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REFRACTORY MOLD MATERIAL

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The present invention relates to an improved refractory mold material, and more particularly to an improved refractory mold material for use in casting high temperature fusing metals and alloys.

The particular improved refractory mold material which we shall describe hereinafter is particularly useful for the production of dental molds in which dentures and similar appliances and dental elements are adapted to be cast, but it is to be understood that the invention may be employed for molding other articles of high temperature fusing metals and alloys, such as articles of jewelry, and for molding other materials as suitable and desired.

The metals and metal alloys used for dental and other work shrink on passing from the casting temperature, at which they are, of course, in molten condition, to ordinary room temperature; and this shrinkage must be compensated for.

For the production of molds and the like for casting low temperature fusing metals and alloys, mold materials containing relatively high percentages of plaster of Paris have been used extensively. However, due to their low resistivity against heat, these mold materials cannot be used for the higher temperature fusing metals and alloys. They will break down or disintegrate at temperatures above about 1200° F.

It previously has been proposed to secure the desired expansion to compensate for the casting shrinkage which takes place as above set forth by means of investment compositions comprising preformed tridymite or cristobalite with a relatively large percentage of a binder consisting of plaster of Paris or the like.

With investment compositions of the character last mentioned, maximum expansion is secured at temperature too low to make such materials suitable for use with high temperature fusing metals and metal alloys. For example, if straight preformed cristobalite is used with a relatively large percentage of plaster of Paris, maximum expansion is secured at about 1200° F. This may be suitable for low temperature fusing metals and alloys, such as gold, which fuses at about 1950° F., but such investment materials are not suited for use with high temperature fusing metals or alloys such, for example, as the alloys disclosed in Charles H. Prange Patent No. 1,958,446, patented May 15, 1934, and in the copending application of Charles H. Prange, Serial No. 725,651, filed May 14, 1934. These latter alloys are known on the market as "Vitallium," and have fusing temperatures of about 2500° F.

We have found it difficult to secure complete castings of high temperature fusing metals and alloys such as those above set forth, particularly in the case of larger and thinner pieces, when the mold temperature is too low; the reason appearing to be that the relatively large temperature difference between the metal or alloy and the investment or mold material causes the metal or alloy to chill prematurely before filling the mold.

The introduction in molten condition of high temperature fusing metals or alloys of the sort herein referred to into molds formed of an investment composition comprising preformed tridymite or preformed cristobalite and a binder of plaster of Paris or the like in relatively large percentage results in breaking down or disintegration of the plaster of Paris binder, extensive porosity, and lack of solidity in the resulting castings, due to the high casting temperatures of these high temperature fusing metals and alloys.

Due to the thermal expansion to which the silica of refractory mold materials consisting principally of ground quartz is subjected during heating and while changing from alpha-quartz to beta-quartz, and especially during the change of beta-quartz into tridymite, the desired expansion of the mold necessary to compensate for casting shrinkage or contraction of the metal to be poured into the mold is obtained, but this transformation takes place only at very high temperatures of about 2300° F., and the reaction or conversion process progresses very slowly or lazily. Where temperatures as high as this are necessary to bring about the desired expansion, it will be noted that they approach closely the melting point of the high fusing metals and alloys. Such high temperatures result in coarse crystallization and a tendency towards dendritic effects and extensive porosity in the castings, which is highly undesirable.

It is one of the primary objects of the present invention to provide an improved refractary mold material in which the desired expansion of the mold material to compensate for casting shrinkage is brought about at essentially lower temperatures than 2300° F., and which mold material has high resistivity against heat and thereby is admirably adapted for use in casting the high temperature fusing metals and alloys of the class hereinbefore mentioned.

Another object of the present invention is to provide an improved refractory mold material having the advantageous characteristics above set

forth, and which has the further advantage of avoiding interference with the setting action of plaster of Paris or organic silicate binders or other binders or setting agents in the mold material.

Another object of the present invention is to provide an improved refractory mold material in which the inversion of the quartz, which takes place in increasing amounts as the temperature of the mold rises, and the resulting expansion to compensate for casting shrinkage are limited by the final temperature reached and are not further increased by prolonged heating at this temperature. In other words, the desired expansion is secured at the final temperature for securing that expansion and is independent of time after the final temperature for the desired expansion is reached. This is highly advantageous in that it enables the operator to bring a large number of molds up to the temperature for securing the desired expansion, and then to introduce the molten metal to be cast into the molds, one after another, without having different expansions in the various molds due to the time interval after the final temperature is reached; for example, between the filling of the first molds and the filling of the last molds.

Another object is to provide an improved refractory mold material in which the conversion and expansion herein referred to are very rapid, particularly under the conditions that we are using it; that is, the conversion takes place completely to the extent that we have added a definite proportion of an agent which will bring about and accelerate the conversion of quartz within the time consumed in bringing the mold up to the casting temperature.

Further objects and advantages of the invention will be apparent from the following detailed description in which we describe certain illustrative embodiments of the invention, it being understood that modifications and variations from the specific embodiments selected for illustration are contemplated within the scope of the appended claims.

One satisfactory formula embodying the present invention is as follows:

	Parts
"Hydrocal"	2
Ground quartz	12
Flint	3
Magnesium sulphate (ground fine)	1/8
Glass (ground fine)	3/16

The ground quartz, which constitutes the refractory aggregate and makes up the principal portion of the mold material, is preferably ground fine, i. e. to about 80 mesh or finer.

The "Hydrocal," which is a plaster base material well known on the market, constitutes a binding agent for the mold material. This particular material has an alpha plaster base, and is resistant to moderately high temperatures without breaking down. It is to be understood, however, that any other grade of plaster or plaster base material may be used within the scope of the present invention.

The glass content is preferably an ordinary soda lime glass, and serves to introduce sodium oxide in insoluble form. It is preferably ground fine, i. e., to about 200 mesh or finer, to secure a better mix and better uniformity of distribution of the same throughout the composition. The sodium oxide which is introduced by this material serves to bring about, by conversion of the silica of the refractory mold material, consisting principally of ground quartz, into tridymite, the desired expansion of the mold material at essentially lower temperatures than 2300° F. The insoluble form in which the sodium oxide is introduced by employing soda lime glass as set forth is advantageous in that objectionable interference with the setting action of the plaster setting agent is avoided. In other words, the sodium oxide in insoluble form does not objectionably hasten the setting action of the mold material, whereas an agent such as water glass (sodium silicate) which introduces the sodium oxide in soluble form will bring about, by conversion of the silica, the desired expansion at essentially lower temperatures than 2300° F., but does greatly accelerate the setting action of the binding agent.

The magnesium sulphate is illustrative of one suitable accelerator for accelerating the setting action. Sodium chloride, magnesium oxide, heat, or any other accelerating agent well known in the art, may be employed within the scope of the present invention.

Due to the small amount of magnesium sulphate and also the small amount of glass used, it is preferable to make pre-mixes of the magnesium sulphate and the glass with ground quartz in making up the mold material.

A pre-mix of glass, hereinafter called *A*, may be formed as follows:

A

	Parts
Glass (powdered)	1
Ground quartz (preferably about 100 mesh)	1

A pre-mix of magnesium sulphate, hereinafter called *B*, may be formed as follows:

B

	Parts
Magnesium sulphate (ground fine)	1
Ground quartz (preferably about 100 mesh)	2

With the pre-mixes of glass and magnesium sulphate, the formula first above set out then becomes the following:

	Parts
"Hydrocal"	2
Ground quartz	11 1/8
Flint	3
B	3/8
A	3/8

We prefer to add to the above formula ¼ part sugar or other suitable temporary binder, but this may vary widely within the scope of the present invention.

In making up the mold material, the ingredients are thoroughly mixed in the mill and subsequently water is added to the composition in an amount to bring the same to the desired consistency. After the composition is brought to the desired consistency, it is molded or shaped into whatever form is desired, and in molding or shaping the material it is preferably compacted by vibration to bring the particles into contact and to produce a hard and relatively non-shrinking mass. The compacting of the mixture by vibration may be accomplished as by means of a suitable revolving cam which will raise the mixture slowly and drop it abruptly, thereby compacting the particles into contact without agitating the mixture. The particular manner of compacting the mixture to obtain the desired results may be accomplished in any other suitable or preferred manner.

Other percentages of ordinary soda lime glass than the particular percentage given may be employed with the plaster of Paris investment above set forth. We contemplate particularly ordinary soda lime glass from about 1% to about 5% with this plaster of Paris investment, but variations outside of that range are contemplated as suitable and desired within the scope of the broader aspects of the invention.

Another suitable refractory mold material embodying the present invention may be made by using substantially 100 parts, or, more particularly, about 99.9 parts ground quartz and .1 part magnesium oxide or other organic or inorganic accelerator with an organic binder, such as tetraethyl silicate in amount to form a heavy paste, mixed with from about ½% to about 3% ordinary soda lime glass.

The soda lime glass which we employ is obtained from the Pittsburgh Plate Glass Company, and introduces a definite percentage of sodium oxide for a definite percentage of such glass employed. Other sodium lime glasses may introduce different percentages of sodium oxide for a definite percentage of such glass employed, and therefore we contemplate the full range of variations of the glass content of the material to meet these variations.

The glass content is ground fine, as set forth in connection with the first described embodiment of the invention, and we find that with 2½% of soda lime glass of the character above set forth, the desired expansion to compensate for shrinkage of the metal in casting the same in the mold is secured at about 1800° F. With a soda lime glass content of ½% the desired expansion to compensate for shrinkage of the metal and to assure the desired accuracy of fit is secured at about 2200° F. With soda lime glass, of the character above set forth, present in amount up to about 3%, the inversion process or transformation from alpha-quartz to beta-quartz, and from beta-quartz to tridymite, is a function of temperature and independent of the elapse of further time after the required degree of expansion is completed, with the resulting advantages previously set forth. With a soda lime glass content above about 3%, the inversion or transformation process is a function not only of temperature, but also is a function of the elapse of further time after the required degree of expansion is completed. We prefer to limit the amount of glass employed to a percentage which will give the desired expansion as a function of temperature and independent of the elapse of further time after the required degree of expansion is completed, because, for example, of the impossibility of casting in all of a plurality of heated molds at the same time.

In making up the mold or mold part of the latter composition, the tetra-ethyl silicate binder is added in an amount to bring the composition to the desired consistency, as explained in connection with the first embodiment of the invention. As before, after the composition is brought to the desired consistency, it is molded or shaped into the desired form, and in molding or shaping the material it is compacted by vibration to bring the particles into contact and to produce a hard and relatively non-shrinking mass. The compacting or vibration of the material settles out or removes any excess amount of the tetraethyl silicate binder. As before, the compacting of the mixture by vibration may be accomplished as by means of a suitable revolving cam which will raise the mixture slowly and drop it abruptly, thereby compacting the particles into contact without agitating the mixture.

Another suitable refractory mold material embodying the present invention may be made of substantially 100 parts ground quartz, or, more particularly, about 99.9 parts ground quartz with .1 part accelerator, or by using heat as the accelerator as herein described, with silicate of soda or water glass as a binder. This binder is in the form of a soluble binder, with the disadvantages previously set forth, but is contemplated within the scope of the broader aspects of our invention. The accelerator, other than heat, as above referred to, may be calcium oxide—that is, lime or compounds containing it, such as Portland cement, which are known to act as accelerators—and various other substances, all of which tend to bring about a setting action with silicate of soda.

With this latter composition, the silicate of soda is employed as a binder and serves the additional purpose of introducing sodium oxide to bring about, by the conversion of the silica, the desired expansion of the mold material to compensate for casting shrinkage at essentially lower temperatures than 2300° F. While this latter composition requires more time in the setting process, it provides the desired expansion at lower temperatures, and, in that respect, embodies the broader aspects of the present invention.

In making up the mold or mold part of the last mentioned composition, the silicate of soda or water glass binder is added in amount to bring the composition to the desired consistency, whereupon the composition is molded or shaped to the desired form and preferably compacted by vibration as set forth in connection with the preceding embodiments of the invention.

The expansion which we provide for securing at essentially lower temperatures than 2300° F. compensates fully and accurately for shrinkage of the high temperature fusing metals and alloys herein mentioned in cooling from the casting temperature to ordinary room temperature. The molten metal is introduced into the molds formed of our improved refractory mold material, which said molds are heated to the temperature to provide the desired expansion.

Upon heating quartz in the presence of the powdered glass, after the alpha-beta transformation has occurred, some quartz is inverted to tridymite, depending upon the amount of glass, or other agent, employed. These changes all result in expansion, and, on cooling, the material contracts to its original dimensions, except for the quartz-tridymite inversion, which change is irreversible. Therefore, in practice, it is desirable to use such proportions of the controlling agent, i. e., powdered glass or other controlling agent as herein described, as will produce the desired net results, which is accomplished by varying the amount of the agent used in various combinations of mold materials, and to suit or compensate for the contraction or shrinkage of the various alloys or other materials cast.

Instead of using soda lime glass, silicate of soda, or water glass for bringing about, by conversion of the silica, consisting principally of ground quartz, the desired expansion of the mold material at essentially lower temperatures than 2300° F., other ingredients are contemplated for this purpose within the broader aspects of our present invention. For example, the

oxides and hydroxides of the alkali metals which include sodium, potassium, lithium, caesium and rubidium, may be used to bring about, by conversion of the silica, consisting principally of ground quartz, the desired expansion at essentially lower temperatures than 2300° F. The last two named alkali metals are unimportant from a practical point of view, being rare elements. The other three are entirely practicable to use as they all form silicates and these silicates are available commercially. We, therefore, contemplate particularly the use of materials containing oxides of the alkali metals, especially sodium, potassium and lithium, as well as insoluble glasses and other compounds containing the oxides of these materials.

Where potassium oxide is used to bring about the desired expansion at essentially lower temperatures, it may be introduced by using ground potash glass instead of soda lime glass as heretofore described.

As already set forth, we secure the conversion and desired expansion in our improved refractory mold material very rapidly, particularly under the conditions that we are using it—that is, the conversion takes place completely to the extent that we have added a definite proportion of glass within the time consumed in bringing the mold up to the casting temperature. To the best of our knowledge, the inversion of quartz into tridymite is a gradual process which takes place progressively, and it probably begins to some extent within a relatively short time but takes a very long time, ordinarily about seventy-two hours or more to bring about complete conversion of all of the quartz into tridymite, whereas we may secure complete conversion for the amount of ground glass or other agent which is incorporated and for the temperature to which the investment is heated, and thereby the desired expansion, in about two and one-half hours or less. This particular time is referred to for purposes of illustrating the advantage in this respect, and, of course, is not in anywise intended to limit the present invention.

We do not intend to be limited to the precise ingredients, nor do we intend to be limited to the precise proportions herein set forth.

We claim:

1. Refractory mold material for making molds into which high melting point metals and alloys are to be cast, comprised essentially of ground quartz and comprising, in addition thereto, a binding agent and up to approximately 1.0 percent of an alkali oxide selected from the group consisting of sodium, potassium and lithium introduced as a constituent of an inert carrier comprising soda lime glass, said inert carrier being substantially insoluble and thereby avoiding any disturbance of the normal setting of the binding agent, said alkali oxide accelerating the transformation of quartz into tridymite at reduced temperature and being introduced in such amount that the resulting expansion is substantially limited at the final casting temperature and is not further increased by continued heating at the casting temperature for an interval of time after the casting temperature is reached.

2. Refractory mold material for making molds into which high melting point metals and alloys are to be cast, comprised essentially of ground quartz and comprising, in addition thereto, a binding agent selected from the group consisting of tetra-ethyl silicate and plaster of Paris and up to approximately 1.0 percent of an alkali oxide selected from the group consisting of sodium, potassium and lithium introduced as a constituent of an inert carrier comprising soda lime glass, said inert carrier being substantially insoluble and thereby avoiding any disturbance of the normal setting of the binding agent, said alkali oxide accelerating the transformation of quartz into tridymite at reduced temperature and being introduced in such amount that the resulting expansion is substantially limited at the final casting temperature and is not further increased by continued heating at the casting temperature for an interval of time after the casting temperature is reached.

3. Refractory mold material for making molds into which high melting point metals and alloys are to be cast, comprised essentially of ground quartz and comprising, in addition thereto, a binding agent selected from the group consisting of tetra-ethyl silicate and plaster of Paris and up to approximately 1.0 percent of an alkali oxide selected from the group consisting of sodium, potassium and lithium introduced as a constituent of an inert carrier comprising soda lime glass, said inert carrier being substantially insoluble and thereby avoiding any disturbance of the normal setting of the binding agent, said alkali oxide accelerating the transformation of quartz into tridymite at reduced temperature and being introduced in such amount that conversion of the quartz into tridymite takes place to the extent necessary to produce the desired expansion.

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