

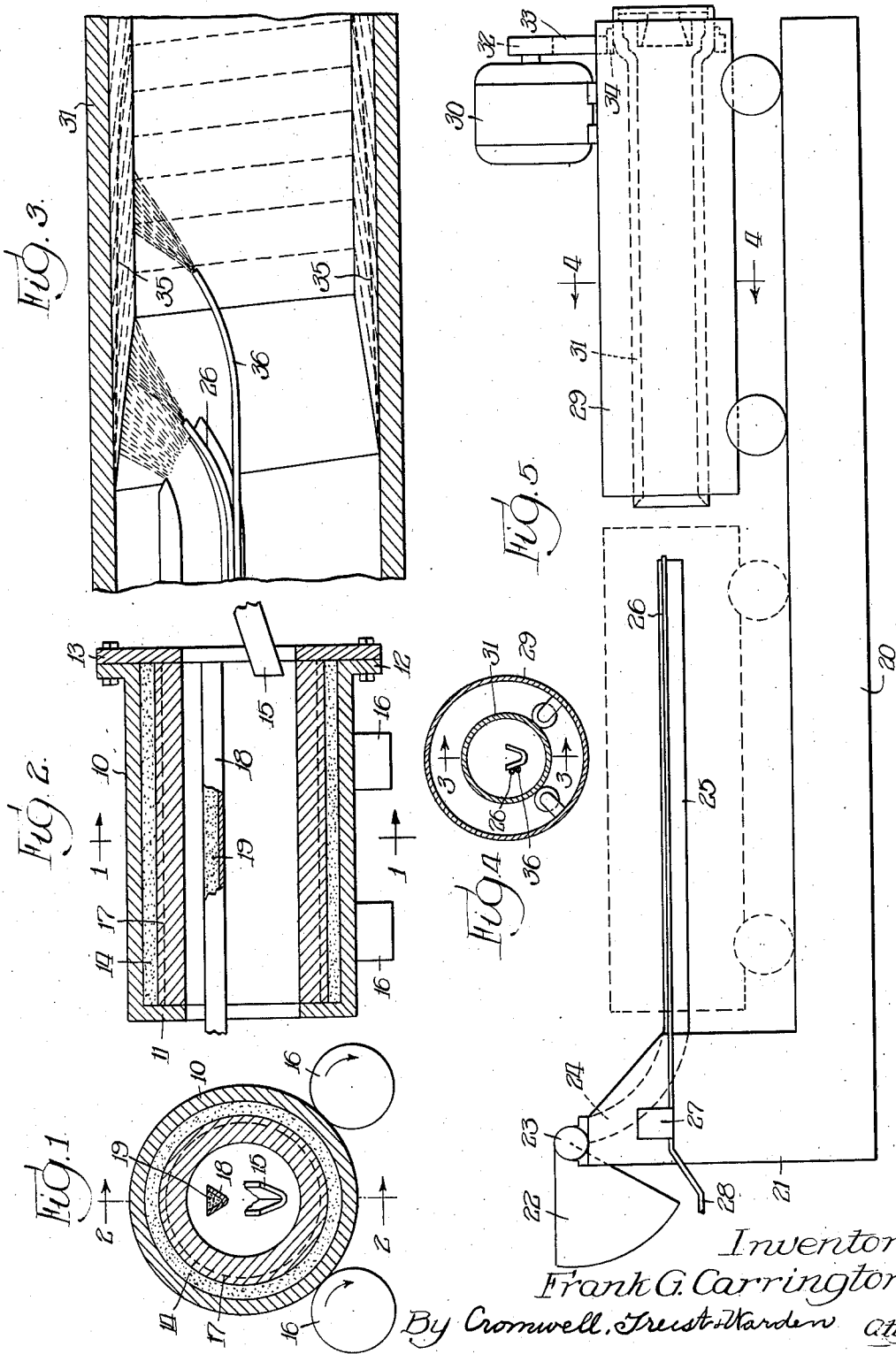
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METALLURGICAL PROCESS

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METALLURGICAL PROCESS

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The present invention relates to an improved form of centrifugally cast metal and to a process and apparatus for producing the same.

A principal object of the invention is the provision of a centrifugally cast or formed metallic object which is interiorly treated with a modifying agent or material.

An additional object is to provide a process whereby a metal such as iron may be centrifugally cast while in a molten form to impart to the metal a predetermined hollow form, the metal being treated through the hollow portion thereof with a modifying agent which disseminates into the interior portion of the metal prior to the hardening thereof.

Another object is to produce a centrifugally cast object composed of metal and having different characteristics on its interior and exterior portions by reason of the interior treatment while the metal is in a molten condition with small quantities of a modifying agent.

Still another object is to provide a method and apparatus for the production of an interiorly modified centrifugally cast metal object in which the metal is maintained in a rotating condition after being poured and is interiorly treated with another metal or with small quantities of a non-metallic modifying agent.

An additional object is to provide a process whereby a molten metal such as cast iron is rotated while in outwardly confined condition to maintain the metal in a predetermined hollow form and the interior of the metal is treated after the metal has assumed its predetermined form with a substance which will modify the properties of the metal being cast by an alloying or a chemical action.

These and other objects will be observed upon a consideration of the following specification and by reference to the accompanying drawing, in which

Fig. 1 is a cross-sectional view taken along line 1-1 of Fig. 2 of an apparatus for producing my improved type of material by the process described herein;

Fig. 2 is a longitudinal sectional view of the apparatus, taken along line 2-2 of Fig. 1;

Fig. 3 is a fragmentary longitudinal view of a preferred form of apparatus for carrying out my method, the view being taken along line 3-3 of Fig. 4;

Fig. 4 is a cross-sectional view of a preferred embodiment of the apparatus taken along line 4-4 of Fig. 3; and

Fig. 5 is a side elevation shown somewhat dia-

grammatically of a complete form of the preferred embodiment of the apparatus showing the casting mold in operating and non-operating positions.

It has been recognized as highly desirable to produce many articles such as pipe and the like by a centrifugal casting method in which a mold is rotated at a relatively high speed sufficient for imparting centrifugal force to molten metal cast therein. A preferred method of effecting the centrifugal casting is to provide overlapping helical ribbons of molten metal which are automatically bonded together to form a uniform article. Apparatus of the type used in centrifugally casting pipe is shown in Patents Nos. 1,699,612 and 1,949,433.

In accordance with the present invention the metal from which the finished article principally is composed is cast in a centrifugal mold and is maintained in a condition of rotation. Thereafter the interior portion of the hollow article formed by the rotation is treated with a modifying agent while the metal is in a molten condition, the modifying agent disseminating into the interior portion of the molten metal to an extent dependent upon such factors as the nature of the modifying agent and the molten metal. The modifying agent may be a material which alloys with the centrifugally cast metal or it may be a material which has a chemical or physical effect upon the cast metal.

In the apparatus shown in Figs. 1 and 2, an outer cylindrical casing 10 is turned over at one end to form a flange 11 and is turned out at the other end to form a flange 12. To the flange 12 is removably secured a plate 13. The plate 13 and the flange 11 form a base into which is fitted a mold indicated at 14. The material from which the mold 14 is constructed may be sand or any other suitable substance. After formation of the mold lining 14 a body of molten metal such as iron is poured into the mold through the spout 15 while the mold is rotated. Rotation may be imparted to the mold by the frictional rollers 16, upon which the mold is mounted. The centrifugal action accompanying this motion causes the molten metal to form a cylinder having its outer walls adjacent the material of the mold lining 14. As the mold lining is at a lower temperature than the molten material the outer surface of the molten material has a tendency to cool and solidify somewhat before the interior surface, the extent of the solidified metal being arbitrarily shown by the dotted line indicated at 17.

After the molten metal has assumed the hollow form as shown in Figs. 1 and 2, the rotation of the mold is continued and a small quantity of a modifying agent is introduced into the hollow portion of the cast metal through the channel member 18. By tilting the channel member 18 the modifying agent is added in powdered or other suitable form to the interior surface of the molten metal and disseminates into the metal.

After this dissemination occurs the metal is allowed to harden to complete the operation. Preferably, the modifying agent indicated at 19 is in a finely divided physical state which will facilitate its being rapidly absorbed by or disseminated in the molten metal.

In the production of certain types of centrifugal castings it will be found desirable initially to cast only a portion of the metal and to treat this initial portion while still molten with an internally applied modifying agent, the remainder of the casting then being poured. A second quantity of a modifying agent may be applied to the internal portion of the second body of metal cast in the manner described. By employing modifying agents for the first and second applications which are different in their characteristics and effect upon the cast metal, it is possible to produce a casting having an outer portion corresponding to the initial treatment and an inner portion corresponding to the secondary treatment with a different modifying agent. Thus, the outside of the casting may be relatively soft iron and the internal portion may be of a chemical-resisting nature.

After the modified casting has solidified the plate 13 is removed and the casting is taken from the mold in the usual manner.

In Figs. 3-5 there is shown a preferred embodiment of apparatus for producing internally modified castings in accordance with the invention. This apparatus is of the "Delavaud" type. In this apparatus a base 20 has at one end an upstanding frame structure 21 upon which is mounted a ladle 22 for molten metal. The ladle is tilted about a pivot 23 at a predetermined rate and the molten metal runs from the ladle into a pouring trough 24. The trough 24 is provided with a slightly inclined longitudinally extending portion 25.

Alongside the longitudinally extending section 25 of the end pouring trough is mounted a tube 26, by which a modifying agent is blown against the molten metal of the casting in the manner shown in Fig. 3. The modifying agent, preferably in a powdered form, may be contained in the hopper 27, a stream of air passing through this hopper from line 28 acting to pick up the desired quantity of the powdered material and to transfer it through line 26.

The top of the base member 20 is provided with a track upon which is mounted a mold carriage 29. Water may be circulated through the carriage to exert a cooling effect on the mold. A motor 30 mounted on the top of the mold carriage rotates the mold 31 which is mounted in the carriage 29 through gears 32, 33, and 34, the latter gear being a relatively large ring gear mounted directly on the mold, as shown in Fig. 5.

The mold carriage in Fig. 5 is shown in the position in which it is between pouring intervals. When it is desired to produce a cast pipe, the mold carriage 39 is rolled into the position shown in dotted lines. The ladle 22 is filled with molten metal and a regulated flow of metal is poured into the trough 25 by tipping the ladle

at a controlled rate. Prior to the start of the pouring operation the motor 30 is started and the mold 31 is rotated rapidly. This rapid rotation causes the metal which issues from the pouring spout of the trough 25 to be maintained in its predetermined hollow form by means of centrifugal force. As the pouring operation continues the carriage 29 is moved away from its telescoped position with respect to the trough 25, so that the molten metal is deposited upon the walls of the mold in an overlapping helical manner, as indicated by the dotted lines in Fig. 3. The pouring operation and the movement imparted to the mold carriage are synchronized so that a pipe of uniform thickness is obtained. Ordinarily, the machine is mounted at a slight inclination and the spout of the pouring trough is curved so that the molten metal falls to the following side of the mold axis. As the turns of the helix overlap, the overlapped portions are autogenously bonded together to produce a continuous casting.

In the progressive solidification which takes place in the mold the outer surface portion of the casting initially hardens and the time for the formation of a surface incrustation of hardened metal may be of the order of a fraction of a second. The hardening continues toward the interior portion of the casting and as the casting continues the zone of molten metal in the casting may be as indicated by the dotted line 35 in Fig. 3. It will be seen that this molten pool extends for some distance after the pouring spout. After the metal has been poured and while it still is in a molten condition it is treated with a disseminating modifying agent which may be represented by the powdered material blown through the line 26. As shown in Fig. 3, the powdered material issuing from the line 26 contacts and is diffused in an intermediate portion of the casting from the interior thereof. The subsequent turns of the helix are deposited over the treated portions.

By adjusting the position of the tube 26 the particular region for application of the modifying agent may be determined as desired. The zone of molten metal in the casting is in somewhat fixed relation with respect to the spout of the pouring trough and a second tube 36 may be employed for treating the interior portion of the casting at a region spaced somewhat after the last turn of the helix. As indicated by the dotted line 35, the solidified exterior portion of the casting is considerably thicker at the region served by the tube 36 and the modifying agent will not be disseminated into as great a proportion of the metal of the pipe at this point as where the powdered modifying agent is applied closer to the pouring operation.

Thus, in this embodiment of the process, the internal treatment may be localized to a restricted and selected zone including the desired portion of the metal of the casting, and the desired disseminating modifying agent may be applied to the molten metal at a predetermined time after the particular portion of the metal to which it is applied has been poured. This zone treatment and local application of a regulated or controlled amount of modifying agent applied directly to the interior portion of the molten metal after the molten metal has assumed the desired form produces a definite recognizable effect which will depend upon the natures of the modifying agent and poured metal and the extent to which solidification of the exterior has pro-

gressed. With respect to the latter factor, the penetration of the modifying agent will be limited by the extent to which the outer portion of the metal has solidified. Where it is desired to exclude an area such as a particular outside region from the treatment, this region is solidified prior to application of the modifying agent. It will be seen that the process may be regulated to exclude certain areas from treatment or treat certain areas by controlling local temperatures and providing local applications of the modifying agent. Thus, one longitudinal portion may have a local treatment of one type and another longitudinal portion may have no treatment or a different treatment. Where the cast is formed by progressively pouring the molten metal, the interior treatment of the molten metal with the modifying agent likewise may be progressive and in predetermined relation with respect to the pouring operation.

The process may be varied widely to produce castings which differ considerably in their characteristics. As has been stated, the modifying agent may be applied to the interior of an intermediate portion of the casting and additional metal then may be poured over the treated portion. This additional metal likewise may be treated with an interiorly applied modifying agent.

The particular nature of the modifying agent likewise may vary to a considerable extent, depending upon the results desired and the nature of the cast metal. In the case of cast iron pipes a desirable modifying agent consists of powdered ferro silicon. When applied internally to the pre-formed molten metal this material and many other modifying agents have a greatly more pronounced effect in modifying the crystalline structure of the metal upon solidification than when added to the metal prior to the pouring operation, and the amount of the modifying agent which may be used for obtaining highly beneficial results may be quite small. For example, in the production of a 400-pound iron pipe approximately 150 grams of ferro silicon may be employed as the modifying agent for the interior treatment of the pipe. This quantity is so small that it can be detected by analysis only with difficulty. However, the change in the physical structure which is obtained by the interior treatment is pronounced. A cast iron pipe having a silicon content of the order of 1.8 per cent may have a chill thickness of approximately $\frac{1}{8}$ inch, and this chill thickness may be reduced to the order of $\frac{1}{16}$ inch by incorporating about 2.5 per cent silicon in the metal prior to casting. By treating the iron containing 1.8 per cent silicon in accordance with my invention, utilizing approximately 4 ounces of silicon, the interior treatment will result in a reduction of the chill thickness to approximately $\frac{1}{64}$ inch without appreciably increasing the percentage of silicon.

Other modifying agents such as iron sulphate, iron sulfide, and iron oxide may be employed. These particular modifying agents have a tendency to act as retardants on graphitization. Where it is desirable to produce a product which is interiorly resistant to certain chemicals, small quantities of powdered molybdenum, nickel or other metals may be employed in the interior treatment of the cast molten metal. If desirable, these modifying agents may be employed in molten condition. After addition of the modifying agent to the molten iron, the former quickly disseminate into the body of the iron. The proc-

ess may be employed in the production of special products, such as rolls for metal working, in which it is desirable to allow for shrinkage phenomenon. That is, intermediate portions of the roll may be treated interiorly as described hereinbefore with powdered chromium and the inner portions may be treated interiorly with a powdered material such as ferro silicon to impart characteristics which inhibit roll cracks. The chromium acts to impart hardness to the outer portion of the roll which is used in working metal.

In certain cases it will be found desirable to produce an iron cylinder having a soft outer portion and an inner portion of different predominating characteristics. The outer portion may be produced by casting the outer portion and treating it interiorly while still in a molten condition with a suitable modifying agent. Thereafter, the inner portion of the cylinder may be cast against the outer portion and interiorly treated with a hardness-imparting modifying agent. Then, the cylinder may be turned in a lathe to remove the outer soft layer and to leave exposed the hard inner layer. Grinding operations also may be employed to reduce the cylinder to the desired extent.

While the process is particularly adapted to the production of cast objects of iron and its alloys, it likewise is possible to produce centrifugally cast products of other metals. For example, a bronze cylinder may be cast and while the metal still is molten it may be interiorly treated with powdered tin to produce an interior surface of reduced friction. If desirable, a portion of the cylinder initially may be cast and while still molten interiorly treated with powdered zinc to impart increased hardness to the outside of the cylinder.

The interior treatment of a whirling body of molten metal in the manner described is particularly effective for rapid and thorough dissemination of the modifying agent. In producing any particular product, experience will indicate the proper extent to which the outer solidification should proceed prior to the interior treatment with the modifying agent. The type and amount of the modifying agent will depend upon the results which it is desired to obtain. By introducing the molten metal at a temperature considerably higher than the melting point thereof, the metal will remain in a molten condition for a longer period of time in the mold than if it is cast at a temperature which is closer to its melting point. A longer time, therefore, will be available for disseminating the modifying agent. When a rapidly rotating body of metal is treated interiorly with a modifying agent, the modifying agent disseminates outwardly against the solidification tendency of the metal.

It will be recognized that many changes may be made in the invention as described herein without departing from the scope thereof, and such changes are intended to be included in the appended claims. For instance, the modifying agent may in some cases be used in other than powdered form. Or, the modifying agent may be added to the interior of the poured metal by a feed screw or otherwise as described.

I claim:

1. A process of the type described, which comprises imparting rotary motion to an outwardly confined body of molten metal to maintain the same in predetermined hollow form, thereafter adding to the interior portion of said confined body of molten metal a modifying agent which

will disseminate therein, casting additional molten metal interiorly of said rotating body of metal, and thereafter adding to the interior of said additional molten metal a modifying agent which will disseminate therein.

2. A process of the type described, which comprises imparting rotary motion to an outwardly confined body of molten metal to maintain the same in predetermined hollow form, thereafter adding to the interior portion of said rotating confined body of molten metal a modifying agent which will disseminate therein, casting additional molten metal interiorly of said rotating body of metal, and thereafter adding to the interior of said additional molten metal a different modifying agent which will disseminate therein, one of said metals being ferrous and the disseminating agent therefor being powdered ferro silicon.

3. A process of the type described, which comprises imparting rotary motion to a molten body of outwardly confined ferrous metal to maintain the same in predetermined hollow form, treating the interior portion of the molten ferrous metal with powdered ferro silicon through the hollow therein while the ferrous metal is rotating, and continuing the rotation of the molten ferrous metal until the ferrous metal solidifies.

4. The process of centrifugally casting pipes composed of ferrous metal, which comprises pouring an axially progressive stream of molten ferrous metal, imparting rotary motion to and outwardly confining the poured stream of metal to form an axially progressively elongated tube, said rotation being sufficiently rapid to cause said stream of metal to form overlapping layers of autogenously bonded ferrous metal, applying a powdered modifying agent which will disseminate into the molten metal against the interior surface of said tube after said metal has been poured and while the metal still is in molten condition, and continuing rotation of said metal after the application of said powder and until said metal has solidified.

5. In the axially progressive method of centrifugally casting pipe, the steps which comprise pouring a stream of molten metal, outwardly confining the poured metal and imparting a sufficiently rapid rotary motion to the confined metal to form the same into interiorly rounded shape, progressively moving said stream of molten metal axially during the pouring operation to produce said stream into overlapping helical layers of metal autogenously bonded together, applying a controlled stream of powdered modifying agent which will disseminate into the molten metal to the interior surface of the poured metal after said metal has been formed into interiorly rounded shape and before the interior surface thereof has solidified, imparting axial motion to said stream of powdered modifying agent, and continuing rotation of said metal after application of said powdered modifying agent and until said metal has solidified.

6. In the axially progressive method of centrifugally casting pipe, the steps which comprise pouring a stream of molten metal, outwardly confining the poured metal and imparting rotary motion thereto to form the poured metal into interiorly rounded shape, progressively moving said stream of molten metal axially during the pouring operation to produce overlapping helical

layers of metal autogenously bonded together, directing a jet of a gas having incorporated therein a powdered modifying agent capable of disseminating into the molten metal directly against the interior surface of the poured metal after said metal has been formed into interiorly rounded shape and before the interior surface to which the powder is applied has solidified, moving said jet of powder-laden gas axially with and somewhat after said stream of molten metal, and continuing rotation of said metal after application of said powdered modifying agent and until said metal has solidified.

7. The process of centrifugally casting pipes composed of ferrous metal, which comprises pouring an axially progressive stream of molten ferrous metal, imparting rotary motion to and outwardly confining the poured stream of metal to form an axially progressively elongated tube, said rotation being sufficiently rapid to cause said stream of metal to form overlapping layers of autogenously bonded ferrous metal, applying powdered silicon compound which will disseminate into the molten metal against the interior surface of said tube after said metal has been poured and while the metal still is in molten condition, and continuing rotation of said metal after the application of said powder and until said metal has solidified.

8. In the axially progressive method of centrifugally casting pipe, the steps which comprise pouring a stream of molten metal, outwardly confining the poured metal and imparting a sufficiently rapid rotary motion to the confined metal to form the same into interiorly rounded shape, progressively moving said stream of molten metal axially during the pouring operation to produce said stream into overlapping helical layers of metal autogenously bonded together, applying powdered ferro silicon as a modifying agent which will disseminate into the molten metal to the interior surface of the poured metal after said metal has been formed into interiorly rounded shape and before the interior surface thereof has solidified, imparting axial motion to said stream of powdered modifying agent, and continuing rotation of said metal after application of said powdered modifying agent and until said metal has solidified.

9. In the axially progressive method of centrifugally casting pipe, the steps which comprise pouring a stream of molten metal, outwardly confining the poured metal and imparting rotary motion thereto to form the poured metal into interiorly rounded shape, progressively moving said stream of molten metal axially during the pouring operation to produce overlapping helical layers of metal autogenously bonded together, directing a jet of a gas having incorporated therein powdered ferro silicon as a modifying agent capable of disseminating into the molten metal directly against the interior surface of the poured metal after said metal has been formed into interiorly rounded shape and before the interior surface to which the powder is applied has solidified, moving said jet of powder-laden gas axially with and somewhat after said stream of molten metal, and continuing rotation of said metal after application of said powdered modifying agent and until said metal has solidified.

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