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CENTRIFUGAL CASTING COATING COMPOSITION FOR CENTRIFUGAL
MOLDS AND METHOD OF COATING MOLDS

2,623,809

Filed May 2, 1949

2 SHEETS—SHEET 1

Fig. 1.

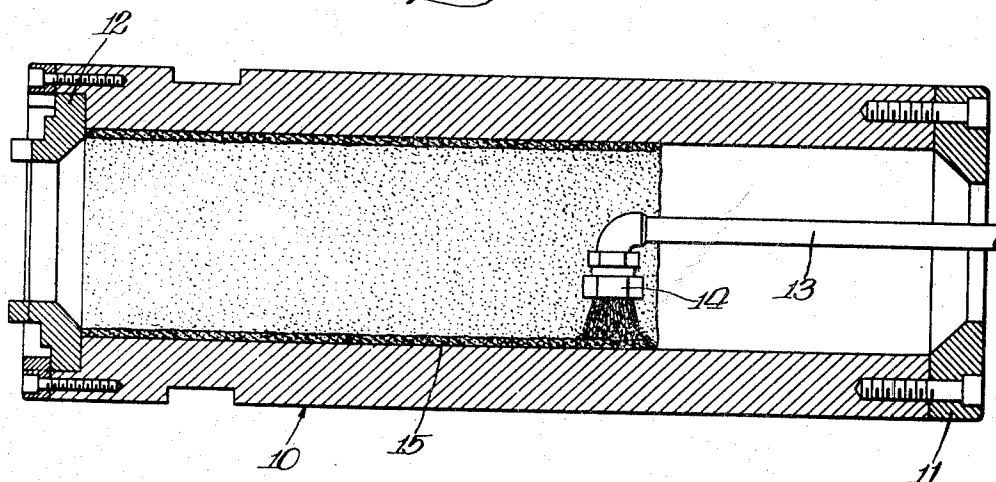
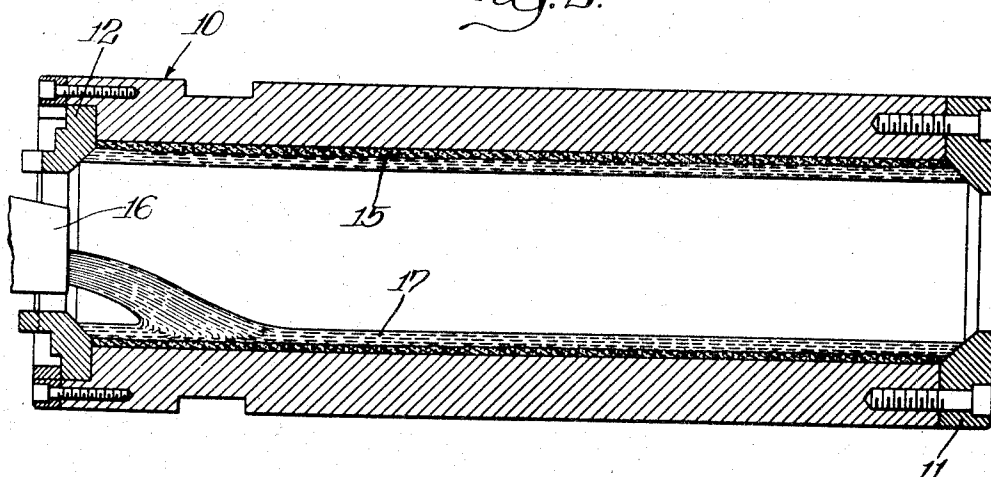


Fig. 2.



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2 SHEETS—SHEET 2

Fig. 3.

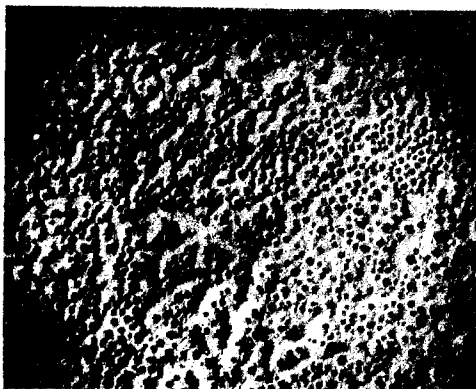
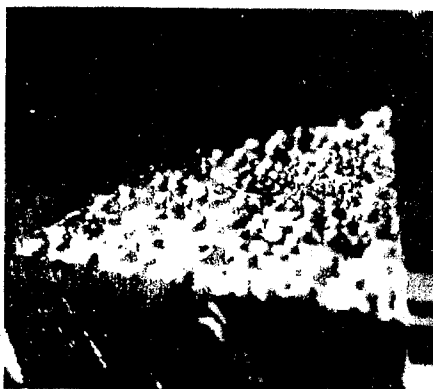


Fig. 4.



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UNITED STATES PATENT OFFICE

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CENTRIFUGAL CASTING COATING COMPOSITION FOR CENTRIFUGAL MOLDS AND METHOD OF COATING MOLDS

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1

The invention relates to centrifugal casting of tubular metal articles in permanent metal dies, and particularly to articles of cast iron.

The general object of the invention is to provide a novel method of and mold for making centrifugal castings, resulting in castings which are free of defects such as pin holes, dents or inclusion of foreign matter, and which have a relatively even exterior surface conforming closely to a desired diameter, so that the castings may be machined to a finished size with a minimum removal of stock.

Another important object is to provide a novel method of and mold for making centrifugal castings of the character referred to in the preceding object, which permit of a high rate of production for the castings.

A further object is to provide a novel method of and mold for making centrifugal castings of cast iron, by which a desired metallurgical structure may be attained.

Still another object is to provide a novel refractory coating for the inner surface of the permanent metal dies.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic longitudinal sectional view of a die being sprayed with a coating composition, to illustrate one of the steps of my novel method.

Fig. 2 is a view similar to Fig. 1 but showing the coating completed and the molten metal being supplied to the die.

Fig. 3 is a photographic view of the inner surface of the coating magnified six times.

Fig. 4 is a photographic view of the outer surface of a casting made by the method disclosed herein, the surface being magnified six times.

In the art of making tubular metal castings in permanent cylindrical metal dies, the dies are usually provided with some sort of refractory liner, both for the purpose of protecting the dies from the action of the heat of the molten metal and for the purpose of preventing too rapid cooling of the metal. If gray cast iron were the metal being cast, such rapid cooling would result in the formation of chills in the castings, which would render the metallurgical structure of the casting unusable for most purposes.

One type of liner is formed of ordinary molding sand placed in the die to form a liner of sufficient thickness to insulate the casting from the metal die. The resulting casting will be simi-

2

lar to an ordinary sand casting made in the usual stationary mold and will have many of the disadvantages thereof. Thus, the exterior of the casting will be relatively rough and irregular and will include particles of sand, so that a substantial amount of metal must be removed from such a casting to bring it to a finished dimension. Another difficulty with such a method is that the rate of production is relatively low. Such a method, however, has the advantage, in making cast iron castings, that the cooling rate of the metal is such that a desired metallurgical structure may be obtained.

Another method of making castings centrifugally in permanent metal dies has been proposed, in which the die is lined with a coating consisting of a powdered refractory material such as silica flour and a binder such as bentonite applied in the form of an aqueous suspension, the method of application being by means of a spray to build up the coating incrementally. In this method, the traction on the metal causing it to rotate with the die is dependent upon the roughness of the inner surface of the coating. Consequently, great care must be exercised in applying the coating to attain such surface roughness, and the incremental application of the material is necessary to this end. Moreover, such roughness necessarily results in a surface on the casting of similar roughness, and to machine such a casting to a finished dimension requires considerable removal of stock.

It frequently occurs, in making castings in a die provided with this type of liner, that the castings have the defects of pin holes and dents in their outer surfaces. These defects may be due to gases forming when the molten metal contacts the liner or may be due to traces of moisture remaining in the coating when the metal is poured. Of course, complete drying out of the coating would eliminate this last mentioned cause, but moisture may be trapped in the coating by the drying of the surrounding coating material and a longer time is required to effect the drying out.

A coating of this sort, while it may have sufficient strength to prevent its being broken up by the pouring of the molten metal, does not have sufficient strength to remain intact when the casting is ejected from the die. Such ejecting is performed when the die is held stationary, so that the centrifugal force is not present to hold the coating against the inner surface of the die, as is the case when the metal is being poured. During the ejecting of the casting, this

3

coating breaks up and tends to jam in the clearance between the casting and the die, thus making it difficult to effect such ejection.

The present invention relates to a coating of this last-mentioned type but distinguishes therefrom in its composition and in its ultimate characteristics, as well as in the method of making centrifugal castings. Thus, while the present coating composition may be, and preferably is, sprayed on the die, no great care need be exercised in so applying it. The composition, almost regardless of the manner in which it is applied, inherently results in a coating having traction features causing a rapid pick-up of the molten metal when poured into the die for rotation therewith and yet provides a surface on the casting which requires much less stock removal, to bring it to a finished dimension, than is necessary with the two processes heretofore referred to. The coating provides for rapid evaporation of the moisture content of the composition, so that a high rate of production may be obtained, with the castings free of defects such as pin holes or other imperfections. The coating provided by the present composition may have sufficient thickness to give the desired insulating qualities which, in connection with the temperature of the die when the metal is poured, and with the temperature of the metal at that time, provides a controlled rate of cooling of the casting so that, in the case of cast iron, a desired metallurgical structure may be attained.

Another important aspect of the present coating is the fact that it has sufficient strength to remain intact throughout the entire casting process. Thus, it not only withstands the action of the molten metal when the latter strikes the coating, but also remains intact during the ejection of the casting from the die. The coating composition, of course, is applied to the die when the latter is rotating at casting speed, and the composition is thus distributed and held in an even coating on the interior of the die during drying. As a result, the dried coating necessarily is held in engagement with the liner, but there is nothing inherent in the coating which causes it to adhere to the die. The strength of the coating is such that it may be said to be self-sustaining. This lack of anything inherent in the coating to cause it to adhere to the die facilitates the removal thereof from the die along with the casting. Thus, because of the strength of the coating, it is removed from the die without breakage along with the casting. In fact, it is so free of any quality of adherence to the die that it facilitates the removal of the casting. The complete removal of the coating with the casting thus leaves the die clean and ready for re-coating.

The coating composition of the present invention is, as heretofore stated, of a character which includes a powdered refractory material and a binder in an aqueous mixture. Preferably, the refractory material is silica flour and the binder is bentonite. These produce a desirable composition and are readily obtainable and for these reasons are preferred, but the invention is by no means limited to these specific materials. To this mixture is added a wetting agent to reduce the surface tension of the water in the mixture. From this, surprising results are obtained. The reduction in surface tension of the water provides a more homogeneous mixture, probably due to the increased wetting action on the surfaces of the particles of the refractory material and the consequent more thorough dispersion or distribu-

4

tion of the binder on the particles, thus obtaining full benefit of the binding action of the binder and providing strength in the ultimate coating. This homogeneous character of the composition may be explanatory of the fact that the present coating is found to be much stronger than coatings of this type heretofore known. An examination of the coating after it is dried shows it to have a spongy structure, which no doubt explains its excellent insulating properties.

Another remarkable characteristic of the present coating is the nature of the inner surface of the coating after it is dried. This surface, while it is generally smooth and even in its major aspect and thus radically different from the rough coating heretofore thought necessary, obtains the necessary traction of the metal by having a multitude of small cavities extending generally radially into the body of the coating. Such cavities may be described as relatively deep and narrow, and are such that, when the molten metal is poured into the die, the metal enters such cavities to form elongated thin spines on the exterior of the casting. Such spines are rapidly cooled because of their small mass and the fact that the heat therein may be rapidly lost. The spines thus tend to anchor the molten metal to the coating to cause the metal to rapidly pick up the rotational movement of the die so that the metal is quickly subjected to the centrifugal action.

The presence of such spines on the casting provides a number of other advantages. Thus, they tend to reinforce the coating and cause it to firmly adhere to the casting. In ejecting the casting from the die, such firm adherence of the coating to the casting and the lack of any adherence between the coating and die cause the coating to be ejected along with the casting without any breakage of the coating. In fact, the coating is so firmly tied to the casting by the spines that, even in the subsequent handling of the castings when they are piled on trucks for transport away from the casting apparatus, the coating remains substantially intact on the castings in spite of the bumping and rubbing to which the castings are subjected in such handling.

The explanation of why such cavities are formed in the coating lies in the use of the wetting agent in the composition, since experiments have amply shown that the cavities are obtained only when a wetting agent is employed, and when the wetting agent is omitted, no such cavities are formed. The presence of the wetting agent reduces the surface tension of water in the composition and thus increases the ability of the water to penetrate the spaces between the particles of silica flour readily. The die, of course, is rotating at casting speed when the coating composition is applied thereto. The specific gravity of the solids in the coating composition is greater than that of water so that, under the centrifugal action, the water will tend to be forced to the inner surface of the coating. The reduced surface tension of the water facilitates this action, so that the water more readily moves to the inner surface. There is thus less chance of any traces of moisture being entrapped in the coating to cause defects such as pin holes and dents in the casting. The separation of the water from the solids in this manner together with the subsequent evaporation thereof may result in the formation of the cavities noted in the coating.

This separating action of the water by the centrifugal force may be termed a wringing ac-

tion, and its occurrence is confirmed by observations made when a coating composition of this character is applied to a die. When the coating composition is first sprayed, the inner surface, which at first has a milky white appearance, quickly changes to a characteristic shiny appearance caused by the preponderance of water at such inner surface.

The die, prior to application of the coating, has been heated to a temperature correlated to other factors to attain a desired metallurgical structure, as hereinafter described, and such temperature is well above the boiling point of water so that, as the water is thus wrung out of the composition, it freely and rapidly evaporates. This evaporation is so fast that a heavy mist may be observed within the die, which clears up in a few moments. The drying, however, is thorough and because of its rapidity permits pouring of the molten metal into the die soon after the coating has been placed therein. Production, therefore, may be maintained at a high rate. The present coating gives ample protection to the die from the heat of the molten metal and thus delays and decreases heat checking of the die. The die life with this form of coating is thus increased over what has heretofore been possible.

Since the spines on the casting cause a rigid adherence of the coating to the casting and prevent the coating from being broken during ejection of the casting from the die, such ejection may be accomplished merely by tilting the die endwise and vibrating it. The casting thereupon slides out easily of its own accord. While, in some instances in the past, it has been felt necessary, with the previous coating, to provide tapered dies to facilitate the ejection, the ease with which the castings slide out of the die in the present instance permits use of straight dies. This, of course, decreases the amount of metal that must be removed in machining a casting.

As heretofore mentioned, the coating tends to adhere to the casting even during subsequent handling of the casting after removal from the die, but the removal of the coating may be readily accomplished by tumbling or by shot-blasting or by a combination of the two operations. Such operations, however, are found to have an additional advantage in that, when the coating is thereby removed, the spines are likewise removed. The spines, of course, are rapidly chilled, as heretofore described, and consequently are relatively brittle. In view of their thinness, the tumbling or shot-blasting, therefore, readily knocks off the spines along with the coating. Since the inner surface of the coating is relatively smooth except for the cavities, the resultant surface of the casting after this operation is quite regular and even and thus closely approaches a truly cylindrical surface. Consequently, a very small amount of metal need be removed in subsequent machining operations to bring the casting to a desired size. In most of the castings made by the present process, not more than .030 of an inch of stock need be removed to clean up the surface. This advantageously compares with the roughness of the exterior surface of castings made by the prior processes and the larger amount of metal that must be removed from a casting made by such prior processes.

To briefly illustrate the preferred manner of coating the die with the present coating compo-

sition, I have shown in Fig. 1 of the drawings a longitudinal section of a die, indicated generally at 10. Such a die is provided with a cap 11 at one end having a central aperture substantially smaller than the internal diameter of the die proper so that neither the coating nor the molten metal will run out of the end, the centrifugal force, of course, acting to hold the coating as well as the molten metal against the side wall of the die. At the other end of the die is a similar cap, but such cap includes a removable portion 12 which is disengaged from the die proper after the casting has been completed so that the latter may be ejected endwise from the die. Fig. 1 shows a preferred means for applying the coating, which, in this instance, comprises a pipe 13 through which the coating composition is supplied under pressure, and which is movable endwise of the die and has a nozzle 14 at its end to spray the coating composition generally radially onto the inner surface of the die. In the preferred arrangement, the pipe 13 moves inwardly through the full length of the die and when it is at the left end of the die as shown in Fig. 1, the spraying of the coating composition is started with the pipe 13 being moved gradually toward the opposite end to apply a uniform amount of coating composition throughout the length of the die. The centrifugal action, of course, effects a uniform distribution of the coating so that the exact manner of spraying the coating on the die is of no great importance. However, in the present instance, the spray is shown in a fan-like form extending in a plane through the axis of the die. The resultant coating is indicated at 15.

Fig. 2 illustrates the die after the coating has been completed and when the molten metal is being poured therein. In the present instance, such metal is introduced into the die through a spout 16 which enters the die through the central aperture in the cap 12. The centrifugal action of the die quickly distributes the metal evenly over the entire inner surface of the coating, as indicated at 17, the quantity of metal determining the thickness of the casting. While the die shown in the drawings is adapted for rotation on a horizontal axis and such position is preferred, the invention is not limited to use of a die in such position.

Fig. 3 is a magnified view of the inner surface of the coating after it has been dried and clearly shows the cavities that are formed by the wringing out of the water due to the effect of the wetting agent, while Fig. 4 is a similar view of the outer surface of the casting formed in the coating. In this latter figure, the spines on the casting are clearly apparent.

The coating composition, as heretofore mentioned, consists essentially of a powdered refractory material and a binder in an aqueous suspension with a wetting agent added to reduce the surface tension of the water, by which the many advantages of the present process are obtained. The preferred refractory material is silica flour, the fineness of which should be such as not to interfere with the spraying of the coating composition. Preferably, silica flour of 140 sieve size is used. Graphite, which is known to be refractory, and mixtures of graphite and silica flour may be used in place of the pure silica flour. The binder is such that it provides the necessary adhesive qualities to result in a self-sustaining coating and, of course, should not contain any material which would tend to cause gases to evolve when the coating is contacted by the

molten metal. Because of its availability, ease of handling and strength, bentonite is the binder which is preferred, but any binder such as the naturally occurring clays, may be used if it has the foregoing qualities.

The exact consistency of the composition is not important except that it must be capable of being readily sprayed onto the die, nor is the exact ratio of refractory material to binder of great import. In a preferred mixture, the silica flour may comprise 90% to 98% of the solids, while the bentonite may constitute the remainder, thus being within the range of 2% to 10%. The amount of water added to these solids is preferably sufficient to bring the Baumé reading to within the range of 55° to 65°.

As to the wetting agent, since its effect in the casting operation is physical and not of a chemical nature, any of the well-known wetting agents may be used. Thus, in actually practicing the invention, the wetting agent known in the trade as Orvus, which is a sodium salt of technical lauryl sulfate, as well as the wetting agent known as Aerosol OT-C, which is dioctyl sodium sulfosuccinate, have both been found to be satisfactory. Any of the wetting agents may be used in amounts not more than a few tenths of a percent, for example, 4 cubic centimeters per gallon of the aqueous composition. The invention, however, is by no means limited to the specific quantities of the various ingredients.

One of the features of the invention lies in the control which may be exercised over the metallurgical structure of the metal, particularly in the case of gray cast iron. In the use of thin coatings heretofore known, an undesirable metallurgical structure of such cast iron was almost invariably encountered. This was due chiefly to the rapid cooling rate of the metal and resulted in a structure having dendritic graphite and a matrix of primary ferrite. Such castings were also exceedingly hard because of the chilling action. While annealing would reduce the hardness, it would not correct or eliminate the presence of the dendritic graphite and the ferrite.

With the present invention, a coating may be placed on the die which, while thin compared to sand linings, nevertheless has sufficient insulating characteristics to result in controlled cooling of the casting. With such insulating characteristics possible, by control of the temperature of the die at the time of pouring and control of the temperature of the molten iron, a desirable metallurgical structure may be obtained. Thus, in a gray cast iron, the graphite may be random and nondendritic and is flaky and not powdery. The matrix obtained may be pearlitic or finer and relatively free from either free primary ferrite or graphite segregations.

In a preferred casting process, the initial die temperature may range from 700° F. to 1000° F., while the pouring temperature of the iron may be in the neighborhood of 2700° F. With a coating thickness of .040 to .060 of an inch, the desired metallurgical structure will be obtained.

The better insulating character of the die coating, compared with the coatings heretofore known, may be explained by the spongy character thereof through the use of the wetting agent. As heretofore mentioned, the reduction of surface tension of the water in the coating composition by the wetting agent results in a more homogeneous structure in the coating and the latter is more completely freed of moisture

than the previous coatings where apparently traces of moisture frequently remain in the coatings to be eliminated only by evaporation. With the present coating, the water appears to be almost completely wrung out of the coating by the centrifugal action and the dried coating thus has a more spongy structure than has heretofore been obtainable. This provides the greater insulating characteristic of the present coating and, consequently gives better control of the cooling rate of the casting to attain the desired metallurgical structure, as aforementioned.

I claim:

1. In the method of making centrifugal metal castings in a cylindrical die, the steps of heating the die to a temperature of about 700° F. to about 1000° F., coating the interior of the die during rotation with an aqueous coating composition of a powdered refractory material, a clay-type binder, and a wetting agent.

2. In the method of making centrifugal metal castings in a cylindrical die, the steps of heating the die to a temperature of about 700° F. to about 1000° F., applying to the interior of the die during rotation an aqueous composition of bentonite, silica flour and a wetting agent, and drying the composition during rotation of the die to form a strong insulating coating on the interior of the die.

3. In the method of making centrifugal metal castings in a cylindrical die, the steps of heating the die to a temperature of about 700° F. to about 1000° F., coating the interior of the die during rotation thereof with an aqueous composition of powdered refractory material, a clay-type binder and a wetting agent, with the heat of the die evaporating the water from the composition, the wetting agent causing the formation, by the evaporation, of cavities in the coating of such form that elongated thin spines are formed on the casting by the molten metal entering the cavities, and pouring a predetermined quantity of molten metal into the die during rotation thereof after such evaporation has occurred.

4. In the method of making centrifugal metal castings in a cylindrical die, the steps of heating the die to a temperature of about 700° F. to about 1000° F., coating the interior of the die during rotation thereof with an aqueous composition of powdered refractory material, a clay-type binder, and a wetting agent, with the heat of the die evaporating the water from the composition, the wetting agent causing the formation, by the evaporation, of cavities in the coating of such form that elongated thin spines are formed on the casting by the molten metal entering the cavities, pouring a predetermined quantity of molten metal into the die during rotation thereof after such evaporation has occurred, and ejecting the casting endwise from the die with the spines securing the coating to the casting for removal therewith and strengthening the coating to prevent breakage thereof during such removal.

5. The method of centrifugally casting cast iron sleeves, which comprises heating a cylindrical metal die to a temperature of about 700° F. to about 1000° F., coating the interior of the die during rotation thereof with an aqueous composition consisting essentially of bentonite, silica flour and a wetting agent with the heat of the die evaporating the water in the compound, to provide on the interior of the die an insulating coating of substantially .040 to .060

of an inch in radial thickness, pouring molten iron at a temperature of about 2700° F. into the die during rotation thereof in a quantity sufficient to provide a sleeve of desired wall thickness, and retaining the sleeve in the die until cooled below its critical temperature, the cooling of the iron being retarded by the temperature of the die and by the insulation provided by the coating to give the iron a metallurgical structure in which the graphite is non-dendritic and the matrix is pearlitic and substantially free of ferrite.

6. The method of making centrifugal castings, which comprises coating the interior of a die, while heated to a temperature of about 700° F. to about 1000° F. and during rotation thereof, with an aqueous coating composition of powdered refractory material, a clay-type binder and a wetting agent with the heat of the die evaporating the water in the composition to form cavities in the coating of such form that elongated thin spines are formed on the casting by the molten metal entering the cavities, pouring a predetermined quantity of molten metal into the die during rotation thereof, said spines being rapidly cooled by their proximity to the die and thus becoming brittle, removing the casting together with the coating from the die, and tumbling the casting to remove the coating and simultaneously to remove the spines to render the casting relatively smooth, whereby the amount of stock removal in subsequently machining the casting is held to a minimum.

7. A permanent metal die for centrifugal casting, having an insulating refractory coating formed on the inner surface thereof by applying to the die when heated to a temperature of about 700° F. to about 1000° F. and while being centrifuged an aqueous composition of powdered refractory material, a clay-type binder and a wetting agent.

8. A coating composition adapted to be applied to a rotating permanent metal die for centrifugal casting, consisting essentially of powdered refractory material, a clay-type binder, water and a wetting agent.

9. A coating composition adapted to be applied to a rotating permanent metal die for centrifugal casting, consisting essentially of a homogeneous mixture of powdered refractory material, a clay-type binder, water and a wetting agent, the coating composition having a uniform dispersion of the ingredients to produce a relatively strong coating in the die.

10. A coating composition adapted to be applied to a rotating centrifugal casting die, consisting essentially of a homogeneous mixture of powdered refractory material, a clay-type binder,

water and a wetting agent, the water being sufficient to permit the mixture to be freely sprayed on the die.

11. A coating composition adapted to be applied to a rotating centrifugal casting die, comprising a mixture of bentonite, silica flour and water, the silica flour comprising from 90% to 98% of the solids and the bentonite the remainder, the water when added to the solids being in sufficient quantity to bring the Baumé reading of the mixture within the range of 55° to 65°, and a wetting agent to give the mixture a homogeneous character.

12. A coating composition adapted to be sprayed on a rotating metal die for centrifugal casting, consisting essentially of bentonite, silica flour, water, and a wetting agent.

13. A permanent metal die having a cylindrical cavity for centrifugally casting hollow cylindrical bodies, having an insulating refractory coating on the inner surface thereof, the coating having a relatively smooth inner surface and having cavities with generally circular openings at its inner surface and generally isolated from one another and extending into the body of the coating to form elongated thin spines of the metal on the outer surface of the casting.

14. A metal casting centrifugally formed in a die comprising an annular hollow cylindrical body of metal having spines on its outer cylindrical surface generally isolated from one another and extending generally radially, and a refractory coating having a substantially uniform thickness at least equal to the maximum length of said spines and interlocked with said spines whereby said coating is secured to the body for removal of the coating from the die along with the body.

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