METHOD OF CENTRIFUGAL MOLDING

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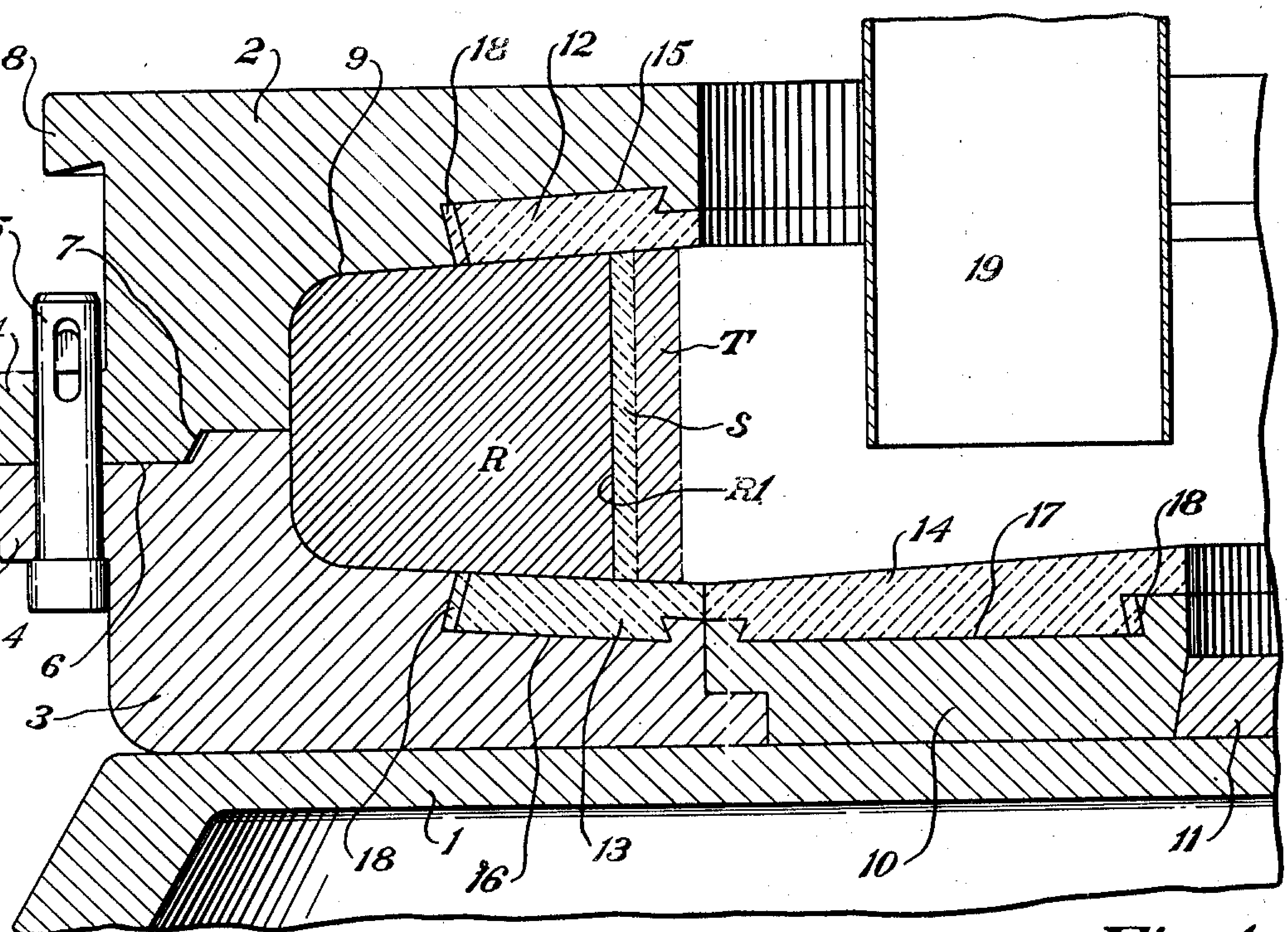

Fig. 1

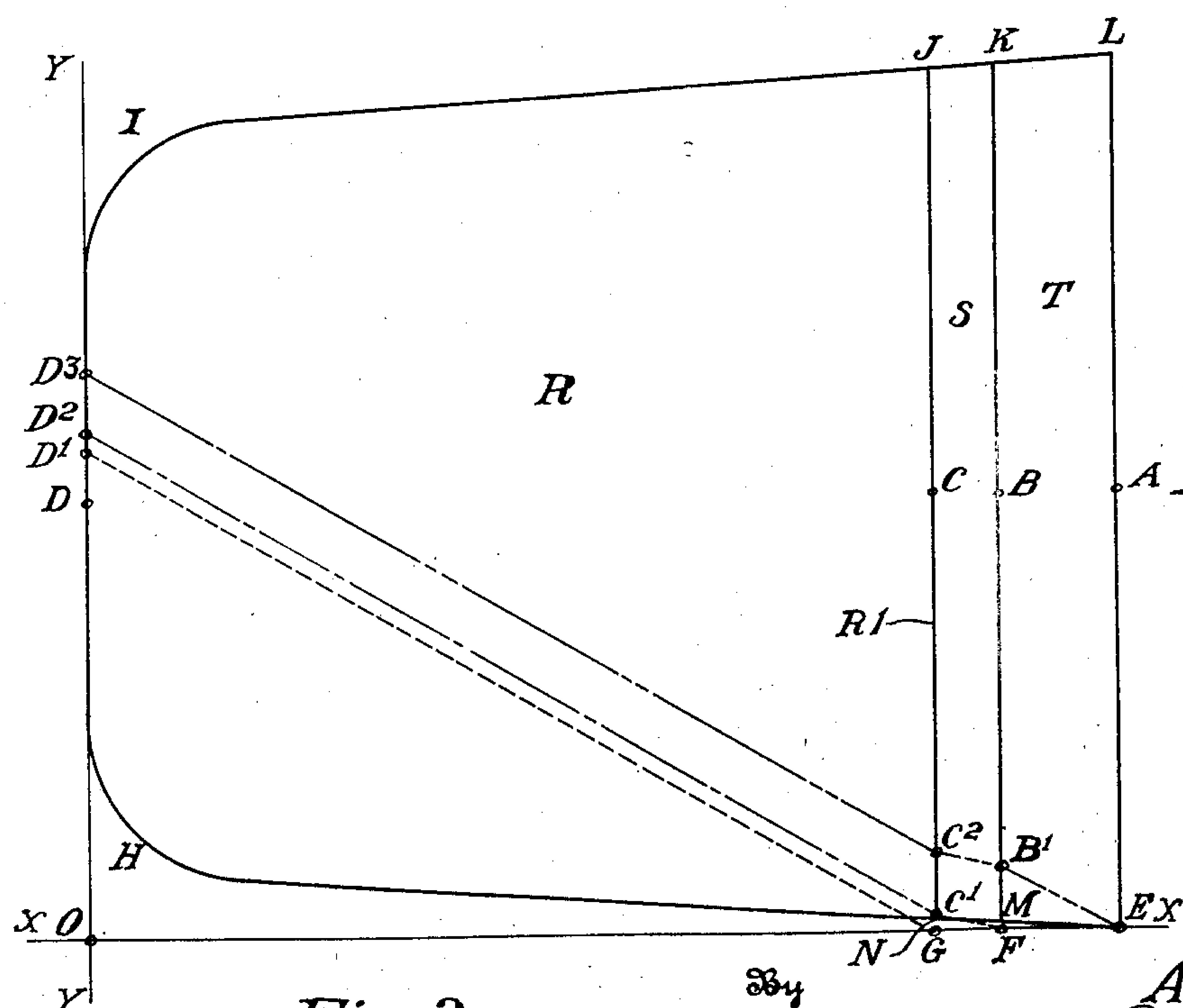

Fig. 2

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METHOD OF CENTRIFUGAL MOLDING

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The invention relates to the centrifugal molding of metal rings, for making steel blooms, slabs and billets free from cavities and openings, so that the metal is homogeneous throughout; and so that substantial pressure may be applied to the entire body of metal forming the ring, and particularly to the inside face of the ring, while the metal is molten and during solidification of the same, to improve the characteristics of all portions of the metal in the ring by the effect of pressure on the same during solidification.

The horizontal pressure normally existing, during the centrifugally molding of a ring in a rotor having a vertical axis, due to the mass of the particles forming the ring, is cumulative; and the pressure existing at and adjacent the outer peripheral surface of the ring has a maximum value, but decreases directly radially across the ring to the inner annular surface thereof where the same has the minimum value of zero.

Thus, the beneficial effects of solidifying molten metal under pressure by centrifugally molding the same, produce a maximum improvement in the structure of the metal at and adjacent the outer peripheral surface of the formed ring, and may only produce a minimum improvement in the same at and adjacent the inner annular surface of the ring.

Accordingly, if the molten metal at and adjacent the inner annular face or surface of the ring is maintained under substantial pressure while solidifying, the structure of the metal is improved at that place; and at the same time the pressure on the metal at and adjacent the outer peripheral surface of the ring is increased a like amount. As a result, the ratio of the pressure existing at the inner surface of the ring to that existing at the outer surface of the ring is materially increased, so as to decrease the variance in the improved structure of the metal radially across a section of the resulting ring.

It is therefore a principal object of the present invention to centrifugally mold an annular ring from molten metal, and to maintain a substantial pressure upon the molten metal at and adjacent the inner face of the ring, from immediately after the metal has been poured until the metal has cooled and solidified to such an extent that the ring may be removed from its mold.

We have discovered that this desideratum may be accomplished by applying or depositing on or adjacent to the inner face of the ring a blanket of heavy pressure producing material; and the application or deposition of such material should be performed promptly after molten metal is poured into a rotating annular mold, and while the metal is still in a fluid condition.

The pressure producing material preferably has a relatively high specific gravity, and preferably is a comminuted material, so that it may be easily and uniformly deposited on the inner face of the ring. Iron ore of either the magnetic or the hematite grades possesses these characteristics; but it is not intended to limit the scope of the present invention to such materials, for it is clear that other high specific gravity materials may be used as heavy pressure producing materials.

The application, per se, of a blanket of heavy pressure producing material directly upon the inner face of molten metal contained in ring formation within a rotating annular mold, may in certain cases damage or injure the inner face of the ring and produce imperfections in the resulting molded ring.

Imperfections may likewise be produced in the molded ring by using pressure producing material directly on the molten metal, because the heat conductivity of certain otherwise desirable heavy pressure producing materials may be so high that heat is rapidly conducted away from the inner face of the ring, thus causing the inner region of the ring to solidify before solidification of the ring has progressed from the outer, upper and lower regions of the ring to the inner face thereof.

Moreover, when pressure producing material is used directly on the inner face of the ring, imperfections may occur because the thermal coefficients of certain otherwise desirable heavy pressure producing materials may be such as to withdraw a considerable amount of heat from the inner region of the ring in order to elevate the temperature of the pressure producing material, thus causing a premature solidification of the inner region of the ring as above described.

Accordingly, it is a further object of the present invention to centrifugally mold an annular ring from molten metal under substantial pressure at and adjacent the inner face of the ring during solidification, by applying a blanket of desirable heavy pressure producing material thereon, and to prevent the heavy pressure producing material from causing imperfections to be present in the resulting ring.

Heavy pressure producing material may be prevented from causing imperfections in the resulting molded ring by first applying a comparatively thin blanket of heat insulating or refractory material directly upon the inner face of the ring promptly after the molten metal is poured, and then promptly depositing a blanket of heavy pressure producing material upon the blanket of heat insulating material, the insulating material thus being interposed between the molten metal and the heavy pressure producing material.

The heat insulating or refractory material blanket produces a small pressure on the inner face of the ring, but because most heat insulating or refractory materials have relatively low specific gravities, a very large volume of the same would have to be deposited in order to cause a pressure on the inner face of the ring equivalent to that produced by a small volume of heavy pressure producing material.

According, it may be impractical to use common or inexpensive refractory materials, per se, for producing a substantial pressure on the inner face of a centrifugally molded ring during solidification thereof, because of the large volume of material which would be required to be handled.

For these reasons, when the characteristics of the heavy pressure producing material utilized in centrifugally molding rings in accordance with the present invention require a relatively small volume of heat insulating or refractory material, sufficient only to separate and insulate the pressure producing material from the inner face of the ring, is used. Likewise, only a relatively small volume of heavy pressure producing material is utilized for maintaining the inner face of the ring under substantial pressure, because a very high specific gravity material may be used. Thus, only small volumes of insulating and pressure producing materials need be handled and provided for in order to greatly improve the structure and homogeneity of a ring being molded.

The principal purposes of the present improvements, may be accomplished by carrying out the methods set forth herein, in apparatus such as is diagrammatically illustrated in the accompanying drawing forming part hereof in which:—

Figure 1 is a cross section of a portion of a centrifugal molding machine annular ring mold; and

Fig. 2 is a diagrammatic graph illustrating the purposes of the present invention.

The centrifugal molding machine preferably includes a round table 1 mounted for rotation on a vertical axis, by suitable driving means not shown. The table is preferably provided with a roller bearing mounting to insure an even, steady and uniform rotation at a high rate of speed.

The mold may include substantially similar opposing upper and lower sections 2 and 3, respectively. Flanges 4 and key bolts 5 are preferably provided for detachably securing the upper and lower sections together, there being a substantially horizontal joint 6 with an offset 7 therebetween, substantially in the median plane of the mold; and a flange 8 may be provided on the upper section by means of which the upper section or both sections may be removed from the table 1 by a suitable crane tackle, not shown.

The annular mold cavity 9 is suitably shaped to give the desired section to a ring, preferably with the upper and lower sides of the mold slightly tapered outward toward each other, and 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 detachable annular wear plate 10, for receiving and flowing molten metal into the mold cavity.

The mold as a whole, or its separable lower section, may be centrally located and maintained on the rotary table 1 by means of a plurality of blocks 11, which may be secured as by welding upon the top of the table 1. Annular rings of heat insulating refractory material 12, 13 and 14 are preferably inserted in annular channels 15, 16 and 17, respectively, provided for that purpose in the upper, lower and wear plate mold walls, at and adjacent to the inner portion of the mold cavity; which rings may be made of a series of arcuate fire brick dovetailed into the channels and secured therein as by fire clay cement 18.

A chute 19 is preferably provided for intrc ducing and depositing comminuted heavy pressure producing material and/or comminuted refractory material for forming one or more blankets on the inner face of the ring after molten metal has been flowed into the mold to form the ring R.

In carrying out the present invention, molten metal at a temperature of 2600° F. and upwards is flowed into the rapidly rotating mold cavity 9, wherein the molten metal, by the action of centrifugal force, assumes an annular ring shape with an annular face R1 exposed. Immediately thereafter, a blanket or coating of heat insulating material illustrated diagrammatically at S is deposited on the inner face R1 of the ring R to delay or control the cooling thereof.

Immediately thereafter, another blanket or coating of heavy pressure producing material indicated diagrammatically at T is deposited upon the blanket S, for producing and maintaining a substantial pressure upon the inner annular face R1 of the molten metal forming the ring R.

The heat insulating refractory material forming the blanket S, and the heavy pressure producing material forming the blanket T are preferably comminuted materials and may be deposited upon the inner face of the ring R through the chute 19.

The relatively thin insulation coating S retards the cooling of the metal at and adjacent the inner face of the ring until the cooling of the metal has progressed inward from the outer, upper and lower portions of the ring substantially to the inner face R1 thereof, so that the region of final cooling and solidifying of the molten metal occurs at or very close to the inner face of the ring substantially in its median plane, and thus prevents the formation of shrinkage cavities or openings in the body of the ring.

The insulation blanket S, likewise separates and insulates the pressure blanket T from the ring, when the characteristics of the heavy pressure producing material require the use of an insulation blanket S. It is pointed out that some heavy pressure producing materials may be used to form a pressure blanket T directly on the inner face R1 of the ring R without the intermediate deposition of an insulation blanket S.

After the blanket or blankets have been deposited, rapid rotation of the annular mold is continued, so as to maintain centrifugal pressure until the metal has cooled under pressure throughout its entire body to a self-sustaining plastic condition, whereupon rotation is reduced to permit the ring to shrink without a granular disintegration of the metal and thereafter the rotating mold may coast to and/or be braked to a stop.

Thereupon, the ring is removed from the mold and is permitted to cool somewhat when the blanket or blankets may be easily removed from the inner face of the ring.

The results of utilizing the improved method are diagrammatically illustrated in Fig. 2 in which HIJN represents a cross section of a centrifugally molded ring bloom R, positioned on an X—X, Y—Y axis with an origin at O; NJKM represents a blanket of insulating material S applied to the inner face of the ring R; and MKLE represents a blanket of heavy pressure producing material T deposited upon the insulation blanket S. The points A, B and C diagrammatically indicate particles of material at the inner face of the blanket T, the blanket S, and the ring R, respectively, while the point D indicates a particle at the outer surface of the ring R.

Immediately after molten metal has been poured, the pressure on any particular particle in the ring R due to the mass of other particles, acts radially in the direction of the arrow shown in Fig. 2. Such pressures are cumulative and vary directly with the position of any particular particle in a section of ring bloom, so that the pressure on the point D is designated by the ordinate OD^1 and the pressure on the point C on the inner face R1 of the ring R is zero and is indicated by the point G. Ordinates measured from the X—X axis to the line GD^1 at any particular place, therefore, represent the pressures upon particles in the ring R located in the plane of the selected ordinate.

When a blanket S of insulation material is deposited on the inner face of the ring, the pressure exerted upon the particle B is zero and indicated by the point F, while the pressure exerted upon the particle C is indicated by the ordinate GC^1; and pressures upon particles of the ring R are increased in amount corresponding to the ordinate GC^1 so that the pressure exerted on the particle D is represented by the ordinate OD^2.

It is pointed out that the slope of the line FC^1 is materially less than the slope of the line GD^1, because the specific gravity of the insulation material forming the blanket S is considerably less than the specific gravity of the metal forming the ring R.

After a blanket T of heavy pressure producing material is deposited, the pressure on the particle A is zero, the pressure on the particle B becomes proportional to the ordinate FB^1, the pressure on the particle C is proportional to the ordinate GC^2, and the pressure on the particle D is represented by the ordinate OD^3. The slop of the line EB^1 approaches the slope of the line GD^1, because the heavy pressure producing material has a high specific gravity, which preferably approaches in value the specific gravity of the metal from which the ring R is formed.

Accordingly, the curve $EB^1\ C^2\ D^3$ represents pressures existing at any particular place across the area EHIL. When heavy pressure producing material is deposited directly on the inner face R1 of the ring R, without the use of insulation material, the pressures maintained between the points C and D are reduced in an amount equivalent to the ordinate GC^1.

In utilizing the present method, a very appreciable and substantial pressure is exerted upon the inner face of the ring by the heavy pressure producing material, and the ratio between the pressure on a particle at the inside face of the ring and at the outside face of the ring is materially increased from that ratio resulting when no heavy pressure producing material is utilized; so that the beneficial effects of pressure upon the resulting ring is materially increased and a variance in homogeneity in the ring is diminished.

The deposition and use of heat insulating or refractory materials, per se, in centrifugally molding annular rings, described, but not claimed herein, may be carried out as set forth and claimed in our prior copending applications, Serial Nos. 563,583, 583,658 and 583,659.

We claim:—

1. The method of making a ring from molten metal in a rotating annular mold, which includes flowing molten metal into the mold until the ring is formed, depositing on the inner face of the ring a blanket of insulation material, and depositing a blanket of heavy pressure producing material on the insulation blanket.

2. The method of making a ring from molten metal in a rotating annular mold, which includes flowing molten metal into the mold until the ring is formed, depositing on the inner face of the ring a thin blanket of low specific gravity refractory material, and depositing a blanket of high specific gravity heavy pressure producing material on said first mentioned blanket.

3. The method of making a ring from molten metal in a rotating annular mold, which includes flowing molten metal into the mold until the ring is formed, depositing on the inner face of the ring a blanket of comminuted refractory material, and depositing a blanket of comminuted heavy pressure producing material on the refractory material blanket.

4. The method of making a ring from molten metal in a rotating annular mold, which includes flowing molten metal into the mold until the ring is formed, depositing on the inner face of the ring a blanket of insulation material, and depositing a blanket of iron ore on the insulation blanket.

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

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