Aug. 3, 1937. E. GATHMANN ET AL 2,088,696

MEANS FOR PRODUCING INGOTS

Filed June 21, 1934

Fig. 1.

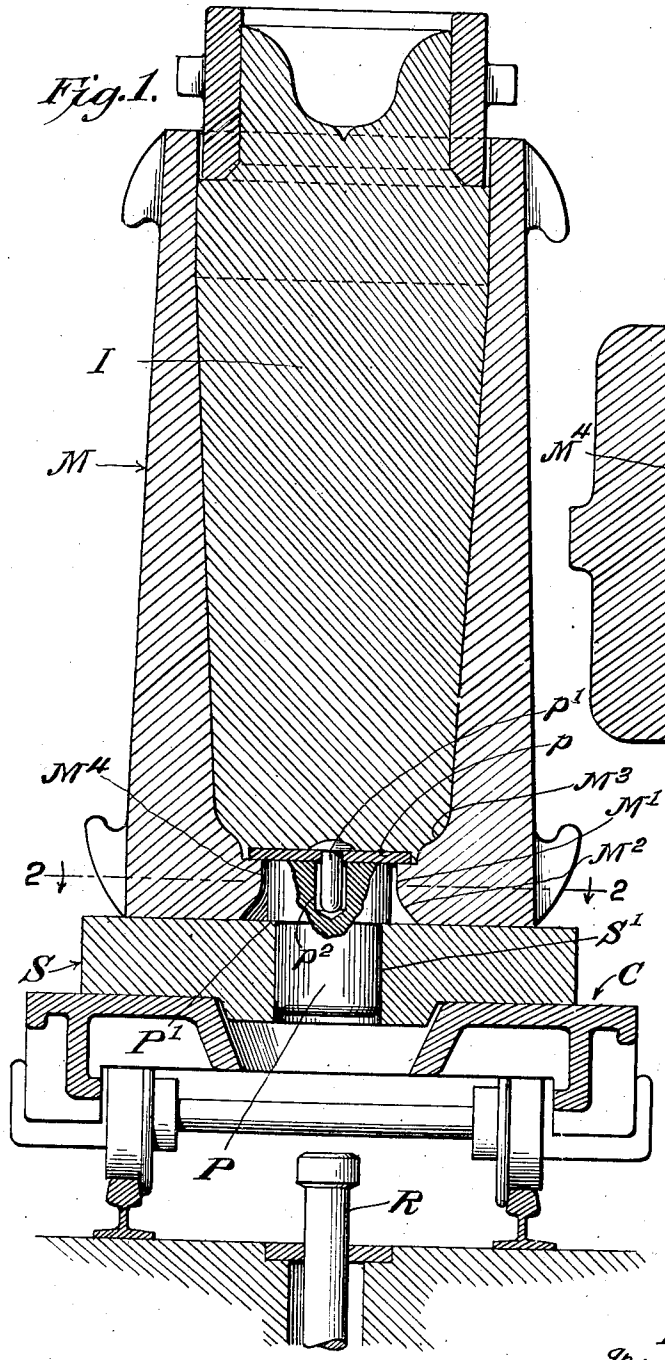


Fig. 2.

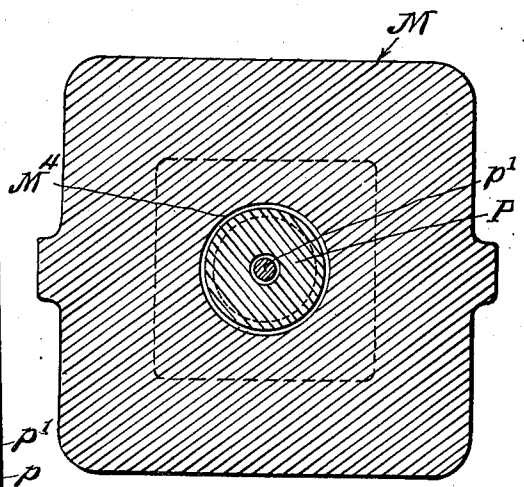
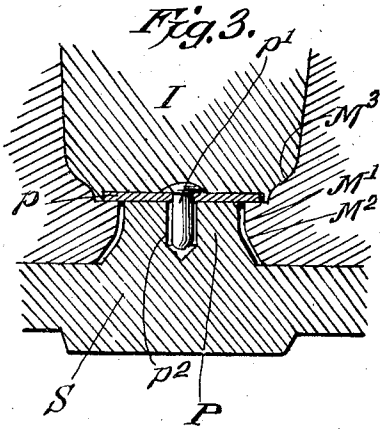


Fig. 3.



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MEANS FOR PRODUCING INGOTS

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4 Claims. (Cl. 22—139)

This invention relates to methods of and means for producing ingots and more particularly to methods of and means for effecting localized accelerated cooling of a particular portion of the ingot metal whereby a more homogeneous ingot is produced, and whereby setting up of the mold assembly and stripping of the ingot is facilitated.

Practically all ingots made in the commercial production of steel are cast in vertical molds, i. e., molds having vertically extending matrices or ingot-forming chambers. Such molds may be classified into two broad categories, namely, big-end-down molds, in which the matrix is larger at the bottom than at the top thereof, and big-end-up molds in which the matrix is larger at the top. The bottom end portions of ingots cast in either big-end-up or big-end-down molds have a crystalline structure usually somewhat different from that of the intermediate and upper portions of the ingot, due to the intersection of the lines of growth of the dendritic crystals from the bottom and lower side walls of the mold. This crystalline structure results in the formation of cleavage planes, which frequently cause lines of weakness within the lower part of the ingot when it is rolled in the mill, necessitating cutting off or "cropping" of a considerable portion of the rolled billet or bloom in which these lines of weaknesses occur. The formation of the undesirable cleavage planes which result in lines of weakness is much more pronounced in big-end-down ingots than in ingots of the big-end-up type.

One object of our invention is to reduce as nearly as possible the formation of these lines of weakness by eliminating or reducing the underlying cause, i. e., by reducing to a minimum the relative dendritic growth in a horizontal direction that causes the formation of cleavage planes at the junction of the horizontal dendrites with the vertically extending dendrites, this being accomplished in accordance with the invention by cooling different portions of the bottom of the ingot at different rates or times.

Another object is to provide an improved ingot mold or assembly constructed or equipped to effect differential cooling of an ingot in accordance with our improved method.

A further object of the invention is to provide an improved assembly of big-end-up mold and bottom cooling element therefor, such as a plug having a high coefficient of heat conductivity compared to that of the mold proper, the arrangement being such that the mold can be lowered on to a support on which the cooling element has previously been positioned and/or secured, and the cooling element thereby extended relatively into the mold bottom opening. In accordance with a further feature of the invention, a relatively thin metallic sealing plate is located within the bottom portion of the mold in heat-transferring relation to the cooling element, and preferably is seated on and supported by the mold bottom walls and the cooling element. Other objects will become apparent from a reading of the following description, the appended claims, and the accompanying drawing, in which:

Figure 1 is a vertical sectional view of a Gathmann mold, cooling element, and sealing plate assembly arranged in accordance with one feature of the invention and being one form adapted for use in practising our improved method of ingot production;

Figure 2 is a horizontal sectional view taken on the line 2—2 of Figure 1; and

Figure 3 is a fragmentary vertical sectional view of a modified form of mold, cooling element, and sealing plate assembly.

Our improved method can be practised by the use of various molds or mold assemblies constructed and/or arranged in accordance with the invention, but for the purpose of illustration and simplicity of disclosure will be described as practised in the production of big-end-up ingots. It will be understood, however, that ingots can be made in accordance with the invention in mold assemblies which may differ in some respects from those shown and described herein.

The mold assembly shown in Figure 1 comprises a big-end-up Gathmann mold M of the general type disclosed in United States Patent 1,419,454, of June 13, 1922, and preferably is made of cast iron. The mold is provided with a bottom opening M^1 which flares outwardly at its lower end portion as at M^2, and may be positioned on any suitable support, as for example, a platform S carried by a transfer car C. The opening M^1 is aligned with an opening S^1 in the support S through which a stripper rod R is adapted to pass.

In accordance with our invention a cooling element having a high coefficient of heat conductivity, in the form shown a copper plug P, is positioned within the opening M^1 in the mold, the lower end of the plug being of reduced diameter and extending downwardly into the opening S^1 in the support S, the annular shoulder P^1 intervening between the upper and lower portions of the plug seating upon the support S for holding the plug in the position shown. A thin metallic sealing plate *p*, which may be of low

carbon steel, is positioned at the bottom of the mold chamber, resting upon the bottom walls of the latter and preferably being partially supported by, and at least being in heat-transferring relation to the plug P. The purpose of the plate p is to act as a primary closure for preventing the egress of molten metal from the mold bottom and also for preventing the stream of molten metal entering the mold from impacting directly upon the plug P. To facilitate centering of the plate p with respect to the plug P, the plate preferably is provided with a pin p^1 adapted to extend into a hole P^2 located centrally in the top of the plug. This preferred arrangement is described in more detail in Patent 1,419,454, of June 13, 1922, issued to Emil Gathmann, one of the joint inventors of the methods of and means for producing ingots disclosed and claimed herein.

The chamber of the mold M is formed with a necked-in bottom end portion M^3 which substantially merges with the top of the cooling plug P; the bottom of the necked-in portion and the top of the plug together defining the bottom seat or bottom wall of the mold M on which the sealing plate is positioned.

In accordance with our improved method, the central portion of the bottom of the ingot is chilled much more rapidly than the surrounding bottom portion, and to this end the cooling plug P, whose upper surface forms the central portion of the mold bottom wall, is formed of a material having a coefficient of heat conductivity considerably higher than that of the cast iron or other material forming the surrounding mold bottom portion M^3. When the mold proper is formed of cast iron, as is usually the case, or a material having a coefficient of heat conductivity comparable to that of cast iron, we prefer to form the cooling plug P of copper, preferably substantially pure copper, since the coefficient of heat conductivity of pure copper is approximately eight times that of cast iron. If it is desired to employ a copper alloy, care should be exercised in the selection of the alloy, and, in any case, the material used for the plug should have a coefficient of heat transfer considerably greater than that of the material of the mold proper. The cooling plug P should be massive and preferably should be of a diameter at least approximately one-half the minimum width of the mold chamber above the necked-in portion M^3, and the depth of the plug should be at least one-fourth as great as its diameter, these relative dimensions having been found to effect the differential cooling rates producing the best results. The term "diameter" is not to be taken in a limiting sense, since the plug need not necessarily be round in cross-section.

In practising our method it is advisable to teem the metal into the mold slowly until the entire bottom portion thereof is covered with molten metal up to a depth which may be between about 50 to 100 percent of the width of the mold bottom, in the mold shown, just above the necked-in portion 5. This will form a relatively quiet pool of molten metal in contact with the plug and the surrounding bottom portion M^3, which is the condition most conducive to obtainment of best results from the cooling of the central and surrounding bottom portions of the ingot at different rates. After the aforesaid pool has been formed by slow teeming, the metal may be introduced in the mold with the pouring nozzle fully open and the nozzle kept wide open until the pouring is completed. The high heat absorbing properties of the plug P result in the ingot metal's being cooled much more rapidly at the central portion of its bottom end than at the surrounding bottom portion, and we have found that this differential cooling reduces and practically eliminates the formation of the damaging cleavage planes hereinbefore referred to. The plate p protects the plug P from direct impact of the entering stream of molten metal, but, being thin, the plate does not interfere appreciably with the cooling action of the plug.

By employing a sealing plate made of a material having a high melting coefficient and a cooling plug made of a material having a high coefficient of heat conductivity, it is possible to seal the mold bottom effectively without the cooling plug's fitting tightly or even snugly in the mold bottom opening; in fact, a considerable clearance space M^4 may be left between the cooling plug and the walls of the mold bottom opening without there being danger of molten metal passing between the vertical walls of the mold bottom opening and the vertical walls of the cooling plug, should there at any time be a slight leakage around the edges of the sealing plate. The ingot metal lying in the bottom of the pool immediately over the sealing plate is chilled so rapidly that even should there be a slight leakage between the sealing plate and the cooling plug the ingot metal will solidify before it can enter the clearance space M^4 to any appreciable extent. This chilling by the cooling plug having a high coefficient of heat transfer is so rapid that the size of the clearance space, which practical experience in practicing an invention has been demonstrated may safely be left, is much greater than would be expected. For example, in a case of molds having a minimum chamber width of about twenty inches and having a bottom opening of about 12'' diameter, a clearance space of as much as one-eighth inch around the plug may be used with no danger of run-outs or the formation of fins which would result in sticking plugs or ingots. The cooling plug, having a high coefficient of heat conductivity, has the capacity to extract heat from the lower surface of the plate p more rapidly than the heat of the molten ingot metal can pass into the plate, so that the plate p will be prevented from reaching a temperature high enough to cause it to stick to the mold bottom.

Because of the large clearance space M^4 thus made permissible, and further because of the tapered or flared opening M^2 in the mold bottom, assembly of the mold and cooling plug on a support preparatory to placing the sealing plate on top of the cooling plug is greatly facilitated, and there is no difficulty in bringing the mold bottom opening I into substantial registration with the plug during lowering of the mold. In most prior big-end-up mold assemblies in which the molds have been provided with bottom openings, these openings have usually been tapered either so as to be smaller at their bottom end or their top end. The arrangement in which the tapered bottom opening is smaller at its lower end possesses the disadvantage of requiring that the closure plug be introduced into the top end of the mold by means of the use of tongs or like implements, and, a cooling plug being quite heavy, weighing at least a hundred to two hundred pounds, this usually necessitates a crane operation. Molds having tapered bottom openings, smallest at their top ends, while permitting

the mold to be lowered over the plug, do not permit a stripping instrumentality to be moved upward through the bottom of the mold. We believe our improved assembly is the first practical arrangement possessing both of the advantages of permitting the mold to be lowered over the plug without exact centering and permitting the plug to be moved upwardly through the mold bottom during stripping.

In the embodiment shown in Figure 3 the cooling plug is made integral with the support or platform upon which the mold rests. While this arrangement does not provide for stripping of the ingot by means of the cooling plug, as is possible with the construction shown in Figure 1, it nevertheless has some advantages for practising our improved methods inasmuch as the volume of the cooling plug is greatly enlarged by the continuous heat transferring character of the unitary plug and mold platform.

The method described above and the apparatus disclosed are the mode of procedure and embodiment of construction preferred at this time, but various changes may be made without departing from the invention as defined in the claims.

We claim:

1. An ingot mold assembly comprising a big-end-up ingot mold having a bottom opening and a cooling plug in said opening, said cooling plug being substantially flush with the lower part of the horizontal mold matrix and being made of material having a coefficient of heat conductivity at least several times that of the body of the mold, in combination with a sealing plate superimposed above said cooling plug, said sealing plate being constructed of a material having a higher melting point than the material comprising said cooling plug.

2. An ingot mold assembly comprising a big-end-up ingot mold having a bottom opening and a cooling plug in said opening, said cooling plug being substantially flush with the lower part of the horizontal mold matrix and being made of material having a coefficient of heat conductivity at least several times that of the body of the mold, in combination with a sealing plate superimposed above said cooling plug, said sealing plate being constructed of a material having a higher melting point than the material comprising said cooling plug, and means for centering said sealing plate with respect to the vertical axis of the cooling plug.

3. An ingot mold assembly comprising a big-end-up cast iron ingot mold having a bottom opening; a heavy copper plug in said opening; and a thin plate of ferrous material in said mold above and in heat-transferring relation to said plug.

4. An ingot mold assembly comprising a cast iron mold having a bottom opening; a closure for said bottom opening consisting of a massive body of relatively thick copper material and a relatively thin sealing plate of ferrous sheet material superimposed and in heat-conducting relation to said copper material.

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