

J. E. YORK,
METHOD OF MAKING INGOTS.
APPLICATION FILED MAR. 21, 1913.

1,206,188.

Patented Nov. 28, 1916.

Fig. 1.

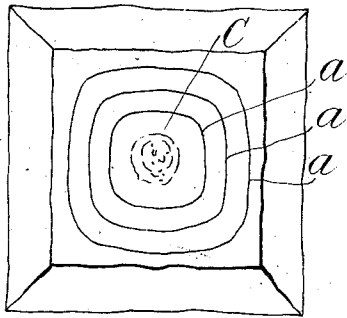


Fig. 2.

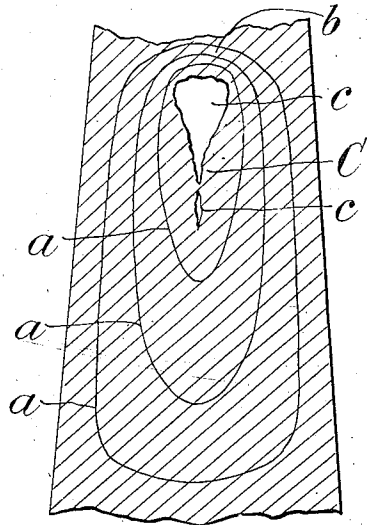


Fig. 3.

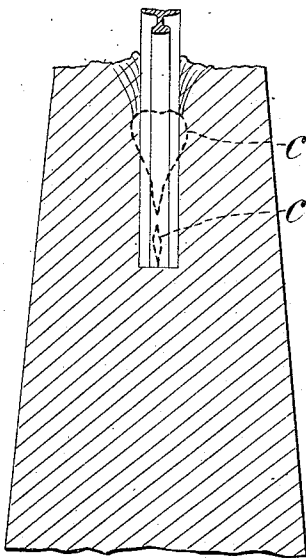
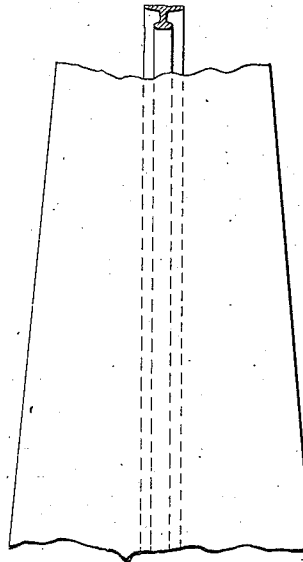


Fig. 4.



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METHOD OF MAKING INGOTS.

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To all whom it may concern:

Be it known that I, JAMES E. YORK, a citizen of the United States, residing in the borough of Brooklyn, county of Kings, city and State of New York, have invented certain new and useful Improvements in Methods of Making Ingots, of which the following is a specification.

This invention relates to methods of making ingots and aims to provide improvements therein.

Shapes or products produced from metal ingots, as at present manufactured, often contain latent defects, which it is practically impossible to detect by any practical means. This is particularly true in the case of rolled steel rails. The defects in the shapes or rails are mainly due to defects which arise in the manufacture of the ingot from which the shapes or rails are formed and which remain in the ingot. When poured into the ingot mold, the molten metal cools more rapidly at the bottom and sides than it does at the center, consequently upon solidifying the metal shrinks or contracts from the center, where the metal is most fluid, toward the sides and bottom, where the solidification is taking place. The result of this is that the sides and bottom of the ingot are ordinarily homogeneous and sound, while the center portion of the ingot at the upper end thereof contains a greater or less number of cavities or hollow spaces, usually running longitudinally of the ingot, and known as "pipes", which are due to this shrinking away of the metal from the center portion or core of the ingot. Furthermore, after the pouring has been completed, the metal of the ingot begins to solidify on the top, thus forming a solid coating over the center portion or core where the defects are being developed, and covering them from view.

When the ingot has been formed and is carried to the rolling mill or other forming device, the "pipes" or cavities in the center portion or core of the ingot are still contained therein. The operation of the rolls or other forming devices upon the ingots does not serve to remove or remedy the "pipes" in the ingot, particularly if there are any oxids formed on the walls of the cavity, or other substances having the same effect, as there almost invariably are, and the defects due to the presence of the "pipe" are

incorporated in the shapes or articles produced by the forming operation. The pressure of the rolls or other forming devices upon the ingot in drawing out or attenuating the ingot, while it may eventually bring the walls of the "pipes" or cavities together, has the effect of lengthening the "pipes" or cavities and spreading them throughout a greater length of the formed article or shape, rather than closing the "pipes". If the ingot is reheated after being allowed to solidify the reheating will in many cases not be sufficient to bring the metal in the vicinity of the cavity to a welding heat, and even though the heat be sufficient for welding this will not take place owing to the presence of the oxids on the walls of the cavity, and other matter hereinafter more fully referred to, which prevent the formation of a weld. The defects in the shapes or products are in fact rendered more imperceptible if anything by rolling than in the ingot. Furthermore, the center portion or core of the ingot is of a different composition from the metal forming the other parts of the ingot. It is here that the substances or compounds dissolved or suspended in the metal for the most part segregate or collect, which substances or compounds are generally referred to as "segregation." It is the zone of the impurities. It is here, for instance, in the case of steel, where the greater amount of carbon and other substances, as for instance, manganese, silicon, sulfur and phosphorus are contained. The upper center portion or core of the ingot, where the "pipes" occur, is therefore of different composition and has different qualities from the metal constituting the other portions of the ingot. It is also in this center portion of the upper end of the ingot where the greater quantity of occluded gases and "inclosures", such as minute quantities of slag, and oxids which have not been reduced in the refining processes, are found. It has been a problem for many years in the metal industry and more especially in the steel industry to overcome these defects occurring in the ingot, and remaining in the shapes or articles manufactured therefrom. Various methods of overcoming these defects have been heretofore tried and practised. The most common and approved method has been to cut off or "crop" a portion of the upper part of the

ingot and use the lower part. This results in considerable loss and in most cases an excessive reduction of tonnage production, which is contrary to the predominating aim of present-day steel manufacturers.

Various other methods for overcoming the above-mentioned defects in ingots have been heretofore proposed:—It has been proposed to remedy these defects by slow pouring of the molten metal in the molds; by the addition of metal alloys; by compression of the ingot while fluid in the mold; and by means of a sinking head, which is a funnel-shaped extension connected with the mold for the purpose of supplying additional molten metal to make up for shrinkage occurring in the ingot. Slow pouring of the metal into the mold is objectionable because it operates to retard production. Metal alloys are expensive and do not serve to satisfactorily render the desired effects. Use of a sinking head involves the use of a heating material, for keeping the head of the ingot molten, and leaves a mass of metal to be cut off from the top of the ingot and discarded. Compression of the ingot is impracticable for the reason that large and expensive apparatus is required and because of the length of time involved. The foregoing and many other methods have been tried and found to be impracticable or unsatisfactory on account of the considerable addition to the cost of the ingot and to the considerable reduction of output involved. It has also been proposed to fill in the cavities formed in the cores of ingots by pouring molten metal therein. This is unsuccessful, however, for the reason that it is necessary that there should be an equalization of the temperatures of the molten metal and of the metal of the ingot at a pasty or fluid consistency in order for welding or fusion to take place, and the mass of the molten metal is usually so small compared with that of the ingot that before the equalization takes place the two masses of metal are at too low a temperature for the union to take place.

From the foregoing it will be seen that a great necessity exists for a simple and reliable method for producing ingots that are solid throughout, which may be formed into shapes or articles which will be thoroughly sound and which will be comparatively free from the defect growing out of the "pipes," segregated matter and concentration of "inclosures" found in the cores or center portions of the present ingots. The present invention has been designed to and meets such necessity or want.

The invention will be more conveniently explained by referring to the accompanying drawings.

In said drawings, Figures 1 and 2 are a top and a side view of an ingot illustrating

diagrammatically the process of solidification or cooling which takes place upon the interior of the ingot, and the formation of the "pipes" or cavities in the center portion or core thereof. Fig. 3 illustrates a method of carrying out the invention. Fig. 4 illustrates another method of carrying out the invention.

When metal is poured into an ingot mold the metal cools and solidifies more rapidly from the sides and bottom than it does from the center, as is indicated by the lines *a, a, a*. After the pouring has been completed, and as the cooling and solidifying progresses, the top *b* of the mass of metal solidifies. During this solidification, the metal shrinks or contracts from the center of the ingot, where the metal is molten, toward the exterior of the mold, thus producing cavities *c c* in the core or center portion *C* of the upper part of the mold, which cavities are known as "pipes." This core or center portion *C* also contains the greatest proportion of those substances or compounds contained in the metal which constitute the "segregation" and "inclosures." The metal of this center portion or core is therefore of a different composition from the metal of the other parts of the ingot and consequently is of a different quality, being inferior and constituting an imperfection in the ingot and the shapes or articles formed therefrom.

In carrying out the present invention a piece or plug of suitable material is inserted into the upper end of the ingot while its interior is mobile, *i. e.* molten or pasty, and into the core or zone wherein the cavities or "pipes" occur, to fill the cavities or "pipes" and to displace the metal in the center portion or core of the ingot, the displaced metal being forced upwardly so as to further fill the cavity or cavities, the displacement is preferably carried further so as to cause the metal to ooze or be forced out at the top of the ingot around the sides of the plug or around the opening formed by the insertion of the plug. In the case of steel the plug is preferably made of steel having approximately the same composition as the steel from which the ingot is to be formed. When the piece or plug of metal is inserted in the ingot either a weld or a fusion will be produced owing to the fact that the temperature of the metal upon the interior of the ingot will raise the temperature of the plug to either a fluid or a pasty condition and to the fact that at a certain stage of the cooling the metal of the ingot itself will come to a similar temperature and condition. Under these circumstances a perfect weld or fusion will be produced.

Oxidation cannot take place in the ingot so as interfere with the weld, inasmuch as the plug is inserted while the metal of the ingot is either fluid or pasty. The plugs

themselves can be kept free from oxidation or be freed of oxids before being used.

The plug or plugs may be inserted at any stage of solidification of the metal at the top of the ingot, but it is preferred to insert the plug when the metal at the top of the ingot is in a fluid or pasty condition and shortly after the casting has been completed. The plug can be heated to a greater or less temperature according to the temperature of the metal of the ingot. The plug is not required to have any particular degree of solidity, so long as it possesses sufficient solidity to enable it to be forced or to sink into the metal of the ingot to fill the cavities therein, and to act further to displace the "segregation" and "inclosures" if desired. Furthermore, any shapes or plugs may be used. The plugs may be sections of old rails, pieces of scrap metal or of other form, or may be formed especially for the purpose. They may be inserted singly, or in numbers; the plugs may be either simple or composite. Furthermore, treatment of the metal, as by the addition of manganese, silicon, aluminum, titanium, vanadium, etc. "churning", or in fact any other treatment which is usual or desirable, may be carried on previous to the insertion of the plugs, or along with the insertion of the plugs. The plugs may be inserted in any manner. They may be inserted manually by dropping them into the top of the mold, or any suitable appliance may be utilized for placing them in position and forcing them into the ingot. If there has been too much solidification of the metal at the top of the ingot, "thermit" or the like may be used to melt the same.

In carrying out the invention, the plugs are preferably inserted gradually (and preferably in elongated pieces or shapes) so that there will be a gradual and substantially continuous oozing or out flow of metal at the top of the ingot. By this means the metal around the opening at the top of the ingot is kept molten or in a mobile state and provides a fluid column of metal, extending to the exterior of the ingot, from which any shrinkage or contraction in the metal of the body of the ingot may be taken up, thus counteracting directly the formation of the cavities or "pipes". The place of the extruded metal is taken by the metal of the plug, which is rendered fluid or pasty by the heat of the interior of the ingot. Heat may be applied during the extrusion to assist in maintaining the fluidity or mobility of the extruded metal at the issuing point.

The insertion of the plugs has the further advantageous effect, that the heat of the interior of the ingot is utilized for doing the useful work of raising the inserted plugs to a temperature at which they are brought to a fluid or pasty state, and the capacity of

the plugs for absorbing heat is utilized for the useful purpose of absorbing heat from the surrounding metal of the ingot and hastening solidification. The hastening of solidification has the useful effect of reducing the concentration of the "inclosures", the "segregation" and the formation of blow-holes. Acceleration of cooling ordinarily has the effect of increasing the size of the "pipes" or cavities in the core, but this effect is not a disadvantage in the present invention for the reason that the "pipes" or cavities are filled by the plugs.

The insertion of the plugs has the further advantageous effect of rendering practically the entire upper end of the ingot available for use, requiring no "cropping" or cutting off at all, and but a minimum amount of discard at the end of the "blooms" or of the rolled shapes. Furthermore by suitably selecting or determining the character of the plugs, the character of the metal at the axis or core of the ingot may be modified so as to obtain a wide range in the properties, and especially the physical properties, of the metal of this part of the ingot. Moreover, owing to the improved texture or properties with metal which has been subjected to mechanical treatment, such as rolling, usually possesses, plugs of this character may be used to advantage. This is of particular advantage in rail making, where the method may be used for inserting plugs of a different composition from the metal of the ingots, to obtain thereby a hard or soft center to a rail where desired, many experts considering a composite rail of this character to have greater strength to resist fracture.

The invention may further be carried out as indicated in Fig. 4 of the drawing. A plug which extends longitudinally the entire length of the ingot, may be inserted before the cooling or solidification begins or immediately thereafter and following the completion of the casting of the ingot. By this means the cooling or solidification of the ingot is accelerated with the resulting advantages above set forth and the ingot is provided with an axis or core of comparatively homogeneous metal, which may be so chosen as to provide a wide range in the physical properties of the metal constituting the center or axial portion of the ingot. The ingot may be subjected to further treatment, preferably after thermal equalization has taken place and the solidification has progressed, by inserting plugs in the top of the ingot, as hereinbefore explained, for the expulsion or elimination of "pipes," "segregation," "inclosures," etc.

The present method of making ingots for rails, by what is known as the "top cast" method, lends itself well to the present process. The top of the ingot is accessible at all times during the cooling or solidification of

the metal and permits of the elimination of the "segregation," "inclosures," etc., by fluid displacement at the top of the mold. The ingots may also be cast either big-end-up or big-end-down, as may be preferred, or be in practice at any particular plant.

By the present process it is not so essential that the metal used in casting the ingot receive such thorough treatment or refining before coming to the mold as is now required in good practice, nor are the results so unfavorable as when improperly or insufficiently refined metal is used at present.

The invention is adaptable to all classes of melted metal where solid and relatively homogeneous ingots are desired, especially where it is desired to roll the ingots.

What is claimed is:—

1. A method of making ingots, comprising inserting metal in piece form into the zone of the ingot wherein "pipes" occur while the metal of the interior of the ingot is mobile, and feeding the metal to compensate for the portion which flows into the cavities in the interior of the ingot.

2. A method of making ingots, comprising inserting metal in piece form into the zone of the ingot wherein "pipes" and "segregation" occur, while the metal of the interior of the ingot is mobile, and gradually displacing said metal of said zone.

3. A method of making ingots, comprising inserting metal in piece form into the zone of the ingot wherein "pipes" and "segregation" occur, while the metal of the interior of the ingot is mobile, and gradually displacing the metal in the interior of the ingot to fill said "pipes" and to expel the portion of said metal containing the "segregation" to the exterior of the ingot.

4. A method of making ingots, comprising inserting metal in piece form into the zone of the ingot wherein "pipes" and "segregation" occur, while the metal of the interior of the ingot is mobile, gradually displacing the metal in the interior of the ingot to fill said "pipes" and to expel the portion of said metal containing the "segregation" to the exterior of the ingot, and heating said

extruded metal at the issuing point to maintain its mobility.

5. A method of making ingots, comprising inserting materials for thermally treating the metal into the interior of the ingot and inserting metal in piece form into the zone of the ingot wherein "pipes" occur while the metal in the interior of the ingot is mobile.

6. A method of making ingots, comprising inserting materials for chemically treating the metal into the interior of the ingot and inserting metal in piece form into the zone of the ingot wherein "pipes" occur while the metal in the interior of the ingot is mobile.

7. A method of making ingots, comprising inserting metal in piece form into the zone of the ingot wherein "pipes" occur while the ingot contains sufficient heat to melt the inserted metal to allow it to flow to fill up the cavities in the ingot and continuing the feeding of the metal until the interior of the ingot is completely filled.

8. A method of making ingots, comprising inserting metal in piece form into the zone of the ingot wherein "pipes" occur while the center portion of the top surface is still in a fluid or plastic condition and maintaining a fluid or plastic condition at the center portion of the top of the ingot by continued feeding of metal and displacement of the plastic or fluid metal from the interior of the ingot.

9. A method of making ingots, comprising inserting metal in piece form into the zone of the ingot wherein "pipes" occur while the center portion of the top surface is still in a fluid or plastic condition, and maintaining a fluid or plastic condition at the center of the top of the ingot by the application of heat.

In witness whereof, I have hereunto signed my name in the presence of two subscribing witnesses.

JAMES E. YORK.

Witnesses:

GUSTAVE R. THOMPSON,
CHAS. LYON RUSSELL.