March 17, 1953 H. L. ROMINE 2,631,342

MOLDING AND CASTING APPARATUS

Filed April 2, 1948 9 Sheets-Sheet 1

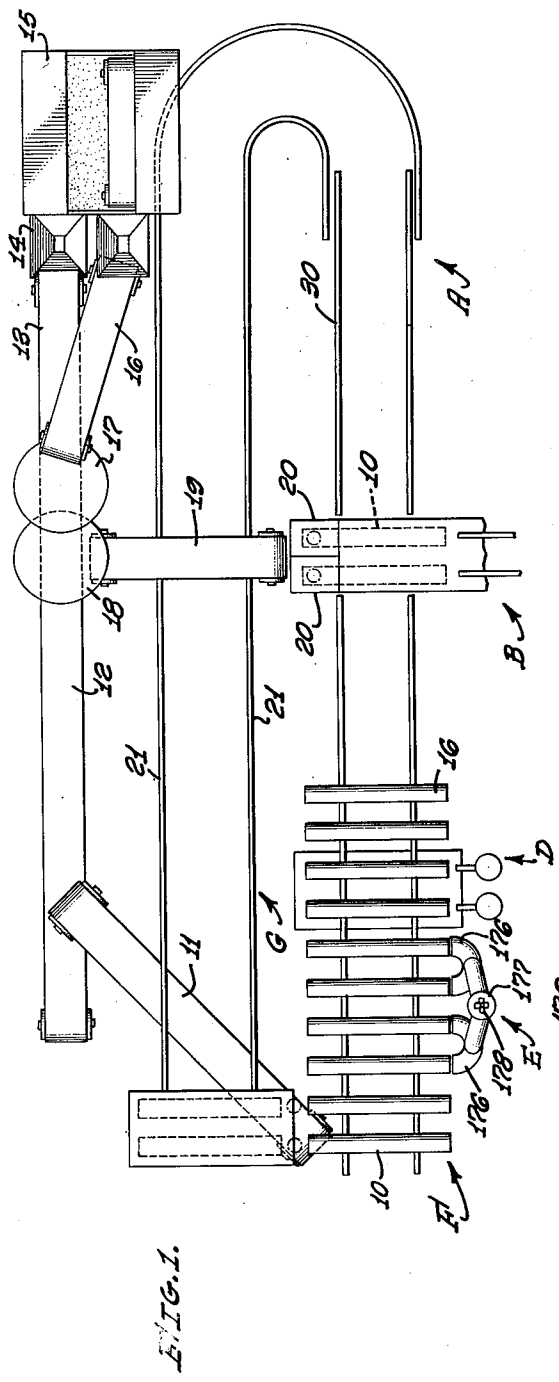


FIG. 1.

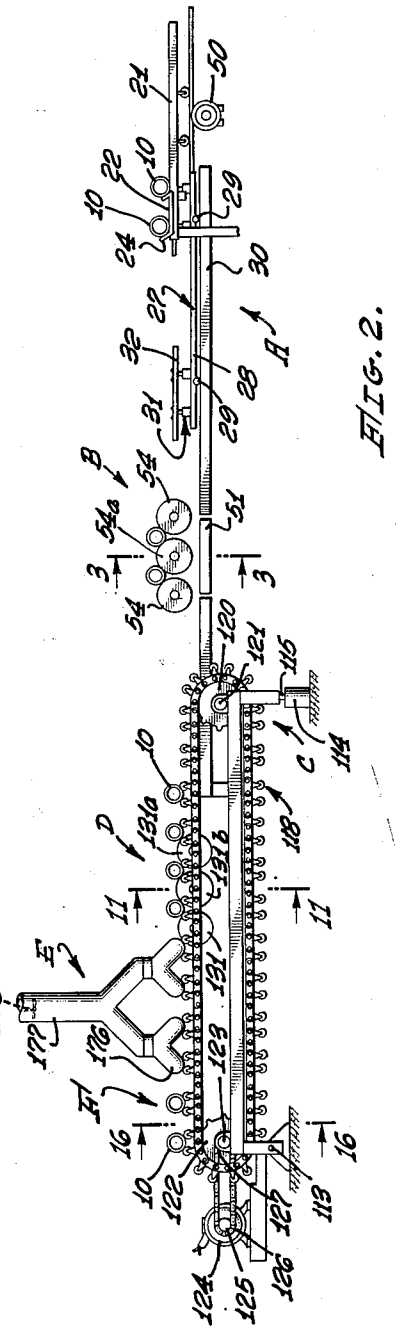


FIG. 2.

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MOLDING AND CASTING APPARATUS

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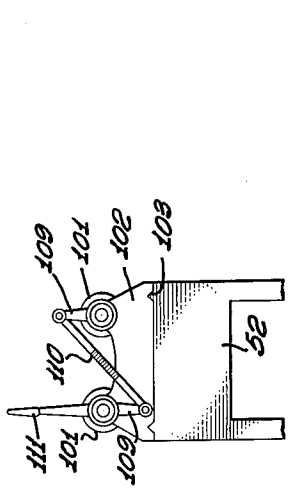


FIG. 4.

FIG. 3.

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MOLDING AND CASTING APPARATUS

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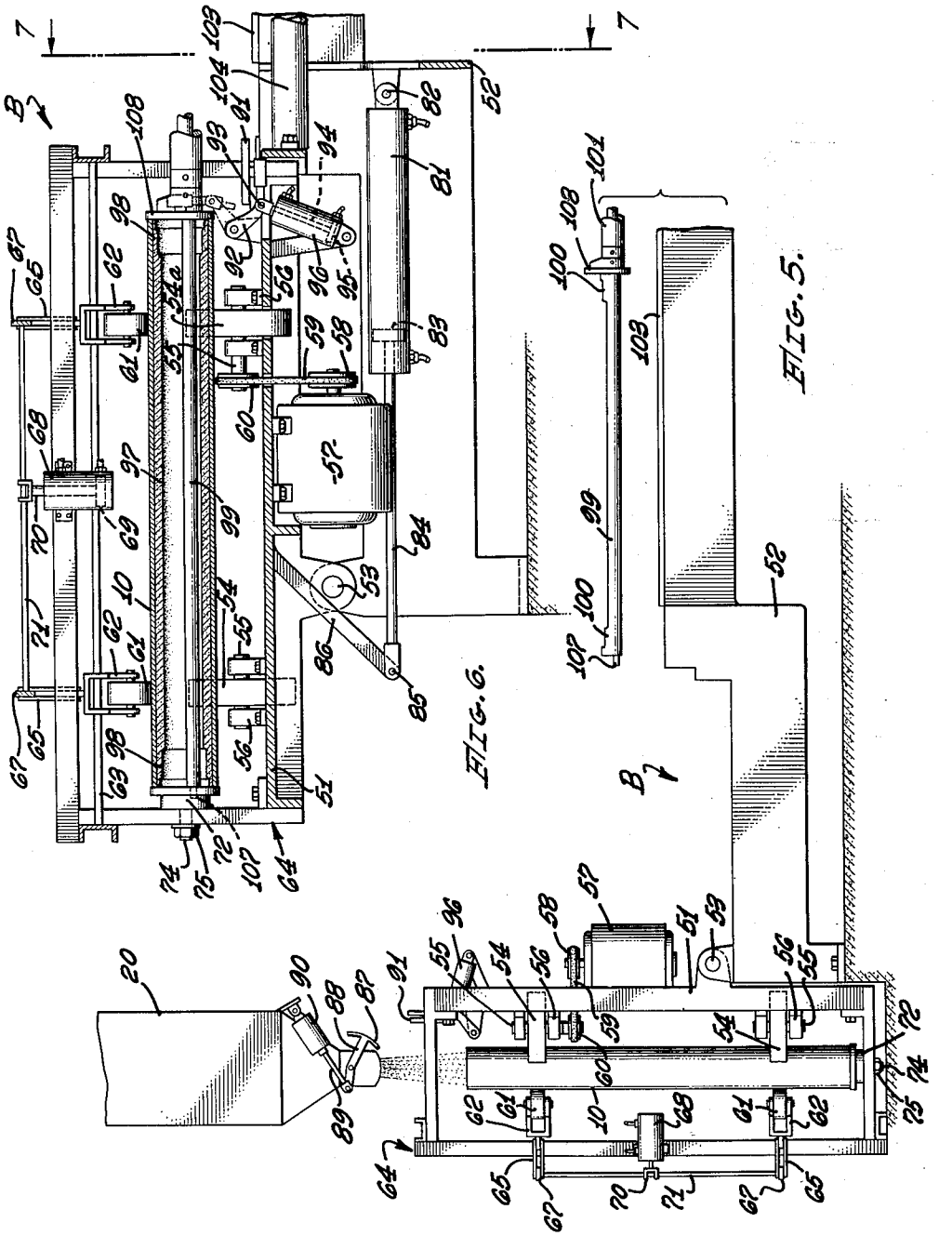


FIG. 5.

FIG. 6.

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MOLDING AND CASTING APPARATUS

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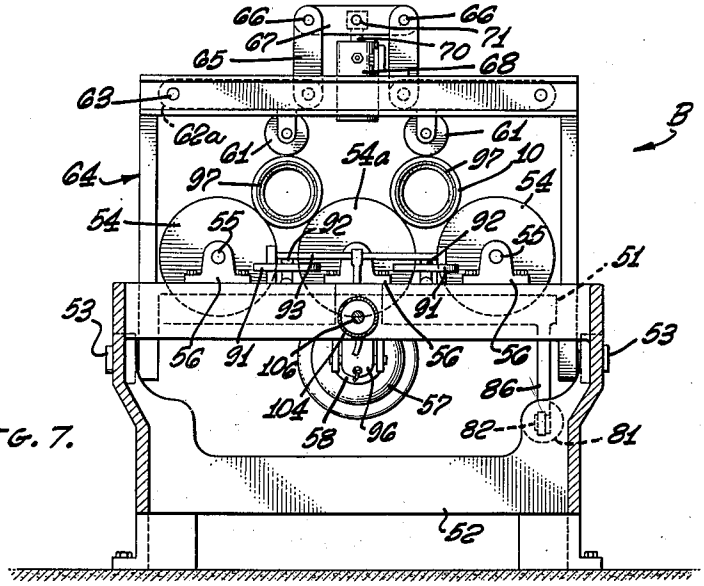
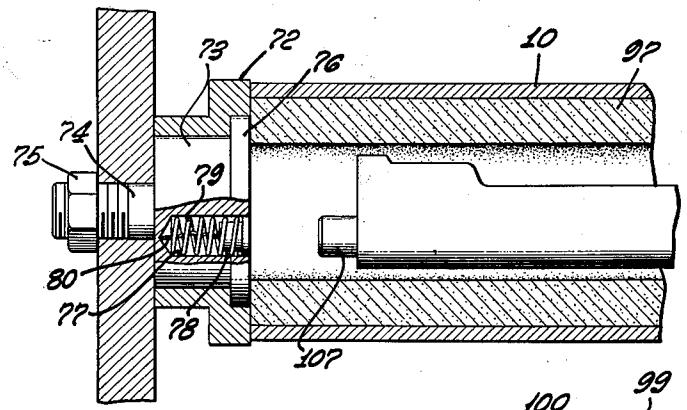


FIG. 7.

FIG. 8.



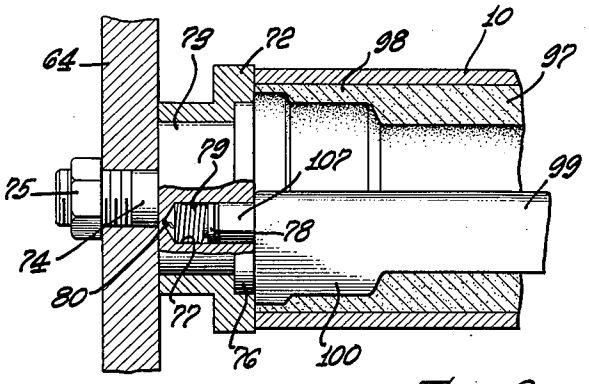


FIG. 9.

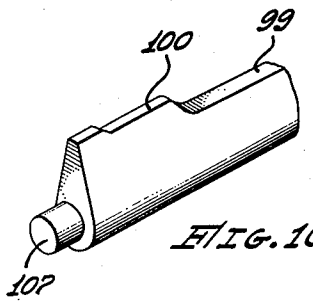


FIG. 10.

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MOLDING AND CASTING APPARATUS

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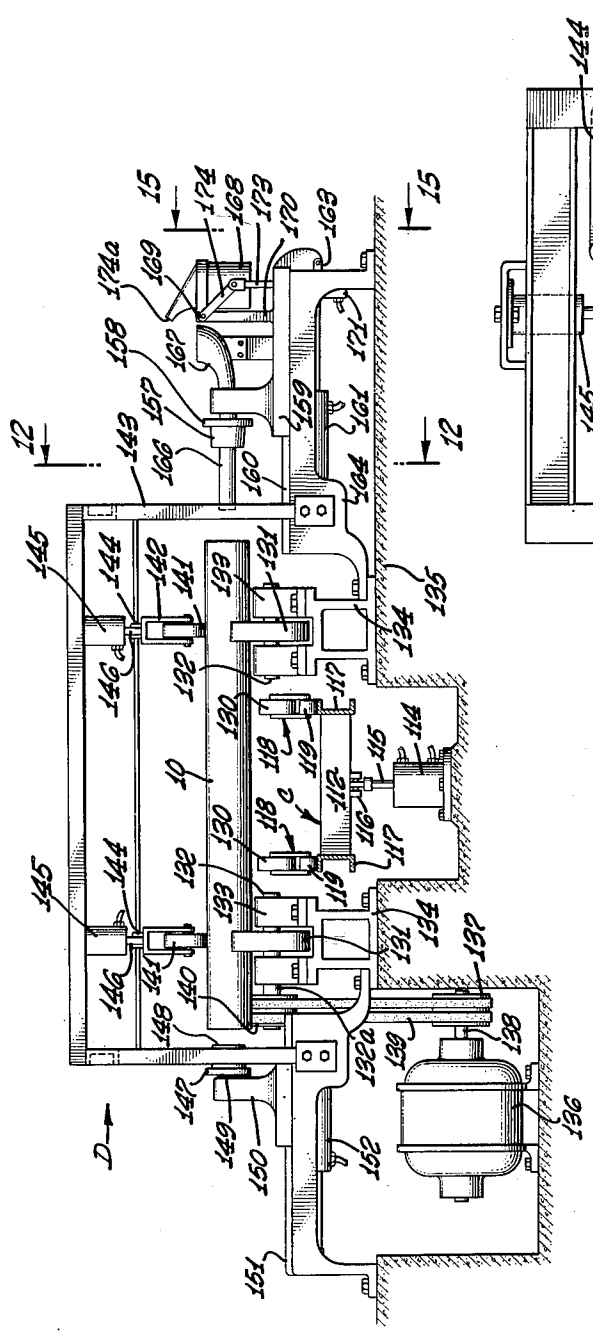


FIG. 11.

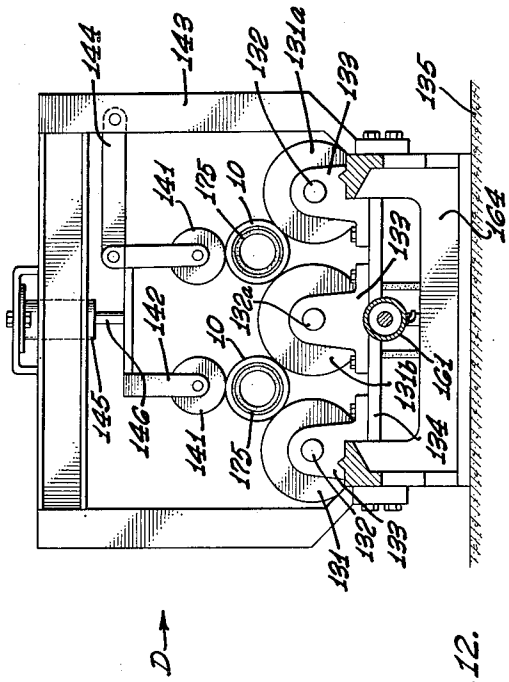


FIG. 12.

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MOLDING AND CASTING APPARATUS

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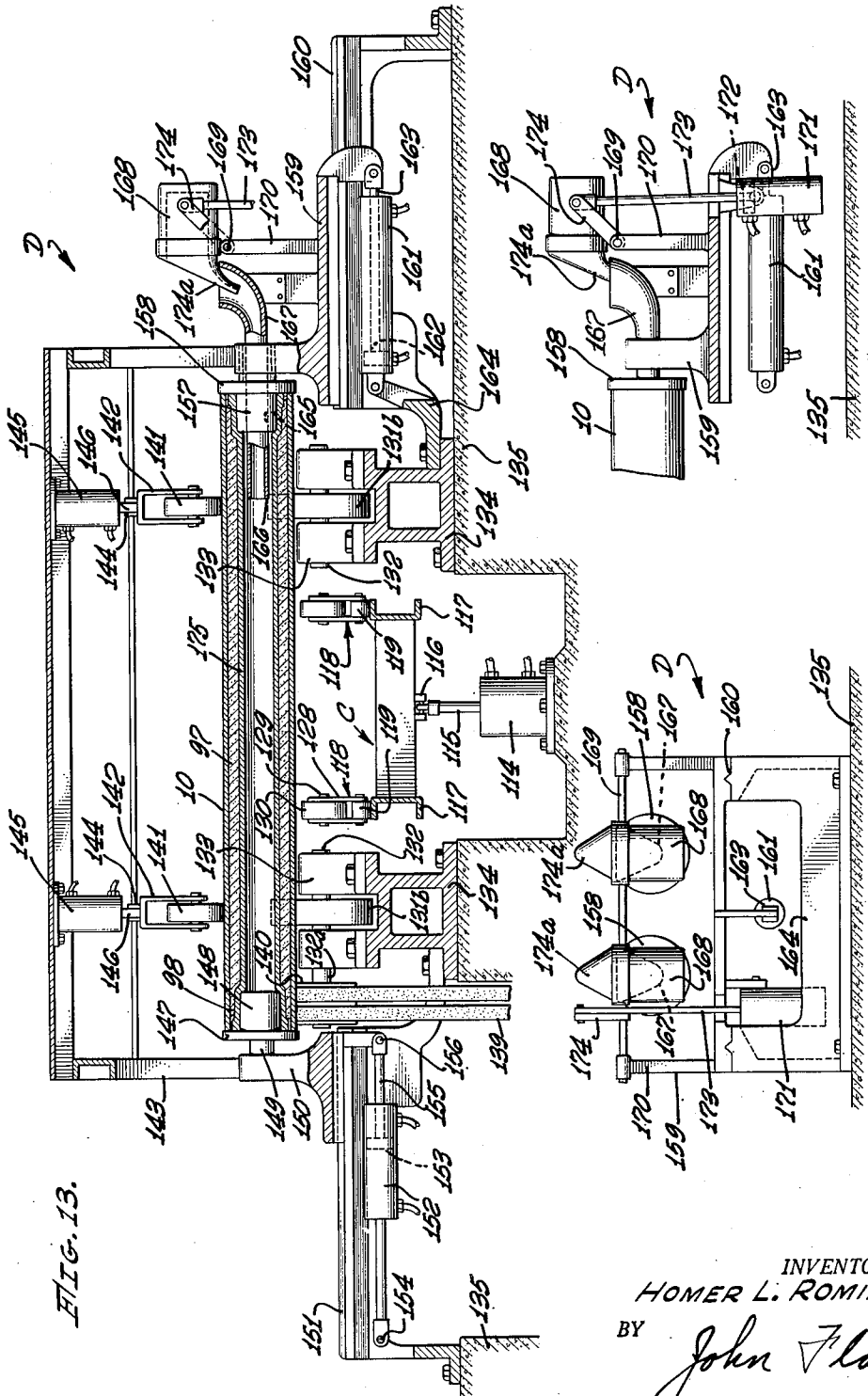


FIG. 13.

FIG. 14.

FIG. 15.

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MOLDING AND CASTING APPARATUS

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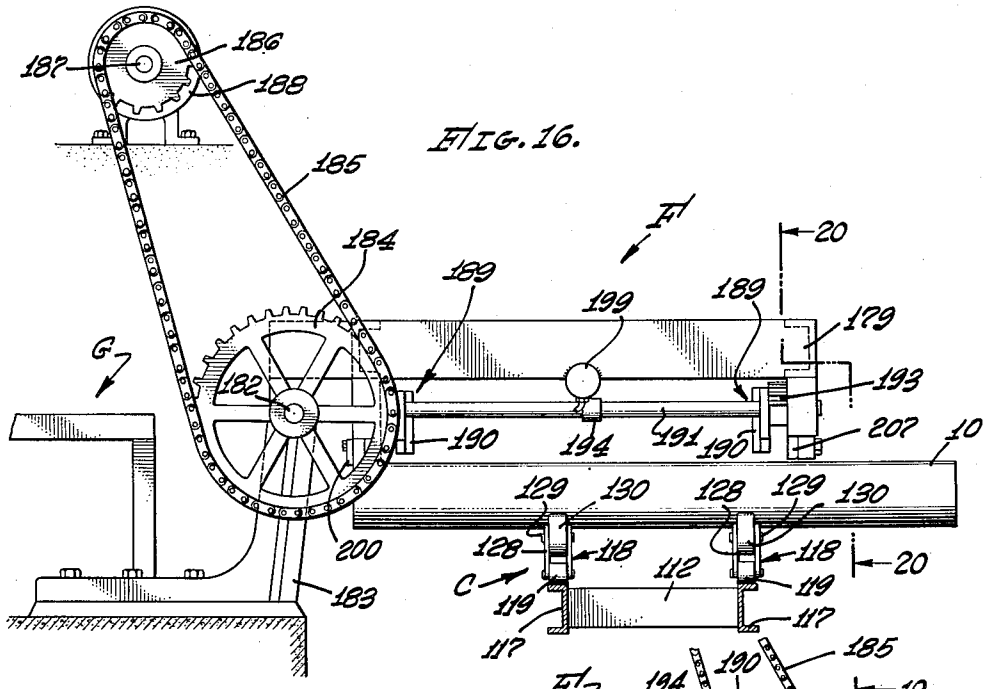


FIG. 16.

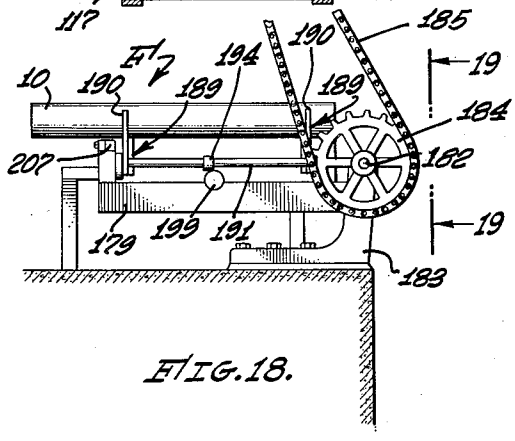


FIG. 18.

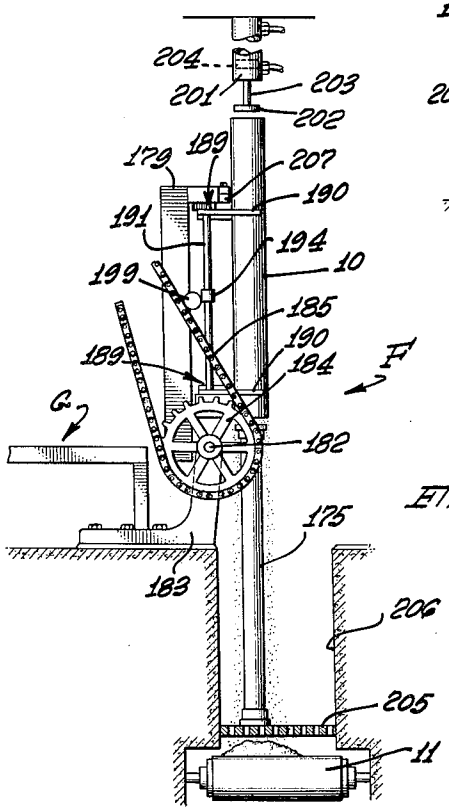


FIG. 17.

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MOLDING AND CASTING APPARATUS

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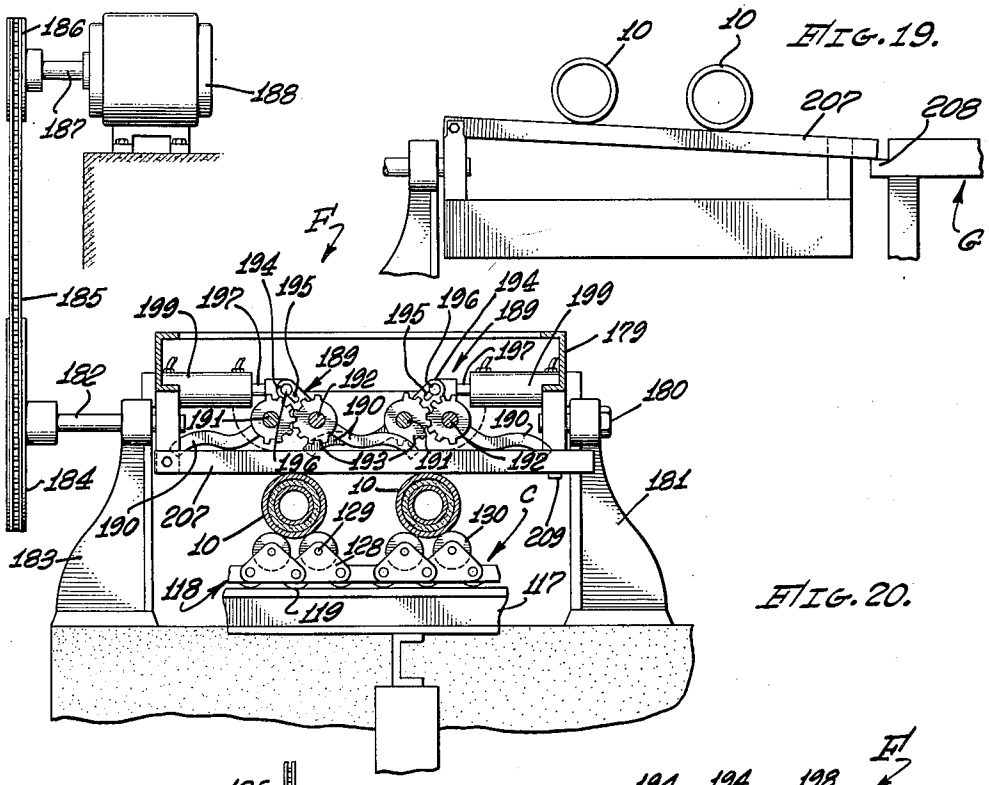


FIG. 19.

FIG. 20.

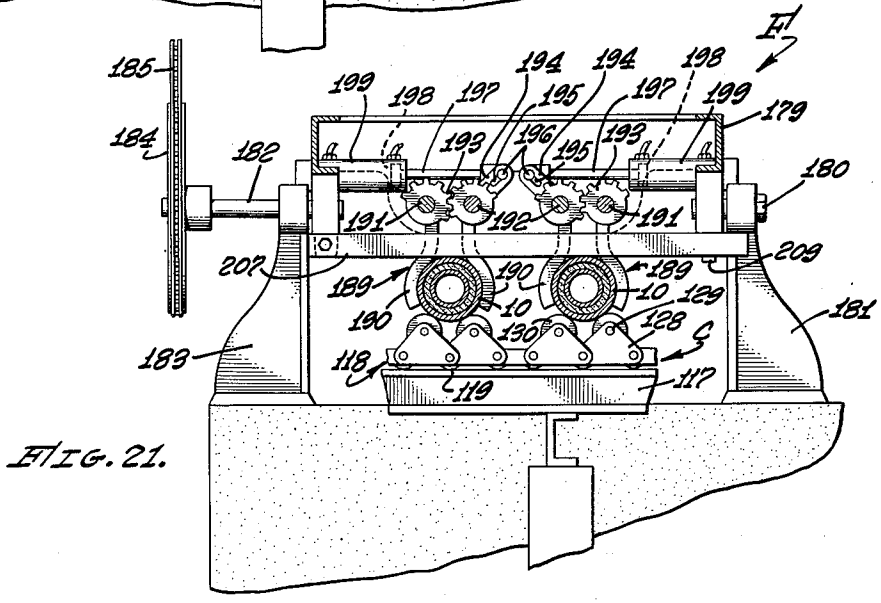


FIG. 21.

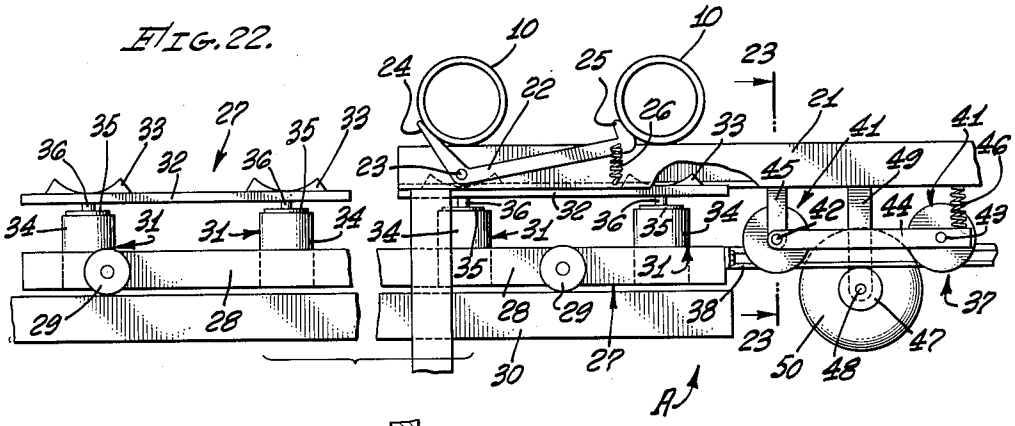
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MOLDING AND CASTING APPARATUS

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FIG. 22.



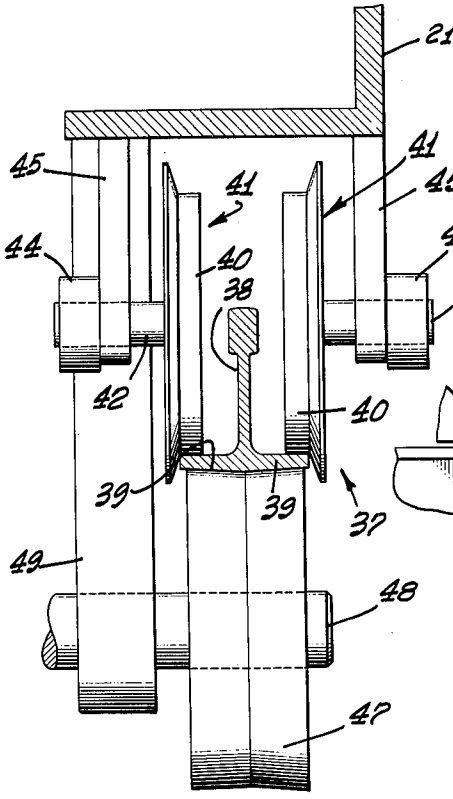
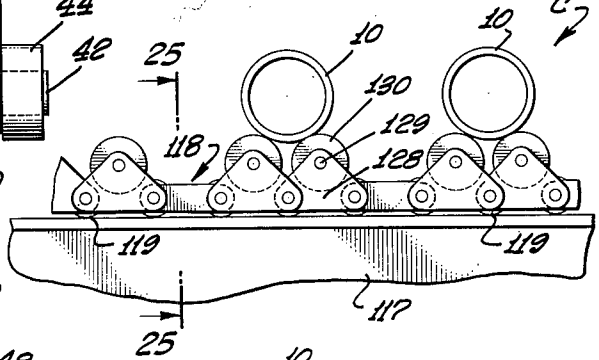


FIG. 23.

FIG. 24.



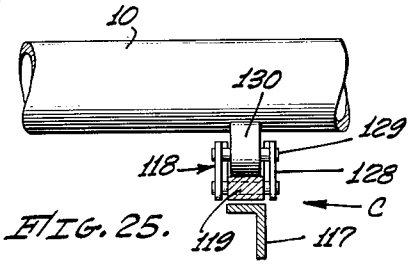


FIG. 25.

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Patented Mar. 17, 1953

2,631,342

UNITED STATES PATENT OFFICE

2,631,342

MOLDING AND CASTING APPARATUS

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Application April 2, 1948, Serial No. 18,626

18 Claims. (Cl. 22—20)

1

The present invention relates to the centrifugal casting of objects, particularly those of tubular shape.

In the centrifugal casting of objects of various types, it has heretofore been necessary to maintain the cast objects in the molds and on the centrifugal casting equipment until the objects had cooled sufficiently to permit their removal. As a result, the equipment has been utilized in the casting of each object for a relatively long period, which greatly limits the rate of production, with its attendant loss in efficiency and economy.

It is, accordingly, an object of the present invention to reduce the time required for centrifugally casting an object, which may be of tubular form.

Another object of the invention is to provide a closed, continuous system for centrifugally casting tubular and other objects.

A further object of the invention is to provide an improved apparatus for centrifugally casting tubular objects, with their opposite ends possessing the desired configuration or configurations.

Still another object of the invention is to provide a system for centrifugally casting tubular objects in flasks, including a plurality of stations between which the flasks are readily transferable without the necessity for manual handling.

Yet a further object of the invention is to provide a conveyor system capable of automatically and accurately spacing a plurality of casting flasks, to enable their simultaneous transfer to a work station, such as one at which sand is molded in the flasks.

Another object of the invention is to provide an improved apparatus for forming a sand mold in one or more rotating flasks.

Still a further object of the invention is to provide an apparatus for simultaneously forming the opposite ends of a sand mold in a rotating flask.

A further object of the invention is to provide an improved apparatus for pouring molten metal into a rotating mold and for insuring production of the desired shape of the object in a rapid and facile manner.

Another object of the invention is to centrifugally cast tubular objects in flasks and reduce the time during which the flasks are required to remain at the pouring station.

Another object of the invention is to provide an apparatus capable of removing a rotating mold from the location at which molten metal is poured into it, after pouring has been completed, but before the mold has ceased rotating.

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A further object of the invention is to provide an improved conveyor for transferring one or more flasks to and from a station at which molten metal is poured into a sand mold contained within the flask.

Another object of the invention is to provide an improved apparatus for rotating a flask during the forming of a sand mold therewithin.

Another phase of this aspect of the invention resides in the provision of improved means for applying contact pressure between the flask and friction supporting and driving rollers to insure rotation of the flask and its maintenance in the desired operating position.

Yet another object of the invention is to provide an improved apparatus for rotating a flask and holding it in operative position during the pouring operation.

A further object of the invention is to provide improved apparatus for removing a cast object and sand from a flask.

Still a further object of the invention is to provide an apparatus for removing the cast object and sand from a flask, and for disposing the empty flask in position for the forming therein of another mold.

This invention has other objects that will be apparent from a consideration of the method described herein and of the embodiment shown in the drawings accompanying and forming part of the present specification. Such form will now be described in detail to illustrate the general principles of the invention, but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the claims appended hereto.

Referring to the drawings:

Figure 1 is a diagrammatic top plan view of the general system employed in centrifugally casting pipe;

Fig. 2 is a somewhat diagrammatic front elevation of the system shown in Fig. 1;

Fig. 3 is an enlarged side elevation of the mold forming station, taken generally along the line 3—3 in Fig. 2;

Fig. 4 is an end elevation, as seen from the right of Fig. 3;

Fig. 5 is a view similar to Fig. 3, with the flasks in position for receiving sand from a hopper;

Fig. 6 is a longitudinal section through the forming portion of the apparatus, disclosing the forming tool in position for shaping the bell ends in the mold;

Fig. 7 is a transverse view taken generally along the line 7—7 on Fig. 6;

Fig. 8 is an enlarged partial longitudinal section, illustrating the movement of the forming bar within the sand in a flask;

Fig. 9 is a view similar to Fig. 8, disclosing the formation by the forming bar of a bell end in the sand disposed in the flask;

Fig. 10 is a partial isometric projection of one end of the forming tool;

Fig. 11 is a transverse view through the pouring station, taken along the line 11—11 on Fig. 2;

Fig. 12 is a cross section taken along the line 12—12 on Fig. 11;

Fig. 13 is a partial longitudinal sectional and elevational view through one of the flasks at the pouring station, with the parts in position for the pouring of the molten metal into the mold;

Fig. 14 is a partial view disclosing the actuating mechanism for moving the ladles to and from pouring positions;

Fig. 15 is an end view at the pouring station disclosing the ladle mechanism for pouring metal into the molds;

Fig. 16 is a transverse view through the shakeout station, taken generally along the line 16—16 on Fig. 2;

Fig. 17 is a partial view, on a reduced scale, similar to Fig. 16, illustrating the swinging of the flasks through ninety degrees from the position shown in Fig. 16, to enable the cast objects and sand to be removed from the flasks;

Fig. 18 is a partial view similar to Fig. 16, disclosing the flasks after they have been swung through 180 degrees from the Fig. 16 position;

Fig. 19 is a view taken along the line 19—19 on Fig. 18;

Fig. 20 is a view taken along the line 20—20 on Fig. 16, with the clamp mechanism in open position;

Fig. 21 is a view similar to Fig. 20, with the clamp mechanism in closed position;

Fig. 22 is a front elevation of the transfer and car mechanism for moving the flasks between stations and for locating the flasks in appropriately spaced relation;

Fig. 23 is an enlarged section taken along the line 23—23 on Fig. 22;

Fig. 24 is an enlarged front elevation of the portion of the roller conveyor for transferring the flasks to and from the pouring station, cooling station, and shakeout station; and

Fig. 25 is a section taken generally along the line 25—25 on Fig. 24.

The system disclosed in the drawings has been designed specifically for the centrifugal casting of pipe having bell ends. It is to be understood that the system is generally applicable to the centrifugal casting of objects, and, particularly, tubular objects.

Referring to Figs. 1 and 2, it will be noted that the system includes a flask transfer station A, where a plurality of cylindrical flasks 10 may be conveyed in properly spaced relation to a molding station B, where sand is disposed in the flasks, which are then centrifugally actuated and operated upon by a forming device to provide the desired sand mold form in the flask. From the molding station, the flasks are transferred to a roller conveyor C, which is operated to place the flasks 10 in operative position at a pouring station D, at which molten metal is poured into the molds while they are being rotated in order to produce the centrifugal casting.

From the pouring station, the roller conveyor C transports the flasks or molds, with the pipe cast therein, to a cooling zone E, where a cooling medium is moved through the pipe to accelerate its cooling. Continued movement of the conveyor C places the flasks, with the pipe cast therein, at a shakeout station F, at which the pipe and sand are removed from the flasks and separated from one another. The empty flasks are deposited on a track or rollway G, to enable their conveyance back to the flask transfer station A. The cast pipe itself is removed from the shakeout station F in any suitable manner, and is placed at any desired location, remote from the casting apparatus.

The sand removed from the flasks at the shakeout station F drops upon a conveyor belt 11, which may extend under the rollway G, and which carries the sand on to another conveyor belt 12 that transports it to an elevator 13. This last-mentioned device raises the used sand to the top of a hopper 14, through which the sand drops into a muller 15 that reconditions it and prepares it for reuse in the flasks. From the bottom of the muller, the reconditioned sand is carried by an elevator to a conveyor belt 16 that carries the sand to a point above a storage bin 17 into which the sand is dumped. The sand may be fed from the bin on to a plate feeder 18, which carries it to another conveyor belt 19 running to a point above a pair of adjacent hoppers 20 at the molding station B. These hoppers feed the sand into the flasks upon their being disposed vertically at the molding station.

As above indicated, a plurality of empty flasks 10 are present on the track or rollway G, and it is desired to transport them in properly spaced relation to the molding station B. In the specific apparatus disclosed, two flasks 10 are to be appropriately spaced at a time and conveyed to the molding station. The spacing is performed by a stop device mounted upon the sides 21 of the rollway G near its forward end (see Figs. 1, 2, 22 and 23). This stop device includes a lever 22 mounted upon a suitable fulcrum pin 23 attached to a rollway. The lever has an upwardly extending forward stop 24 projecting above the rollway on one side of the pin 23, and a rear stop 25 normally disposed below the upper surface of the rollway, but adapted to project thereabove. A tension spring 26 is secured to the lever 22 adjacent the rear stop and to the rollway G, tending to swing the rear stop 25 downwardly below the surface of the rollway.

As a flask 10 moves along the rollway into engagement with the forward stop 24, which always projects above the rollway, the force exerted by the flask on the forward stop rocks the lever 22 on its pivot pin 23 and swings the rear stop 25 above the rollway surface. The next succeeding flask upon the rollway then comes to rest against the rear stop 25. It is, accordingly, apparent that the stop device has arrested a pair of flasks in appropriately spaced relation with respect to one another upon the forward end of the rollway G.

The flasks are transferred or conveyed from the rollway G by a hoist and car mechanism 27 (Figs. 2, 22 and 23). The car includes a frame 28 carrying wheels 29 on opposite sides for engagement with a bed or floor 30. A plurality of air hoists 31 are mounted upon the car frame 28 for elevating a pair of spaced platforms 32 carrying cradles or saddles 33, in which the flasks 10 are receivable. As specifically shown in the drawings, each platform 32 may be raised or lowered by a pair of air hoists 31, each of which includes telescoping cylinders 34 and a piston 35

in the inner cylinder secured to a piston rod 36 attached to the platform 32. The introduction of air into the cylinders 34 in any suitable manner will effect elevation of the associated platform 32 disposed above the car frame 28. The use of telescope cylinders in the hoists permits collapsing of the latter to a relatively small vertical height.

The cradles 33 on each platform are spaced from one another the same distance as the flasks 10 when bearing against the forward and rearward stops 24, 25. Accordingly, when the car 27 is disposed under the flasks at the end of the rollway G, actuation of the air hoists 31 elevates the platform 32 between the sides 21 of the rollway and causes the flasks 10 to become nested in the cradles 33, which move them upwardly above the stops 24, 25. The car 27 may now be moved forwardly along the bed 30 toward the molding station B.

As indicated, the car also has another platform, hoist and cradle structure similar to the one just described, to enable conveyance of the flasks 10 from the molding station B to the roller conveyor C, in the manner described hereinafter.

The car 27 is moved along the wheel bed or floor 30 by a monorail and wheel device 37. A monorail 38 is secured to the rear portion of the car 28 and extends a substantial distance therefrom, generally parallel to the rollway G. The monorail has oppositely directed horizontal flanges 39 engageable with the rims 40 of flanged wheels 41 secured to axles 42, 43 rotatably mounted in a pair of arms 44 carried by and depending from the rollway. The forward portions of the arms 44 are mounted on the forward flanged wheel axles 42 which are fulcrumed within a pair of hangers 45 secured to and depending from the rollway G. The rear pair of flanged wheels are mounted on axles 43 rotatable in the arms 44. Such rear portions of the arms are urged downwardly, to force the rear pair of flanged wheels against the monorail 38, by a compression spring 46 bearing against the undersurface of the rollway G and against the arms 44.

The spring arrangement 46 described insures the maintenance of the flanged wheels 41 in frictional engagement with the monorail flanges 39. It also insures frictional engagement of the under surface of the monorail with a drive roller 47 secured to a drive shaft 48 rotatable in a support 49 depending from the rollway G. A reversible electric motor 50 is coupled to the drive shaft 48, to rotate the drive roller 47 in either direction, and, in view of its frictional engagement with the monorail 38, move the monorail and car 28 in a forward or rearward direction. The monorail 38 is sufficiently long to enable the car to travel from the flask transfer station A to a point between the members of the roller conveyor C, in order that the flasks 10 may be transferred from the rollway G to the molding station B, and from the latter station to the roller conveyor C.

The empty flasks 10 are picked up from the rollway G by the car 27 in the manner described, and are transported by suitable rotation of the drive motor 50 and movement of the monorail arrangement 37 in a forward direction to the molding station B. The wheels 29 of the car frame roll along the bed 30 on to the base 51 at the molding station, which is not connected with the other bed (see Fig. 2). As a matter of fact, the molding base 51 forms part of the molding machine, as will become apparent from an inspection of Fig. 3.

The apparatus at the molding station includes a main supporting frame 52 on which the base 51 is pivotally mounted through the agency of hinge pins 53, to enable swinging of the base between horizontal and vertical positions. A plurality of spaced rollers 54 are rotatably mounted on the base 51, each roller having trunnions 55 rotatable in bearings 56 attached to the base. Three pairs of rollers are disclosed in the drawings in side by side adjacency, the rollers of each pair being coaxial, but spaced apart to permit movement of the car 27 therebetween. A pair of flasks 10 are adapted to be nested in the concavities between adjacent pairs of rollers 54, in the manner disclosed in Figs. 2 and 7, so that the rollers appropriately support the flasks.

One of the intermediate rollers 54*a* may be a drive roller for frictionally engaging both flasks 10 and insuring their rotation during the molding operation. As shown in Fig. 6, this roller is rotatable by a suitable electric motor 57 secured to the underside of the base 51, and having a driving connection with the drive roller 54*a* through a suitable drive pulley 58, belt 59 and driven pulley 60 fixed to one of the trunnions 55 for the drive roller.

Rotation of the drive motor 57 will effect simultaneous rotation of the flasks 10 nested between the rollers 54, 54*a*. In order to maintain the flasks in such nested positions and to insure their proper frictional contact with the rollers, pressure is applied to the flasks from above. As disclosed most clearly in Figs. 3, 5, 6 and 7, a pair of aligned pressure rollers 61 is disposed centrally above each flask 10. Each pressure roller is rotatable in a bracket 62 fixed to a lever 62*a* whose outer end is mounted on a pivot rod 63 suitably supported in the frame 64 of the molding apparatus. The inner end of each lever is pivotally connected to the lower end of a link 65 whose upper end is mounted upon a pin 66 received within a cross link 67 connected to the pin 66 of the link and lever arrangement 65, 62*a* for the pressure roller 61 bearing against the other flask. The link and lever arrangement for each flask is the same, the parts merely being oppositely disposed to one another, but movable conjointly through the cross link interconnection 67 (see Fig. 7).

The aligned pressure rollers 61 near one end of the flasks 10 are movable simultaneously with the aligned pressure rollers at the other ends of the flasks by a cylinder and piston arrangement, including a double-acting cylinder 68 suitably mounted on the frame 64 and having a piston 69 slidable therein attached to a piston rod 70 extending upwardly from the cylinder for pivotal connection with a rod 71, parallel to the pressure roller axes, and connected to the cross links 67 (see Figs. 3, 5 and 6).

It is apparent that air under pressure entering the upper end of the cylinder 68 will move the piston downwardly and will urge all pressure rollers 61 simultaneously against the flasks 10, pressing them downwardly into engagement with the rollers 54, 54*a*. Similarly, air entering the lower end of the cylinder 68 will effect elevation of the pressure rollers 61 from the flasks and permit them to be placed in the car frame cradles 33 for elevation from the rollers 54, 54*a* and transportation to the roller conveyor C.

When the flasks 10 have been placed upon the rollers 54, 54*a* at the forming station B, their rear ends are each disposed in alignment with

an end closure plate 72 rotatably mounted upon a bearing 73. This bearing is secured to the end portion of the frame 64 by a projecting stud 74 integral therewith and with a nut 75 mounted on the stud and bearing against the frame (see Figs. 6, 8, 9). Endwise movement of the closure plate 72 is prevented by the frame 64, and also by an outwardly extending flange 76 on the bearing whose forward surface is substantially flush with the forward surface of the closure plate. Each bearing 73 is also provided with an eccentrically disposed socket 77 normally closed by a plug 78 urged outwardly of the bearing by a compression spring 79 located in the socket and bearing against the plug. Outward movement of the plug is limited by a chain 80 secured to it and to the bearing 73. This chain is of such length as to dispose the outer surface of the plug 78 in alignment with the outer surfaces of the bearing 73 and closure plate 72.

After the pair of flasks 10 have been placed on the rollers 54, 54a, the entire frame 64 is tilted to dispose the flasks 10 vertically with their open ends under the pair of sand hoppers 20 (see Fig. 5). Tilting of the frame 64 in this manner carries the roller and drive mechanism with it, since all of those parts are mounted on the frame. Tilting of the frame is effected by an air cylinder 81 (see Fig. 6), whose forward end is pivotally secured to the base 52 by a suitable pin 82. A piston 83 is slidable in the cylinder and has a piston rod 84 extending rearwardly therefrom which is connected by a pin 85 to an actuating arm 86 depending from and secured to the base portion 51 of the frame 64. Air under pressure may be admitted to either end of the tilting cylinder 81. When admitted to its rod end, the piston 83 is moved forwardly and will tilt the frame to dispose the flasks 10 in a vertical position under the sand hoppers 20.

The hopper gates 87 are opened by air means, to allow sand to flow into the flasks 10 until they are substantially completely filled. Each gate 87 may be secured to a lever 88 pivoted on the hopper, with its other end connected to a rod 89 having a piston (not shown) slidable in an air cylinder 90 pivoted on the hopper. Air may be fed selectively to either end of the cylinder 90 to open or close the gate 87.

After the flasks 10 have been filled with sand, the hopper gates 87 are closed and the tilting air cylinder and piston mechanism 81 to 86 actuated to return the frame 64 to its horizontal position. Air is fed into the pressure cylinder 60 and the pressure rollers 61 caused to bear upon the sand laden flasks. The rear ends of the flasks are closed by the end closure plates 72 and bearings 73. The forward ends of the flasks are closed by forward closure plates 91 (see Figs. 6, 7), each of which is rotatably mounted upon the outer end of a lever arm 92 pivotally mounted on the frame 64. A cross rod 93 interconnects the lever arms 92 and has the outer end of a piston rod 94 mounted on it, whose piston 95 is slidable within a double-acting cylinder 96 pivotally mounted upon the tilting frame 64 of the molding apparatus. Air entering the head end of the cylinder 96 moves the piston 95 upwardly and swings both closure plates 91 against the outer ends of the flasks 10. Closing of the forward ends of the flasks preferably occurs before their return to the horizontal, to prevent loss of sand by spilling. The flasks are now closed at both ends, and the drive motor 57 is started to rotate them at the desired speed.

The centrifugal force incident to rotation of the flasks 10 about their axes causes the initially loose sand that has been poured into the flasks to be compacted against their inner walls. Since the flasks are tubular or cylindrical in form, the sand will be compacted in the form of a hollow cylinder 97. It is, however, desired to form the ends of the sand mold to a particular shape. More specifically, it is desired to form the ends of the sand mold to provide a bell shape therein.

The bell ends 98 are formed simultaneously by a forming device adapted to enter the flasks (Figs. 3 to 6). This device includes an elongate forming rod or bar 99 having opposed forming tools 100 integral therewith, or secured thereto, at spaced points corresponding to the distance between the ends of each flask. The forming bar is rotatable in a bearing 101 at the upper end of a support 102 slidable along guideways 103 on the bed 52 of the apparatus. There is one forming bar for each flask, but the support 102 and guideways 103 are common to both bars.

Each bar 99 is mounted for movement about an axis slightly eccentric to the axis of the companion flask 10. This axis is the axis of the bearing socket 77 containing the plug 78 (Fig. 8). The support 102 is moved toward the flasks 10 to shift the forming bars 99 thereinto pneumatically. For this purpose, an air cylinder 104 is secured to the bed 52 and contains a piston 105 having a rod 106 secured to the support 102 (Fig. 3). Entry of air into the rod end of the cylinder 104 will cause the support 102 to be advanced toward the flasks 10 and will dispose the forming bars 99 completely within the latter, with the inner end 107 of each bar piloted within the bearing socket 77 (Figs. 6 and 9). Entry of such end in the socket is permitted by retraction of the plug 78 against the force of the compression spring 79. Of course, prior to movement of the forming rods 99 into the flasks, the air cylinder and piston 95, 96 have been appropriately actuated to remove the closure plates 91 from the ends of the flasks.

When the forming bars 99 have been disposed completely within the flasks 10, the outer ends of the flasks are again closed by end closure plates 108, each of which is rotatably mounted on the bearing support 101 eccentric to the axis of the forming bar 99, but concentric of the flask axis 10. This disposition of the closure members 108 permits their rotation with the flasks.

The forming bars 99 are movable about their axes simultaneously in order to move the forming tools 100 into or out of engagement with the sand 97 that has been previously compressed centrifugally by rotation of the flasks. When moved into the flasks the forming tools 100 are disposed in such position as to be free from contact with the sand. However, upon being fully disposed within the flasks with their ends 107 piloted within the sockets 77 and the closure members 108 closing the outer ends of the flasks, the forming bars are rotatable, or angularly movable, about their axes to press the forming tool portions 100 and their intermediate portions against the compacted sand. This movement of the forming bars is undertaken while the drive motor 57 continues to rotate the flasks 10. During rotation, the forming bars 99 are turned on their axes and the entire length of the bars 99, including the forming tools 100, pressed against the sand to further compress the sand and their end portions to form the desired bell shapes 98

therein, and the intervening cylindrical shapes, as disclosed in Figs. 6 and 9. Thereafter, the forming bars are moved angularly about their axes in the opposite direction to insure clearance of the cutting tools 100 with the sand and enable the bars 99 to be removed from the molds.

The forming bars are rotated about their axes simultaneously to and from mold-forming positions by any suitable mechanism. As disclosed most clearly in Figs. 3 and 4, the bars 99 extend outwardly of their bearing supports and have levers 109 attached thereto, which are interconnected by a suitable link 110. One of the levers has a handle 111, which may be grasped by the operator and moved in either direction to effect simultaneous movement of the bars 99 about their axes.

Air is fed into the head end of the cylinder 104, in order to effect movement of the forming bars 99 from the flasks 10, after which air is also fed to the head end of the pressure cylinder 68 and the pressure rollers 61 elevated from the flasks. The car 27 is then moved on to the frame or base 51 at the forming station B, with the saddles 33 disposed under the flasks, the hoists 31 being actuated to elevate the flasks from the rollers 54, 54a. The car 27 is then rolled forwardly to transport the sand lined flasks to the roller conveyor C.

As described above, the car 27 has two platforms 32 arranged in tandem, each of which can cradle two flasks. Each platform is individually elevated and lowered by its own air hoists 31. The platforms are so disposed along the car frame 28 as to enable the forward platform to be used in elevating the molds 10 from the rollers 54, 54a at the molding station B and move them to the roller conveyor C. The rear platform 32 is ordinarily used for transferring the empty flasks 10 from the rollway G to the forming station B.

Assuming that the sand lined flasks 10 are disposed on the rollers 54, 54a at the forming station B, the car is moved back until the rear platform 32 is disposed under the empty flasks 10 on the rollway G. The hoists 32 are actuated to elevate these empty flasks from the rollway in the cradles 33. Following completion of the mold forming operation at station B, the car 27, with the empty flasks 10 disposed on the rear platform 32, is moved forwardly to place the forward platform 32 under the molds 10 on the forming station rollers 54, 54a. The air hoists 31 for the forward platform are then elevated to elevate the molds 10 from the rollers 54, 54a, after which the car is moved forward to transport the forward platform to a position in which the molds 10 may be deposited on the roller conveyor C. When the molds are so disposed, the empty flasks 10 on the rear platform 32 are disposed above the forming station rollers 54, 54a. The air hoists 31 on both platforms may now be lowered to deposit the molds on the roller conveyor C and the empty flasks on the forming station rollers. The car 27 is now returned to its initial position, in which the rear platform 32 is disposed under the empty, spaced flasks on the rollway G. The foregoing cycle of operation is repeated in moving empty flasks from the rollway G to the forming station B, and molds from the forming station B to the roller conveyor C.

The roller conveyor C transports the flasks to the pouring, cooling and shakeout stations D, E, F. The conveyor C includes a conveyor frame 112 pivotally mounted on hinge pins 113 at its lower forward portion, to enable tilting of the conveyor about the pivot pins upon introduction of air into a cylinder 114, which will elevate the piston 115 therein that is connected to the rear portion of the frame through the agency of a connecting pin 116 (see Figs. 2, 11, 24, 25). The side members 117 of the frame form guideways for a pair of endless chains 118 having rollers 119 adapted to ride upon the upper surfaces of the guides 117. These chains each pass over a rear idler sprocket 120 mounted on a stud 121 journaled in the frame 112 and over a driving sprocket 122. Both sprockets 122 are fixed to a shaft 123 journaled in the forward portion of the frame. An electric motor 124 transmits its rotation to the drive shaft 123 through a driving sprocket 125, endless chain 126, and driven sprocket 127 affixed to the drive shaft 123. To insure the appropriate axial spacing between the driving and driven sprockets 125, 127, the electric motor 124 is mounted on the chain conveyor frame 112 itself, so that pivoting of the frame about the hinge pins 113 does not interfere with the drive.

As seen most clearly in Figs. 24 and 25, the links 128 of each roller chain 118 have shafts 129 secured to their upper portions on which rollers 130 are mounted, preferably on ball bearings (not shown). These rollers 130 may have rubber rims, or the equivalent, in order to prevent slippage against the flasks 10 mounted thereon. From Fig. 24, it is apparent that the side links 128 of the chain have pairs of rollers 130 upon which a flask 10 may rest, and that the pairs of rollers are spaced from one another lengthwise of the chain 118 a distance corresponding to the spacing of the flasks 10 in the car saddles 33, and at the molding station B upon the rollers 54, 54a.

Upon operation of the electric conveyor motor 124, the lined flasks or molds placed upon the rollers 130 on the conveyor chain by the car 27 are movable to the pouring station D, the conveyor passing through and under such station (see Figs. 11 and 13). The conveyor C is advanced an appropriate distance to carry a pair of molds 10 immediately above the rollers 131, 131a, 131b at the pouring station D, which are disposed in substantially the same manner as the rollers 54 at the molding station B. That is, three pairs of rollers are disposed in substantially the same forward and rearward planes, with the rollers of each pair being coaxial. The rollers 131, 131a, 131b are spaced from one another to form concavities therebetween for the reception of a pair of lined flasks 10 between the intermediate rollers 131b and the end rollers 131, 131a. These rollers are secured to shafts 132 rotatably mounted in suitable bearings 133 carried on supports 134 bolted to a foundation 135. One of the intermediate rollers 131b may be a driving roller, which is rotated by an electric motor 136, having a driving pulley or sheave 137 on its shaft 138. Rotation of this sheave is transmitted through belts 139 to one or more driven sheaves 140 fixed to a shaft 132a secured to the driving roller 131b. Operation of the motor 136 will effect frictional rotation of the pair of molds 10 disposed on the rollers 131, 131a, 131b.

In order to maintain the proper frictional contact between the rollers 131, 131a, 131b and flasks 10, and to insure maintenance of the flasks in proper operative position on the rollers at the pouring station, pressure rollers 141 are engaged with the forward and rearward upper portions of each lined flask 10. The rear pressure rollers 141 are rotatably supported on a frame 142 pivot-

ally connected to the main frame 143 at the pouring station by a link 144. The pressure roller frame 142 is lowered and elevated by compressed air entering the head end or rod end of a double-acting cylinder 145 having a piston therein (not shown) attached to a rod 146 connected to the frame. The rear pressure rollers are similarly mounted and actuated.

When the molds 10, which have been deposited on the roller conveyor C by the car 27, are to be moved on to the rollers 131, 131*a*, 131*b* at the pouring station D, air is fed into the head end of the conveyor air cylinder 114 to tilt the conveyor frame 112 about its hinge pins 113. The conveyor motor 124 is then started and the roller conveyor 118 moved a distance sufficient to dispose these molds 10 immediately above the supporting and driving rollers 131, 131*a*, 131*b* at the pouring station. Thereafter, the conveyor cylinder and piston 114, 115 are actuated to lower the conveyor frame 112, which moves the conveyor chain rollers 130 out of contact with the lined molds 10 and allows the latter to rest upon the pouring station rollers.

In order to prevent the outer rollers 131 from contacting adjacent flasks 10 in advance of and to the rear of the pouring station D, the diameters of the outer rollers 131 are made slightly less than the diameters of the intermediate rollers 131*a*, 131*b* since the spacing between the pairs of rollers 130 on the conveyor chain is uniform.

The molds 10 are then confined against endwise movement (Figs. 11, 13). To accomplish this purpose, the rear end of each mold is moved into engagement with the flange portion 147 of a cast iron, or similar, core 148, which is spaced laterally inward from the bell end 98 of the formed sand 97. The core 148 for each mold is fixed to a pin 149, the pins for both cores being rotatably mounted in a bearing bracket 150 slidable along a guideway 151 secured to the foundation 135 in any suitable manner. The bearing bracket 150 is moved to and from the molds 10 by leading air into either end of a double-acting cylinder 152 and piston 153 arrangement. This cylinder 152 is pivoted on the frame 151 by a pin 154, and the piston rod 155 is pivotally connected to the bearing bracket 150 by a pin 156. Air entering the head end of the cylinder 152 moves the piston rod 155 outwardly and shifts the bearing bracket 150 towards the flasks 10, to dispose the hub of the cores 148 within the ends of the lined flasks, and the flanges 147 in engagement with the rear flask ends, closing them completely (Fig. 13).

The other forward ends of the lined flasks or molds are also adapted to be closed by cores 157 of cast iron, or similar material, whose exterior is shaped to conform to the desired interior of the finished bell end of the pipe to be cast in the molds. Each core has an outwardly directed flange 158, and is rotatable in a bearing support 159 movable along guideways 160, to and from the flasks 10, by an air cylinder 161 and piston 162 arrangement. The piston rod 163 is pivotally connected to the bearing bracket 159 and the cylinder 162 is pivotally connected to the frame portion 164 of the apparatus. Air may be led to either end of the cylinder 161 to move the bearing bracket 159 to and from the forward ends of the flasks 10. When air enters the rod end of the cylinder, the bracket 159 is moved toward the flasks 10, to dispose the cores 157 therewithin and the flanges 158 in closed engagement with the flask ends.

The outer hub cores 157 each have a central passage 165 therethrough, through which the inner tubular portion 166 of a pouring spout 167 extends. This pouring spout 167 is suitably carried on the bearing bracket 159, and has its outer portion opening upwardly to facilitate pouring of molten metal thereinto. This metal is disposed in a ladle 168 for each pouring spout. The pair of ladles are secured to a rod 169 journaled in standards 170 carried on the bearing bracket 159. The rod 169 is oscillatable, to swing the ladles through approximately ninety degrees, by an air cylinder and piston device 171, 172, the air cylinder 171 being pivotally mounted on the bearing bracket 159, and the piston being secured to a piston rod 173, which is pin connected to a lever 174 affixed to the ladle rod 169.

Introduction of air into the head end of the cylinder 171 will elevate the piston 172 and swing the ladles 168 to horizontal positions, in which their spouts 175 are disposed within the pouring spouts 167, in order that molten metal will flow into the latter and through the latter into the interior of the molds 10. Entry of air into the rod end of the cylinder 171 will swing the ladles to the vertical position, allowing them to be filled with the molten metal.

The ladles 168 are of such size as to contain the quantity of metal required to form a pipe section within each mold. Thus, filling of each ladle to the top when in the vertical position, and its pouring into the spout 167, after the bearing brackets 150, 159 have been moved to dispose the cores 143, 157 in closed positions within and against the molds, insures the formation of a pipe section 175 of the desired wall thickness during the casting operation.

After the pair of molds 10 has been disposed on the rollers 131, 131*a*, 131*b* and the bearing brackets 150, 159 moved toward each other to close the ends of the molds, air is admitted to the pressure roller cylinders 145 to force the pressure rollers 141 against the molds. The motor 136 is then started to rotate the molds at the desired speed, the cores 148, 157 rotating with the molds and the pressure rollers 141 insuring against displacement of the molds from their proper positions at the pouring station. The ladles 168, which have been filled with molten metal to the top, are then tilted to the horizontal position to pour the molten metal into the spouts 167, through which it flows into the interior of the molds 10. The centrifugal force incident to rotation of the latter distributes the molten metal along the length of each mold and into the bell end space between the ends 98 of the formed sand and the cores 148, 157. Rotation is continued until the molten metal has cooled and solidified sufficiently to be form sustaining, after which the motor 136 can be shut off and the bearing brackets 150, 159 moved away from the flasks 10 through suitable direction of air into the cylinders 152, 161.

The molds 10, with the pipe sections 175 cast therein, may now be removed from the pouring station D, and such removal can occur while they are still rotating. Following removal of the cores 148, 157 and pouring spouts 166, 167 from the molds, air is again led into the head end of the conveyor cylinder 114 and the conveyor frame 112 tilted to cause the conveyor rollers 130 to engage the flasks 10 and elevate them above the pouring station rollers 131, 131*a*, 131*b*. The conveyor motor 124 is then started to move the flasks 10, with the pipe 175 cast therein, to the

cooling station or zone E, and to dispose the next succeeding pair of lined molds on the pouring station rollers. The air cylinder 114 is then operated to lower the conveyor frame 112 and place the empty, lined molds on the pouring station rollers 131, 131a, 131b.

During removal of the molds 10 (with pipe 175 therein) from the pouring station D, they can continue rotating because of their support upon the conveyor chain rollers 130. This allows the flasks 10 to be removed from the pouring station before they come to rest, which saves considerable time in the production of cast pipe by the apparatus, and enables greater quantities to be produced in any given period.

At the cooling zone E, air is drawn through one end of the molds 10 by suction, the air passing from the other end of the molds into ducts 176 disposed closely adjacent thereto. These ducts are spaced along the conveyor C a distance corresponding to the spacing of the molds 10, and lead into a common header 177 that is evacuated by a suitable motor driven exhaust fan 178. The cooling equipment is not essential, since the casting will cool during its travel between the pouring and shakeout stations D and F. However, the passing of air through the molds 10 accelerates the cooling of the cast pipe 175, and insures that it will be in condition for appropriate handling after being removed from the flasks at the shakeout station F.

At the shakeout station, the cast pipe 175 and sand are removed from the flasks 10, and the latter started on their return trip along the rollway G to the spacing and flask transfer station A. Flasks 10 with the pipes 175 cast therein are adapted to be grasped and moved from the roller conveyor C to a vertical position, where suitable means is forced through the flasks to shake the pipe and sand therefrom.

In the form disclosed in the drawings (Figs. 16 to 21, inclusive), the shakeout device includes a frame 179 mounted for movement about an axis disposed to one side of the ends of the flasks 10. Specifically, one side of the frame is mounted upon a hinge pin 180 secured in a frame or standard 181 bolted to the foundation, while the other side of the frame is fixed to a coaxial shaft 182 journaled in another standard 183 secured to the foundation. This shaft has a sprocket 184 attached to it, engageable with an endless chain 185 encompassing a driving sprocket 186 fixed on the shaft 187 of an electric motor 188.

The frame 179 is provided with clamping devices 189 for grasping a pair of flasks 10 and for holding them during swinging of the frame about the common axis of the shaft 182 and hinge pin axis 180. There is a set of clamps for each flask, each set comprising opposed forward and rearward clamp jaws 190 adapted to grasp the flask. The jaws to one side of a flask are fixed to a shaft 191 journaled in the frame 179, and the jaws on the other side of the same flask are similarly fixed to another parallel shaft 192 journaled in the frame. The shafts 191, 192 are angularly movable in opposite directions at the same time by securing intermeshing gear sectors 193 thereto. One of the shafts 192 has an operating arm 194 fixed to it, provided with a slot 195 for receiving a pin 196 attached to a piston rod 197 extending from a piston 198 slidable in a double-acting air cylinder 199. Thus, entry of air under pressure into the head end of the cylinder 199 will rock the shafts 191, 192 in such a direction as to swing the jaws 190 toward one another and clamp them around the flask 10. The clamping mechanism for the other flask of the pair is essentially the same as the one just described.

When the conveyor motor 124 has been rotated to dispose the flasks at the shakeout station F, the latter are arranged immediately under the clamps 189, as shown in Fig. 20. The inner ends of the flasks 10 are then disposed in alignment with stops 200 suitably secured to the frame 179. Air is fed into the clamp cylinders 199 to effect movement of the jaws 190 into clamping position around the flasks 10, after which the shakeout motor 188 is rotated to swing the frame 179 through substantially ninety degrees about its pivot axis. This swinging movement removes the flasks 10 from the roller conveyor C and causes their inner, bottom ends to rest upon the stops 200 (see Fig. 17). When disposed in the vertical position, the flasks 10 are in alignment with a pair of elongate, double-acting air cylinders 201. A plunger 202 is secured to the end of each piston rod 203 connected to a piston 204 in each cylinder 201. This plunger is adapted to slide through the flask.

Air is fed into the upper ends of the cylinders 201, forcing the plungers 202 downwardly and completely through the flasks 10, which forcibly ejects the cast pipe 175 from the flasks and also completely removes the sand therefrom. To accomplish this purpose most effectively, the plunger preferably has a sliding fit with the wall of the flask 10. The cast pipe 175 may come to rest on a suitable screen 205 disposed in a pit 206, through which the sand will drop on to the conveyor belt 11 leading back to the other conveyor belt 12 and sand reconditioning equipment 15. The pipe 175 itself may be removed manually, or otherwise, from the pit 206 for any required subsequent operation or storage.

The shakeout station F is disposed immediately behind the end of the track or rollway G. After the pipe and sand have been removed from the flasks, the motor 188 is started again and swinging of the frame 179 continued substantially another ninety degrees to dispose the empty flasks 10 in alignment with the rollway G. When in this position, the outer ends of the clamp jaws 190 are disposed upwardly (Fig. 18). The clamp cylinders 199 are appropriately actuated to open the jaws, which allows the flasks 10 to drop upon a table 207 pivotally mounted on the frame 179. The free end of the table 207 comes to rest upon a flange or shoulder 208 projecting from the rollway G, in order to dispose the supporting surface of the table 207 in position in which it essentially forms a continuation of the rollway, tapering downwardly toward the latter so that the empty flasks will roll by gravity on to the rollway after the clamps 189 have been released from them. When the shakeout frame 179 and its clamps 189 are disposed over the roller conveyor (Fig. 20), downward movement of the table 207 about its pivot is limited to a slight extent by its engagement with a suitable stop 209 attached to the frame.

The frame may be swung through 180 degrees to its initial position over the roller conveyor (Fig. 20) for the purpose of grasping another pair of filled flasks 10, swinging them through ninety degrees to the vertical position at which the pipe sections 175 and sand are removed. Swinging is continued through another ninety degrees to dispose the empty flasks in alignment

with the rollway G, on to which they will roll by gravity upon release of the clamps 189.

The operation of the entire system may be recapitulated. All of the foregoing operations at the various stations are taking place substantially simultaneously on different pairs of flasks. Thus, after the system has been in operation, a pair of flasks 10 is disposed on the conveyor chain 118 at the shakeout station F; one or several pairs may be disposed in the cooling zone E; a pair of flasks will be disposed at the pouring station D; one or several pairs may be disposed on the roller conveyor C between the pouring and forming stations D, B; a pair will be disposed at the forming station B; and another pair disposed against the stops 24, 25 at the flask transfer station A. The rollway G, of course, may have an adequate supply of empty flasks.

While the sand is being poured into the flasks at the molding station B and the molds formed at that station, the pouring operation is being conducted on a pair of molds or lined flasks at the pouring station D. Simultaneously therewith, the cast objects 175 are being cooled in the cooling zone E, and the pipe 175 and sand is being removed from a pair of flasks at the shakeout station F. After these operations have been performed at the various stations, the roller conveyor C is suitably manipulated to remove the flasks from the pouring station D and advance them to the cooling station E. During movement of the conveyor, a pair of flasks is also transported from the cooling zone E to the shakeout station F, and another pair of flasks, with the sand molded therein, is placed from the conveyor C in position at the pouring station D. This leaves conveyor space available for the reception of molds from the molding station B. Accordingly, the car 27 is moved to place the forward platform 32 under the molds at the molding station, and, since the rear platform has already been elevated to receive the flasks in spaced position at the end of the rollway G, the car may be advanced to dispose the molds above the chain conveyor 118 and the empty flasks above the forming station rollers 54, 54*a*. Both sets of hoists may now be lowered to place the molds on the chain conveyor 118 and the empty flasks on the forming station rollers. The car 27 is then returned to its initial position and another pair of empty flasks picked up from the rollway G upon the rear platform 32.

The foregoing cycle of operation can be repeated. Each station may have its own operator or operators to control the sequence of operation of the apparatus.

It is, accordingly, apparent that a closed continuous centrifugal casting system has been provided, in which the flasks are readily transferable from station to station. The flasks are arrested and spaced at the transfer station A, the sand is molded at the molding station B by means of a tool capable of forming both bell ends at the same time. At the pouring station D, the flasks may be rotated without fear of rotating other adjacent flasks, in view of the differences in diameters between the rollers 131 and rollers 131*a*, 131*b*. During bringing of the molds into position at the pouring station D, the ladles 168 can be filled, these operations not interfering with one another and saving considerable time in the cycle. After the molten metal has been poured into the molds, the latter may be removed from the pouring station D before their rotation ceases, which also saves considerable time in the cycle and enables the apparatus to have a high production rate. The cast objects 175 are readily cooled and are removed with facility by novel mechanisms, which insure complete removal of the objects and sand from the flasks, allowing reuse of substantially all equipment and materials.

The inventor claims:

1. Apparatus for lining a cylindrical flask to form a mold, comprising a flask support pivoted to move a flask between horizontal and vertical positions; a plurality of rollers positioned to engage the periphery of a flask on the support; said rollers being rotatable on axes parallel to that of the flask and at least one of said rollers being power-operated for rotating the flask; means on the support for pressing the flask against the driving roller; means for feeding sand into the flask when in vertical position; means carried by the support for closing the ends of the flask; a forming tool, and means for moving the forming tool into and out of the flask when the flask is in horizontal position.

2. Apparatus for lining a cylindrical flask to form a mold, comprising a flask support pivoted to move a flask between horizontal and vertical positions; a plurality of rollers positioned to engage the periphery of a flask on the support; said rollers being rotatable on axes parallel to that of the flask and at least one of said rollers being power-operated for rotating the flask; means on the support for pressing the flask against the driving roller; and means for feeding sand into the flask when in vertical position.

3. An apparatus for rotating a cylindrical flask, comprising a plurality of supporting rollers having axes parallel to that of the flask; power means driving one of said rollers to rotate the flask; pressure rollers bearing on said flask to hold it on the supporting rollers; a conveyor for moving a flask transversely of its axis into and out of said apparatus; means for lifting the pressure rollers so as to permit said flask to pass them; a forming tool; and means for moving the forming tool into and out of the flask when the flask is in horizontal position.

4. Mechanism for cyclic centrifugal formation of castings comprising a support having spaced abutments for maintaining a pair of cylindrical flasks spaced apart in substantially horizontal position with their axes parallel to each other; a lining station having means for charging sand into said flasks simultaneously; friction rollers at the lining station mounted on axes parallel to those of the flasks, said rollers having peripheral engagement with the flasks for rotating them and maintaining them in the same relative positions; an endless conveyor having means for supporting said flasks in the same relative positions; an elongated carriage having cradles at each end for supporting the flasks in the same relative positions, and means in the carriage for raising and lowering said cradles; means for reciprocating said carriage and operating said raising and lowering means to transfer said flasks pairwise from the carriage to the lining station and thence to said conveyor; a pouring station including means for spacing said flasks from said conveyor, means for charging molten metal into the flasks, friction rollers for rotating them simultaneously and means for returning them simultaneously to the conveyor; a shakeout station; means for transferring the flasks simultaneously to the shakeout station from said conveyor; a rollway extension from the shakeout station to said support; and means for trans-

ferring the flasks simultaneously from the shakeout station to said rollway.

5. A device as in claim 4 including means between said pouring station and said shakeout station for passing a current of air through said flasks.

6. A device as in claim 4, wherein the supporting means on said conveyor comprises spaced rollers extending transversely of the conveyor, and wherein the flasks are returned to a position between a pair of rollers on the conveyor while still rotating.

7. Apparatus for casting tubular articles centrifugally in a closed circuit, comprising a loading station, a carriage, a flask lining station; and an endless chain conveyor, each having means for supporting a pair of cylindrical flasks in spaced relation in substantially horizontal position with their longitudinal axes parallel to each other; vertically movable cradles on said carriage; means for moving the carriage and cradles to transfer pairs of flasks from the loading station to the lining station and from the lining station to the conveyor; a pouring station to which flasks are carried by said conveyor; spaced flask-rotating rollers at the pouring station on axes parallel to those of flasks on the conveyor; means for causing a pair of flasks on the conveyor to be rotated by the rollers at the pouring station while maintaining their relative position; means for charging molten metal into said flasks; means for returning the flasks to the conveyor; a flask shakeout station; means for transferring the pair of flasks simultaneously from the conveyor to the shakeout station; a rollway extending from the shakeout station to the loading station; and means for transferring said pair of flasks simultaneously from the shakeout station to the rollway.

8. An apparatus as in claim 7, wherein the flask supporting means on the conveyor includes spaced rollers on parallel axes, and means for returning the flask to the rollers on the conveyor while the flasks are still rotating.

9. An apparatus as in claim 7, wherein the rollers at the pouring station are located at a higher level than the adjacent part of the conveyor, and said apparatus includes means for raising and lowering a part of the conveyor to move the flasks into and out of driving engagement with the rollers at the pouring station.

10. Mechanism for continuous cyclic centrifugal formation of tubular objects comprising a support having abutments for maintaining a set of cylindrical flasks spaced apart in substantially horizontal position with their axes parallel to each other; a lining station including means for supporting said set of flasks in the same relative positions; means for charging sand into said flasks and means for rotating them; an endless conveyor having means for supporting said flasks in the same relative positions; an elongated carriage having elevating means at its ends and cradles on said elevating means spaced similarly to said abutments; means for reciprocating said carriage and actuating said elevating means to transfer said set of flasks successively from said support to said lining means and thence to said conveyor; a pouring station comprising means for charging molten metal into said flasks, means independent of the conveyor for rotating said flasks, means for moving the flasks from the conveyor into driving relation to said rollers and for returning them to the conveyor; a shakeout station; means for transferring said flasks simultaneously from the conveyor to the shakeout station; a rollway extending from said shakeout station to the support; and means for transferring the said flasks simultaneously from the shakeout station to the rollway.

11. In a centrifugal casting system for making tubular objects, a rollway, abutments on the rollway for holding a plurality of cylindrical flasks in spaced relation with their longitudinal axes horizontal and parallel to each other; a lining station having rotary rollers for supporting said plurality flasks in the same relative positions and rotating them on their axes; means for feeding sand to said flasks at the lining station; a casting station; rollers at the casting station arranged to maintain the relative positions of said plurality of flasks while rotating them; means for supplying molten metal to the flasks at the casting station; and conveyors for transferring the spaced flasks from the rollway to the lining means and from the lining means to the casting means while maintaining the same relative positions of the flasks.

12. A device as in claim 11, said conveyors including an endless conveyor between the lining station and the casting station; a carriage having cradles spaced to support said plurality of flasks while maintaining their said relative positions; means for raising and lowering the cradles and means for reciprocating the carriage in coordination with the operation of the raising and lowering means so as to transfer said plurality of flasks from the rollway to the lining means and thence to the endless conveyor while maintaining the said plurality of flasks in horizontal position with their axes in parallelism.

13. A device as in claim 12, including a shakeout station; and means for transferring said plurality of flasks simultaneously from the endless conveyor to the shakeout station.

14. Mechanism for cyclic centrifugal casting of tubular articles comprising a flask support for holding a cylindrical flask in substantially horizontal position; a lining station having means for charging sand into the flask and means engaging the periphery of the flask to rotate it while in substantially horizontal position; an endless conveyor having rollers mounted on axes parallel to that of the flask for supporting the flask in horizontal position; an elongated carriage having a cradle; means for reciprocating the carriage and coordinated means for raising and lowering the cradle to transfer the flask successively from the support to the lining station and thence to the conveyor while maintaining it in horizontal position; a pouring station having means for spacing the flask from the conveyor while maintaining it in horizontal position; means for charging molten metal into the flask; means for rotating the flask and means for returning the flask to the conveyor; a shakeout station; a rollway leading from the shakeout station to said flask support; means for transferring a flask from the conveyor to the shakeout station; and means for transferring an empty flask from the shakeout station to the rollway.

15. A device as in claim 14, wherein the supporting means on the conveyor comprises pairs of rollers spaced to engage the under side of a flask, and means for returning said flask to the rollers on the conveyor while the flask is still rotating.

16. Apparatus for centrifugally forming tubular castings comprising lining means with spaced rollers for engaging and rotating a cylin-

drical flask in a prone position and means for charging said flask with sand; an endless conveyor having spaced rollers rotatable on parallel horizontal axes for supporting said flask in prone position; a carriage having means for lifting said flask from said lining means and depositing it on rollers of the conveyor; a pouring station with spaced rollers for engaging the periphery of a lined prone flask and rotating it; means for spacing the flask from the rollers of the conveyor and positioning it to be driven by the rollers at the pouring station, means for charging molten metal into the lined flask and means for returning the flask to a position on the conveyor where it is supported by engagement of the outer face of the flask with those of the rollers.

17. In apparatus for lining a cylindrical flask to form a mold: a support; a plurality of rollers rotatable on axes parallel to that of a flask supported thereby, at least one of said rollers having driving engagement with said flask; power means to drive said roller, means carried by said support and bearing on said flask for pressing it against said rollers; means pivotally mounting said support for movement of the flask between substantially horizontal and vertical positions; means for introducing sand into said flask when the flask is in a vertical position; means carried by the support for closing the ends of the flask; a forming tool; and means supporting said tool for movement into and out of said flask when said support is in a horizontal position to provide the desired contour in the sand.

18. In apparatus for lining a cylindrical flask to form a mold; a tiltable support; a plurality of rollers on said support, said flask resting upon said rollers; means on the support for positively driving one of said rollers; means for tilting the support to move the flask between substantially

horizontal and vertical positions; a member on the support engageable with the flask to prevent its endwise movement; means for introducing sand into the flask while said support is in a vertical position; a forming tool; and means for moving said tool into the flask while the support is in horizontal position, for providing the desired contour in the sand.

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