B. TALBOT.

PROCESS OF TREATING STEEL INGOTS.

APPLICATION FILED AUG. 1, 1912.

1,055,831. Patented Mar. 11, 1913.

Fig. 1.

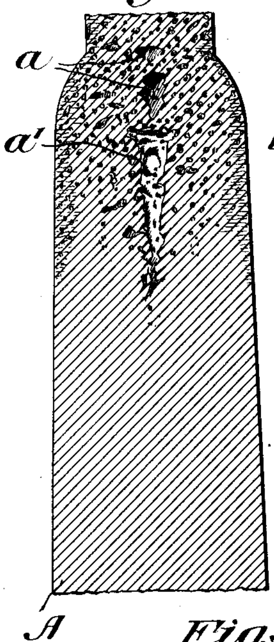


Fig. 2.

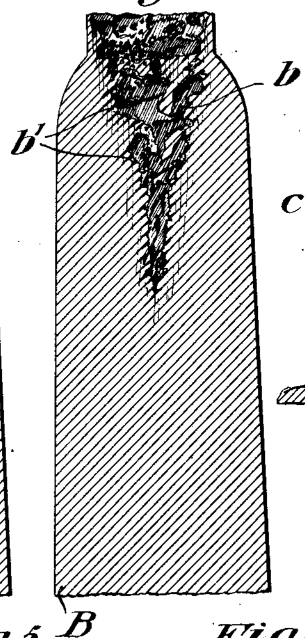


Fig. 3.

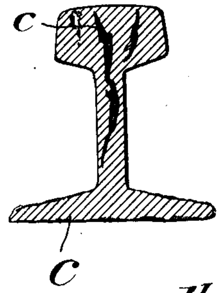


Fig. 4.

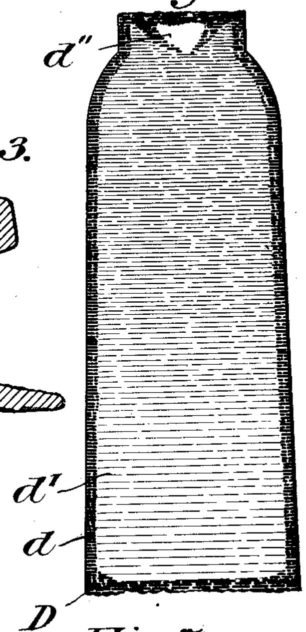


Fig. 5.

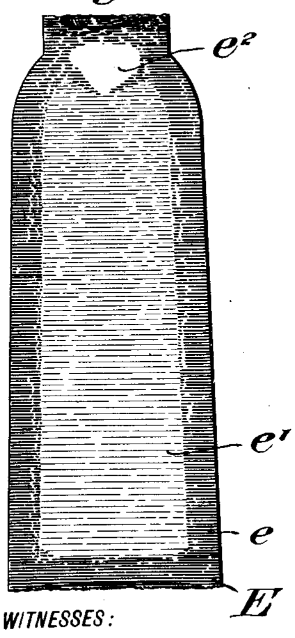


Fig. 6.

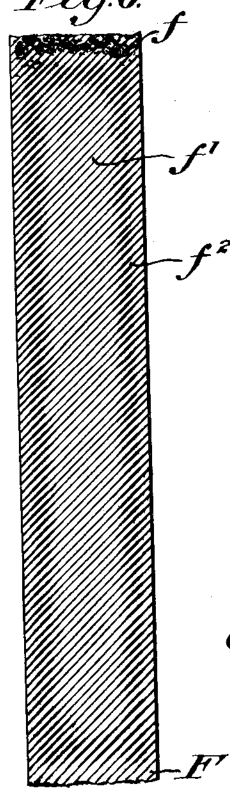
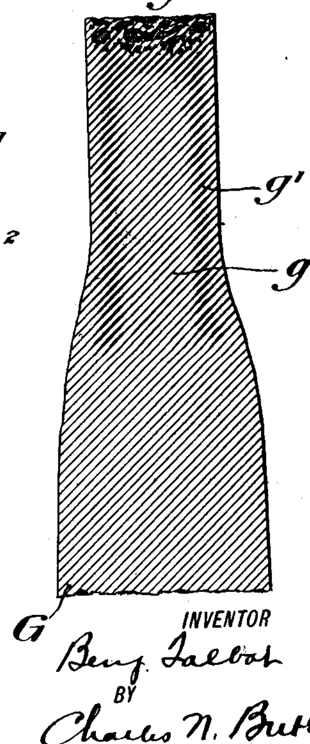


Fig. 7.



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PROCESS OF TREATING STEEL INGOTS.

1,055,831. Specification of Letters Patent. Patented Mar. 11, 1913.

Application filed August 1, 1912. Serial No. 712,733.

To all whom it may concern:

Be it known that I, BENJAMIN TALBOT, a British subject, residing at Woodburn, Darlington, Durham county, England, have invented an Improved Process of Treating Steel Ingots, of which the following is a specification.

This invention relates to an improved process of treating steel ingots for the purpose of eliminating or greatly reducing pipes or cavities and segregation.

The process comprises the operations of stripping the ingot while its center is still fluid, heating it in a furnace or soaking pit at such temperature and for such time as to secure a shell or envelop ductile and thick enough to work without rupturing, and squeezing it so as to reduce the cross-sectional area and effect consolidation while the interior of the ingot is fluid and the shell or outer strata can be compressed without rupturing. These operations have been found to eliminate or practically eliminate the blow holes and cavities from that portion of the ingot (say 85 to 90% of its weight) which it is desired to retain, and to prevent objectionable or excessive segregation, effecting a desired diffusion of the carbon, sulfur and phosphorus in the mass of the metal, so that when the ingot is finally rolled out into a desired shape there is a desired disposition of such carbon and other elements, and moreover, little or no tendency to the formation of splits or lines of weakness in the finished product.

When an ordinary steel ingot is allowed to go cold it will be found that the metal composing the body of the ingot is far from being either solid or homogeneous; small cavities and blow holes will be found scattered unevenly over the upper third of the ingot. These blow holes rarely occur at the surface and, in order to detect them, it is necessary to cut the ingot open. If a cross-section of the ingot be chemically examined it will be found that very considerable differences exist in the amounts of carbon, sulfur and phosphorus in metal taken from different parts of the section. The most impure portion of the ingot will be found to be the center of its upper third part. The tendency of the impurities in the molten steel to move inward and upward in the ingot as it solidifies is generally known as segregation. Such segregation is generally objectionable and frequently produces defects of dangerous character in the finished products, especially in rails, forgings and the like. To obviate the formation of these blow holes and to prevent excessive segregation, it has been customary to add some powerful deoxidizer to the molten steel either in the furnace, or in the ladle, or in the mold after it has left the furnace. Such deoxidizers are metallic aluminium, silicon, ferro-silicon, silico-manganese and ferro-titanium, which are useful in eliminating small blow holes scattered through the steel, as well as in preventing excessive segregation, but they have the disadvantage of causing the formation of a large cavity.

In order to eliminate or obviate the formation of the cavity or pipe, particularly from that portion of the ingot (say 85 to 90% of its weight) retained for use, and to stop or greatly lessen the segregation of the impurities which has heretofore obtained under the most favorable conditions, the ingot, whose metal has preferably been treated with one of the deoxidizers specified, is, according to this invention, stripped when the outer strata have hardened sufficiently and removed to a heating furnace or soaking pit while its center is still in a fluid condition, where it is subjected to a heating operation at a sufficient temperature and for a sufficient time to bring the envelop or hardened shell to a workable condition of ductility while permitting the outer strata of the fluid interior to solidify so as to increase the thickness of the ductile envelop for the still fluid center. The ingot is then subjected to lateral pressure or a squeezing operation which reduces the cross-sectional area so as to compensate for the contraction which results within the mass due to cooling, to effect consolidation which prevents the formation of the usual cavity or pipe, and to effect the dissemination of the impurities in a comparatively uniform manner so as to obviate the usual segregation. The desired results are obtained by the application of lateral pressure so as to reduce the cross-sectional area of the upper third only of the ingot, as well as by the application of pressure so as to reduce the cross-sectional area of the ingot throughout its length. The pressure may be applied by a few passes in a cogging mill so as to reduce the cross-sectional area of the ingot, or of a part of it. It will be found, as the result of this treatment, that the formation of the usual long tapering cavity has been prevented and that the small cavity or cavities which may have formed are confined to the extreme upper end of the ingot, where they are cut off in a small crop. It will also be found that a faint line of segregation exists some few inches from the sides of the compressed ingot, but the actual center of the ingot, in that portion where segregation generally forms, will be found to be even purer than the average of the whole ingot, which is directly opposite to what usually takes place.

After sufficient pressure has been applied, the compressed ingot will usually be returned to the heating furnace or soaking pit for diffusion of heat, and to permit its center to solidify, but the rolling down may be finished without returning it to the pit or furnace when it is judged that this may be safely done owing to the solidifying of the fluid or nearly fluid interior.

By stopping the segregation at a point but little removed from the outside of the ingot, and obtaining a purer and therefore softer center, there is brought about a very considerable advantage when the pressed ingot is rolled down into a shape, particularly a rail, which will be found to be lower in carbon and phosphorus in the center than in the outer strata. Such rail, of softer center and harder exterior, is, by reason of these characteristics, possessed of greater wearing qualities and greater toughness than the ordinary rail, and, by reason of the elimination of the usual segregation, free from hidden flaws and faults liable to cause serious accidents.

In steel which has been treated by an electrical refining process the amount of segregation usually observed is small, but the cavity forms in the same way as in steel made by the Bessemer or Siemens processes, and the present invention can be equally well applied to the reduction of the cavity found in such electrically produced steel ingot.

In the accompanying drawings, Figure 1 represents a longitudinal sectional view of a typical steel ingot having cavities in its upper part; Fig. 2 represents a longitudinal sectional view of a typical ingot of steel that has been treated with a deoxidizer; Fig. 3 is a transverse sectional view of a rail containing flaws such as result from cavities or pipes in ingots; Fig. 4 is a longitudinal sectional view representing a steel ingot having a solidified envelop and a fluid center such as obtain after stripping; Fig. 5 is a longitudinal sectional view representing the ingot that has been heated to soften its envelop while permitting the same to increase in thickness; Fig. 6 is a longitudinal sectional view representing the ingot or bloom produced by the application of lateral pressure to the ingot in the condition shown in Fig. 5; and Fig. 7 is a longitudinal sectional view representing the product obtained by squeezing the upper part of the ingot shown in Fig. 5.

As illustrated in Fig. 1, the ingot A, of steel which has not been treated with a deoxidizer, is commonly found to contain the cavities a in the upper part thereof due to confined gases and shrinkage in the process of cooling, while a section a' is commonly found in which the steel is defective due to the segregation of carbon, sulfur and phosphorus or some of these elements. As illustrated in Fig. 2, the ingot B, composed of steel which has been treated with a deoxidizer, is generally free of blow holes and comparatively solid, excepting in the center of its upper third, where comparatively large cavities or pipes b form and segregated carbon, phosphorus and sulfur form a section b' of defective metal. It will be understood that each of these ingots will produce defective products (unless a large part thereof is cropped and discarded) when rolled or otherwise formed into shapes, because the defective interiors cannot be brought back to fluid condition by reheating for rolling or to a condition which will permit the metal to be diffused, mingled and united so as to dissipate the segregate or eliminate the flaws, and while there is great waste in discarding the defective top, there is great danger that the whole of the defective metal may not be contained in the discard because of the hidden character of the flaws.

As illustrated in Fig. 3, the rail C, rolled from the ingot B, contains the splits or cracks c resulting from defects in the ingot.

In Fig. 4 is represented a stripped ingot D having a solidified envelop d, comparatively thin, and a liquid center d', with a partially developed cavity d'' in the top thereof, due to confined gases and shrinkage. In compressing this ingot by applying lateral pressure thereto, it is found in practice that the envelop d is too thin and hard to work, with the result that such envelop is liable to bulge or rupture, the fluid metal is liable to escape, and the finished product contains cracks or fissures in the outer strata thereof. It has therefore been found necessary in practice to subject such ingot to a heating operation with the production of the ingot E having the envelop e and the fluid center e' in the top of which is shown the partially formed pipe e^2. This envelop has been heated so that the metal therein is sufficiently ductile or plastic and sufficiently thick to work without rupturing or cracking. The ingot shown in Fig. 4 is approximately

20″ across the base while the solidified metal of the envelop is, say, 1″ in thickness, and the solidified but ductile envelop of Fig. 5 is, say, 3″ in thickness. These dimensions are, however, to be understood as illustrations merely and not limitations.

When the ingot shown in Fig. 5 is subjected to lateral pressure so as to compensate for the internal shrinkage, it will, if such pressure is applied throughout its length, produce the ingot or bloom F solid throughout its entire length, excepting small cavities f in a limited part of its top, the central part f' of the ingot being free from segregates, the outer strata f^2 higher in carbon than the part f', and a stratum slightly higher in carbon, phosphorus and sulfur lies adjacent to the part f' and within the strata f^2. If the top part only of the ingot E is reduced in cross sectional area, it will be found that in the resulting ingot G there is a pure and solid center g in this part with the outer strata g' higher in carbon, phosphorus and sulfur than the center, while the remainder of the ingot is undisturbed.

Having described my invention, I claim:

1. The improved process of treating steel ingots which consists in stripping the mold from the ingot while its interior is still in a fluid condition, heating said ingot so as to soften the outer solidified strata and permit the same to become thicker, and squeezing the ingot thus heated while the interior thereof is still liquid so as to reduce the cross sectional area of its top.

2. The improved process of treating steel ingots which consists in stripping the mold from the ingot while its interior is still in a fluid condition, heating said ingot so as to soften the outer solidified strata and increasing the thickness of such strata by the solidification of the adjacent fluid metal, and applying lateral pressure to the sides of said ingot so as to reduce its cross sectional area and substantially eleminate the usual cavity.

3. The improved process of treating steel ingots which consists in stripping the mold from the ingot while its interior is still in a fluid condition, heating said ingot so as to soften the outer solidified shell and permit the thickness thereof to be increased by the cooling of the adjacent fluid metal, and preventing segregation in the central part of the top of the ingot by applying lateral pressure to the sides adjacent thereto and pressing the same inwardly while said shell is ductile and said interior is fluid.

4. The improved process of treating steel ingots which consists in stripping the same while their interiors are still fluid, heating them so as to soften the outer envelop while permitting it to increase in thickness, and squeezing the upper section only of such ingots so as to reduce the cross sectional area thereof while the center is still fluid.

5. The improved process of treating steel ingots which consists in stripping the same while their centers are still fluid, heating them so as to soften the outer envelop, squeezing said ingots so as to reduce cross sectional areas thereof while the interior is still fluid, and reheating the resulting products for the approximate equalization of the heat and the condition of the metal therein.

6. The improved process which consists in treating steel with a deoxidizer and forming an ingot thereof which shall have blow holes eliminated from the outer envelop, heating said ingot while the interior is still fluid so as to increase the ductility of said envelop while permitting the same to become thicker, and subjecting said ingot to a squeezing operation so as to reduce its cross sectional area while its center is still fluid.

In witness whereof I have hereunto set my hand in the presence of two subscribing witnesses.

BENJAMIN TALBOT.

Witnesses:
WILFRED W. GROVES,
CHAS. J. FALCONER.