

Feb. 16, 1971

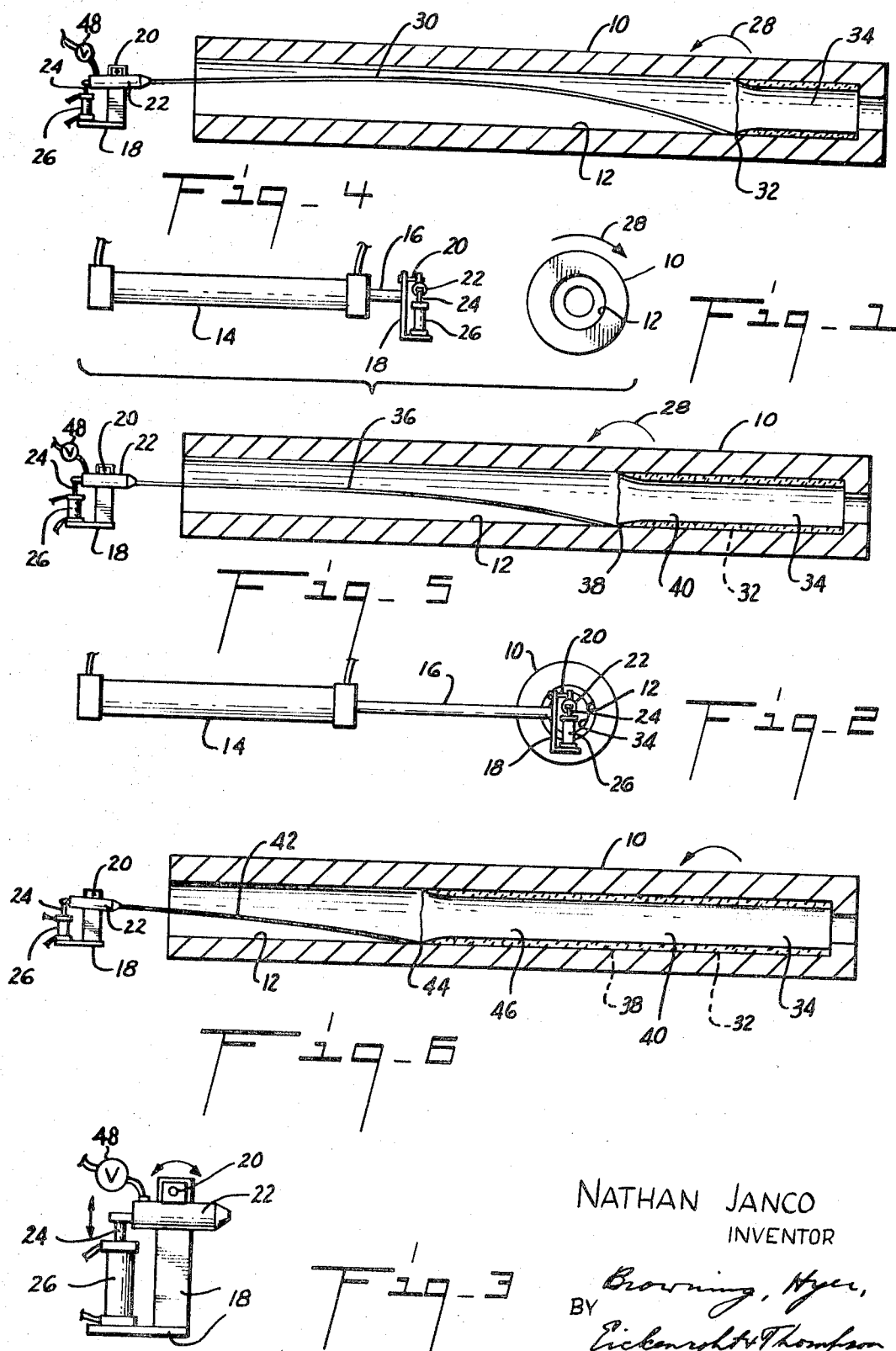
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3,563,791

METHOD OF COATING THE INSIDE OF A CYLINDRICAL MEMBER

Filed May 9, 1969

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig - 7

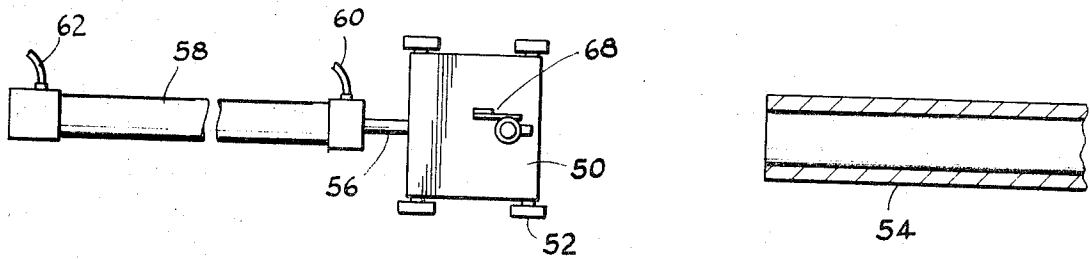


Fig - 8

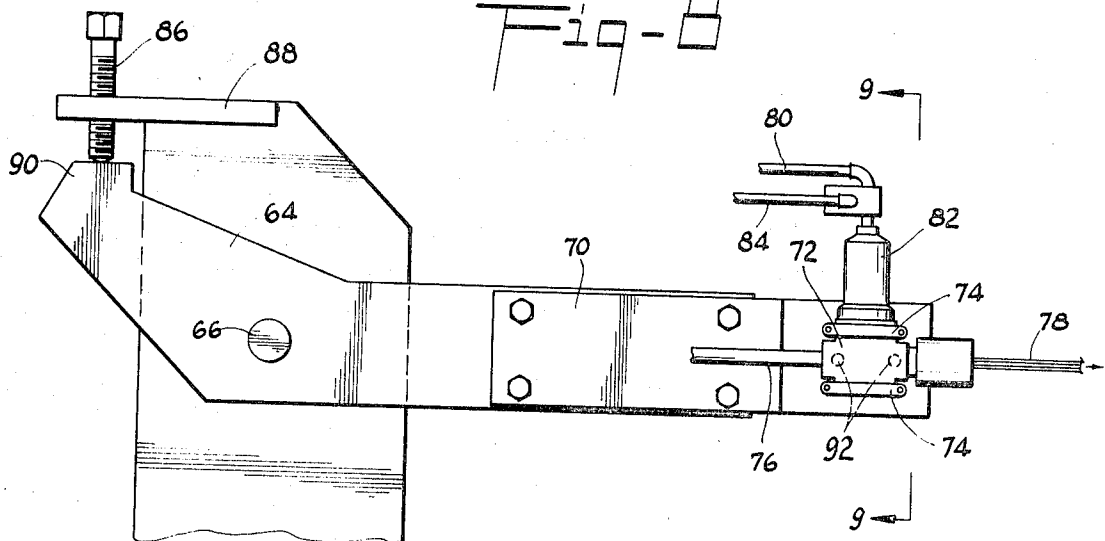
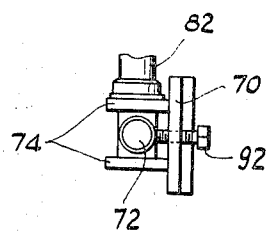


Fig - 9



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1

3,563,791

METHOD OF COATING THE INSIDE OF A CYLINDRICAL MEMBER

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Continuation-in-part of application Ser. No. 689,862,
Dec. 12, 1967. This application May 9, 1969, Ser.
No. 823,468

Int. Cl. B04c 13/06; B05c 7/02
U.S. Cl. 117—95

5 Claims

ABSTRACT OF THE DISCLOSURE

In preferred form the invention involves coating the inside of a permanent mold used in centrifugal casting, the coating being an insulating refractory. The mold is rotated at a speed such that the coating material supplied as liquid or slurry will be spread over the inside of the mold by centrifugal action. While the mold is rotating an unbroken stream of the coating material of suitable consistency or viscosity, which will solidify on passage of time, is directed into the mold in an axial direction from one end thereof and at such an inclination to the axis and with such force that it will impinge upon the inner surface of the mold adjacent but spaced from the opposite end whereupon its momentum will cause it to flow toward said opposite end and part of it to reach said opposite end after it impinges on the surface of the mold. This stream, after being allowed to flow for a sufficient time to coat the portion of the mold between its point of initial impingement and said opposite end, is directed at a gradually lowering angle or pressure or from a gradually receding portion so that it progressively impinges at points closer to said one end until the entire interior of the mold is coated. The flow of coating material is then shut off and rotation continued until the coating solidifies sufficiently that it will remain in place.

This application is a continuation-in-part of my prior copending application Ser. No. 689,862, filed Dec. 12, 1967, now abandoned.

This invention relates in general to the coating of the inside of a cylindrical member which may be rotated on a horizontal axis. A specific example of its application has to do with the coating of the inside of a permanent type centrifugal mold used in centrifugal casting, in which it is necessary to coat such molds with a refractory insulating coating.

Ordinarily in the past this coating for centrifugal molds has been accomplished by means of a long tube or lance which has a spray head on the end. The nature of the mold and of the coating require that the mold be heated to a temperature of somewhat above 300° F. during coating. The mold is then revolved at a relatively high speed. A slurry of the refractory coating mixed with air is forced through the lance which is extended into the mold and from the lance is sprayed on the inside of the mold. The lance is moved progressively along the length of the mold during such spraying. Usually the wash or slurry employed dries immediately after it is sprayed into the mold or it may be of a nature to require somewhat longer for its solidification. In order to obtain a uniform coating it is usual practice to apply the coating in at least two passes of the lance through the mold and sometimes many more. At times the mixture of coating material is applied without air admixture. By utilizing proper formulas for coating material it is usually possible to apply the coating in either one or two passes.

In coating molds and the like with the method just described, small diameter molds naturally require that the spray lance be of small diameter with the result that it

2

cannot be as stiff as might be desired. The lance will then vibrate excessively and sometimes catch the rotating mold in which case the lance will usually be destroyed and the entire operation is necessarily stopped while the replacement lance is put in place. Furthermore, the rate of traverse of the spray equipment such as just described is usually of the order of one foot per second so that a very appreciable length of time is consumed in spraying a rotating mold because the lance must move both into and out of the mold. The time so required represents an appreciable percentage of the entire cycle for producing a mold.

It is an object of the present invention to provide a method and apparatus for coating the inside of a cylindrical member which will avoid the necessity for the use of small diameter very limber lances in the application of coatings to the inside of very small internal diameter tubes.

It is a further object to avoid the necessity, in the coating of the insides of cylindrical members, for projecting the lance or nozzle into the interiors of such members when they are rotated during the coating operation.

Another object of this invention is to avoid the difficulty due to accidental contact between the nozzle carrying lance and the interior of a rapidly rotating cylindrical member during the process of coating such interior, together with the difficulties due to such contact doing damage to the lance and the coated interior of the member.

Another object of this invention is to provide a method and apparatus for coating the interiors of rotating cylindrical members which will require only a small portion of the time heretofore required in the use of nozzle carrying lances for applying such coating.

Other objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings wherein are set forth by way of illustration and example the preferred methods and apparatuses for carrying out the coating process.

Generally it is preferred in connection with this invention that a cylindrical member be rotated on a substantially horizontal axis at such a rate of speed that coating material applied to the inside thereof will tend to spread not only circumferentially but longitudinally in respect to the rotating interior of the mold. Thereupon an unbroken stream of coating material in liquid form will be directed under substantial pressure into an open end of the rotating member and generally along its axis. Such stream will be directed at such an angle that, for the pressure of the liquid, the stream of liquid coating material will impinge upon the interior of the rotating member at a point adjacent but spaced from the opposite end of the rotating member from which the stream of material is injected and by this means momentum of the coating material striking the interior of the mold will carry it on after impingement toward the opposite end of the mold from that into which the material was injected initially. This action is assisted by the rotation of the mold until the entire length of the interior of the mold beyond the point of impingement is coated. At this point the angle at which the stream is directed into the mold is changed slowly so that the point of impingement will begin to travel toward the end of the mold into which the stream is being injected. The speed of such travel with respect to the end at which the coating material is being injected will be so regulated that as the point of impingement moves toward the end of the mold into which the material is being injected it will leave the desired thickness of coating on the interior of the mold behind it. Upon the point of impingement reaching the end of the mold into which it is being injected, flow of coating material will be

3

cut off and rotation of the mold continued until the material solidifies.

It will be understood that by reference to liquid coating material it is intended to include all viscosities or consistencies of material which are suitable for being injected in an unbroken stream, whether this be a thin liquid or a slurry of substantial viscosity.

Inasmuch as one of the most desirable applications for this invention involves the coating of the inside of a centrifugal mold while it is being rotated in a horizontal position by the centrifugal casting machine, this invention contemplates an apparatus involving a nozzle by which such stream of coating material may be directed into such mold. The nozzle will be mounted for movement substantially away from the end of the mold preferably leaving a clear space axially from the end of the mold at least equal in length to the length of the mold when the mold is in position for rotation, so that the casting operation can be carried forward without interference with the nozzle, yet by which the nozzle may be moved into operative position adjacent the end of the mold when the coating operation is to take place. This movement away from the mold end may be laterally, in which case the only result is to clear the mold for pouring, or it may be moved parallel to the axis of the mold, in which event it will not only clear the mold but also may spray the mold interior from end to end. Also, it is preferable that the mounting for such nozzle have the necessary stops for positioning the nozzle initially so that under the pressure with which the coating material is to be delivered it will impinge at the desired position adjacent but spaced from the opposite end of the mold. Switch or trigger means preferably actuated by movement of the nozzle, is also provided by which after a predetermined nozzle movement or time interval after the flow of coating material is started, which movement or time will be sufficient to coat the end of the mold between the point of impingement and the end opposite the point of injection, a change either in the pressure of the liquid or in the attitude of the nozzle or to position along the axis of the mold will be initiated and caused to progress until the point of impingement reaches the end of the mold into which the coating material is being injected. Thereupon the switch or trigger means will again act to shut off the flow of coating material.

Other objects and advantages of this invention will become apparent from the following description and the accompanying drawings wherein are set forth by the way of illustration and example, but not by way of limitation, certain preferred embodiments of this invention.

In the drawings:

FIG. 1 is a diagrammatic view showing an end elevation of a mold whose interior is to be coated, the coating nozzle and means for mounting it for shifting laterally into and out of alignment with the mold, and means for tilting it in a vertical plane to change the point of impingement of the supply of slurry.

FIG. 2 is a view similar to FIG. 1 but showing the apparatus with the nozzle in substantial alignment at the end of the mold, which position it would occupy during the actual coating operation.

FIG. 3 is an enlarged fragmentary illustration of the coating nozzle showing its pivotal mounting and the means for changing its inclination in a vertical plane so as to move the point of impingement of the coating.

FIG. 4 is a longitudinal cross section through a mold substantially along its central plane and illustrating the path of coating material from the nozzle into the mold at the initiation of the coating operation.

FIG. 5 is a view similar to FIG. 4 but showing the angle of the nozzle after the coating operation has passed the initial stage and during the time that the point of impingement is being moved toward the nozzle as by changing of the angle of inclination of the nozzle.

FIG. 6 is a view similar to FIGS. 4 and 5 showing the

4

point of impingement as having passed still further toward the end of the mold into which the coating material is being injected and nearing the termination of the coating operation.

FIG. 7 is a plan view of a modification.

FIG. 8 is a side elevation on an enlarged scale of a portion of the modification shown in FIG. 7.

FIG. 9 is a view in cross section along the line 9—9 of FIG. 8.

Referring more specifically to the drawings, this invention is illustrated as being applied to the coating of the interior of a cylindrical member such as a centrifugal mold employed in centrifugal casting. This member 10 is required to have its inside surface 12 coated with a refractory insulating coating.

With reference to FIG. 1, it is seen that the mold 10 which is shown in end elevation, has the end illustrated clear of coating apparatus for whatever purpose may be desired as in the actual casting of material within the mold. During such time means for injecting the coating material will be supported out of the way of the pouring and casting removal operation, in this case in a lateral position relative to the mold. It is supported by means such as cylinder 14 and piston rod 16 providing together a means for mounting and advancing and retracting the nozzle bracket 18 and the coating nozzle thereon. In its retracted position shown in FIG. 1 this coating nozzle 22 is supported on the bracket 18 by means of a pivot 20, whereby the nozzle may be rotated about the pivot 20 in a vertical plane and directed above or below a horizontal line. In order to pivot it in such vertical plane it is illustrated as having connected to its end opposite the end from which the jet of coating material emerges, a piston rod 24, which is mounted on a piston carried in the cylinder 26. This cylinder in turn is carried on the bracket 18. It will readily be seen that by application of fluid pressure to the piston within the cylinder 26 either above or below such piston the angle of the nozzle 22 relative to the axis of the rotating mold may be changed.

The mold is rotated on its own axis in a suitable direction such as that indicated by the arrow 28, it being immaterial, however, for the purposes of this method which direction of rotation is employed. Fluid pressure will be applied to the left end of the cylinder 14 to move nozzle 22 into substantial alignment with the axis of the mold when positioned as illustrated in FIG. 1 to that illustrated in FIG. 2.

Thereupon, the angle of the nozzle 22 is adjusted such that when the available supply of pressure of coating to be applied is forced through the nozzle, such coating will emerge in a solid or unbroken and unaerated stream 30 from the nozzle and impinge on the interior of the rotating mold at some preselected point such as 32 adjacent to but spaced from the end opposite the nozzle. The combined pressure, position and inclination condition will be selected to produce a trajectory flat enough and so located that it will not strike the mold until its trajectory end at such preselected point. The coating flow will then be started and will contact the mold interior at said point 32. The coating material after impingement will spread by its own momentum toward the end opposite the nozzle and shortly will provide a coating or layer of coating material 34 from its point of impingement to such opposite end. When this layer of coating material has acquired the desired thickness, the point of impingement will be shifted gradually toward the location of the nozzle. This can be controlled by appropriate timing of the period during which the impingement at the point 32 continues. At the end of such time automatic timing mechanism of any well known variety, not shown, may be caused to initiate such change in the combined condition of pressure, position and angle as to cause the point of impingement to move toward the source of said stream at a controlled rate. In this form of the invention this is

5

accomplished by the controlled injection of fluid into the lower end of the cylinder 26 while allowing it to escape from the upper end thereof so as to change the angle factor of said combined condition. The rate of such application of fluid to the cylinder 26 should be controlled so as to move the point of impingement, continually changing the path of the stream of coating material so that it moves toward the nozzle end of the rotating mold. FIG. 5 illustrates the trajectory 36 of such stream of coating material after it has moved some distance from the initial point 32 where it at first impinged to a new point of impingement 38, and in the course of such movement applied a coating 40 to the portion of the mold between the initial point of impingement 32 and the later point 38. Such tilting action of the nozzle will be continued at a predetermined controlled rate such as to apply the appropriate thickness of coating to the interior of the mold as it progresses, a still further progress of such process being illustrated in FIG. 6 in which the stream is shown following a trajectory 42 and impinging at a point 44 in the mold and in which there is illustrated the additional coating 46 applied to the interior of the mold during such progress.

Such progress in changing of the angle of the nozzle 22 should be continued until the point of impingement reaches the end of the mold adjacent the nozzle 22 whereupon the flow of coating material should be cut off and the nozzle retracted through operation of the cylinder 14 and the piston contained therein to return the parts to the position shown in FIG. 1.

It has been found from experience that a uniform coating may be obtained by having constant pressure jetting the fluid into the mold, having the nozzle slightly elevated initially, leaving it elevated for a previously determined length of time, and then angularly moving it downward to coat the entire length of the mold, but that a substantially similar result may be obtained by varying the pressure factor of the above-mentioned combined condition and thereby changing the point of impingement to follow substantially the same pattern as above described. A regulating valve 48 may be provided in the liquid coating supply to the nozzle to cut off or regulate such flow and the pressure thereof as desired.

Turning now to FIG. 7 of the drawings, there is illustrated a spray and puller car 50 such as used heretofore in supporting an elongated lance adapted to extend into a hollow member for spray coating its interior in the manner heretofore known. In this instance, however, this car 50 is supported on wheels 52 and adapted to be extended toward and retracted from the spinning hollow member 54 by means of a piston rod 56 attached thereto and forming part of a combination with a cylinder 58 having fluid connections at its opposite ends 60 and 62.

The car 50 as here employed has mounted thereon a suitable pivot plate mounting for a nozzle intended to provide the fluid stream as hereinbefore discussed. This pivot plate 64 is mounted in any suitable fashion on the car as by means of a pivot 66 engageable with a suitable bracket or angle member 68 on the car 50. Suitably mounted on this pivot plate 64 by means of bolts or the like is an adapter 70 carrying a nozzle 72 thereon, the nozzle 72 being secured in place on the adapter 70 by suitable means such as clamping straps 74.

This nozzle 72 has suitable conduit connections such as 76 for water or other fluid to be ejected in the fluid stream 78, and a connection 80 suitable for connecting an air supply for compressed air if the same be desired in connection with the stream of fluid. Such nozzle is preferably also fitted with suitable valves such as 82 adapted to be controlled electrically or in other suitable means as by conduit entering the valve assembly through the connection 84.

The tilting of the nozzle and hence the tilting of the angle of direction of the stream 78 will be accomplished by means of a tilt adjusting screw 86 extending through

6

a suitable stationary portion of the bracket 68, which portion is designated 88, and engaged with a heel portion 90 of the pivot plate 64. It will readily be seen that when the screw 86 is turned in a direction to move it downwardly as seen in FIG. 8, this will force the heel end 90 of the pivot plate 64 downwardly and raise the angle or increase the angle with respect to the horizontal which the ejected stream 78 will take.

For the purpose of adjusting the nozzle angularly in a horizontal plane, there are provided extending through the adapter 70 a pair of side adjustment screws 92. It will be seen that by tightening one of the screws 92 and loosening the other the angle in the horizontal plane may be adjusted within limits as desired.

In this form illustrated in FIGS. 7, 8 and 9, it will readily be seen that with the pivot plate so adjusted initially that when the nozzle is located adjacent the end of the hollow member 54 its stream will achieve the desired initial trajectory, the point of impact of the stream against the inside of the spinning member 54 may be moved toward the open end of the member 54 by merely backing off the car 50 under use of the piston and cylinder combination 58, until the point of impingement of the stream reaches the open adjacent end of the spinning member 54.

Switch or trigger means of a well-known nature may be provided for starting the stream and causing it to flow while the mechanism is in position for the initial trajectory to coat the rotating member beyond the point of initial impingement, and then while the nozzle is tilting downward or moving away from the rotating member or its pressure is being reduced at a predetermined speed until the trajectory reaches the open end thereof. Thereupon the switch or trigger means would be preset to close the valve 82 and shut off the stream. Such switch or trigger means is preferably positioned to be actuated by movement of the nozzle or the reduction of pressure and thus synchronized therewith, but other well-known controls could be employed to achieve synchronization.

The mechanism moving the car 50, however, would be allowed to continue in operation until the space between the end of the nozzle 72 and the open end of the spinning member 54 is at least equal to the length of the spinning member so as to allow sufficient space for the operation of pouring the spinning member if it be a centrifugal mold, or for producing whatever other operation is adapted to be carried out with the spinning member after it has been coated.

Details of the mechanism for supporting and rotating the mold, the means for supporting the nozzle other than means for shifting it and tilting it, and the means for synchronizing or timing the various operations, have not been illustrated as details of such means, which form no part of this invention, are within the skill of persons skilled in the art to which this invention applies and, for the most part, are readily available on the market.

With the invention just described a very smooth uniform coating may be applied to the mold in a much shorter time than with previous methods such as those employing a spray lance as hereinbefore described. The result is that the supply is distributed in a shorter length of time while it is still quite fluid, and that the centrifugal force tends to uniformly distribute the slurry. By this means a production of molds for and hence of relatively thin walled castings in long lengths, is much facilitated.

Since any variation in the thickness of the mold coating affects the rate of solidification of a casting produced in the mold and thus tends to produce castings which are warped, the coating method and apparatus just described permits the production of castings of higher quality and greater straightness.

The invention having been described, what is claimed is:

1. In a method of coating the inside of a cylinder which comprises rotating the cylinder and applying the coating in liquid form to the inside of the cylinder, the

7

improvement which comprises rotating the cylinder at a speed that liquid coating material applied to the inner surface tends to be spread by centrifugal action over such surface, directing a substantially unsupported unbroken stream of solidifiable liquid coating material into one end of said rotating cylinder from such position and at such pressure and such an angle to the cylinder axis that it will impinge on the inner surface of the cylinder adjacent but spaced from the opposite end of the cylinder so that its momentum will cause part of it to reach the said opposite end after impingement, changing the initial combined conditions of position, angle and pressure direction of said stream to move its point of impingement toward said one end until it reaches same, such movement being at such a speed relative to the rate of flow of coating that the desired thickness of coating will be applied to the interior of the cylinder during movement, discontinuing said stream, and continuing said rotation until said coating solidifies.

2. The method set forth in claim 1 in which said initial conditions direction of said stream are maintained until the inner cylindrical surface is coated to said other end before beginning the change in stream direction conditions.

3. The method set forth in claim 1 in which the change

8

from initial direction is accomplished by changing the angle of the stream relative to the cylinder axis as the stream enters said one end.

4. The method set forth in claim 1 in which the change from initial direction is accomplished by moving the point from which said substantially solid stream is directed, such motion being in a direction parallel to the axis of the rotating member and away from same.

5. The method set forth in claim 1 in which the change from initial direction is accomplished by changing the pressure conditions of the direction of said stream.

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U.S. Cl. X.R.

117—5.1, 5.3, 96, 97, 101; 118—318