obtain even a sample of the material. This was rather aggravating. It was not the fault of Dr. Price, for he is willing to give the results of his labors free to the profession, but the manufacturers would not put up the material, because they claim they have no demand for it. It appears that the artificial stone is difficult to make. The lecturer explained that the artificial stone was a silicate cement, and is made by fusing an alluminum silicate in excess for reaction with calcium and magnesium oxy-silicates. This product forms with orthophosphoric acid an artificial stone.

Nevertheless, one of the dental dealers in Toronto say they have the artificial stone for sale as put up by a brother of Dr. Price, so all who wish to try it may get some to experiment with.