No. 805,728. PATENTED NOV. 28, 1905.

R. W. HUNT.

PROCESS OF PERFECTING CAST STEEL INGOTS.

APPLICATION FILED MAY 20, 1903.

Fig. 1.

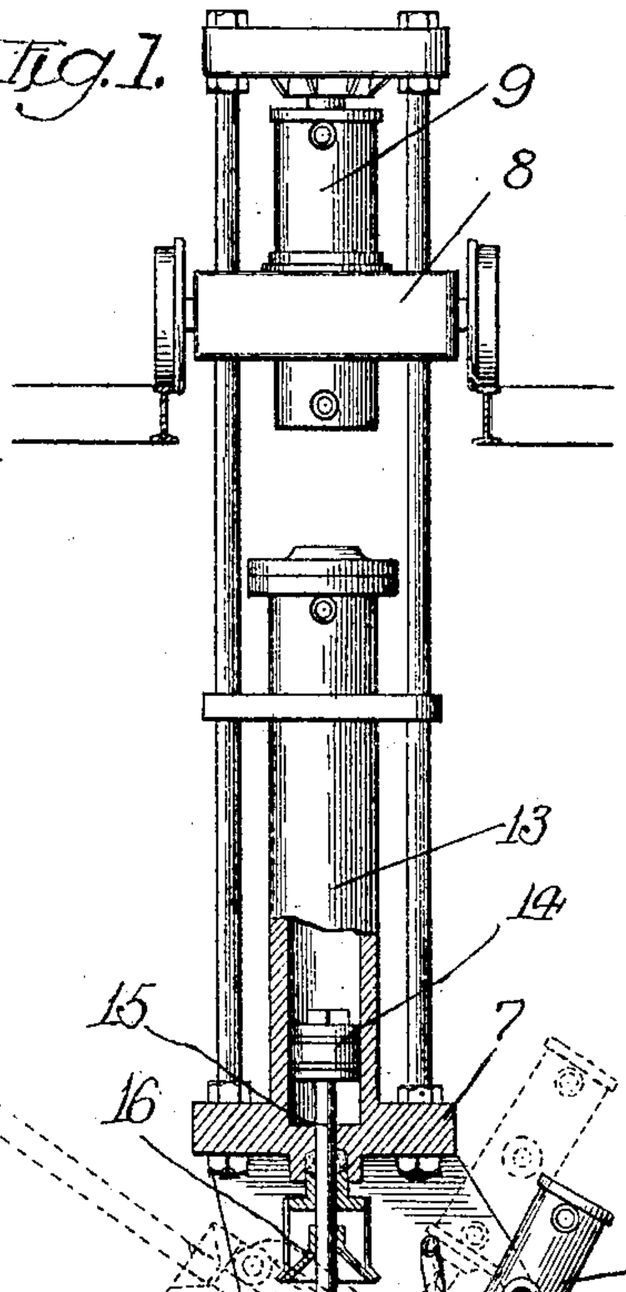


Fig. 3.

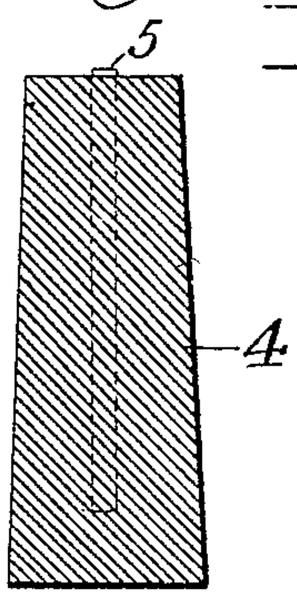
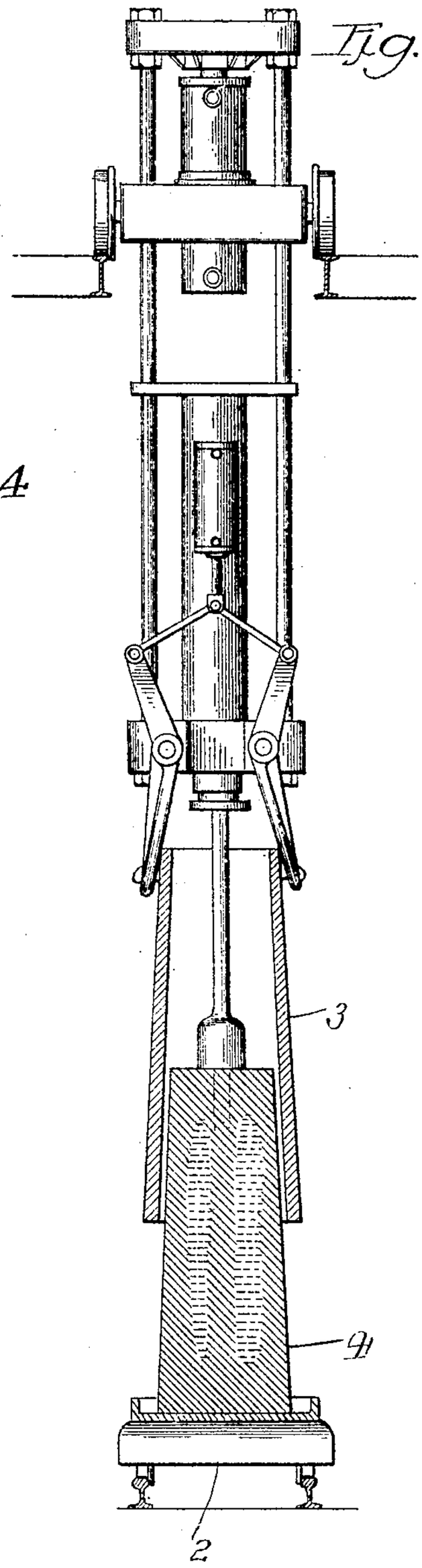


Fig. 2.



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PROCESS OF PERFECTING CAST-STEEL INGOTS.

No. 805,728. Specification of Letters Patent. Patented Nov. 28, 1905.

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To all whom it may concern:

Be it known that I, ROBERT W. HUNT, of the city of Chicago, county of Cook, and State of Illinois, have invented a certain new, useful, and Improved Process of Perfecting Cast-Steel Ingots, of which the following is a specification.

My invention relates to improvements in the art of manufacturing cast-steel ingots, particularly those intended to be made into rails and beams.

The process as commonly conducted in a rail or beam mill is as follows: The molten steel is taken from the converter and poured into the ingot-mold with the least possible delay. The filled mold then makes way for another and is allowed to stand until the ingot becomes sufficiently solid to retain its form, whereupon the mold is stripped from the ingot. Then the partially-cooled ingot is taken to the soaking-pit or reheating-furnace and is there heated until its temperature becomes uniform throughout. Upon the completion of this process the ingot is removed from the soaking-pit and is ready to be manufactured into rails. An ingot which is made and treated in this manner is apt to be piped—that is, to contain a large central cavity. Commercial steel contains considerable quantities of various metalloids, and when a cavity forms within an ingot the metalloids collect upon the walls of the cavity and there refuse to weld when the ingot is reheated and compressed or rolled. As a result the rails which are made from piped ingots are worthless and should be discarded. Not infrequently, however, they escape detection and being placed in use cause disastrous railroad wrecks. The present value of the manufactured product is such that the entire process of casting and rolling rail-steel ingots to be profitable must be conducted with celerity and with as little labor as possible. Although it is possible to produce sound ingots, the known precautions against extensive piping involve prohibitive outlays of time, labor, or material and are generally disregarded. Thus such measures as the slow pouring of ingots, the packing of the tops thereof, the spraying thereof, the subjection of the ingots to heavy internal and external pressure, the insertion, expansion, and welding of large masses of steel therein and therewith all require too much time, occasion too many delays, and are too expensive in labor and material to admit of their use in a rail or beam mill.

The object of my invention is to improve the above-described process in ways and by means that shall operate to improve the quality of steel ingots and which shall neither prolong the work of a steel-mill as usually performed nor materially add to the cost thereof.

The particular object of my invention is to provide a process of casting and perfecting steel ingots that shall admit of the perfecting of the ingot after it leaves the pouring-station, to the end that the work in the pouring-station or converter-house be not interrupted or delayed.

The particular object of the invention may be further stated to be the provision of a process of casting and perfecting steel ingots that shall operate to exclude the gases and metalloids from the axial or central portion of the ingot and cause them either to be retained substantially in their original states of occlusion and suspension or to accumulate in a shallow cavity in the extreme top of the ingot.

Briefly stated, the object of my invention is to replenish or fill all ingots in which cavities may have begun to form during the cooling period, and, further, to improve the central or axial portion of every ingot, whether or not it is piped.

My novel process is coextensive with the process in common use; and it consists in casting molten steel in a mold, then permitting the walls or crusts of the ingot to form preparatory to stripping the mold from the ingot, then after the formation of the top crust and prior to the removal of the mold by the introduction of a relatively small steel bar or rod initiating and forcing the solidification of the central or axial portion of the ingot—*i. e.*, creating from and in the central portion of the ingot mass an initially small but increasing solid column of plastic or denser steel, thereby filling or replenishing the ingot and excluding from its central portion the gases and metalloids that would otherwise tend to form an objectionable pipe—then stripping the mold from the ingot, and then reheating the ingot to substantially equalize its temperature and consistency throughout, all preparatory to the working of the ingot.

The invention will be more readily under-

stood by reference to the accompanying drawings, forming a part of this specification, and in which I have illustrated the apparatus and the steps incident to the carrying out of my process.

In said drawings, Figure 1 illustrates that step of the process which follows the pouring and the casting of the ingot—to wit, the filling of the ingot and the cooling of the axial part thereof by the introduction and permanent addition of a cooler steel rod or bar—and also shows the complete machine for performing such operation. Fig. 2 illustrates the stripping of the ingot-mold from the ingot after the ingot has been perfected by the introduction of the bar or rod, and Fig. 3 is a longitudinal section of the novel perfected ingot.

The first step of my process comprises the pouring of the molten steel into the mold. The second step comprises the cooling of the molten steel by allowing the filled mold to stand for a considerable length of time. This continues until the bottom, side, and top walls or crusts of the ingot have become solid and until in most cases a pipe or cavity has begun to form within the inclosing walls or crusts. Up to such time the shrinkage of the metal has no detrimental effect. The third step of my process comprises the piercing of the top crust of the partially-cooled ingot by the forcible introduction of a slender bar or rod of steel of as good or better quality than the ingot-steel. This bar or rod is usually nearly as long as the ingot, and its size is such that when introduced it displaces enough molten metal to raise the surface thereof within the ingot and thus deflate the cavity, the effect being to fill said cavity. The gases are discharged through the opening through which the rod enters, and the ingot is thus relieved from any pressure that would tend to disrupt its walls or crusts. The metal soon congeals around the upper end of the rod, and thus secures the same. The bar enters the axial portion of the ingot. It may be heated preparatory to its introduction; but it is always much cooler than the molten metal. It serves, therefore, to extract heat from the surrounding molten metal, and thereby said metal is caused to become plastic or more dense than the remainder of the molten metal within the ingot crusts. In this manner I build up or create within the ingot a column of denser metal, which column serves to displace, expel, or exclude the gases and the metalloids from the center of the ingot and also serves to entirely prevent the collection of gases and metalloids at the center or axis of the ingot. In this manner the development of the objectionable pipe is prevented. The shrinkage that follows the introduction of the rod or bar has no serious effect, as any gases which may be evolved thereafter and which ascend to the upper end of the ingot are excluded from the central portion of the barrier constituted by the column referred to.

The step which consists in stripping the ingot is well known and only requires mention. What may be regarded as a step of my process begins with the introduction of the rod and resides in the destruction of the identity of said rod. The rod quickly assumes the approximate temperature of the interior of the ingot and is quickly reduced almost if not quite to the melting-point, and the final incorporation of the rod as such in the ingot is insured by the reheating of the ingot preparatory to its being rolled. This portion of my process preferably takes place in the reheating-furnace, (not shown,) wherein the temperature of the ingot is equalized and the rod becomes an incorporated part of the ingot.

An incidental step in the process resides in subjecting the top crust of the ingot to restraint or pressure at the moment when the rod is driven through said crust, the purpose thereof being to prevent the eruption of said top crust by the momentary pressure which the entrance of the rod sometimes creates within the ingot. Such pressure is momentary only, because excessive pressure so created is quickly relieved through the opening around the rod in the top crust. It should be observed at this point that the tendency of the relief of pressure is to permit the molten metal within the ingot to seek a level, and thus elevate the metalloids which may have collected to a point near the upper crust of the ingot, there to be further displaced by the entrance of the rod.

A further improvement incident to my process resides in the betterment of the center of the ingot through the addition of the metal composing the perfecting rod or bar and which, as explained, is ultimately absorbed into the ingot. By using a steel bar of as good or better quality than the ingot-steel the axial portion may be much improved in quality. The dimensions of the rod, principally its diameter, are determined by the temperature at which the same is introduced and by the capacity of the pipe or cavity which is likely to exist in the ingot treated. The use of a rod in excess of the dimensions established by this rule would have a detrimental effect, inasmuch as its insertion would operate to expel too great a quantity of the molten metal through the opening in the top of the ingot, and thereby increase the quantity of metal which it would be necessary to crop off, and, further, because a large bar would not incorporate with the ingot.

In the drawings illustrating apparatus suited to the needs of my process, 2, 3, and 4 represent the ingot stool or car, the ingot-mold, and the ingot, respectively. After the ingot is cast it is permitted to cool until the crusts are complete, and it is then taken,

first, to the perfecting-machine, (illustrated in Fig. 1,) then to the stripping-machine, (shown in Fig. 2,) and finally to the soaking-pit or reheating-furnace. Said perfecting-machine preferably comprises a gravity-press, by which considerable weight or pressure may be momentarily imposed upon the top of an ingot while the latter is in its mold beneath the machine. In addition to being a press this machine constitutes a holder, guide, and driver for the perfecting rod, bar, or billet 5. The essential parts of the machine are the guide-barrel or cozy 6 and the rod-driver 15, contained in or carried by a frame 7. This latter is suspended from and is laterally movable with the truck 8 and is vertically movable by a hydraulic engine 9 on said truck. The frame has arms in which the cozy 6 is trunnioned. Said cozy may be longer than the rod in it, and the engine 10 on the frame 7 is adapted to swing the cozy, as shown by dotted lines in Fig. 1. In that position the cozy is adapted to receive a rod 5. A stop 11 on the frame retains the rod in the cozy while inclined. A latch or dog 12 is provided on the cozy to hold the rod when the cozy is swung to a vertical position.

13 is a steam or hydraulic cylinder on the frame 11, and 14 is a piston having a piston-rod 15, adapted to be projected into the cozy when the latter is vertical, said rod serving as the perfecting-rod driver for forcibly expelling a rod from said cozy.

16 is a protecting-hood to prevent leakage of water from cylinder 13 into the cozy. The cozy is preferably hollow and may have suitable air or water connections for cooling it when necessary.

Any suitable means (not shown) may be employed for preheating the rods when and if desired, and the cozy may be used to keep the rod hot while waiting to be driven.

The stripping-machine (shown in Fig. 2) is of the usual construction, and it operates in a well-known manner unnecessary to describe. The same is true of the reheating-furnace to which the ingots are taken as fast as the molds are removed.

The operation of the apparatus described is as follows: A mold having been placed beneath a steel ladle is partially filled with molten steel. So far as the piping of the ingot is concerned it is not necessary to use special care in pouring the ingot or in caring for it immediately after it is poured, for the reason that adequate means and measures are hereby provided for finishing or perfecting the ingot after it has partly cooled. From the ladle the filled mold is taken to a convenient place to cool, and after it has cooled to such extent that the crusts have become solid it is taken to the perfecting-machine. Here the mold is placed beneath the perfecting-machine, and one of the slender perfecting-rods having been placed in the cozy or guide said cozy is lowered into the top of the mold and preferably permitted to rest upon the top crust of the ingot. The lower end of the cozy is preferably as large, but not larger, than the mold will admit, and part or all of the weight of the perfecting-machine may be placed upon the ingot by partially or wholly releasing the hoisting-engine 9. The cozy being cool serves to accelerate the thickening of the upper crust of the ingot, and said upper crust being then under sufficient pressure or restraint to prevent its eruption the perfecting-rod is driven through said crust and into the ingot by means of the driver 15. Any gases which may have accumulated at the top of the ingot will be released and the rod will be lodged in the center of the ingot, its upper end being quickly fastened by the congealing of the metal around it in the upper crust. Obviously the rod fills or replenishes the ingot center—*i. e.*, it compensates for any shrinkage that may have occurred therein prior to its introduction. The shrinkage at most is slight in volume. As shown in the drawings, the rod or bar is very small with relation to the ingot, displacing only an inconsiderable quantity of molten metal. Nevertheless, being cooler than the molten metal in contact with it it serves to initiate the solidification of the molten steel at the axis of the ingot. Solidification having been thus initiated will progress steadily and will result in forming within the ingot a central body or column of denser or plastic steel. This column or body increases in diameter and strength as the metal parts with its heat, and inasmuch as it occupies the upper and central parts of the mass it obviously excludes therefrom both gases and metalloids, and therefore prevents the formation and development of an objectionable central pipe or cavity in the ingot. The gases and metalloids being excluded and their accumulation at the center of the ingot being prevented, it follows that the same are, in effect, held or distributed in the remote portions of the ingot mass and that the internal shrinkage-cavity, if any, will be confined to the extreme top of the ingot surrounding said column. The several figures of the drawings illustrate the formation of the pipe-preventing column and the progressive stages of ingot solidification. The cozy may be lifted from the ingot almost immediately after the rod is driven. As soon as this is done the mold with its ingot is moved to the stripping-machine, where the mold is pulled off the ingot. The ingot is then hurried to the soaking-pit or reheating-furnace, where it is exposed to a high degree of heat, which has the effect of equalizing the temperature and consistency of the ingot throughout. To further improve the quality of the axial portion of the ingot, I prefer to employ in each ingot a bar that is of equal or better quality or

grade than rail-steel—such, for example, as open-hearth steel—which becoming incorporated with the mass improves the physical and chemical composition thereof, particularly that of the central portion. Thus the introduction of the bar provides a convenient means of diluting the impurities of the ingot-steel, and my ingots are distinguishable from others by reason of their better centers. The operation of inserting the bar occurs during the period that is usually allowed for the cooling of the ingot, and therefore in no wise interrupts the work of the mill. On the contrary, the insertion of the rod and the strengthening of the interior of the ingot makes it possible to accelerate the passage of the ingot from the converter-house to the soaking-pit or reheating-furnace. The perfected ingot, as shown in Fig. 3, is solid throughout and has a strong central portion of much better quality than usual, and the blow-holes in the ingot, if any, are so small and so well distributed that they do not detract from the strength or value of the ingot or the product which is made therefrom.

As my invention is susceptible of various modifications and as it is capable of general employment, I do not confine or limit my invention to the specific steps, materials, apparatus, or uses herein shown and described.

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

1. The herein-described improvement in the art of casting and perfecting simple ingots that consists in first casting molten metal in a suitable mold or chill, then permitting the ingot to cool until the top crust thereof has formed, then by the introduction of a relatively small bar or rod, of like metal, through said top crust and into the molten interor of the ingot, initiating and forcing the solidification of the axial portion of the ingot mass, thereby creating from and in the ingot mass an initially small but increasing solid column of denser metal that occupies the center of the ingot and prevents the development of a central pipe therein, and thereafter removing the mold from the ingot and heating the ingot, substantially as and for the purpose specified.

2. The herein-described improvement in the art of casting and perfecting simple steel ingots, that consists in casting molten metal in a suitable mold and then permitting the ingot to cool in the mold until all of the crusts of the ingot have formed, then driving through the end crust of the ingot a small steel rod and incorporating the same with the axial portion of the ingot, said rod first replenishing the shrunken central portion of the ingot and thereafter effecting the formation of a central column of denser steel within said mass, which column prevents the development therein of a central pipe or cavity, the ingot being finally removed from its mold and reheated, substantially as and for the purpose specified.

3. The herein-described improvement in the art of casting and perfecting simple steel ingots that consists in casting the molten steel in a metal ingot mold or chill and incorporating with the axial portion of the ingot mass a quantity of better steel, the latter being supplied in the form of a steel rod, which is forcibly placed axially within the mass after the top crust has formed and which effects the formation of a pipe-excluding column from and within said mass, the ingot being finally removed from its mold and reheated, substantially as described.

4. The herein-described improvement in the art of casting and perfecting rail-steel ingots and the like, that consists in casting molten steel in a mold, then permitting the external portions of the ingot to solidify until the top crust has formed, then hastening the solidification of the axial portion of the ingot and thus forming from and within the ingot-mass a central column of denser steel substantially coextensive with and preventing the formation of the usual central pipe or cavity and then stripping the ingot and reheating the same, substantially as and for the purpose specified.

5. The improvement in the art of manufacturing simple metal ingots that consists in pouring the molten metal into a mold, then cooling or permitting the metal to cool in said mold until the walls or crusts of the ingot have formed and inclose a still molten body of metal, then thrusting a slender rod of like metal through the end crust into the axial portion of said molten body within said crust, meantime subjecting said crusts to sufficient restraint to prevent the eruption thereof, thereby excluding collected gases, filling any existing cavity and effecting the formation of a central column of plastic metal, then removing the mold from the ingot and finally increasing the temperature of the partially-cooled ingot containing said rod, substantially as described.

6. The herein-described improvement in the art of manufacturing steel ingots, that consists in pouring the steel into a mold, then cooling or permitting the metal to cool in the mold until the dimensions of the ingot are determined by the solidification of all the crusts or walls of the ingot, then piercing the top crust of the ingot to relieve pressure internal thereto, and placing or locating a steel rod or bar in the axial portion of said ingot, thereby supplying the deficiency previously created within the ingot, and also creating a central column of denser or plastic steel within the ingot to exclude gases and metalloids

from the center of the ingot and then removing the ingot from its mold and reheating the ingot, substantially as described.

7. That step of the herein-described process that consists in forcibly thrusting a slender steel rod or bar through the upper crust of a partially-solidified steel ingot and lodging the said bar therein, thereby compensating for the internal shrinkage of the ingot, and creating a column of denser steel within the ingot, as and for the purpose specified.

8. The herein-described process of improving the quality of a partially-solidified steel ingot that consists in forcibly driving a bar or rod of steel of better quality through the crust of said ingot and into the interior thereof, retaining said bar or rod in the axial portion of the ingot and thereafter raising the temperature of the ingot, substantially as described.

9. That step of the herein-described process of improving steel ingots that consists in expelling and displacing the gases contained in a partially-cooled fully-crusted ingot by driving a rod or bar of steel through the end crust and into the interior of the ingot, and retaining said rod or bar in the ingot, thereby initiating and creating from and within the ingot mass a column of denser or plastic steel which permanently prevents the collection of gases in the central portion of the ingot, substantially as described.

10. The herein-described improvement in the art of perfecting steel ingots that consists in first pouring the molten metal into the mold, then permitting the ingot to cool until the upper crust thereof has formed and then supplying any deficiency of metal within the ingot by thrusting a rod or billet through the crust of the ingot, permitting the same to remain therein, and stripping and reheating the ingot, substantially as described.

In testimony whereof I have hereunto set my hand, this 11th day of May, 1903, at Chicago, Illinois, in the presence of two witnesses.

ROBERT W. HUNT.

Witnesses:
C. E. HAWLEY,
JOHN H. GARNSEY.