SPECIAL RESEARCHES IN PHYSICS

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(Read before National Association at Rochester, N. Y., July 7, 1914.)

THE special physical researches that have been conducted during the past several years in this office on the properties of waxes, investment materials and metals have been continued and have consisted, chiefly, during this year, in repeating the studies made previously to narrow the margin of former errors and to correct rather than to verify. We acknowledge the assistance particularly of Mr. Frank A. Fahrenwald, Professor Dayton C. Miller, Professor of Physics of Case School of Applied Science, Dr. Thomas J. Hill and Dr. George A. Shilling. Only a small part of the expense for these researches during this year have been met by the Commission. The results, however, are cheerfully given to them.

The coefficient of expansion of the waxes, as previously reported by the writer, (see Dental Cosmos, March 1911*) has been checked over and the change in the coefficient, with the increase of temperature, or progressive increase in the rate of expansion, has been carefully noted and tabulated. Some waxes that have been put on the market more recently than the time of the original studies have been added to the list. By comparing the results in table No. 1 of this issue with table No. 2, page 271, of the previous article above referred to, you will note the great similarity in the readings, which indicate, chiefly, that the waxes with corresponding names and readings have practically the same formula, as the samples secured in the open market some years ago. Several of the former waxes have been withdrawn from the market and several new ones are available. A word of explanation will probably make the table more easily interpreted. All are familiar with the fact that pattern and impression waxes have a considerable range of temperature

Figure 1

Wax	Approximate Working Range Min.	Approximate Working Range Max.	Contraction from Min. working range to 67.° F.	Expansion from 67.° F. to Max. Working range	Excess of Expansion over Contraction
S.S. White (Crown Sticky)	106°F	130.	1.06%	1.52	0.46
Standard inlay wax	110.	135.	1.12	3.07	1.95
Cleveland Dental.	109.	128.	1.20	3.47	2.27
Klewes	118	139.	1.30	2.90	1.60
S.S. White (black)	116	125	2.05	3.50	1.45
Paraffin	100	120	1.08	1.80	0.94
Kerrs	107	125	1.00	2.43	1.43
Consolidated	116	131	1.50	2.76	1.26
Caulks	112	130	1.25	2.31	1.06
Security	112	130	1.05	2.89	1.84
Japan (insect wax)	95	101	1.61	1.98	0.30
Carnauba	104	122	0.15	1.35	1.20
Ceracin	86	113.	0.72	1.42	0.70
Dum Dower	107.	122.	0.17	1.04	1.24
Stearin	104	122.	1.00	1.90	0.90
Taggarts (green)	104	130.	1.10	2.10	1.00
Van Horns.	112	130.	1.24	2.95	1.71

through which they may be moulded and worked but which ranges vary with different formulas. The two columns of temperatures underneath the general heading of "Approximate Working Range" indicate respectively the lowest and highest temperatures, bounding the range through which that particular wax can be moulded. The center column indicates the change in linear dimension (which is one-third the volume change) which takes place between the lowest working range and room temperature in the wax in question. The second column from the reader's right, while called ex-

*"The Laws Determining the Behavior of Gold in Fusing and Casting."

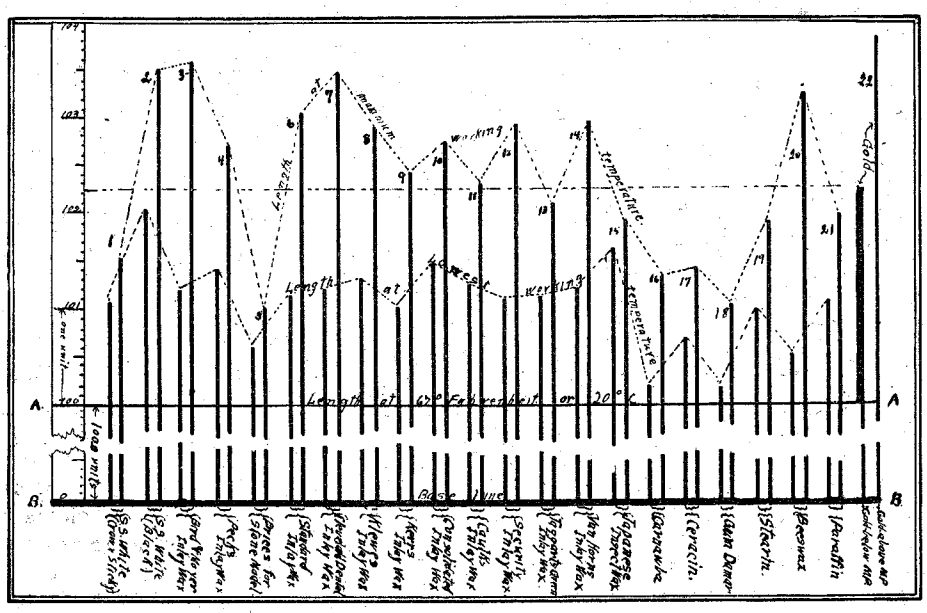
pansion, expresses the same dimension changes for the additional range in temperature up to the maximum working temperature and will be the same amount whether it is a cooling process or a heating process. The last column at the right expresses the difference, or the expansion, or contraction, taking place between the working limits of temperature. It will readily be noted that this dimension change within the working range varies from half of one per cent linear to two and one-fourth per cent linear, according to the wax. For those who are not familiar with the significance of this data and the enormous advantage or disadvantage it may be in the operations of making dental castings, we will review, briefly, the processes in which it is involved. When the wax pattern material is placed in the cavity at a temperature at which it is just plastic, see first column to the left, and is then removed from the cavity, either before or after being chilled, but finally brought to room temperature, 67° F. or 20° C.; its dimension change will be indicated in the middle column. If the wax is invested in the moulding material, usually plaster and silica, at this temperature the dimension of the mould will be in error the amount of the contraction of the wax. If, however, it is still further chilled by being invested in a very cold investment, this error will be increased. On the other hand if it is invested in a very warm investment, comparable to the upper working range of the wax (see second last column) the pattern may be brought back to its original dimension and enlarged a definite per cent above it in proportion to the formula of the wax and the temperature of the investment. (See the last column.)

Neglecting for the present the relatively small change in dimension that may be made in the investment material by heating it and passing to the process of putting the molten gold into the mould and allowing it to cool, we have with all investments (except stone hard investment materials, which may be strong enough to stretch the gold) a definite fixed contraction always present with the cooling gold, which amounts to 11.53% volume of 3.84% linear, from the time the gold is in the molten state until it is at room temperature, but of this 4.93% volume, or 1.64% linear, is due to change of state of the gold and occurs in a change of temperature of less than one degree and which expresses itself as a fault or hollow in the side of the casting, which, however, need not appear, and does not, if fresh molten gold is permitted to pass into the form and take the place of this first contraction. The larger part of the contraction of the gold from its crystalizing point to normal temperature, amounted to 6.6% volume or 2.2% linear, is always present, even though its location is disturbed by holding the mass and stretching it.

It is this large fixed error, due to the contraction of the gold after it leaves the molten state, which is the large embarrassment we have been seeking to find a solution for and which our practical results show the justification of. Since the contraction of the gold is a constant factor and of a definite amount, we may plan, systematically and definitely, to introduce an error that will precisely compensate or offset for the contraction of the gold, and whether we are so precise as to produce approximately the exact amount or not is not so important as that we work with sufficient intelligence and consistency as not to add to that fixed error, an additional amount which may even exceed that of the contracting gold, due to change in dimension of our wax pattern. We are not, in this observation, stating a new truth, or suggesting a new method or process, but reviewing briefly for clearness. For a more elaborate statement of this procedure see the article referred to above by the

writer.* Also one by Dr. C. S. Van Horn, Dental Cosmos, October 1911.** It should be clear that, if possible, we should so handle our wax pattern as not to add its large dimension change to that of the gold's fixed change, but, if possible, so thoroughly understand the wax with which we are working as to know what treatment to give it that would correct for the contraction of the gold. have been able to secure in the open market, placed in a graphic chart where at a glance we can see the fixed dimension change due to the contraction of the gold and by the side of it the available dimension change that takes place in the various waxes and which amount can largely, or in part, be added to, or subtracted from, the dimension change of the gold. These are shown in Figure No.

Figure 2


A.
B.
Length at 67° Fahrenheit or 20° C.
Base Line
Gold
Wax
Temperature
Working
Length at
Wax
Temperature
Working
Wax
Temperature
Working
Wax
Temperature
Working

it is the distance from 100 to 101, etc. Also, the actual distance between lines A. & B. Each pair of double vertical lines represents one of the waxes but a few are constituent or basic waxes used for making them. The elevation above the line A., which is labeled "Length at 67° F. or 20° C." represents the expansion which occurs above that when the wax is heated to its low working range, represented in the shortest of the two columns, and to its high working range as shown in the longer column. The two columns at the extreme left marked 22 represent the dimension changes in gold. The long column represents the total dimension change in a column of gold one hundred units long between its molten state and room temperature, namely 3.84% linears. The heavy shorter column next to it represents the dimension change between its first crystaline form and room temperature, or 2.2% linear, and the difference between their lengths, the dimension change due to change of state from liquid to solid, namely, 1.64%. These two columns are marked gold. The names of the respective waxes are given below the base line and the columns are numbered above. The dotted line extending across the chart from the level of the shorter double blacked gold column to the point 102.2 on the scale indicates the amount of expansion that would require to be used with each wax if we were to just compensate for the fixed contraction of the gold. The names of the waxes from left to right are:

1. S. S. White Crown Sticky.
2. S. S. White Black.
3. Bird & Moyer Inlay.
4. Peck's Inlay.
5. Price's for Stone Model.
6. Standard Inlay.
7. Cleveland Dental Inlay (old formula).
8. Klewes Inlay.
9. Kerr's Inlay.
10. Consolidated Inlay.
11. Caulk's Inlay.
12. Security Inlay.
13. Taggart's Crown Inlay.
14. Van Horn's Inlay.
15. Japanese Insect.
16. Carnawba.
17. Ceracin.
18. Gum Damar.
19. Stearin.
20. Beeswax.
21. Paraffin.
22. Gold.

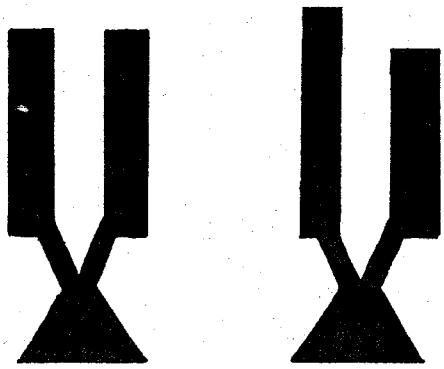
The Asterisk on Carnawba and Gum Damar indicates that their softening points, which are high, were not reached at the temperature used.

It will readily be seen from this chart that many of the waxes do not have sufficient change to offset or equal that of the contracting gold, while several others have more than is necessary if in any case it could all be utilized. Note particularly that several have relatively a small difference in dimension between their high and their low working range, which is clearly the part that can most easily be made use of. Others have a very large dimension change between these points. Let us for illustration apply the information in the chart to practical procedure. No. 1 is not a pattern wax, yet many dentists use it for taking impressions because of its great strength. If we were to take it from the cavity at its low working range and cool it to room temperature and invest at that temperature and cast, we will carry forward 1% contraction error to add to our 2.2% of the gold. If we heat this wax to try to put in an error of expansion to offset the gold's contraction, we can only get half of one per cent above the dimension at which we removed it from the cavity. If we make the same tests with wax No. 2 we may either add two per cent to the error or we may take out 1½%, or even more, up to 3% if we use nearly all the available expansion. With No. 3 the difference between the dimensions at low and high working range is 2.4%, or more

than enough to offset the gold contraction. If Nos. 2 or 3 were removed at a temperature near their high working range and invested in an ice water investment, a contraction error of over 3% could be carried forward to which that of the gold would be added, making a total of 5%. If, on the other hand, these same waxes could express, by their volume, the exact dimension of the cavity when they were at a temperature of 67° F. and could then be heated to their high working range and invested, they would produce a mould 3.5% larger than the cavity which, when the gold was cast into it and contracted its fixed 2.2%, would produce a cast still 1.3% larger than the cavity. These results can readily be produced, as will presently be shown. There is no doubt that many of the profession have been introducing an error with their wax, thereby increasing that of the contraction of the gold and probably not infrequently doubling it.

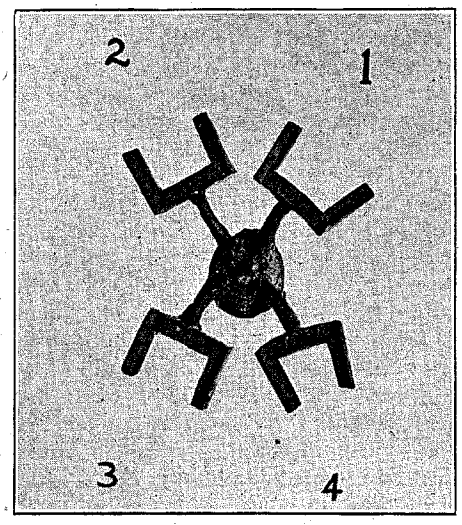
This would seem to be an ideal and simple way to correct for the fixed contraction of the gold and is, if the next distortion error is prevented from entering, which arises out of the elasticity of the wax. Figure No. 3 demonstrates this, as does also Figure No. 4. In Figure No. 3 we have two cast columns of gold both attached to the same sprue and hence from the time of investment they have had the same treatment. These two bars differ 18% in length, yet they were cast at once from wax patterns which were the same length. All waxes are more or less elastic when heated to their low working range. Any one can produce the error shown in Figure 3 as follows: Take two pieces, or bars, of inlay pattern wax, (These were made from Cleveland Dental—their old formula) and place them in warm water and heat to the low working range. Take one of the bars out and stretch it and while holding it plunge into cold water to chill, and thereby retain the elasticity. Then take the other piece and do the opposite by condensing it endwise and chilling. While cold cut a piece one inch long from each and attach to a sprue. Mix the investment with water at the temperature of the high working range for the wax used and invest. When you last see

Figure 3



Two similar wax bars placed in a warm investment and cast. A, Before heating. B, After heating.

Figure 4



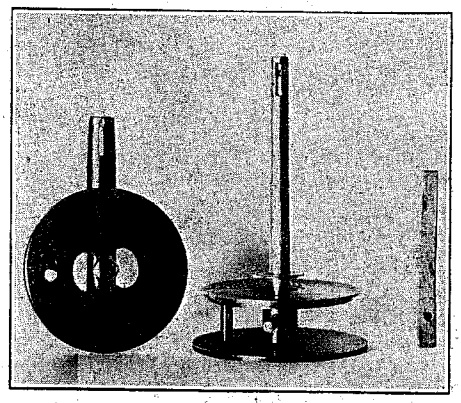
the waxes they are the same length but the warm investment releases their elasticity like the thawing of a frozen stretched rubber band. Each relaxes to its normal molecular state of rest without strain. The elongated one shortens and the shortened one elongates. It is true that these are extreme conditions, however, there is abundant evidence that in a considerable degree this error enters into much of our technic. We are liable to be misled and conclude that this is an extreme test and, therefore, not comparable to dental precedures, and particularly that it would be impossible to produce any considerable elastic distortion in the production of an MOD restoration. Figure No. 4 clearly demonstrates that it is possible to very simply introduce this error in our ordinary technic, for all four of the MOD reproductions were cast at the same time, being attached to the same sprue, and all had precisely the same treatment and conditions except the elastic content of the wax. These patterns, when in the wax and attached to the sprue before investing in the warm investment, were uniform in size and shape, so much so that they could not be discerned one from another. It is particularly interesting to note that Nos. 1 and 2 had the wax put into the cavity by one technic, except that in No. 2 the elasticity was released, and Nos. 3 and 4 by another technic, except that No. 3 had the elasticity released. As you will readily see No. 1 opened and No. 4 closed so much that they would not fit the form at all, while Nos. 2 and 3 fit very correctly. Before stating the difference in the technic of these two bars we should review the physical conditions obtaining in the compound MOD cavity. When a restoration is being made, for a simple occlusal cavity with all walls present, we have only to adapt to inside dimensions and if our inlay is prepared with bevel margins, the fact that it has contracted does not prevent it going to place but simply gives it cavity surface freedom and allows it to settle in a little farther, unless it rides on the pulpal floor, which surface of the inlay can easily be ground. The fact that the gold has contracted makes the inlay enter the cavity more easily than if it had not. If, however, we must restore outside dimensions, only as for example a band surrounding a root or porcelain tooth, the same contraction prevents the gold from going to place by drawing it toward the wall at every point instead of away from it as in the former case. This would be relieved by an expansion and the surface freedom would be in proportion to that expansion. If our restoration is for conditions having both inside and outside dimensions, we immediately meet a new set of restrictions, for while an excess of contraction of our gold will give us cavity freedom on the inside dimensions, it brings embarrassment to the outside dimensions and an excess of expansion, while producing the desired freedom on the outside dimensions will embarrass the inside dimensions. We are required, therefore, in this case of restoration, to work with relative exactness or to introduce a technic that will increase our surface freedom on all surfaces. This can be accomplished by moving the pattern back and forth, in the cavity, thereby planing off as it were all surfaces and producing a free space on all surfaces. This can also be accomplished by compelling the wax to have an excessive shrinkage away from all margins which follow inside dimensions and secure the required freedom for outside dimensions by the expansion of the mass. A suitable technic for this will be described later.

Returning to the description of Figure No. 5 the wax material of the pattern, for both one and two, was introduced by taking a bar of the wax, after it had been kneaded with the fingers, and bending it like a horseshoe at its low working range and in this way placing it in the cavity. The contained elastic strain tended to

make the heals open outward when it was placed in the warm investment, which occurred in No. 1. No. 2 was treated in precisely the same way except that before it was removed from the cavity it had its elasticity released by placing a warm instrument, warm enough to melt the wax, into the mass of wax extended to what would be the gingival floor of the cavity, which released its elasticity. This is also accomplished by flooding the tooth or form with hot water after the wax has been inserted, which accomplished the double purpose, namely, of releasing the elasticity and by an excessive expansion makes some of the wax bulge out of the cavity, which should be scraped off instead of being pressed in after the temperature is reduced. Nos. 3 and 4, Figure 4, had the wax inserted by moulding it into a ball and while at its low working range pressing the ball into the occlusal surface and into the mesial and distal chambers, which introduced into the wax an elastic strain, which tended to make the heals draw toward each other when all four were placed together in the warm investment. This is shown in No. 4. No 3 had identically the same treatment except that before the removal from the cavity its elasticity was released. Nos. 2 and 3, Figure 4, had, therefore, their elastic strain in opposite directions, as expressed in Nos. 1 and 4, but both are of closely the same size after casting and therefore their elastic strain must have been released. The contraction and distortion errors we are here studying become most embarrassing when we are making very complicated restorations, such as the casting of a crown base when it involves outside dimensions or MOD inlays, involving both inside and outside dimensions. It is probable, however, that few of the profession have appreciated how universally this embarrassment enters into our work. This has been most forcibly demonstrated in the past two years by the results of a series of tests made by different members of the profession, partly because of a premium that was offered by the writer of $150.00, which was placed in the hands of the Program Committee of the Cleveland Dental Society, to be given as three prizes for the first three members who would produce a cast restoration which would go to place within one-fiftieth of an inch. The judges were to consist of a committee of five, four of whom were to be dentists and one a Professor of Physics, which committee has done its work very patiently and efficiently. The form that was first provided consisted of a taper column one-fourth inch in diameter. The taper of the sides was to be one per cent per inch with respect to a common perpendicular. This form was expected to reproduce, approximately, the conditions that obtained when casting a gold base for a molar porcelain crown, where the gold extended over the bevel of the porcelain, as well as over a bevel on the roots, but where these bevels were one per cent to a common perpendicular. This condition provides for the reproducing of both an inside and outside dimension at the same time. As stated, the outside dimension, represented by the periphery of the root and the base of the porcelain, was represented by the taper column, the inside dimensions being the pulp chamber and post hole in the porcelain, were represented by surfaces on the inside of a ring. See Figure No. 5. A number of restorations were made for this form from different parts of the country. The conditions for securing the premiums required that the ring go to place over the outside dimensions and in the inside dimensions of this form to within one-fiftieth of an inch of its position when the pattern was made, for in making the pattern the taper column was drawn through it. This would be equivalent to the porcelain tooth going to place in its cast base when placed in the mouth so that the tooth of the opposite jaw, which had been in a normal occlusion at

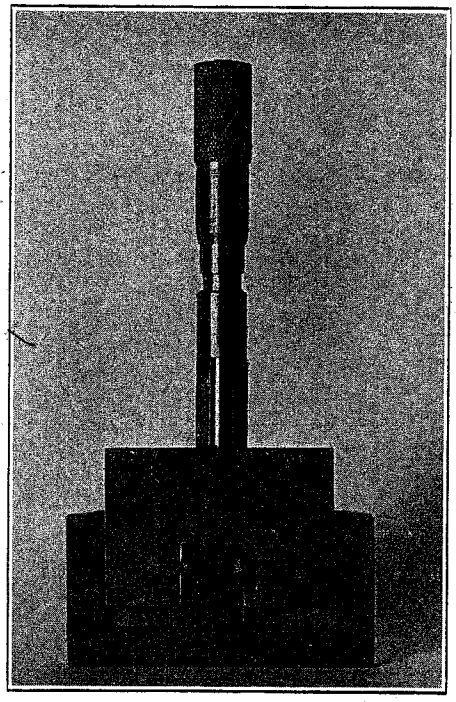
the time the impression was taken, would be not more than one-fifth of an inch from being in occlusion again. A brass plate represented the porcelain tooth in this form. The nearest that any of the restorations came to going to place on this form was one-half inch instead of one-fiftieth of an inch, because of the contraction around this taper column. Objection was made to this form, many dentists stating that they did not cast crown bases but that they could cast MOD fillings with accuracy. Others

Figure 5



stated that they could cast half a ring, even if they could not cast a whole ring, that it was the hole that made the trouble. The explanations for the failures were varied and interesting. Accordingly, the form in which the tests would be made was changed to represent the conditions of an MOD filling, but unfortunately the mechanic got his dimensions large. The wax was put in from the side instead of the end of what would represent the mesial and distal chambers of the cavity. This form is shown in Figure No. 6. The surfaces representing the pulpal walls had a bevel to a common perpendicular of one per cent. The restorations made in this form did not go to place much better than those made for the previous form. Objection was made to this form on the ground that it was abnormally large and that the wax was put in from the side instead of the end. Accordingly, the third form was made, which reproduced, in a very hard steel, as nearly as possible, the actual condition obtaining in the molar tooth one-fourth inch in diameter with an MOD

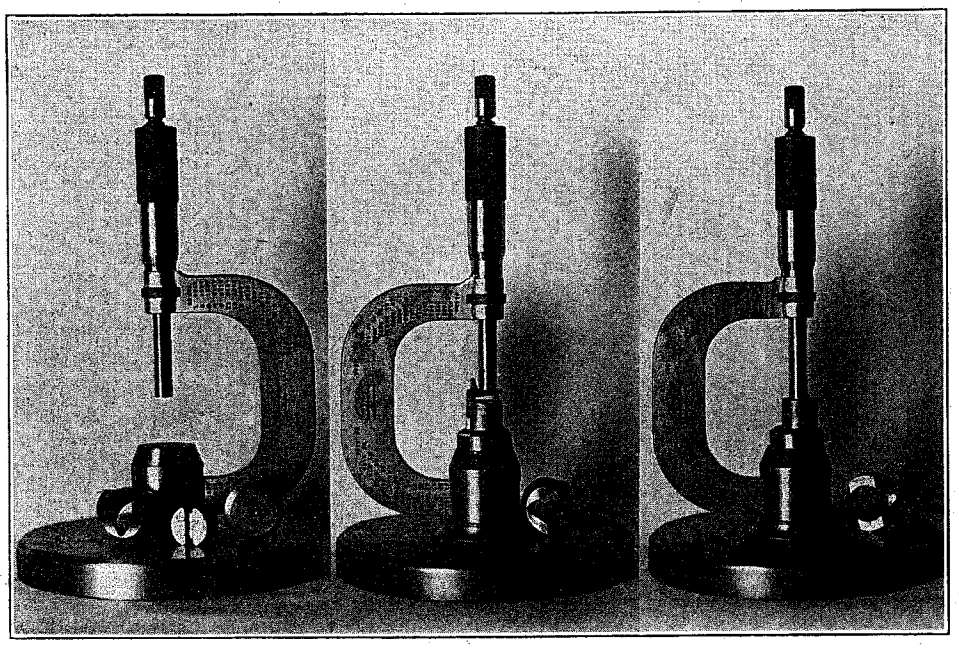
Figure 6



cavity, all walls of which had a taper of one per cent to a common perpendicular. This instrument is shown in Figure No. 7. It is interesting to note that no restorations were made in this form, under the conditions prescribed by the committee, which went nearly to place. The prime condition to secure the premiums required that the restoration go to place within one-fiftieth of an inch, under a pressure not exceeding five pounds. No restorations made in the test went even half way to place and many would not enter

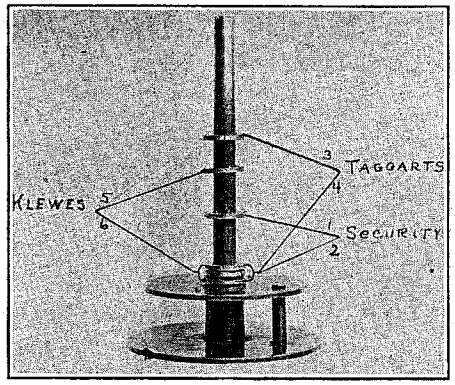
the cavity. Had the contestants used the information that is contained in Figure No. 2, they probably could easily have secured the premiums, for many restorations have been made by following these directions, which were within the requirements. Figure No. 8 shows two rings made with each of three waxes shown on this list, namely, The Cleveland Dental, Klewe and Taggart. With each wax an effort was made to make two rings, one of which would be large and the other small, the latter produced by adding the error of the wax to the error of the gold, and the other, which was large, by subtracting the error of the wax from that of the gold. In other words by introducing a correction. The three rings, Nos. 2, 4 and 6, shown on the bottom of the column in Figure No. 8 are all so large that they will pass readily over the base of the taper column, while the duplicate of each. Nos. 1, 3, 5, stop high on the column, as shown. A large number of restorations have been made in the MOD form, which are so loose that they will rattle. The procedure is as follows: When we make an MOD pattern, and chill it in the cavity, the wax contracts and by being held takes on a condition of elastic strain. If this pattern is removed from the form or tooth, after being chilled, and we undertake to introduce an expansion sufficient to overcome the contraction of the gold, the warming of the pattern releases this elasticity, producing a distortion. If, however, we will remove this wax while it is warm and place it in cold water, producing its contraction without strain, it does not take on an elastic stress. It would, however, be too small to go back into position in the form or tooth. If, now, we will break it across the occlusal and while keeping it chilled replace it in the form or tooth, we will have quite

Figure 7



a wide crack between the broken surfaces. We will now take a wedge of new wax and force it into this opening, after softening the edges with a warm instrument. This will introduce enough new wax in that particular part which has to do with our outside dimensions, so that when the pattern is removed and invested in a warm investment, which temperature is dependent upon the formula of the pattern material, we will produce sufficient expansion of the mass of wax so that it will readily go over the outside dimensions. Care should be taken, however, to release the elasticity of the wax, as previously described, namely, by either flooding the tooth with hot water, prior to fracturing it across the occlusal surface, or by using a hot instrument, passing well up to the cervical floor of the cavity. Another method that answers well, instead of breaking the MOD pattern, is to cut it across the occlusal surface with a sharp knife in one or two places before chilling in the tooth, thereby allowing the contraction to express itself at the point of separation, and after producing the contraction insert additional wax as before. Rings can be made by this same method, which will introduce an expansion correction in the wax more than sufficient to compensate for the fixed contraction of the gold.

Figure 8



Inasmuch as ordinary dental MOD cavities are not prepared with walls so near parallel as one per cent to a common perpendicular, their wider bevel allows them to go more nearly to perfect seating before binding and a less exacting technic will be sufficient to control the contraction of these cavities, which is as follows: Place the wax in the cavity at any desired temperature and after trimming and carving to form, warm thoroughly through, making it very soft by means of a stream of hot water. This will expand the wax, pushing the excess slightly out of the cavity, which will be recarved while hot. Next, place a threaded molybdenum or tungsten bar or wire into the occlusal mass of the wax and recarve, or cut through the occlusal and chill in the cavity and introduce more wax in the cut. Remove and invest in each case in a warm investment. The coefficient of expansion of molybdenum and tungsten is very much less than the gold, the former, being about one-fourth that of gold at normal temperature, and through the entire range of the melting of gold less than one-fifth.

A series of quantitative studies were made to ascertain the laws governing the elasticity of wax. It was found that the standard inlay waxes have an elastic content ranging, 20, 30, 40 and 50 per cent, according to the treatment of the wax, and also that this elastic content tended to release itself if the wax was held for a sufficient length of time, amounting in some cases to days. Figure No. 9 gives a series of curves, showing the rate of release of elasticity of retained wax bars, due to molecular flow. The continuous lines represent tests with bent bars, the dotted lines compressed bars and the alternate line and dotted line stretched bars. This chart shows that with the various waxes and various treatments, the elastic content, though starting as high as fifty and forty per cent, drops to within ten per cent in twenty-four hours, and is practically

gone in ten days. The numbers on the base line indicate the number of days during which the molecular flow is allowed to take place and during which time the wax was retained in its bent position. It clearly is not possible for us to leave our wax patterns in the tooth for a day, or days, in order that the elastic stress may be released by a molecular flow, but it does answer the question why, when a wax pattern is made in the form and left in the form for days before being removed and then cast, it produces a better fitting inlay than if removed at once, unless the elastic content has been released by a quicker method, as by raising the temperature of the wax to the point at which it speedily releases it while the wax is still in the form or tooth. Figure No. 10 shows graphically the form in which the wax bars were bent and held for measuring their elastic stress. A represents the position of the wax bar with its base fastened securely in the angular groove. B shows the amount of bend put in the wax while at its low working temperature. C represents the amount of return, or elastic content, which takes place if the pressure is withdrawn and the temperature slightly raised, which, with all waxes, is large and with many amounting to forty and fifty per cent of the original bend.

Figure 9

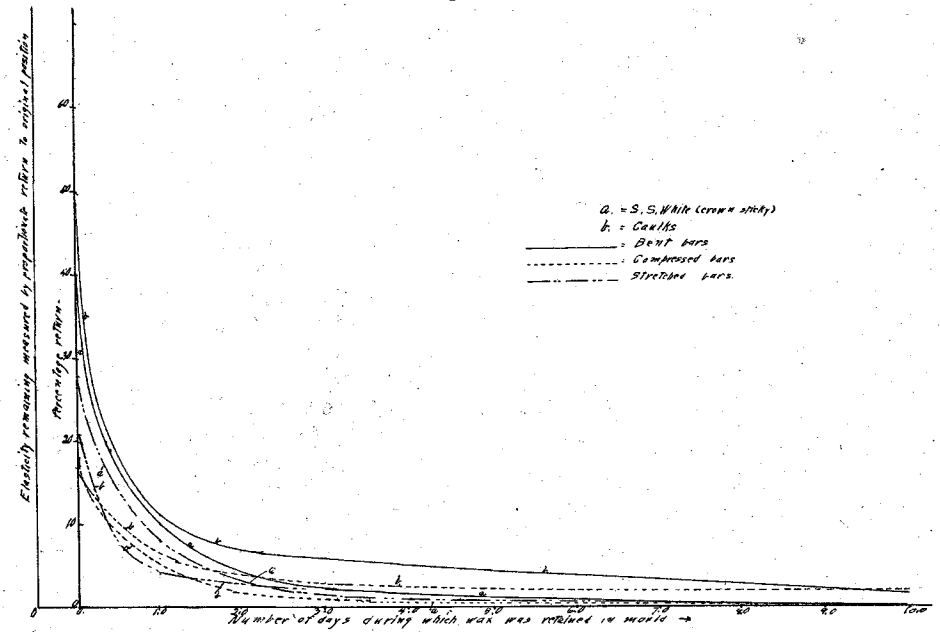
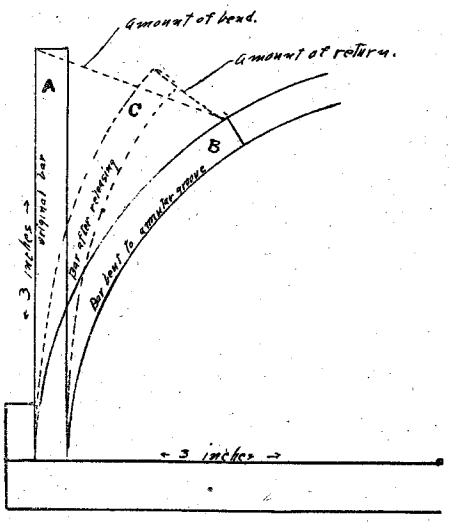


Fig. No. 9 - Curves showing the rate of release of the elasticity of retained wax bars due to molecular flow.

The members of our profession will find great benefit and satisfaction in the placing of either staples, or a piece of straight tungsten or molybdenum, threaded or roughened, bars in their complicated patterns, which will control, largely, the warpage of the wax, due to elastic strain, and in a large measure will control the contraction of both the wax and the gold. They will also find it a great advantage to make themselves familiar with means for controling and

Figure 10



releasing the elasticity of the wax and thereby prevent its distressing distortions. We will strongly recommend that you study the coefficient of expansion of the wax you are using, if it is not shown on the chart in Figure No. 2, which contains all the waxes that could be obtained in the open market, make tests to determine its co-efficient of expansion and endeavor to so manipulate it that you will make its dimension change compensate for the fixed contraction of your gold, and this without introducing the errors of the elasticity of the wax. We would recommend that you familiarize yourself with the information shown so graphically in Figure No. 4, which shows the errors and corrections all in one simple casting.

REPORTS OF RESEARCHES IN PROGRESS UNDER THE AUSPICES AND SUPPORT OF THE SCIENTIFIC FOUNDATION AND RESEARCH COMMISSION OF THE NATIONAL DENTAL ASSOCIATION

Organized July, 1913

(Read before National Association at Rochester, N. Y., July 7, 1914.)

Executive Board—Weston A. Price, Chairman, 10406 Euclid Avenue, Cleveland, Ohio; Thomas P. Hinman, Vice Chairman, Fourth National Bank Building, Atlanta, Georgia; Clarence J. Grieves, Secretary-Treasurer, 201 W. Madison Street, Baltimore, Maryland; John V. Conzett, 256 13th Street, Dubuque, Iowa; Eugene R. Warner, 401 California Building, Denver, Colorado.

Members—George T. Williams, Seattle, Washington; *George E. Hunt, Indianapolis, Indiana; W. T. Farrar, Louisville, Kentucky; Percy M. Williams, Rutland, Vermont; Samuel H. McAfee, New Orleans, Louisiana; Edward C. Kirk, Philadelphia, Pennsylvania; William Carr, New York City, New York; Truman W. Brophy, Chicago, Illinois; Greene V. Black, Chicago, Illinois; Homer C. Brown, Columbus, Ohio; Thomas B. Hartzell, Minneapolis, Minnesota; Arthur R. Melendy, Knoxville, Tennessee; Edward S. Gaylord, New Haven, Connecticut; Henry C. Ferris, New York City, New York; Charles Channing Allen, Kansas City, Missouri; Frank O. Hetrick, Ottawa, Kansas; Marcus L. Ward, Ann Arbor, Michigan; Frank L. Platt, San Francisco, California; Chris. S. Van Horn, Bloomsburg, Pennsylvania; Roscoe H. Volland, Iowa City, Iowa.

Ex-Officio Members—Donald M. Gallie, President National Dental Association, Chicago, Illinois; Otto U. King, Secretary National Dental Association, Huntington, Indiana.

*Deceased.

In addition to the researches herewith reported, the Commission has assisted, during the past year, the researches being conducted by Dr. G. V. Black, of Chicago,, Illinois, on "Studies of the Peri-Dental Membrane and of Salivary Calculus" and Dr. Frederick B. Noyes, of Chicago, Illinois, on "The Dental Pulp and Peri-Dental Tissue." Their results will be reported in due time.

The Commission hereby disclaims any and all responsibility for the statements made in this issue or that shall, at any time, be made or published by the research workers, whether technicians or directors, whom the Commission is endeavoring to assist. The authors themselves are individually responsible for their statements.

No money has been paid by the Commission to any of the Directors of these researches for their time or efforts, the assistance given them has been in the form of supplies and a fund for providing technicians to assist in the detail work. The entire cost of the researches of the past year do not reach $4500.00, which is approximately equivalent to an expense of twelve cents for each member of the dental profession practicing in the United States. It is confidently expected that with the increasing support of the profession the work can be very largely increased this next year, both by continuing and enlarging the present researches and by supporting and establishing some new ones. The budget as planned by the Commis-

sion for this year amounts to nearly $8,000.00.

In addition to continuing and enlarging the researches of the past year, the Commission is arranging to assist some additional studies, including Dr. Marcus L. Ward, Ann Arbor, Michigan, on "Cements," and Dr. Wm. J. Gies, New York City, on "The Relation of the Ductless Glands to Definite Dental Problems."

The receipts and disbursements to date are briefly itemized as follows:

Amount of subscriptions, due annually for five years, July 8, 1913	$ 2500.00
Or for five years	12500.00
Amount of subscriptions, due annually for five years, on July 6, 1914, including the former, are	8179.50
Or for five years	40897.50
Total cash collected to July 6, 1914	7067.50
Total disbursements to the close of the National meeting, July, 1914	4378.06
Balance in the Treasury	2689.44

Itemized Disbursements.

To Technicians to July 1, 1914:

Mr. Fahrenwald, assisting Dr. Price	$ 1100.00
Mr. Rickert, assisting Dr. Bunting	500.00
Dr. Leonard, assisting Dr. Hartzell	343.75
Mr. Gaskill, assisting Dr. Hartzell	376.32
Dr. Henrici, assisting Dr. Hartzell	300.00
Dr. Potts, assisting Dr. Black	300.00
Dr. Larsen, assisting Dr. Hartzell	100.00
	$ 3020.07
For laboratory equipment for Dr. Hartzell	$ 368.50
For laboratory expenses for Dr. Noyes	100.00
For Metallurgical Laboratory expenses	186.25
Traveling expenses to December, 1913, meeting of the Board at Toledo, Drs. Warner and Hinman	129.25
Bond for Dr. Grieves	7.50
Postage, Printing, Stationery, Stenographer, (including all office expenses) from January 1, 1914, to July 1, 1914	565.89

The expenses, including printing, postage, stationery, clerical work, etc.; incidental to the organization and development of this department from September, 1912, to January 1, 1914, amounting to $1073.39, were contributed by the Chairman. The Executive Board and Commission refused to permit this and ordered that it be carried as an expense bill with interest at six per cent. The Chairman thereupon contributed this amount to the Endowment Fund, which fund, it is expected, will, ultimately, become large enough to enlarge and carry on the work perpetually.

THE EXECUTIVE BOARD.

TRANSACTIONS

OF THE

EIGHTEENTH ANNUAL MEETING OF THE NATIONAL DENTAL ASSOCIATION

Held at Rochester, N. Y., July 7-10, 1914

FIRST GENERAL SESSION

The first general session of the Eighteenth Annual Meeting of the National Dental Association was called to order at 11 o'clock Tuesday morning, July 7th in Assembly Hall, Exposition Park, Rochester, N. Y., by the President, Dr. Homer C. Brown, of Columbus, Ohio.

The President introduced the Rev. C. Waldo Cherry, of Rochester, who invoked the Divine blessing upon the deliberations of the Association.

THE PRESIDENT: Gov. Martin H. Glynn had expected to be present to welcome us in behalf of this great State, but in his absence he has delegated Dr. Downing to act for him on this occasion. I take pleasure in introducing to you Dr. Augustus S. Downing, Assistant Commissioner for Higher Education of the State of New York. (Applause).

Address of Welcome.

Mr. President, Ladies and Gentlemen:

It is a very unexpected but distinguished honor that comes to be my lot this morning, to present the sincere regrets of His Excellency, the Governor of this State, that he is, because of his official duties, unable to be present with you. In lieu of his presence, he has sent to you his greeting and welcome in the form of a letter which I have the honor now to read.

To the President and Members of the National Dental Association, Assembled in Rochester:

Ladies and Gentlemen:

I appreciate the invitation to meet the members of this conference, and regret that my engagements do not permit me to be present. This is perhaps the first time that my regret at foregoing a visit with members of your profession has been entirely sincere, for all other invitations have been from doctors of dentistry in their official capacity, and for professional purposes.

The reluctance with which the average man approaches the dentist's chair is in a way a measure of the usefulness of such gatherings as this. The more man dreads the operations which are necessary for his health and comfort, the greater is the need for co-operation which will make these operations easier and more comfortable. There is counsel as well as safety in numbers, and the foregathering of members of the dental profession from all over the country indicates that they are seeking an exchange of ideas which is the surest guarantee of progress, and, far from being indifferent to your deliberations, men from other walks of life are interested in the progress of your profession. This country should take an especial pride in the profession which you represent, for, just as we are apt to look abroad for leadership in medicine and surgery, the rest of the world looks to America for leadership in the field of dentistry.

I bespeak for you a pleasant and successful conference, and extend to our visitors from other commonwealths a cordial greeting on behalf of this State.

Yours sincerely,

MARTIN H. GLYNN.

(Applause.)