April 8, 1969 M. N. ORNITZ 3,437,131

CENTRIFUGAL CASTING APPARATUS WITH SMOOTH REFRACTORY NONHYDROCARBON MOLD COATING

Filed Oct. 7, 1965

Sheet 1 of 2

Fig. 1.

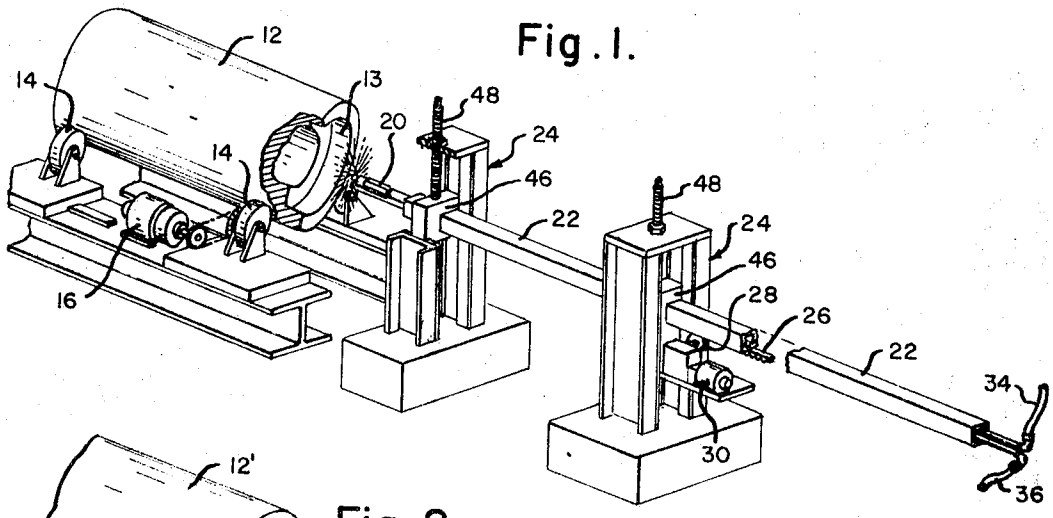


Fig. 2.

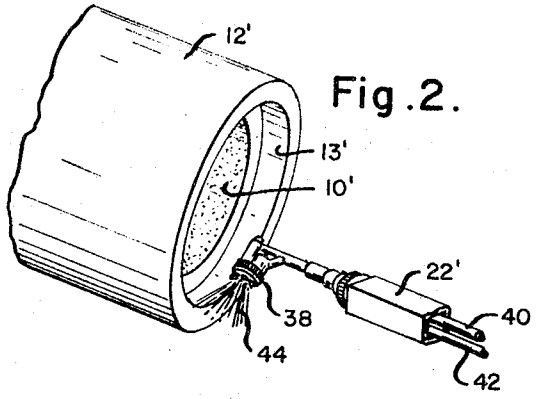


Fig. 4.

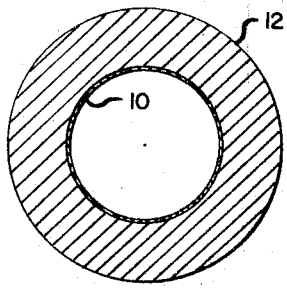
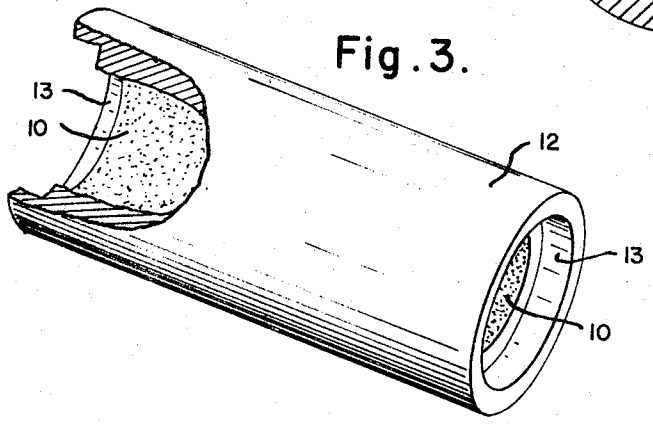


Fig. 3.



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Sheet 2 of 2

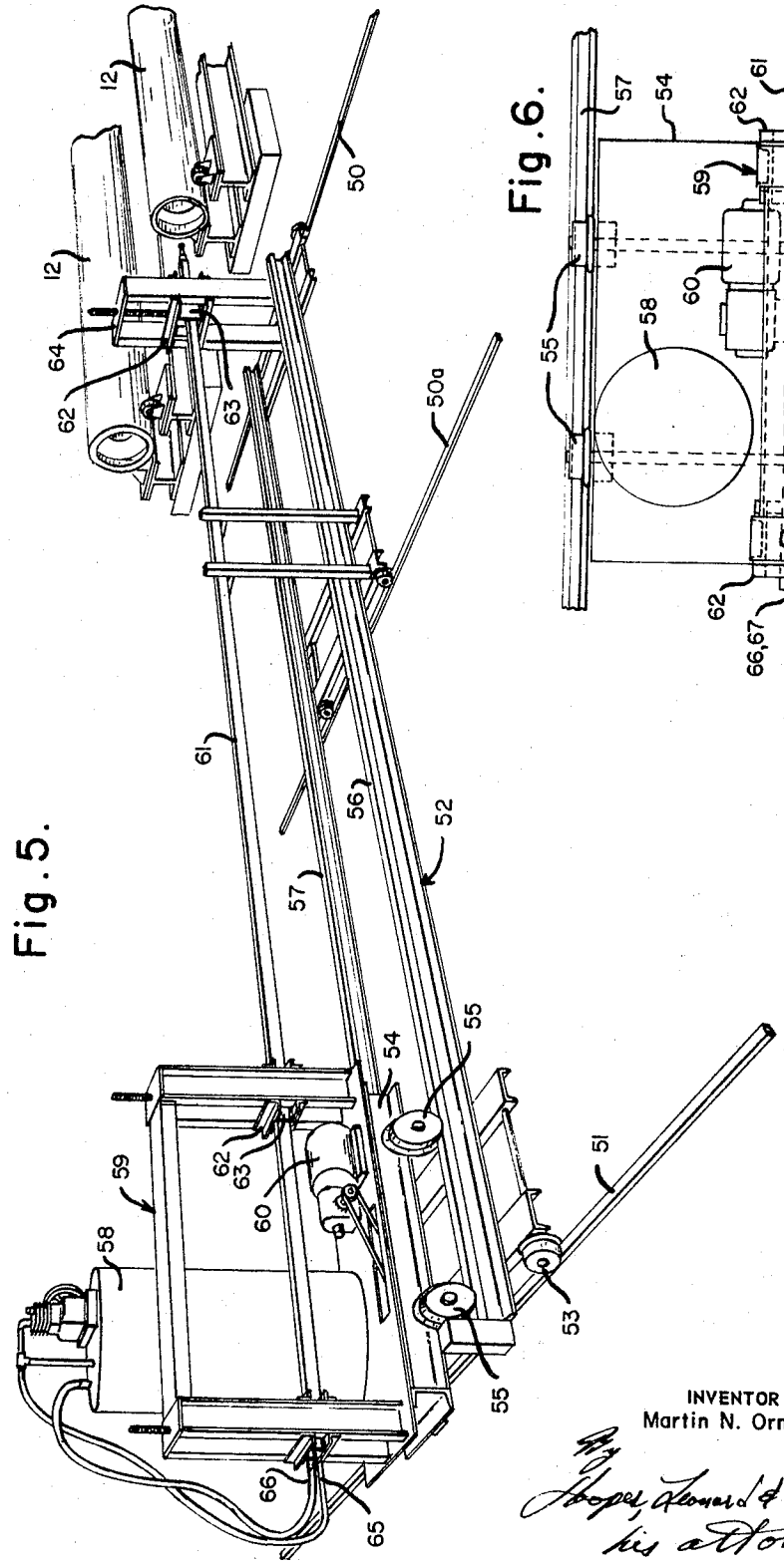


Fig. 5.

Fig. 6.

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3,437,131

CENTRIFUGAL CASTING APPARATUS WITH SMOOTH REFRACTORY NONHYDROCARBON MOLD COATING

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Int. Cl. B22c 15/20, 9/12
U.S. Cl. 164—298 7 Claims

ABSTRACT OF THE DISCLOSURE

A centrifugal casting mold is provided with an annular stop member receiving recess at each end, means for rotation of the mold and a smooth refractory coating adhered to the mold surfaces between said recesses to provide a thermal barrier for elimination of chills in metal cast therein.

The present invention relates to the manufacture of tubular metal castings and is directed particularly to certain improvements in the manufacture of such castings by centrifugal techniques in permanent metal molds. The molds may be rotated horizontally or substantially so about their longitudinal axes.

When employing centrifugal casting techniques in this manner and particularly when casting a relatively long tubular member, the art has long been confronted with the problem of producing a casting in which the metal is completely fused throughout the length of the casting and which has a smooth, substantially defect-free outer surface. In particularly, it has been difficult to obtain a centrifugal casting in this manner, especially in the greater lengths and diameters thereof, which has an acceptable surface smoothness without further finishing.

These problems are more or less acute depending upon the particular method of centrifugal casting employed, and in any case an acceptable solution thereto has not hitherto been found.

During conventional centrifugal casting operations, it has been found that when the advancing molten metal slips over the rotated mold, moving lengthwise thereof intermittently and/or too rapidly, it tends to result in the formation of pin holes originating in the outer surface of the casting. Laps or cold shuts are produced when the leading edge of the molten metal moves longitudinally of the mold more or less intermittently and/or discontinuously, at a speed such that it becomes so thin that it rapidly cools, prematurely solidifies and also oxidizes, to such an extent that it does not properly weld to or unite with the mass of metal which subsequently flows over it as the distribution of the charge progresses. These pin holes, laps or cold shuts sometimes extend throughout the thickness of the wall of the casting, but usually occur only in the outer portion of the wall, i.e., in the outer surface of the casting.

In one particular method of centrifugal casting heretofore employed, the production of cast tubular members in centrifugal molds involves the pouring of the charge of molten metal into the metal mold in such a manner that the distribution of the metal longitudinally of the mold is effected primarily by the action of centrifugal force. A common way of doing this is to pour the metal from a spout occupying a relatively fixed position lengthwise of the mold and located, for example, at one end thereof. However, attempts to produce long tubular castings centrifugally by such method have heretofore resulted in the formation of castings having the aforementioned pin holes and laps or cold shuts which render the castings commercially unacceptable.

In another centrifugal technique which is widely employed commercially, the molten metal is delivered to the mold by means of a pouring trough relatively retractable over the length of the mold so that molten metal is deposited progressively to form a helix, the convolutions of which fuse together to form an integral structure. In this method, the metal is distributed longitudinally of the mold surface primarily by means of the retractive pour, and the centrifugal force holds the molten metal against the mold, as an all centrifugal casting. However, in actual practice, the metal upon being so deposited does spread to some extent because of the lateral pressure resulting from the centrifugal force, and is thus caused to flow longitudinally of the mold to advance beyond the helical zone of metal deposition. This spreading is sometimes excessive, and is frequently irregular, or, as it is sometimes called, discontinuous on the leading edge, and thus also results in the formation of excessively thin offshoots which solidify almost instantaneously and, therefore, produces the aforementioned laps or cold shuts in at least the outer surface portion of the casting. While this method reduces the troublesome defects, it does not solve the problems to which reference is made above.

In connection with more recently developed centrifugal techniques of the prior art, it has been conjectured that the aforementioned pin holes and other defects have resulted from a too rapid advance of the molten metal in moving lengthwise of the mold without sufficiently partaking of the rotational motion of the centrifugal mold. Thus, it was proposed to provide the mold surfaces with a coating having a large number of protuberances, which would hasten the molten metal pick-up by the centrifugal mold and at the same time would slow the lateral advance of the molten metal throughout the mold. This method was successful to some extent in reducing the pin holes and laps or cold shuts referred to previously, but it had the effect of limiting the length of the tubular casting to the order of about 3 or 4 times its outside diameter. For most applications, moreover, the surface of the centrifugal casting was commercially unacceptable due to the rough outer surfaces thereof produced by the intentionally roughened mold surfaces.

In a more recently developed method, a resin-bonded sand is coated upon the mold surface for the purpose of slowing down the cooling rate in the production of cast iron piping by centrifugal techniques. The lateral advance of the molten metal throughout the centrifugal mold also is slowed down in this method due to the roughness of the sand coating. Although this method involves some improvement over prior methods, the resultant surfaces of the casting still are not sufficiently smooth for many commercial applications. The restricted lateral movement of the molten metal, by the resin-bonded sand coating, also limits the lengths of centrifugal castings which can be fabricated by this technique.

The centrifugal casting technique disclosed herein overcomes these problems by providing a centrifugal mold which permits rapid lateral transfer of the molten metal to the extremities thereof before the molten metal has an opportunity to develop localized congealing and the forementioned pin holes and laps or cold shuts. The outer surface of the casting, moreover, is free from defects, is smooth, and does not require further finishing. These aims are accomplished by the present centrifugal casting technique which provides a centrifugal mold having an exceptionally smooth refractory coating upon the mold surfaces thereof to promote rapid lateral advance of the molten metal and to provide an exceptionally smooth outer surface of the finished casting. The mold coating desirably is formed from suitable refractory materials which will not decompose at elevated temperatures with attendant oxidation of adjacent molten metal. The refrac-

tory coating also is applied in sufficient thickness, in accordance with another feature of the centrifugal casting technique, to provide a uniform thermal insulation for the molten metal throughout the length of the centrifugal mold to prevent localized congealing or chills in the molten metal. The disclosed centrifugal casting technique also contemplates a novel method for the application of such coating to the centrifugal mold. This coating method, for many applications results in a coated mold which can be used directly due to the smoothness of the coating. Where an extremely smooth surface finish of the casting is desired, the coating method of the disclosed casting technique produces a sufficiently adherent mold coating which can be further smoothed, prior to use of the mold, by conventional techniques, such as sanding.

The apparatus of the present invention makes possible the production of tubular castings made of steel or other metals or alloys, of a length not hitherto possible without exhibiting the aforementioned pin holes and laps or cold shuts, as would detract from the quality of the castings or render them commercially unacceptable. The centrifugal castings thus produced meet present-day standards of surface finishes without further grinding, polishing, or other smoothing operation.

The apparatus disclosed herein facilitates centrifugal casting techniques by promoting the distribution in both the circumferential and longitudinal directions of the molten metal poured into the mold. The rate of pick-up of the molten metal by the mold can be accelerated by a more rapid rotation of the mold. At the same time, the longitudinal distribution of the molten metal is accelerated by the provision of a very smooth mold coating, the thickness and character of which provides a thermal barrier for the molten metal. The heat flow to the mold from the leading edge of the longitudinally advancing molten metal is sufficiently arrested to maintain the leading edge at a temperature to fuse the leading edge portion with molten metal which subsequently flows thereover.

This is accomplished by controlling the thickness of the mold coating in relation to the outside diameter of the centrifugal casting to provide the required thermal insulation depending upon the amount and thickness of the molten metal being cast. The mold coating is provided with uniform smoothness which, in accordance with the disclosed coating technique, in turn produces uniformity of coating thickness throughout the length of the mold to prevent the development of chills or cold spots as the molten metal flows longitudinally of the mold. At the same time, the acceleration in rate of longitudinal metal flow provides an immediate fusion of the leading edges of metal flow with subsequent flows to ensure complete fusion therebetween.

The aforementioned mold coating can be applied, for example, by spraying a liquid suspension of the coating material on the mold, and the aforementioned required properties of the coating can be varied and controlled by proper selection of spraying equipment in accordance with the invention and by regulation of the spraying operation.

A composition which has been found suitable for providing a coating having the desired characteristics referred to above is composed of a suspension of zircon flour, diatomaceous earth, and bentonite in water, and is applied to the mold by a spraying operation in which the composition is atomized and discharged on the inner surface of the metal mold by a relative reciprocation of a spray nozzle thereover, while the mold is rotated. The speed of rotation of the mold during the spray operation is found to be critical for optimum coating characteristics, including smoothness, and the desired or optimum speed of mold rotation is found to vary with the size of the mold.

While the coating composition can be varied, a uniform aqueous suspension made up of 87% by weight of zircon flour, 10% diatomaceous earth, and 3% bentonite, with enough water to mix to a 60° Baumé, has proven to be satisfactory for many applications. The particles of

zircon flour should be of such fineness that the composition is sprayable in an atomizing type of spray equipment, and are desirably of about #325 seive size or finer. The bentonite aids in keeping the ziron flour in suspension while the diatomaceous earth increases the thermal impedance of the coating. It will be realized that other equivalent coating expensions can be utilized in keeping with the aims of the invention, for example, one or more of the coating compositions disclosed and claimed in applicant's copending and coassigned application entitled Mold Coating Composition Particularly for Centrifugal Molds, filed concurrently herewith, Ser. No. 493,917.

In the application of one of the aforementioned compositions to the inner surfaces of the mold, it is essential that the composition be atomized and sprayed on the mold at such a rate that the water or other carrier liquid will undergo a controlled evaporation so that the sprayed globules will contact the mold surface and merge with one another to produce a very smooth and adherent coating. In furtherance of this purpose, the spray nozzle is held as close to the mold surface as possible without causing the coating to run and a maximum condition of atomization is utilized. During the coating process the mold is rotated, which improves the resulting smoothness of the coating. For a mold of relatively small diameter, for example about 9 inches, the speed of rotation is about 800 r.p.m. while for larger mold diameters the speed of rotation is correspondingly slower. As an example, a rather larger mold of about 17 inches in diameter, requires a rotational speed of about 500 r.p.m.

The rotational speed is varied with variations in the lance speeds. Excessive rotational speed detracts from longitudinal distribution of the coating and should be avoided. Coating may be applied at temperatures as high as about 700° F., considerably above the temperature of conventional coatings.

The quality of the coating surface can be readily varied from a fairly smooth as-sprayed condition, to a very smooth surface condition by sanding or grinding or other surface treatment depending upon the application of the invention or surface finish requirements of the centrifugal casting. For very long castings, such surface treatment is desirable to further accelerate the longitudinal flow of the metal mold throughout the centrifugal mold.

While different forms of nozzles or spray heads can be utilized in applying the coating composition, it has been found most beneficial to support the spray nozzle such that the major proportion of the spray issuing therefrom is directed normally of the mold surface, i.e., substantially at right angles to the longitudinal axis of the mold. For certain sizes of molds it has been found best to employ a fan type spray nozzle while for other sizes, for example, the smaller sizes, a ring-type spray is found to be more effective. In either case, the spray is directed substantially normally of the mold surface as aforesaid.

As an example, the smaller sizes of centrifugal molds in the order of 9 inches in diameter or under are coated with a ring-spray nozzle which is reciprocated longitudinally within the bore of the mold and desirably concentrically therewith. For the type of spray equipment noted hereinafter, and mounted on a suitable lance or other support, the smaller sizes of centrifugal molds can be rotated at a stationary location and the spray nozzle support or lance can be fed axially therethrough at a rate of about 27 feet per minute while the mold is being rotated at the aforementioned speed.

In the case of the larger sizes of molds, i.e., over 9 inches in diameter, the fan-type nozzle can be similarly mounted, with the exception that the lance or support may be mounted eccentrically of the mold axis depending upon the size thereof, in order to hold the spray nozzle at the proper distance from the mold wall. In the latter arrangement, a 90° fan spray nozzle is preferred and is supported such that the axis of the spray fan is substan-

tially normal to the axis of the mold and to the mold surface. In one example, the lance feed of the fan nozzle is at the same rate for the larger mold sizes or about 27 feet per minute while the rotational speed of the mold is correspondingly less, being about 500 r.p.m. for the 17 inch diameter mold noted above.

The proper rotational speed of the centrifugal mold during the spray operation permits the spray nozzle to be located rather close to the mold surfaces without danger of the coating running, owing to the centrifugal forces developed. A smoother and more adherent coating is thereby obtained. If the rotation of the mold is too slow, the aforementioned coating runs will be encountered; on the other hand if the rotational speed is too high, accretional build-up in the coating will occur producing roughness owing to the premature evaporation of the coating carrier liquid and to lag in rotational pick-up of the coating by the rotating mold. Increasing the distance of the nozzle from the mold surface will also tend to increase the roughness of the coating surface as a result of excessive evaporation. Increasing the density of the coating suspension will also aid in preventing coating runs as long as the density is not increased to the extent to interfere with proper atomization of the coating when sprayed. On the other hand, a decrease in coating density can render the coating difficult to maintain in proper suspension during the coating application.

The thickness of the applied coating can be varied optimally with the size of the centrifugal and the quantity of molten metal to be deposited therein. The coating thickness for a given nozzle is selected such that an adequate thermal barrier is provided to prevent premature cooling of the molten metal as it flows longitudinally along the mold. It has been found that the average thickness of a coating of one of the aforementioned compositions can vary within a range of from 0.005 inch to .08 inch for the smaller sizes of molds of about 9 inches and under and between .08 inch and 0.125 inch for the larger mold sizes. Within each range of mold sizes the thickness of the coating can be varied to some extent with casting conditions, such as with the particular centrifugal casting method employed, the metal being cast, and the length and diameter ratio of the tubular casting, the wall thickness of the casting, and the particular coating composition used. For example, a thinner mold coating can be utilized by increasing the proportion of diatomaceous earth in the coating composition in order to ensure an adequately high thermal impedance.

The aforedescribed coating method produces a mold coating which adheres together and to the mold and yet which is suffiicently friable upon the completion of the casting operation that the coating facilitates the ready withdrawal of the casting from the mold. This coating appears to be somewhat more friable following the casting operation than before it, but will adequately resist the washing away effect of the molten metal stream as it is poured into the mold. It may also be noted that the friability of the coating can be varied and controlled by varying the proportion of the bentonite in the coating suspension.

A mold coating for the aforedescribed purposes is of a temporary character, and is applied to the mold before each casting operation. After the application of the coating, the coated mold may be subjected to handling, inspection, recoating and/or storage as required without interfering with its subsequent use. Upon the withdrawal of the casting, the coating may, because of its friability, be readily removed or stripped from the mold by means of a wire brush, jet of compressed air, or the like to facilitate preparation of the metal mold for the next casting. As the same mold is used repeatedly its temperature rises from the heat given off by the metal being cast. It is the the practice to cool the mold with water sprays to a temperature sufficiently low to accept the mold coating. The present coating may be applied at higher temperatures up to about 700° F., thereby requiring less coolant and less lost time in preparation.

Various other compositions can be used in the practice of the invention to provide, when sprayed upon the mold, a refractory coating having the requisite thickness and surface smoothness to provide the thermal barrier action, to facilitate longitudinal movement of the metal mold, and to afford a smooth outer surface of the casting. For instance, while zircon flour is a most satisfactory refractory, and when applied in the above described suspensions, produces the necessary thermal impedance, other suitable refractory materials, for example, the oxides of aluminum, magnesium, beryllium, silicon, chromium, titanium, or mixtures or compounds thereof alone or with other compounds such as mixtures of forsterite and fayalite, can be utilized depending upon the application of the invention, the metal being cast, etc. The use of zirconia is desirable for many applications, however, because of its nontoxicity, its smooth surface characteristic as sprayed, and its higher fusion temperature permitting the molten metal to be poured at a hotter temperature. As indicated above, bentonite has been found to be a satisfactory binder as it serves not only as a binding agent for the refractory particles but also as a suspending agent for the coating particles in the liquid carrier. Nevertheless, other suitable binding agents can be utilized, provided they have the necessary adhesive qualities to enable the coating to withstand the forces exerted thereon by the charge of molten metal, as well as to adhere properly to the metallic mold surfaces, and are sufficiently refractory and free of components tending to emit gases during the casting operation. The use of diatomaceous earth increases the thermal impedance of the refractory material and serves also as an inert binder for the coating suspension. On the other hand, this latter component increases the friability of the coating particularly following the casting operation and thus permits easy stripping of the casting from the mold in preparation for succeeding casting operations. Other suitable and known materials can be utilized for these purposes providing that they exhibit the necessary adhesive and thermal properties. For example, additional bonding action can be imparted to the coating through the addition of relatively small amounts of sodium silicate in the range of about 0.25 to 4%, and is particularly useful under those conditions where the mold coating tends to spall. Furthermore, while water is a convenient carrier vehicle for the solid ingredients of the composition, it is to be understood that any other suitable liquid can be employed for this purpose. While a coating density of about 60° Baumé is desirable for most applications of the invention, it is contemplated that sufficient carrier liquid can be utilized to obtain a range of coating densities from about 50 to 80° Baumé. If the coating suspension is too fluid, such as under 50° Baumé, it will settle to rapidly and requires continuous agitation during the spraying operation; on the other hand, if the Baumé density is too high, the suspension becomes too thick for optimum spraying conditions. Regardless of the particular composition used in the practice of the invention, it is to be noted that the thickness and attendant thermal impedance of the coating together with the smooth character thereof are such that the rate of longitudinal movement of the metal mold is greatly accelerated. This action in itself minimizes the development of shills and the resultant laps or cold shuts in the centrifugal casing, which are further and cooperatively avoided by the proper amount of thermal impedance imparted to the coating through the practice of this invention.

In order that the herein disclosed improvements may be better understood reference is made to the accompanying drawings wherein are illustrated certain presently pre-

ferred modifications of the invention, together with certain presently preferred methods of practicing the same.

In the drawings:

FIGURE 1 is a side and end isometric view of apparatus employed in coating a centrifugal mold of relatively small diameter;

FIGURE 2 is a side and end isometric view of apparatus employed in coating a centrifugal mold of relatively large diameter;

FIGURE 3 is an isometric view partially cut away of a centrifugal mold coated in accordance with the invention;

FIGURE 4 is a cross-sectional view of the coated mold illustrated in FIGURE 3;

FIGURE 5 is an isometric view of a complete coating machine and line for practicing the invention; and

FIGURE 6 is a top plan view of the carriage of FIGURE 5.

Referring now more partciularly to FIGURE 1 of the drawings, a method and apparatus are illustrated therein for applying a smooth coating **10** of substantially uniform thickness and high thermal impedance to the inner or molding surfaces of a centrifugal mold **12**. An annularly or circumferentially shouldered recess **13** is formed at each end of the mold **12** to recess suitable stop members (not shown) inserted therein during the casting operation to limit the longitudinal flow of the molten metal charge. The mold **12** in this arrangement is supported for horizontal rotation about its longitudinal axis upon spaced pairs of rollers **14**. The rollers **14** are rotated all in the same rotational direction, by a suitable drive mechanism including motor **16**. The pairs of rolls **14** are spaced in this example such that they engage the centrifugal mold **12** adjacent the ends respectively thereof. Desirably, one pair of rolls **14** can be moved longitudinally of the mold **12** relative to the other pair of rolls **14**, by conventional means (not shown), so that the centrifugal molds of differing lengths can be accommodated.

For purposes of applying one of the aforementioned coating suspensions to the inner surfaces of the mold **12**, a suitable spray nozzle or head **20** is mounted on the end of lance or supporting member **22**. The lance **22** is slidably mounted upon a suitable support **24** therefor and is thereby disposed for longitudinal and axial movement of the lance **22** and the spray nozzle **20** throughout the length of the mold **12**. In furtherance of this purpose, the lance can be provided with a rack thereon **26** of a length equivalent to that of the mold **12**, or to that of the longest mold anticipated for use with the apparatus,, and disposed therealong for cooperatoin with pinion **28** driven by a suitable motor and gear reduction unit indicated generally by reference character **30**. Desirably, the output speed of the drive unit **30** is variable such that the pinion **28** in engagement with the lance rack **26** operates to drive the lance at a speed in the neighborhood of about 27 feet per minute along the longitudinal axis of the tube **12**.

In this arrangement of the invention, as seen in FIGURE 1, the spray nozzle **20** is of the ring-type and emits a circumferential or ring spray from a circumferential slot, which is substantially perpendicular to the mold axis and to the mold surfaces thereof. The spray nozzle **20** preferably is aligned with the centrifugal mold axis and is inserted substantially concentrically of the mold **12** as the nozzle **20** is moved therethrough by the lance **22** in order to deposit the coating suspension equally and uniformly upon the adjacent mold surfaces.

To further aid in a uniform build-up of the coating and to prevent coating runs and roughness, the mold **12** is rotated about its longitudinal axis, during the spraying operation, at a rotational speed of about 800 r.p.m. This rotational speed has been found to be fairly critical, as speeds substantially above or below the aforementioned speed tend to produce a roughened surface coating which is undesirable for the reasons mentioned previously.

The coating suspension being used is supplied to the spray nozzle **20** from a suitable container (not shown) and compressed air for controlling the atomization thereof are supplied to the spray nozzle **20** through suitable conduits represented by the hose connections **34** and **36** respectively.

As noted previously, in order to obtain an exceptionally smooth coating, the spray noozle **20** is supported as close to the mold surface as practical during the spraying operation at a maximum distance of about 4½ inches. Inasmuch as the spray nozzle **20** is supported concentrically of the centrifugal mold, in the arrangement of the apparatus according to FIGURE 1, the diameter of the mold becomes a limiting factor in the use of this arrangement of the apparatus. When the mold diameter is increased to an extent such that the radial distance between the mold surface being coated and the spray nozzle **20** displaces the spray nozzle at too great a distance from the surface being coated for the requisite coating smoothness, the spraying apparatus as arranged in accordance with FIGURE 2 of the drawings is preferably utilized. In the latter arrangement of the invention, as illustrated in FIGURE 2, the ring-type spray nozzle **20** of FIGURE 1 is replaced by a fan spray nozzle **38** having coating and compressed air connections denoted at **40** and **42**. The spray nozzle **38** is similarly mounted on the adjacent end of lance **22'** for reciprocable and axial movement thereof relative to the centrifugal mold **12'**, and is supported at a maximum spray distance of about 4½ inches.

In this example, however, the spray nozzle **38**, is of the fan type and is supported perpendicularly to the centrifugal mold axis and thus to the mold surfaces to which the coating **10'** is being applied. The axis of the fan or sheet of the coating spray **44** is, therefore, likewise directed normally of the coated surfaces **10'**. The lance **22'** is not necessarily positioned coaxially of the centrifugal mold **12'** when reciprocated therethrough but rather can be supported, in this example, at such elevation parallel to the axis as determined by the optimum spray distance between the spray nozzle **38** and the mold surfaces. In furtherance of this purpose, the lance **22'** is secured in a guide member **46**, which in turn is slidably mounted upon the vertical lance support **24**. The guide member **46** is provided with screw adjusting means **48** whereby the clamping member can be secured at a selected elevation along the upright lance support **24**.

In the latter arrangement of the invention, the interior of the mold **12'** can be coated by moving the lance **22'** at a longitudinal rate relative to the mold **12'** of about 27 feet per minute, which is sufficient to coat the interior of the mold **12'** in one pass on small diameter rolls, however large diameter molds may require up to 6 or 7 passes. At the same time, the mold **12'** is rotated at a rotational speed of about 500 r.p.m. in the example of FIGURE 2, which depicts a mold of about 17 inches in diameter.

The rotational speed of the mold **12** or **12'** during the coating operation is somewhat critical as noted previously and is related to the diameter of the mold surface. In the arrangement of FIGURE 1, for example, a mold **12** having a diameter of about 6 inches was utilized and was rotated at a speed of about 800 r.p.m. On the other hand, in the centrifugal mold coating operation as described in FIGURE 2 a centrifugal mold **12'** having a diameter of 17 inches was rotated at a speed of 500 r.p.m. Other mold sizes will dictate rotational speeds relative to the aforementioned speeds depending upon their diametric relationship.

As illustrated in FIGURE 3, the coated surfaces produced with the application of FIGURE 1 or 2 affords a very smooth mold lining, which can be further finished as by sanding or grinding, for example, through the use of suitable tool (not shown) affixed to the forward end of the lance **22** in place of the spray nozzle **20** or **38**. As better

shown in FIGURE 3, the resulting surface of a centrifugal casing made in accordance with the invention presents a very smooth surface characteristic, regardless of the size or outside diameter of the centrifugal casting. Thus a superior degree of smoothness can be obtained and the usual, rough surfaces of the prior art are obviated.

In FIGURE 5 there is illustrated a complete assembly for coating rotary molds. In such an assembly a series of molds **12** are mounted side by side on roll carriers as shown in FIGURE 1. Spaced rails **50**, **50***a* and **51** pass in front of such molds and perpendicular to their axis. A movable bridge **52** is mounted on wheels **53** which run on rails **50**, **50***a* and **51**. A carriage **54** is mounted on wheels **55** to run on rails **56**, **57** on bridge **52**. The rails **56** and **57** are perpendicular to rails **50**, **50***a* and **51**. The carriage **54** carries a tank **58** of coating agent together with lance support frame **59** and drive motor **60** for driving wheels **55**. A lance **61** of the same configuration as lance **22** of FIGURE 1 is mounted in frame **59**, and is movable in guide frame **62** on trunnions **63**. The guide frame **62** is vertically movable in vertical frame **64** on the end of bridge **52** opposite the carriage. The treating fluid or coating is delivered to pipes **65** and **66** and to a spray head **67** identical with pipes **34** and **36** and spray head **20** of FIGURE 1. The spray head is advanced into and withdrawn from the molds by moving carriage **54** on tracks **56** and **57**.

From the foregoing it will be apparent that novel and efficient centrifugal casting techniques have been disclosed herein. While certain presently preferred embodiments of the invention, together with certain presently preferred methods of practicing the same have been shown and described herein, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

I claim:

1. A centrifugal casting mold comprising an elongated tubular non-vented metal member, an annular stop member receiving recess in each end of said tubular member, means for rotating said tubular member about its longitudinal axis, and a smooth refractory nonhydrocarbon coating adhered to the metal mold surfaces of said centrifugal mold and extending substantially between said recesses, the thickness of said coating providing a thermal barrier for the elimination of chills in the charge of molten metal supplied to said centrifugal mold.

2. A centrifugal casting mold comprising an elongated tubular non-vented metal member, an annular stop member receiving recess in each end of said tubular member, means for rotating said tubular member about its longitudinal axis, and a smooth refractory nonhydrocarbon coating adhered to the metal mold surfaces of said centrifugal mold and extending substantially between said recesses, the thickness of said coating providing a thermal barrier for the elimination of chills in the charge of molten metal supplied to said centrifugal mold, the thickness of said coating varying between 5 and 125 mils.

3. A centrifugal casting mold comprising an elongated tubular nonvented metal member, an annular stop member receiving recess in each end of said tubular member, means for rotating said tubular member about its longitudinal axis, and a smooth refractory nonhydrocarbon coating adhered to the metal mold surfaces of said centrifugal mold and extending substantially between said recesses, the thickness of said coating providing a thermal barrier for the elimination of chills in the charge of molten poured into said centrifugal mold, the thickness of said coating varying between 5 and 80 mils for centrifugal molds of about 9 inches in diameter or less and between 80 and 125 mils for centrifugal molds greater than about 9 inches in diameter.

4. The combination according to claim **1** characterized in that said coating is refractory based, such as zirconium oxide based.

5. The combination according to claim **4** characterized further in that said refractory coating includes a suspending agent such as bentonite and a thermal impedance and stripping agent such as diatomaceous earth.

6. The combination according to claim **4** characterized further in that said refractory coating includes a binder selected from at least one of the group consisting of bentonite, and sodium silicate.

7. The combination according to claim **4** characterized further in that said refractory coating includes a binder selected from at least one of the group consisting of bentonite and sodium silicate; a thermal impedance and stripping agent such as diatomaceous earth, and a suspending agent selected from at least one of the group consisting of bentonite and sodium silicate.

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