This invention relates to an improved foundry sand composition. In one of its aspects, this invention relates to a binder for foundry sand compositions. In another of its aspects, this invention relates to a method for the preparation of foundry sand compositions. In still another of its aspects, this invention relates to a method for the preparation of foundry core sands and molds.

The use of binders in foundry sand compositions is generally fundamental to a utility and as a consequence a great deal of research has been done providing binders which meet the rather severe requirements of their use. For example, a binder must hold sand grains together strongly when the core or mold is exposed to the flow of metal, the grains will not wash from the surface; it should generate a minimum of gas when it is contacted by the molten metal; it should provide sufficient strength to hold its shape until the metal begins to contract which point the strength should decrease rapidly and the core or mold should so that, cracks or hot tears will not form in the casting; it should produce a core or mold which will withstand the handling required before actual use; it should possess adequate dispersing properties so it can be distributed evenly throughout the mixture with a minimum of milling; it should provide a mixture which is formed into a core or mold without following the patterns on core boxes by sticking to them; and finally it should be economical. Numerous binders have been employed in the past including such things as water, oils, both vegetable and mineral, gums, such as rosin, Portland cement, pitch, asphalt, molasses, cereals such as wheat, corn and rye flour, clays, chemical resins and plastics, and the like. Water, glass, viz., sodium silicate, and other alkali metal silicates have also been employed. The recently developed and well known CO₂ process relies upon the use of alkali metal carbonates which are converted to colloidal silica in situ to produce a strong bond between the sand particles. A disadvantage of the CO₂ process is the need for expensive gas pressing equipment which is necessary to force the CO₂ gas into the formed core or mold in order to achieve the binding effect. In accordance with the present invention, we have provided an improved foundry sand composition which permits the benefits of the CO₂ process without the need for expensive gas pressing equipment. It is, therefore, an object of the present invention to provide an improved foundry sand composition. It is a further object of the present invention to provide a method for preparing foundry core sands and molds. Still another object of this invention is to provide a method for preparing foundry core sands and molds. The accomplishment of these and other additional objects will be apparent from the description which follows.

The foundry sand composition of the present invention is comprised of sand, water, an alkali metal silicate and a hydrolyzable organic carbonate ester having from 3 to about 30 carbon atoms. The binder for the sand particles in the composition is the in situ reaction product of the aqueous alkali metal silicate and the hydrolyzable organic carbonate ester. The various ingredients contained in the composition will be described in greater detail hereinafter.

The sand which can be used in accordance with the present invention is any conventional foundry sand or mixtures thereof, as for example, silica sands found in various parts of the country determined to be especially desirable for foundry purposes. A description of such sands can be found in "Foundry Core Practice," H. W. Dietert, 1950, published by American Foundry Men's Society, Chicago, III., pages 3 through 74. Specific examples include Ottawa sand, McComelisville sand, Providence sand, and the like.

The hydrolyzable organic carbonate ester which can be used in accordance with the present invention contain from about 3 to about 30 carbon atoms and may be either cyclic or acyclic. The cyclic carbonate esters, which are the preferred type of carbonate esters, include, illustratively, ethylene carbonate, propylene carbonate, 2,3-butylen carbonate, 1,2-butylen carbonate, cyclopentyl carbonate, and 3,4-heptyl carbonate. The first two mentioned compounds are available commercially from the Jefferson Chemical Company, Houston, Tex. More generally, the cyclic carbonate esters can be represented by the formula

\[ \text{O}-\text{R}-\text{O} \]

wherein R, may be aliphatic, aromatic, aryalkyl alkylaryl radicals containing between about 1 and about 15 carbon atoms. The alkylene radical may contain non-interfering constituent groups. The acyclic carbonate esters can be represented by the formula

\[ \text{O}-\text{R}-\text{O} \]

wherein R₁ and R₂ may be aliphatic, aromatic, aryalkylalkylaryl radicals containing between about 1 and about 15 carbon atoms. Specific illustrative examples of compounds coming within this class include ethyl carbonate, propionyl carbonate, butyl carbonate, hexyl carbonate, octyl carbonate, decyl carbonate, dodecyl carbonate, phenyl carbonate, tolyl carbonate, p,p'-dichlorophenyl carbonate, benzyl carbonate and the like. The prime criterion of the organic carbonate esters is that they be hydrolyzable by the aqueous alkali metal silicate employed. In those instances where the carbonate esters are liquids, they may be used as such. In other cases it may be desirable to use a solvent such as alcohol, kerosene, aromatic solvents, and the like. It is often desirable to employ a solvent for the purpose of controlling the rate of reaction between the carbonate ester and the aqueous alkali metal silicate. In such cases the solvent is preferably only slightly miscible with water.

The alkali metal silicates which can be used in accordance with the present invention include sodium, potassium and lithium silicates. These silicates are manufactured generally by fusing silica with the carbonate at the selected alkali metal and vary in their alkalinity. They are available either as solids or as aqueous solu-
tions with varying amounts of water and having different weight ratios of \( \text{M}_2\text{O}:\text{SiO}_2 \). Primarily because of its cost, sodium silicate is the preferred silicate. Preferably, aqueous alkali metal silicates are employed having a solids concentration in the range between about 30 and about 50 weight percent and having an \( \text{M}_2\text{O}:\text{SiO}_2 \) weight ratio in the range between about 1:1 and about 1:4. A preferred alkali metal silicate is a sodium silicate containing about 44% by weight solids and having a weight ratio of \( \text{Na}_2\text{O}:\text{SiO}_2 \) of 1:2.0. This silicate contains approximately 14.7 weight percent \( \text{Na}_2\text{O} \) and 29.4 weight percent \( \text{SiO}_2 \), has a viscosity of about 350 centipoises and a density of approximately 1.28 pounds per gallon. Another sodium silicate that can be used in the present invention is one containing about 52% solids and having an \( \text{Na}_2\text{O}:\text{SiO}_2 \) weight ratio of 1:3.87, which contains about 6.75% \( \text{Na}_2\text{O} \) and 25.3% \( \text{SiO}_2 \), has a viscosity of about 220 centipoises and a density of approximately 110 pounds per gallon. A potassium silicate which can be used is sold under the trade name Kasil #6. This potassium silicate contains 38.7% solids and has a \( \text{K}_2\text{O}:\text{SiO}_2 \) ratio of 1:2.10. The important characteristic of the alkali metal silicate employed in the present invention is its reactivity or capability for hydrolyzing the organic carbonate ester. It is desirable that this reactivity be adequate, but not so great as to cause an immediate reaction; that is, to react so quickly that the sand particles set up into a hard cohesive mass before they are shaped or rammed into a mold. As mentioned earlier herein, the degree of reactivity between the carbonate ester and the alkali metal silicate can be controlled through the use of solvents. It can be determined before actual use in foundry sand by the simple expedient of mixing together the selected silicates, carbonate ester, and solvent, if used, to see how quickly or slowly reaction takes place. It is also possible to use less reactive ingredients and effect reaction by heating, as for example, by baking in a conventional core baking oven. Core sand should also be exercised in the selection of the sodium silicate so as to avoid the "water glass" effect. This effect will be noted if the inherent adhesive ability of the silicate itself through the evaporation of water after mixing with the sand particles but prior to admixing with the carbonate ester.

The foundry sand composition of the present invention is comprised of a major portion of a suitable foundry sand, and a minor portion of a binder comprising the reaction product of water, an alkali metal silicate and a hydrolyzable organic carbonate ester having about 3 to about 30 carbon atoms, the total binding ingredients comprising in general between about 2 and about 7 weight percent of the total composition. The binder for the sand particles in our composition is the in situ reaction product of the three ingredients. The reaction can be illustrated by either of the following equations:

\[
\text{O} \quad \equiv \quad \text{H}_2\text{O} \quad \text{+} \quad \text{M}_2\text{O}_n \quad \rightarrow \quad \text{H}_2\text{O}_2\text{R} \quad \text{+} \quad \text{M}_2\text{O}_n \quad \text{+} \quad \text{M}_2\text{O}_n
\]

It will be noted that depending upon the character of the carbonate ester employed, one of the reaction products is either an alcohol or a glycol. It is possible that the selection of a particular carbonate ester will result in the formation of a product which contributes to the collapsibility of the core or mold after pouring of the molten metal. In general, however, the binding is achieved by the reaction or precipitation of colloidal silica particles which, by virtue of their common character, adhere to the silica said grains. A preferred foundry sand composition of the present invention contains between about 93 and about 98 weight percent of silica sand, between about 2 and about 7 weight percent of an aqueous sodium silicate having about 50 weight percent solids and an \( \text{Na}_2\text{O}:\text{SiO}_2 \) weight ratio of about 1:2.0, and a stoichiometric proportion, based on the alkali metal silicate and water, of propylene carbonate. The composition may contain other conventional core or mold ingredients in addition to those specified above, as for example, cereal, clay, and resin.

In preparing the foundry sand composition of the present invention, about 2 to about 7 parts by weight of a selected aqueous alkali metal silicate is admixed with about 93 to 98 parts by weight of a suitable foundry sand to promote uniform distribution of the silicate throughout the mixture. To the mixture there is added a quantity of the selected hydrolyzable organic carbonate ester, preferably at least a stoichiometric proportion which is thoroughly and uniformly blended into the sand composition. The mixing times, in general, should not exceed between about 1 and about 6 minutes, which time may be longer, depending upon the rate of reaction between the aqueous alkali metal silicate and the carbonate ester. After blending has been achieved, the sand is formed into a shaped core or mold, as for example by ramming or sanding, and then permitted to cure. Curing can be effected either by allowing the shaped article to stand, or it can be accelerated by baking according to conventional techniques at a temperature of about 120 to about 450 °F. For sufficient time to reach a maximum tensile strength. In baking cores and molds, the temperature and time required will vary widely depending upon the size of the core, the surface volume ratio, the water content, the type of sand, and the nature of the core binder. In the present instance, the degree of reactivity of the silicate and the carbonate ester is important as well as the manner in which they have been blended together; that is, whether or not solvents have been employed to promote or inhibit the contacting of the individual components.

Although the above method describes first admixing the sand particles with the aqueous alkali metal silicate and then adding the carbonate ester, it is also possible to first blend the sand particles with the organic carbonate ester followed by blending of the aqueous alkali metal silicate. In the latter procedure, using a solvent such as kerosene, for the carbonate will provide the sand grains with a coating of a slippery material which may form a thin film barrier between the ultimately precipitated colloidal silica and the original silica sand grains, thus providing some collapsibility to the ultimate core or mold. It will be appreciated, however, that this procedure may sacrifice some of the strength properties of the final core or mold.

In another aspect, the sand is blended with the desired quantity of aqueous alkali metal silicate after which the mixture is formed into a core mold. The surface of the mold is then coated with the organic carbonate, either in its pure form or as a solution. This procedure will set the reaction at the surface and to the depth of penetration of the carbonate ester. It is also possible, when using a solution of the carbonate ester in an alcohol or kerosene, to speed up the reaction between the carbonate ester and the aqueous alkali metal silicate by igniting the residual solvent fumes at the surface. It is also possible to include in the solution of the carbonate ester a pitch and/or a plastic resin, such as urea-formaldehyde or phenol-formaldehyde. Such a composition after spraying or painting onto the surface of the cores or molds, when ignited, causes the carbonate reaction to take place and provide hardness. There is also provided additional hardness on the surface by virtue of the resin used in the penetration of the composition. Further, the inclusion of carbon-containing materials in such a composition provides a reducing atmosphere to offset the normal burn-in or penetration effects of sodium silicate molds.

The following examples will help to illustrate the under-
5 lying principles of the present invention and are not to be construed as unduly limiting thereof.

**Example I**

400 grams of No. 50 Ottawa silica sand was thoroughly mixed with 16 grams of an aqueous sodium silicate containing 44.1% solids consisting of 14.7 weight percent Na₂O and 29.4 weight percent SiO₂ (Na₂O:SiO₂ ratio = 1:2.0) having a viscosity of about 350 centipoises and a density of approximately 12.8 pounds per gallon. 3.2 grams of propylene carbonate was thoroughly blended with the above mixture and 105 to 110 grams of the resultant mixture was formed into "dog biscuit" core samples using standard techniques and then heated at about 220° F. for 3 to 10 minutes. On cooling the cores were found to have a breaking strength (dry shear test) greater than 100. The tests employed were in conformity with standard practices as described in "Foundry Sand Handbook," 6th edition, 1952, published by the American Foundrymen's Society, Chicago, Ill.

Other cores were prepared in similar fashion and held to room temperatures for 10 to 15 minutes to give cores which could be handled.  In all cases, after baking for at least some overnight, the cores prepared without baking had a dry shear strength of about 75 pounds.

**Example II**

In this example 400 grams of sand was thoroughly blended with the same sodium silicate as employed in Example I. After thorough mixing, the mixture containing 3.2 grams of propylene carbonate and 3.2 grams of an alkylated benzene solvent (HISol198F) were added to the sand. Mixing was continued for another 2 minutes. Within 10 minutes after the addition of the propylene carbonate, the sand started to set up. Test cores were prepared before like manner, however, which after baking for approximately 5 minutes at 220° F., one core had a breaking strength of approximately 115 pounds and another had a breaking strength of about 65 pounds.

While this invention has been described in terms of its preferred embodiment, those skilled in the art will appreciate that modifications can be made without departing from the spirit and scope of the invention.

We claim:

1. A foundry sand composition containing sand and a binder in sand-binding amount consisting essentially of water, an alkali metal silicate and at least a stoichiometric amount, based on the silicate, of a hydrolyzable organic carbonate ester having from 3 to 30 carbon atoms.

2. A foundry sand composition according to claim 1 wherein said carbonate ester is an alkylene carbonate having from 3 to 8 carbon atoms.

3. A foundry sand composition according to claim 1 wherein said carbonate ester is a dialkyl carbonate having from 3 to 30 carbon atoms.

4. A foundry sand composition according to claim 1 wherein the alkali metal silicate is sodium silicate and the organic carbonate ester is propylene carbonate.

5. A foundry sand composition according to claim 1 wherein the alkali metal silicate is sodium silicate and the organic carbonate ester is ethylene carbonate.

6. A foundry sand composition containing as essential ingredients thereof a major proportion of sand, water, a sand binding quantity of, an alkali-metal silicate having an M₉O:SiO₂ weight ratio in the range between about 1:1 and about 1:4 and at least a stoichiometric proportion, based on said silicate, of a hydrolyzable organic carbonate ester having from 3 to 30 carbon atoms.

7. A foundry sand composition containing as essential ingredients thereof a major proportion of sand, water, from about 2 to about 7 weight percent of a sodium silicate having a Na₂O:SiO₂ weight ratio in the range between about 1:1 and 1:4, and a stoichiometric proportion of an alkylene carbonate having from 3 to 8 carbon atoms.

8. A foundry sand composition containing as essential ingredients thereof about 95 weight percent silica sand, 1 weight percent water, 4 weight percent of a sodium silicate having a Na₂O:SiO₂ weight ratio of about 1:2.0 and about 1 part by weight of propylene carbonate.

9. In a foundry core containing sand as its major ingredient, a sand-binding amount of a binder consisting essentially of the in situ reaction product of an aqueous alkali metal silicate and at least a stoichiometric quantity of a hydrolyzable organic carbonate ester having from 3 to 30 carbon atoms.

10. A core binder according to claim 9 wherein the alkali-metal silicate is sodium silicate and the organic carbonate ester is an alkylene carbonate having from 3 to 8 carbon atoms.

11. A core binder in accordance with claim 9 wherein the alkali-metal silicate is a sodium silicate having a Na₂O:SiO₂ weight ratio in the range between about 1:1.0 and 1:4.0 and the carbonate ester is propylene carbonate.

12. A method for the preparation of a foundry sand composition which comprises admixing a major proportion of a foundry sand with a sand-binding amount of an aqueous alkali-metal silicate and at least a stoichiometric quantity of a hydrolyzable organic carbonate ester having from 3 to about 30 carbon atoms whereby said aqueous alkali-metal silicate and organic carbonate ester react to bind the sand particles into a cohesive mass having strength properties adequate for foundry use.

13. A method according to claim 12 wherein said organic carbonate ester is an alkylene carbonate having from 3 to 8 carbon atoms.

14. A method according to claim 12 wherein said organic carbonate ester is a dialkyl carbonate having from 3 to 30 carbon atoms.

15. A method according to claim 12 wherein the alkali-metal silicate has a M₉O:SiO₂ weight ratio in the range between about 1:1.0 and about 1:4.0.

16. A method according to claim 15 wherein the alkali-metal silicate is a sodium silicate.

17. A method for the preparation of a foundry sand composition which comprises mixing thoroughly a major proportion of a foundry sand with a sand-binding amount of an aqueous alkali-metal silicate and then uniformly admixing therewith at least a stoichiometric quantity, based on the silicate, of a composition comprising an organic carbonate ester having from 3 to about 30 carbon atoms and allowing the aqueous alkali-metal silicate and organic carbonate ester to react and bind the sand particles into a cohesive mass having adequate strength properties for foundry use.

18. A method according to claim 17 wherein said organic carbonate ester is an alkylene carbonate having from 3 to 8 carbon atoms.

19. A method according to claim 17 wherein said organic carbonate ester is a dialkyl carbonate having from 3 to 30 carbon atoms.

20. A method according to claim 17 wherein the alkali-metal silicate has a M₉O:SiO₂ weight ratio in the range between about 1:1.0 and about 1:4.

21. A method according to claim 20 wherein the alkali-metal silicate is a sodium silicate.

22. A method for the preparation of a foundry sand composition which comprises uniformly admixing 95 parts by weight of a foundry sand with 5 parts by weight of an aqueous sodium silicate solution containing 30 weight percent solids and having a Na₂O:SiO₂ ratio of about 1:2.0 and then thoroughly admixing therewith at least a stoichiometric proportion, based on the sodium silicate of propylene carbonate.

23. A method for the preparation of a foundry sand composition which comprises uniformly mixing a major proportion of a foundry sand with a minor proportion of an aqueous alkali-metal silicate containing from about 30 to about 60 weight percent solids and having a M₉O:SiO₂.
weight ratio of a range between about 1:1.0 and about 1:4.0; forming the resulting mixture into a shaped article, and coating the surface of said shaped article with a composition comprising a hydrolyzable organic carbonate ester having from 3 to about 30 carbon atoms whereby the surface of said shaped article is hardened into a cohesive mass of bound sand particles by the reaction product of the alkali-metal silicate and the organic carbonate ester.

References Cited in the file of this patent

UNITED STATES PATENTS

2,883,723 Moore ---------------- Apr. 28, 1959
2,895,838 Ilanda ---------------- July 21, 1959

FOREIGN PATENTS

964,785 France ---------------- Feb. 8, 1950
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,137,046

Thomas E. Barlow et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 47, for "p,p'-dichlorophenyl" read
-- p,p'-dichlorophenyl --; column 3, line 45, for "said"
read -- sand --; lines 56 to 58, in the equation, for "HOROR"
read -- HOROH --; same column 3, line 73, for "said grains"
read -- sand grains --.

Signed and sealed this 16th day of March 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents