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APPARATUS FOR LINING CENTRIFUGAL CASTING MOLDS

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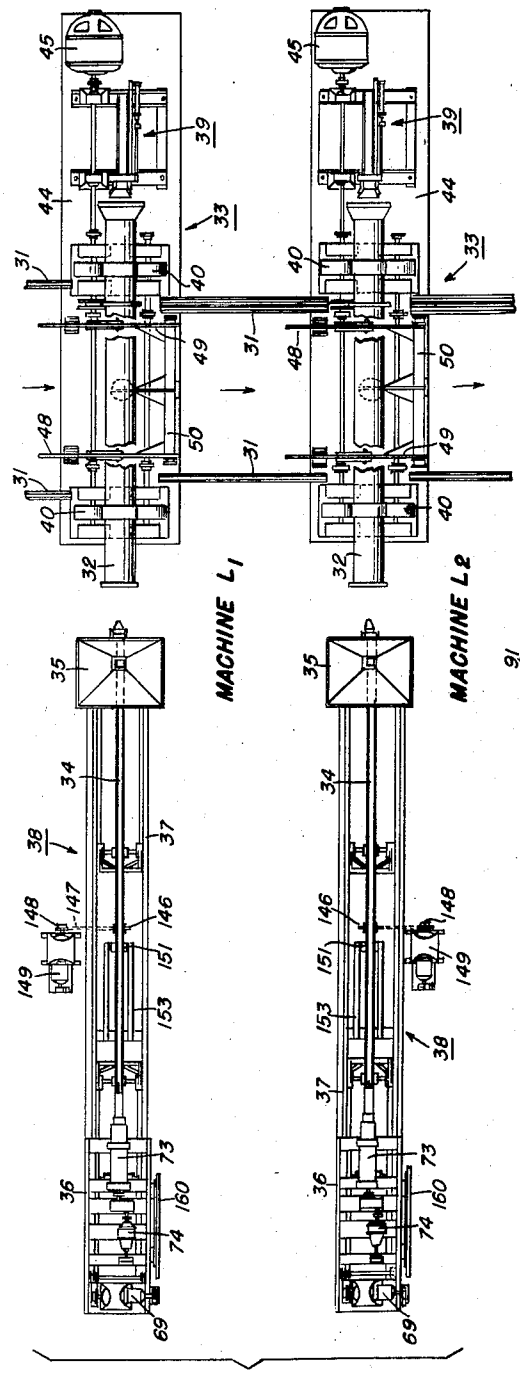


FIG. 1

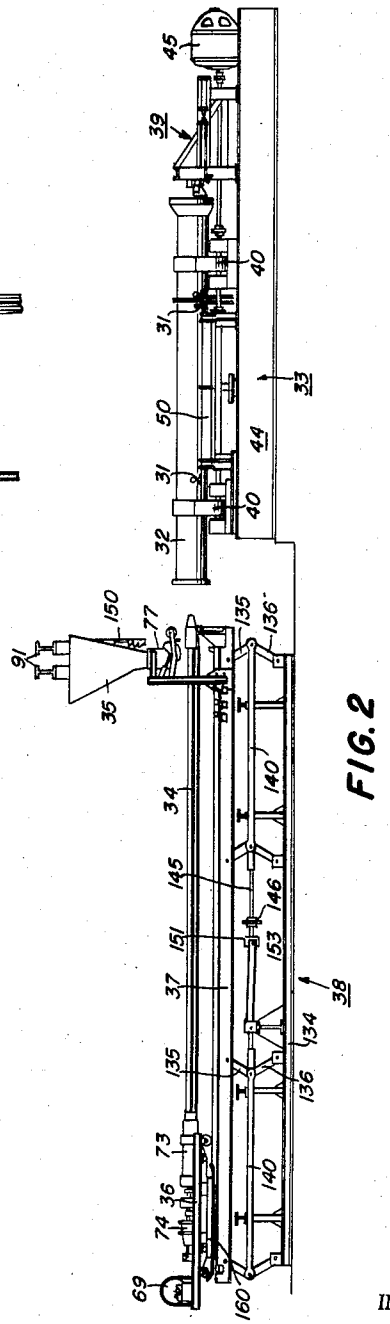


FIG. 2

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FIG. 3

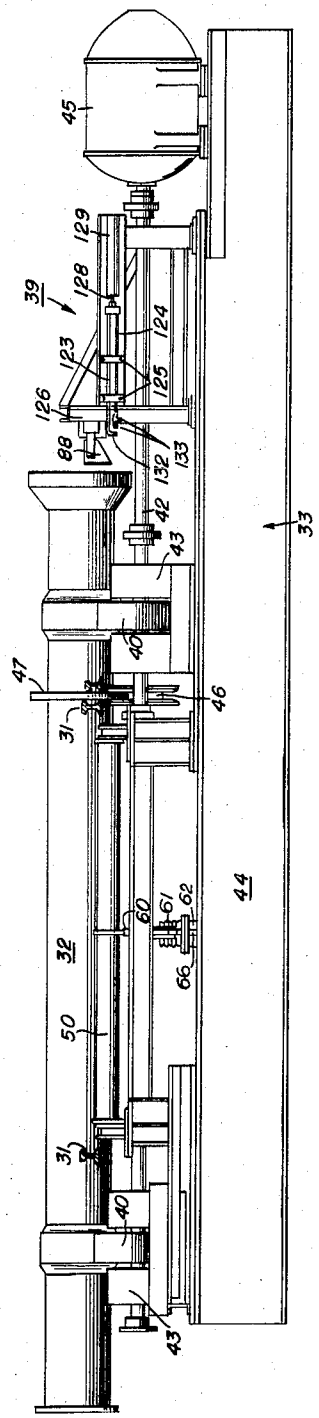
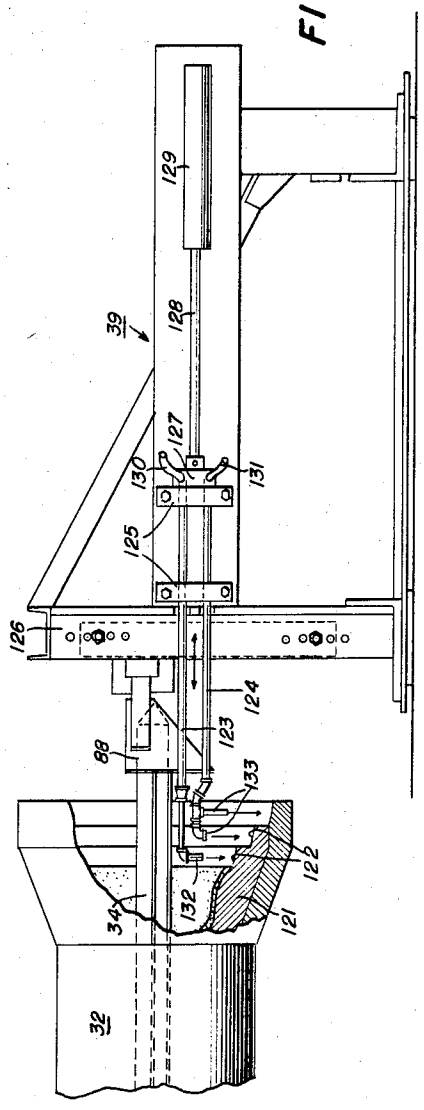


FIG. 17



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FIG. 4

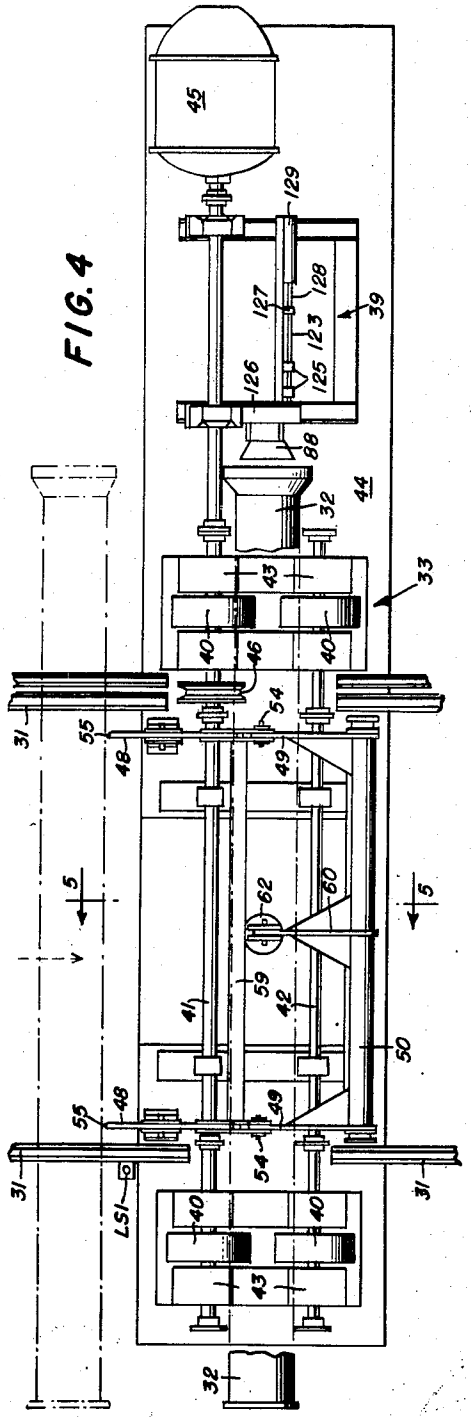


FIG. 5

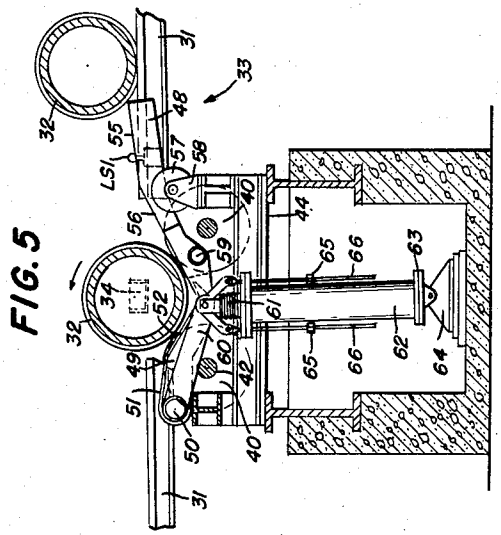
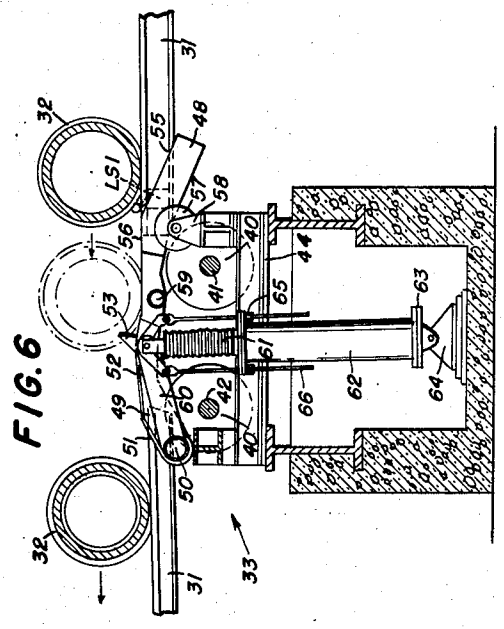


FIG. 6



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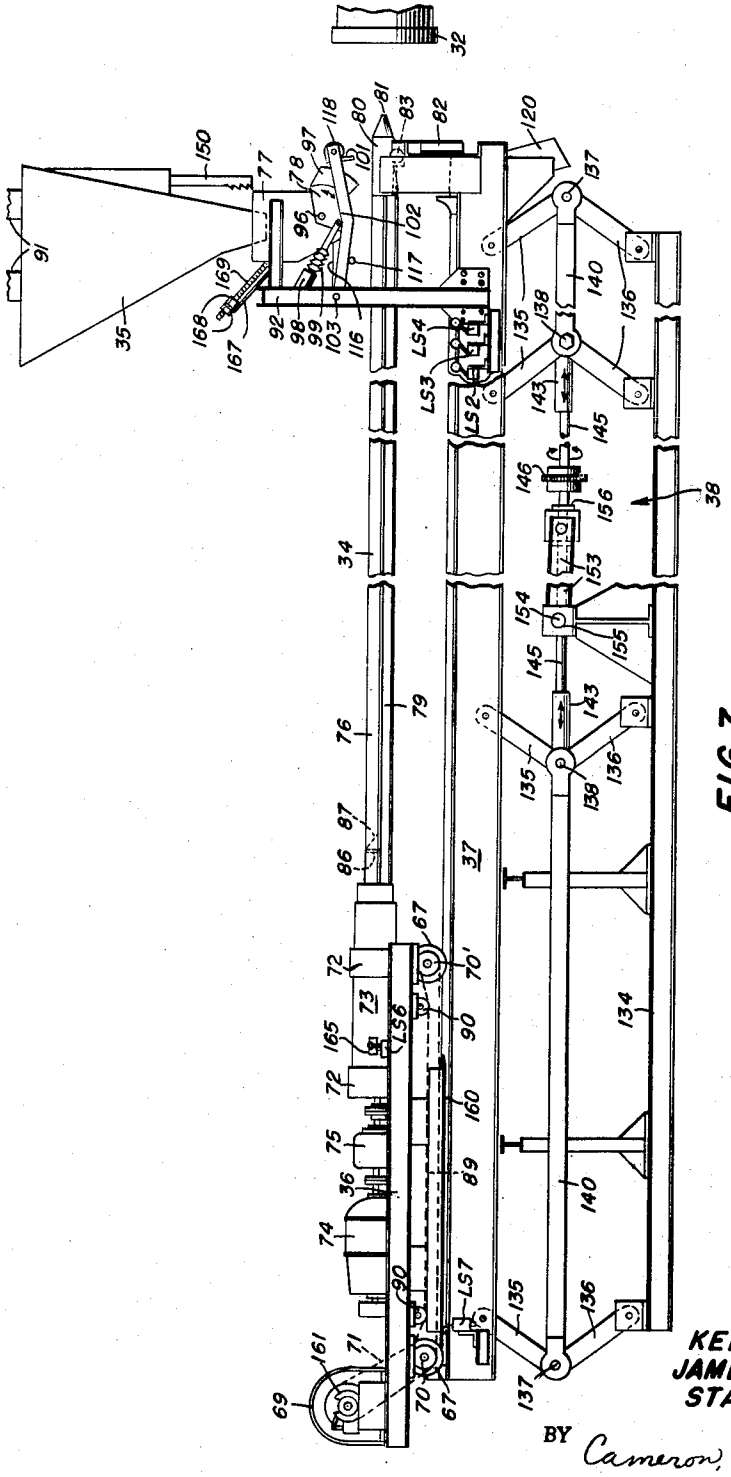


FIG. 7

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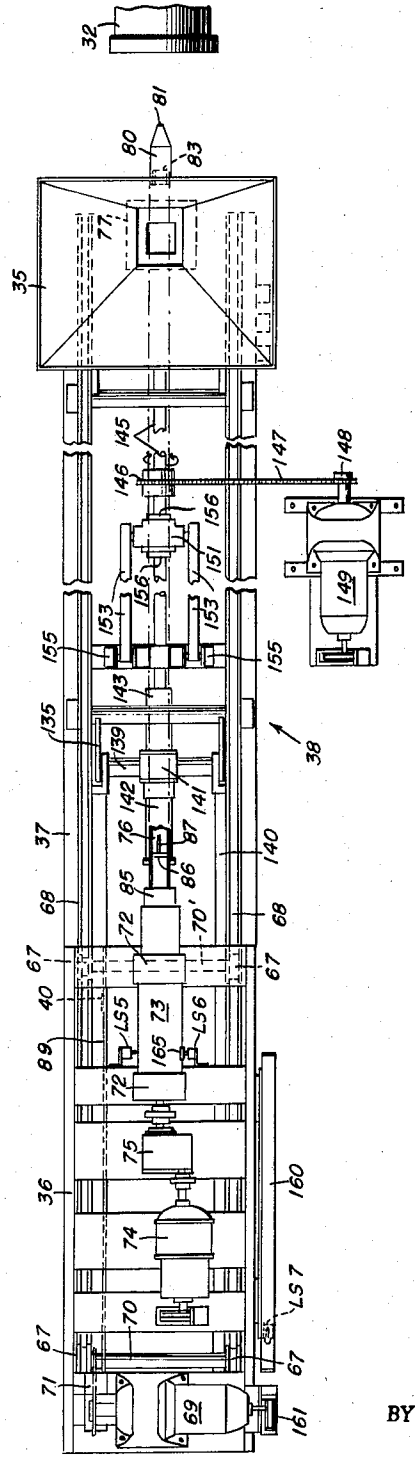
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FIG. 8



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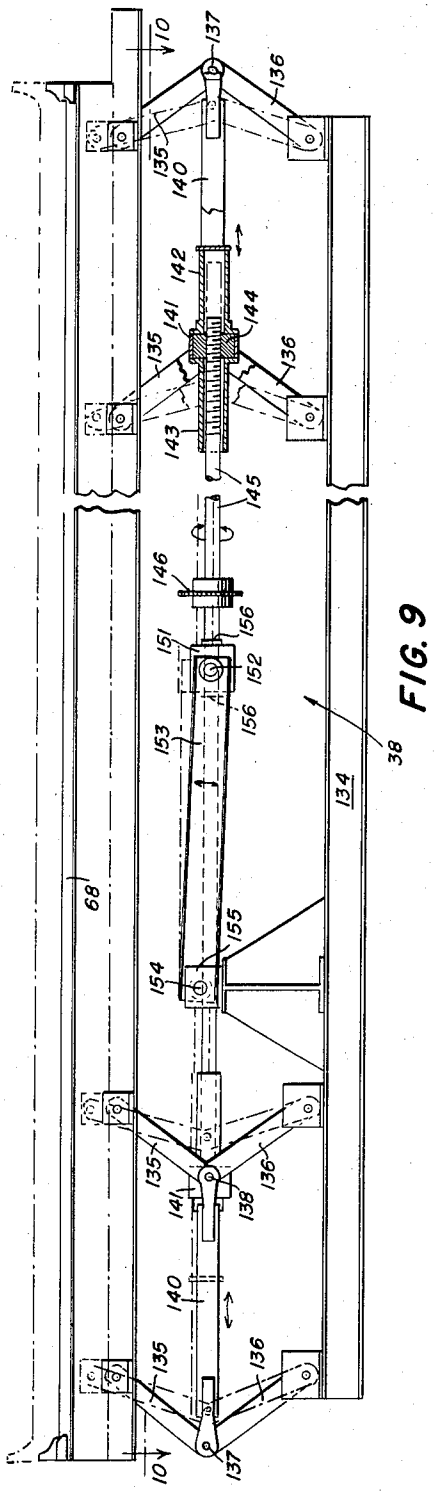


FIG. 9

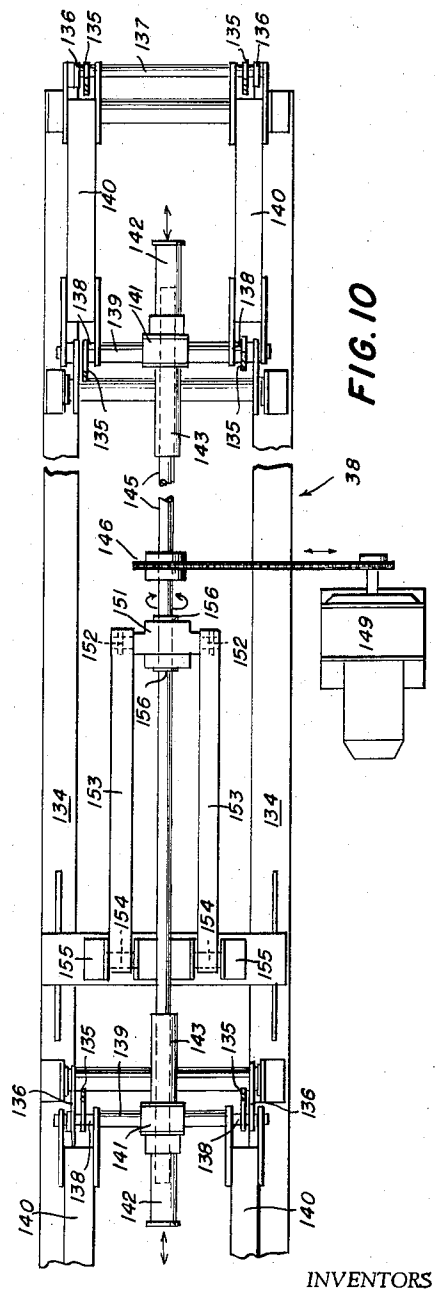


FIG. 10

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APPARATUS FOR LINING CENTRIFUGAL CASTING MOLDS

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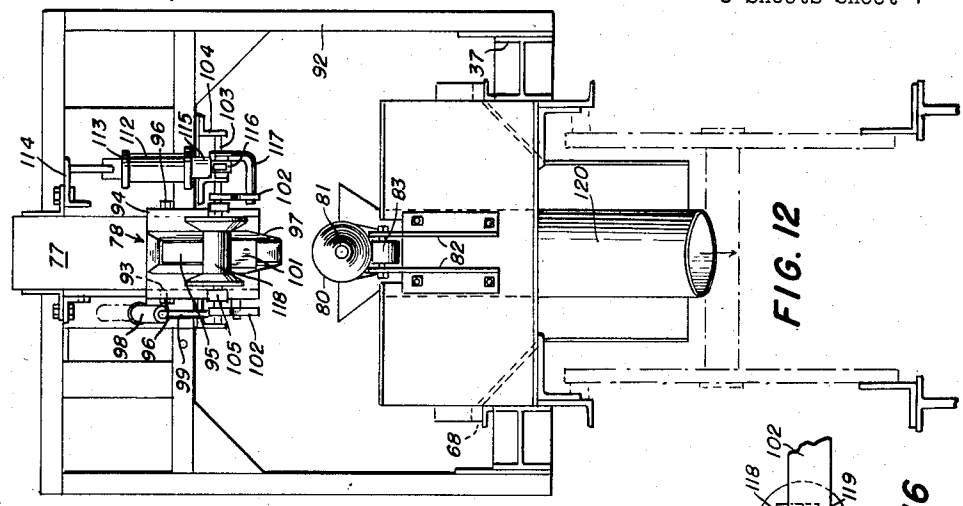


FIG. 12

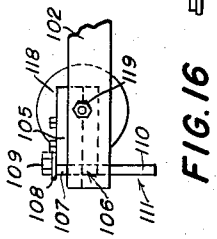


FIG. 16

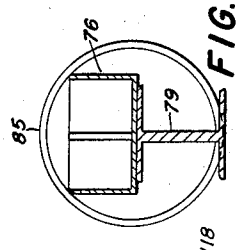


FIG. 13

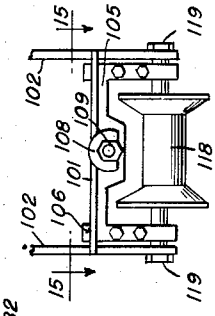


FIG. 14

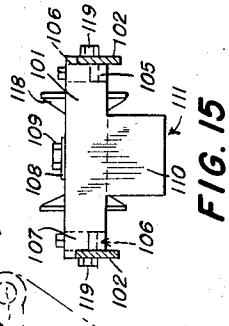


FIG. 15

FIG. 11

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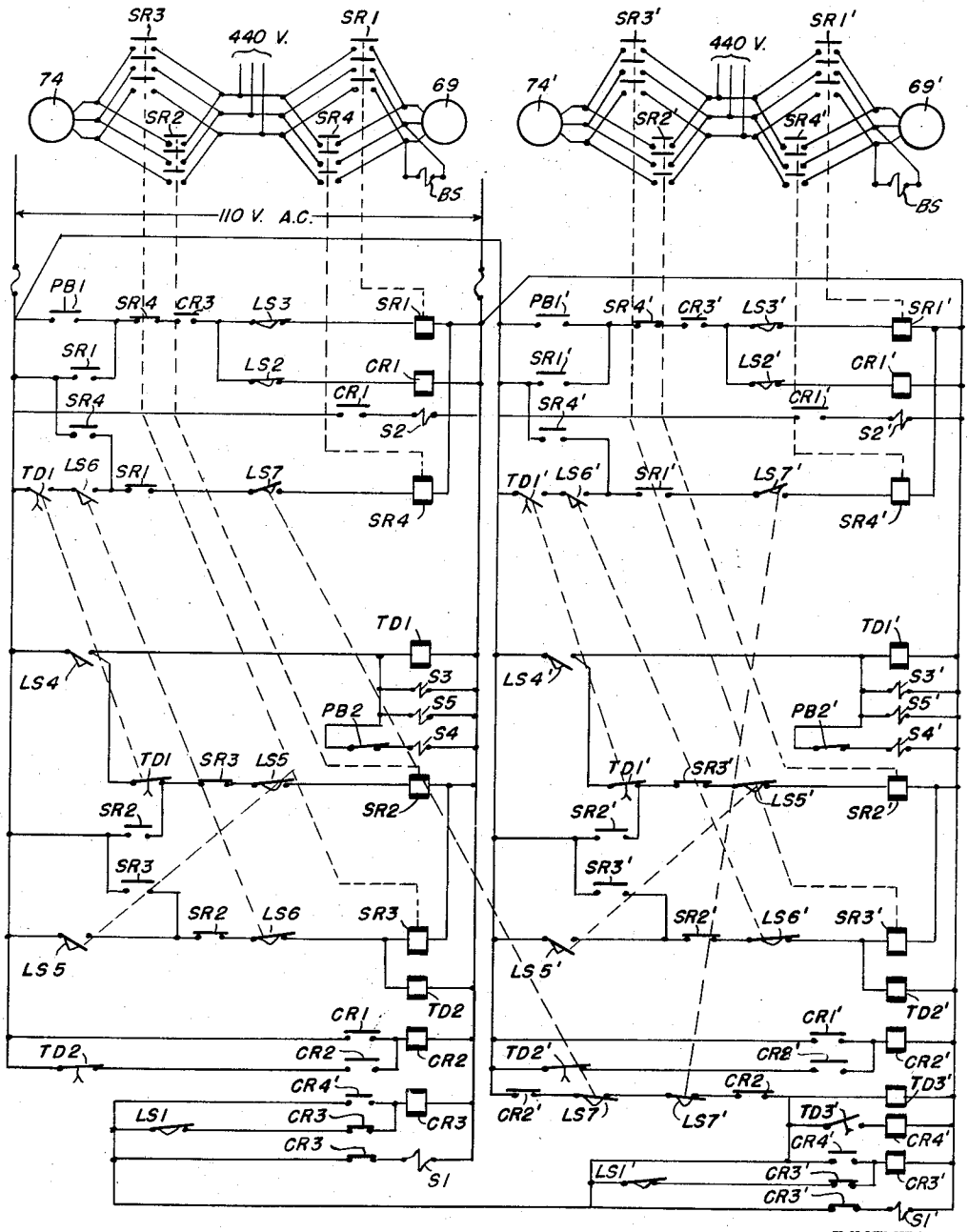


FIG. 18

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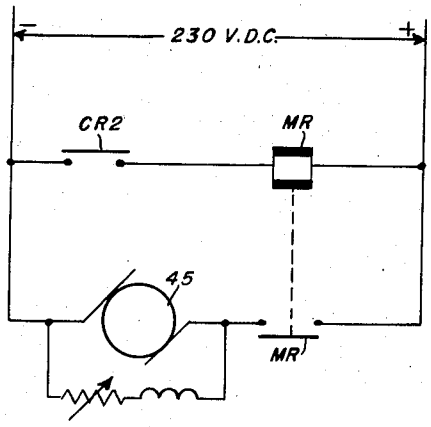


FIG. 19

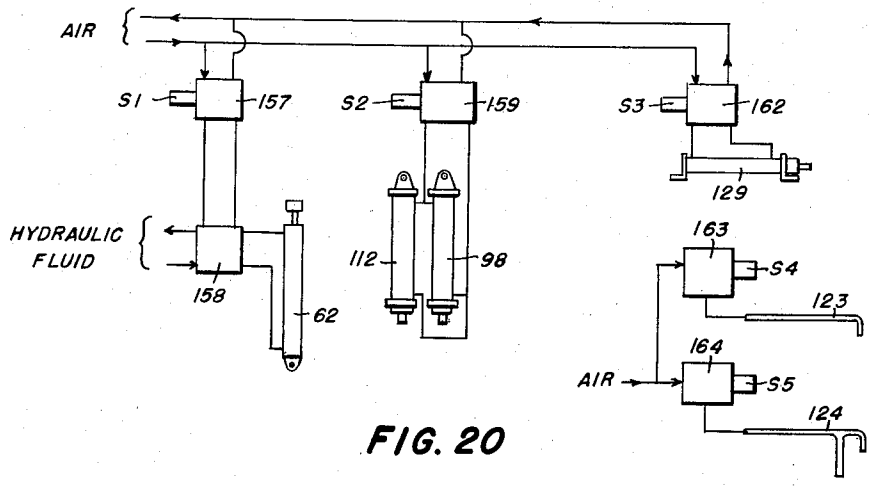


FIG. 20

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United States Patent Office 2,873,716 Patented Feb. 17, 1959

2,873,716

APPARATUS FOR LINING CENTRIFUGAL CASTING MOLDS

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Application December 28, 1955, Serial No. 555,934

24 Claims. (Cl. 118—55)

This invention relates to apparatus for lining metal molds used in the centrifugal casting of tubular metal articles, and is particularly directed to mechanism for forming refractory linings in vented metal molds in accordance with the method disclosed in the application of Frank H. Coupland et al., Serial No. 446,488, filed July 29,1954, now Patent No. 2,731,690, granted January 24, 1956.

As pointed out in the Coupland et al. application, there are two conventional centrifugal casting procedures: the de Lavaud process wherein the metal is cast directly against the inner surface of an unvented, water-cooled metal mold and a chilled casting is produced which must be annealed; and the Sandspun method which uses a vented mold having a green sand lining of from one to two inches in thickness and produces an unchilled casting requiring no annealing. In comparison with these old processes, the characteristic feature of the Coupland et al. method is the use of a vented metal mold having a smooth, dense resin bonded sand lining of uniform and accurately controlled thickness which, although much thinner than the green sand lining of the Sandspun procedure, is effective to avoid unduly rapid freezing of the casting metal while at the same time materially reducing the casting time.

The principal object of the present invention is to provide new and improved apparatus for lining vented metal molds with resin bonded refractory linings of the character employed in the above-mentioned Coupland et al. method of centrifugally casting tubular metal articles.

Another object is to provide a novel mold lining mechanism which is adjustable for use with molds of different sizes.

A further object is the provision of a machine for forming a strongly bonded sand lining of predetermined thickness in a cylindrical metal mold while the mold is being rotated at a speed calculated to distribute the lining material uniformly over the inner surface of the mold and to produce a lining of the desired density.

Still another object of the invention is to incorporate in a mold lining apparatus of the character described a novel combination of trough and trough filling means which cooperate to deliver into the mold an accurately measured quantity of lining material, and novel means for preventing the lining material from adhering to certain predetermined areas of the mold.

A still further object is to provide a pair of commonly controlled lining machines which are adapted to form successive layers of resin bonded refractory lining in a metal mold at adjacent lining stations.

These and other objects, including the provision of means for automatically controlling the sequence of operations of mold lining apparatus of the character described, will appear more fully upon consideration of the detailed description of the embodiment of the invention which follows. In this connection, although only one specific form of lining apparatus is described and illustrated in the accompanying drawings, it is to be expressly understood that these drawings are for purposes of illustration only and are not to be construed as defining the limits of the invention, for which latter purpose reference should be had to the appended claims.

In general, the apparatus of the present invention comprises two machines of substantially identical construction arranged in tandem at adjacent stations of a centrifugal casting production line, the two machines being adapted to form successive layers of a resin bonded refractory lining in a vented metal mold while the mold is being rotated at a predetermined speed. Each lining machine includes a mold supporting and rotating mechanism; a trough which is movable axially into and out of the mold, and rotatable about its axis while within the mold, for delivering the lining material into the mold; means for placing in the trough an accurately measured quantity of the lining material; mechanism for adjusting the elevation of the lining trough so as to properly align it with molds of different sizes; and means for preventing the lining material from adhering to certain areas of the mold where a bonded lining is not desired. The apparatus also comprises a system of switches, relays, valves, fluid pressure cylinders and other elements which automatically controls the sequence of operations of each lining machine, and interlocks the two machines to insure simultaneous unloading of the mold supporting and rotating mechanisms. It will be obvious, of course, that the apparatus of the present invention is readily adaptable to the formation of single layer, instead of two layer, linings either by omitting the second lining machine from the assembly line, or by lining two molds at a time and then discharging both lined molds from the apparatus before again starting the lining cycle.

Inasmuch as the apparatus of the invention is especially well adapted for use in the manufacture of cast iron pipe, the following disclosure will be directed primarily to this particular application of the inventive concept. By so doing, however, it is not intended to limit the scope of the invention to mechanism for lining pipe casting molds, because it will be evident that the apparatus also has utility in connection with molds for producing other forms of castings.

In the drawings, wherein for illustrative purposes the molds are assumed to be of the type used for centrifugally casting bell and spigot pipe by the previously mentioned Coupland et al. process (although the vents in the mold walls are not shown in the drawings), and wherein like reference characters indicate like parts throughout the several views:

Figs. 1 and 2 are somewhat diagrammatic plan and side views, respectively, of one form of apparatus for lining metal pipe casting molds in accordance with the present invention, certain of the elements of the machine having been omitted in the interest of simplicity;

Fig. 3 is an enlarged side view of the mold supporting and rotating mechanism of one of the machines of Fig. 1;

Fig. 4 is a plan view corresponding to Fig. 3 with the central portion of the mold on the spinning rollers broken away so as to more clearly illustrate certain features of the construction;

Fig. 5 is a cross section taken substantially on line 5—5 in Fig. 4, showing the means by which molds are delivered to and discharged from the rotating mechanism, the parts being shown in the positions occupied when a mold is being rotated;

Fig. 6 is a cross sectional view similar to Fig. 5, but showing the parts in the positions occupied when a lined mold is being discharged and an unlined mold is being delivered to the rotating mechanism;

Fig. 7 is an enlarged side view, broken at several points along the length thereof, of that part of one of the machines of Fig. 1, shown at the left-hand side of

said figure, by which an accurately measured quantity of lining material is delivered into a mold while it is being rotated by the mechanism shown at the right-hand side of Fig. 1;

Fig. 8 is a plan view corresponding to the side view of Fig. 7, with most of the lining trough broken away in order to more clearly illustrate the parts lying therebeneath;

Fig. 9 is a partially sectioned side view on a still larger scale of the means by which the lining trough and associated elements are adjusted in elevation in order to operate with molds of different diameters;

Fig. 10 is a plan view corresponding to Fig. 9 sectioned substantially on the line **10—10** in the latter figure;

Figs. 11 and 12 are side and end views, respectively, of the front end of the lining trough and the associated means by which the lining material is delivered to the trough in accurately meaured amounts;

Fig. 13 is an enlarged cross section taken substantially on line **13—13** in Fig. 11, showing the construction of the lining trough;

Fig. 14 is a fragmentary plan view of the front end of the striker device by which excess lining material is removed from the trough;

Fig. 15 is a vertical cross section taken substantially on line **15—15** in Fig. 14, showing the shape of the striker plate;

Fig. 16 is a side view corresponding to Figs. 14 and 15;

Fig. 17 is a fragmentary side view on a still larger scale of the right-hand end of the mechanism shown in Fig. 3, showing in operative position the means by which the lining material is prevented from adhering to certain surfaces of the mold bell;

Fig. 18 is a simplified schematic diagram of the electrical control system for the two mold lining machines indicated in Fig. 1, showing the positions of the various switches and relays in their at rest or inoperative condition, i. e., when both lining machines are empty awaiting the delivery of molds to the supporting and rotating mechanisms thereof;

Fig. 19 is a simplified schematic diagram of the electrical circuit of one of the motors which drives the mold rotating mechanisms; and

Fig. 20 is a schematic diagram illustrating the supply of air and hydraulic fluid to various elements of one machine.

As indicated in Fig. 1, the apparatus of the present invention comprises a pair of lining machines L_1 and L_2 located closely adjacent one another in tandam relationship with their principal axes perpendicular to the rails **31** of a mold run on which molds **32** may be rolled to and from the lining machines by gravity, in the direction indicated by the arrows in Fig. 1. Although in practicing the Coupland et al. process machines L_1 and L_2 may be used to form successive lining layers of slightly different sand-resin mixtures in each mold, the construction and operation of both machines are identical. Accordingly, except for the interlocking feature of the electrical control system shown in Fig. 18, only one of the machines, L_1, will be described.

Referring first to the generalized showing of Figs. 1 and 2, the principal elements of each machine include a mold rotating mechanism **33**, a lining trough **34** adapted to receive a measured quantity of sand-resin lining material from a hopper **35** and to deliver it into mold **32** while the latter is being rotated by mechanism **33**, a lining car **36** by which trough **34** is supported and moved axially into and out of mold **32**, a vertically movable frame **37** on which lining car **36** is movably supported, a mechanism indicated generally at **38** for adjusting the elevation of frame **37**, and a device indicated generally at **39** associated with mold rotating mechanism **33** by which the lining material may be prevented from adhering to certain surfaces of the bell end of the mold.

Turning now to the mold rotating mechanism **33**, shown best in Figs. 3–6, a plurality of spinning rollers **40** are provided for supporting and rotating mold **32** in a horizontal position during the lining operation, said rollers being mounted in two sets on shafts **41** and **42** which extend parallel to the axis of the mold and are journaled in bearings **43** mounted on a stationary base **44** suitably fixed to the machine foundation. In the embodiment illustrated, shaft **41** is adapted to be driven by a variable speed motor **45** while shaft **42** is an idler, the rollers on the latter shaft deriving their rotation from the mold **32** which in turn is frictionally dirven by the rollers of shaft **41**. Shaft **41** is also provided with a flanged wheel **46** which receives the guide flange **47** of mold **32** and holds the mold against movement in an axial direction during its rotation. As shown, the mold is positioned on the rollers with its bell end to the right as viewed in the drawings and its spigot end closely adjacent the forward end of lining trough **34**.

In order to properly control the delivery and discharge of molds to and from spinning rollers **40**, mold rotating mechanism **33** includes a pair of parallel, axially spaced detent-guide arms **48** which control the delivery of molds to said mechanism, and a cooperating pair of kickout arms **49** the primary purpose of which is to eject the molds from the machine after they have been lined.

As indicated in Fig. 4, kickout arms **49** are fixed to the ends of a torque tube **50** which is mounted for oscillatory movement about a fixed axis parallel to the axes of spinning roller shafts **41** and **42** at a position beneath the ends of mold run rails **31** at the discharge side of the machine. The upper surface of each kickout arm **49** is of bent shape, having a portion **51** which is substantially tangent to the upper surface of torque tube **50** and a second portion **52** which is inclined downwardly relative to radially extending portion **51**, and terminates in an upwardly extending pointed end portion **53** which projects slightly beyond the vertical axial plane of mold **32**, toward the side of the machine from which the molds are loaded, when the mold is in spinning position on rollers **40**.

Each of detent-guide arms **48** is provided with a clevis shaped inner end pivotally connected to the free end of the associated kickout arm **49** by a pin **54** at a point just below the junction between pointed end portion **53** and inclined portion **52** of the kickout arm, and is also of irregular shape. As shown in Figs. 5 and 6, the upper surface of each detent-guide arm **48** is bent at substantially the same angle as the upper surface of kickout arm **49**, having a portion **55** at the outer end of the arm which is inclined downwardly with respect to the portion **56** at the inner end of said arm. The bottom edge of each detent-guide arm **48** rests on a flanged roller **57** rotatably mounted in a bearing bracket **58** fixed to base **44**. Rollers **57** engage the bottom edges of detent-guide arms **48** at points substantially directly beneath the junctions between surfaces **55** and **56**, and support said arms in a position such that said junctions lie in approximately the same plane as the rolling surfaces of rails **31**. The two detent-guide arms **48** are interconnected by a tie tube or rod **59** at points intermediate the axes of flanged rollers **57** and the inner ends of said arms where they are pivoted to kickout arms **49**, tie tube **59** extending parallel to torque tube **50**.

Fixed to torque tube **50** intermediate its ends is a radially extending operating arm **60** which lies in substantially the same plane as kickout arms **49** and is pivotally connected at its inner end to the upper end of the piston **61** of a hydraulic cylinder **62**. Cylinder **62** extends downwardly through a central opening in the base **44** of mold rotating mechanism **33** and is provided at its lower end with a base cap **63** which is pivotally connected to a supporting bracket **64** fixed to the machine foundation.

When a mold is in lining position on spinning rollers

40, piston 61 of hydraulic cylinder 62 is in its fully retracted position and detent-guide arms 48 and kickout arms 49 form a wide V, as indicated in Fig. 5, with their upper surfaces completely out of contact with the surface of mold 32. At this time, the outer ends of detent-guide arms 48 project upwardly above the rolling surfaces of rails 31 in such position as to prevent the next mold on the delivery side of the machine from entering the mold rotating mechanism.

When the mold on rollers 40 has been lined, it is ejected or discharged from the machine by admitting hydraulic fluid to cylinder 62 so as to raise piston 61 to the uppermost position permitted by adjustable stop nuts 65 which are threaded on rods 66 depending from the upper end of said piston and passing through openings in the cylinder head. The upward motion of piston 61 is transmitted by operating arm 60 to torque tube 50 and results in a counterclockwise rotation of the latter and movement of kickout arms 49 to the position indicated in Fig. 6. As kickout arms 49 are raised from the position shown in Fig. 5, their pointed end portions 53 and inclined surfaces 52 come into contact with the surface of mold 32 at points on opposite sides of the vertical axial plane thereof, raise the mold, and then, as inclined surfaces 52 rise above the level of the rolling surfaces of rails 31, roll the mold off the kickout arms and onto said rails, as indicated in Fig. 6.

Due to the pivoted connection between kickout arms 49 and detent-guide arms 48, elevation of the former also raises the inner portions of the latter to a substantially horizontal position, level with rails 31, and lowers the outer ends thereof below the rolling surfaces of the rails so that the next mold in line may roll into the machine to the position indicated in broken lines in Fig. 6, where the pointed ends of kickout arms 49 hold the mold until it is lowered onto rollers 40 when hydraulic cylinder 62 is exhausted and piston 61 returns to the retracted position shown in Fig. 5. As the inner ends of detent-guide arms 48 are raised by virtue of their pinned connection with the ends of kickout arms 49, rollers 57 permit arms 48 to adjust their positions accordingly, forming in effect movable fulcrums.

As will be explained hereinafter in connection with the automatic control system of the lining machine, retraction of piston 61 is accomplished automatically as the result of actuation of a kickout down limit switch LS1 which is positioned alongside one of rails 31 closely adjacent the end of said rail from which the mold rolls into the lining machine, and the operating lever of which is depressed by the mold as it rolls thereover.

Turning now to the mechanism by which the lining material is measured and delivered into the mold 32 as it is being supported and rotated with its axis in a fixed horizontal position, i. e., the means shown at the left-hand sides of Figs. 1 and 2, it will be seen best from Figs. 7 and 8 that car 36 which supports lining trough 34 is provided with two pairs of wheels 67 running on tracks 68 fixed to the upper surfaces of the side members of vertically movable frame 37. Mounted at the rear end of car 36 is a variable speed, reversible, three phase A. C. motor 69 the shaft of which extends transversely of the frame parallel to the axle 70 of the rear pair of wheels 67, and is drivably connected to said axle by a chain and sprocket drive 71. Axle 70 is in turn drivably connected to the axle 70' of the front pair of wheels 67 by a chain and sprocket drive 89 which includes a pair of idler sprockets 90 so mounted as to be adjustable forwardly or rearwardly for the purpose of taking up slack in the chain.

The forward end of car 36 carries a pair of axially spaced bearings 72 which rotatably support an enlarged cylindrical barrel 73 fixed to the rear end of lining trough 34. Intermediate car driving motor 69 and trough bearings 72 the car carries a reversible, three phase A. C. motor 74 and a speed reduction gear 75 which are drivably connected to barrel 73 of trough 34 for the purpose of slowly rotating the trough through an arc of approximately 180° so as to dump the contents thereof into the mold after the trough has been moved into the mold by a forward movement of car 36 from the normal, at rest position indicated in the drawings to the forward end of frame 37.

As best illustrated in Figs. 11 and 13, trough 34 comprises a body portion 76, substantially rectangular in cross section and open at the top, which is adapted to receive the lining material from hopper 35 through a nozzle 77 and an automatically controlled gate 78, and a stiffening base member 79 in the form of a I-beam which extends the full length of and is welded to body portion 76. At the forward end of the trough, the bottom portion of base member 79 is cut away and the thus reduced end of the trough is fitted with a cylindrical nose piece 80 having a conically shaped end 81. In order to assist in maintaining trough 34 in a horizontal position as it moves into and out of the mold, the forward end of frame 37 is provided with a pair of bearing brackets 82 rotatably supporting a roller 83 on which trough nose piece 80 rests when the trough is in its rearmost position as shown in the drawings. In order that the bottom flange of trough base 79 may be guided onto roller 83 as the trough moves forwardly, a wedge-shaped fillet plate 84 is fixed to the rear portion of the bottom surface of nose piece 80 abutting the cut-away portion of base member 79.

The bottom flange of base member 79 is also cut away at the rear end of the trough so as to receive a cylindrical sleeve 85 which is welded to the trough and fixedly connects the latter to the enlarged barrel 73 journaled in bearings 72. At a point just forward of sleeve 85, trough body portion 76 is provided with a transverse end plate 86 (Figs. 7, 8 and 13) which defines the rear end of the open portion of the trough intended to carry the lining material, and with a triangular plate 87, perpendicular to and extending forwardly from end plate 86 centrally of the trough, which is adapted for a purpose hereinafter explained.

With the structure thus far described, it is evident that lining trough 34 may be moved by car 36 axially into and out of a mold 32 as the latter is being supported and rotated by the mechanism indicated generally at 33. As trough 34 is moved forwardly into the mold, it is maintained in a horizontal position both by supporting roller 83 and by the stiffness of I-beam base member 79. When the trough has been advanced to its forwardmost position and extends entirely through the mold, the conical end 81 of trough nose piece 80 comes into contact with a substantially semiconical trough guide 88 (Figs. 3, 4 and 17) which is mounted on the framework 126 of bell cleaning device 39 closely adjacent the bell portion of mold 32. Trough guide 88 is so mounted that its position may be adjusted for molds of different diameters in order to support the front end of the trough at the proper elevation for the size of mold being lined. It is also evident from the preceding description that, when the trough has been moved into the mold, it may be rotated by motor 74 and speed reduction gear 75 so as to dump its contents into the mold. After the trough has been inverted, it is automatically returned to its normal upright position by a reversal of motor 74 by the control system later to be described.

Referring now to the mechanism, including nozzle 77 and gate 78, by which an accurately measured quantity of sand-resin lining material is delivered into open-top trough body 76 from hopper 35 as the lining trough is moved axially into a spinning mold, it should first be noted that hopper 35 is mounted in a permanently fixed position, as by suspension from overhead beams 91 (Fig. 2). Nozzle 77 and gate 78, however, are carried by a framework 92 which is mounted on and extends upwardly

from vertically movable frame 37 at the forward end thereof, the open top of nozzle 77 being so positioned as to receive the discharge end of hopper 35.

As shown in Figs. 11–16, gate 78 comprises a pair of sector-shaped side walls 93 and a curved bottom end wall 94 interconnecting the arcuate edges of side walls 93, end wall 94 having a discharge opening 95 therein which extends from its upper edge (as viewed in Fig. 11) downwardly for approximately half the arcuate extent of said end wall, the side edges of said opening being parallel to and spaced inwardly from side walls 93 so as to form a laterally restricted exit from the nozzle. Side walls 93 of the gate are rotatably mounted on studs 96 carried by the side walls of nozzle 77, the pivotal axis of studs 96 passing through the centers of the arcuate edges of the gate. Fixed to gate end wall 94 beneath opening 95 is a spout 97 having downwardly converging sides by which the lining material discharged from nozzle 77 through gate opening 95 is guided into trough 34. The rate of flow of the sand-resin mixture out of nozzle 77 may be varied by adjustment of an inclined baffle plate 166 which is slidably mounted within the nozzle and has an outwardly projecting arm 167 adjustably fixed by a pair of nuts 168 to a threaded supporting rod 169 suitably mounted on the rear wall of nozzle 77.

The position of gate 78 is controlled by a pneumatic cylinder 98 fixedly mounted on framework 92 with its axis inclined to the vertical, and having a downwardly extending piston 99 the lower end of which is pivotally connected to a lug 100 fixed to one of gate side walls 93. The gate is normally maintained in the position indicated in Figs. 11 and 12, where in the solid portion of end wall 94 closes the opening at the bottom end of nozzle 77. When pneumatic cylinder 98 is actuated so as to retract piston 99, gate 78 is moved in a clockwise direction about the axis of studs 96 so as to bring discharge opening 95 of end wall 94 into registration with the open bottom end of nozzle 77, whereupon the sand-resin lining mixture may flow by gravity through spout 97 into trough 34.

Inasmuch as the thickness of the lining formed in the spinning mold is determined directly by the amount of lining material delivered by the trough into the mold, it is necessary to accurately measure the amount of such material held by the trough. In accordance with the present invention, this measurement is made by controlling the depth or height of the lining material in the trough and by removing any material delivered to the trough in excess of that required to establish the proper depth or height.

In the embodiment illustrated, the measuring means comprises a striker plate 101 adapted to be lowered into trough 34 by a pair of arms 102, normally maintained in a substantially horizontal position, the rear ends of which are pivotally mounted on a shaft 103 carried by a bracket 104 fixed to framework 92. Fixed to the forward ends of arms 102 is a supporting member 105, substantially U-shaped in plan, having at the rear ends of the side arms of the U a pair of notches 106 adapted to receive the stepped ends 107 of the upper portion of striker plate 101. The striker plate is secured in position in notches 106 by a washer 108 which is retained in engagement with the upper edge of the striker plate by a screw 109 threaded into supporting member 105. Extending downwardly from the stepped end portion of the striker plate is a tongue portion 110 which is adapted to enter the lining trough and to establish the depth of the lining material retained therein by the position of its lower edge 111.

It will be understood that the width and length of tongue portion 110 of striker plate 101 are accurately dimensioned in relation to the width and depth of trough body portion 76 so that the space within the trough below the lower edge 111 of the striker plate when the latter has entered the trough will hold the correct amount of lining material to form a lining of the thickness desired. It will also be evident that striker plate 101 is readily replaceable by other striker plates of different dimensions which are adapted to retain different amounts of lining material in the trough.

Striker plate 101 and its supporting arms 102 may be lowered and raised relatively to trough 34 by the action of a vertically disposed pneumatic cylinder 112 having at its upper end a cap 113 pivotally suspended from a bracket 114 fixed to framework 92. The piston 115 of cylinder 112 is pivotally connected to the forward end of a substantially horizontal striker lifting arm 116 the rear end of which is pivotally mounted on the same shaft 103 as that on which striker arms 102 are pivoted. Intermediate its ends, striker lifting arm 116 is provided with a downwardly extending J-shaped finger 117 which is adapted to engage the lower edge of one of striker supporting arms 102. With this construction, when pneumatic cylinder 112 is so actuated as to extend its piston 115 downwardly, finger 117 drops with striker lifting arm 116 away from the lower edge of the adjacent striker supporting arm and permits arms 102 to rotate in a clockwise direction about shaft 103 so as to lower striker plate 101 into trough body 76. The operation of cylinder 112 is automatically synchronized with the operation of cylinder 98 which opens the gate 78 of nozzle 77, and with the movement of car 36 and trough 34, by the control system hereinafter described so that the striker plate enters the forward end of the open body portion of the trough just as the gate opens to deliver lining material thereto.

Although the vertical position of the lower edge 111 of striker plate 101 might be established by simply permitting the lower edges of stepped ends 107 of the striker plate to slide on the upper edges of the side walls of trough body 76, it is preferable to use a flanged roller 118 rotatably supported on a shaft 119 carried by the forward ends of striker supporting arms 102 and supporting member 105, which roller rests on the upper edges of the trough without imposing any substantial amount of frictional resistance to the forward and rearward movement of the trough.

As the trough moves forwardly into the mold, striker plate 101 levels the lining material delivered to the trough through gate 78 and holds back any material in excess of the desired amount. When the trough approaches the end of its forward movement, lower edge 111 of the striker plate comes into engagement with the inclined edge of triangular plate 87 and is lifted thereby, carrying with it out of the trough any excess lining material which may have accumulated behind the striker plate. A chute 120 having an outwardly flared upper end is mounted at the forward end of frame 37 to receive any excess lining material removed from the trough by the striker plate and deliver it to a conveyor (not shown) for appropriate disposal. When the lining trough approaches the limit of its forward movement, pneumatic cylinders 98 and 112 are actuated to close gate 78 and raise striker plate 101 and its associated elements to their original positions shown in Figs. 11 and 12, these operations also being automatically controlled in a manner hereinafter described.

Returning now to the mold supporting and rotating portion of the machine, with particular reference to Fig. 17, it is customary to provide a mold for casting bell and spigot pipe with a metallic insert 121 at the bell end of the mold which establishes the contour of the bell end of the pipe and is also formed with stepped surfaces 122 adapted to support the bell core during the casting operation. Since it is desirable that these stepped surfaces be kept clean of the lining material, means are provided for removing from said surfaces any lining material that may be dumped thereon by the lining trough.

In the embodiment of the invention illustrated, wherein insert 121 is shown as having two stepped surfaces, this means comprises a pair of metal tubes 123 and 124 which are supported for reciprocation in a horizontal direction

by suitable brackets 125 secured to the same framework 126 as that on which trough supporting member 88 is mounted. The rear ends of tubes 123 and 124 are threaded into a manifold block 127 which is connected to the piston 128 of a pneumatic cylinder 129, also mounted on framework 126 in a horizontal position. Manifold block 127 is provided with hoses 130 and 131 adapted to deliver compressed air to tubes 123 and 124, respectively. The inner end of tube 123 is fitted with a downwardly directed nozzle 132 adapted to deliver a blast of air against the axially inner stepped surface 122 of insert 121, while tube 124 is provided with a double nozzle 133 adapted to blow on the axially outer stepped surface 122 of insert 121 and the exposed end of the inner surface of mold bell.

Normally, tubes 123 and 124 and the associated elements are maintained in the retracted position shown in Fig. 3. However, when lining trough 34 has been moved forwardly into mold 32 ready to dump the lining material into the mold, pneumatic cylinder 129 is automatically actuated to move tubes 123 and 124 toward the bell end of the mold so as to bring nozzles 132 and 133 into the positions shown in Fig. 17. Air under pressure is then supplied through hoses 130 and 131 and tubes 123 and 124 to nozzles 132 and 133, respectively, so as to blow off of the stepped surfaces of insert 121 and the exposed end surface of mold 32 any lining material that may be deposited thereon. When the lining trough has been dumped and starts its rearward movement out of the mold, cylinder 129 is again automatically actuated to retract tubes 123 and 124, and the supply of air thereto is cut off.

Inasmuch as the apparatus of the present invention is intended to line molds of different diameters, means are provided for adjusting the lining mechanism so as to insure proper operation with molds of different sizes. In the machine illustrated, this adjustment is effected by varying the elevation of frame 37 and the elements supported thereby, including lining trough 34, so that the lining trough is maintained in a substantially coaxial position with respect to the mold to be lined.

As shown best in Figs. 7–10, frame 37 is supported above a fixed foundation framework 134 by a parallel motion linkage comprising a plurality of pairs of upper links 135 and lower links 136 arranged in scissor relationship, the pairs of links positioned adjacent the front end of frame 37 being so arranged that the hinge connections between their upper and lower links move oppositely to the connections between the links of the pairs adjacent the rear end of the frame when the frame is moved either upwardly or downwardly. In the apparatus shown in the drawings, there are eight pairs of upper links 135 and lower links 136, four adjacent each end of frame 37, the upper end of each upper link 135 being pivotally connected to frame 37 and the lower end of each lower link 136 being similarly pivoted to foundation framework 134. The hinge connections between the links of the four outboard pairs, i. e., the pairs nearest the ends of frame 37, are formed by a pair of transversely extending shafts or pins 137, while the links of the four inboard pairs are hinged on the reduced end portions 138 of a pair of relatively massive bolster members 139. Each hinge shaft 137 and the adjacent bolster member 139 are interconnected by a pair of horizontally extending links 140 so as to insure that the hinge connections between the respective pairs of links move in unison.

As indicated in Figs. 9 and 10, each bolster member 139 includes an enlarged central portion 141 which, in conjunction with tubular caps 142 and 143 extending from the opposite sides thereof in fore-and-aft directions, forms a housing for a nut 144 and the cooperating end of a screw shaft 145. The two nuts 144 are oppositely threaded, as are the ends of screw shaft 145. Each nut 144 is securely fixed in its housing so as to transmit thereto and to the bolster 139 any thrust imposed on the nut by rotation of screw shaft 145. Screw shaft 145 has fixed thereto intermediate its ends a sprocket wheel 146 which is drivably connected by a chain 147 to a similar sprocket 148 mounted on the shaft of and driven by a reversible, three-phase A. C. electric motor 149.

With the construction above described, frame 37 on which lining car 36 and trough 34 are mounted may be raised or lowered to any desired elevation by simply energizing motor 149 so as to rotate screw shaft 145 in one direction or the other. Since the ends of shaft 145 and the cooperating nuts 144 are oppositely threaded, rotation of the shaft will move the hinge connections of links 135 and 136 at opposite ends of the frame in opposite directions and thereby raise or lower the frame while maintaining its horizontal position. The machine operator may determine when to deenergize motor 149 so as to stop the frame at the desired elevation by observing the position of some part of the vertically movable mechanism, such as the upper edge of nozzle 77, relative to a fixed elevation indicator, such as a gauge 150 which may conveniently be mounted on hopper 35 and suitably graduated to indicate the correct elevation for each different size of mold which the machine is adapted to line.

In order to insure that screw shaft 145 maintains a horizontal position at all times and to absorb from nuts 144 thrust forces produced by the movements of car 36 on frame 37, the shaft is supported approximately halfway between its ends by a double thrust bearing 151 the outer races of which are rigidly held in a housing having laterally extending trunions 152 journaled in the free ends of a pair of parallel thrust absorbing arms 153. The opposite ends of arms 153 are journaled on a pair of pins 154 mounted at the upper ends of brackets 155 fixed to foundation framework 134. Bearing 151 is held in fixed relationship to screw shaft 145 by a pair of collars or nuts 156 which are threaded onto the shaft and abut the opposite ends of the bearing. With this construction, bearing 151 may adjust itself to the elevation of screw shaft 145 as the latter moves upwardly or downwardly with changes in the elevation of frame 37, while still supporting said shaft in horizontal position, and will transmit to the machine foundation through arms 153 any thrust reactions resulting from the starting and stopping of lining car 36.

The electrical and fluid pressure systems by which operation of the apparatus of the present invention is automatically controlled are shown schematically in Figs. 18, 19 and 20, and will be readily understood upon consideration of the circuits therein illustrated in the light of the foregoing description and the following résumé of the operating cycle.

Assuming that detent-guide arms 48 and kickout arms 49 of the mold rotating mechanism 43 of each of lining machines L_1 and L_2 are in the "up" positions illustrated in Fig. 6 and that an unlined mold 32 is rolling along rails 31 leading to machine L_1, the operation of the latter machine is as follows, it being understood that machine L_2 operates simultansously in the same manner on the partially lined mold which has just been ejected from machine L_1. At this time, the switches and relay contacts of the electrical system are in the positions illustrated in Figs. 18 and 19, hereinafter referred to as the normal positions.

As the mold approaches the lining station, it rolls over and opens normally closed kickout down limit switch LS1 thereby deenergizing a normally energized control relay CR3 so as to open the latter's normally closed contacts which are in series with limit switch LS1 and control relay CR3, close a set of normally open contacts which are in series with a normally open car in push button switch PB1, and open a third set of normally closed contacts to deenergize the normally energized solenoid S1 of a pneumatic pilot valve 157 (Figs. 18 and 20) which in turn actuates a four-way valve 158 controlling the supply of hydraulic fluid to cylinder 62 so as to lower piston 61, detent-guide arms

48 and kickout arms 49 to the positions shown in Fig. 5 and thereby deliver mold 32 onto spinning rollers 40. After visually inspecting the interior of the mold, the machine operator closes car in push button switch PB1 which energizes a normally deenergized in travel starter relay SR1 and a normally deenergized control relay CR1 (Fig. 18) and starts the automatic cycle.

In travel starter relay SR1 energizes the circuit of motor 69 so as to drive lining car 36 in a forward or "in" direction and move lining trough 34 into the mold. Relay CR1 energizes a normally deenergized control relay CR2 which in turn energizes a normally deenergized motor contactor relay MR (Fig. 19) so as to start motor 45 and rotate the mold on spinning rollers 40. Energization of relay CR1 also energizes the normally deenergized solenoid S2 of a four-way valve 159 which controls the supply of air to cylinder 98 which opens gate 78 of nozzle 77 through which the lining material is delivered into the trough, and to cylinder 112 which lowers striker plate 101 into the trough.

As the lining trough passes under nozzle 77, it receives more lining material than is required to form the desired thickness of lining, but striker plate 101 removes the excess material in the manner previously described. When the end of the open portion of lining trough 34 (defined by end plate 86) passes under the nozzle, the forward end of a switch trip bar 160 (Figs. 7 and 8), which is attached to lining car 36 at one side thereof forward to its rear wheels 67, opens a normally closed lining material cutoff limit switch LS2 mounted on vertically movable frame 37 just to the rear of nozzle supporting framework 92. Opening of limit switch LS2 deenergizes relay CR1 which in turn deenergizes solenoid S2 of valve 159 and causes cylinders 98 and 112 to close gate 78 and raise striker plate 101 out of the trough. Lining car 36 continues to move forwardly until switch trip bar 160 opens a normally closed car in limit switch LS3 mounted just forwardly of limit switch LS2 which deenergizes in travel starter relay SR1 and the forward circuit of car driving motor 69. Opening of the motor circuit also results in application of solenoid actuated brakes 161 to the motor shaft, the brakes being applied by springs and released by solenoids BS (Fig. 18) in known manner. As lining car 36 is decelerated to a stop, switch trip bar 160 closes a normally open trough starting limit switch LS4 mounted forwardly of car in limit switch LS3 to energize a normally deenergized trough dump starter relay SR2 through the normally closed contacts of a time delay relay TD1. Simultaneously limit switch LS4 energizes the normally deenergized solenoid S3 of a four-way valve 162 which controls the supply of air to cylinder 129 so as to move blowout tubes 123 and 124 into the bell end of the rotating mold in order to direct jets of air, as previously described, on those areas which it is desired to keep clean of lining material. Limit switch LS4 also energizes the normally deenergized solenoids S4 and S5 of off-on valves 163 and 164, respectively, to supply compressed air to tubes 123 and 124. An off-on push button switch PB2 is provided so that the machine operator can control the energization of solenoid S4 in accordance with the type of mold being lined.

Trough dump starter relay SR2 energizes trough rotating motor 74 so as to rotate lining trough 34 in a clockwise direction as viewed from the front and dump the lining material into the mold. When the trough has been rotated to a substantial inverted position, a switch trip member 165 mounted on barrel 73 of the trough (Figs. 7 and 8) actuates a double contact trough reset limit switch LS5 the normally closed side of which opens and deenergizes trough dump starter relay SR2 while closure of its normally open side energizes both a normally deenergized trough reset starter relay SR3 and a normally deenergized time delay relay TD2. Trough reset starter relay SR3 reverses the direction of trough motor 74 so as to rotate the trough back to its original upright position. After a preset time interval, the normally closed contacts of time delay relay TD2 open to deenergize relay CR2 which in turn deenergizes motor contactor relay MR and mold rotating motor 45 so as to stop rotation of the mold, the time interval being so selected that the spinning of the mold continues until the resin of the sand-resin lining material has polymerized and bonded the sand particles together to form a relatively smooth, hard lining adherent to the mold wall.

When the lining trough returns to an upright position, switch trip member 165 actuates a double contact trough stop limit switch LS6 the normally closed side of which opens and deenergizes trough reset starter relay SR3 and thereby stops trough rotating motor 74. Simultaneously, the normally open side of limit switch LS6 closes and energizes a normally deenergized out travel starter relay SR4 which energizes car driving motor 69 so as to move the car rearwardly and withdraw the lining trough from the mold. As the lining car starts to move rearwardly, switch trip bar 160 releases trough starting limit switch LS4 which returns to its normally open position and thereby deenergizes solenoids S3, S4 and S5 of valves 162, 163 and 164, respectively, so as to result in the return of blowout tubes 123 and 124 to their original positions shown in Fig. 13 and in cutting off of the supply of compressed air to said tubes.

The lining car continues to move in the "out" or rearward direction until the lining trough is removed from the mold and the car approaches the rear end of its run on tracks 68, at which time the rear end of switch trip bar 160 opens a normally open set of contacts of car out limit switch LS7 to deenergize out travel starter relay SR4 and car driving motor 69, whereupon the solenoid released brakes 161 are again spring applied to bring the car to a stop.

As will be seen from the right-hand side of Fig. 18, which represents the electrical control circuit of machine L_2, and wherein all of the elements duplicating those of the circuit of machine L_1 are designated by the same reference characters plus prime marks, car out limit switch LS7 of machine L_1 has a second set of normally closed contacts connected in series with a second set of normally closed contacts of car out limit switch LS7' of machine L_2 and a relay CR4' and a time delay relay TD3' which relays have no counterparts in the circuit of machine L_1. These two relays are adapted to control the unloading of the line molds from the two machines simultaneously, and cannot be energized until the lining cars of both machines have reached the end of their rearward movement and have actuated both of car out limit switches LS7 and LS7'. When this condition is satisfied and relay CR4' is energized, it energizes relays CR3 and CR3' of the two machines which in turn energize solenoids S1 and S1' of the pilot valves 157 of valves 158 so as to actuated hydraulic cylinders 62 to lift detent-guide arms 48 and kickout arms 49 and discharge the lined molds in the manner previously described. Time delay relay TD3' opens its normally open contacts and deenergizes relay CR4' after a very short interval, on the order of one second, following energization of said relay by closure of the second sets of contacts of car out limit switches LS7 and LS7', but relays CR3 and CR3' remain energized through their own normally closed contacts and normally closed kickout down limit switches LS1 and LS1'. The latter are then ready to individually control the lowering of the detent-guide arms and kickout arms of the two machines when actuated by molds rolling along rails 31, and the control system is in condition to repeat the cycle.

It will be understood that various manually operable electrical controls (not shown) may also be provided to enable the machine operator to start and stop the mechanism at will, and to cause it to perform various opera-

tions individually without going through the entire cycle.

Although only one specific form of apparatus embodying the invention has been described and illustrated in the accompanying drawings, it will be obvious that the invention is not limited to the exact structure shown but is capable of a variety of mechanical embodiments. Various changes, which will now suggest themselves to those skilled in the art, may be made in the form, details of construction and arrangement of the mechanical parts, and in the electrical and fluid pressure means used for controlling various elements of the apparatus, without departing from the spirit of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. A machine for centrifugally lining cylindrical articles comprising means for supporting a cylindrical article with its axis in a substantially horizontal position and for rotating said article about said axis, means movable into and out of said article while it is being rotated for delivering a quantity of lining material to the interior of said article, including a container for said material, a supporting frame on which said container is reciprocable in a substantially horizontal path, and means for raising and lowering said frame relative to said article supporting and rotating means to adjust the elevation of the path of movement of said container for operation with articles of different sizes.

2. A machine for centrifugally lining cylindrical articles comprising means for supporting a cylindrical article with its axis in a substantially horizontal position and for rotating said article about said axis, means for delivering a quantity of lining material to the interior of said article, and means operative while the article is being rotated for removing said lining material from selected areas of the interior of said article.

3. A machine for centrifugally lining cylindrical articles comprising means for supporting a cylindrical article with its axis in a substantially horizontal position and for rotating said articile about said axis, means for automatically controlling the delivery of unlined articles to said supporting and rotating means, means movable in a substantially horizontal path into and out of an article while it is being supported and rotated by said supporting and rotating means for delivering a quantity of lining material to the interior of said article, and means controlled by the movement of said material delivery means for automatically ejecting said article from said supporting and rotating means upon completion of the lining operation.

4. A machine for centrifugally lining cylindrical articles comprising means for supporting a cylindrical article with its axis in a fixed, substantially horizontal position and for rotating said article about said axis, means normally positioned above said supporting and rotating means for receiving said article and lowering the latter onto said supporting and rotating means, means movable in a substantially horizontal path into and out of said article while it is being rotated for delivering a quantity of lining material to the interior of said article, and means operable automatically at the end of a predetermined period of time after the lining material has been delivered into said article for stopping the rotating action of said supporting and rotating means.

5. A machine as defined in claim 4 including means responsive to the movement of an unlined article onto said said receiving and lowering means for causing the latter to lower said article onto said supporting and rotating means.

6. In a machine for centrifugally lining cylindrical casting molds, the combination of a plurality of spinning rollers mounted on a pair of parallel shafts for supporting a mold with its axis in a fixed, substantially horizontal position and for rotating said mold about said axis, mold run rails on which molds are rolled toward said spinning rollers for lining and on which lined molds are rolled away from said rollers after lining, and means for delivering mold to and ejecting molds from said spinning rollers comprising a plurality of parallel detent-guide arms extending perpendicularly to the axes of said roller shafts from points intermediate said shafts outwardly to points beyond the ends of said mold run rails from which the molds are delivered to said spinning rollers, a like plurality of parallel kickout arms pivotally connected adjacent their inner ends to the inner ends of said detent-guide arms and extending in the opposite direction thereto, the outer ends of said kickout arms being mounted for oscillatory movement about a fixed axis parallel to the axis of said spinning roller shafts and positioned beneath the ends of said mold run rails onto which the molds are ejected from said spinning rollers, means for raising and lowering the pivotally connected inner ends of said detent-guide arms and kickout arms, the upper edges of said detent-guide arms and kickout arms forming mold rolling surfaces when the pivotally connected inner ends of said arms are raised to substantially the same level as that of said mold run rails and forming a V-shaped mold supporting cradle when said pivotally connected inner ends are lowered below said plane, and means forming a variable fulcrum for said detent-guide arms and so supporting said arms that the outer ends thereof project above the level of said mold run rails in mold stopping position when the pivotally connected inner ends of said detent-guide arms and kickout arms are lowered to deliver a mold onto said spinning rollers, but drop below the level of said rails when the pivotally connected inner ends of said arms are raised to eject a mold from said rollers.

7. In a machine for centrifugally lining cylindrical casting molds, the combination defined in claim 6 wherein the inner ends of said kickout arms including upwardly projecting portions which, when said kickout arms and detent-guide arms are raised with a mold supported thereon, engage the outer surface of the mold at points offset from the vertical axial plane thereof and cause the mold to roll off said arms onto said mold run rails when the upper edges of said kickout arms are raised above the level of said rails.

8. In a machine for centrifugally lining cylindrical casting molds, the combination, defined in claim 6 including fluid pressure actuated means for raising and lowering the pivotally connected inner ends of said detent-guide arms and kickout arms, and means for controlling the operation of said fluid pressure actuated means mounted adjacent said mold run rails in a position such that it is actuated by the rolling movement of a mold along said rails as it approaches the mold rolling surfaces of said detent-guide arms when the inner ends of said arms are in their raised positions.

9. A machine for centrifugally lining cylindrical molds adapted for use in centrifugally casting tubular metal articles comprising means for supporting a mold with its axis in a substantially horizontal position and for rotating said mold about said axis, an elongated trough for delivering lining material to the interior of said mold, means for moving said trough axially into and out of said mold, means for filling said trough with a measured quantity of lining material while said trough is being moved into said mold, and means for rotating said trough automatically when the latter reaches the limit of its inward movement to deliver the lining material into the interior of said mold.

10. A machine as defined in claim 9 including a frame on which said trough is reciprocable in a horizontal direction, and means for raising and lowering said frame relative to said mold supporting and rotating means so as to adjust the height of said trough for operation with molds of different diameters.

11. A machine as defined in claim 9 including means

for automatically synchronizing the axial and rotational movements of said trough.

12. A machine as claimed in claim 9 including means for automatically synchronizing the operation of said trough filling means with the axial movements of said trough.

13. A machine as defined in claim 9 wherein said trough filling means includes a container for holding lining material, a gate for controlling the delivery of lining material from said container to said trough, a striker member for establishing the amount of lining material retained in said trough during its axial movement into said mold, means for supporting said striker member, and means for so moving said supporting means as to move said striker member into and out of said trough.

14. A machine as defined in claim 13 wherein said striker supporting means is so constructed and arranged as to accommodate interchangeable striker members of different sizes.

15. A machine as defined in claim 13 including means for automatically synchronizing the opening and closing of said gate, and the movements of said striker supporting means with the axial movements of said trough.

16. A machine as defined in claim 13 including fluid pressure actuated means for opening and closing said gate and for moving said striker member supporting means, and means for automatically controlling the operation of said fluid pressure actuated means in accordance with the axial movements of said trough.

17. A machine as defined in claim 10 wherein said means for raising and lowering the trough supporting frame includes a plurality of hinged arms pivotally connected at their lower ends to a fixed base and at their upper ends to said frame, and means for moving the hinged connections between said arms in unison to raise or lower said frame, said last named means including a rotatable shaft having oppositely threaded ends engaging nut members carried by two of said hinge connections, and means for rotating said shaft.

18. A machine as defined in claim 17 including means for preventing the transmission to said threaded shaft of thrust reactions resulting from the axial movements of said trough on said frame.

19. In a machine for centrifugally lining cylindrical articles, the combination of means for supporting a cylindrical article with its axis in a substantially horizontal position and for rotating said article about said axis, an elongated trough for delivering lining material to the interior of said article, means for filling said trough with lining material, a wheeled car on which said trough is mounted, a track for said car parallel to the axis of said article, a reversible electric motor for driving said car so as to move said trough into and out of said article, electrical control means for automatically deenergizing the forward driving circuit of said motor when said trough has been moved into said article, means for rotating said trough to dump the lining material into the interior of said article and to return the trough to upright position after the dumping operation, and electrical control means for automatically energizing the reverse driving circuit of said motor upon return of said trough to upright position.

20. In a machine for centrifugally lining cylindrical articles, the combination defined in claim 19 including an electric motor for rotating said trough, and electrical control means for automatically energizing said trough rotating motor after the forward driving circuit of said car driving motor has been deenergized.

21. In a machine for centrifugally lining cylindrical articles, the combination defined in claim 19 including a gate for controlling the filling of said trough with lining material, means for opening and closing said gate, electrical control means for simultaneously energizing the forward driving circuit of said car driving motor and effecting opening of said gate, and electrical control means for effecting closure of said gate just before the forward driving circuit of said car driving motor is deenergized.

22. A machine for centrifugally lining cylindrical articles comprising means for supporting a cylindrical article with its axis in a substantially horizontal position and for rotating said article about its axis, means movable into and out of said article from one end thereof while it is being rotated for delivering lining material to the interior of said article, and means movable into and out of the opposite end of said article while the article is being rotated for preventing the adherence of said lining material to selected areas of the interior of said article.

23. A machine as defined in claim 22 wherein said last named means includes a nozzle for directing a blast of air against said selected areas.

24. A machine as defined in claim 22 including means for automatically synchronizing the movements of said lining material delivery means and said means for preventing the adherence of lining material to selected areas of the interior of said article.

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