May 13, 1924. 1,493,602

R. G. COATES

METHOD AND APPARATUS FOR CASTING STEEL INGOTS

Filed July 21, 1920

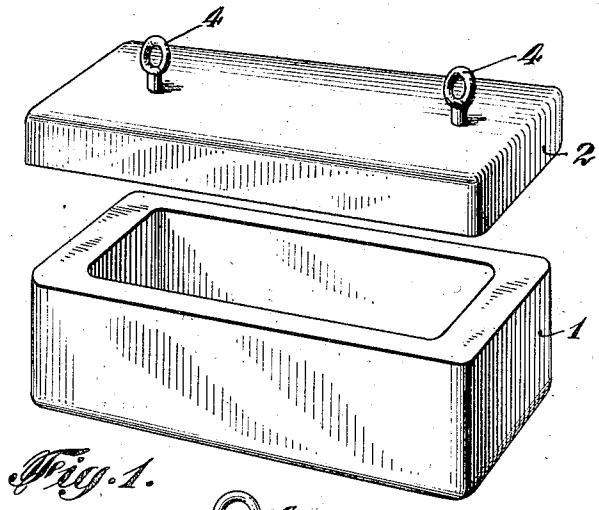


Fig. 1.

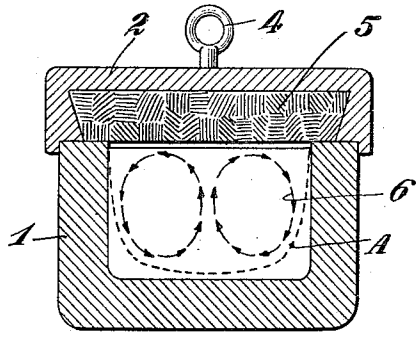


Fig. 2.

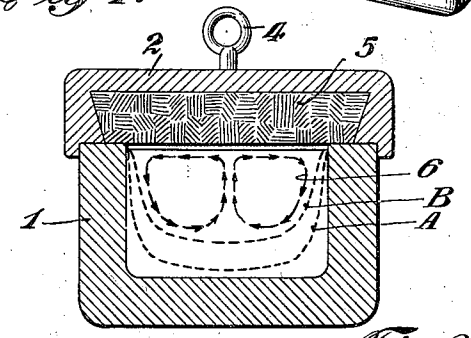


Fig. 3.

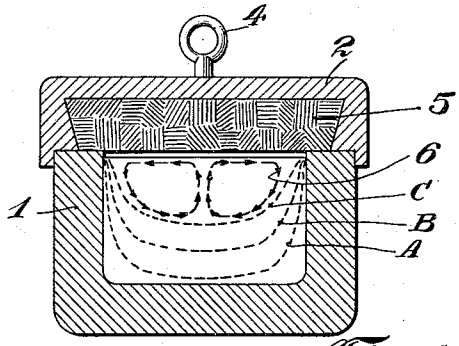


Fig. 4.

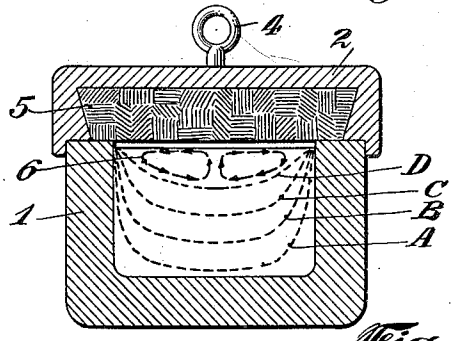


Fig. 5.

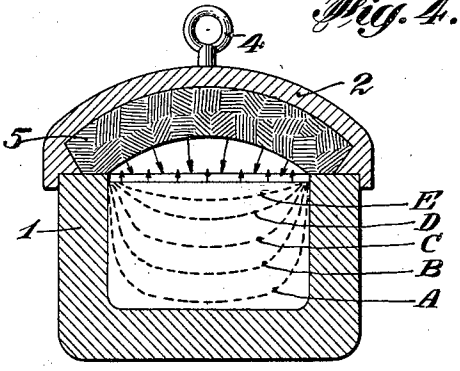


Fig. 6.

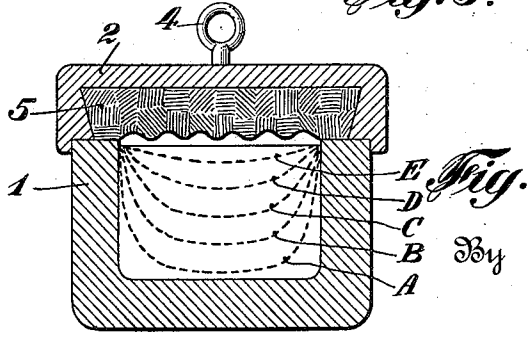


Fig. 7.

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UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR CASTING STEEL INGOTS.

Application filed July 21, 1920. Serial No. 397,371.

To all whom it may concern:

Be it known that I, RAY G. COATES, a citizen of the United States, and a resident of the city of Pasadena, in the county of Los Angeles, State of California, have invented new and useful Improvements in Methods and Apparatus for Casting Steel Ingots, of which the following is a specification.

This invention relates broadly to metallurgy and more particularly to a process and apparatus for casting steel ingots and the like.

The principal object of the present invention is a process and apparatus for casting steel ingots and maintaining the surface of the steel molten by conserving the excess heat in the molten steel while causing a chilling action to progress upwardly from the bottom of the mold.

A still further and important object of the present invention is a method and apparatus for casting steel ingots wherein convectional currents are maintained in the molten steel during the casting operation by maintaining the top surface hot while causing the steel to cool gradually from the bottom of the mold upwardly.

A still further and important object of the present invention is the method and apparatus for casting elongated steel ingots by maintaining the surface of the steel molten while causing convectional currents to occur in the molten steel from the bottom of the molten steel to the top surface thereof while gradually cooling the steel from the bottom side progressively toward the top surface.

A still further and important object of the present invention is the process and apparatus of casting elongated steel ingots and maintaining the top surface molten by conserving the excess heat from the molten steel adjacent the top surface thereof and reflecting the same back upon the steel while causing convectional currents in the steel during the gradual cooling of the steel from the bottom side upwardly toward the top side.

A still further and more specific object of the present invention is a method and apparatus for casting elongated steel ingots and maintaining the top surface of the steel molten while the lower side of the ingot is gradually solidified by providing a suitable reflecting surface over the top surface of the molten steel to reflect excessive heat from the steel back into the steel and wherein the reflecting surface is formed in such manner as to concentrate the reflected heat.

Other and further objects of the present invention will in part be obvious and will in part be pointed out in the specification hereinafter by reference to the accompanying drawings wherein like parts are represented by like characters throughout the several figures thereof.

Realizing the present invention may be carried out in structures and by methods other than those herein specifically disclosed, I desire the disclosure herewith shall be understood as illustrative and not in the limiting sense.

Figure 1 is a perspective view diagrammatically illustrating an elongated chill mold and cover therefor embodying the present invention;

Figure 2 is a sectional view diagrammatically illustrating the beginning of the convectional currents;

Figure 3 is a view similar to Figure 2 showing convectional currents being maintained while the lower portion of the ingot is crystallizing;

Figures 4 and 5 are similar to Figure 3 but illustrate further progress in the crystallizing of the metal;

Figure 6 illustrates a slightly modified form of heat reflecting cover;

Figure 7 illustrates a form of heat reflecting cover.

Heretofore in the art the common practice has been to cast steel ingots in vertical molds and attempts have been made to maintain the upper portion of the mold hot while permitting the lower end of the mold to cool in order to try to avoid the forming of "pipes" in the ingot. Such attempts in the prior art have not been entirely successful because the occluded gases which are freed during the crystallizing of the steel have a relatively long distance to travel in a vertical mold from the chilled metal in the bottom of the mold to the top surface of the steel and the result has been to produce a spongy condition in the upper end of the ingot due to the very fact that the upwardly moving gases passed through the

molten steel while this portion was cooling under delayed action after the crystallization in the base of the ingot was well established.

In my Patent No. 1,327,987, January 13, 1920, the objections of the prior art were overcome by casting the steel ingots in an elongated horizontal mold wherein one long side of the ingot was formed by the upper or top surface of the steel.

As explained in the patent, the steel is poured in a shallow pool and it is desirable to maintain the top surface of this pool fluid so that it will be the last of the metal crystallized and in the said patent this was accomplished by adding heat by means of a hot refractory cover which is heated to a temperature above the melting point of the steel. This cover is heated and is applied to the mold after the mold is filled in order to add heat to the top of the metal and prevent the surface of the metal from solidifying until the remaining part of the ingot has crystallized.

The present invention relates to the discovery that since the molten steel is considerably above crystallizing temperature when it is poured into the shallow pool, the relatively large surface of the molten steel may be maintained liquid by conserving the heat of the steel instead of adding heat to the steel. This may be due to the fact that in using an elongated mold the proportion of the upper surface of the molten metal to the area of the chill sides and bottom is very much greater than where a vertical mold is used. Therefore by conserving the heat from this large area and reflecting the heat rays back upon the steel it is possible to maintain the desired temperatures without the trouble and cost of using a previously heated cap. In view of the chilling action of the lower part of the mold, and because of the fact that the mold is relatively shallow, there is a tendency to establish convectional currents in the fluid metal, which currents move from the central metal portion down the sides toward the bottom and up through the center. This convectional action has a tendency to release occluded gases and carry the gases upwardly by movement of the steel and at the same time tends to bring the hot steel to the surface and by preventing the surface from losing heat as compared to the sides and bottom of the mold, the desired effect of maintaining the surface fluid while the bottom crystallizes is attained and no "pipe" is formed.

In carrying out the present invention a cover is used for the mold, with the cover constructed of material having a small total heat absorbing capacity and preferably of low heat conductivity. Preferably, but not necessarily, the cover is arranged in the form of a reflector having a surface best calculated to reflect the heat from the molten steel back upon the steel so that the heat at the surface is maintained without substantial loss. Such a cover may be substantially white heat on the side adjacent the fused metal and yet be comparatively cool on the opposite side. Preferably the under side of the cover is placed as near as possible to the surface of the fused metal without coming in contact therewith so that the fused metal quickly heats the cover by radiation to approximately the temperature of the molten steel and at the same time the gases may escape freely from the steel. The upper surface of the metal is maintained hot both by internal radiation and convection so that the radiation from the cover and the heat from the metal beneath provides a superficial top layer of fluid metal which is maintained fluid long after the lower side of the ingot has crystallized.

The present invention further contemplates maintaining the steel in such condition by use of the original surplus heat in the liquid metal itself. While the top surface is maintained above the crystallization point, the remaining part of the ingot gradually crystallizes in cupped zones which enclose the liquid metal that is still molten and is moving under convectional currents. Thus a substantially homogeneous mixture of metal is provided throughout the cross-section of the ingot, and since the cupped zones of crystallization gradually flatten from the maximum zone, comprising the sides and bottom of the mold, to the minimum zone comprising substantially the top surface of the mold, the crystals in the metal extend in directions which facilitate the release of the gases and the convectional currents, moving along a cupped zone, help to carry the gases to the surface and all sponginess of the metal is avoided.

The cover preferably comprises materials of low heat conductivity and small specific heat so that the total heat capacity of the material will be low and the material should be of such character as to be substantially surface heated without the heat penetrating to any great extent or into the body of the cover or without robbing the surface of the fused metal of any large quantity of heat. Such materials as are in common use for sustaining high temperatures may be utilized, for example, suitable fire clay products or clay mixtures with sawdust or ground wood, which burns out and leaves a porous cellular substance. Magnesium mixtures with sawdust or ground wood or other chemicals which act as a leavening material to give off gas when the material is burned in order to provide a great number of small air cells in the mass may be used. Infusorial earth, largely siliceous as a base, with finely divided cells throughout the mass, may answer

satisfactorily for carrying out the present invention. As a matter of fact, any non-conductor of heat having a low total heat capacity and low conductivity and which is capable of standing high temperatures, may be utilized for carrying out the present invention.

In order to provide for conveniently handling the cover, the infusorial material may be secured within a suitable retaining member which may comprise a cast of wrought metal skeleton so that the material comprising the heat refractory will be protected when the cover is handled in practical use.

Referring now to the drawings, which disclose more or less diagrammatically a simple form of mold for carrying out the process herein disclosed, the mold or chill preferably comprises an elongated trough 1 which preferably is so proportioned that the cross-section thereof is substantially square so that the cross-section of an ingot cast in the mold will be nearly square, although a very slight draw is provided at the sides of the mold in order to facilitate the removing of the ingot. This mold is adapted to be capped immediately after the hot molten steel is poured, by means of a cover 2, which is provided with handling rings 4 and which comprises a casing or backing to receive and support the refractory material 5. This material may comprise infusorial earth burned with a leavening material to provide a spongy mass adapted to reflect the excess heat from the molten steel back upon the surface of the molten steel so that the surface thereof becomes a superficially heated area. Since the sides and bottom of the ingot are losing heat due to the chill mold, convectional currents are established in the molten steel and immediately after the steel is poured these currents operate as a vortex ring, a cross-section of which moves substantially in the direction of the arrows 6 in Figures 2, 3 and 4. As the zones of crystallization A, B, C, D and E gradually approach the top surface of the ingot the vortex ring gradually flattens until it is substantially coincident with the top surface, at which time the ingot will be substantially solidified.

In Figure 6 the cover portion is illustrated as being curved and preferably this curve will comprise substantially a parabola so that the heat rays rising vertically from the surface of the molten steel are reflected back on the molten steel by the parabolic reflecting surface in such manner that the heat is concentrated in substantially the mid zone of the ingot, thereby accentuating the convectional currents by maintaining a very hot zone over the upper middle portion of the ingot.

In Figure 7 the reflecting surface is ridged in such manner as to comprise a plurality of reflectors which have a substantially parabolic cross-section and each reflector is divided from its neighbor by a rib. This type of reflector produces a plurality of hot zones over the surface of the steel and maintains a condition which tends to cause the upper surface of the steel to move toward the sides and produces a flatter vortex ring action.

The present invention provides a very simple, economical, and at the same time efficient method and apparatus for producing an ingot of solid homogeneous structure without pipes and without the application of additional heat during the process.

Having thus described my invention, what I claim is:

1. The method of forming steel ingots and the like which comprises pouring the molten steel to form a shallow pool of molten steel, then controlling the temperature of the steel by conserving the excess heat of the steel adjacent the surface of the steel by reflecting radiating heat back upon said surface while permitting gases from the steel to escape freely, and causing solidification of the steel to proceed gradually from the sides and bottom of the pool while the surface thereof is maintained liquid until the top side of the ingot is the last portion to solidify.

2. The method of forming steel ingots and the like which comprises pouring the molten steel to form a shallow pool of molten steel then controlling the temperature of the steel by conserving the excess heat of the steel adjacent the surface of the steel while permitting gases from the steel to escape freely by capping the elongated mold with a non-conducting heat reflecting member and causing solidification of the steel to proceed gradually from the sides and bottom of the pool while the surface thereof is maintained liquid until the top side of the ingot is the last portion to solidify.

3. The method of forming steel ingots and the like which method comprises pouring molten steel into a mold having its maximum longitudinal direction substantially horizontal, then conserving the excess heat of the steel adjacent the surface thereof by reflecting radiating heat back upon said surface while permitting gases to escape freely from the steel and causing the metal to gradually solidify in cupped zones, with the maximum zone comprising substantially the sides and bottom of the mold and the minimum zone comprising substantially the top surface of the ingot.

4. The method of forming steel ingots and the like which method comprises pouring molten steel into a mold having its maximum longitudinal direction substantially horizontal and of a substantially square cross-section, then capping the open

top side of the mold to conserve the excess heat of the steel adjacent the surface thereof by radiation and reflection from a cap of material of low specific heat and low heat conductivity while permitting gases to escape freely from the steel and causing the metal to gradually solidify in cupped zones, with the maximum zone comprising substantially the sides and bottom of the mold and the minimum zone comprising substantially the top surface of the ingot, and maintaining convectional currents in the steel above the zones.

5. The method of forming ingots of steel and the like which method comprises pouring molten steel into a horizontal chill mold, then providing a heat reflecting surface adjacent the surface of said molten steel and out of contact therewith to conserve the excess heat in the steel adjacent the surface thereof by reflecting radiating heat back upon said surface while chilling the steel mass gradually adjacent the sides and bottom thereof to cause cupped zones of fusion to form while maintaining the vortex ring of convectional currents within the molten steel above the cupped zones and above the zone of fusion.

6. The method of forming ingots of steel and the like which method comprises pouring molten steel into a horizontal chill mold, then providing a heat reflecting surface adjacent the surface of said molten steel and out of contact therewith to conserve the excess heat in the steel adjacent the surface thereof with the heat reflected in such manner as to provide a hot zone in the middle of the top surface of the molten steel, while chilling the steel mass gradually adjacent the sides and bottom thereof to cause cupped zones of fusion to form while maintaining a vortex ring of convectional currents within the cupped zones and above the zone of fusion.

7. An apparatus for use in casting steel ingots and the like comprising an elongated trough of material adapted to chill the sides and bottom of the steel which may be poured into said trough, and a cover adapted to be placed over the long open mouth of the trough, with said cover comprising material of low specific heat and low heat conductivity whereby the heat of molten steel in the trough will be conserved.

8. An apparatus for use in casting steel ingots and the like comprising a long horizontal elongated trough having a substantially square cross-section and being formed of material adapted to chill the sides and bottom of the steel which may be poured into said trough, and a cover adapted to be placed over the long open mouth of the trough, with said cover comprising material of low specific heat an low heat conductivity whereby the heat of molten steel in the trough will be conserved.

9. An apparatus for use in casting steel ingots and the like comprising an elongated trough of material adapted to chill the sides and bottom of the steel which may be poured into said trough, and a reflecting cover adapted to be placed over the long open mouth of the trough, with said cover comprising material of low specific heat and low heat conductivity and having an under surface shaped to concentrate the heat rays whereby the heat of the molten steel in the trough will be conserved and reflected back on the steel.

10. An apparatus for use in casting steel ingots and the like comprising an elongated trough of material adapted to chill the sides and bottom of the steel which may be poured into said trough, and a cover adapted to be placed over the long open mouth of the trough, with said cover comprising non-fusible material of low specific heat and low heat conductivity whereby the heat of molten steel in the trough will be conserved.

11. The method of casting steel ingots and the like which comprises pouring the molten metal into an elongated horizontal chill mold to form a shallow pool, and then placing a heat-reflecting member over the surface of the molten metal to delay the freezing thereof by conserving the heat radiated from such surface and reflecting same back upon the molten metal.

12. The method of casting steel ingots and the like which comprises pouring the molten metal into an elongated horizontal chill mold to form a shallow pool therein causing solidification to proceed gradually from the sides and bottom of the pool, and then placing a non-conducting heat-reflecting member over the surface of the molten metal to delay the freezing thereof by conserving the heat radiated from such surface and reflecting same back upon the metal.

13. The method of casting steel ingots and the like which comprises pouring the molten metal into an elongated horizontal chill mold to form a shallow pool to cause solidification to proceed gradually from the sides and bottom of the pool, and maintaining the surface of the pool molten by radiated heat reflected back to such surface until the top side of ingot is last to solidify.

14. A horizontal ingot-mold comprising an elongated open mouthed trough formed of material of high conductivity to chill the sides and botom of the molten metal therein, and a cover for the trough comprising material of low specific heat and low heat conductivity arranged in proximity to the top surface of the molten metal.

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