April 1, 1952 H. J. DAUSSAN 2,591,517

METHOD AND DEVICE FOR CASTING INGOTS OF RIMMING STEEL

Filed May 21, 1945 2 SHEETS—SHEET 1

Fig. 1

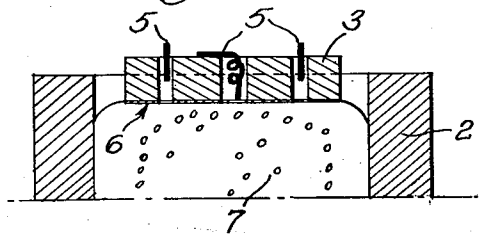

Fig. 2

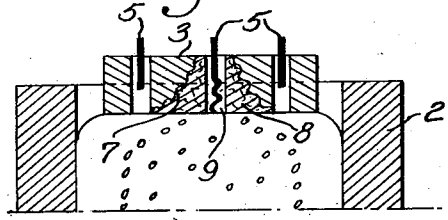

Fig. 3

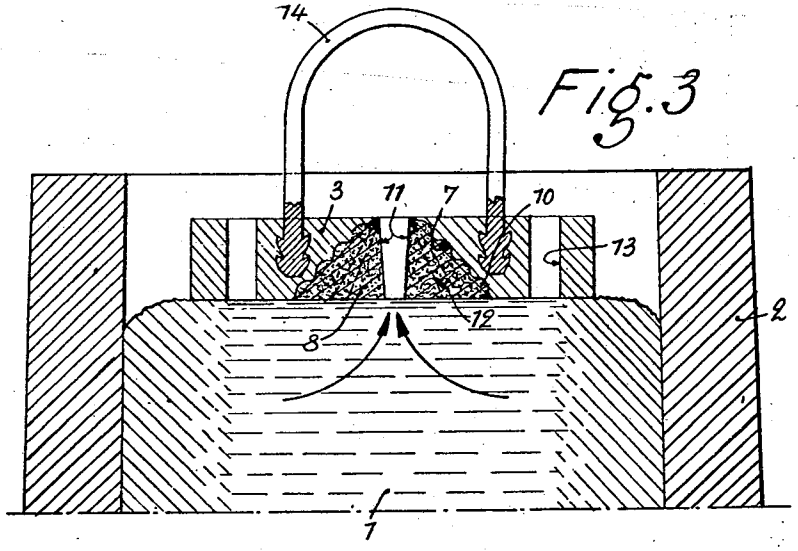

Fig. 4

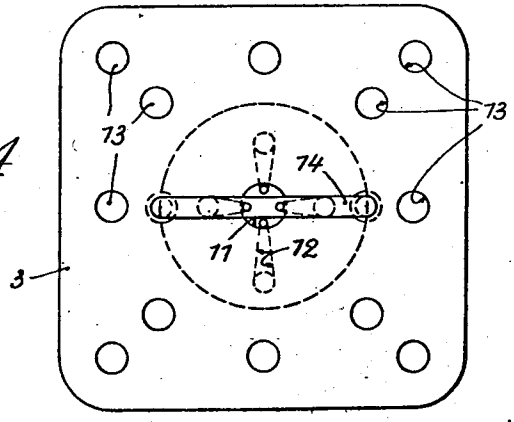

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Fig. 5

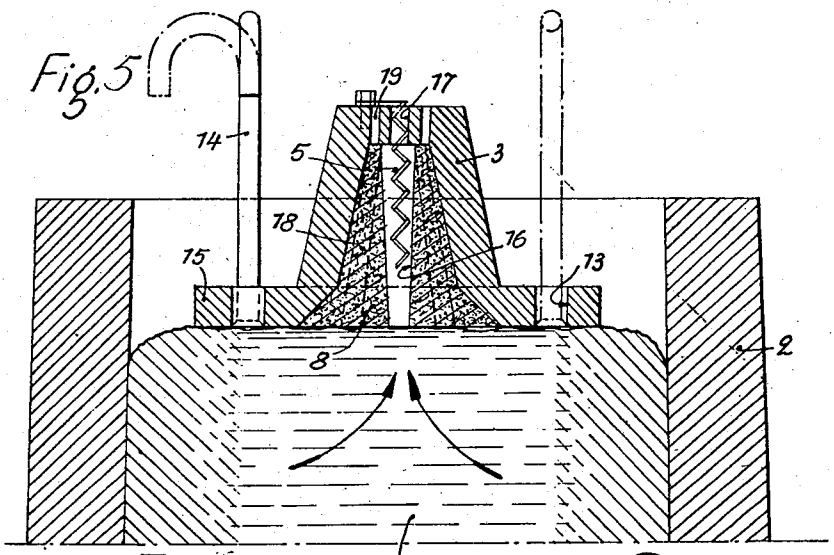


Fig. 6

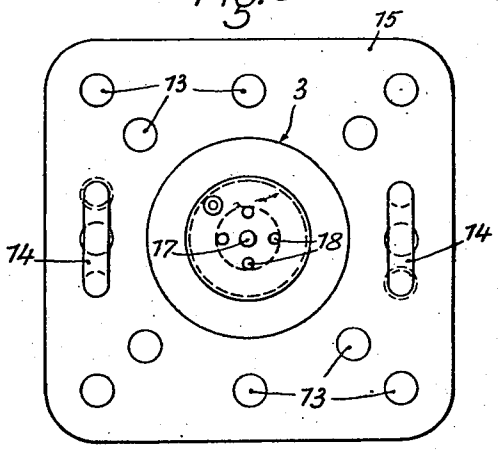


Fig. 7

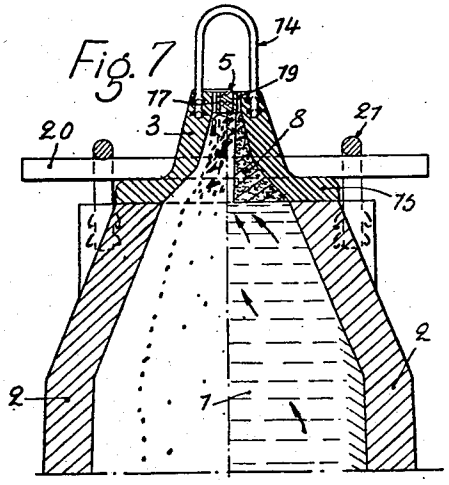


Fig. 8

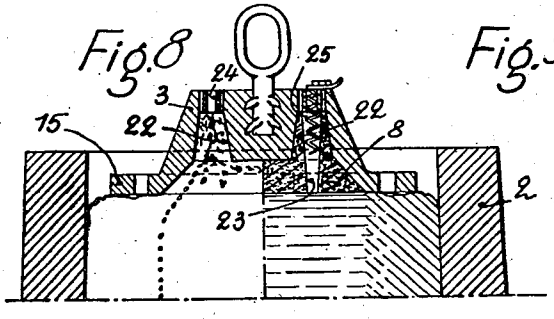
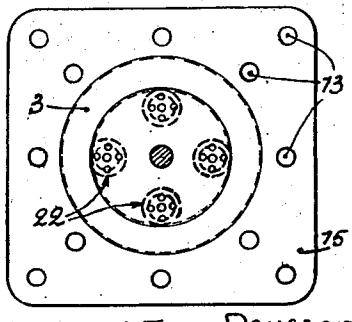


Fig. 9



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UNITED STATES PATENT OFFICE

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METHOD AND DEVICE FOR CASTING INGOTS OF RIMMING STEEL

Henri Jean Daussan, Metz, France, assignor to The Ferro Engineering Company

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Patent expires December 24, 1962

5 Claims. (Cl. 22—147)

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The invention relates to a method and apparatus for improving the quality and yield of ingots of effervescent steel. This steel being also commonly known as rimming steel and also open steel.

A close relationship exists between the formation of the head of ingots of effervescent steel (i. e. of more or less turbulent steel giving off gases during solidification in the mould) and the internal structure or texture of the ingot.

In order to have a clear understanding concerning the subject matter of the present invention, it is necessary to clearly differentiate between the casting of effervescent steel ingots and "killed steel" ingots.

In connection with the casting of ingots of killed steel, the molten metal which is teemed into the ingot mold has, prior to such teeming, been essentially completely deoxidized or "killed" so that the metal in the mold is quiet and solidifies in what might be termed "a quiet manner" and this metal is essentially free from gas.

Ingots of this type are characterized by the formation of a "pipe" which occurs interiorly of the ingot which, before complete solidification, must be filled with molten metal, either by what is known as back pouring or by the provision of a volume of molten metal retained in a hot top or sink head, which metal feeds the "pipe."

With respect to effervescent or rimming steel, the situation is quite different. When the molten metal of this character of steel is teemed into the ingot mold, due to chemical action taking place in the molten metal, there is an ebullition of gas which seeks to escape at the top of the ingot as solidification of the ingot proceeds. This ebullition of gas may be relatively moderate, or quite strong, apparently depending upon internal conditions in the ingot.

Solidification normally progresses from the sides and bottom of the mold and to some extent at the top and in the course of this procedure there is formed in the ingot a central reservoir of molten steel (sometimes herein referred to as a "sack") which is agitated or caused to "boil" by virtue of the gases which are rising through the molten metal and escaping at the top of the ingot.

While the periphery of the top of the ingot is solidified or rimmed in from the side of the mold,

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the central portion is molten as is the metal in the reservoir to which reference has been made, the gas rising through the molten metal of the reservoir and escaping at the top of the ingot. This situation will continue with diminishing effect until the ingot top is solidified.

Having regard to the quality of effervescent steel, it may be advantageous to obtain a flat, concave or convex head, or even a protuberant or prominent head.

For instance, in the process of casting ingots of effervescent steel, it happens that gases liberated at the surface of the molten portion of the ingots carry along with them a certain amount of metal above the casting level, thus causing the formation above this level of a metallic spongeous bulged head of cauliflower shape, which sometimes reaches a large size and causes an appreciable loss of metal, as the metal of the head is worthless and must be discarded; moreover, it complicates stripping off the block from the mould.

It has been endeavoured to avoid the formation of such bulged heads by covering the metal in the mould with a metallic plate, but although this procedure is efficient in avoiding the spongeous head referred to, the gases remain shut up in the metal, especially at the top of the ingot, where they form hollow pockets or voids, a circumstance which also entails a considerable loss of ingot as a consequence of discarding its upper part. It may also happen that the entrapped gases cause the explosion of the solid crust formed under the plate and blow to a great height the still liquid central part of the ingot; this involves a serious danger for the laborer and makes a large part of the ingot unfit for use.

An object of the present invention is to obtain a limited rimming-in action of the metal at the top of the ingot by chilling the peripheral portions of the ingot at the top thereof but at the same time maintaining a molten condition of the metal at essentially the central portion at the top of the ingot so that the rising gas may escape and any incipient formation of spongy metal or rising of the molten metal is controlled and further to impart to the head of the ingot the desired shape and to facilitate the escape of the entrapped gases during a period of time as long as possible, until the complete solidification

of the ingot, keeping at the same time within narrow (or exactly determined) limits the rising of the metal, thus avoiding the formation of large blisters or reducing the number of blisters which would else inevitably be formed, especially at the upper part of the ingot. The size of the top portion which must be cropped off is thus considerably reduced.

With these objects in view, the invention is carried out by the employment of a cover of lesser area than the area at the top of the ingot with which it is to be used, which cover has a rim portion and is provided with one or more open-ended cavities, at least one of said cavities being centrally located and above the central molten area of the teemed ingot. This cover is laid on the top of the ingot, preferably after the metal at the top of the ingot has rimmed in sufficiently to provide a support for the cover and therefore the rim of the cover is in contact with the peripheral portions of the ingot while the cavity is positioned above the still molten portion at the top of the ingot, thus providing a channel for the escape of the gas expelled from the molten metal while at the same time controlling the expulsion of metal particles which might be carried by the expelled gas. The cavity or cavities of the cover may be associated with a deoxidizing or calmative substance or body which counteracts the tendency of the molten metal to rise and prevent spongeous metal formation.

The peripheral or rim portions of the cover when in contact with the top of the ingot will act as a chill and tend to thicken the rimmed-in portion at the top of the ingot, but on the other hand, the central portion of the cover in the vicinity of the at least centrally arranged cavity will remain highly heated because of its proximity to the molten metal and also because of the contact with the exceedingly hot escaping gases. This situation in and of itself has a calmative effect upon the metal and is effective in maintaining liquidity of the molten metal at the top of the ingot. This situation is maintained until the solidification of the top of the ingot or at least so long as there is gas escaping at the top of the ingot.

The foregoing is the important departure of the present invention with respect to that practice which has heretofore and even now obtains in the art, to wit; capping the top of the ingot and so chilling the entire top of the ingot so that the metal freezes at the top of the ingot with the result and consequences which have heretofore been set forth.

Further features and advantages of this invention will be apparent from the following description, with reference to the accompanying drawings which illustrate, by way of example, some embodiments of the present invention and in which:

Fig. 1 shows diagrammatically the upper part of a mould provided with a contrivance according to this invention;

Fig. 2 shows diagrammatically another form of the same contrivance;

Figs. 3 and 4 show respectively in vertical section and in plan view and on a larger scale, one embodiment of the invention.

Figs. 5 and 6 are views similar to Figs. 3 and 4 of a modification;

Fig. 7 is a vertical section of a further modification;

Figs. 8 and 9 show respectively in vertical section and in plan view a device according to the present invention, provided with multiple gas escape vents.

As shown in Fig. 1, molten metal 1 contained in a mould 2 is covered with a strong cover 3, formed with a number of cavities 4. Cover 3 serves to prevent the formation of a cauliflower shaped head, but the cavities 4 provide for the escape of the gases, entrapped in the still effervescent metal, instead of keeping said gases occluded in the upper part of the ingot.

In the case of actively gassing ingots, said gases tend to carry metal along with them, which would soon stop up the holes 4 and then prevent the escape of the gases still left in the ingot. To avoid this defect, cover 3 is associated with a calmative or deoxidizing substance, such as aluminium, silicon, calcium, titanium, boron, etc., or corresponding ferro-alloys, in the shape of powders, shavings, filings, etc.

It is well known, for instance, that some grams of aluminium thrown on an effervescent steel ingot of several tons produce lowering of the level of molten metal to a relatively large extent. However, this addition must be moderate, otherwise the gases will reappear later on when the metal has become more viscous. The deoxidizing or calmative substances are so associated with the cover 3 that they act only intermittently, that is when there is a rising of the metal which, if unrestrained, would tend to plug up the cavity or cavities. Thus, in the case of Fig. 1, straight or spiral aluminium wires 5 are arranged in the holes 4 of cover 3. As the metal tends to rise in the cavities, it makes contact with the lower part of wires 5 and is driven back downwards by virtue of the well-known effect above referred to. When the gases again carry along some metal, a fresh portion of the wires will operate and so forth, until the metal of the ingot is solidified.

Thus, the action of the calmative substance is in some way automatic; it takes place in due time, only as the steel rises in the cavities 4, and only to such an extent as to cause this steel to subside and to keep the cavities 4 open for the escape of the gases. Moreover, said calmative substances give rise to exothermic reactions, which tend to keep the surface of the metal in molten condition, thus avoiding all obstruction; finally, as the molten metal tends to rise in cavities 4, it is driven back by the calmative substance 5 or is maintained in the liquid state in these cavities, without the evolving of the gases being stopped.

The cover 3 may also be associated with such substances which produce exothermic reactions in consequence of which the metal in contact with them is maintained in liquid condition, or which produce purifying slags, these substances being used for instance in the shape of a plastering, lining or coating 6 as shown in Fig. 1; this lining may contain for instance metallic powders tempered with water or mixed with solutions of alkaline or other silicates, or with tar, dextrine, or other binding agents. Alkaline silicate contributes to purifying the ingot, owing to the presence of SiO_2, formed by dissociation of the silicate; the oxides or sulfides such as MnO, FeO, MnS, which rise in the ingot during solidification, combine with one another or coalesce with SiO_2, thus forming a new slag whose ascensional speed is considerably increased and which comes to float over the metal.

Fig. 2 shows a modification of Fig. 1, in which the hole-bored cover 3 contains a central cavity or pit 7 whose wall is coated with some heat-

insulating and/or slag-forming substance, intended to delay cooling and solidification of the central zone of the ingot. This insulating coating 8 is formed with one or several holes 9, for the escape of gases. This heat-insulating substance may advantageously consist of a body of material provided with a multiplicity of passages such as a wadding of animal, vegetable or mineral fibres, woven, twisted or intertwined in any suitable manner. Use may be made, for instance of wooden fibres or shavings, straw, wood shavings, asbestos, mica, etc. On the contrary, cover 3 itself will preferably be made of a heat-conducting substance, such as steel or cast iron, in order that the portions of this cover in contact with the metal around the central zone should hasten cooling by conduction of heat of the peripheral zone of the surface of the ingot. The sack formed by the solidified metal will thus tend to have a profile incurved towards the central zone and guiding the gases towards this latter, and then through the cavities 9 and 4 of the wadding 8 and cover 3.

As in the case of Fig. 1, wires, tubes or other pieces 5 made of aluminium or of some other calmative substance are placed in cavities 9 and 4 to perform the same function as above explained.

A similar result would be obtained by incorporating the deoxidizing or calmative substance in the wadding, e. g. by lining the latter with powdered aluminium mixed with a binding agent. Both these methods of using the calmative substance may also be used. Similarly, wadding 8 can further be impregnated with substances causing exothermic reactions or the formation of purifying slags, such as silicates, exerting the same action as described in connection with Fig. 1.

By way of example, 1 part (by weight) of very finely powdered aluminium is mixed with 3 parts of sodium silicate (40° Bé); the silvery viscous liquid thus obtained is used to saturate the wadding, which is thereafter compressed and dried by exposure to air. The impregnations by a silicate can be dispensed with if the substance used as a wadding itself fulfills the necessary conditions, as in the case of asbestos (silicate of Ca and Mg) or mica (silico-aluminates of K, Fe and Mg).

In the embodiment of Fig. 2, the heat-insulating wadding and the calmative substance, consisting of wires or impregnating the wadding, are gradually consumed as the steel rises, whereby the steel carried along by the gases comes finally to occupy cavity or pit 7, where the impurities and the still entrapped gases will collect. It is thus possible to impart to the head of the ingot the desired shape and to collect in a minimum space the gases and the impurities, thus reducing the losses arising from the discard or the dead head of the ingot.

In Figs. 1 and 2, the lower surface of cover 3 is level, so as to obtain a flat surface on the top of the ingot. However, the lower face of cover 3 may as well be concave or convex, in order to force the steel, when solidifying, to assume one or the other of these two shapes.

Figs. 3 and 4 illustrate a practical embodiment of the invention as diagrammatically represented in Fig. 2. On the molten metal 1 contained in mould 2 is laid a cover 3 of cast iron or steel and formed with a cavity or pit 7 containing a wadding 8, composed for instance of wooden fibres, wooden shavings, charcoal or some other similar substance. As above explained, there may be

incorporated with this wadding a suitable amount of sodium silicate and powdered aluminium, ferrosilicon or some other deoxidizing or calmative substance. The wadding 8 is fixed within pit 7 by means of a putty or cement 10. It is formed with a central hole 11 and lateral holes 12, for the escape of the gases. Cover 3 is likewise formed with cavities 13 (without calmative substance) for the escape of gases as long as the steel is not solidified thereunder. A stirrup or a handle 14, secured to cover 3 is adapted to facilitate handling. Central hole 11 may also be fitted with a tube, made of aluminium or of some other calmative substance or a similar wire may be suspended therein.

In the embodiment of Figs. 5 and 6, cover 3 has the shape of a hood, the rim 15 of which is adapted to lie on the surface of the ingot around the central zone. The wadding, impregnated or not, which lines the inside of the hood is formed with a central hole 16, communicating with a hole 17 formed in the top of the hood. A spiral aluminium wire 5 or an aluminium tube is suspended in holes 16—17. Further holes 18 may be formed in the wadding, with a view to conducting the gases to the exhaust vents 19 of the hood; there are also holes 13 without calmative substance. When the wadding is entirely consumed, the head of the ingot fills the inside of hood 3 where the slags and entrapped gases collect, while the metal situated under the hood 3 is practically faultless.

Fig. 7 shows another embodiment, in which the mould 2 ends at the top in a restricted neck, the contrivance according to the invention, instead of resting on the ingot as in the preceding examples, being tightly fixed over the upper edge of the mould, by means of bars 20 engaging the rim 15 of the hood and stirrups 21, anchored in the mould 2. The right half of the Fig. 7 shows the contrivance as first applied to the ingot; the left part of the same figure shows how the wadding wears out, when the blisters and impurities have collected in the part of the metal contained in the hood.

Figs. 8 and 9 show a cover or hood provided with multiple gas escaping cavities 22 (four in the example represented) every one of which contains a wadding 8 impregnated or not with alkaline silicate and/or with calmative substances, and formed with a chimney 23 adapted to guide the gases towards outlet ports 24 of the hood. A wire or tube 25 made of aluminum or of another calmative substance is placed in every cavity to prevent the metal from being carried along by the gases. The right half of Fig. 8 shows the contrivance as first applied to the ingot and the left half after solidification of the ingot. It may be advantageous to use this embodiment for ingots of large section.

It is obvious that this invention is not limited to the embodiments above described and illustrated and various modifications may be made without departing from the scope of the invention.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:

1. The method of casting an ingot of effervescent or rimming steel which consists in teeming the molten steel into an ingot mold, permitting a limited solidification or rimming-in action of the metal at the top of the ingot while essentially the central portion at the top of the ingot is molten and gassing and maintaining such molten

condition to allow free escape of the gases until there is essentially cessation of escaping gas.

2. The method of casting an ingot of effervescent or rimming steel which consists in teeming the molten metal into the ingot mold, permitting a limited solidification or rimming-in action of the metal at the top of the ingot while essentially the central portion of the ingot at the top thereof is molten and gassing, promoting a chilling condition at the peripheral portions at the top of the ingot while promoting the molten condition of the central portion at the top of the ingot, until the escaping gas has essentially ceased.

3. The method of casting an ingot of effervescent or rimming steel, which consists in teeming the molten metal into an ingot mold, permitting a limited solidification or rimming-in action of the metal at the top of the ingot while essentially the central portion of the top of the ingot is molten and gassing, and maintaining the molten condition and controlling any rising of the metal during the gassing of the metal until the escaping gas has essentially ceased.

4. A device for use in the casting of an ingot of effervescent steel prior to solidification thereof and while there is a molten area at the top of the ingot, and comprising a cover of substantial heat conducting material having a portion of less area than the top of the ingot and adapted to rest upon the top of the ingot, said cover being provided with a cavity which is open at both ends, a body of material provided with a multiplicity of passages located in said cavity, and a deoxidizing material in the form of a wire within said body.

5. A device for use in the casting of an ingot of effervescent steel prior to solidification thereof and while there is a molten area at the top of the ingot and comprising a cover of substantial heat conducting material of less area than the top of the ingot and having a portion adapted to rest upon the top of the ingot, said cover having a hollow extension, a mass of material provided with a multiplicity of passages located within the interior of said extension, and a deoxidizing material in the form of a wire also supported within said extension and depending therein.

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