June 9, 1942. L. B. LINDEMUTH 2,285,523

PRODUCTION OF SOUND METAL INGOTS

Filed Jan. 19, 1939 3 Sheets-Sheet 1

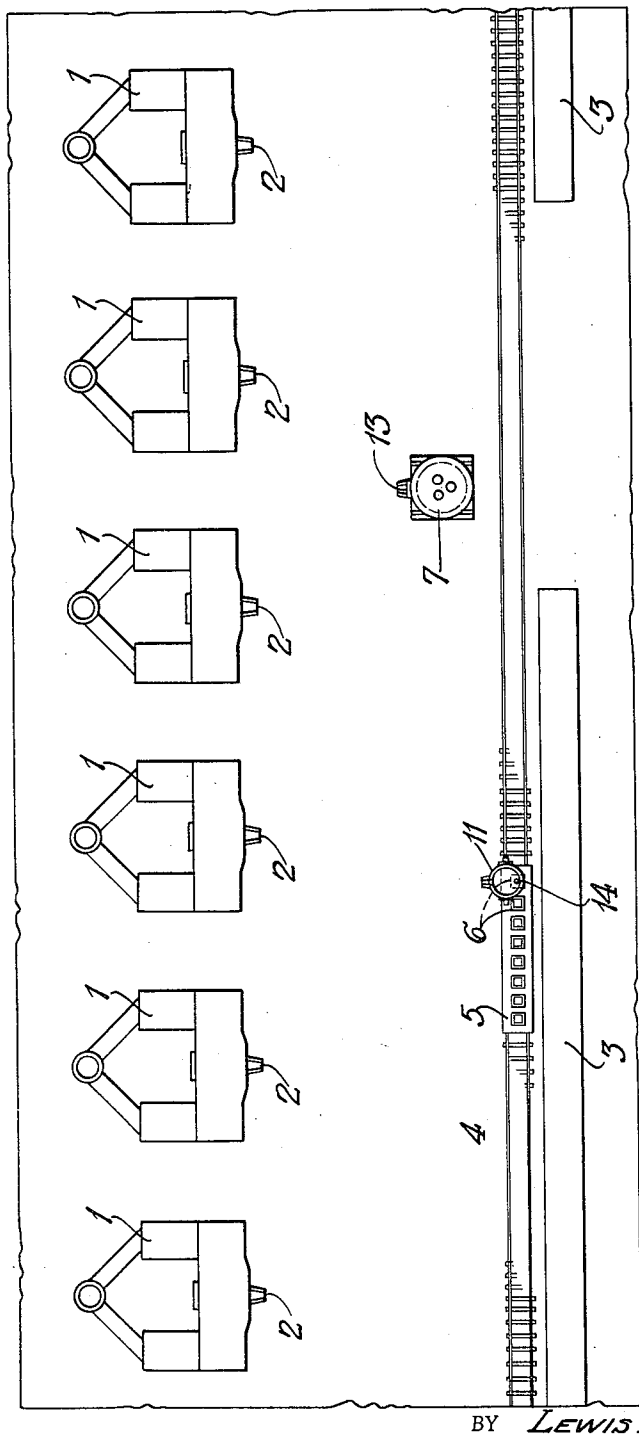


Fig. 1.

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Filed Jan. 19, 1939 3 Sheets-Sheet 2

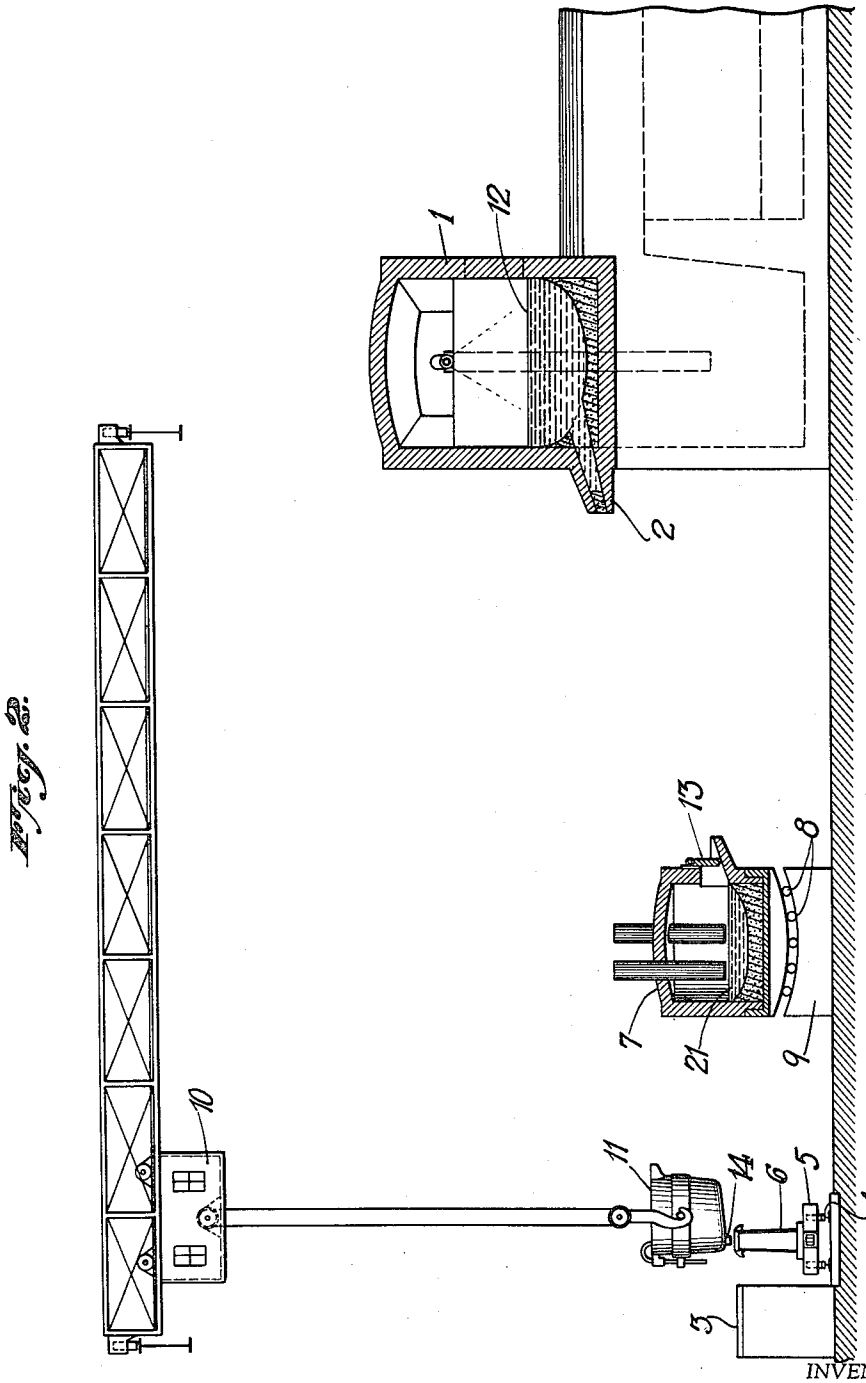


Fig. 2.

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PRODUCTION OF SOUND METAL INGOTS

Filed Jan. 19, 1939 3 Sheets-Sheet 3

Fig. 6.

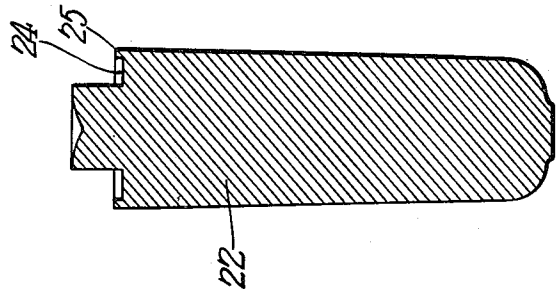


Fig. 5.

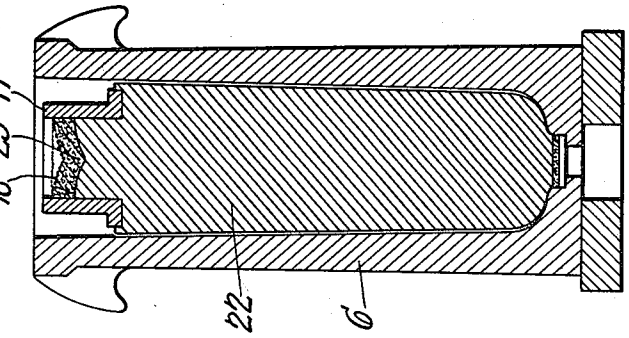


Fig. 4.

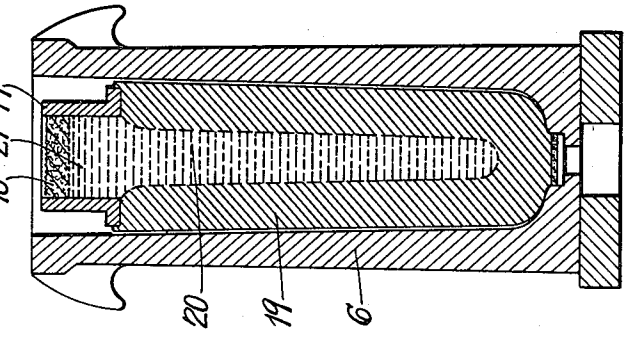
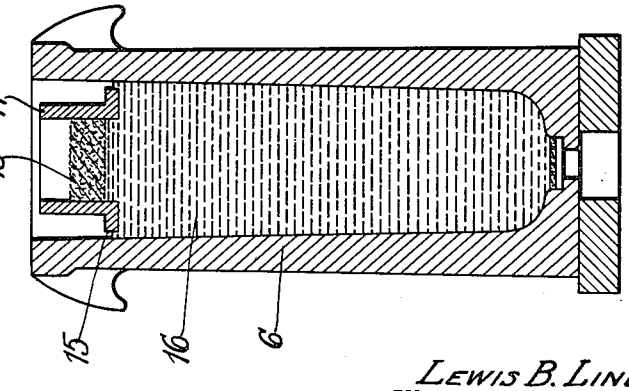


Fig. 3.



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UNITED STATES PATENT OFFICE

2,285,523

PRODUCTION OF SOUND METAL INGOTS

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Application January 19, 1939, Serial No. 251,659

2 Claims. (Cl. 22—216)

This invention relates to improvements in the production of metal ingots, and more especially steel ingots, particularly ingots of open hearth steel, and has for its principal object an efficient method of producing in quantity sound metal ingots which are substantially free from piping and segregations.

In accordance with the usual practice of casting ingots in one pouring operation, piping and segregations occur to such a marked degree that a large fraction of the ingot must be discarded even where the best types of shrinkhead casings or hot tops are employed. Moreover, even in the retained portion of the ingot, the carbides and intermetallic compounds are segregated to such a marked degree as to render the ingot non-homogeneous.

In order to overcome these defects it has been proposed to cast ingots by a process of initial pouring and subsequent refilling of the molds, the approved procedure comprising the steps of: filling a mold to a desired depth with the molten metal; floating a retaining form or shrinkhead on the metal and blanketing the metal surface thereof with a buoyant and permeable heat-insulating material, such as slag, diatomaceous earth, etc., to retard the rate of cooling thereat for causing the surface metal to solidify last; allowing the metal to solidify until only a core comprising about one-half to two-thirds of the ingot remains molten, thereupon refilling the ingot to a level within the retaining form or shrinkhead; and finally allowing the ingot to solidify throughout. The refilling stirs up and diffuses the segregating elements throughout the still molten portion of the metal to such a degree that they are redistributed in harmless proportions. Also the refilling prevents the formation of pipe in the ingot proper or to any substantial extent even in the retaining form. The present invention improves upon this method of casting ingots as explained hereinafter.

A difficulty which has been encountered in the quantity production of ingots by the above method, results from the fact that the appropriate time for refilling ordinarily involves some delay after the initial pouring is complete, during which interval the relatively small amount of metal retained in the ladle for refilling tends to undercool and solidify therein. For example, in the pouring of ingots of about 20 x 20 x 72", i. e. about 7000 pounds each, the time required for teeming a 100-ton heat from the ladle into the ingot molds is about 30 to 35 minutes, whereas the most appropriate time for refilling is about 40 to 45 minutes after the initial pouring is started. If the refilling is done too soon a pipe will form in the refill portion.

In order to prevent undercooling and freezing of the refill metal, I propose in accordance with one aspect of the present invention, to employ a relatively small electric furnace in conjunction with the converters or open hearth or other furnaces in which the metal is prepared for casting, and upon tapping a heat from such converter or furnace, to immediately transfer to the electric furnace and to maintain molten therein, a sufficient portion of the heat for subsequent refilling of the ingot molds. Meantime, the remaining and principal portion of the heat is cast into the molds and the molds prepared for refilling in the manner above explained, following which, when the appropriate time for refilling has arrived, the refill metal is transferred from the electric furnace into the molds.

In accordance with this arrangement, my preferred procedure is to tap the heat when ready for casting into a ladle from which the required portion, say 5 to 10%, is immediately poured into the electric furnace, following which the remainder of the heat, i. e. about 90 to 95%, is teemed into the ingot molds. The ladle is then cleaned out and otherwise prepared as ordinarily. The refill metal, at the appropriate time, is tapped from the electric furnace into a ladle and teemed therefrom into the molds.

Although other types of furnaces may be employed for maintaining the refill metal molten, I prefer to use an electric furnace, since it can be so operated, in a known manner, as to produce substantially no further reaction in the steel or to produce a controlled degree of further reaction, as may be desired. Also it permits of accurate temperature control of the refill metal.

With respect to the detailed procedure of filling and refilling the ingot molds, there are certain precautions to be observed for best results. For purposes of refilling, the mold may be provided with any of the existing forms of shrinkhead casings or hot tops, but if no hot top is used, it is necessary, after the initial pouring, to float on the molten metal some sort of a retaining form to hold the refill metal and prevent it from running down into the space between the ingot mold and the ingot formed by contraction of the ingot away from the mold walls on cooling. Otherwise, an objectionable scale or scab will be formed on the surface of the finished ingot.

As between the use of a hot top and a retain-

ing form adapted to be floated on the metal, the latter has the advantage that it permits of employing the same molds for making ingots of varying weights. The retaining form may be made of any appropriate material, such as fire clay, a preferred construction consisting of a hollow retaining form of sheet steel filled with a refractory, heat-insulating material, such as diatomaceous earth, mica, vermiculite, etc. Its design should be such, however, that it does not sink in the molten metal to a depth of more than about one to one-and-one-half inches, since otherwise the peripheral groove which the form makes in the end of the ingot will, on subsequent rolling of the ingot, result in the formation of outwardly projecting ribs of such height during the first passage through the rolls, that the ingot will not enter the rolls on the second passage. This difficulty may be overcome by appropriately designing the form in relation to its specific gravity, as by making the walls of the form thicker at the base than at the top, if necessary, or by providing the form with a horizontal flange extending outwardly from the base of the form.

In order that the refill be effective to accomplish the results above stated, it is necessary that the top central portion of the ingot remain molten during the initial solidification of the outer side and bottom portions, as a freezing over of the upper surface would prevent refilling. It is, therefore, necessary to blanket the upper surfact of the molten metal with a heat-insulating material which is permeable in order that the refill metal may be poured through it, and which is sufficiently buoyant to float on the surface of the metal and to rise to the surface within the retaining form on refilling. Also the material must not change the composition of the metal or contain non-metallic or other injurious constituents which might become occluded in the metal. Good materials are cork, cork composition, straw, or similar materials which will not burn too rapidly.

The proper time for refilling is when the width of the molten core of the ingot is in about 6 to 8 inches, or stated more generally, when the ratio of the retainer aperture area to that of the molten core of the ingot is sufficiently large to assure that the refill metal contained in the retainer will be molten longer than the metal of the ingot proper. Ordinarily the molten core of the ingot will comprise about one-half to two-thirds of the ingot at the appropriate time for refilling.

In the drawings:

Figs. 1 and 2 are, respectively, a plan view and a view in end elevation showing, in more or less schematic form, a proposed layout of an open hearth steel plant employing an electric furnace in accordance with the invention for reception of the refill metal as above explained. In Fig. 2, the electric furnace and one of the open hearth furnaces are shown partly in section for purposes of more fully explaining the invention.

Figs. 3 to 5 inclusive are views in longitudinal section through an ingot mold at successive stages of ingot production in accordance with the invention. Fig. 3 shows the arrangement and condition of the mold and ingot following the initial pouring and prior to any solidification of the metal; Fig. 4 illustrates the partially solidified ingot immediately following the refilling operation; and Fig. 5 shows the ingot in the mold after it has completely solidified following the refill. Fig. 6 is a longitudinal section of the finished ingot after its removal from the mold.

Referring to Figs. 1 and 2, a bank of open hearth furnaces 1 are arranged with their tapping spouts 2 facing pouring platforms 3 along which runs a track 4 for conveying a car 5 carrying ingot molds 6 to the pouring platforms. Conveniently arranged between the platforms 3 on the furnace side of the track 4, is an electric furnace 7 supported on rollers 8 and a carriage 9 to permit of tilting the furnace for pouring. Overhead is the usual traveling crane 10 for transporting a ladle 11 between the furnaces and the pouring platforms as explained below.

In the operation of the plant in accordance with the invention, the ladle 11 is deposited by crane 10 beneath a pouring spout 2 of one of the open hearth furnaces 1, and the heat 12 thereafter tapped into the ladle. The ladle is thereupon conveyed to the electric furnace 7 and a small fraction, approximately 5%, of the ladle charge poured into the electric furnace through its pouring spout 13 while the furnace is arranged in the horizontal position. Thereafter, the ladle is conveyed to the pouring platform 3, and the molten metal therein teemed through the ladle nozzle 14 into the ingot molds 6 successively, each mold being filled, referring now to Fig. 3, to a desired depth 15 with the molten metal 16. A retaining form 17, of the character above described, is now floated on the metal and the surface of the metal within the retaining form is blanketed to a depth of about three or four inches with a buoyant heat-insulating material 18 as above mentioned.

With the molds as thus arranged, the metal in each mold is allowed to cool until the outer portion 19, Fig. 4, has solidified, and only a central core 20 of about six to eight inches in diameter remains molten. During this solidification, the form 17 will become frozen or attached to the solid portions of the metal in contact therewith.

Meantime, a ladle is prepared for the refill metal and placed beneath the pouring spout 13 of the electric furnace and, at the appropriate time, the furnace is tilted and the molten refill metal 21 therein, poured into the ladle, following which the ladle is returned to the pouring platform, and an appropriate amount of refill metal teemed into each of the retaining forms 17 in molds 6 until the level of the molten metal extends up into the retaining form as shown at 21*a*, in Fig. 4, which illustrates the conditions in the ingot mold immediately following the refill.

The metal in the molds is now allowed to solidify throughout resulting in a condition of the ingot 22 as shown in Fig. 5. The complete solidification results in the formation of a slight pipe 23 which, however, is restricted to the portion of the metal within the retaining form 17. The mold is thereupon removed together with the retaining form 17 and the heat-insulating material 18 resulting in the finished ingot 22, shown in Fig. 6, having a peripheral groove 24 in its upper surface formed by the retaining form 17. As above stated, this pheripheral groove should not extend to a depth of more than about one to one and one-half inches below the outer ridge 25, since otherwise it will prevent the ingot from entering the roll in the subsequent rolling operation.

I claim:

1. A method of casting sound metal ingots which comprises: preparing a molten bath of the

metal for casting and tapping into a ladle, transferring a portion of the ladle charge to a tiltable, stationarily positioned electric furnace for maintaining it molten, and casting the remainder into a series of ingot molds, floating a retaining form on the metal in each of said molds, and blanketing the metal therein with a buoyant and permeable heat-insulating medium, allowing said metal to solidify until only the cores of said castings remain molten, tapping the metal from said electric furnace into a ladle and casting a portion thereof into each of said molds until the metal rises to a level within the form, and allowing the castings in said molds to solidify throughout.

2. A method of casting sound metal ingots which comprises: preparing a molten bath of the metal for casting, and tapping into a ladle, transferring a portion of the ladle charge to a tiltable, stationarily positioned electric furnace for maintaining it molten, casting the remainder of said charge into a series of ingot molds, allowing the metal therein to solidify until only the cores of said castings remain molten, thereupon tapping the metal from said electric furnace into a ladle, casting a sufficient portion of the metal therefrom into each of said molds to prevent appreciable piping of the ingots, and allowing the metal in said castings to solidify throughout.

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