

July 15, 1924.

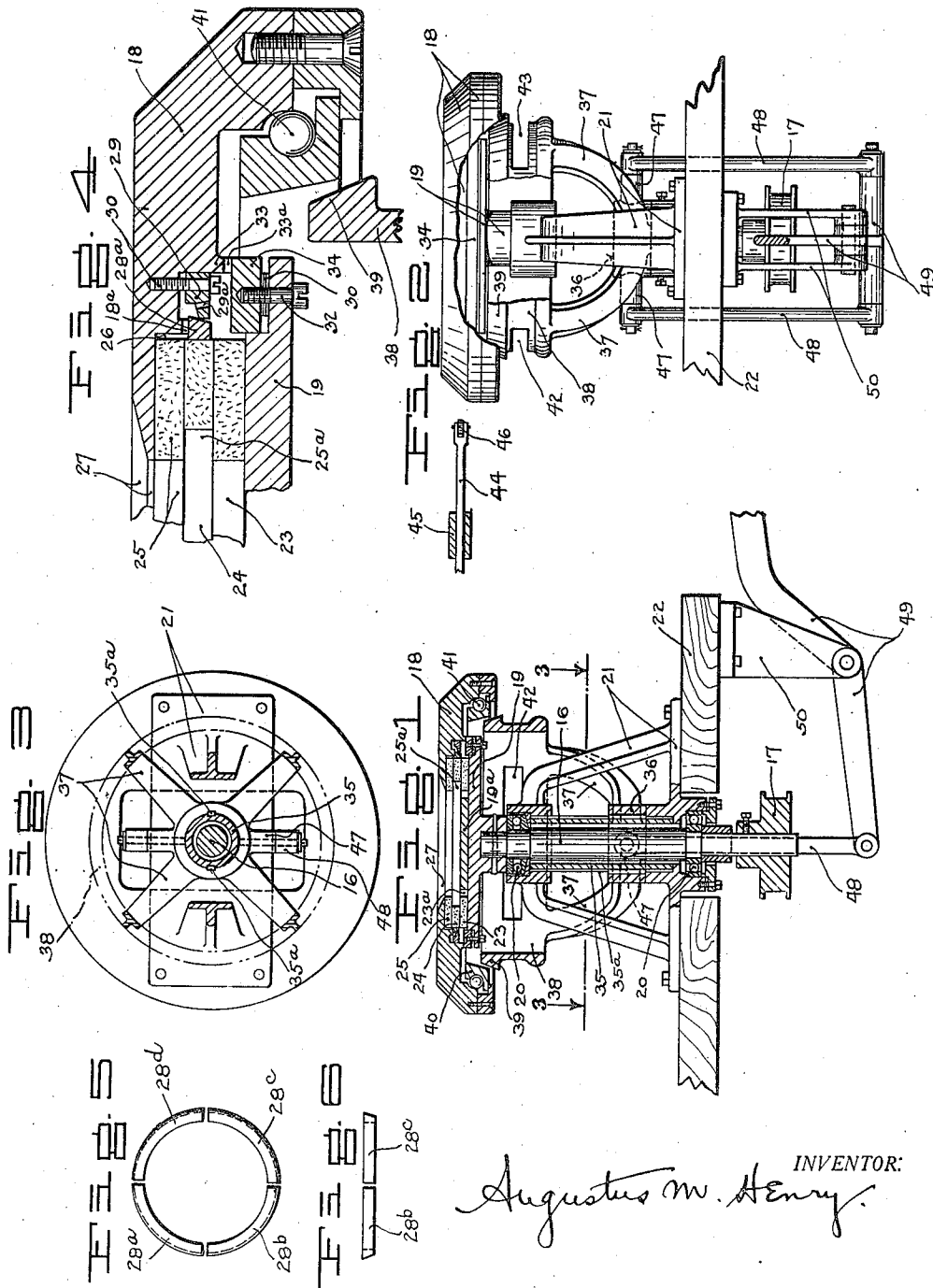
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A. M. HENRY

ROTARY CASTING

Filed May 24, 1921

3 Sheets-Sheet 1



INVENTOR:
Augustus M. Henry

July 15 , 1924.

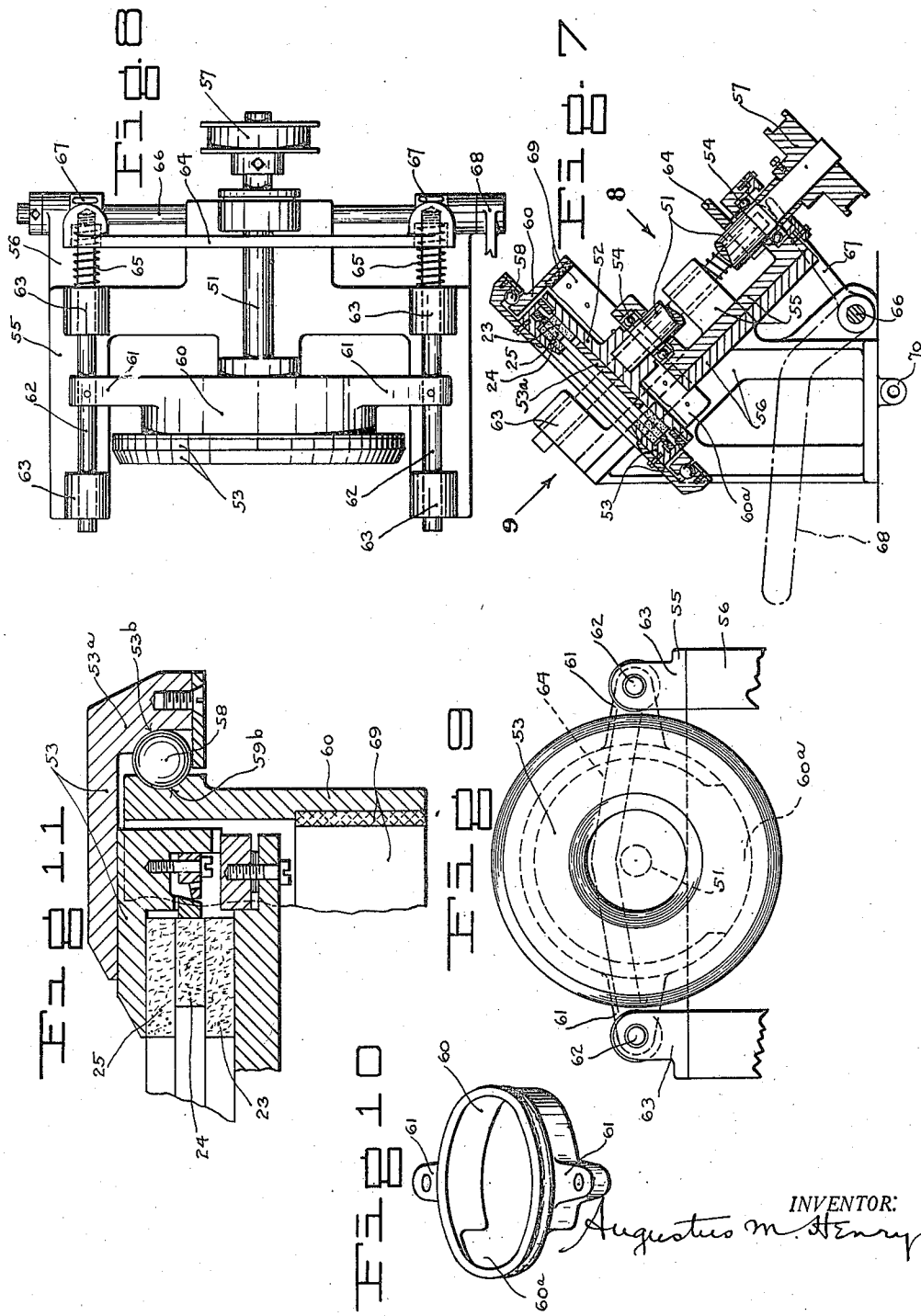
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Fig. 13

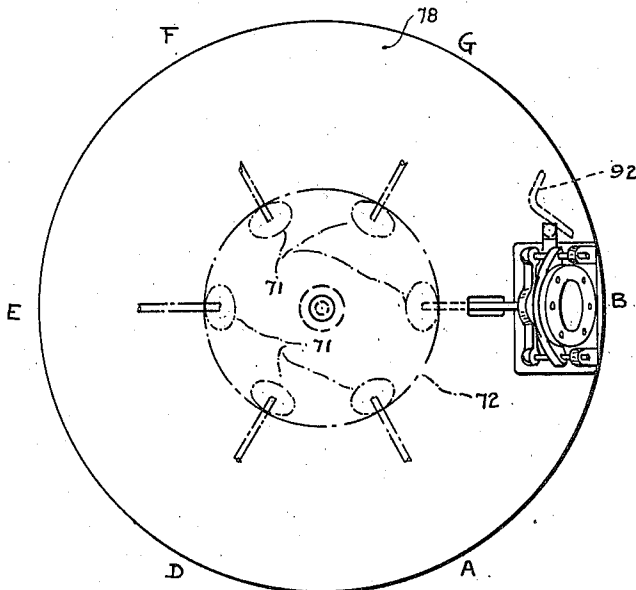


Fig. 14

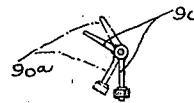


Fig. 12

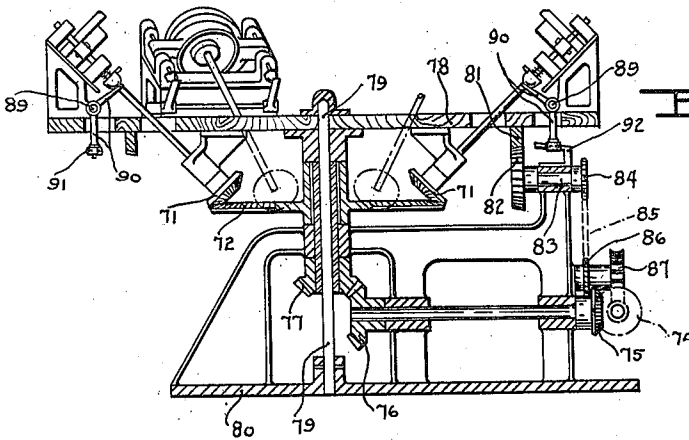
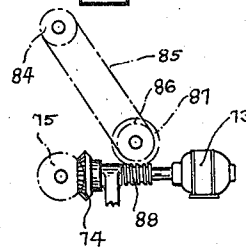


Fig. 15



Augustus M. Henry ^{INVENTOR:}

UNITED STATES PATENT OFFICE.

AUGUSTUS M. HENRY, OF BROOKLYN, NEW YORK.

ROTARY CASTING.

Application filed May 24, 1921. Serial No. 472,169.

To all whom it may concern:

Be it known that I, AUGUSTUS M. HENRY, a citizen of the United States, and a resident of Brooklyn, New York, in the county of Kings and State of New York, have invented certain new and useful Improvements in Rotary Castings, of which the following is a specification.

This invention relates to centrifugal or rotary casting, and aims to provide a process of and apparatus for making, reliably, economically and rapidly, high-quality ferrous castings preferably of ring form.

A particular object of the invention is to provide a process and apparatus as just indicated for the manufacture of iron castings for piston-rings, which shall be of high-quality cast iron, so far as the known metallurgical requirements of a theoretically perfect piston-ring are concerned.

Heretofore, in the manufacture of such castings by the rotary casting method, that is, by the employment of rotating moulds, attempts have been made to use metal moulds. This, of course, has resulted in the casting of hard white cast iron, utterly useless for machining into a piston-ring. Attempts were then made to anneal such castings to convert them into soft gray iron castings, to permit them to be machined or finished as is necessary, on a lathe, grinder or the like. But then an apparently insuperable difficulty presented itself, which may be explained as follows: In the first place, the purpose of the annealing was to convert the combined carbon characteristic in the hard white iron, into graphitic carbon, the carbon form characteristic of soft gray iron. But it was found that at all times and in every instance, the conversion of the combined carbon into graphitic carbon resulted in the graphitic carbon being finally arranged as temper carbon. Temper carbon, however, is the characteristic of malleable iron. Malleable iron is entirely unsatisfactory for piston-rings—indeed, is positively destructive of the cylinder against which it rubs in operation; due to its toughness and what may be termed its relative plasticity, causing its edges to feather or form minute comb teeth or scrapers. These scrapers or feathers chew away the cylinder lining in very quick time.

Acquainted with these facts, I first attempted to use various mixtures of ordinary

foundry sand and even core mixtures as a lining for a rotating mould, so that the molten iron admitted to the mould would then congeal against the refractory moulding surface thus provided, thereby to avoid chilling the casting, and so obtain a soft gray iron directly as a result of the casting operation, thereby in turn obviating the annealing step and hence removing the possibility of graphitic carbon in the temper form. Thereupon the discovery was made by me that a fundamental advantage of rotary casting, so far as piston-rings are concerned, was lost. This may be explained as follows: In the first place, a piston-ring's practical value depends in the main on its capacity for satisfying three requirements at once. That is to say, the ideal or theoretically perfect piston-ring is one which, when actually in operation on a piston in the cylinder of an engine, will itself take up all wear and so preserve the cylinder against all wear; which will continuously prevent the escape of any of the compressed fluids from behind the piston; and which will have very long life. I have found that the ability of a piston-ring to satisfy these three requirements varies directly as the fineness and uniformity of size of the carbon particles, provided these particles are finely and uniformly distributed, and provided further that these particles are all graphitic carbon and yet not of temper form, and are dispersed as above throughout a mass of densified or compacted iron. In this connection, I may add, or rather point out, that an iron casting having its graphitic but non-temper carbon constituted and distributed as just described and having its main ferrous mass densified or compacted as just described, is of course exceedingly desirable for very many types of centrifugal castings of annular, arcuate or other cross section, as well as for piston rings. I have found also that such a carbon distribution in the cast iron may, and apparently only may be accomplished when the rate of congelation of the molten iron, after the latter has been deposited in the rotating mould, is quicker than the rate at which such metal congeals in a fixed sand mould or in a rotating mould lined with mixtures of ordinary foundry sand and other ingredients.

One feature of the present invention, 110

therefore, is the process of making annular articles by rotary casting, which includes providing a mould, rotating the mould, and depositing molten iron in the mould, while
 5 controlling the time of solidification of the iron, relative to the time required for the iron to become predeterminedly deposited around the mould, so that the iron solidifies in less time than iron similarly cast in a
 10 mould having molten-iron-contacting surfaces of the usual foundry-sand type, and yet so that the iron requires a long enough time to solidify, relative to iron similarly cast in a permanent mould having molten
 15 iron contacting surfaces of metal, to prevent chill, that is to say, the hardening or partial hardening of the casting as white iron rather than gray, due to the carbon content being in the combined rather than in the graphitic
 20 form. Preferably, such process is so carried out that the iron solidifies into the predetermined shape within less than one minute, to cause a fine distribution of the combined carbon, but after the expiration of at least
 25 five seconds, to prevent chilling. Good results are also obtained where the congelation or solidification control is such that the iron finally and firmly takes the shape predetermined for the casting after the expiration of
 30 three seconds, a full second, and even one-half of a second; and where the setting of the molten iron occurs within considerably less than one minute, as good results are obtained when the iron sets within something
 35 less than ten seconds after admission to the rotating mould.

A very satisfactory means for carrying out the discovery just defined, as I have proved by actual workings, is obtained by
 40 using a rotating mould made up of, or lined with, carefully shaped pieces of greatly-compressed refractory material of a kind whose high refractory quality (that is, whose resistance to melting or deformation or disintegration due to high heat is very great)
 45 and whose relative rate of heat absorption and radiation, may be readily predetermined as the result of the ingredients and methods of admixture and bonding into the required
 50 article. It will be understood that the just-mentioned qualities of the shaped pieces will predetermine absolutely the rate of heat release of the molten iron, and hence predetermine absolutely the rate of congelation
 55 of the iron; all other things, and particularly the composition of the molten metal and the centrifugal force factors of the rotating mould, being equal. Said qualities, I find, at least in the case of the materials tested,
 60 may be thus predetermined in advance by properly selecting the ingredients of the first batch mixture out of which the pieces are to be formed, and by forming such pieces from the batch mixture as the result of two sequential
 65 manufacturing steps. These two

steps are, first, the subjection of a definite portion of the batch mixture to very high pressure,—good results having been so far obtained when the pressure employed, in the case of the hereinafter mentioned sillimanite
 70 or krausgrain, is 30 tons per square inch and, second, the heating of the compressed piece thus obtained to very high temperature, preferably in a kiln,—good results
 75 having been so far obtained when the temperature employed is 2800 to 3000 degrees Fahrenheit. The ingredients used in making the batch mixture for the pieces tested are in the case of said krausgrain clay bases or grogs, preferably in fine particles and
 80 preferably so treated that such particles are in another physical form than that of the usual crystals. As to this phase of the invention, however, I do not wish to be limited to the use of any particular mixture or material
 85 for the mould lining; provided only, of course, that the lining used should, for practical casting on a real production basis, be one such that the shaped pieces may be shaped or moulded accurately and so as to
 90 have mould surfaces of as fine and smooth texture as possible; bearing in mind also that such pieces should be so made as to have as great permanence as possible, in regard to deferred chemical reaction between
 95 the materials of the pieces and the ingredients of the molten iron, and particularly in regard to the formation of silicon and iron compounds which would have the effect, I have found, of bonding the casting
 100 to the mould lining and so causing removal of the former to ruin or injure the latter; in regard to resistance to repeated temperature-change shocks; in regard to resistance to abrasion by the moving molecules of the
 105 molten metal before the casting congeals; and in regard to toughness and strength in withstanding chipping, flaking, splitting or other damaging from the momentary slight expansion of the molten iron which
 110 apparently occurs at the instant of solidification as a preliminary to a subsequent and greater contraction of the metal during its cooling period.

In actual tests, I have found several materials produce desirable results, and particularly sillimanite, krausgrain and carbon. Such sillimanite is a product of the Norton Co., Worcester, Mass., also sometimes called alundum; with the base alumina rather than silica. Such krausgrain is a product of the Krause Research Laboratories, New York, N. Y. The carbon used was that as commercially placed on the market in thick slabs or blocks by the National Carbon Co., New York, N. Y., which
 120 carbon is of the kind often called gas carbon,—such as is used for making arcing electrodes for electric furnaces and arc lights and for making the brushes for dynamos
 130

and the like. In this connection, it may be explained that, in order to attain that object of the invention which is to provide a substantially permanent mould or mould lining, the carbon to be employed, if employed, is, in any event, to be carbon not previously submitted to the graphitization process or a process or conditions effective to transform the carbonaceous material into the light, soft, weak and friable crystalline state characteristic of graphite, as contradistinguished from the heavy, hard, strong and tough state characteristic of substantially pure ungraphitized carbon.

15 If sillimanite or krausgrain is used, a piston ring casting meeting the above indicated requirements is produced, and, further, a piston ring casting not requiring a subsequent heat treatment of any kind to adapt it to its appointed work. If gas
20 carbon is used, however, a more desirable mould lining is provided for certain kinds of castings than when sillimanite or krausgrain is used, especially so far as resistance
25 to cracking due to an extra high and sudden heat shock, is concerned; but then it is desirable to subject the casting to such subsequent heat treatment if the casting is to be subsequently finished off by turning or
30 otherwise for use as a piston ring. On the other hand, however, if such casting is to be used for other purposes than for making piston rings, as, for instance, for making ferrous metal rims for railroad car-wheels,
35 such subsequent heat treatment may be dispensed with, even in the case of a casting made in a mold with a carbon lining, because then the casting will not require subsequent finishing as above and the case-hardening found at the outer peripheral
40 surface of the casting will be advantageous rather than otherwise. In this regard, the specific use of carbon as a mould lining for deliberately obtaining such a case-hardened
45 casting, for use in various industries, is fully discussed and claimed in my co-pending application filed October 9, 1923, Serial No. 667,524.

A further particular object of the present invention is to provide a process, auxiliary to that just described, for the reliable, economical and rapid handling of the molten metal and the piston ring castings made from such metal, while controlling, as above explained, the character of the metal at all times during such handling; and to provide novel apparatus to facilitate all the processes involved.

Heretofore, in the attempted manufacture of piston-ring castings by power-driven machines including rotary moulds, machines having a capacity of one ring per mould-carrying-rotor per molten-metal-pour have been apparently supplanted by machines having a capacity of a plurality of

rings per mould-carrying-rotor per molten-metal-pour. The reason for this has been that machines of the first class, hereinafter referred to as machines of the unit-casting type, have been altogether too complicated, bulky and slow for rapid and economical production. On the other hand, machines of the second class, hereinafter referred to as machines of the multiple-casting type, have been found unsatisfactory because the castings have not been accurately formed to the precise dimensions predetermined. Such an accurate casting is of the highest importance, because after the founder has delivered the casting to the machine shop, the most expensive part of the manufacture of the piston-ring commences, its machining to specifications. There should of course be enough surplus metal all over the ring casting to permit machining all over, yet the amount of surplus metal should be uniformly thick all over and as few thousandths of an inch thick as possible, to standardize the finishing of the various surfaces, and to minimize the time and expense of the entire machining operation. It will be understood, then, from what is known in the art, that when a single metal pour, made by means of the familiar elongated tilting feed-trough or ladle inserted within the rotating mould, is made relative to a line of annular grooves arranged side by side in the mould of a machine of the multiple-casting type, identical portions of the molten metal are seldom if ever discharged into all the different grooves. As a result, the various individual rings, each of which is supposed to be congealed in one of the grooves as the mould continues rotation, are of different dimensions, so far as their inside diameters are concerned, and sometimes of different shapes, so far as their inner peripheral surfaces are concerned.

According to the present invention, however, the rapid production advantages of the multiple-casting type machine are preserved in a unit-type casting machine by a novel process of operating a unit-type casting machine of new and improved form. So far as such novel process is concerned, in relation to the operation of such unit-type casting machine, the present invention may be briefly described, in that particular, as involving the art of manufacturing annular articles by the rotary casting method, which includes providing a two-part mould, separable axially of the annular article when cast,—rotating the mould parts simultaneously,—introducing molten metal within the mould,—continuing such simultaneous rotation of the mould parts until the article is solidified,—separating the mould parts axially while both continue rotation, to permit extraction of the cast article,—and then bringing the mould parts

together to reconstitute the mould for a subsequent casting operation; whereby during a plurality of successive casting operations at least one of the mould parts is continuously rotated by suitable power-means. According to this arrangement, since at least one of the mould parts continues rotation at all times, centrifugal force is permitted to act positively to facilitate ejection of the cast article. Expressed in another way, the invention attains its rapid and efficient production possibilities as the result of providing a unit-type casting machine wherein the mould-carrying rotor is continuously driven at a constant speed by suitable power-means during the casting and ejection of a plurality of piston ring castings,—such castings being made within the machine, and ejected therefrom, one after another; and this end, in turn, is accomplished by separating axially the parts of a multi-part rotating mould while the main or power-driven part is power driven as above. In the preferred embodiments, the complementary part of the mould is arranged to rotate frictionlessly and hence on momentum during the period of separation of the mould-parts and during the ejection of the casting just previously made, which ejection takes place coincidentally with such period of separation. As a result, when the mould parts are again brought together, immediately after the ejection of said castings, friction between mutually engaging surfaces of the two mould-parts permits the power means instantaneously to resume driving both mould-parts simultaneously and positively, and incidentally before the momentum of the complementary mould-part is so much dissipated as to cause a material speed variation of, or impose any sudden load-shock on, the power-shaft.

Such features of the invention are embodied, preferably, in a quantity-production machine of the turret type, that is, a machine comprising essentially a turn-table on which are mounted a suitable plurality of simultaneously and continuously rotating mould-carrying rotors, arranged radially on the table. During production, the table rotates so that each rotor, in turn, first passes a feeding station, whereat a charge of molten metal is delivered to the rotor,—then traverses a path of such length that the time of traverse is just that required to solidify and congeal the ring casting sufficiently to permit harmless centrifugal ejection,—then passes an ejection station, whereat a fixed cam-rail or the like automatically engages an instrumentality on the rotor to separate the complementary mould-part from the main mould-part of that rotor to cause ejection of the casting into a suitable fixed receptacle,—and finally, and immediately thereafter, again passes the

feeding station, for a second charge of molten metal, as before; all as will be more clearly understood hereinbelow when the disclosures of the drawings are described in detail. It has been determined that in a machine of this class, piston ring castings may be turned out at the rate of very many a minute, in fact almost at the speed with which a heavy punch press delivers stampings; yet the casting of each ring is under constant supervision, and particularly during the pouring of the molten metal charge, thus permitting the delivery to each mould of a nicely defined amount of metal and so predetermining a casting of accurate dimensions all over.

The process as above described, it will be seen, has the important advantage, among others, of dispensing with the necessity of any tangible means for ejecting the casting during the period of separation of the mould parts. Such casting is ejected in the smallest fraction of a second imaginable, by the same intangible means which functioned to form, congeal and densify the molten metal admitted to the rotating mould to make the piston ring casting itself,—the intangible means of centrifugal force.

Still a further object of the present invention is to provide a process of and apparatus for the making of a piston ring casting in a rotating mould which will at once facilitate the feeding of the precise quantity of molten metal desired for each casting operation, facilitate the quick and uniform circumferential distribution of such molten metal within the mould, expedite the congelation and rate of solidification of the metal, increase the density of the metal as finally set in the casting, and form an almost perfect cylindrical surface for the inner peripheral face of the casting. I have discovered that all these highly important practical effects may be brought about if the axis of rotation of the mould be maintained continuously at an inclination removed from both the horizontal and the vertical; best results so far having been obtained when the mould axis is maintained at or substantially at 45 degrees to the vertical.

The apparatus I have so far found the best for carrying out this feature of the process just last referred to, is embodied in a power-driven mould comprising a disc fixed perpendicularly on the upper end of a shaft arranged for rotation about an axis inclined as above specified, the upper side of the disc having mounted thereon for rotation therewith three cylindrical walls, one concentrically above the other, with the middle wall of greater internal diameter than the top and bottom walls, so that, counting upward from the disc, the upper plane surface

of the first wall moulds the under plane surface of the ring casting, the inner peripheral surface of the second wall moulds the outer peripheral surface of the casting, and the under plane surface of the third wall moulds the upper plane surface of the casting—the first wall being countersunk in an annular groove on the disc so that the first wall's upper plane surface is flush with the surface of the central portion of the disc; all as will be more clearly understood hereinafter when the disclosures of the drawings are described in detail.

Preferably, of course, the three annular walls just mentioned are each either constructed of a single piece of the refractory material above described or built up of a plurality of such pieces; in which case the delayed rate of congelation and solidification of the molten metal, resulting from the heat-refractory nature of such material, increases and intensifies the beneficial effects caused by the process of making the casting in a rotary mould on an inclined axis pursuant to the preferable method of carrying out the invention.

Preferably, further, in the case of operating and controlling the mould and the action of its molten metal contents by rotating the mould on a continuously maintained inclined axis as specified, the above-explained process of providing a multi-part mould and axially separating the two parts of such mould to cause centrifugal ejection of each ring casting as made, is utilized. According to this preferable mode of combining all the various mechanisms and processes herein disclosed, all their separate advantages are simultaneously retained, and at the same time a further important advantage is secured in regard to the automatic or centrifugal ejection of each ring casting at the appointed instant. This last advantage, flowing from the fact that the mould's axis of rotation is inclined both to the vertical and to the horizontal, may be explained as follows: If the axis of the mould is horizontal, that is, if the ring is cast in a vertical plane, centrifugal force, I have found, will tend to eject the casting prematurely, that is, before the mould parts are completely separated, resulting in a comparatively quick destruction of the adjacent exposed portions of the comparatively brittle mould pieces, necessarily separated when the mould parts are separated. If the axis of the mould is vertical, that is, if the ring is cast in a horizontal plane, centrifugal force may not absolutely be relied on to eject the casting, since, on separation of the mould parts, the center of mass of the cast ring will be, and in many cases will remain for some seconds, concentric with the axis of rotation of the mould; and centrifugal force will not function at all in the direction of ejecting the

casting. If, however, the axis of the mould is inclined to both the vertical and the horizontal, as herein disclosed, the ring is cast in a similarly inclined plane, and I have found that the separation of the mould-parts always occurs before the ring casting may damage the moulding pieces; while on the other hand, as soon as such separation is complete, that is, as soon as the complementary mould-part is completely raised away from above the ring and the lower main-mould-part, gravity is sufficient to just overcome friction between the ring and the mould-part supporting it. Thereupon, the ring drops slightly, so that its center of mass is slightly below the center of rotation of the main mould part; whereupon, instantaneously, the ring is ejected with lightning speed—and always in a downward direction, and without danger to the workmen.

The invention will be more clearly understood from the following description, when taken in connection with the accompanying drawings, illustrating preferred types of apparatus to facilitate carrying out the various processes involved.

In these drawings

Fig. 1 is a vertical axial section illustrating one embodiment of the invention;

Fig. 2 is a side elevation of the parts shown in Fig. 1, partially broken away, and looking to the left in Fig. 1;

Fig. 3 is a horizontal section, taken on the line 3—3 of Fig. 1;

Fig. 4 is an enlarged detail view of certain of the parts shown in Fig. 1;

Fig. 5 is a top plan view of a four-part wedge ring shown in section in Fig. 4;

Fig. 6 is a side elevation of the ring shown in Fig. 5;

Fig. 7 is a view similar to Fig. 1, but showing a different embodiment;

Fig. 8 is a view showing the parts of Fig. 7, when viewed in the direction of the arrow 8 of Fig. 7;

Fig. 9 is a view showing certain of the parts shown in Fig. 7, when viewed in the direction of the arrow 9 of Fig. 7;

Fig. 10 is a perspective view of one of the parts shown in Figs. 7, 8 and 9;

Fig. 11 is an enlarged view of certain of the parts disclosed in Fig. 7, but swung around in a clockwise direction so that parts which are inclined in Fig. 7 are vertically arranged in Fig. 11;

Fig. 12 is a vertical axial view of a turret-type machine for quantity production, including several radially arranged rotors, with such rotors arranged on axes inclined to both the horizontal and the vertical, as in the case of the embodiment shown in Figs. 7, 8 and 9;

Fig. 13 is a top plan view of the parts shown in Fig. 12;

Fig. 14 is an isolated view showing one

of the working parts of Fig. 12 in two of its functioning positions; and

Fig. 15 is a fragmentary view, showing certain details of driving mechanism shown also in Fig. 12.

Similar reference characters refer to similar parts throughout the several views of the drawings.

Referring to the construction shown in Figs. 1, 2, 3, 4, 5 and 6:

The machine shown here is not at the present time deemed the preferable one, but has shown certain practical values. This machine is one wherein the separable mould is mounted on a vertical shaft 16, adapted to be driven by a belt or the like, passing over a pulley 17 fast on the shaft.

The multi-part mould comprises an upper mould-part 18, which is the complementary mould-part, and a lower mould part 19, which is the power-driven part, that is, the part which continuously rotates at a constant speed. As will be noted, this part is pinned on the upper end of shaft 16.

Shaft 16 is suitably mounted on anti-friction bearings, as indicated at 20, these bearings being housed in the upper and lower portions of a casting 21; this casting being bolted to a suitable table 22.

Referring to the lower mould-part 19, this mould-part carries a central circular plate 19^a, which is fixed to the mould part and may be formed integrally therewith if desired. Mounted on the annular upper face of mould part 19 surrounding plate 19^a is an annular piece of the refractory material above referred to; this piece being indicated by the reference character 23.

The piece 23 is assembled on the mould part 19 by merely laying it on top of the mould part as shown and then filling in the annular groove left at 23^a with fire clay or the like; so that finally the upper plane surface of piece 23 is flush with the upper plane surface of plate 19^a.

The other two annular pieces of refractory material, one being indicated at 24 and the other at 25, are fixedly clamped in place within the upper complementary mould-part 18. The manner in which such pieces 24 and 25 are thus clamped in place will be described in the paragraph immediately below; but at this point it may be explained that the idea in thus securely mounting these pieces 24 and 25 in the complementary mould-part 18 is to permit such mould part to be elevated relative to the constantly rotating main mould-part 19, so that then the congealed and solidified ring which has been cast in the groove indicated at 25^a (formed by the three pieces 23, 24 and 25) will lie on a single plane unobstructed rotating surface in readiness for centrifugal ejection as hereinafter explained.

Referring now particularly to Figs. 4, 5

and 6, it will be seen that pieces 24 and 25 are secured in place in a recess 26 on the under side of complementary mould-part 18, so that the inner peripheral surfaces of pieces 24 and 25 concentrically surround a central circular opening 27 in complementary mould-part 18. These pieces 24 and 25 are thus held in place by means of the four-part wedge-ring shown in Figs. 5 and 6 and they are marked 28^a, 28^b, 28^c, 28^d; the part of the wedge ring shown in section in Fig. 4 being indicated as 28^a. This wedge ring is preferably formed of the four sawed sections of a copper ring. They are clamped in place to radially compress themselves against piece 24 by means of a closed clamp-ring 29 drawn up tight against the mould-part 18 by means of a suitable number of circumferentially spaced screws one of which is shown at 30 in Fig. 4.

During the interval when the two mould-parts 18 and 19 are rotating in unison, the upper part 18 is driven by frictional contact with the lower part 19, which latter is power driven as above explained by shaft 16. However, it is not desirable to have such friction set up at the cost of abrasive contact between the under surface of piece 24 and the upper surface of piece 23, as this might cause undue and premature wear of the two pieces last mentioned. Hence main or lower mould-part 19 is provided with an adjustable ring 34, secured to mould-part 19 by a suitable number of circumferentially spaced screws one of which is indicated at 32 in Fig. 4. In order nicely to set the height of ring 34, in regard to a particular set of pieces 23, 24 and 25 set up in the multi-part mould, so that, when the mould-parts are close together during a casting operation, an annular rib 33 dependent from the under side of mould-part 18 will frictionally engage the upper surface of ring 34, and yet so that while pieces 23 and 24 will not be in frictional contact they will not be so much separated that molten metal may creep in between the two pieces beyond the bounds of groove 25^a, the design is such that suitable shims of different thicknesses may be set up below ring 34 around each screw like the screw 32 of Fig. 4, such shims being there indicated at 30.

Referring now to the means for axially separating the mould-parts, in preparation for the centrifugal ejection of a ring casting made within the mould when the mould was rotating in the condition shown in Fig. 1: Disposed within casting 21, and surrounding drive-shaft 16, is a fixed sleeve On this sleeve are a pair of exterior vertical keys or feathers indicated at 35^a in Fig. 3. Slidable on the sleeve, and held against rotation by the feathers, is a collar 36 carrying four upwardly and outwardly

arched arms 37 and terminating at their upper ends in a cylindrical vertically arranged barrel 38. At its upper marginal periphery this barrel carries a cone-clutch surface 39 adapted to engage a cooperant cone surface forming the inner periphery of a ring 40. The ring 40 constitutes a floating member when the two mould-parts 18 and 19 are together and rotating in unison during a casting operation; ring 40 acting as the retainer for a circumferentially arranged series of balls 41. However, when barrel 38 is elevated so that clutch 39 engages ring 40, and is further elevated to cause the upper mould-part 18 to be lifted out of frictional contact with the continuously rotating lower mould-part 19, mould-part 18 will continue to rotate on balls 41 as anti-friction guides and yet merely on its own momentum—almost at the speed at which it was rotating with mould-part 19, despite the clutch action functioning between clutch 39 and ring 40. Thus, the moulds will be axially separated, the lower or main mould-part 19 will continue to rotate as before, and the upper mould part 18 will continue also to rotate, but on its own momentum, almost at the same speed as the lower mould part, and yet nevertheless, the two parts will be separated sufficiently and for a long enough time to permit ejection of the casting now lying on lower mould part 19 and piece 23.

The design of the parts is such that when the barrel 38 is fully elevated, that is, when it is above its position of partial elevation shown, and therefore upper mould-part 18 and ring 40 are so elevated that such parts are above the level of the upper plane surface of the main or power-driven mould-part 19, the rotating surface on which such casting rests will be entirely surrounded by the cylindrical inner wall of barrel 38 except where two openings 42 and 43 are located, as shown best in Fig. 2. These two openings will then lie in the same horizontal plane as the line of actuation of a kick-member or jabber 44 shown in Fig. 2. This jabber 44 comprises, as shown in Fig. 2, a slide rod working through a fixed bearing 45, and carrying at its right end a roller 46. By suitable means (not shown) this jabber may be caused to enter opening 42, when the ring is ready for ejection, to let the roller 46 engage the outer peripheral surface of the ring, and thereupon, as the jabber is further advanced, to kick the ring a little off center toward the opening 43; whereupon centrifugal force will instantaneously eject the ring through said opening 43.

In order to provide a convenient means for elevating the barrel 38 at the proper times, the casting which comprises collar 36, arms 37 and barrel 38, also carries, as best shown

in Fig. 2, offset bosses 47, from which are pivotally hung a pair of links 48, the lower ends of which are pivoted to a hand-lever 49, fixedly pivoted to a bracket 50, hung from the under side of table 22.

In order to facilitate the escape of gases beyond the outer limits of pieces 23, 24 and 25, the dependent annular wall surrounding recess 26 in mould-part 18 is provided with a plurality of spaced notches, one of which is shown at 18^a in Fig. 4; clamp-ring 29 is provided with a plurality of spaced openings, one of which is shown at 29^a in Figure 4, and rib 33 is provided with a plurality of spaced notches, one of which is shown at 33^a in Fig. 4.

Referring now to Figs. 7, 8, 9, 10 and 11:

The machine here shown is a variation from that shown in Figs. 1 to 6, particularly in that the driving shaft 51 for the mould is arranged at an angle of approximately 45 degrees to the horizontal. One of the great advantages of this construction, as pointed out above, and as will be more clearly understood from what follows, is that gravity aids centrifugal force in ejecting the ring casting when the latter is solidified, and more than this, and of even greater importance, a better and more accurately formed ring casting results.

Here the main mould-part is indicated at 52 and the complementary mould-part at 53. The main mould-part carries on its upper side a central plate 53^a; at its under side is pinned on the upper end of driving shaft 51. This shaft runs in anti-friction bearings indicated at 54 in Fig. 7, set in an upper casting 55, which casting, together with a lower casting 56, forms the framework of the machine. Shaft 51 has fixed thereon at its lower end a pulley 57 adapted to be driven by a suitable belt (not shown) or the like.

The complementary mould-part 53 (see Fig. 11) is provided with an outer flange 53^a having therein a groove 53^b constituting as shown the outer race for a circumferentially arranged series of balls 58. The cooperant inner race for these balls is carried by a groove 59^b formed on the upper exterior of a skirt 60. This skirt is provided with two offset portions 61 through which are passed slide-rods 62 working through bearings 63 on casting 55. The offset portions 61 of the skirt 60 are suitably pinned to the slide-rods; so that each upward sliding movement of the slide-rods causes an upward separating movement of complementary mould-part 53 relative to main mould-part 52, due to the mould-part 53 being locked to skirt 60, for movement therewith axially of the mould, by means of the series of balls 58; these balls being also provided as anti-friction members permitting rotation of complementary mould-

part 53, on its own momentum, after the latter has been moved upward and away from the constantly spinning main mould-part 52 for the ejection of a casting just previously made.

Refractory pieces 23, 24 and 25 are provided as in the case of the embodiment of Figs. 1 to 6, and are preferably fixed to their respective mould-parts in the same manner and by the same means as illustrated here and as described in connection with said Figs. 1 to 6.

In order normally to hold the two mould-parts together, and yet to permit axial separation thereof when desired for the ejection of casting, the following parts are provided: The two lower ends of slide-rods 62 are joined by a cross-bar 64. Expansile springs 65 are arranged as shown normally to hold the mould-parts in mutual engagement so that such parts will rotate as one in unison with shaft 51. Carried by a cross-shaft 66, journaled in the framework, are two arms 67 and a hand-lever 68.

On depressing the hand lever 68, the arms 67 swing up and force the slide-rods 62 upward against springs 65. Thereupon the skirt 60 moves upward relative to the constantly spinning main mould-part 52 and the skirt carries with it the complementary mould-part 53, which latter nevertheless continues to spin under momentum due to the anti-friction bearing afforded by the balls 58.

This operation of course separates the two mould-parts, so that the ring casting just before made, lying on the flush upper surface of main-mould part 52, commences to drop slightly, due to gravity; whereupon centrifugal force acts, and instantaneously the ring is ejected in a downward direction.

However, in order to provide extra, certain provision against any possibility of such a ring casting, during ejection, flying upward, possibly to injure a workman, the skirt 60, it will be noted, is provided with an opening, at 60^a on its under side, and the skirt is so designed that when the two mould parts are separated to the maximum, the opening will lie opposite the upper surface of piece 23 carried by main-mould part, 52. In this way, a ring casting may not leave the mould except by a movement downward, that is, through opening 60^a. And in order to prevent the possibility, in the event of a ring flying upward so far as to strike a part of the skirt beyond the bounds of said opening, of said casting becoming injured as the result of impact against the skirt, the skirt is lined with a buffer 69. This buffer is preferably formed of asbestos, the better to withstand the high heat conditions prevailing. I have found it very convenient to use a length of ordinary sized asbestos brake-lining.

In order to permit the angle of the shaft 51 to be altered slightly when desired, the framework comprised of castings 55 and 56 is shown as being provided with a depending boss 70 formed as a sleeve adapted to take around a suitable transverse shaft (not shown).

It will be understood that such shaft supports the framework and at the same time the construction is such that the angle of inclination of the mould-shaft 52 may be varied when desired.

Referring now to Figs. 12, 13, 14 and 15:

The embodiment here shown comprises a turret-type machine in which a plurality of rotors of the class shown in Figs. 7 to 11 are incorporated, these rotors being radially arranged on a turn-table 78 and each being of the same construction as the embodiment shown in said Figs. 7 to 11 with the exception that the mould-separating means of said Figs. 7 to 11 (parts 66, 67 and 68) are dispensed with and the pulley 57 is removed. Each mould driving-shaft is elongated, and carries, instead of such a pulley, a beveled gear 71. All such bevelled gears 71 are simultaneously driven by a bevel gear 72. Referring to Figs. 12 and 15, it will be seen that gear 72 is driven, from a motor 73, by means of bevel gears 74 and 75 and bevel gears 76 and 77. Turn-table 78 is adapted to rotate about a fixed vertical shaft 79 set in a main frame 80. Table 78 is turned by the following means: Secured to the underside of the table is a bevel-gear 81 meshing with a bevel pinion 82 fast on a shaft 83 carrying a sprocket wheel 84. Sprocket wheel 84 is coupled by a chain 85 to a sprocket wheel 86 on a common shaft (not shown) with a worm-gear 87 meshing with a worm 88 on the shaft of motor 73.

Instead of the mould-separating means of Figs. 7 to 11, above referred to, here each radially arranged moulding unit is provided with a mould-separating means as follows: Pivoted below each unit at 89, as shown, is a lever 90 carrying at its bottom a roller 91. To coact with such means predeterminedly is a fixed cam-rail 92, it being understood that each lever 90 is rocked as its unit passes the station whereat such rail is located during rotation of table 78. Referring to Figs. 12 and 14 each lever 90 normally hangs as shown in full lines, but on a lever 90 passing over cam 92 such lever is rocked to the position shown in broken lines at 90^a in Fig. 14.

In operation:

Assume the table 78 of Fig. 13 is rotating in a clockwise direction. Let A represent the metal feeding station. Then B will represent the ejection station. It will be seen that each casting will be congealing and solidifying as the unit in which it lies is passing the stations D, E, F, and G. Yet

pouring, and also ejection, is continuous. The number of stations between the pouring and ejection stations, here four, is merely illustrative, as preferably the machine will be so designed that, in view of the number of seconds required between pouring and ejection relative to each casting unit, and in view of the number of units on the table, the speed of rotation of the table is such that a ladler at the feeding station may pour metal as fast as he can handle his ladle.

I claim:

1. The art of making articles of annular cross-section by rotary casting, which includes providing a mould, rotating the mould, and depositing molten iron in the mould, while controlling the time of solidification of the iron, relative to the time required for the iron to be predeterminedly deposited around the mould, so that the iron solidifies in less time than iron similarly cast in a mould having molten iron-contacting surfaces of the usual foundry-sand type, to obtain a very fine, close grain, and yet so that the iron requires a long enough time to solidify, relative to iron similarly cast in a permanent mould having molten iron-contacting surfaces of metal, to prevent chilling.

2. The combination with a rotary casting machine, of a mould therefor including a mould body and a lining for the latter including a plurality of preformed shaped blocks constructed of a material having the qualities of being highly refractory to temperatures at least as high as the lowest practical pouring temperature of molten iron, of including ingredients none of which will combine with the components of the molten metal in such a way as so to bond the casting to the lining as to preclude removal of the casting without appreciable injury to such lining, of substantially absolute resistance to the abrasive action of the molecules of the molten metal subjected to centrifugal action during rotation of the mould, of substantially absolute resistance to distortion from repeated temperature-change shocks, and of substantially absolute resistance to chipping, flaking, splitting and other damage from such shocks or from the momentary slight expansion of the molten metal, if any, at the instant of solidification.

3. The art of manufacturing articles of annular cross-section by the rotary casting method, which includes providing a two-part mould, separable axially of the annular article when cast, rotating the mould parts simultaneously, introducing molten metal within the mould, continuing such simultaneous rotation of the mould parts until the article is solidified, and then while maintaining the axis of rotation of the mould inclined to the vertical, separating the mould parts axially while at least one of the mould

parts continues rotation, to permit centrifugal force to act positively to facilitate ejection of the cast article.

4. The process defined in claim 3, wherein the same further involves maintaining the axis of rotation of the mould inclined to the vertical and also to the horizontal.

5. The process defined in claim 3, wherein the same further involves maintaining the axis of rotation of the mould inclined to the vertical substantially 45 degrees away from the horizontal.

6. In a rotary casting machine, combination, a main mould having an incomplete annular moulding cavity, a complementary mould for completing such cavity during a casting operation but separable from the main mould axially of said cavity, a power-means for rotating the main mould continuously during a number of successive casting operations, journalling means for the complementary mould independent of the journalling means for the main mould, the two moulds carrying cooperant surfaces for mutual engagement when the two moulds are brought together whereby during a casting operation the power-means rotates the two moulds simultaneously and at the same speed, means for separating the two moulds after the completion of each casting operation, and guiding means carried by one of the moulds for spanning a part of the bounds of the space between the moulds when they are separated, thereby, when a cast article is ejected from between the moulds, to direct said article to be ejected by way of another part of said bounds.

7. The machine defined in claim 6, wherein the axis of rotation of the main mould is inclined to the vertical, whereby gravity cooperates with centrifugal force in automatically ejecting the cast article after the moulds are separated following a casting operation.

8. The machine defined in claim 6, wherein said journalling means for the complementary mould includes an anti-friction bearing whereby the complementary mould continues to rotate under momentum during the ejection of said cast article, whereby, in turn, when the two moulds are again brought together for a subsequent casting operation, inconsiderable shock is imparted to the power-means.

9. In a rotary casting machine, in combination, a main mould having an incomplete annular moulding cavity, a complementary mould for completing such cavity during a casting operation but separable from the main mould axially of said cavity, a power-means for rotating the main mould continuously during a number of successive casting operations, journalling means for the complementary mould independent of the journalling means for the main mould, the two

moulds carrying cooperant surfaces for mutual engagement when the two moulds are brought together whereby during a casting operation the power-means rotates the two
 5 moulds simultaneously and at the same speed, means for separating the two moulds after the completion of each casting operation, said journalling means for the complementary mould including an anti-friction
 10 bearing whereby the complementary mould continues to rotate under momentum after the moulds are separated for the ejection of said cast article, said journalling means for the complementary mould including a series
 15 of rolling anti-friction elements and an inner race and an outer race, there being also provided a ring member having thereon one of said races, and a movable member for engaging said ring member to move the
 20 same axially of the mould and consequently separate the complementary mould from the main mould, said movable member constituting a part of said separating means.

10. In a rotary casting machine, the combination of a rotor adapted to be power-driven and being mounted for rotation about an axis obliquely inclined to the horizontal, said rotor carrying part of a mould, a second rotor carrying a complementary part of
 25 said mould and arranged for rotation about the axis aforesaid, a frame fixed against rotation, anti-friction bearings for the second rotor carried partially by said frame, guiding means for supporting said frame and
 30 along which said frame is slidable in a line parallel to said axis, and means for sliding said frame on said guiding means to separate the two moulds after a casting operation to permit centrifugal force to eject a
 35 cast article.
 40

11. The machine defined in claim 10, wherein said frame carries a shield on its upper portion for overlying the space between the two moulds when the two moulds
 45 are separated as described, to prevent accidental ejection of a cast article in an upward direction.

12. In a rotary casting machine, in combination, a main mould having an incom-

plete annular moulding cavity, a complementary mould for completing such cavity during a casting operation but separable from the main mould axially of said cavity, a power-means for rotating the mould
 50 parts; the axis of rotation of the mould parts being inclined to the vertical, whereby gravity is instrumental in ejecting the cast article after the moulds are separated following a casting operation.
 55

13. The art of making ferrous metal articles of annular cross-section by rotary casting, which includes providing a mould, rotating the mould, and depositing a molten
 60 such metal in the mould, while controlling the time of solidification of said metal, relative to the time required for the same to be predeterminedly deposited around the
 65 mould, so that said metal solidifies in less time than similar metal similarly cast in a mould having molten iron-contacting surfaces of the usual foundry-sand type, to obtain a very fine, close grain, and yet so that
 70 the deposited metal requires a long enough time to solidify, relative to similar metal similarly cast in a permanent mould having molten iron-contacting surfaces of metal, to minimize chilling.
 75

14. The art of making ferrous metal articles of annular cross-section by rotary casting, which includes providing a mold, rotating the mold, and depositing a molten
 80 such metal in the mold, while controlling the time of solidification of said metal, relative to the time required for the same to be predeterminedly deposited around the mold, so that said metal solidifies in less time than
 85 similar metal similarly cast in a mold having molten iron-contacting surfaces of the usual foundry-sand type, to obtain a very fine, close grain, and yet so that the deposited metal requires a longer time to solidify
 90 than similar metal similarly cast in a permanent mold having molten iron-contacting surfaces of metal.
 95

Signed at New York, in the county of New York and State of New York, this 19th day of May, A. D. 1921.

AUGUSTUS M. HENRY