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REFRACTORY MOLD MATERIAL FOR CAST METAL PRODUCTS

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This invention relates to refractory materials for cast metal products and more particularly to refractory mixtures adapted for the forming of molds for casting molten metal therein and more specifically to refractory mold material adapted for use in the manufacture of cast metallic dentures.

One of the objects of the present invention is to provide a refractory mixture adapted to be cast while in the plastic state about a form or pattern defining the desired cast metal product and which in the "as cast" and "as fired" condition is dense and strong especially at the surface defined by the pattern and substantially free from surface irregularities and of loose material the loss of which materially alters the dimensions in the mold. Another object is to provide a refractory mixture for dental molds which satisfactorily meets all the exacting requirements for mold material for cast metallic dentures. Another object is to improve the manufacture of cast metallic dentures and to provide an improved mold material therefor. Other objects and advantages will be apparent as the invention is more fully hereinafter disclosed.

In accordance with these objects, I have discovered that a mixture of fine and coarse silica, preferably one consisting of particles of a size passing about 20 mesh with from 20-40% thereof passing about 200 mesh is the most satisfactory refractory for the manufacture of molds for cast metallic dentures. The difficulty in the use of this refractory is in the bonding of this material at low temperatures and at high temperatures, or in the "as cast" and "pre-fired" condition respectively.

In the forming of molds for cast metallic dentures, a pattern is first formed of wax or similar material of the size, shape and configuration of the metal denture desired. The mold material is then formed into a plastic mass and cast about the pattern preferably by vibrating the same there around and is backed up with suitable refractory backing material such as plaster of Paris. The molded refractory then is dried and is slowly heated to a temperature approximately 1500° F. to thoroughly consolidate the same and then is allowed to cool slowly to a lower temperature known as the "pre-heat" temperature desired for casting the molten metal in the mold. The molten metal then is cast, preferably by centrifugal casting means, into the pre-fired and pre-heated mold.

In the forming of cast metallic dentures it is highly desirable that the mold material employed in addition to surface density and smoothness shall evidence substantially no shrinkage or expansion within the temperature range atmospheric to about 1500° F. and also that the binding agent employed for strength in the "as cast"

and "as fired" condition shall be substantially free from carbon and sulfur.

I have discovered that by mixing magnesium trisilicate with the silica and by employing an acid phosphate solution in the forming of the plastic solution in the forming of the plastic refractory mass to mold around the pattern, I may obtain a relatively quick setting bond for the silica in the "as cast" condition of adequate strength for the purpose which on firing retains its strength up to the maximum firing temperatures usually employed, namely about 1500° F. The resultant fired refractory product meets all the exacting requirements for molds for cast metallic dentures, particularly the non-expanding and non-shrinking requirement.

The exact reaction involved in the use of these materials is not clearly apparent. The magnesium tri-silicate appears to react initially while in the plastic or moistened condition with the acid phosphate to form complex magnesium-silico-phosphates which serve as a low temperature bonding agent. It is possible that the phosphoric acid reacts also, at least superficially, with the silica refractory to form silico phosphates. On firing the silico-phosphates appear to retain the original bond even at temperatures materially above 1500° F.

The silica refractory employed is preferably pre-fired or pre-shrunk silica of approximately the maximum density obtainable, for example electrically fused silica. Natural flint silica, however, has proven satisfactory for the present invention.

The magnesium tri-silicate is preferably freshly precipitated and unfired silicate of the maximum chemical reactivity towards phosphoric acid, although various admixtures of pre-fired and freshly precipitated silicate may be employed without departure from the present invention, as one skilled in the art may perceive. In place of magnesium tri-silicate or in partial substitution therefor other silicate compounds reactive with phosphoric acid to form refractory silico-phosphate compounds, may be employed without departure from the present invention, as one skilled in the art also will perceive.

The acid phosphate solution employed may be varied widely with respect to composition and strength without essential departure from the present invention. In most cases, I prefer to employ phosphoric acid for reaction with the magnesium tri-silicate as it is the simplest and most direct reaction and is most easily controlled as to time of "set" by appropriate regulation of the relative proportions of the tri-silicate and acid.

Alternatively, when magnesium tri-silicate is employed as hereinabove described, I have found that various acid phosphate compounds are of equal reactivity with the tri-silicate and produce

the desired strength and density in refractory in the "as cast" condition. The chemical reactivity of these acid phosphate compounds may be increased, if desired, by additions of an acid
5 to the water solution of the same, preferably phosphoric or hydrochloric acid. To obtain the desired high temperature bond, the metal component of the acid phosphate preferably is one capable of forming refractory phosphate and silico-phosphate compounds.

10 In many cases, I have found it desirable to increase the bond strength in the "as cast" and "pre-fired" condition by additions of magnesium oxide to the refractory mixture of silica and magnesium tri-silicate. Preferably such oxide should be freshly precipitated oxide to obtain its maximum chemical reactivity. The oxide appears to react with the phosphoric acid or acid phosphate compounds to form acid magnesium phosphates
15 which evidence excellent bonding properties at least superficially on the silica refractory augmenting that obtained by the silico-phosphate compounds formed by the reaction of the tri-silicate and acid phosphate.

20 Additions of zirconium or of titanium double silicates such as the zirconium magnesium double silicate appear to materially increase the pre-fired strength of the mold material and to give added surface density and coherence to the same.

30 From the above disclosure it is believed apparent that the present invention may be widely varied without essential departure therefrom. As examples of the practice of the same the following specific embodiment thereof is disclosed:

35 To the mixture of coarse and fine sized silica refractory disclosed hereinabove I may add magnesium tri-silicate in amounts ranging from small but effective amounts up to about 20% and form the same into a plastic mass using a phosphoric acid solution having a strength varying from 5%
40 to 25% phosphoric acid, to obtain a fast setting mold material which on firing will evidence excellent strength and density for most purposes.

45 As an illustration, a mixture consisting of 90% electrically fused silica with about 80% of the grains passing 20 mesh but retained on 200 mesh and about 20% of the grains passing 200 mesh, with about 10% magnesium tri-silicate as a fine powder (each dry weight) when intimately mixed
50 together in the dry state and then formed into a plastic mass with a 10% phosphoric acid solution will set to a relatively hard and dense mass within a few minutes. The mold when fired at 1500° F. for several hours will be found to produce accurately dimensioned castings of the pattern employed with any of the metals commonly employed in the forming of metallic dentures.

55 By lowering the tri-silicate content of this mixture to about 5% the setting time of the mass will be lengthened to about ½ hour; by increasing the phosphoric acid strength to 20% the mold strength will be materially increased and the setting time decreased; by substituting an acid phosphate, such as Al or Mg acid phosphate in part or in whole for the phosphoric
60 acid disclosed, I may obtain improved mold strength and density in the "as cast" condition without material shortening of the setting time, or material alteration of the strength and density of the same in the "as fired" condition.

70 Alternatively, by incorporating magnesium oxide or similar refractory metal oxides reactive with phosphoric acid and phosphates into the

refractory mixture in addition to the silica and tri-silicate compounds specified above, in amounts ranging from small but effective amounts up to about 5%, the normal mold strength and density, particular surface density
5 in the "as fired" condition may be benefited. Acid soluble refractory metal hydroxides are substantial equivalents for the oxide.

As a further improvement, particularly with respect to the pre-fired strength and density of the mold, I may add to the refractory mixture above given from small but effective amounts up to about 30% (dry weight) of zirconium or titanium double silicate compounds, such as the zirconium magnesium silicate compound, ground
15 to pass about 200 mesh, preferably replacing equivalent amounts of the fine silica content specified. Such additions materially increase the pre-fired strength and density of the mold and are particularly desirable to improve the surface strength and density.

Wherein in the above specific embodiment I have specified a mixture consisting of 80% coarse silica and 20% fine silica, it is not to be construed that I am limited thereby as any mixture of coarse and fine silica wherein the fine silica passing 200 mesh is within the range
25 20-40% and the coarse silica size is below about 20 mesh is within the scope of the present invention.

Having hereinabove described the present invention generically and specifically and given the specific embodiment thereof with modifications thereof, it is believed apparent that the present invention may be widely varied without essential departure therefrom and all such modifications and departures are contemplated as
35 may fall within the scope of the following claims:

What I claim is:

1. A refractory mixture for use with phosphoric acid or a similar binder to form molds for casting molten metal therein, said mixture comprising at least 60% of a mixture of fine and coarse silica and magnesium tri-silicate, the latter constituent being present in amount ranging from small but effective amounts up to about 20%.

2. A refractory mixture for use with phosphoric acid or a similar binder to form a mold for cast metallic dentures, said mixture comprising of about 80% silica passing about 20 mesh and retained on about 200 mesh, about 20% silica passing about 200 mesh and about 10% magnesium tri-silicate.

3. A refractory mixture for use with phosphoric acid or a similar binder to form a mold for casting molten metal therein, said mixture comprising at least 60% of a mixture of fine and coarse silica and magnesium tri-silicate.

4. The method of forming a refractory mold for cast metallic dentures which comprises forming a mixture comprising at least 60% of silica and magnesium tri-silicate, forming the mixture into a plastic mass with phosphoric acid or similar binder and flowing the plastic mass over the surface of a pattern in a plurality of coatings to the depth and thickness desired, allowing the coatings to set, drying the coatings and then slowly heating the same to the desired preheat temperature of the mold before casting the molten metal therein.

5. A refractory mold comprising at least 60% of silica and magnesium tri-silicate.

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