Dec. 17, 1946. F. G. CARRINGTON 2,412,601

APPARATUS FOR CASTING ANNULAR ARTICLES

Filed July 8, 1943 3 Sheets-Sheet 1

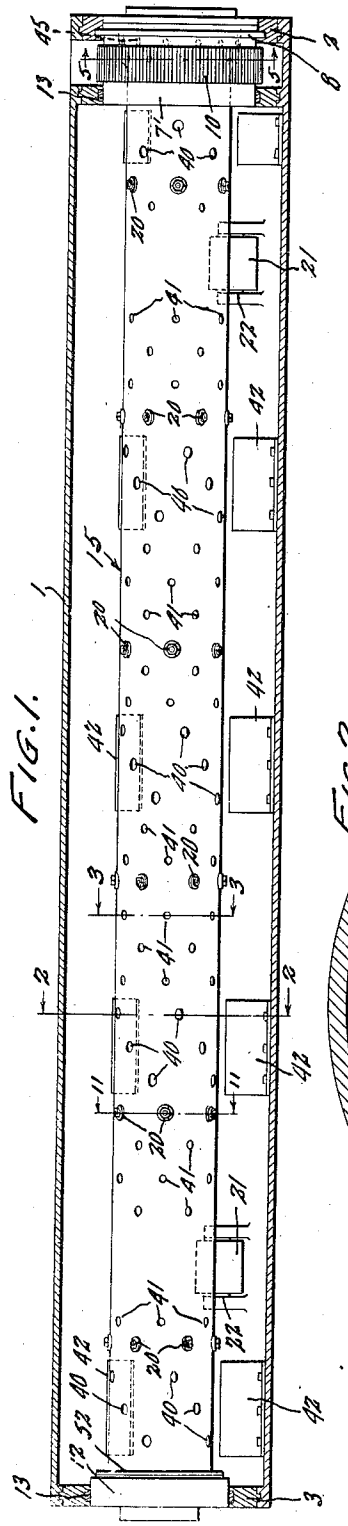


FIG. 1.

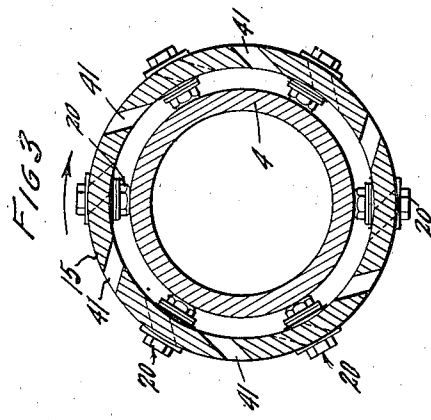


FIG. 3



FIG. 4.

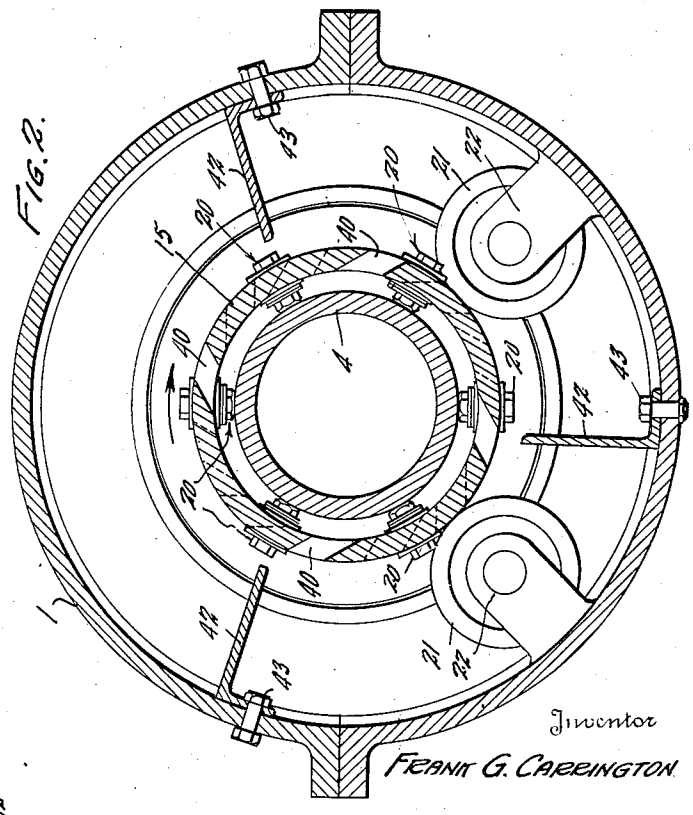


FIG. 2.

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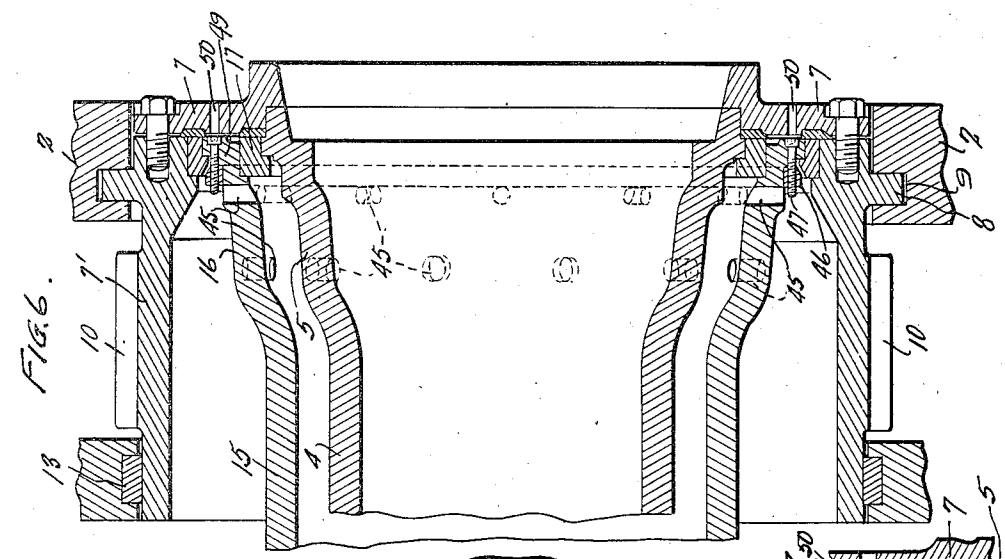


FIG. 6.

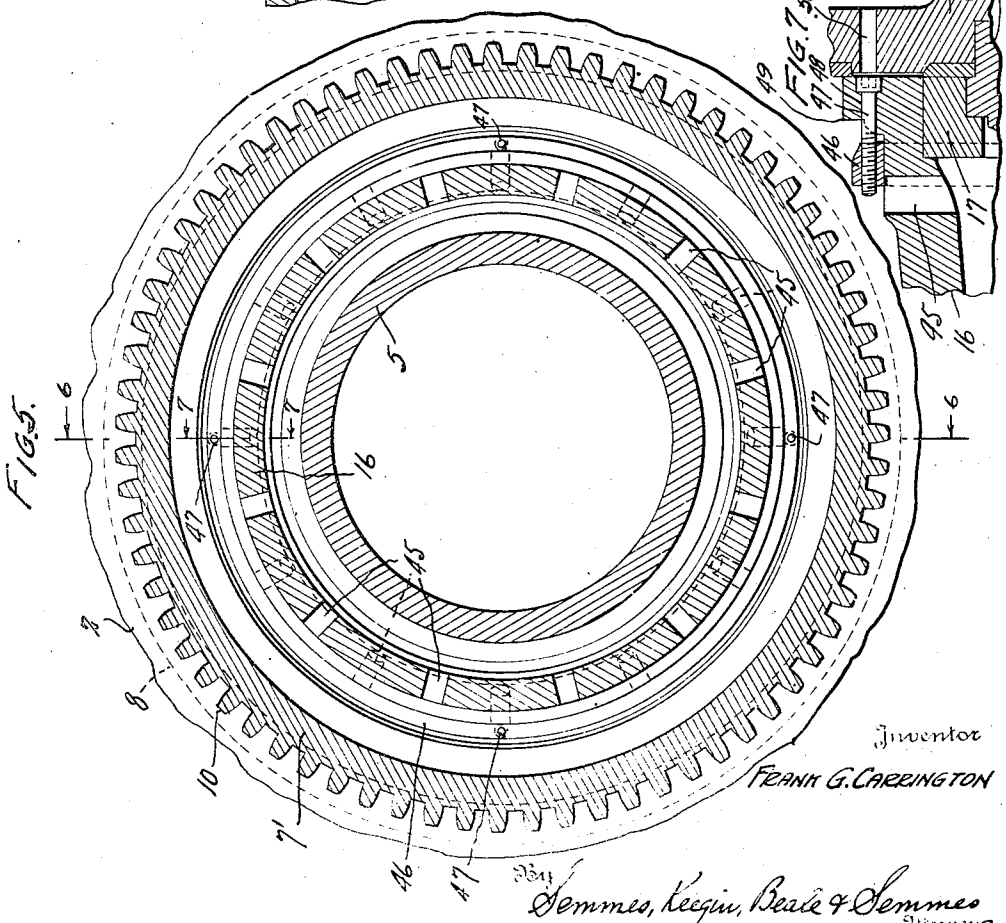


FIG. 5.

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FIG. 10.

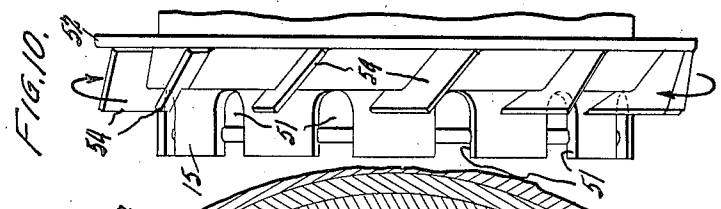


FIG. 9.

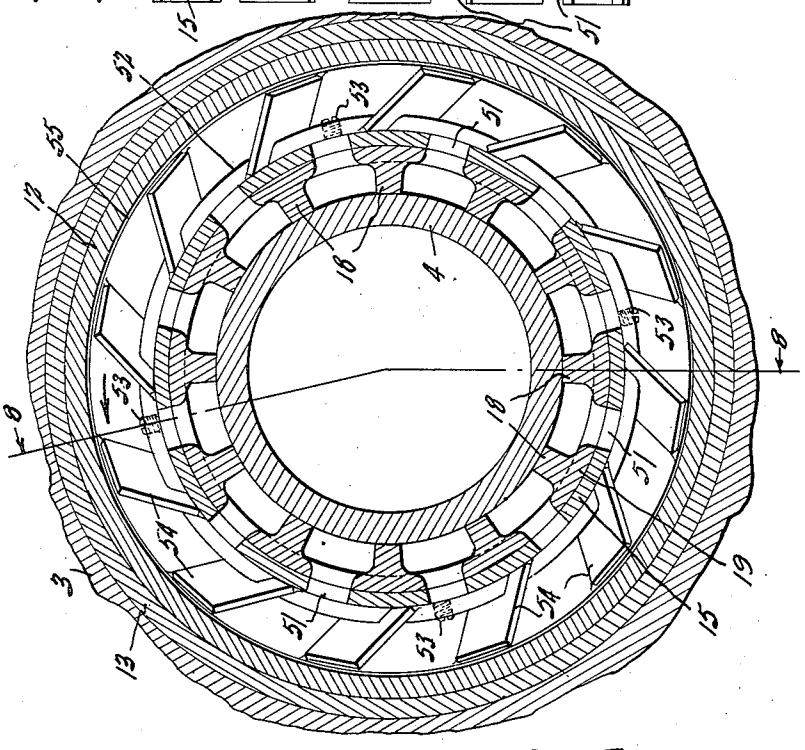
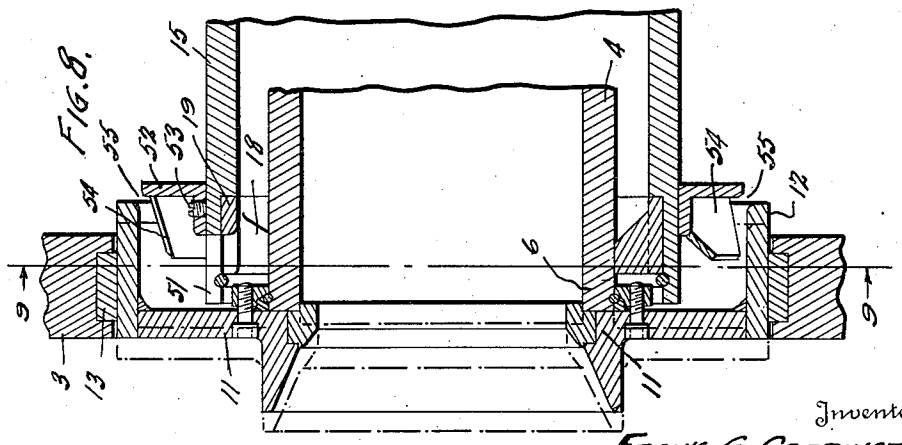


FIG. 8.



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Patented Dec. 17, 1946

2,412,601

UNITED STATES PATENT OFFICE

2,412,601

APPARATUS FOR CASTING ANNULAR ARTICLES

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Application July 8, 1943, Serial No. 493,908

8 Claims. (Cl. 22—65)

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The present invention relates to the centrifugal casting of pipe and more particularly has reference to apparatus wherein warpage of the mold is prevented and uniform cooling of the mold is maintained. More specifically, the invention covers a stiffening sleeve for the mold which extends the full length thereof and is held in spaced circumferential relation thereto by spring loaded pins of novel design. Means are incorporated in the sleeve whereby a controlled circulation of water is maintained about the mold during the casting cycle. Moreover, the design of the sleeve is such that circulation of the cooling water is continued after the pipe has been cast and as long as the mold is in a heated condition.

This invention is particularly adaptable to centrifugal pipe casting machines of the De Lavaud type which employ a non-rotating water box in which is mounted for rotation a metallic mold. These molds have certain inherent, deleterious features which both lower their efficiency and materially reduce their useful life. The molds are made usually from steel in lengths of 18 feet and in diameters to cast 3" and larger pipe and considering these molds as beams supported adjacent their ends, it will be seen that they will be subjected, especially in the smaller sizes, to bending stresses and in the larger sizes to stresses which tend to flatten or distort them out of round. Both of these effects are accentuated and may become undesirably great when the molds are heated to the temperatures reached in casting.

In addition, they are subject to warpage and cracking from stresses set up in the mold wall when the mold is heated during the casting cycle. If the thickness of the mold wall is increased to overcome the bending and flattening tendency, an increase in expansion stresses will result, due to a lessening of the heat transfer property of the mold, resulting in distortions and cracks in the mold wall. As an example, it has been found that while a mold having a one-inch wall thickness will cast approximately 4,000 pipe, if the wall is increased to 1½ inches, the useful life of the mold will be reduced to approximately 1,000 pipe.

From the above, it will be seen that while a thin wall mold has distinct advantages, in order to obtain its maximum efficiency, its beam strength must be increased or stiffened to counteract its warping tendencies. Various attempts have been made in the past to accomplish this, none of which have been entirely satisfactory. Reinforcing sleeves have been placed around the mold but their positions with respect to the mold have resulted in low cooling efficiency and their method of attachment to the mold has introduced new destructive stresses in the mold.

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Another deleterious feature found in pipe casting machines of the above type is wide variations in mold temperature which occur during the casting operation. These variations occur both in the temperature of different sections of the mold and in the mean temperature of the mold at different times as pipe are cast. While the mass of the cooling medium is maintained at an optimum cooling temperature, no provision is made either to vary this temperature over different longitudinal elements of the mold or to vary its cooling effect at different times in the casting cycle, or to control the mean temperature of the cooling medium in contact with the mold to suit different casting conditions.

It is therefore the principal object of my invention to overcome the disadvantages of the prior art by providing an improved means for stiffening a centrifugal pipe mold.

Another important object is to utilize the advantages of a thin wall mold by providing improved means to increase the beam strength of the mold to prevent warping.

Yet another important object of my invention is to provide a structure for stiffening the mold of a liquid cooled centrifugal pipe casting machine against warping which will also increase the cooling efficiency of the machine.

A further object is to provide a stiffening sleeve for a centrifugal pipe mold which surrounds the mold and is coextensive with its entire casting surface.

A still further object is to provide a stiffener for a centrifugal pipe mold which surrounds the entire mold and is spaced therefrom by diametrically opposed preloaded elements which function to exert their force only against the convex arc of warp occurring in the mold.

Another object is to provide a mold stiffener of the above described character which incorporates means for uniformly cooling the mold by a liquid circulating system which rapidly replaces the heated water in contact with the mold; which will automatically vary the rate of cooling with the rate of casting; and will vary the degree of cooling at different parts of the mold by varying the circulation over the mold in amounts controlled by the heat radiated from different parts of the molds.

Other objects and advantages will be apparent

to those skilled in the art from the following description and by reference to the accompanying drawings which form a part of this specification and in which:

Figure 1 is a longitudinal sectional view of a pipe casting machine of the De Lavaud type embodying my novel stiffening sleeve.

Figure 2 is a transverse sectional view taken along the line 2—2 of Figure 1 looking in the direction of the arrows.

Figure 3 is a transverse sectional view taken along the line 3—3 of Figure 1 looking in the direction of the arrows.

Figure 4 is a fragmental sectional view of a modified form of outlet port wherein pressure reducing means are incorporated with the outlet port.

Figure 5 is a transverse sectional view taken along the line 5—5 of Figure 1 looking in the direction of the arrows.

Figure 6 is a longitudinal sectional view taken along the line 6—6 of Figure 5 looking in the direction of the arrows.

Figure 7 is a longitudinal sectional view taken along the line 7—7 of Figure 5 looking in the direction of the arrows.

Figure 8 is a longitudinal sectional view taken along the line 8—8 of Figure 9 looking in the direction of the arrows.

Figure 9 is a transverse sectional view taken along the line 9—9 of Figure 8 looking in the direction of the arrows.

Figure 10 is a view in side elevation of the impeller provided at the spigot end of the apparatus.

As stated, my invention comprises an improvement to a centrifugal pipe casting machine of the De Lavaud type which includes, as shown in Figure 1, a non-rotating water box 1 which is substantially cylindrical in cross section and is provided with end walls 2 and 3. Rotatably mounted axially within the water box 1 is a cylindrical pipe mold 4 having a flared end 5, adapted to form the bell of the pipe, and a spigot end 6. It is to be noted that while a mold for casting bell end pipe has been shown, the improvements herein described are equally adaptable to other types of cylindrical molds.

The bell end 5 is provided with a ring or flange 7 which has attached to the outer periphery thereof a rearwardly extending sleeve 7'. The sleeve 7' is formed with an external flange 8 adapted to be journaled in an internal annular groove 9 machined in the end plate 2 of the water box. It will be seen that this construction will permit rotation of the mold but will fix the bell end against axial displacement with respect to the water box. The sleeve 7' also carries torque transmitting means, such as gear teeth 10, to effect rotation of the mold from a source of power (not shown).

The spigot end 6 of the mold is also provided with a flange, represented by the numeral 11, to form the squared spigot end of the pipe. This flange 11 is provided with a peripheral collar 12 by means of which it is journaled in the end wall 3 for both rotary and sliding movement. Suitable packing elements 13 are provided at each end of the water box to effect a substantial liquid seal between the mold and water box.

The stiffening sleeve which I have designated generally as 15 surrounds the mold 4 and extends the full length of the casting surface thereof. At the bell end, the sleeve is flared as at 16 to follow the general contour of the bell of the

mold and is attached to the mold by means of a spacer ring 17 with just sufficient clearance to allow for radial expansion of the mold at this point without exerting undue stresses. It is to be noted that the flange 16 at this point and the flange 11 at the spigot end of the mold will both tend to conduct the heat away from the mold in these zones thereby resulting in a reduced heating and expansion at the ends.

The spigot end is spaced from the mold by rigid lugs 18 projecting radially inward from a ring 19 secured to the inner periphery of the end of the sleeve. These lugs permit a sliding engagement between the sleeve and the spigot end of the mold and also permit egress of water from between the mold and sleeve at this end, as will be later described.

Intermediate its ends, the sleeve is spaced from the mold by a series of circumferential rows of diametrically opposed radial pins 20 of a novel construction. The mold and stiffener assembly is rotatably supported on pairs of rollers 21 journaled in bearings 22 affixed to the inner surface of the water box 1 adjacent each end thereof.

During the casting cycle, the mold is subjected to warpage and the maximum warpage for a mold of a given length, wall thickness and diameter and under given conditions of heating has been learned from experience. For example, in a six-inch mold having a one-inch wall and a length of eighteen feet, the amount of this warping has been found to be about one-quarter inch. This factor being known, it is a simple matter from well-known formulae, to calculate the number, distribution and amount of loads necessary to counteract this warping throughout the length of the mold. In calculating these loads, the tendency of the cylindrical mold to corrugate during expansion at the points at which they are applied must also be considered. Here again well-known formulae may be applied to determine the maximum load which will not exceed the strength of the wall section of the cylinder. From these calculations, considering a mold of 6'' diameter and 18' length having a wall thickness of 1'', it is determined that if six loads, each capable of exerting a known force, are radially spaced at equal distances about the circumference of the mold and each circumferential row of loads arranged at three foot intervals along the length of the mold, the force necessary to counteract the ¼'' warpage normally to be expected will be several times less than that which will produce corrugating distortion of the cylinder.

Cooling of a De Lavaud mold is effected by means of water circulated through the water box and maintained at an optimum mean temperature, the degree of cooling of the mold being controlled by the temperature of the mass of water in the water box. This system of cooling, however, has proved inefficient due partly to the progressive method of pouring the metal, changes in rotational speed of the mold to suit varying casting conditions, differential heating over the length of the mold and to other reasons. I propose, therefore, to incorporate with my stiffening sleeve means to control the circulation of water about the mold whereby the cooling rate may be varied to suit the varying heating conditions.

To accomplish this, I perforate the stiffening sleeve 15 over its length with inlet and discharge ports designated 40 and 41 respectively. These ports are radially spaced around the sleeve and are arranged longitudinally of the mold so that

circumferential groups of inlet ports will alternate with circumferential groups of discharge ports. It is to be noted that the capacity of the inlet ports is made greater than that of the discharge ports and that the axial arrangement of the ports is such that there is an inflow of water near the center of the sleeve and a longitudinal flow toward each end from that point. It will be also noted from Figure 1 that each circumferential row of ports is indexed with respect to the adjoining row and also with respect to the loading elements 20 to minimize weakening the sleeve.

Referring to Figures 2 and 3, I have shown the inlet ports 40 and the discharge ports 41 are drilled at an angle to the surface of the sleeve, the inlet ports being inclined outwardly in the direction of rotation while the discharge ports 41 are inclined in a direction opposite the direction of rotation. These ports form, in effect, a pump to induce a flow of the water into the space between the sleeve and the mold and move it longitudinally in this space when the mold is rotating. To assist this pumping action, radial baffles 42 are secured to the inner wall of the water box 1 as shown at 43 in the areas adjacent the inlet ports to inhibit spinning of the water which would normally be caused in these areas by the rotation of the mold. Additionally, under certain conditions of operation it may be desirable to induce a more vigorous circulation of the water. This can be accomplished by hooding the discharge ports as indicated at 44 in Figure 4 to create areas of reduced pressure adjacent the discharge ports.

As shown in Figures 5 and 6, the bell end 16 of the stiffening sleeve 15 is provided with a series of radial discharge ports 45. Since the water between the mold and sleeve is discharged through these ports on a greater diameter, a flow will be induced toward the bell end of the mold. Means are provided to control this longitudinal flow which include a ring 46 slidably positioned around the bell end 16 of the stiffener adjacent a circumferential row of the discharge ports 45 in a manner to be capable of restricting these ports. Movement of the ring is effected by means of headed screws 47 positioned in counterbored apertures 48 located in the flanged end 49 of the stiffener 15. Since the inner face of the mold flange 6 lies adjacent this flange 49, access holes 50 are provided therein coaxially with the screws 47. These holes 50 are drilled a smaller diameter than the heads of the screws 47 to prevent longitudinal displacement of the screws when the ring 46 is adjusted to regulate the ports 45.

In order to induce a flow from the center toward the spigot end of the mold, I provide the spigot end of the stiffener 15 with a series of discharge slots 51 located between the spacing lugs 18 of the ring 19. Adjacent these slots 51 is a flanged ring 52 adjustably mounted exteriorly of the stiffener by means of set screws 53. A series of angularly disposed vanes 54 are integrally attached to the flanged ring, as best shown in Figures 9 and 10, to accelerate water circulation. This structure forms, with the spigot ring 12, a pump whose inlet is the series of slots 51 and whose outlet is the space 55 formed between the peripheral edge of the flange 52 and the free end of the ring 12. The space 55 is variable in size depending upon the heat of the mold and, as shown in Figure 8 by dotted lines, as the mold expands during the casting operation, the bell end being fixed, the spigot end will tend to move longitudinally outward. This increase in size of the discharge gap 55 results in an increase in the discharge rate of the pump and a consequent increase in water circulation over the mold.

In operation, the mold 4 is put in rotation and molten metal is deposited therein progressively from the bell to the spigot end, adhering to the inner surface of the mold by centrifugal action where it is cooled and solidified by transfer of its heat through the wall of the mold to the cooling liquid in the water box. After the pipe has solidified, the mold is stopped, the pipe withdrawn from the mold and the mold then put in operation for the next casting.

During the casting operation water enters the space between the mold and the sleeve through the inlet ports 40 and its flow is induced longitudinally toward both ends. This water is heated upon coming in contact with the mold but, because of the proportion and disposition of the inlet and outlet ports intermediate the center and ends and because of the discharge arrangement provided at each end of the sleeve, the heated water is rapidly replaced by cool water from outside the sleeve. As the pouring progresses and the mold becomes increasingly hotter it will expand longitudinally and widen the discharge gap 55, increase the rate of flow toward the spigot end of the mold, and thereby displace the mean point of intake toward the bell end. With pouring terminating at the spigot end, this end of the mold becomes hottest at the finish of the casting cycle and the above cooling conditions are found to be highly advantageous in that they automatically provide for more vigorous cooling for the hottest portions of the mold. Another distinct advantage which results from this automatic increase in circulation with increase in mold temperature is that it effectively prevents overheating and damage to the mold.

Automatic control of cooling is likewise provided to vary the rate of circulation with varying pouring rates. For efficient operation of the mold the cooling rate should be in proportion to the rate at which the molten metal is being admitted into the mold, and, as the pouring rate is governed by the mold speed, the rate of coolant circulation, because of the pumping properties of the sleeve, will also automatically be controlled by the rotational speed of the mold. In other words, when the speed of the mold has been increased to provide for a faster pouring rate, the water circulation will also increase resulting in a consequent increase in heat transfer as the hot water in the space between the mold and sleeve is replaced more rapidly by cool.

Beside the automatic control of the flow of water between the mold and sleeve, as described above its circulation, particularly in regard to the mean point of intake, may be further controlled by manipulation of the closure element 46 to increase or decrease the amount of water discharged at the bell end of the sleeve. This control is effected by the operator between casting operations to provide the optimum cooling for given casting conditions.

After the casting cycle is completed and the mold stopped, the circulation is continued through both the inlet and discharge ports and ends by the heated water in contact with the mold rising upwardly.

Having shown and described only a preferred embodiment of my invention I wish it understood that changes may be made therein which would be obvious to those skilled in the art without departing from its spirit and therefore I wish to

be limited only by the scope of the appended claims and the state of the prior art.

I claim:

1. In a cooling system for centrifugal pipe casting apparatus having a water box and a tubular mold rotatively mounted therein, a sleeve surrounding the full length of the mold and spaced therefrom, a plurality of inlet passages in the sleeve for introducing fluid through the sleeve into the space between the mold and sleeve, fluid impelling means disposed at each end of the sleeve for discharging fluid from the space and serving thereby to circulate fluid simultaneously towards opposite ends of the mold to cool the same, and means responsive to the temperature of the mold for controlling the rate of discharge through one of the said impelling means.

2. In a cooling system for centrifugal pipe casting apparatus having a water box and a tubular mold rotatively mounted therein, a sleeve surrounding the full length of the mold and spaced therefrom, a plurality of inlet passages in the sleeve for introducing fluid through the sleeve into the space between the mold and sleeve, fluid impelling means disposed at each end of the sleeve for discharging fluid from the space and serving thereby to circulate fluid simultaneously towards opposite ends of the mold to cool the same, manually adjustable means for controlling the rate of discharge of fluid from one of said fluid impelling means, and means responsive to the temperature of the mold for controlling the rate of discharge from the other of said impelling means.

3. In a centrifugal pipe casting apparatus having a water box and a tubular mold extending through said box and rotatably supported therein, said mold being adapted to receive molten metal progressively from one end towards the other, a sleeve surrounding the full length of the mold and spaced therefrom, means for introducing fluid from the water box into the space between the mold and sleeve intermediate the ends of the sleeve, fluid impelling means adjacent each end of the sleeve for discharging fluid from the space and serving thereby to circulate fluid over the mold to cool the same, and means responsive to the temperature of the mold for controlling the discharge of fluid from the end last receiving molten metal.

4. In a centrifugal pipe casting apparatus having a water box and a tubular mold extending through said box and rotatably supported therein, said mold being adapted to receive molten metal progressively from one end towards the other, a sleeve surrounding the full length of the mold and spaced therefrom, means for introducing fluid from the water box into the space between the mold and sleeve intermediate the ends of the sleeve, fluid impelling means adjacent each end of the sleeve for discharging fluid from the space and serving thereby to circulate fluid over the mold to cool the same, manually adjustable means for controlling the impelling means at the end first receiving molten metal, and means responsive to the temperature of the mold for controlling the amount of fluid discharged by the impelling means at the end last receiving molten metal.

5. In a cooling system for centrifugal pipe casting apparatus having a water box, and a tubular mold rotatively mounted therein, a sleeve surrounding the full length of the mold and spaced therefrom, a plurality of fluid inlet and outlet passages alternately arranged in the sleeve for

introducing and ejecting fluid to and from the water box into the space between the mold and sleeve, said inlet passages being disposed substantially tangentially to the sleeve in the direction of rotation thereof and said outlet passages being disposed substantially tangentially to the sleeve counter to the direction of rotation of the sleeve, deflecting means associated with the water box and disposed adjacent the sleeve in the areas of the inlet passages, fluid impelling means adjacent each end of the sleeve for circulating the introduced fluid simultaneously towards opposite ends of the space serving thereby to cool the mold, and means responsive to a change in temperature of the mold for controlling the rate of discharge through one of the said impelling means.

6. In a centrifugal pipe casting apparatus having a water box and a tubular mold extending therethrough and rotatably supported therein, said mold having a bell end and a spigot end, a sleeve surrounding the mold and uniformly spaced therefrom throughout its length, means for introducing fluid from the water box into the space between the mold and sleeve intermediate the ends of the sleeve, fluid impelling means adjacent the spigot end of the mold, additional fluid impelling means adjacent the bell end of the mold, both said means tending to regulate the discharge of fluid from the space, means responsive to temperature changes in the mold for controlling the discharge through the first named impelling means, and manually adjustable means for controlling the discharge through the additional impelling means.

7. In a centrifugal pipe casting apparatus including a water box and a rotatable tubular mold having a bell end and a spigot end extending therethrough, a sleeve surrounding the mold and uniformly spaced therefrom, said sleeve being positively secured with the mold at the bell end, fluid passages in the sleeve intermediate its ends for introducing cooling fluid from the water box into the space between the mold and sleeve, centrifugal fluid impelling means adjacent the bell end of the mold for discharging fluid from the space, a flange carried by the spigot end of the mold and being slidably supported with respect to the sleeve, a ring member supported by the sleeve and cooperating with said flange to form a pumping chamber, said chamber having a discharge port, impeller blades extending into the chamber, and rotatable with the mold for discharging fluid from the space through the port, said mold and sleeve being so constructed and arranged that as the mold expands longitudinally under an increase of temperature during the casting operation the discharge port will be enlarged to thereby increase the circulation of cooling fluid over the mold.

8. In a cooling system for a centrifugal pipe casting apparatus having a water box and a tubular mold rotatably mounted therein, a sleeve surrounding the mold and spaced therefrom, a plurality of inlet passages in the sleeve for introducing fluid through the sleeve into the space between the mold and sleeve, fluid impelling means disposed at each end of the sleeve for discharging fluid from the space and serving thereby to circulate fluid simultaneously towards opposite ends of the mold to cool the same, and means responsive to the temperature of the mold for controlling the rate of discharge through one of the said impelling means.

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