

Oct. 23, 1962

J. W. NORTH

3,059,296

CERAMIC BODY

Filed June 4, 1957

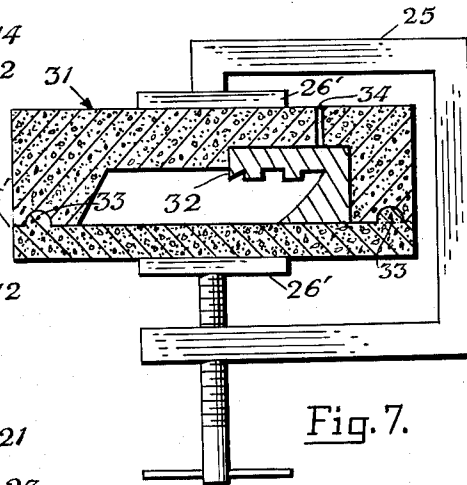
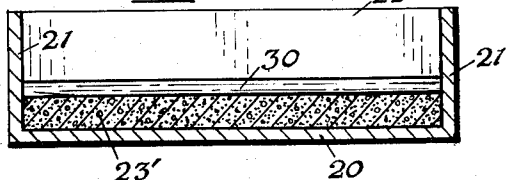
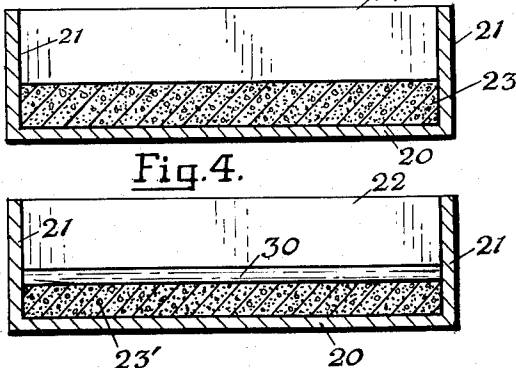
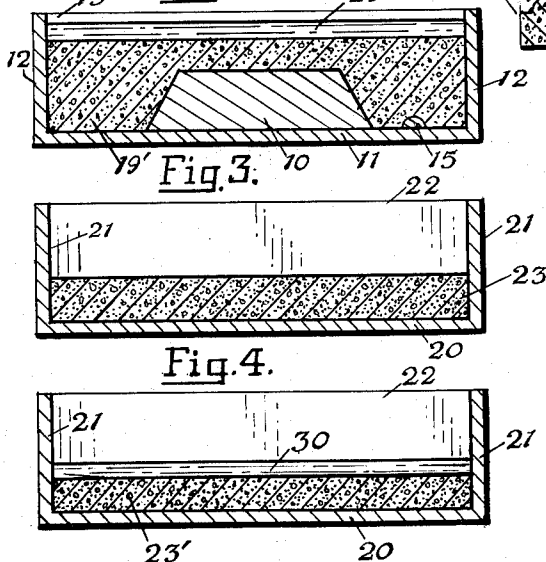
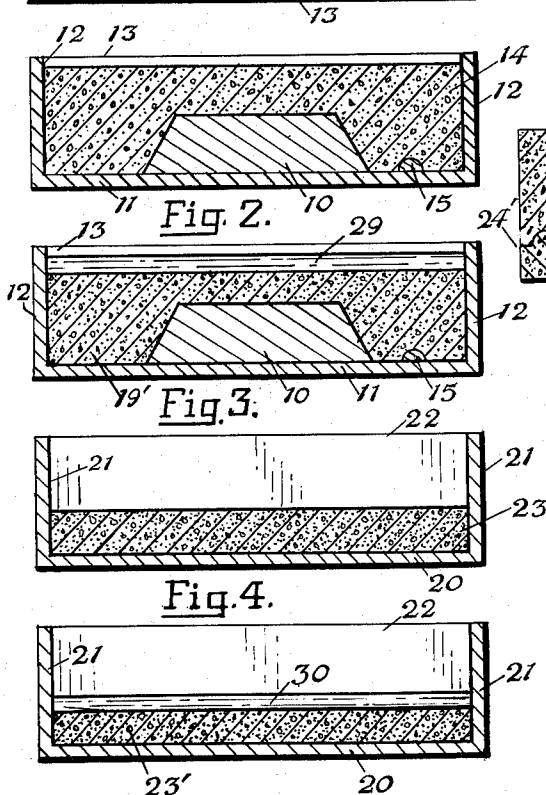
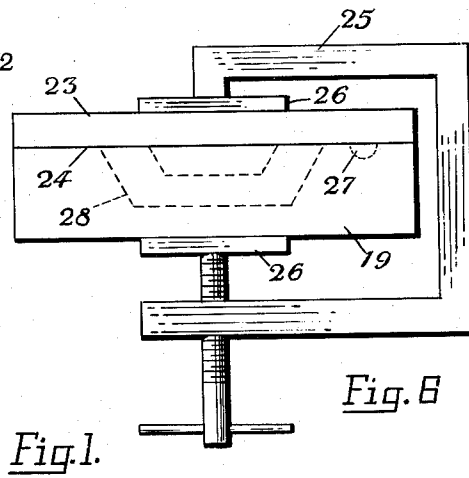
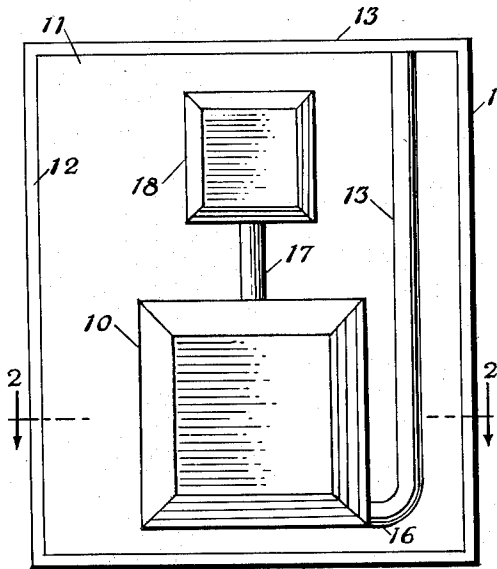


Fig. 5.

INVENTOR:

JOHN W. NORTH

BY

Edw. J. Johnston

ATTORNEY

1

3,059,296

CERAMIC BODY

John Walton North, Decatur, Ga., assignor, by mesne assignments, to Glasrock Products, Inc., Atlanta, Ga., a corporation of Georgia

Filed June 4, 1957, Ser. No. 663,398

2 Claims. (Cl. 22-193)

This invention relates to ceramic body and more particularly the present invention relates to a reusable foundry mold formed essentially of amorphous silica and to the method of preparing and forming the mold and thereafter repairing the mold as required by use.

In the prior art there are several types of molds which may be used for casting molten metal into predetermined shapes. A sand mold is one such type and is considered a temporary mold since it may only be used once to provide one casting. In such a mold, the sand is bound by a liquid or moistened bonding agent into a bulk of predetermined shape and may be left in its moistened condition or dried. If the sand contains water and is in a moist condition when the molten metal is poured into the mold, the water will be vaporized and must escape through the body of the mold. Therefore, the sand must be sufficiently coarse or loose that venting of the vapor or gas through the sand will be permitted. If other liquids are employed the mold is usually more expensive and noxious fumes may be produced when the molten metal is poured. On the other hand, drying of the bulky sand mass of the mold is time consuming and expensive and there is always a danger of distorting the casting cavity during drying.

Another problem in the prior art use of the green sand mold is the fact that it must be bulky and heavy in order to withstand hydrostatic pressures exerted by the molten metal without undue alteration of the dimensions of the casting cavity. Thermal expansion of the green sand charge, when the molten metal is received is another ever present problem. Because of these difficulties, the ramming pressures of the mold are controlled within practical limits in the foundry; however, even with extreme care, green sand castings always have some variations in surface finish and dimensions, the result being that, in many instances, the castings have excessive weight, require excessive machining or must be rejected.

More recently, a molding system termed "shell molding" has been employed. The shell mold is usually prepared by depositing a quantity of sand and resin in a heated flask whereby the resin bonds the sand in a shell segment which, when joined with other segments, defines the casting cavity. A shell so formed is used only once and usually gives off noxious fumes when the resin burns or is polymerized. The cost of the resin usually makes a shell mold expensive and the cost of the equipment employed to form the shell prevents small scale use of this system. The castings from shell molds are usually superior in surface texture to green sand; however, surface defects and dimensional deviations are present to a great extent therein.

Die casting, investment molding, and other precision casting systems have also been employed. These systems usually require a substantial amount of complicated machinery and, in some instances, expensive permanent molds. Such systems sometimes employ fine grained materials on the surfaces of the mold cavity to impart a smooth surface to the casting. In such molds, a colloidal silica binder and also a crystalline form of silica which has a more favorable temperature expansion characteristic than quartz sand, have each been used as surfacing agents. With thermal expansion and contraction of the mold, however, cracks in, and flaking of, the silica sur-

2

face occur, requiring such surfaces to be replaced substantially each time the mold is used.

In addition to being expensive, the prior art permanent molds are not easily adapted to relatively complicated shapes requiring a crushable type cavity area whereby a portion of the mold cavity must be removed with each casting and that portion replaced for a successive casting. For this reason and others, precision methods are not generally employed for large or complicated castings.

Permanent dies usually are made of metal and therefore are limited by the melting point and reactive characteristics of the metal within the mold. These dies, as pointed out above, are also expensive.

The patent literature discloses other types of molds such as those formed of various types of crystalline silica such as silica flour. It is believed that such molds would have expansion and thermal shock characteristics which would cause the mold to crack or deteriorate with repeated use since the thermal expansion of silica flour is about ten times that of the material of the present invention, namely amorphous silica.

It is generally accepted in the art that amorphous silica is unstable over about 1000° C. and therefore would be unsuitable for use as a reusable mold body since the temperature of the molten metal which the mold body receives is usually in excess of this critical temperature, the assumption being that the mold body would be heated by the molten metal to a temperature in excess of the critical temperature. Text books vary as to the exact temperature at which the amorphous silica will become unstable; however, the unstable condition which is attained by the amorphous silica is called devitrification, and is characterized by the amorphous silica converging into cristobolite. One text book states that at 870° C. B-quartz changes suddenly to B₂-tridymite, and at 1470° C. this changes to B-cristobolite. At 1625° C. cristobolite melts to silica glass. On cooling, B-cristobolite changes at temperatures ranging from 222° to 275° C. to another form called X-cristobolite. Other text books state that the main disadvantage of silica as a refractory material is its tendency to spall and crack during heating and cooling. For these reasons, heretofore, no reusable "permanent" type mold for use above a temperature of 1000° C. has been devised utilizing essentially the amorphous silica.

Contrary to the prior art beliefs and practices, I have devised a ceramic body which, for convenience, may be discussed as a mold form essentially of silica in fine granular or flour form which may be utilized for receiving molten metals whose pouring temperatures are relatively high, my mold being reusable for successive castings and repairable, as will be brought out more fully hereinafter. The mold formed according to my invention is highly resistant to thermal shock and thermal distortion, thereby permitting, in some instances, the forming of simpler surfaces within the casting and the forming of gating and riser systems directly in the mold body.

It is also contemplated by my invention that more complicated molds may be formed by employing the shaped bonded amorphous silica for the main body of the mold and a shell or cope of bonded sand within the casting cavity or defining a portion of the casting cavity. In the latter instance the sprue, ingate and riser systems are preferably defined by the main mold body of my invention. By such an arrangement, the shell or bonded sand portion of my mold may have weaker bonding than has heretofore been deemed advisable, without sacrificing dimensional accuracy, since the shell portion of my mold is backed by the main mold body.

When molds are prepared, according to my invention, the amorphous silica may be recovered after the mold has served its useful life and this material reprocessed

for use in forming other molds. It is also apparent that the amount of expendable material employed, in forming the shell or core is reduced to a minimum.

No sacrifice in quality of the resulting casting is necessary to accomplish economical operation, according to my invention, since the casting therefrom would be considered superior to a casting from green sand and would, in many instances, be comparable to a casting from investment molding. I have found the castings from my mold to be within close dimensional tolerances and essentially free from distortion, with the surfaces of the castings being relatively smooth.

Accordingly, it is a primary object of my invention to provide an inexpensive permanent or reuseable mold and a process of manufacturing this mold.

Another main object of my invention is to provide a reuseable mold formed of amorphous silica so disposed that molten metals having a pouring temperature above the critical temperature of amorphous silica may be poured into the mold without appreciably damaging the structure of the amorphous silica.

Another object of my invention is to provide a reuseable mold which is resistant to thermal shock and distortion.

Another object of my invention is to provide a reuseable mold which may be easily and effectively repaired, if necessary.

Another object of my invention is to provide a reuseable mold formed of a material which, when the mold has served its useful life, the material therein may be reprocessed for use in other molds made according to my invention.

Another object of my invention is to provide a reuseable mold, part or the entire area of which may be easily cooled or heated by external means while the mold contains the casting metal.

Another object of my invention is to provide a lightweight reuseable mold of ceramic material which is suitable for retaining casting metal under pressure.

Another object of my invention is to provide a process of repairing a ceramic mold.

Another object of my invention is to provide a means and method of inexpensively and effectively producing a superior type of metal casting.

Other and further objects of my invention will become apparent from the following description when taken in conjunction with the accompanying drawings wherein like characters of reference designate corresponding parts throughout the several views and wherein:

FIG. 1 is a plan view of a cope box or flask adapted to receive ceramic material to form a segment of a mold constructed in accordance with my invention;

FIG. 2 is a cross sectional view taken along line 2—2 in FIG. 1, the cope box being shown containing damp ceramic material;

FIG. 3 is a cross sectional view similar to the view of FIG. 2 showing wet ceramic material after it has been standing in the cope box;

FIG. 4 is a cross sectional view of another flask or drag box provided with damp ceramic material for forming the other segment of my mold;

FIG. 5 is a cross sectional view similar to the view shown in FIG. 4 showing wet ceramic material after standing in the drag box;

FIG. 6 is a plan view of an assembled mold constructed of the mold segments shown in FIGS. 3 and 5; and

FIG. 7 is a cross sectional view of a modified form of my invention showing an assembled mold having a bonded sand partial shell.

In more detail, the ceramic body of my mold segments, by way of examples, may be formed following either of two methods which I shall term respectively the damp aggregate method and the wet aggregate method. In either method I employ silica aggregates formed essentially

ly of granulated or powdered amorphous silica, fused silica or high silica glass. Preferably, as pure a silica as possible should be used for best results; however, I do not wish to exclude the use of a silica material, such as high silica glass which contains above 90% amorphous silica, which would give satisfactory results, according to my invention.

The silica aggregates should be sufficiently fine in size that they will pass through a 30 mesh screen, since larger particles with no finer particles intermixed therewith do not band together as readily. I prefer, however, that the aggregates be sufficiently fine to pass through a 100 mesh screen since such aggregates form a smooth surface and band together well. It is not necessary that all particles of the silica aggregate be uniform in size. Amorphous silica or high silica glass, which is ground to a size on the order of silica sands, crushed sands, or flours, is suitable for use. The amorphous silica or fused silica, which is a more limited term for amorphous silica, differs from sand commonly found in nature, in that the amorphous material has been fused, then cooled quickly, then comminuted to a small size. Of course, other methods may be employed for obtaining the amorphous silica such as fusing the silica granules as they fall freely and then cooling the granules by permitting them to continue to fall. Round shots are formed in this manner and these round shots are suitable for use as my silica aggregate.

In either method of preparing the mold body, I bond the silica aggregates with a liquid suspension of colloidal silica which, when mixed with the silica aggregate, may be caused to set, as will be described hereinafter, to form a monolithic body. Being amorphous silica itself, the silica of the binder has essentially the same characteristics as the silica aggregates and therefore is equally able to resist thermal shock.

In making the mold body according to the damp aggregate method, the binder is prepared by suspending from about 2% to about 35% colloidal silica by volume with water or some other suitable vehicle such as alcohol. The manufacture of a colloidal silica suspension is disclosed in the prior art and therefore no detailed discussion of its production is necessary. Such suspensions are available commercially under trade names such as "Ludox" produced by the Grasse Chemical Co., Inc., of Wilmington, Delaware, department of E. I. Du Pont de Nemour; and "Nalcoag" produced by National Aluminate Corporation of Chicago, Illinois. These commercially available colloidal dispersions are suitable for use according to my invention in the form in which they are shipped.

The damp aggregate is prepared by mixing or commingling about 100 parts of the silica aggregate with from about 4 to about 15 parts of binder prepared as above described or as commercially received. If this charge of silica aggregate and binder is not to be used immediately, it should be kept covered so that it does not dry out.

When forming a mold segment, the charge is shaped to define a portion of the casting cavity together with the connecting sprue, gating and riser systems in a manner similar to forming a green sand mold. In FIGS. 1 and 2 I have disclosed one convenient way to form a mold segment, wherein a cavity pattern 10 is mounted centrally on a pattern plate 11 having upstanding sides 12 and ends 13. The sides 12 and ends 13 together with the plate 11 define a flask or cope box for receiving the damp charge denoted by numeral 14. In the present embodiment, the sprue pattern 15, ingate pattern 16, riser pattern 17 and plenum chamber pattern 18 are disposed with cavity pattern 10 to define a conventional pattern arrangement.

As is well understood in the art, it may be necessary to prepare the various patterns and the pattern plate for easy removal from the mold segment 19 formed by

5

charge 14 by treating these parts of the cope box with a releasing agent such as wax, silicone, chlorinated hydrocarbon and the like. The use of these releasing agents is well known and therefore mere mention of some releasing agents is sufficient. In cases where the patterns are formed from gypsum plaster or other material which will shrink, such patterns should be soaked in water and then dipped, sprayed or coated with wax, grease, or lacquer, so that if the patterns shrink upon drying of the mold segment in the cope box, the original shape of the pattern will remain in the mold segment.

Patterns for my mold may also be made of wax which may be melted from the mold or burned out. Of course, a pattern may be made from the damp aggregate itself, in which case it should be coated as by lacquer or varnish after final shape is obtained and the wet mix poured around it. The mold segment should then be fired, after gelling or drying, until the coating of lacquer or varnish is burned out. This leaves the pattern in a loose condition.

If the pattern is made of metal, it should not be fired to high temperature or oven heated with the mold segment since the metal pattern will expand and crack the mold segment. Other methods and techniques used in fine metal work and ordinary foundry practice are also adaptable to my mold casting system.

It is to be noted that if great accuracy and smoothness of casting is desired, I prefer to employ a pattern made of the same aggregate mix as is to be used for the mold segment, the aggregate mix being coated as described above and fired with the mold segment. Further, the entire cope box may be made of the charge 14 so that it will have the same shrinkage as the mold segment 19 when dried and/or fired with the charge 14.

According to my damp aggregate method, the charge, prepared as above described, is placed in the flask in a manner similar to the charging of green sand into a cope box. For strength, the mold segment 19 thus formed is then dried by removing the water from the colloidal silica to leave a hard ceramic body. For additional strength, mold segment 19 may be sprinkled or asperged with additional binder, and then redried. Sintering in an oven at about 1000° F. to 1900° F. for a few minutes will strengthen mold segment 19 even further.

It is noted here that once the binder is dry or has been sintered, rewetting does not redisperse or cut the dried binder. Further, the mold segment may be dried, sintered, and rewet in any sequence, just so that the drying is completed before the mold segment 19 is rewet.

After drying, mold segment 19 is removed from the cope box and inspected for imperfections. If damage has occurred to mold segment 19, it may be easily repaired by spreading additional charge with a spatula, trowel, screeding tool or other suitable instrument over the broken area and thereafter carving, scraping or sanding the surface so formed, either before or after it has dried. If the damage is superficial, the mold segment 19 may be used before the repaired portion is dry. Of course, if the damage is severe, mold segment 19, after being repaired, should be redried and/or refired.

In the same manner as the cope box of FIGS. 1, 2 and 3, the drag box shown in FIGS. 4 and 5 includes a pattern plate 20, sides 21 and ends 22. The charge is supplied to the drag box in a manner similar to the charges of the cope box described above. The mold segment 23 thus formed is dried and sintered as described for mold segment 19. In this particular instance, simply a flat mold segment 23 is prepared and hence no configuration, other than a flat surface, is imparted to the casting cavity area of mold segment 23 or other areas thereof. It will be understood, however, that any conventional pattern may be utilized for a particular configuration to be imparted to mold segment 23 if desired.

After being prepared properly, the ceramic bodies formed as the mold segments 19 and 23 are removed

6

from their flasks and joined as shown in FIG. 6, the abutting surfaces of the mold segments being contiguous along a part line 24. For retaining the mold segments in appropriate registry, a C-clamp 25 is provided having abutments 26 which urge the respective mold segments together. The mold is thereafter ready to receive the molten metal via sprue 27 into the casting cavity 28.

In the wet aggregate method of preparing my mold, 100 parts of the amorphous silica aggregate are mixed and thoroughly commingled with from about 14 to about 38 parts by weight of the binder. For purposes of illustration, I have employed the same cope and drag boxes as previously used. The wet aggregate charge, prepared of the amorphous silica and binder in the proportions above stated, is poured into the boxes. Usually it is desirable to fill the boxes about half full and in all instances cover the entire pattern with the wet charge. Thereafter, the charge is permitted to settle. For reducing the time necessary for settling, the boxes may be vibrated in a vertical direction until the particles of the charge are well packed and as much as possible of the liquid, denoted by numerals 29 and 30, has been driven to the top. Jolting of the boxes may be accomplished by electromagnetic or air-mechanical means (not shown). When the liquids 29, 30 float to the top of the boxes they should be poured off to facilitate setting up of the wet charge.

If it is desired to set the binder, rather than to dry the charge as described above, an electrolyte is added to the wet charge either immediately before or after it has been dumped into the boxes. If the wet charge is to be kept for extended periods of time, of course, the electrolyte should not be added thereto until it is ready for use. The electrolyte causes the colloidal silica to gel so that the ceramic body becomes hard, as does the drying of the water from the damp aggregate charge in the previous method. Descriptions of methods of gelling the colloidal silica are disclosed in the E. I. du Pont de Nemour's Product information bulletin entitled "Du Pont Ludox Colloidal Silica" and in other literature. Therefore, little description is necessary as to particular methods of gelling the colloidal silica except to state that substantially any electrolyte when added to the colloidal silica suspension will tend to gel the silica. For my purposes, from .5% to about 4% ammonium chloride, added to the colloidal silica suspension, will cause gelling. Also, sufficient hydrochloric acid added to the colloidal silica suspension to provide a pH of from 5 to 6 will cause gelling for the purposes herein described.

I prefer to use either ammonium chloride or hydrochloric acid as a gelling agent or electrolyte since both of the above chemicals may be evaporated from the charge after gelling of the colloidal silica and therefore no impurities will remain to contaminate the silica mold segment. Magnesium sulfate, however, will accomplish gelling of the colloidal silica much faster than the chlorides mentioned above and, in the event that the amorphous silica is not to be reused, perhaps this electrolyte would be more desirable as a gelling agent.

If the gelling agent is added to the charge before the same is jolted, it would be advisable to ascertain, in advance, the time lapse involved in gelling so as to be certain that the jolting is completed before gelling has proceeded noticeably. The time required for gelling cannot be described here because there are too many variables which would effect it. Therefore, by simply taking a part of the particular charge and adding the gelling agent thereto before the gelling agent is added to the entire charge is an easy method of determining the gelling time for the particular charge.

In all cases where the binder of my wet aggregate charge is to be gelled, the same should be accomplished before the mold segments, denoted by numerals 19' and 23' are dried; since, if drying is permitted before gelling, a portion of the binder will be drawn to the surface of

the mold by capillary action before it has had an opportunity to gel, thereby enriching the outer surface with binder while making other parts of the mold segments lean in binder, whereby cracks in the mold segment may develop.

After the mold segments 19' and 23' have been hardened within the cope and drag boxes, the pattern plates 15, 20 are removed and pattern 10 withdrawn. The mold segments 19' and 23' are then assembled as shown in FIG. 6 for the assembly of mold segments 19 and 23.

Before pouring molten metal into the mold, it is advisable, in order to aid in the release of the casting from the mold, to coat the areas to be contacted with a releasing agent. Soot, smoked on with an acetylene torch, or other carbon such as graphite or carbon black may be employed. In liquid suspension, the carbon or graphite may be sprayed on. Further water suspensions of silica, zircon, alumina, zirconia, calcium silicate, magnesium carbonate or powdered aluminum may be employed. Also, various clays in combination with the above substances may be used.

Referring now to FIG. 7 of the drawing, it is seen that my silica mold segments, denoted generally by numeral 31, are aligned by a conventional key 33 fitting into a key way and held in registry along a part line 24' by C-clamp 25' and abutments 26'. Numeral 32 denotes a foundry sand shell or core cake which may be cast with my silica mold as shown. Many means such as adhesion or dowel pins (not shown), may be used for retaining the foundry sand shell 32 in place. The construction of FIG. 7 is used when a casting is so shaped that it would be difficult to remove from a monolithic mold such as shown in FIG. 6. In preparing the composite mold of FIG. 7, the mold segments 31 are prepared with an oversize casting cavity as outlined above according to my damp aggregate or wet aggregate method. Thereafter, the space left in the mold for the shell 32 is filled with a bonded sand insert or an external core print formed according to prior art practices. Of course after each pouring, a new insert or shell 32 must be provided.

For cooling the shell 32, it may be found desirable to provide a vent hole 34 in mold segments 31 and behind shell 32.

It will also be understood that the composite mold of FIG. 7 may be provided with a bonded sand shell completely surrounding the casting cavity. Such a composite mold may prove desirable with extremely high temperature pourings.

When forming a bonded shell completely surrounding the casting cavity, several vent holes such as hole 34 may be provided in the mold segments. One advantageous method, according to my invention, for forming a complete shell around the casting cavity is to make each of the mold segments 31 oversize and then fit each segment respectively over the patterns, such as pattern 10. Thereafter, the bonded or foundry sand is blown into the area between the segment and the pattern through vent holes such as hole 34. Of course, more than one vent hole 34 must be provided so that the air or other impelling fluid may escape, leaving the sand in place.

The mold segments are then removed from the pattern and joined together. The molten metal may then be charged into the casting cavity of the composite type mold while the shell is still damp or the shell may be dried to reduce to a minimum the "gassing" of the sand.

By the term "bonded sand" as used herein, it will be understood that I mean conventional foundry sands such as silica sand impregnated with cereals, proteins, oils, clays, sugars, resins, or sodium silicate solution, and also coke fines, zircon, alumina, amorphous silica, alone or in admixture with carbon or aluminum powders and/or combined with the above binders.

To test the fact which I have discovered, that the amorphous silica, if prepared in the form of a mold as above

described, will withstand temperatures far in excess of the critical temperature of 1000° C. where the amorphous silica is expected to be converted to a crystalline form, samples of the silica mold material prepared according to my invention were fired at 2600° F. One sample was maintained at 2600° F. for 15 minutes, another 30 minutes, another 45 minutes and still another for one hour. All samples were removed and placed in air for rapid cooling. When cooled, the surface of the samples seemed to become harder, rather than softer. The samples also showed good resistance to thermoshock, in that the last sample of the material was cycled, by first heating the sample to 2600° F. and then air quenching for four cycles. No noticeable change took place in this sample.

To further test the characteristic of my silica mold, blocks of silica were formed according to the process outlined above. The first block was 2 inches by 2 inches by ½ inch and was placed on a supporting surface on its 2 inch by 2 inch side with a thermocouple extending from beneath the supporting surface into the block to within ¼ inch of the upper surface. This sample block was inserted into an oven which had been preheated to 2600° F. (1427° C.) and the time was measured for the thermocouple to indicate that the block was at oven temperature. It required 5 minutes for the interior of the block to be heated to oven temperature.

Next, two samples, each a block 4 inches by 1 inch by ½ inch, were placed on their ends in an oven which was preheated to 2600° F. The first block was left in the oven for 5 minutes and then removed for cooling in air. When cool, this block was compared with an unheated similar sample by X-ray analysis. No change in crystalline structure in this block was observed, thus indicating that no additional crystobolite had formed.

The second block was left in the oven 10 minutes and examined in a manner similar to the previous sample. This later sample indicated that some crystobolite had formed. From other test, however, it may be stated that even if the block were left in the oven for 96 hours, no additional appreciable change in structure would have taken place.

Therefore, since in practice, the molten metal poured into my molds, remains at high temperature less than five minutes for each pouring, no appreciable damage to my mold will take place on repeated heating, except for the normal wear.

For comparison, a block of foamed silica was inserted into an oven at 2600° F. and left there for a period of 15 minutes. When removed, the surface of the foamed silica showed marked signs of disintegration into a powdery crystalline form. X-ray analysis confirmed that crystals of silica were present in the powdered surface.

For a most severe test of my mold, I poured molten metal at a temperature of 2700° F. into a mold I had prepared by using 100 parts amorphous silica to 25 parts binder. Immediately after pouring the metal into the mold, I immersed the mold in water. Thereafter, the casting was removed and the mold inspected. The inspection revealed no damage or deterioration to the mold.

In still another test, I poured molten metal into a mold made in accordance with my invention for eighty successive pourings, cooling rapidly in air after each pouring and removing the casting thus formed. An inspection of my mold after the eightieth pouring revealed no apparent deterioration to the mold.

From the foregoing discussion it is apparent that I have provided a permanent type mold which incorporates such desirable characteristics as being inexpensive, durable and resistant to thermal shock. I have found that, parallel to the parting line, tolerances may be maintained in my mold to .002 inch per linear foot; and, across the parting line, the tolerances may be maintained to within .004 inch per linear foot. In my composite type mold, tolerances may be maintained to the above values if the disposable part of the mold is made of amorphous silica. If bonded sand

forms the disposable part of my mold, an additional .002 inch per linear foot should be added to the above tolerances.

In operation, the hot metal may be poured directly against the surface of my mold and/or various prior art lubricants, coatings, washes or the above described shell liners may be used to protect the cavity surface of my molds to prevent sticking of the casting in the molds. The liner shell, such as shell 32, is normally made so that it will drop out with each casting.

Since my molds are dry, as compared to the wet green sand, the molten metal may be poured at a lower temperature than has, heretofore, been used for sand castings. Also, my mold may be preheated if desired so that the surface of the molten metal is not chilled when it strikes the casting cavity. On the other hand, my molds may be quenched in water or otherwise quickly cooled after receiving the molten metal.

It will be obvious to those skilled in the art that many variations may be made in the embodiment chosen for purpose of illustration without departing from the scope of my invention as defined by the appended claims.

I claim:

1. Process of forming a composite mold segment comprising the steps of forming a dispersion of colloidal silica and liquid, commingling finely divided amorphous silica with said dispersion to form a mix, shaping said mix into

predetermined shape having an inner surface to define a volume larger than a portion of a casting cavity, forming holes through said shaped mix, removing the liquid from said mix to provide an outer shell, fitting said outer shell on a pattern, substantially the size of said portion of a casting cavity and introducing foundry sand through said holes to fill the space between said pattern and said inner surface of the shell.

2. The process defined in claim 1 wherein at least one additional composite mold segment is formed and said composite mold segments are fitted together to define a casting cavity surrounded by the foundry sand of said composite mold segments.

References Cited in the file of this patent

UNITED STATES PATENTS

1,901,427	Alley	Mar. 14, 1933
1,918,089	Durand	July 11, 1933
2,517,902	Luebke	Aug. 8, 1950
2,521,839	Feagin	Sept. 12, 1950
2,795,022	Noel Shaw	June 11, 1957

FOREIGN PATENTS

575,734	Great Britain	Mar. 4, 1946
606,119	Great Britain	Aug. 6, 1948
1,039,893	France	May 20, 1953
203,919	Australia	Aug. 31, 1956