

tion to end products resultant upon putrefactive changes. Wash and dry with alcohol and warm air. If there yet remains any vital pulp tissue in the apical region, apply cocaine adrenalin solution as in the second step, with Class 2.

Those who are opposed to the use of arsenic will reflect that in this class of cases we have a suspended circulation and the peridental membrane is not endangered as in the case of a vigorous circulation.

In closing, it should be remembered that in all pressure anaesthesia cases we have a pulp stump which is vital and in a short time will be liable to post-extirpation pains. This may be entirely avoided if a temporary dressing is used wherein one of the ingredients is carbolic acid, or a thorough cauterization with carbolic acid is made before dressing root canals.

THE ADVANTAGES OF THE PYROMETER FOR OBTAINING EXACT RESULTS IN BAKING PORCELAINS.*

BY WESTON A. PRICE, M. E., D. D. S., CLEVELAND, OHIO.

While successful porcelain work is dependent upon several factors which are both mechanical and artistic, yet if we use porcelain as a material for filling and crowns because of its better color we only accomplish that end when we so perfectly reproduce and restore the natural color as to completely conceal its artificiality, for in this branch of dentistry as in no other, "The perfection of art is the concealing of art."

To exactly reproduce the color of a tooth, we must be able to accomplish two things; viz., select the porcelains that will produce those exact color effects, and to produce those exact and definite results in color with that porcelain after selecting it.

The former depends largely on the artistic taste of the operator, and the latter on his ability to manipulate it so as to get exact and universal results. It is here that the pyrometer will be of greatest assistance, for with it he can be sure to produce exact and universal results which few, if any, can do so well, if at all without it. It will also assist him greatly, as will be shown in the purely artistic part of the work, the matching of the color.

*Read before the Ohio State Dental Society, December, 1904.

The greatest difficulty we encounter is that the color of all porcelains bakes out in a greater or lesser degree with increases of temperature. With most shades of most makes of porcelains an overbake of 100 degrees Cent. will remove 75 per cent. of the color and 25 degrees, not quite a proportional amount. This requires that with most colors for the exact production of a given shade with a given body we must bake it to within a few degrees of the same temperatures. This can be done with precision with the aid of the pyrometer and certainly cannot be done every time by many, if any, without. We will illustrate with these cards carrying buttons of baked porcelains of nearly all the principal makes.

This card of White's inlay porcelain shows the relative color and contraction when baked at each 50 degrees Cent. and 100 degrees Cent. too high and too low. It also shows the relative crushing strength which is reduced by both over and under baking. In general the results are the same except in degree with all porcelains, viz., that the color is considerably baked out at 50 degrees Cent. too high and nearly all baked out at 100 degrees Cent. too high. The contraction continues with the over-fusing and is greater with some porcelains than others, but in general is greater for low-fusing bodies than for high. Some bodies tend to spheroid much more than others with over baking. There is considerable difference in the working range or variable fusing temperature of different porcelains and of different shades of the same make of porcelain.

For example, Brewster's foundation body, shade brown, allows a range of 50 degrees Cent. too high or too low without materially effecting the shape or color, while Jenkins' body at the same amount of overbake changes shape materially and some shades of Brewster's enamel body and several shades of other bodies are very naturally changed by that amount of overbakes. With some colors ten or twenty degrees is sufficient to perceptibly change the color. I will pass cards bearing sets of six shades produced from each of Brewster's enamel bodies, each being baked at 25 degrees Cent. higher than the last. You will note that many of the shades of the shade-ring can be produced with just one color, for example: With F. you have about the steps A., B., C., D., E. and F., and with K. you have the shades I., J. and K., etc., so that the operator may say I should have selected D. or E. instead of F. to match this case,

while in fact he can still get it precisely by baking just exactly 25 degrees higher.

You will note from these cards of shades that some colors bake out more rapidly than others, which may if you have found out by experience, but they are all constant with the same baking.

The shade N., for example, loses its color very much less rapidly than most of the other colors and this by the way was the color fused for nearly all the trial bakes by other operators. The color that gave the widest range of baking temperatures without changing the color.

Now the average operator will say that the difference in color between the different shades of, say yellow, is so slight that if he selects the shade nearest to the tooth in question he will match the color near enough. If he could produce precisely just that shade with that porcelain it might be as high a standard of excellence as we should expect of the average operator, though the real expert will work to a much closer ideal with the means for doing so. But that is just where the trouble comes in, viz., can the average operator or any operator produce invariably a definite exact shade with a given porcelain and does he in practice? I know there are many who think they can, but after seeing from the results of tests that many of the most confident and supposed most competent have sadly failed, I personally am convinced that but few if any can produce a uniformly definite result. We each will, for example, take the shade-ring with the same shades as nearly as the manufacturer can make them the same shade and match them to the same tooth, and decide that the same color or shade will just exactly match, and then each of us bakes an inlay for it from porcelain from the same bottle mixed in the same mixture, and the only way on earth for us all to match that same tooth is to all produce that same color. I did precisely this, selecting the tooth and matching the color and then sent the formed pellet to over a score of the best operators all over the country and told them alike just what the material was and asked them all to bake, preserving the color and producing a full glaze. They were all from the same bottle and therefore precisely alike. They very kindly baked them promptly and returned them, stating they were glad to favor me and to let them know if they could serve me farther. They were all prominent men in porcelain work,

the majority known from east to west for their reputation in porcelain work.

Gentlemen, it nearly made me sick at heart when I numbered and mounted these pellets on a card beside each other, for there is almost as much difference and variety in color as there is on the Brewster shade-ring, yet they were all supposed to match the same tooth. Then to see if it could be true that this difference was due simply to a difference in ideals which was claimed later, I sent them each another set of the same from the same bottle and there was as much difference in the different bakes of the same men as between those of different men. To explain the difference in results by saying that it is a difference in ideals is both absurd and certainly a questionable compliment and is proved by the fact that two and three different bakes were all different. When the second button was sent I got several amusing replies. One man wrote, "I have burned the color out, kindly send me another," and when I wrote him that it was not fair for him to have two chances and the others one he wrote: "You may say for me that the only way to accurately fuse porcelain is by the use of a pyrometer." Another wrote for two more and one who had made a wager that he could bake two dozen for me identically the same color has not sent back second and third tests yet, after seeing that his first trial was second worst burned out of the lot.

I also sent pellets to several who had pyrometers and have mounted their different bakes side by side and there is a very close similarity in all the bakes in marked contrast to work done without a pyrometer.

I have frequently watched our best men giving a clinic of making a porcelain inlay and after the last bake hear them say in effect, when comparing it to the tooth, "well, I made a little mistake in selecting that last color," when in fact they had made a little mistake in baking it.

Porcelain in many operators' hands is treacherous, changeable and uncertain, while in fact it is only exacting, but when its laws are complied with it is as constant and uniform in result as the manipulation of gold.

I will give you a method of manipulation that I believe will enable you to produce exceedingly constant and accurate results in matching colors with any make of porcelain. First, you cannot depend on the shades furnished by any maker corre-

sponding exactly to the material in the corresponding bottle, hence it becomes necessary to bake a new color shade for every bottle, even of the same color. Make a set of shades for each bottle at regular increases of temperature like those I sent round, both for the shades and to show you the exact rate at which that color burns out. This is done once for all and by comparison you will soon become familiar with the variations from your shading as a guide. Take your shade-guide for the porcelain you decide is best suited to the case and select the color or colors best suited to produce the shades desired, suppose it is K. and N. Next compare the shade-test cards for those colors to see the rate at which the color burns out. You note that K. burns out more at 25 degrees Cent. overbake than N. does at 75 degrees Cent. Consider and decide from the shape and size of the piece about the number of bakings that will be necessary for each successive bake to the same temperature, take out a little more color about equal to going to 10 degrees higher for a slowly baking out color and 25 degrees Cent. for a rapidly baking out color of any make. In the colors selected, N. and K., you have an example of each, therefore you will add a little more of K. than your finished case will require if it is going to take three or four bakings instead of one. When selecting and mixing or superimposing the shades, plan to be exact or if any error, a small fraction on the dark side.

When building your inlay into your matrix place a small mass about the same general size on the tray on a separate piece of platinum and bake together. This will give you a test of color without the platinum matrix to change the color, and as you build on to the matrix add some of the same to this test piece and for your best bake, having decided both from your inlay in the matrix and your test-piece out of the matrix just what fraction of a shade too deep in color your inlay is. Compare it to the shade-cards if you have not the facts in mind and decide just how many degrees higher you shall bake it to make just the required slight change and your pyrometer will enable you to produce results in this way that are exceedingly gratifying, for as we have said, "the perfection of art is the concealing of art." A very sure test of this and every other method was recently encountered when I could not procure from any of the supply houses or by sending direct to S. S. White's the exact shade desired for a lot of

crowns. It could not be found in any kind of a tooth and I was required to place thirteen crowns all in conspicuous view. It became necessary to build all of these up from the body and the shade was a very difficult one. With the pyrometer and this exact method of procedure the writer was able to so perfectly produce the color of the natural tooth, and still harder, make all the crowns identical in quality and shade of color that they were as uniform as a set of natural teeth, though blending several colors, besides having the individuality that crowns or bridge teeth of a set have not until now modified. I know very well that I could not have accomplished it without the pyrometer, and until I see it done, cannot believe it can be done without one.

In simple inlays, even if the operator has not a really keen ability in selecting the precise shade by the means of definitely modifying the shade of the inlay by a definite increase in temperature, he can produce a very close match of shade.

But you say, why are not the methods we use regularly capable of producing an exact and universally definite result?

This requires a discussion of the various methods of controlling a furnace.

First, the time method, starting from a certain low temperature and increasing by a certain time on each or certain steps of the rheostat. That is not absolutely constant because the increase in temperature is only in the same proportion to the time when the starting temperature and the radiation are the same, which does not obtain without letting the furnace cool very low each time and is only constant when the voltage remains constant, which in blocks where the load on the lines varies is not constant. In most blocks where the elevator is run from the same line the voltage will vary from 6 to 10 volts and in some even more. Where this or any variation obtains, the time factor cannot be constant. Also, since in a warm muffle the temperature will rise much faster than in a cold one, just so in a very hot one, it will rise much faster than in a warm one. All the factors do not affect the pyrometer-controlled furnace when intelligently used, for the temperature itself is alone the controlling factor. I recently had an operator make two series of tests with the same furnace, which was connected to a pyrometer, to ascertain how nearly he could go to a definite temperature in successive heats. He used great care to cool the furnace away down to the same very dull red heat and to have every condition

as accurate as possible, yet even though at night when the load of voltage was constant he varied from twenty to forty degrees.

The method of timing from the melting point of pure gold is constantly better than the last, because it shortens the range of errors which are the same as in the last method, viz., rates of radiation due to initial temperature and temperature of surrounding mass and variations of voltage. This method unfortunately requires that the operator strain his eyes. The method of watching the glaze is dependent upon the condition of the eye, the shape of the surface and the light illuminating the surface and the difficulties, which are many, increase as the temperature increases and notwithstanding its serious injury to the eyes and the temporary effect of making it impossible to correctly see colors it is not constant in results owing to the variable conditions. The method of judging the temperature by looking into the furnace is dependent upon the light the eye has been used in during the preceding minutes or hour and upon the relaxed or tired conditions of the eyes. For example, what appears to be bright red at night is scarcely dull red in the day time. It is also very injurious to the eyes with high-fusing porcelains.

The method of having the furnace as hot as required before starting and placing the inlay or crown into it for a sufficient time and suddenly withdrawing, keeping the furnace hot and getting hotter all the time, cannot bake evenly through a large crown, and leaves an impossible factor for the operator to adjust, viz, the time to leave it in the white hot furnace which of necessity will change in temperature.

The advantages of the pyrometer in my mind are that it enables the operator to obtain definite and uniform results with any porcelain or shades, and with it saves much time, for since the temperature is the controlling factor, no close regularity of time for heating up to near the baking point is necessary. I have built up and baked an inlay three times in fifteen minutes from the time matrix was completed, and had it ready for etching. It also saves time by saving the operator's time, for his assistant can bake just as good as he can. It enables the operator to modify the shade to a definite amount brighter with certainty, thereby assisting him to match the colors.

It saves the operator's eyes. It enables the operator to see where he makes his mistakes, which is half their correction.

In brief, it enables him to produce the maximum result with the minimum care and uncertainty and time and strain. It will not furnish the operator brains, but it will furnish him the facts his brain cannot furnish and enable a poor porcelain worker to do good work and a good one to do better work.

DISCUSSION.

DR. M. H. FLETCHER: To discuss Doctor Price's paper is only to agree with him, for his evidence has been so well collected and so clearly put before us that one could hardly disprove it if he so desired.

His plan of sending to different porcelain operators samples from the same bottle of body and having them baked seems conclusive.

The variety of results this shows is astonishing to me, for I thought only I had such results in destroying color in the furnace, but it seems others also have had results.

I take it that the main object in using porcelain for a filling material, is to so conceal the results of repair that it is not visible, or not conspicuous at least. From the essayist's own idea to so perfect our art that it is entirely concealed, is the real object in using porcelain, but to accomplish this result with exactness and to be able to repeat it each time with porcelain seems only to be possible by use of the pyrometer.

The specimens shown of the different bodies furnished us by the various makers, baked by the aid of the pyrometer, is another revelation to me, for I had no idea that so many varieties of shades could be produced from one batch of body.

The comparatively slight difference in degrees of heat necessary to produce these different results is another surprise, as well as the accuracy with which this can be repeated.

With these evidences before us—as stated—there is no room for disagreement. The wonder is, why any of us continue to waste our time and effort in trying to accomplish the impossible.

To me, Doctor's Price's pyrometer in connection with his furnace seems to have completely solved the problem over which many of us have labored and worried so much.

Whether the pyrometer accomplishes the same result with other furnaces or not the Doctor does not state.

Many of us have furnaces recently bought which we hesitate to lay aside, and yet, I, for one, certainly am tempted to do so immediately.

I feel that Doctor Price merits the gratitude of the profession for the definite and scientific results he has brought to us with his beautiful and accurate pyrometer and furnace.

DR. E. BALLARD LODGE: The essayist, Doctor Price, has very lucidly presented facts relating to the fusing of dental porcelain, which to my mind are incontrovertible. He has shown that without the pyrometer, it is impossible to get exactly uniform results.