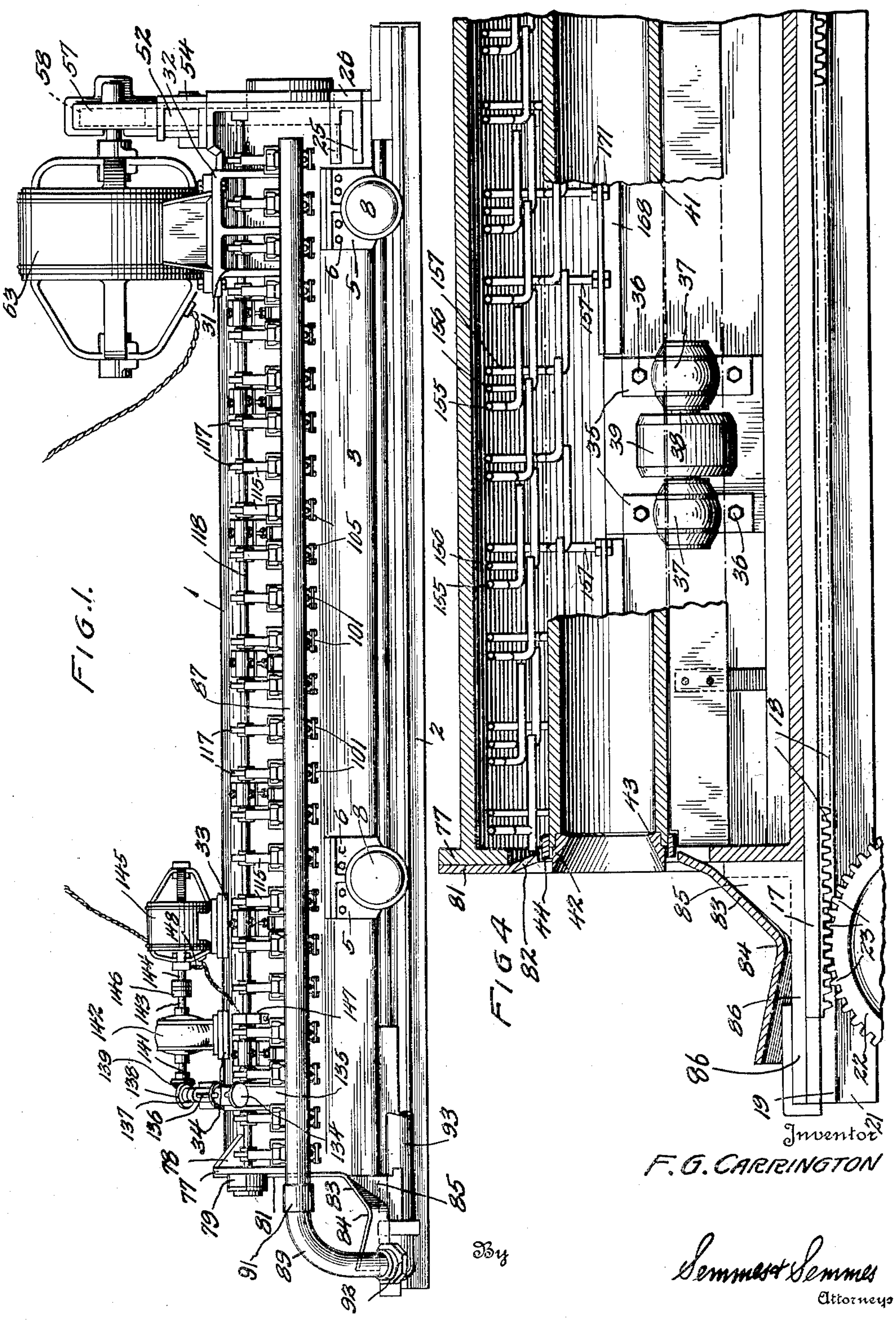
March 17, 1931. F. G. CARRINGTON 1,796,645

APPARATUS FOR CENTRIFUGAL CASTING

Filed Sept. 17, 1927 4 Sheets-Sheet 1



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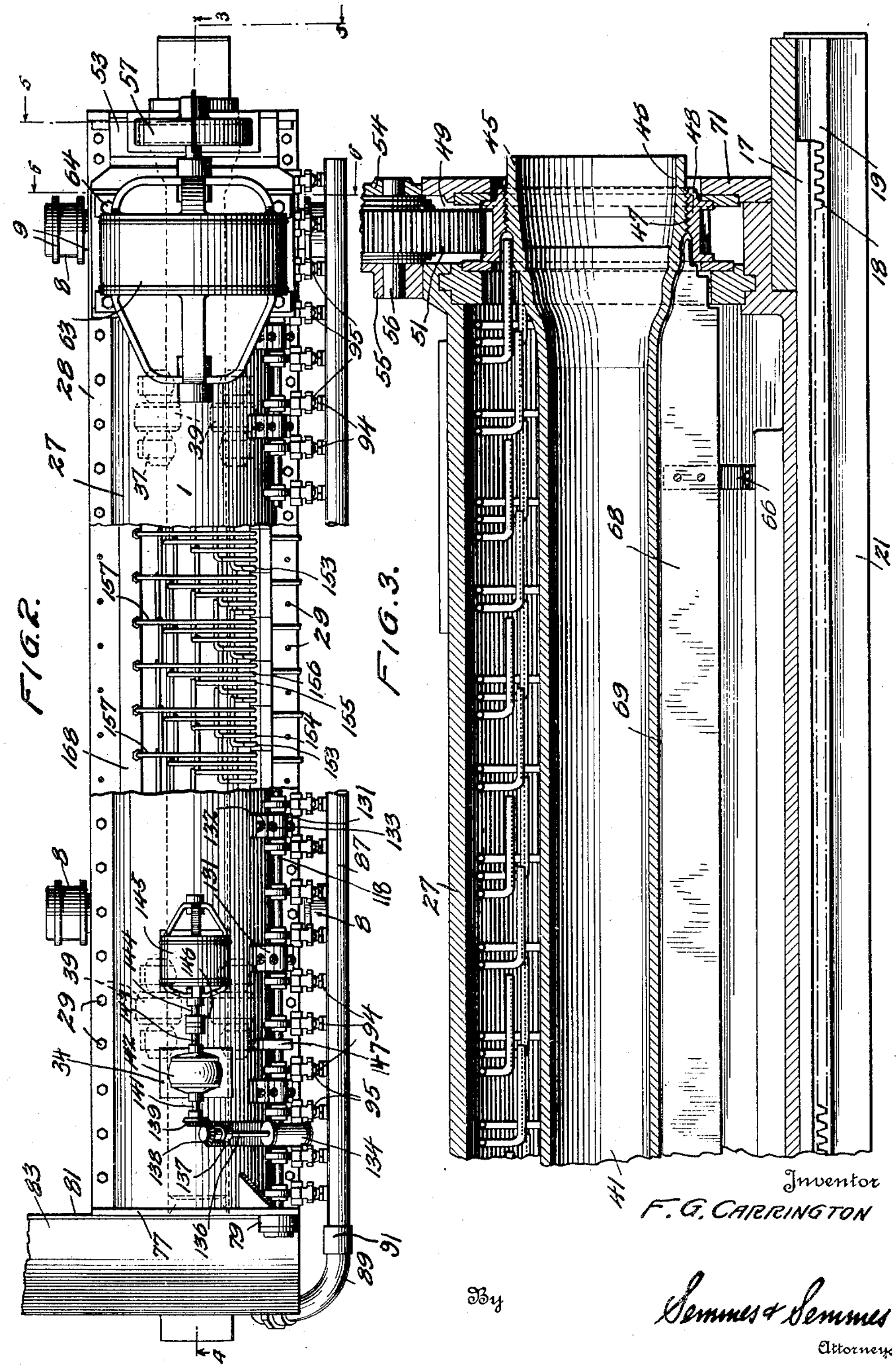
APPARATUS FOR CENTRIFUGAL CASTING

Filed Sept. 17, 1927 4 Sheets-Sheet 2



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APPARATUS FOR CENTRIFUGAL CASTING

Filed Sept. 17, 1927 4 Sheets-Sheet 3

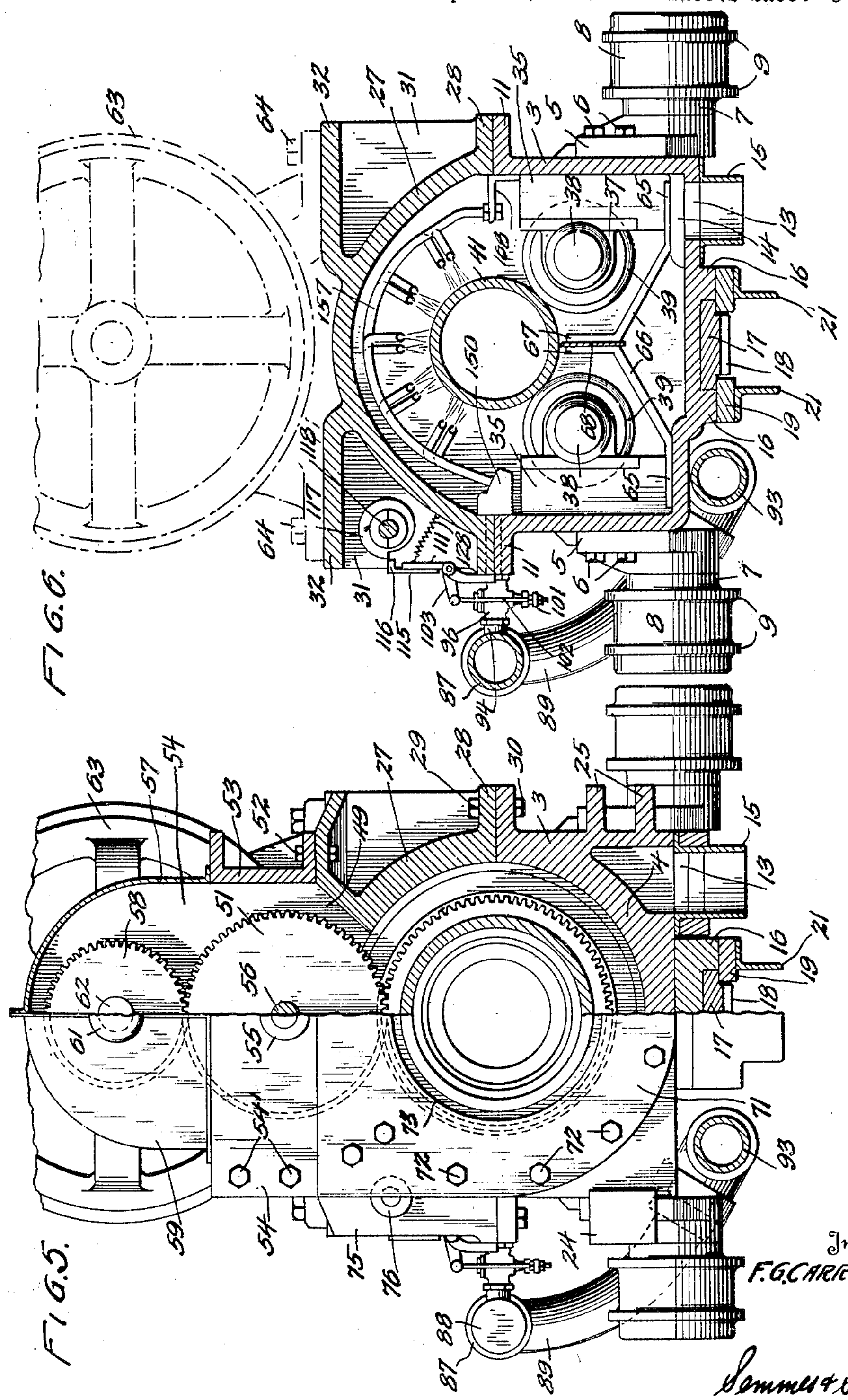

FIG. 5.

FIG. 6.

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FIG. 7.

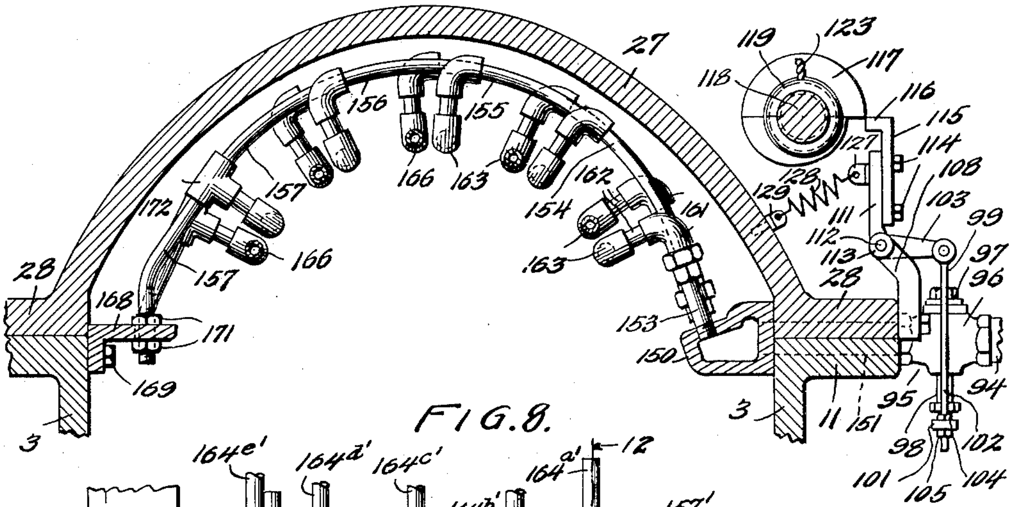


FIG. 8.

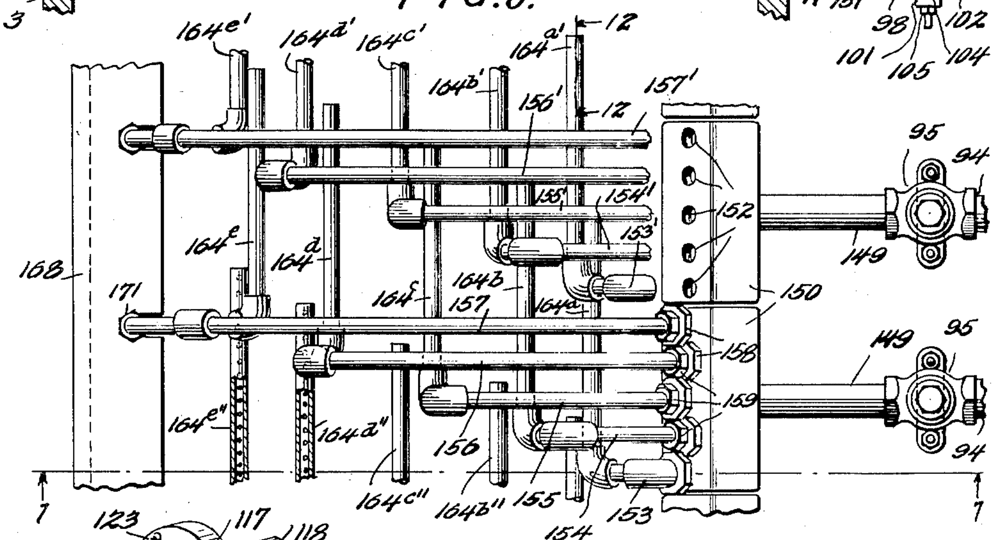


FIG. 9.

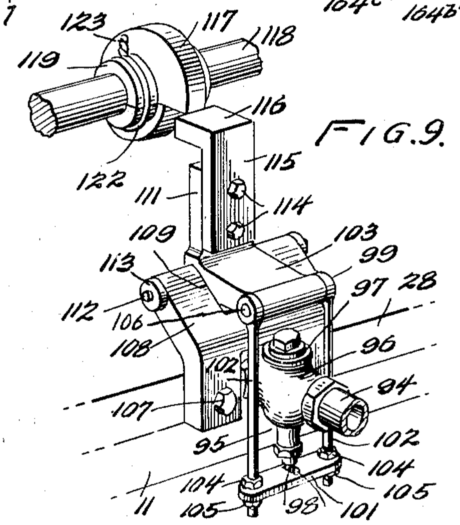


FIG. 10.

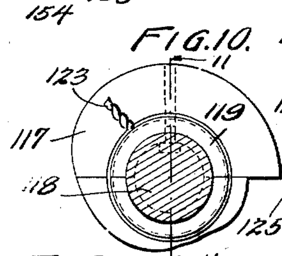


FIG. 11.

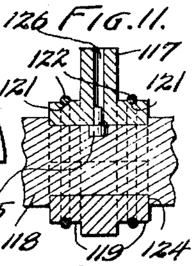
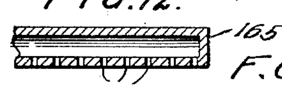


FIG. 12.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR CENTRIFUGAL CASTING

Application filed September 17, 1927. Serial No. 220,105.

This invention relates to apparatus for casting annular objects by centrifugal force.

In the centrifugal casting of pipe according to one of the methods practiced at the present time, molten metal is poured within a substantially horizontal rotating mold and the centrifugal force generated by rotation of the mold serves to press the metal upon the inner periphery of the mold to a substantially uniform thickness. After the casting has solidified it is removed from the mold. In the type of centrifugal casting machine to which this invention is particularly directed, a so-called "end pouring trough" extends within the mold and the mold and the trough is displaced axially relatively to each other so that the metal which is discharged from the trough builds up on the inside of the mold in the form of a helix. This mode of casting is not new and therefore requires no detailed description.

In the type of mold just described it is necessary to provide cooling means for the mold, because of its great heat conductivity, to prevent burning out and for bringing about the solidification of the casting. The usual systems for cooling the mold have consisted of either surrounding the mold with a water jacket or by sprinkling a cooling medium upon the exterior of the mold. These systems have not proved wholly satisfactory, however, for use in a casting apparatus in which an end pouring trough is employed which progressively pours the metal along the length of the mold for the reason that they commence to cool the mold along its entire length at the same moment. But since the mold receives its heat from the metal deposited within it and because of the fact that the metal is being continuously laid down within the mold from one end toward the other, it follows that the temperature of different sections or zones of the mold is not uniform at any one moment. In other words the time differential existing in the continuous deposition of increments of hot metal within the mold results in a temperature differential along the mold which renders unsuitable any means for the instantaneous or simultaneous cooling of the mold and precludes any satisfactory heat treatment of the casting.

The rate of cooling of a casting governs among other things the graphitization, the intercrystalline structure, and the internal stresses set up in the finished casting. As the metal cools there is a tendency for the carbon, which in the molten phase of the metal exists in the form of iron carbide, to migrate to the free state. But inasmuch as solidification serves to prevent this migration it is apparent that by properly controlling the cooling stages of the metal, and hence its solidification, the desired degree of graphitization may be realized. This is a desideratum, for the presence of iron carbide, although providing a tough coating, by the same token renders a casting unmachinable.

With respect to the effect of cooling upon the intercrystalline structure of the pipe, generally speaking two forms of crystals exist in the solid state of cast iron, those known as alpha crystals appearing in the lower temperature ranges and so-called gamma crystals existing at the higher temperatures, the tendency for the crystals to coalesce increasing in the upper regions of the alpha and gamma ranges decreasing with a drop in temperature. Consequently the longer a coating remains at a given temperaure the more pronounced will be this coalition of crystals and since the formation of large crystals is usually to be avoided resulting as they do in the formation of planes of cleavage, a rapid cooling of the metal through the higher temperatures of the alpha and gamma crystal ranges is desirable.

Another result of non-uniform cooling of the mold is the possibility of deleterious stresses being set up in the pipe. As the molten metal is cooled there is a cross-sectional differential in cooling. This is largely due to the fact that the outside layers of metal poured into a mold contact with the mold and exchange heat rapidly whereas the inner layers of metal cannot send off the heat they contain so rapidly. As a consequence the metal that cools more rapidly is subjected to expansion stresses by adjoining laminations that are at a higher temperature while the hotter layers are compressed by adjoining layers that are cooler. These stresses are objectionable because they materially weaken the casting and, like the larger crystals previously mentioned, afford lines of cleavage throughout the finished casting.

The use to be made of a finished pipe should determine the characteristics of the pipe. A pipe adapted for use on a suspension bridge where elasticity and strength are demanded, for instances, would fail to meet the necessities of a coal or ash chute which calls for hard and non-abrasive material.

It will therefore be apparent that control of the temperature of the casting is of prime importance to insure a product free from internal defects. The object therefor of this invention is to provide a method and apparatus whereby the cooling of a centrifugal mold can be nicely regulated and various parts of the mold cooled selectively. In applying the invention to axially movable molds in which the casting is helically deposited, the mold is cooled progressively as the casting proceeds.

In the revolution of the mold there is created a blanket of gases immediately adjacent its exterior which rotates with the mold. When the sprinkled cooling medium reaches this blanket of gases it is carried by it and either finally thrown off by the centrifugal force of the revolving blanket or reaches the circumference of the mold at some point other than that desired. My invention has as an additional aim the provision of means to prevent or to greatly retard the formation of such blankets.

Figure 1 is a side view in elevation of my invention;

Figure 2 is a top plan view of my invention with a portion of the mold housing cut away;

Figure 3 is a view of the bell end of my invention along the line 3 of Figure 2, looking in the direction of the arrow;

Figure 4 is a view of the opposite end of the machine taken along the line 4 of Figure 2, looking in the direction of the arrow;

Figure 5 is a view of the bell end taken along the line 5—5 of Figure 2, looking in the direction of the arrows;

Figure 6 is a view along the line 6—6 of Figure 2, looking in the direction of the arrows;

Figure 7 is a view taken along the line 7—7 of Figure 8, looking in the direction of the arrow;

Figure 8 is a top plan view of a portion of the cooling system and associated mechanism;

Figure 9 is a view in perspective of the valve regulating mechanism of my invention;

Figure 10 is a view in detail of a cam showing its method of mounting upon a rotatable shaft;

Figure 11 is a sectional view along the line 11—11 of Figure 10, looking in the direction of the arrow;

Figure 12 is a sectional view along the line 12—12 of Figure 8, looking in the direction of the arrows.

I have shown in Figure 1 a mold casing 1 suitably mounted for longitudinal movement upon a track 2, which is secured, by means not shown, to a suitable support member or floor.

Referring to Figures 5 and 6, the casing 1 comprises a base portion 3 of substantially channel section, but provided at its end with a semi-circular member 4 that is adapted to maintain in position an end plate. Upon the base member 3 there are mounted plates 5 secured to the base members by bolts 6 or other suitable means. The plates 5 support, either integrally or otherwise, stub axles 7. Mounted upon the stub axles are wheels 8 provided with interior and exterior annular flanges 9 which fit upon either side of the rails 2. While I have shown a machine provided with four wheels, it is, of course, understood that variations may be made in this number.

At the top of the sides of the base member 3 are flanges 11. These flanges project outwardly from the sides, and, as will be more clearly pointed out hereinafter one of the flanges is provided with transverse channels along its length.

The floor portion of the base member 3 slopes slightly to one side. Along the length of its lower side the floor is cut away as at 13 in Figure 5, and provides a longitudinal opening through which any liquid within the casing may be discharged. As shown in Figure 6, there are spaced along the length of the casing support members 14 adapted to strengthen the casing at the place of the opening 13. The member 14 is secured to a side of the base member and to the floor by a suitable means (not shown). Surrounding the opening 13 are downwardly projecting flanges 15. These flanges provide an apron and are adapted to prevent a splash ensuing from the discharge of the liquid from the casing.

In the center of the floor of the base and projecting downwardly therefrom are flanges 16. Within the channel formed by these flanges there fits a rack comprising a body portion 17 and teeth 18. The rack is secured to the floor member by suitable means that are not shown, such as rivets, bolts or welding. Blocks 19 extend beneath the body portion 17 of the rack and support an apron 21 for the gear teeth 18 and actuating gear. The blocks 19 are suitably secured to the flanges 16 by suitable means not shown, and may be removed when replacement of the rack is desired.

Referring to Figure 4 there is shown a gear 22, provided with teeth 23 adapted to engage the teeth 18 on the rack. The gear 22 is rotatably mounted below the track 2 and is provided with a suitable driving means not shown herein. The machine is moved longitudinally by rotating the gear 22 which meshes with the rack and forces the machine along the track.

Referring to Figure 5, I have shown bumpers 24 for the machine which comprise flanges 25 extending from the side of the base member 3 and an end bumping plate 26 as is more clearly shown in Figure 1. The flanges may be either integral with the base member 3 as shown in the drawings, or they may be secured to the base member by bolts or other appropriate means.

A top for the casing 1 is provided comprising a partially circular cover plate 27 and flange 28 which rest upon the flanges 11 of the base member 3. Bolts 29 extending through the flanges 28 and 11 and nuts 30 secure the cover plate and the base member 3 together. A platform is provided at one end of the cover plate and is adapted to support a suitable motor. The platform comprises support plates 31 extending outwardly from the cover plate 27 and upwardly from the flange 28, and upon these support members 31 there rest plates 32 integral with the cover 27, upon which the motor is mounted.

While I have shown the supports 31 and plates 32 integral with the cover 27, it is, of course, understood that these members may be securely mounted upon the cover 27 by other suitable means.

Referring to Figure 1, platforms 33 and 34 are also appropriately mounted on the cover plate 27 to support another motor and a gear arrangement.

Referring to Figures 4 and 6, I have shown mounted on the base members 3 suitable means for rotatively supporting a mold within the casing. These means comprise blocks 35 which are secured to the side walls of the base member 3 by bolts and nuts 36 or other suitable means. Integral with each plate 35 is a roller box 37, which provides a suitable bearing for shafts 38 which support rollers 39. The blocks 35 project sufficiently from the sides of the base 3 to permit the rollers 39 to rotate between the blocks without contacting with the side walls of the base member 3. I have shown in the drawings four rollers, but under certain circumstances, it may be necessary to diminish or increase the number of rollers.

In Figure 6 there is shown a mold 41 resting upon the rollers 39. As shown in Figure 4 the spigot end of the mold is provided with a detachable ring 42 secured in the end of the mold. The ring prevents any of the molten metal that is poured within the mold from flowing therefrom, and the shape of the edges 43 of the ring determines the shape of the end face of the casting.

A detachable annular shield 44 is suitably mounted on the mold by means not shown, and extends over a portion of the ring 42. The shield 44 prevents any liquid that might be discharged upon the mold from falling upon the ring 42, or that portion of the mold in contact with the ring. As will be hereinafter pointed out the mold will be sprayed by a cooling liquid, which will tend to decrease expansion of the mold that is caused by the heat interchange with the molten metal. The metal, contacting as it does with the ring 42, will also cause the ring to expand. By shielding the ring 42 from the spray of the cooling medium, its expansion is not counteracted, and it will, therefore, expand at as great a rate, if not greater, than the mold. This will insure a tight fit between the mold and the ring, and will offer no crevices into which the molten metal may flow and form fins on the finished casting. Heretofore considerable difficulty has been experienced by reason of the formation of such fins, which have necessitated additional treatment of the casting for their removal.

In Figure 3 the mold is shown provided with an enlarged end portion or bell 45. The shape of this portion, of course, determines the shape of the finished casting, and as heretofore stated, the so-called plain end mold may be substituted for a mold of the bell type under certain circumstances. Within the bell, there is a recess 46 adapted to receive a head core which is not shown. This core serves the same general function as the ring 42 at the plain end of the mold; namely, it prevents an efflux of molten metal from the mold and aids in the formation of the pipe. The exterior of the bell 45 is provided with threads 47, on which is enthreaded a ring gear 48.

The cover plate 27 is provided with a slot 49 adjacent the bell end and at the top of the cover, through which extends an idle gear 51. Mounted upon the cover plate by means of nuts and bolts 52 is a gear casing 53 as shown in Figure 5. Plates 54 are secured to the gear casing 53 by means of bolts 54′, and provide bearings 55 for a shaft 56 on which the gear 51 is mounted.

Imposed upon the top of the gear casing 53 is another gear casing 57 in which there is positioned a gear 58 which meshes with the idle gear 51. A plate 59 is mounted on the casing 57 and is provided with a bearing 61 for an armature shaft 62 on which the gear 58 is keyed. It will be observed from Figure 5 that the rear plate 54 extends over the housing 57 as well as the housing 53, and also serves as a bearing for the shaft 62.

While I have diagrammatically shown an electric motor 63 of a conventional type, under certain circumstances other types of motor may be employed. The motor 63 is secured to the plate 32 of the platform heretofore described by means of nuts and bolts 64. The motor and the gear train effect a rotation of the mold 41. By inserting the idler 51 in the train, a suitable reduction in gearing and a rotation of the mold in the same direction as the armature shaft may be obtained.

When the motor 63 is started the mold is rotated and is supported by the rollers 39. Rotation of the mold sets up in its vicinity a revolving blanket of air or other gas. This blanket would impede the sprinkling of the mold in the absence of appropriate provisions, for a liquid or gas that might be discharged in the direction of the mold would be caught by the revolving blanket, and either thrown off by the centrifugal force generated or the cooling medium would strike the mold at some point other than that at which it was directed. To prevent this, I have provided in my apparatus an air baffle designed to break up any layer of gas that might be formed by the revolution of the motor.

Mounted on the members 14 and the opposite side of the floor of the base member 3 are foot members 65. These members are secured by appropriate means, such as welding or bolts or rivets, and are provided with support arms 66 which are bent out at their ends as at 67. Positioned between the arms 67 is a plate 68, which extends the length of the mold and takes the shape of the mold. As will be observed in Figure 3, the plate 68 has a configuration corresponding to the outside of the bell of the mold. A small space 69 is left between the mold and the plate 68 to allow for slight irregularities in the mold. The supporting means for the plate 68 are spaced along its length.

Referring to Figure 5, a bell end plate 71 is mounted over the body portion of the housing and is secured thereto by means of bolts 72. The end plate is provided with a circular opening 73 of slightly larger diameter than the bell of the mold. This plate is adapted to prevent the admission of dirt or other foreign substances into the casing where they might impede the efficient operation of the mechanism.

The cover plate 27 is provided with a flange 75 at its bell end which is of substantially the same shape as the upper portion of the end plate 71, although projecting a short distance beyond the face of the end plate. In this flange there is a bearing 76 which will be later discussed.

Referring to Figures 1 and 4, the plain end of the cover 27 is provided with a flange 77 supported by a block 78 mounted on the cover plate. The flange 77 is provided with a bearing 79.

A plate 81 is mounted on the plain end of the casing, and is provided with a circular opening slightly larger than the plain end of the mold. The plate 81 adjacent the opening is bent inwardly, as at 82, so that the plate surrounds the shield 44 on the plain end of the mold. This plate 81 prevents any water that may be discharged on the mold from splashing or running out of the casing.

I have shown an apron 83 integral with the casing 81, which is adapted to catch any molten metal that may drip from the end of a trough that pours the metal and which also catches any metal that may be splashed from the mold. The apron 83 forms a channel 84 that slants to one side of the machine where the metal may flow into a gutter or other receptacles provided for the receipt of such waste metal. The apron is supported by means of uprights 85 that are mounted on a platform 86 extending from the base member 3 beyond the mold casing. It will be observed in Figure 4 that the gear rack also extends beyond the end of the mold housing.

Referring to Figure 1, I have shown a pipe 87 that extends along the side of the casing and that is closed at one end as at 88 in Figure 5. The opposite end of the pipe 87 is joined to a bent section 89 by means of the coupling 91. The bent section 89 extends downwardly, and by means of the joint 92 is in fluid tight connection with a section of pipe 93 as shown in Figure 1 cut away. The section 93 telescopes within a section of pipe (not shown) mounted stationary with respect to the rails 2. A water tight gland, also not shown, is provided to permit movement of the section 93 within the stationary pipe and at the same time preventing any leakage by reason of this movement. As the machine moves along the rail 2, therefore, water may be supplied to the pipe 87 at all times. As shown in Figure 2, the pipe 87 is provided along its length with outlets 94.

Referring to Figures 7 and 9, there are suitably enthreaded upon the outlets 94, or joined thereto by other appropriate means in a water tight fit, valves 95. These valves comprise a valve casing 96 having a top portion 97 removable in case of repair or special adjustment. A reciprocating stem 98 projects in a water tight fit from the base of the valve casing 96 and extends through a slot 99 in a base member 101 of a stirrup. The rod 98 is maintained in contact with the member 101 by means of a spring not shown within the valve. The base of the stirrup is supported by rods 102 that are pivotally secured to an arm 103 of an angle bar. The rods 102 are threaded at their lower end and nuts 104 are screwed thereon. The plate 101 which is provided with apertures adapted to receive the arms 102 is placed on the bars and nuts 105 are then enthreaded on the rod. The nuts 104 and 105 fix the plate 102 in position. Regulation of the valve may be effected by raising or lowering the base 101 on the supports 102. A bolt or rivet 106 extends through the upper end of the rods 102 and through the arm 103, providing a pivot joint for the members.

Mounted on the flange 28 of the casing cover by means of nuts and bolts 107 is a plate 108. The top end of this plate is bifurcated as at 109. At the angle of the arm 103 and another arm 111, the angle bar is pivoted within the recess of the plate 108. The angle member is held in position by means of the bolt 112 and washer 113. The bolt 112 extends through the member 108 and through the angle member providing a pivot about which the arms 103 and 111 can oscillate.

Secured to the arm 111 by means of nuts and bolts 114 is an angle bar 115. The bar 115 is provided with a projecting portion 116 that is adapted to contact with a cam surface. By means of the bolts and nuts 114, the member 115 may be removed and shims placed between the arm 111 and the member 115. The presence of these shims will vary the angle of the bar 111, which in turn will vary the regulation of the valve. The member 116 contacts with a rotary cam 117 mounted on a shaft 118 and is held in contact therewith by means of a spring 128 extending between ears 127 and 129 on member 111 and the cover 27 respectively. As the angle arm oscillates about its point of pivot, the arm 103 will be raised or lowered. The movement of the arm 103 will be reflected in the position of the rods 102 which in turn, will regulate the valve. As the member 115 is moved toward the cover 27 of the casing, the stirrup will be raised and the valve opened. As the member 115 is forced away from the casing the arm 103 will be lowered and the stirrup will descend and close the valve.

As shown in Figure 10, the cam 117 is of the split type and is provided with annular shoulders 119. These shoulders are grooved as at 121 in Figure 11, and, held in position by the grooves 121, are wire bands 122 which are twisted as at 123. These bands when tightened and twisted maintain the two sections of the cam in position. The cams are mounted on the shaft 118 within annular channels which provide shoulders 124, preventing any longitudinal movement of the cam on the shaft. Embedded within the channel of the shaft is a projecting stud 125 which is adapted to fit in an aperture 126 in one section of the cam. The aperture 126 is of the same size as the projecting portion of the stud 125, and prevents any rotation of the cam section with respect to the shaft 118. A cam may readily be assembled on the shaft therefore by placing the section with the aperture 126 within a chanel of the shaft and fitting the aperture 126 over the stud 125. The other section of the cam may then be placed in position and the wires 122 fitted in the grooves 121 and twisted. This arrangement permits of quick and ready replacement of cams and at the same time insures that there will be no movement of the cam with respect to the shaft.

Referring to Figure 2, it will be observed that the valves and associated mechanism just described are positioned along the length of the mold casing. The shaft 118 also extends the length of the casing and is supported by bearings 131, preferably of the split type, mounted on the cover plate 27 by means of bolts 132 and nuts 133. These bearings are placed at proper lengths along the shafts to insure adequate support. The ends of the shaft 118 are mounted in the end bearings 76 and 79, heretofore described.

In Figure 2, I have shown a gear box 134 of a conventional type suitably secured to the casing cover 27 by means of the member 135 shown in Figure 1. This gear box 134 houses gears adapted to transmit motion from a shaft 136 to the shaft 118. The shaft 136 is also supported by a bearing 137. On the end of the shaft 136, there is keyed a bevel gear 138 which meshes with another bevel gear 139 mounted on a shaft 141. The shaft 141 extends within a gear reducing mechanism 142 suitably mounted on the platform 34. The driving member of the gear reducer 142 comprises a shaft 143 which meshes within the member 142 with the shaft 141. The shaft 143 is joined to an armature shaft 144 of a motor 145 by means of a sleeve 146. The motor 145 is mounted upon the platform 33 and furnishes the power for rotation of the shaft 118. The speed is considerably reduced by means of the gear reducing mechanism 142 in order to secure the proper rate of rotation for the shaft 118. An automatic circuit breaker 147 is mounted on the shaft and is connected by means of a wire 148 to the motor 145. The circuit breaker 147 is of a conventional type and is subject to adjustment so that it may be set to stop the motor 145 at any particular time during the rotation of the shaft 118. When the motor 145 is started the shaft 118 is caused to rotate which in turn, by means of the cam and associated mechanism, regulates the valves 95.

Enthreaded in the discharge ends of the valves 95 are pipe sections 149 which are connected to water tight boxes 150. The sections 149 extend through the channels, heretofore referred to, in the flanges 11 and 28 as indicated by the dotted lines 151, and are supported by the flanges. The boxes 150 rest against the inside of the mold casing as shown in Figure 7.

Referring to Figure 8 the boxes 150 are provided with five apertures 152 in which are fitted sections of pipe 153, 154, 155, 156, and 157. These pipes are suitably secured in water-tight connection with the box 150 by means of gaskets 158 and 159. As will be seen in Figures 7 and 9, the length of the pipes 153 to 157 vary, being graduated along the arc as described by the cover plate 27. As will be seen in Figure 7, each pipe is provided with an elbow 161 which connects to a section of pipe 162, which also is provided with an elbow 163. Enthreaded in the elbows 163 are pipes 164*a*, 164*b*, 164*c*, 164*d*, 164*e*, which extend lengthwise of the mold and which are fed by the pipes 153, 154, 155, 156 and 157 respectively. The pipes 164*a* to 164*e* are closed at the end opposite the elbow 163 as shown at 165 in Figure 12, and are provided with apertures 166 spaced along their length which are adapted to disperse a fluid on the mold.

Referring to Figure 7, it will be observed that the pipes 153 and 157 describe in general a semi-circle, and take, in rough, the shape of the mold. It will be observed also from this figure that the apertures 166 are radial with respect to the same point, which is the center of the mold. In this way, there is dispersed radially upon the circumference of the mold a stream of fluid as shown at 167 in Figure 6.

A bracket 168 is shown in Figure 7 mounted on the wall of the base member 3 opposite the wall on which the boxes 150 are mounted. This member is secured to the wall by means of a bolt and nut 169 and the free arm of the bracket is apertured and receives the pipe 157, affording it support. Nuts 171 are enthreaded on the pipe 157 and securely hold the pipe on the bracket. The pipe itself may extend to the bracket, or the portion extending beyond a T joint 172, which in the case of this pipe takes the place of the elbow 161, may be a solid rod. If the pipe itself extends, it will, of course, be necessary to close its end, but if it is merely a rod that projects from the T joint, the insertion of this rod within the joint will be sufficient to prevent any leakage.

Referring more particularly to Figure 8, it will be observed that the pipes 164*a* to 164*e* are of uniform length, but by reason of the position of the various pipes 153 to 157 in the box 151, they are not co-extensive. In this way, there is an overlapping among several pipes 164*a* to 164*e* along a portion of their length, and an overlapping along the remainder of their length with corresponding pipes emanating from another different box 150. In order to insure a more complete comprehension of my invention, I have primed the pipes 153 to 157 and 164*a* to 164*e* that are connected to the other box 150 shown in Figure 8. It will be observed, for instance, that when both of the valves 95 are open the pipe 164*a* overlaps pipes 164*b*, 164*c*, 164*d* and 164*e* and in turn is overlapped for instance by pipes 164*b*″ to 164*e*″. The pipe 164*b* overlaps for a portion of its length pipes 164*a*, 164*c*, 164*e*, 164*a*′ 164*c*″ to 164*e*″. By reason of the positions of the apertures 166 in the pipes 164, the corresponding pipes or different boxes 150 do not overlap each other.

It will thus be observed that a set of pipes from one box are overlapped by the set of pipes from the two adjoining boxes, and that the cooling along the length of the mold progresses uniformly rather than by sudden additional changes.

This arrangement is of particular importance when considering the varying rates of cooling over a period within each section.

In order to obtain a progressive cooling effect the cams 117 are positioned on the shaft 118 with a lead about the shaft so that the points of their surface at which they commence to operate are spaced about the circumference of the shaft. In this way, the various valves 95 are opened at different times and are liksewise closed at different times. For instance, assuming that the bell end of the casting is to be poured first the valve nearest the bell end of the mold is opened first and the other valves are successively opened toward the spigot end of the mold. Due to the configuration of the cam surface there is a constant diminution in the operation of those valves already in operation and on the other hand there are an increasing number of valves coming into operation. The effect of all of this is to provide a uniformly varying cooling along the length of the mold with no abrupt changes in the rate where all of the cams used have the same contour.

This cooling is of particular importance for by altering the cam surface, the desired rate of cooling, either for one section, or for the casting as a whole, may be obtained. As pointed out in the first part of this specification, the rate of cooling determines the structure of the finished casting.

From the foregoing, the operation of my invention is apparent. With the type of machine disclosed in this application the trough which conveys the molten metal to the mold is usually stationary. At the commencement of operation, it extends within the mold from the plain end to within a short distance of the interior face of the head core, which, as heretofore stated, is inserted in the bell end. To accomplish this, the apparatus shown in Figure 1 is moved to the left until the end of the pouring trough is at the desired position. As above stated, this movement of the machine on the track 2 is accomplished by rotation of the gear 22 which meshes with the rack 18. The motor 63 is then started, which through the gears 58, 51, and 48 rotates the mold.

Molten metal is poured into the trough and is discharged therefrom into the mold at its bell end. At the moment the metal is poured in the mold the motor that operates the gear 22 is started and the mold commences to run to the right on the track 2. The rate of this movement varies under different circumstances, and it may vary during one casting operation, for it is sometimes necessary to have a different speed of axial movement at the time metal is being poured in the bell from the speed necessary when the metal is being poured in the barrel of the mold.

At the moment that the metal is poured into the mold the motor 145 is also started. A common control may be used for the motor 145 and the motor that drives the gear 22. Operation of the motor 145 causes a rotation of the shaft 118, in synchronism with the longitudinal movement of the mold and consequently of the cams positioned on the shaft. The cam at the bell end of the shaft should be in the position of the cam shown in Figure 7,—that is, in such a position that the slightest rotation of the shaft will cause the member 116 to fall to the lower level on the cam surface and thus open the valve to the maximum extent. The pipes from the box 150 that is nearest the bell end will then be dispersing on the mold a heavy sheet of cooling medium.

During all of this time, the mold is, of course, being rotated and is also moving along the track, so that the stationary trough is discharging the molten metal at different points along the length of the mold. The shaft 118 is also rotating which means that the cams are revolving. Just prior to the time when the metal is discharged into that portion of the mold covered by the pipes emanating from the next box 150, the cam for that box is in the position of the cam shown in Figure 7. The first mentioned cam has been revolving and is now closing the valve which it controls. On slight further rotation of the second cam, the member 111 is drawn to the lowest part of the cam surface and its valve opened to the fullest extent.

In this way, the metal is poured in the mold along its length and there is a decreasing discharge from those sections in operation and a progressive increase in the number of sections operating. The rotation of the shaft 118 must, of course, be synchronized with the movement of the machine along the track so that there is a definite relationship between the time the metal is poured within a section of the mold and the time when that section commences to be cooled.

The cam illustrated in Figure 10 is designed to open its valve rapidly and then gradually close it through a closing arc of 180° or during half of a revolution of the shaft, and from then on is concentric, so that when the shaft 118 has made one half revolution the first cam cuts off the water flowing through its valve and any further rotation of the shaft does not affect the operation of the valve. When the shaft has made one complete revolution and when the first cam is in the position shown in Figure 7 all of the valves will have been closed. This type of cam is very useful in experimental work or where cooling conditions are to be changed because by raising or lowering the crosshead 101 on the rods 102, Fig. 9, the valves may be made to close at any point on the closing arc. The valve itself would not be opened as wide where only a short portion of this arc is used, as it would where a longer portion was being taken for closing, but the intensity of the spray may be regulated by the pressure on the water in the manifold 87.

With this arrangement, the shaft 118 makes a half revolution in the time that it takes to pour metal the length of the mold—in other words, the duration of the pouring operation is the interval between the opening of the first valve and the opening of the last valve, which are spaced 180° apart. When the shaft has made one complete revolution, the circuit breaker 147 stops the motor 145 and all cooling of the mold and casting ceases. The casting may now be removed from the mold by suitable means and the machine returned to position for another casting operation.

It is not essential that the casting arc be 180°. It may be less, but should not be more if the cams are all alike. The last cam, that is the one nearest the spigot end of the mold, must rotate in closed position while the other cams are opening their respective valves. The length of this closed arc is obviously equal to that of the casting arc so that 180° is the limiting condition. If the casting arc be more, then the first valve will be reopened before the last valve has closed.

By varying the cam surfaces, the rate of cooling may be altered. For instance, it may be desired to cool the molten metal rapidly down to the point of solidification and then to slowly cool the casting down through the critical ranges. As above pointed out, such a method of cooling would facilitate the graphitization of carbon and would tend to obviate the internal stresses that are set up by reason of a non-uniform cooling in cross section of the pipe. Such a product would require no annealing, or at least to only a limited extent, and would be admirably adapted for most types of use. If, however, it is desired to secure a pipe that will be resistant to abrasion and where strength is not a particularly important factor, a rapid cooling can be secured by altering the cam surface so that it will remain substantially concentric for the time that it takes the metal to cool through the critical ranges, after which the rate of cooling would be of little importance. Or again, the cams might be designed to turn the water on only when the metal is being poured and then turn it off so that a cooling zone follows the pouring metal. Such a cam is illustrated in Figure 10. In brief, the mold can be selectively cooled in the manner desired by designing the cams to open and close their respective valves at the desired times. As above pointed out, the manner in which the cams are mounted upon the shaft 118 is such that replacement or change of cams may be readily made.

The advantages of my invention are apparent. I have provided a casting apparatus that requires little manual labor for its operation, that is precise, and the product of which is certain of determination. It will be observed that not only is the casting cooled along its length, but that the cooling can be varied for any particular longitudinal section. As above pointed out, this is of the utmost importance, for it insures that every longitudinal portion of the finished casting has been subjected to the same degree of cooling as every other section, and hence a casting of uniform structure is obtained. As stated above, the cooling systems heretofore employed have subjected the casting to different rates of cooling and have resulted in finished products of non-uniform texture.

I claim as my invention:

1. A centrifugal casting apparatus comprising a rotatable mold, a cooling system for the mold, and stationary deflecting means to prevent the formation of a revolving blanket of gas created by the rotation of the mold.

2. A centrifugal casting apparatus comprising a rotatable mold and a stationary baffle mounted adjacent the mold adapted to prevent the formation of a revolving blanket of gases.

3. A centrifugal casting apparatus comprising a rotatable mold, a plurality of groups of perforated pipes arranged adjacent said mold and adapted to disperse a cooling medium on said mold, said pipes extending longitudinally of the mold, means for independently supplying a cooling medium to each of said groups, the pipes in each group being arranged in overlapping relation and the pipes in one group overlapping the pipes in an adjacent group.

4. A centrifugal casting apparatus comprising a rotatable mold, a plurality of groups of perforated pipes arranged adjacent said mold and adapted to disperse a cooling medium on said mold, said pipes extending longitudinally of the mold, means for independently supplying a cooling medium to each of said groups and means positioned in each of said supply means for controlling the supply of cooling medium to said groups of pipes, said means comprising a plurality of cam-actuated valves and a cam shaft carrying a plurality of cam surfaces for actuating the valves.

5. A centrifugal casting apparatus comprising a rotatable mold, a plurality of groups of perforated pipes arranged adjacent said mold and adapted to disperse a cooling medium on said mold, said pipes extending longitudinally of the mold, means for independently supplying a cooling medium to each of said groups and means positioned in each of said supply means for controlling the supply of cooling medium to said groups of pipes, said means comprising a plurality of cam-actuated valves and a cam shaft carrying a plurality of cam surfaces for actuating the valves, each of said cam surfaces being angularly arranged with respect to other cam surfaces carried by the shaft for effecting operation of the several groups at different times.

6. A centrifugal casting apparatus comprising a rotary mold, a plurality of spraying devices positioned adjacent the mold and adapted to spray a cooling medium thereon, a plurality of valves for controlling the flow of cooling medium to said spraying devices, a cam shaft associated with said casting apparatus and cooperating with said valves for actuating them.

7. A centrifugal casting apparatus comprising a rotary mold, a plurality of spraying devices positioned adjacent the mold and adapted to spray a cooling medium thereon, a plurality of valves for controlling the flow of cooling medium to said spraying devices, a cam shaft associated with said casting apparatus and cooperating with said valves for actuating them, means for operating the cam shaft and means associated with the cam shaft for rendering the operating means inoperative.

8. A centrifugal casting apparatus comprising a rotary mold, a housing for the mold, a plurality of cooling-medium-dispersing elements in said housing adapted to disperse a cooling medium on said mold, said elements being arranged in groups, each group adapted to cool a longitudinal section of said mold, means for conducting a cooling medium to said groups and valves in the conducting means for controlling the flow of cooling medium to said groups and a member cooperatively associated with said valves for actuating the valves to cool progressive sections of the mold.

9. A centrifugal casting apparatus comprising a rotary mold, a housing for the mold, a plurality of cooling-medium-dispersing elements in said housing adapted to disperse a cooling medium on said mold, said elements being arranged in groups, each group adapted to cool a longitudinal section of the mold, means for conducting a cooling medium to said groups and valves in the conducting means for controlling the flow of cooling medium to said groups, a shaft associated with said casting apparatus, a plurality of cams mounted on said shaft and means connecting said cams with actuating elements of said valves.

10. A centrifugal casting apparatus com-

prising a rotary mold, a housing for the mold, a plurality of cooling-medium-dispersing elements in said housing adapted to disperse a cooling medium on said mold, said elements being arranged in groups, each group adapted to cool a longitudinal section of the mold, means for conducting a cooling medium to said groups and valves in the conducting means for controlling the flow of cooling medium to said groups, a shaft associated with said casting apparatus, a plurality of cams mounted on said shaft and means connecting said cams with actuating elements of said valves, the cams on said shaft being angularly arranged with respect to each other.

11. A centrifugal casting apparatus comprising a rotary mold, a housing for the mold, a plurality of cooling-medium-dispersing elements in said housing adapted to disperse a cooling medium on said mold, said elements being arranged in groups, each group adapted to cool a longitudinal section of the mold, means for conducting a cooling medium to said groups and valves in the conducting means for controlling the flow of cooling medium to said groups, a shaft associated with said casting apparatus, a plurality of cams mounted on said shaft and means connecting said cams with actuating elements of said valves, the cam surfaces being so constructed and arranged to open said valves through said actuating elements to different extents so that the rate of flow of the cooling fluid to one group is varied during its operation.

12. A centrifugal casting apparatus comprising a rotatable mold and stationary baffle mounted adjacent the mold adapted to prevent the formation of a revolving blanket of gases, said baffle extending parallel to the axis of the mold.

13. An apparatus for casting metal centrifugally comprising the combination of a mold, means for rotating the mold, means for pouring a stream of molten metal into the rotating mold, means for imparting relative axial movement between the mold and the pouring means to build up a casting helically and means for cooling the mold, said cooling means comprising a plurality of spraying devices positioned adjacent and longitudinally of the mold and being so constructed and arranged as to discharge a cooling medium in overlapping areas upon the circumference of the mold, and means for independently operating said spraying devices.

In testimony whereof I affix my signature.

FRANK G. CARRINGTON.