May 9, 1933. H. M. NAUGLE ET AL 1,908,169

MASSIVE RING MANUFACTURE

Filed Sept. 18, 1931 4 Sheets-Sheet 1

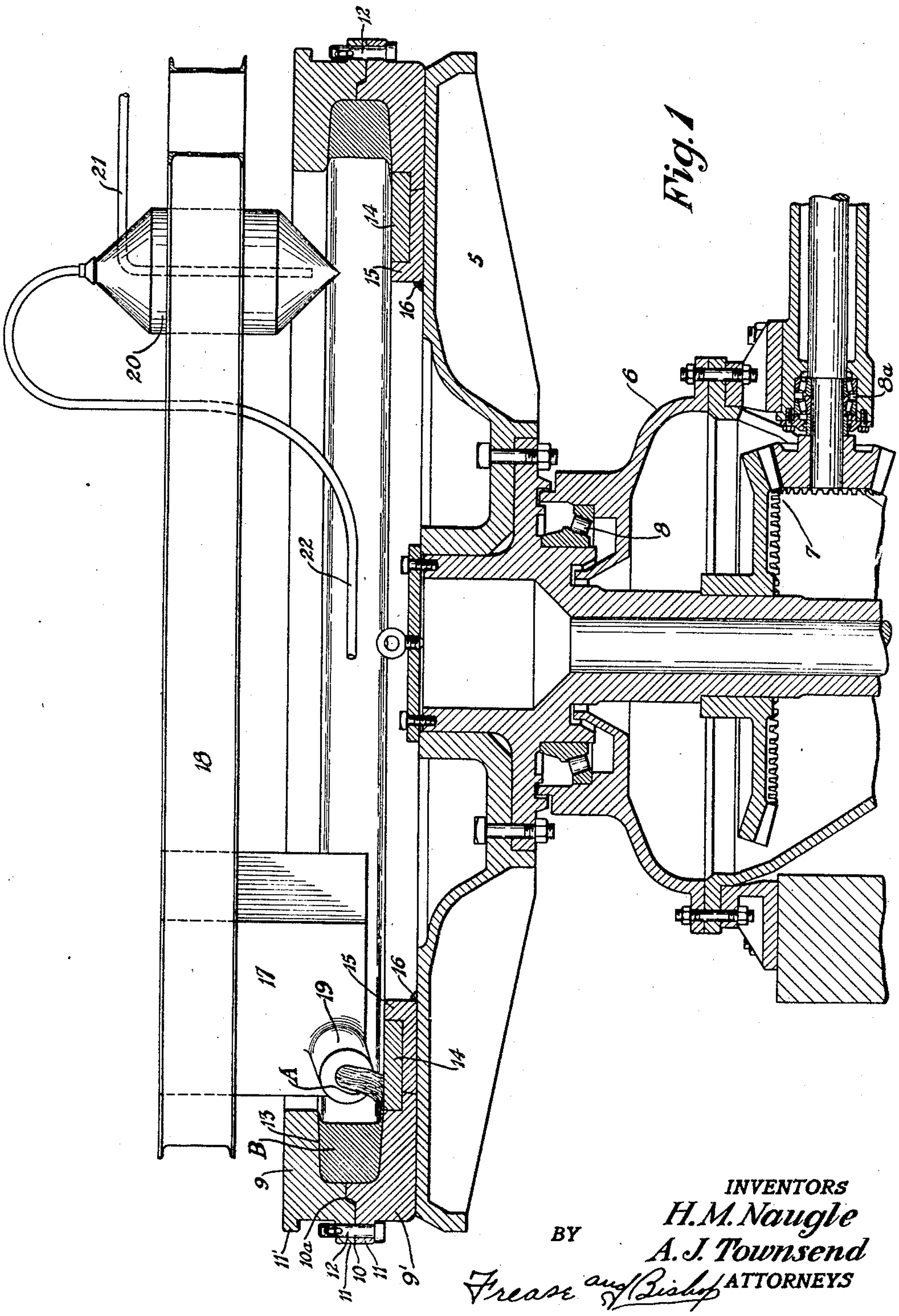

Fig. 1

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4 Sheets-Sheet 2

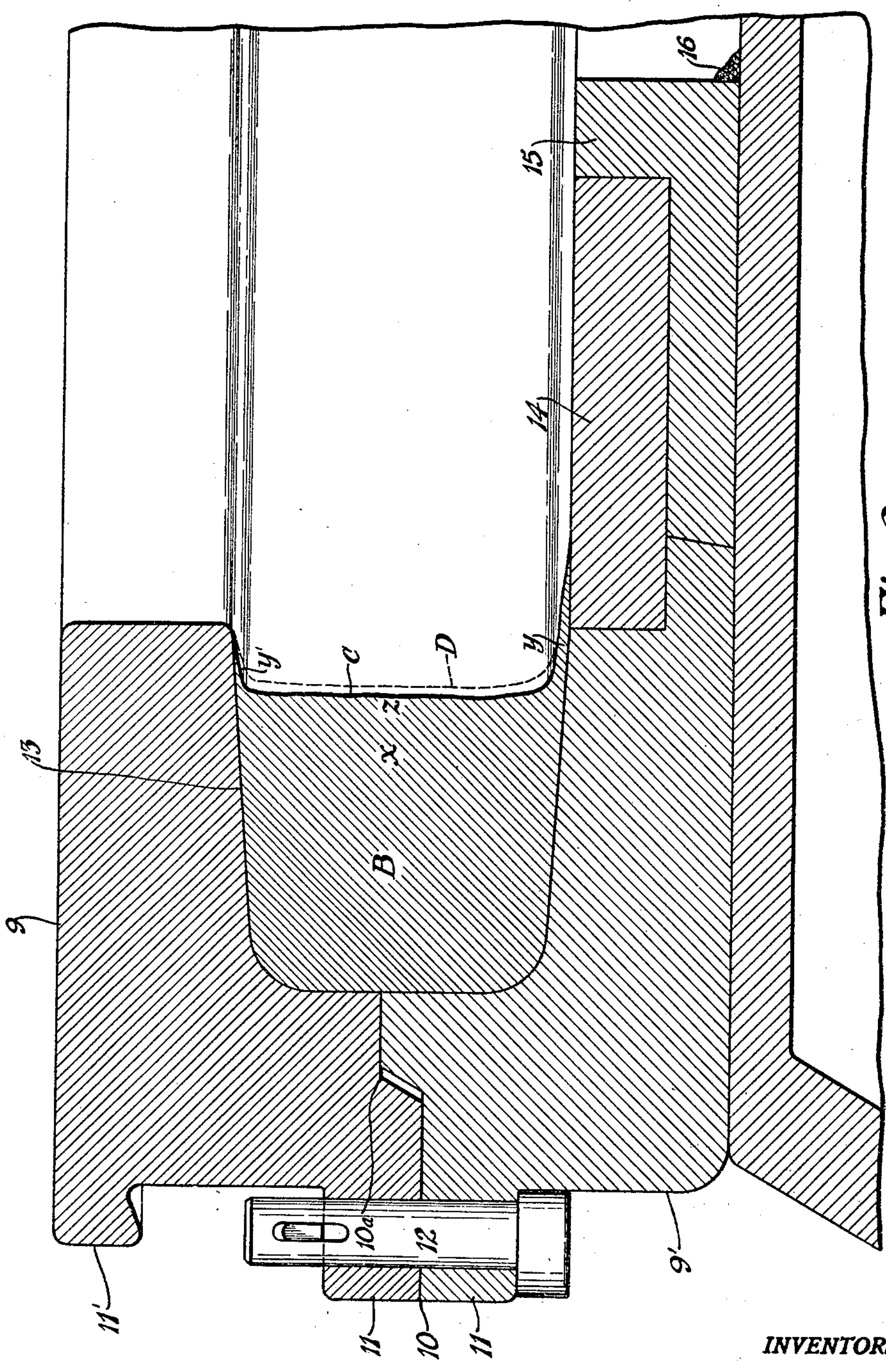

Fig. 2

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MASSIVE RING MANUFACTURE

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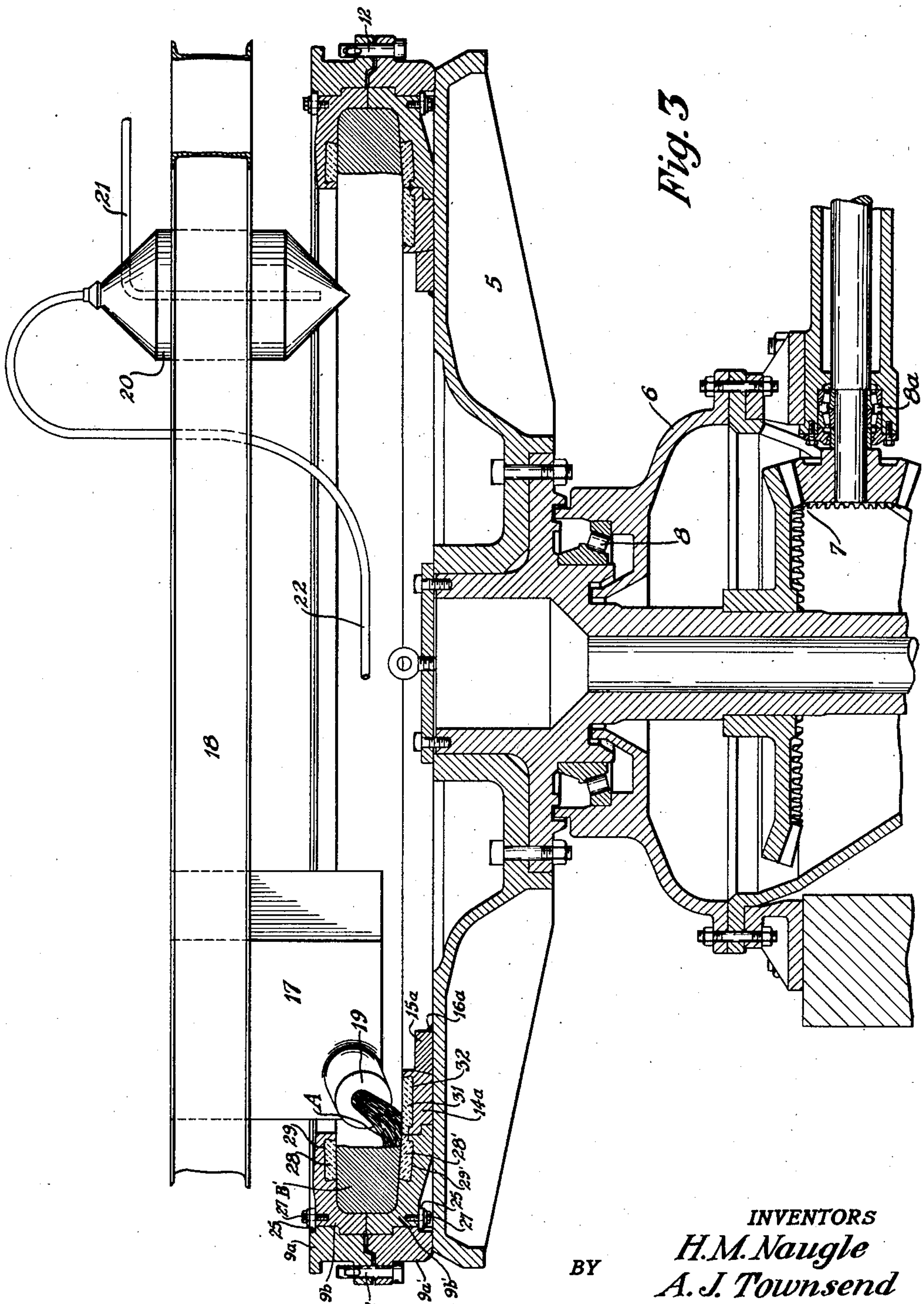

Fig. 3

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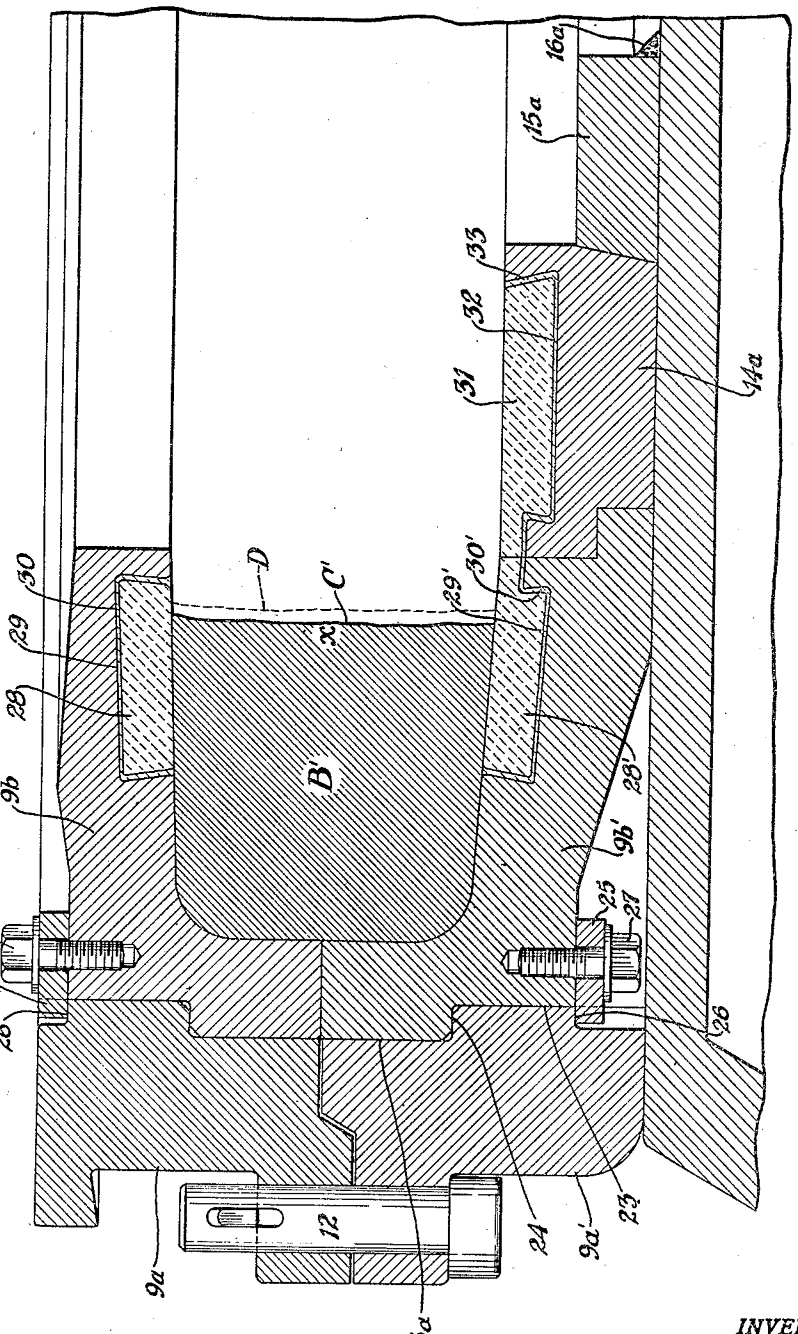

Fig. 4

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Patented May 9, 1933 **1,908,169**

UNITED STATES PATENT OFFICE

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MASSIVE RING MANUFACTURE

Application filed September 18, 1931. Serial No. 563,583.

Substantial progress has been made in the manufacture of massive metal rings having a substantially square cross section of sixteen square inches and upwards and a circumferential length of twenty-five feet and upwards, for making deoxidized or "killed" steel blooms, slabs and billets free of cavities and openings, in which the metal is homogeneous throughout; by the methods and apparatus set forth in our prior applications filed, respectively, May 17, 1930, Serial No. 453,310 since abandoned, and July 2, 1930, Serial No. 465,303, matured in Patent No. 1,882,516 on October 11, 1932.

In the practical operation of the apparatus and the use of the methods set forth in said prior applications, some difficulties have been experienced because of the formation of cavities or openings in certain portions or regions of the rings; arising, no doubt, from the differential rate of cooling and solidifying of the molten metal in different regions of the cross section of the metal which forms the ring.

Even though the ring is made by flowing and compressing molten metal which has previously been deoxidized, at a temperature of 2600° F. and upward, into a rapidly rotating annular mold, maintaining centrifugal pressure until the metal is cooled to a self-sustaining, plastic condition, and then reducing the centrifugal pressure until the metal has further cooled to permit the ring to shrink without a granular disintegration of the metal, as set forth in said application Serial No. 465,303; certain cavities or openings may be formed in different portions or regions of the ring, and inwardly extending flanges or fins are usually formed on one or both, especially on the lower one of the inner corners of the ring, which fins must be severed and removed therefrom before straightening and rolling a section of the ring, as set forth in said application, Serial No. 453,310.

When such cavities or openings are formed in the body of the metal, even though deoxidized or "killed" steel is used, they usually occur in or near the median plane, about midway between the upper and lower faces of the ring, and considerably nearer to the inner face than to the outer face or periphery of the ring; and although the cavities or openings do not usually extend entirely around the ring, their presence in any part or region thereof is very objectionable, and unless the section of the ring containing such cavities or openings can be located and eliminated, there may be a serious flaw in the finished product made therefrom.

It is, therefore, the principal purpose of the present improvements, to prevent the formation of cavities or openings in the body of massive metal rings made in rotating molds from deoxidized steel, and to prevent the formation of projecting fins on the inner corners thereof; and that purpose may be accomplished in a general way, by controlling the rate and progress of cooling of the molten metal as it flows into and solidifies or freezes within the cavity of the mold, and/or in a particular way, by increasing the temperature of the molten metal at the inner face of the ring, after it is formed and before it has cooled enough to solidify.

It has been discovered by practical experience, that the cooling of the molten metal progresses quite rapidly inward from the outer side of the cavity of the mold, and also quite rapidly upward and downward from the lower and upper sides of the mold, depending upon the relative thickness of the metal walls of the mold; and that the molten metal at the inner face of the ring begins to cool and solidify very quickly after the ring is formed, and before the cooling from the outer, upper and lower walls of the mold has progressed inward to the inner face of the ring, so that the last portion of the metal to cool and solidify is in the median plane of the ring nearer to the inner face than to the outer face thereof.

As that location is the same place in which cavities or openings are sometimes formed in certain portions or regions of the ring, the formation thereof is, no doubt, caused by a shrinkage of the metal away from the place of the final cooling and solidifying of the molten metal, toward the outer faces of the ring, from which the cooling and solidifying has progressed.

We have, therefore, discovered that the general purpose of the present invention may be accomplished by retarding or delaying the cooling of the molten metal throughout the entire area of the inner face portion of the ring, as by applying thereto a heat insulating or non-conducting material to prevent the radiation of heat therefrom, and/or by locally retarding or delaying the cooling of the upper and lower portions of the ring adjacent to its inner face until the cooling has progressed inward from the outer face or periphery of the ring entirely to the inner face thereof, before the molten metal has cooled and solidified at that place; so that the shrinkage of the metal away from the place of final cooling and solidifying may cause a depression in the inner face of the ring, rather than a cavity or opening in the body of the metal.

We have found that the first result referred to, of retarding the cooling of the metal at the inner face of the ring, may be accomplished by utilizing the normal slag which may be permitted to remain in the molten metal, or by running molten slag, or other substance, such as magnesium compounds or sand, into the mold, or by applying a blanket of fire clay or burned dolomite to the inner surface of the molten metal immediately after the molten metal has been poured; and as the slag or other substance is lighter than the molten metal, it forms a heat insulating coating or blanket upon the inner face of the ring, and by retarding the cooling thereof, brings the final point or place of solidification in the median plane at or very close to the inner face of the ring.

We have also found that the second result referred to, of locally retarding the cooling of the upper and lower portion of the ring adjacent to its inner face, may be accomplished by inserting rings of refractory heat insulating material, such as fire brick and the like, in the walls of the mold, and especially in the upper and lower walls thereof, at and adjacent to the inner face of the ring cast therein; so as to cause a selective freezing of the molten metal in the ring, and retard the cooling and solidifying of the inner portions thereof until the cooling and solidifying has progressed from the peripheral portions of the ring inward to the inner face thereof, thus bringing the final point of solidification at or very close to the same.

And we have further found that, by providing an annular zone of refractory heat insulating material in the bottom of the rotary mold table, immediately inside of the cavity of the mold, so as to receive the molten metal as it is poured and flows into the mold, the same will retard the cooling of the metal as it is poured upon the table and prevent the formation of a fin or flange extending inward from the lower corner of the ring; and that the presence of refractory heat insulating rings in the upper and lower sides of the mold, at and adjacent to the inner face of the ring, serves to prevent the formation of any fins or flanges whatever on the inner corners of the ring, and saves the waste of labor and material required for removing the same.

We have also discovered that in event the inner face of the ring cools so rapidly that it begins to solidify before the cooling from the outer side of the ring progresses to the inner side thereof, it may be desirable, if not necessary, to temporarily increase the temperature at the inner face of the ring as soon as it is formed, either with or without a subsequent application of heat insulating material thereto; and the same may be done by the application to the molten inner face of the ring, and elsewhere, if desired, of a substance or a combination of substances, as for instance, the combination of finely divided aluminum and iron oxide, the chemical reaction of which increases the temperature of the metal and delays the cooling and solidifying thereof at the place or places where the substance is applied.

The principal purposes of the present improvement, thus set forth in general terms, and ancillary advantages in the operation of rotary molds for making massive metal rings, have been successfully accomplished by means of the apparatus illustrated in the accompanying drawings, forming part hereof, in which—

Figure 1 is an axial elevation section of a portion of a centrifugal casting machine showing a supporting table with an ordinary form of annular ring mold thereon, by which some of the improved process steps have been successfully carried out;

Fig. 2, an enlargement of the cross section, at one side of the ordinary mold;

Fig. 3, an axial elevation section of the same machine with an improved form of annular ring mold thereon, by which all of the inmproved process steps have been successfully carried out; and

Fig. 4, an enlargement of the cross section, at one side of the improved mold.

Similar numerals refer to similar parts throughout the drawings.

The centrifugal casting machine preferably includes a round table 5 mounted on a vertical axis, for rotating upon a supporting base 6 by driving gearing 7 provided with roller bearings 8 and 8*a* to insure an even, steady and uniform rotation of the table at a high rate of speed, which may be some 200 R. P. M.

The ordinary mold may include substantially similar opposing sections 9 and 9′, having a substantially horizontal joint 10 with an offset 10*a* therein substantially in the median plane of the mold; with the necessary flanges 11 and key bolts 12 for detachably securing the sections together, and/or a flange 11′ on the upper section by means of which the upper section or both sections may be raised and carried by suitable crane tackle, not shown.

The annular mold cavity 13 is suitably shaped to give the desired section to a massive ring, preferably with the upper and lower sides of the mold slightly tapered outward toward each other, with rounded corners at the outer side of the mold; and the lower side of the mold may be extended inward by means of a replaceable annular wear plate 14, for receiving and flowing molten metal into the mold cavity, as indicated conventionally at A in Fig. 1.

The mold as a whole, or its separable lower section, may be centrally located and maintained on the rotary table, by means of a centering ring or plurality of blocks 15, which may be secured as by welding 16 upon the top of the table.

A molten metal pouring box 17 is removably supported and suspended, as by a frame 18 movable upon a support, not shown; which box is provided with a discharge spout 19 located adjacent the inner side of the mold and directed to discharge molten metal, substantially tangentially, upon the annular plate 14, at the inner side of the mold cavity whence the metal flows by action of centrifugal force, outward into the mold cavity when the machine is rotated, as indicated at A.

A container 20 for a powdered iron-oxid aluminum mixture may be supported over the machine upon the same frame 18, into which container compressed air may be injected through a pipe 21 for discharging the powdered mixture through an outlet pipe 22, having its open end directed substantially tangentially adjacent the inside of the metal ring B when formed, so as to spray and coat the inner area of the ring as and after it is formed, with the oxid-aluminum mixture, to temporarily increase the temperature at the inner area of the ring as and after it is formed.

In the improved form of mold illustrated in Figs. 3 and 4, each upper and lower section of the mold is divided into an outer and inner part, respectively 9*a*, 9*b*, 9*a′* and 9*b′*, the division being by a substantially vertical joint 23 and 23*a* having an offset 24 therein, so that the inner parts may be readily detached for replacement; but will normally be secured to the outer part, as by means of rings 25 bearing upon a shoulder 26 on the outer part, and secured to the inner part as by means of bolts 27.

An annular ring of heat insulating refractory material 28 is inserted in an annular channel 29 provided for that purpose in the upper wall of the mold, to face a portion of the mold cavity adjacent the inner portion thereof, which ring may be made of a series of arcuate fire brick dovetailed into the channel and secured therein, as by a fire clay cement 30.

A similar annular ring 28′ of heat insulating refractory material is inserted in an annular channel 29′ provided for that purpose in the lower wall of the mold, to face a portion of the mold cavity at and adjacent the inner portion thereof; which ring may be made of a series of arcuate fire brick dovetailed into the channel and secured therein, as by a fire clay cement 30′, all as well shown in Fig. 4.

The lower side of the mold may be extended inward by means of a detachable annular wear plate 14*a*, for receiving and flowing molten metal into the mold cavity, as indicated conventionally at A′ in Fig. 3; and in the improved form of mold, an annular zone of heat insulating refractory material 31 is inserted in an annular channel 32 provided for that purpose in the upper side of the ring, and extending from the outer corner thereof to a point adjacent the inner corner thereof, to receive and insulate the molten metal as it is poured upon the wear plate 14*a*; and this zone may be made of a series of arcuate fire brick dove tailed into the channel 32 and secured therein, as by a fire clay cement 33, as well shown in Fig. 4.

The improved mold as a whole, or its separable lower section, is preferably centrally located and maintained on the rotary table by means of a centering ring or plurality of blocks 15*a* which may be secured as by welding at 16*a* upon the top of the table.

In operating the ordinary form of mold illustrated in Figs. 1 and 2, the molten metal poured upon the table from the spout 19, flows immediately outward by action of centrifugal force, until the ring B is formed, as conventionally shown in Figs. 3 and 4; and without the improved methods set forth herein, one or more openings or cavities may be formed at or in the region of the place marked *x* in Fig. 2, and a considerable flange or fin *y* is usually formed at the lower inner corner of the ring, no doubt by a premature cooling of the molten metal as it flows into the cavity of the mold; and a smaller fin *y′* is sometimes formed at the upper inner corner of the ring by a slight flowing and freezing of the molten metal inside of the formed face C of the ring.

By use of the insulating material 28 and 28′ in the upper and lower walls of the mold at and adjacent to the corresponding corners of the formed ring, and the use of slag or other insulating material in the molten metal to form a heat insulating coating or blanket, shown by dotted lines at D on the inner face of the formed ring, the cooling of the molten metal in the inner portions of the ring is so retarded that the cooling of the metal has progressed inward from the outer portions of the ring entirely to the inner face thereof, and that the final cooling and solidifying will occur at or about *z*, as shown in Fig. 2.

A similar result may be accomplished, either with or without the insulations referred to herein, by spraying a mixture of finely divided aluminum and iron-oxid so as to form a coating upon the entire inner area of the ring as and after it is formed, so as to increase the temperature and delay the cooling and solidifying of the metal in the inner portion of the ring, until it has progressed inward from the outer peripheral portions entirely to the inner face thereof.

In practice, however, either one, any two, or all of the three method steps set forth herein may be employed, according to the varying conditions which may be present during the molding of a massive metal ring; so that the cooling and solidifying of the molten metal throughout the entire area of the inner face portion of the ring will be uniformly retarded until the cooling and solidification of the molten metal has progressed from the outer peripheral portion of the ring inward to the inner face thereof.

The presence of the insulating zone 31 in the annular wear plate 14*a* in the improved mold, and the adjoining insulating ring 28′ in the lower section of the mold, retards the cooling and prevents a solidification of the molten metal as it is poured upon the table at the inner side of the mold and flows upon the same into the mold, and the formation of a flange or fin upon the inner lower corner of the ring B′ is thus avoided.

And the presence of the insulating ring 28 in the upper section of the mold likewise prevents the formation of a fin at the inner upper corner of the ring B′, so that the inner face C′ of the ring is formed without any flanges or fins upon its inner corners, as shown in Fig. 4, thus saving the waste and expense of removing the same before the ring can be cut into sections and blooms formed and thereby rolled into bars or other products.

We claim:—

1. The method of making a massive ring from molten metal in a rotating annular mold, which includes flowing molten metal into the mold until the ring is formed, and uniformly retarding the cooling and solidification of the molten metal throughout the entire area of the inner face portion of the ring until the cooling and solidification of the molten metal has progressed from the outer peripheral portion of the ring inward to the inner face thereof.

2. The method of making a massive ring from molten metal in a rotating annular mold, which includes flowing molten metal into the mold until the ring is formed, retarding the cooling and solidification of the upper and lower faces of the ring at and adjacent the inner corners thereof as and after the ring is formed, applying a coating of heat creating material to the inner area of the ring, and applying a blanket of heat insulating material to the inner face of the ring.

3. The method of making a massive ring from molten metal in a rotating annular mold, which incudes flowing molten metal into the mold until the ring is formed, retarding the cooling and solidification of the upper and lower faces of the ring at and adjacent the inner corners thereof as and after the ring is formed, and applying a blanket of heat insulating material to the inner face of the ring.

4. The method of making a massive ring from molten metal in a rotating annular mold, which includes flowing molten metal into the mold until the ring is formed, applying a coating of heat creating material to the inner area of the ring, and applying a blanket of heat insulating material to the inner face of the ring.

5. The method of making a massive ring from molten metal in a rotating annular mold, which includes flowing molten metal into the mold until the ring is formed, retarding the cooling and solidification of the upper and lower faces of the ring at and adjacent the inner corners thereof as and when the ring is formed and applying a coating of heat creating material to the inner area of the ring.

6. The method of making a massive ring from molten metal in an annular mold supported on a rotating table, which includes pouring molten metal upon the rotating table and flowing it into the mold until the ring is formed, retarding the cooling and solidification of the metal adjacent the inner face of the ring to be formed, as it is poured upon the table and flowed into the mold, and applying a coating of heat creating material to the inner area of the ring.

7. The method of making a massive ring from molten metal in an annular mold supported on a rotating table, which includes pouring molten metal upon the rotating table and flowing it into the mold until the ring is formed, retarding the cooling and solidification of the metal adjacent the inner face of the ring to be formed, as it is poured upon the table and flowed into the mold, and applying a blanket of heat insulating material to the inner face of the ring.

8. The method of making a massive metal ring which includes flowing molten metal into a rotating annular mold defining the upper, lower and outer faces of the ring until a ring having a substantially square cross section of sixteen square inches and upwards is formed with a free inner face, and applying a blanket of heat insulating material to the inner free face of the ring for uniformly retarding the cooling and solidification of the

molten inner face portion of the ring until the cooling and solidification of the molten metal has progressed from the upper, lower and outer peripheral portions of the ring inward to bring the final place of solidification in the median plane substantially at the inner face of the ring.

9. The method of making a massive metal ring which includes flowing molten metal into a rotating annular mold defining the upper, lower and outer faces of the ring until a ring having a substantially square cross section of sixteen square inches and upwards is formed with a free inner face, and applying a coating of heat creating material to the inner area of the ring for uniformly retarding the cooling and solidification of the molten inner face portion of the ring until the cooling and solidification of the molten metal has progressed from the upper, lower and outer peripheral portions of the ring inward to bring the final place of solidification in the median plane substantially at the inner face of the ring.

10. The method of making a massive metal ring which includes flowing molten metal into a rotating annular mold, defining the upper, lower and outer faces of the ring until a ring having a substantially square cross section of sixteen square inches and upward is formed with a free inner face, and locally retarding the cooling and solidification of the upper and lower face portions of the ring at and adjacent the inner corners only thereof as and when the ring is formed.

11. The method of making a massive ring from molten metal in an annular mold at the periphery of a rotating table, which includes pouring molten metal upon the table at the inner side of the mold and flowing it into the mold until the ring is formed, and retarding the cooling and preventing a solidification of the metal on the table at the inner face of the ring to be formed, as it is poured upon the table and flowed into the mold.

In testimony that we claim the above, we have hereunto subscribed our names.

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