No. 609,693. Patented Aug. 23, 1898.

R. A. McDONALD.

CASTING INGOTS.

(Application filed Dec. 9, 1897.)

(No Model.)

FIG. 1.

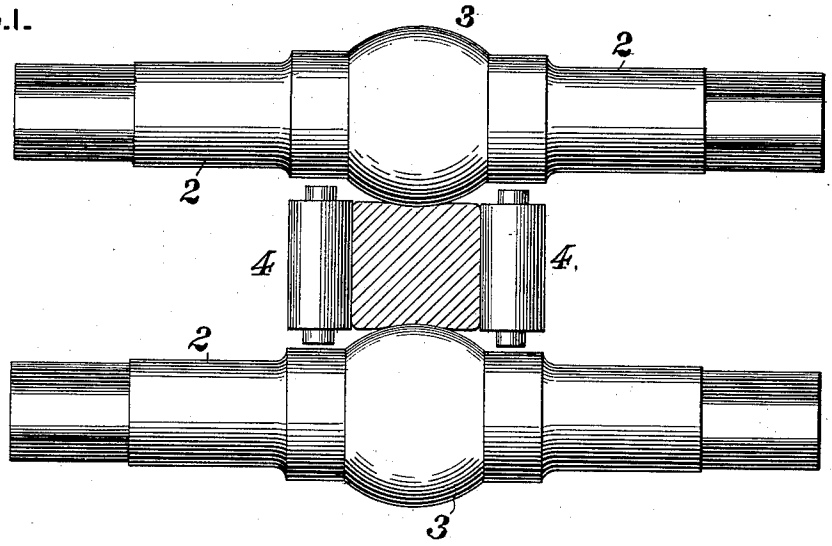


FIG. 2.

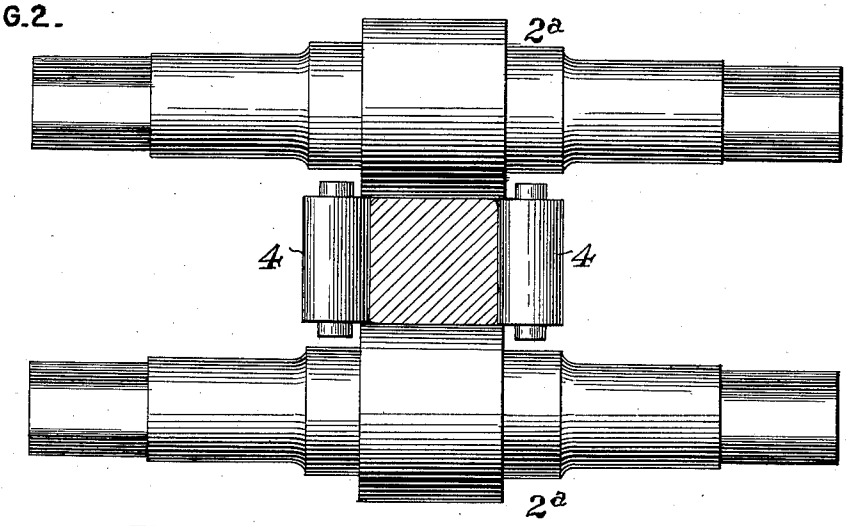


FIG. 3.

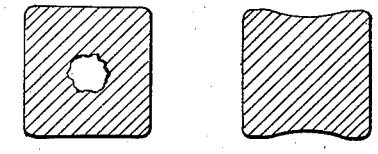
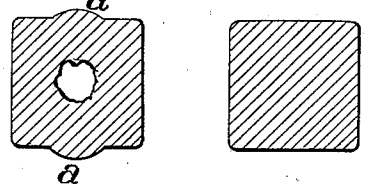


FIG. 4.



WITNESSES:

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UNITED STATES PATENT OFFICE.

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CASTING INGOTS.

SPECIFICATION forming part of Letters Patent No. 609,693, dated August 23, 1898.

Application filed December 9, 1897. Serial No. 661,237. (No specimens.)

To all whom it may concern:

Be it known that I, ROBERT A. McDONALD, a citizen of the United States, residing at Aspinwall, in the county of Allegheny and State of Pennsylvania, have invented or discovered certain new and useful Improvements in Casting Ingots, of which improvements the following is a specification.

As is well known to steel-workers, ingots of all sizes are subject to what is known as "piping," or the formation of a conical cavity of greater or less depth at the upper end of the ingot during cooling and solidification. It is thought that this piping is caused by the sinking of the metal in the upper portion of the ingot to compensate for the contraction due to solidification in the interior lower portions of the ingot. When the ingot is cast, an external shell is formed throughout the entire length of the ingot by contact of the molten metal with the cool walls of the mold. This shell is formed while the interior portion of the ingot is in a molten condition, and as the solidification proceeds, it is thought, from the bottom and sides toward the top and interior of the ingot the metal will settle or be drawn down, forming a conical cavity at the upper end. It is also characteristic of this manner of cooling and solidification that gases which are generated in the metal or caught therein during the teeming will tend to rise toward the upper end of the ingot or be forced up by the contraction of the cooling metal, but will be prevented from escaping by the solidification of the metal and the thin skin or hardened shell formed across the upper end. It has been attempted to avoid this piping and the collection of the gases at the upper end of the ingot by opening or moving outward one side of the mold as soon as the external shell has been formed, placing a bar or rod against the exposed side, and then forcing such bar or rod into the body of the ingot by pushing in the removed side of the mold. The purpose of such operation is to displace the molten metal in the interior of the ingot, with the idea that such displaced metal will fill up or prevent the formation of the "pipe" or cavity.

This method is wholly ineffective for the reason that displacement occurs simultaneously throughout the entire length of the ingot, with the result of simply elongating the ingot. If a cavity had been formed prior to the squeezing operation, as above described, the pressure which is exerted at the upper end simultaneously with the pressure on the other portions will simply force together the sides of the cavity without producing any welding thereof. If, on the other hand, the squeezing was effected before any material piping had occurred, the ingot would be elongated and the cooling and solidification subsequent to such elongation would produce a pipe or cavity.

The object of the present invention is to provide for the gradual upward forcing or displacement of the interior molten portions of the ingot toward the upper end as the cooling and solidification proceed, and thereby prevent the formation of the pipe or cavity or insure the filling up of the formed pipe or cavity by the metal so forced upwardly from the lower portions of the interior of the ingot.

In the accompanying drawings, forming a part of this specification, Figure 1 is a top plan view of a form of rolls or apparatus applicable for use in the practice of my invention. Fig. 2 is a similar view of a modified form or construction of apparatus. Fig. 3 shows in sectional plan view an untreated ingot and one after it has been treated or operated upon, the plane of section being through the upper portion of the ingot; and Fig. 4 shows similar views of an ingot before and after it has been subjected to the mechanism shown in Fig. 2.

In the practice of my invention the metal is teemed into an ingot-mold in the usual manner, and as soon as an external shell or skin of sufficient thickness or rigidity to permit of the handling of the ingot has been formed it is removed from the mold and fed in a vertical position between the reducing-rolls 2. As shown in Fig. 1, these rolls are provided with collars 3 of such size or shape as compared with the expected piping of the ingot that they will displace, by forcing in-

wardly opposite sides of the shell, a sufficient quantity of metal to compensate for the expected contraction. These rolls are mounted in suitable housings or supports in such manner as to permit of the feeding of the ingot with its lower end foremost into the bite of the rolls and preferably while in a vertical position, so as to prevent the bleeding or escape of molten metal from the interior of the ingot. As it is desired to effect in this operation only a displacement of the interior molten metal in a direction of the axis of the ingot, retaining-rolls 4 are arranged in such relation to the displacing-rolls as to prevent any material cross-sectional enlargement of the ingot while passing between the rolls 2. If desired, these rolls 4 may be constructed to effect a portion of the displacement of the interior molten portion of the ingot.

In some instances it may be desirable to effect what might be termed a "graduated displacement"—*i. e.*, a displacement which would gradually decrease from the lower toward the upper end of the ingot. This graduated displacement can be produced by employing rolls whose operative perimeter will be practically equal to the length of the ingot operated on and by forming the collar eccentric, or the same effect can be produced by changing the position of its rolls with relation to each other—*i. e.*, gradually separating them as the ingot passes between them.

It will be readily understood by those skilled in the art that as the lower end of the ingot enters the bite of the rolls, thereby forcing in portions of one or more side walls, the molten metal in line with such forced-in portions will be forced or pressed toward the opposite end of the ingot. As this forcing in proceeds more and more metal will be pushed up toward the upper end of the ingot, thereby filling in from its lower end the pipe or cavity.

If desired, the speed of the rolls may be so adjusted that the displacement will occur with approximately the same rapidity as the solidification, thereby compensating at each point in the length of the ingot for the contraction and consequent solidification.

In addition to this filling in of the cavity or compensation for contraction this progressive squeezing will also effect an upward displacement of gases caught by or generated within the metal in the mold, thereby eliminating blow-holes from the ingot or forcing them to and out of the extreme upper end of the ingot.

In lieu of forcing portions of one or more of the sides of the ingot in beyond the general plane of such sides, as above described, the ingot may be cast with portions of one or more of its sides projecting beyond the general planes of such sides, as clearly shown at *a* in Fig. 4. These projecting portions, which may extend from the lower end toward or to the upper end of the ingot, are so proportioned as to cross-sectional dimensions that when forced inwardly to the general plane of the sides of the ingot the amount of metal in the interior of the ingot displaced thereby will compensate for the expected contraction and consequent piping. When the ingot is formed with these projecting portions along one or more of its sides, the squeezing or reducing rolls have their operative faces plain, as shown at 2^a in Fig. 2.

In order to effect what has heretofore been termed a "graduated displacement," the projecting portions of the sides of the ingot are made larger at the lower end thereof and gradually diminish in width and projection toward the upper end, where such projecting portions may merge into the general wall or sides of the ingot.

While the form of apparatus shown—*i. e.*, reducing-rolls—seems at present to be the most convenient and practical manner for the practice of my invention, I desire to include as a part of this invention any form or construction of apparatus whereby a progressive displacement of the metal in the interior of the ingot may be effected, such displacement proceeding from the lower toward the upper end of the ingot.

I claim herein as my invention—

1. As an improvement in the art of treating ingots, the method herein described, which consists in progressively displacing in a longitudinal direction from the lower toward the upper end of the ingot the molten interior portions of the ingot, by pressure applied to the exterior of the ingot, substantially as set forth.

2. As an improvement in the art of treating ingots, the method herein described, which consists in removing the ingot from the mold while the interior portions are in a plastic condition, and then forcing inwardly a portion of one or more sides of the ingot progressively from its lower toward its upper end, substantially as set forth.

3. As an improvement in the art of treating ingots, the method herein described, which consists in forcing inwardly a portion of one or more sides of the ingot while the metal of the interior is plastic, such inward movement being progressive and graduated from the lower toward the upper end of the ingot, substantially as set forth.

In testimony whereof I have hereunto set my hand.

ROBERT A. McDONALD.

Witnesses:
DARWIN S. WOLCOTT,
F. E. GAITHER.