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INVESTMENT

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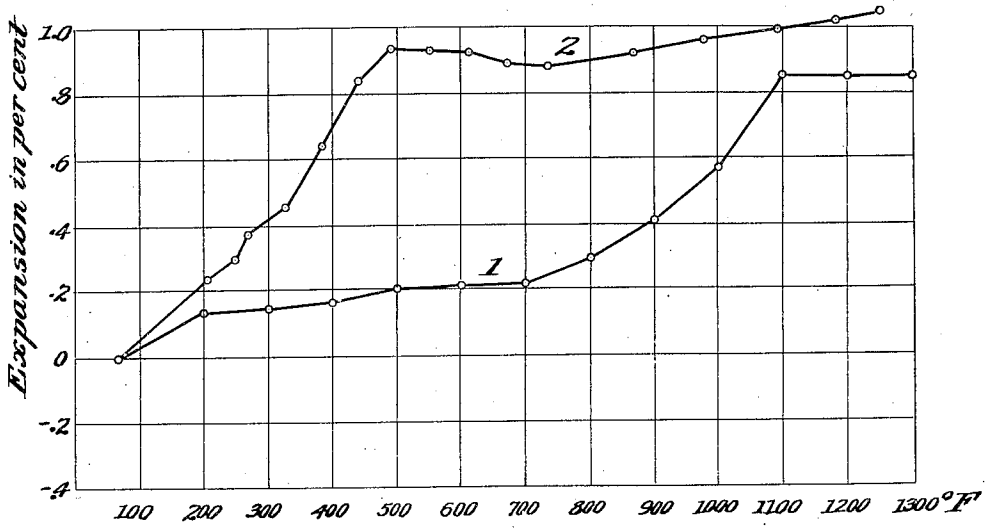

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1,932,202

INVESTMENT

Richard L. Coleman and Louis J. Weinstein, Hartford, Conn.; Dorothy S. Dugan and Richard L. Coleman, executors of said Louis J. Weinstein, deceased, assignors, by direct and mesne assignments, of seventy-five per cent to Richard L. Coleman and twenty-five per cent to Dorothy S. Dugan

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14 Claims. (Cl. 22—188)

This invention relates to investment compositions, that is to compositions for making refractory molds for casting metal, such as gold, gold alloy, or other suitable casting material into inlays or other objects, where the article cast must conform as exactly as possible, in detail, to the size and shape required.

This invention is of general application in industry, but we will describe it particularly with respect to dental inlays. In reconstructing a tooth which has been partly decayed or otherwise damaged, the dentist makes a cavity in the tooth of the size and shape which he considers the best dental practice, and he then proceeds to make or to procure a casting of the metal or alloy he desires, and such casting must fit as exactly as possible into the tooth cavity. The conventional method followed is to force warm wax into the tooth cavity to fill it, heat a small metal rod or sprue, insert it into the wax, and then after chilling, removing the wax pattern by means of the sprue. A mold is then formed by carefully placing a cementitious mass about the pattern and the sprue, and this cementitious mass, known as the investment, is allowed to harden. The mold is then heated to burn out the wax, the sprue having been removed, and to heat the mold or investment up to a temperature suitable for casting.

The metals used for making dental inlays, such as the gold alloys now in use, undergo certain changes in volume, with change of temperature and on passing either from the solid or the liquid to the liquid or the solid state. The investment materials now in use likewise undergo certain changes in volume and also in other physical characteristics with changes of temperature, some of which may not be reversible, that is they may be more or less permanent depending upon the particular investment material used.

The metal ordinarily used for dental work, and frequently used for other work shrinks on passing from the casting temperature, at which it is, of course, in molten condition, to ordinary room temperature; and this shrinkage must be compensated for.

A great many of the investment materials proposed and in use consist of a binder material, for example, plaster of Paris, a filler material, and various other inert or modifying materials.

The most commonly used filler material is ground silex, the term "silex" being used loosely in the dental and related industries to designate quartz, flint, chalcedony or any of the other forms of silica commonly found in nature. The silex usually employed for this purpose is of the quartz type.

In addition to the above mentioned forms, silica may exist at atmospheric temperatures in various other forms as cristobalite, tridymite and vitreous silica, all having the same chemical composition, SiO_2, but differing widely in such properties as crystalline form, optical index of refraction, density or specific gravity and thermal expansion. The latter forms, namely: cristobalite, tridymite and vitreous silica occur only rarely in nature but are produced commercially by prolonged heating of the naturally occurring forms such as quartz, flint, chalcedony, etc. at relatively high temperatures.

Chalcedonic silica is mainly micro-crystalline-fibrous silica but may contain some micro-fibrous amorphous silica and even some micro-fibrous hydrated amorphous silica.

The properties of chalcedonic silica fall nearer to those of quartz than to those of any other of the principal forms. There is enough difference, however, to justify the statement that chalcedony is not quartz.

Chalcedony is a variety of chalcedonic silica. Flint is the English name and silex the French name for the same material. It is one of the varieties of chalcedonic silica.

The word "flint" has been carried over in ceramics as a technical term almost synonymous with "silica" and so including quartz, but in the sciences the word is now restricted to mean impure dark colored micro-crystalline silica.

Our invention comprises broadly the use of cristobalite in dental and like investments, together with a binder material, and either with or without silex, quartz, tridymite, and/or other inert filler or modifying materials. Devitrification of quartz glass may produce cristobalite, or tridymite or quartz or mixtures thereof depending on conditions. The ordinary forms of silica, that is quartz, chalcedony, flint, and the like, can be converted into cristobalite by prolonged heating at high temperatures, that is at about 1850° F. or above, and the conversion may be hastened by the

addition of very small quantities of a substance that will act as a flux, for example, lime, sodium tungstate, etc. Chalcedony and flint can in fact be converted into cristobalite a little more readily than quartz.

Pure cristobalite is not readily obtainable commercially because of the difficulty involved in completely converting any of the other forms of silica to cristobalite. For example: starting with quartz, if the conversion is carried far enough so that there is no quartz remaining in the material, there will usually be present varying amounts of tridymite or of vitreous silica or of both, depending upon the time of firing, the temperature, the constancy of the temperature, the fineness and previous treatment of the quartz, the presence of fluxes or impurities, etc.

The conversion, therefore, is usually not carried to completion and there are small amounts of unconverted quartz as well as small amounts of tridymite in the final product. A very good source for a "cristobalite base" for making investments is ground silica brick, the better grades of which contain about 70% cristobalite, the remainder being quartz, tridymite, and small amounts of impurities, etc. Some grades of silica brick run as low as about 20% cristobalite, while some of the best grades run over 80%.

The figure on the accompanying drawing presents two comparative expansion curves, the curve designated 1 representing the expansion of an investment composition containing about 75% of coarse ground silex or quartz, and the curve designated 2 representing the expansion of a similar composition but containing about 75% of silica brick or "cristobalite base" ground to about the same fineness, the binder in both cases being plaster of Paris of the same grade and the investments being mixed with the same proportion of water, boric acid being absent from both compositions.

In obtaining the data from which the curves are plotted, a test sample of any convenient length is used. The length thereof is measured before heating, that is at ordinary room temperature (70° F.) as well as the lengths thereof at various temperatures to which the sample has been heated. The changes in length multiplied by one hundred and divided by the original length are the linear expansions of the sample expressed in percentages of the original length, and these are plotted as ordinates, the various temperatures at which measurements are made being plotted as abscissæ. The two curves on the drawing illustrate the radical difference in the expansions of the two materials particularly around 500 to 600° F. rather than the actual amounts of the expansion of the two types of investments which will depend somewhat on the grade of material, the fineness, and other characteristics and conditions.

Quartz, or the ordinary form of silica used in dental investments, expands more or less uniformly when heated until a temperature of about 1065° F. is reached, when the quartz undergoes a transformation from the so called "low quartz" or the form that is stable below 1065° F., to "high quartz" or the form that is stable from 1065° F. to the temperature at which quartz begins to change over into tridymite or cristobalite. This transformation of quartz at 1065° F. is accompanied by a relatively large increase in volume, which accounts for the large expansion of ordinary investments at about 1000° F. to 1100° F. (See curve 1). In order to take advantage of this large expansion of the investment mold to compensate for part of the shrinkage of gold, it is necessary to heat the mold to about 1100° F. and maintain it at this temperature until the gold is cast. It is difficult to follow this procedure with the equipment available in the usual dental laboratory. Also, in some instances, casting into a mold at such a high temperature is undesirable because of the metallurgical factors involved, a cooler or chill mold usually producing castings of superior physical and mechanical properties.

Cristobalite expands more or less uniformly when heated until a temprature of about 390° to 525° F. is reached, when it undergoes a transformation from low cristobalite to high cristobalite, somewhat similar to that which occurs in quartz at 1065° F. This transformation of cristobalite at about 390° to 525° F. is accompanied by a large increase in volume, which accounts for the large expansion of the cristobalite investment at about 400 to 600° F. (See curve 2). Thus, one advantage of substituting cristobalite for the ordinary quartz in an investment is that the cristobalite investment, at about 400 to 600° F. has expanded about as much as, or more than, the ordinary investment containing ordinary silica when heated at 1100° F.

It will thus be apparent that there is a great advantage in using silica in the form of cristobalite over silica in the form of quartz, since in the case of cristobalite greater expansion occurs than in the case of quartz, and this occurs at even a much lower temperature, as a result of which it is possible to compensate, to a greater degree and at a lower temperature, for the shrinkage of the particular metal used when it passes from the temperature at which it is cast in liquid form to the solid condition at ordinary room temperature. The metals ordinarily used for dental purposes are gold alloys, but it is to be understood that the invention is not to be restricted to the use of such particular metals. It may be applied to welding, soldering, and other purposes where these processes are carried out in molds or investments. It is applicable in the manufacture of jewelry, and in other arts as well as to the dental art.

The cristobalite may be used in compositions in combination with different binders, for example, plaster of Paris, Keene's cement, Portland cement, oxy salts cements, magnesium oxide cements, phosphoric acid cements, sodium silicate cements, and the like, but at present we find that plaster of Paris is best suited for the purpose. We will therefore describe the invention specifically with respect to the plaster of Paris binder. This binder, or the other binders may be used in practically all proportions as will be understood by those skilled in the art. For most purposes the plaster of Paris will be present in amounts of not much less than 20%.

We have found that an investment composition containing between 1 part of plaster of Paris to 4 of cristobalite and 3 parts of plaster of Paris to 2 of cristobalite by weight gives very good results, these figures being merely illustrative and not expressing any limitations; and likewise when some of the cristobalite is replaced with tridymite or with a mixture of tridymite and ordinary quartz type silica.

For example, good results have been obtained by the use of ground silica brick containing approximately 65 to 75% cristobalite, 0 to 30% quartz and 0 to 30% tridymite, either with or without small amounts of vitreous silica and impurities. However, these proportions may be varied widely. The addition of quartz or tri-

dymite may be used to control or reduce the expansion for certain purposes where a lower expansion is desirable.

Such compositions will expand up to about 1.5%, which is sufficient to compensate for the contraction of the gold or gold alloys in the usual dental casting process. A suitable formula is

	Parts
Plaster of Paris	40
Cristobalite	45
Tridymite	10
Ordinary silica, as quartz, sand, flint, etc., together with impurities	5

Another good formula is

	Parts
Plaster of Paris	30
Cristobalite	50
Tridymite and ordinary silica	20

It may be desirable to add other inert fillers, highly refractory materials such as alumina, zirconia and the like, various accelerators or retarders to hasten or slow up the time of setting or other modifying agents, or to use a mixture of binders instead of one binder or to add other inert, active or modifying agents as may seem best. We prefer to add particularly in some cases boric acid to the composition as this increases the desirable characteristics of the investment material. 2% of boric acid calculated on the total dry weight of the mass gives very good results, but good results are also noticeable when this amounts to only a small fraction of 1%. Good results may also be obtained with the amount of boric acid running up to considerably more than 2%, that is 5%, 10% or even considerably higher since any excess thereof is sweated out on heating the investment preparatory to casting. Any amount of boric acid then present usually does not exceed 2½% or so. Generally such excess is sweated out when heating the investment preporatory to casting and forms fuzzy crystals on the outside of the investment. If the maximum effective amount of boric acid is to be used, it is therefore not necessary to gage the amount of boric acid added with any degree of accuracy provided only that the maximum effective amount be added. The composition is generally prepared and sold ready mixed in dry condition, and it is only necessary to add enough water to make a workable paste for forming the investment about the pattern. If desired the boric acid may be added to the water instead of to the dry mixture, or it may be added partly to each. We might state that excellent investment compositions may be made with the plaster of Paris at a minimum of 20%, cristobalite at a maximum of 80%, boric acid at a maximum of 10%, and tridymite and ordinary silica at a maximum of 20% these amounts not being given as limits, but as indicating a variety of very useful investment compositions. Excellent "cristobalite effects" are apparent with the cristobalite as low as 50%, or even considerably lower.

Having described our invention, what we claim is:

1. An investment composition comprising cristobalite and a binder.

2. An investment composition comprising cristobalite and plaster of Paris.

3. An investment composition comprising ground silica brick and a binder, said silica brick containing a material of the class consisting of cristobalite and tridymite.

4. An investment composition comprising ground silica brick and plaster of Paris, said silica brick containing a material of the class consisting of cristobalite and tridymite.

5. An investment composition comprising ground silica brick and a binder, said silica brick containing cristobalite.

6. An investment composition comprising ground silica brick and plaster of Paris, said silica brick containing cristobalite.

7. An investment composition comprising ground silica brick and a binder, said silica brick containing at least twenty percent of cristobalite.

8. An investment composition comprising ground silica brick and plaster of Paris, said silica brick containing at least twenty percent of cristobalite.

9. An investment composition comprising ground silica brick and a binder, at least half of said silica brick being cristobalite.

10. An investment composition comprising ground silica brick and plaster of Paris, at least half of said silica brick being cristobalite.

11. An investment composition comprising cristobalite and a binder, the amount of cristobalite being at least 50% of the whole.

12. An investment composition comprising cristobalite and plaster of Paris, the amount of cristobalite being at least 50% of the whole.

13. An investment composition containing cristobalite and a binder, the amount of cristobalite being sufficient to make the investment sufficiently larger than the pattern, when the investment is at a predetermined temperature above room temperature and less than that of the molten metal, to correspond to the shrinkage of the casting from the molten to the cooled state.

14. An investment composition containing cristobalite and plaster of Paris, the amount of cristobalite being sufficient to make the investment sufficiently larger than the pattern, when the investment is at a predetermined temperature above room temperature and less than that of the molten metal, to correspond to the shrinkage of the casting from the molten to the cooled state.

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