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2,230,296

METHOD OF CASTING METAL BODIES

Filed Feb. 10, 1937

FIG. 1

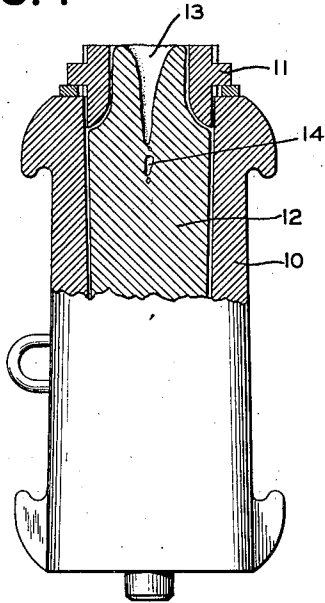


FIG. 2

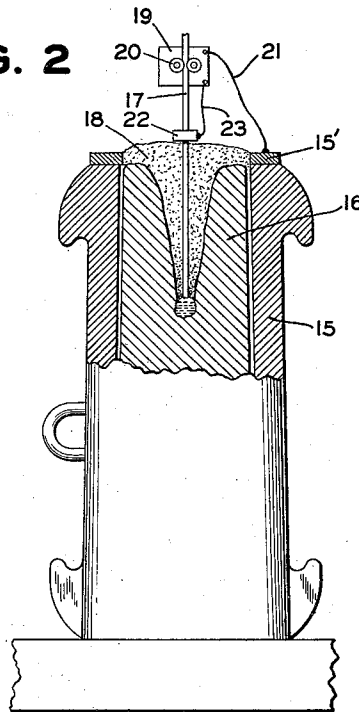


FIG. 3

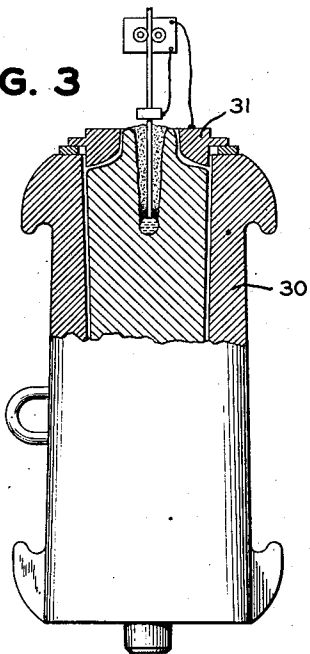
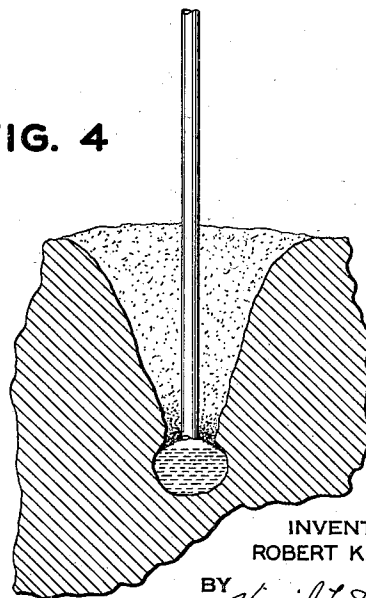


FIG. 4



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METHOD OF CASTING METAL BODIES

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This invention relates in general to the casting of metal bodies and in particular to an improved method for casting metal bodies in which a maximum of dense sound metal is produced from the metal cast.

Metal sold in the form of worked shapes is generally cast into ingots preparatory to the working operations. The casting of the ingots is a very important operation as the quality of the final product as well as the saleable yield is largely determined by the quality of the ingots. A great deal of time and effort have been expended in perfecting ingot molds and ingot casting technique with the result that in the present practice many of the causes of unsound ingot metal have been eliminated. One of the main causes for the lowering of the saleable yield, particularly with killed steels and comparable materials, is the central pipe or pipes that form in the upper end of the ingot during the cooling of the cast metal. The formation of a central pipe or pipes is inherent in the casting operation and results from the manner in which the cast metal solidifies.

I have found that the problem presented by the piping of ingots may be solved in an efficient manner.

According to my invention I provide a method for forming sound pipeless ingots in which the loss in volume of the metal of the ingot, that takes place during the cooling thereof and that results in the usual pipe or pipes, is compensated for by the deposition of molten metal in the ingot, which molten metal welds to the metal of the ingot and thereby produces a sound pipeless ingot. The metal deposited is preferably deposited as fusing weld metal under the influence of a discharge of electric current through a gap between the end of the electrode and the ingot metal. The deposition is preferably carried out under a blanket of flux that protects the metal of the ingot and the deposited metal from the atmosphere and also absorbs or floats out impurities and segregations from the molten metal. The deposition of the molten metal may be initiated during the cooling and solidification of the cast metal or it may be initiated after the cast metal has been completely solidified. Also, the novel method may be used with any preferred type of mold. Thus, hot tops, or shrink heads, or shrink heads may be used or omitted as preferred. If the expedients, just mentioned, are employed they need only be of small relative size as the metal required to prevent the formation of pipes can more economically be supplied as deposited fusing metal.

The further objects and advantages of the invention will be readily appreciated from a consideration of the following detailed description of the mode of carrying it out in practice taken with the accompanying drawing, in which,

Fig. 1 is a view partly in side elevation and partly in vertical section of a mold of the present practice showing the use of a hot top,

Fig. 2 is a view similar to that of Fig. 1 illustrating my invention,

Fig. 3 is a view similar to Fig. 2 but showing the use of hot top or shrink head, and

Fig. 4 is an enlarged fragmentary sectional view illustrating the deposition of the fusing metal.

The novel method of this invention may be used in connection with the forming of metal ingots in general and is not limited to any particular type of ingot or ingots of metal of any particular composition. However, since it is admirably suited to the formation of ingots of partly, or completely, deoxidized steel it will be particularly described in connection with this type of metal.

In Fig. 1, is shown an ingot mold 10 of the large end up type provided with a hot top or shrink head 11. Hot top 11 is usually made of refractory material while the mold 10 is usually made of cast iron. Ingot 12, as shown, is slightly separated from the mold sides due to the shrinkage that takes place during the initial cooling and solidification of the cast metal. The shrinkage of the metal upon solidification also results in the production of primary pipe 13 and sometimes in the production of secondary pipe 14. As is well known, the metal adjacent pipes 13 and 14 is generally contaminated with segregated impurities because of the fact that this metal, particularly that around secondary pipe 14, is the last to cool.

In carrying out my novel method any preferred type of mold and any preferred casting technique may be employed. The mold 15 of Fig. 2 is generally the same as that of Fig. 1 but with the exceptions that hot top 11 has been omitted and that it is a big end down mold rather than a big end up mold. Big end up molds may be used but since this necessitates special arrangements for the removal of the mold relative to the ingot the more simple type is shown. The metal to be cast, as for example carbon steel, is prepared as in the usual manner, i. e. the required additions are made and it is either partly or entirely deoxidized by addition thereto of ferro-silicon, aluminum, or other preferred deoxidizing agents,

and then allowed to come to the preferred pouring temperature. It is then poured into mold 15 and allowed to cool.

When the cast metal has cooled to such a point that the sides of the ingot 16 have solidified and substantially all the molten metal that is left is to be found around the loci of primary and secondary pipes the ingot 16 is ready for the addition of the fusing metal. This condition of the ingot 16 is readily determined by sounding it from time to time as with a metal bar. With any type and size mold and with any analysis of cast metal the loci mentioned above are more or less fixed and readily ascertained by any skilled operator by following the above relatively simple procedure.

A metallic electrode 17 is then inserted into the ingot 16 at, or near, the center thereof and an electric current caused to flow through a gap between the end thereof and the metal of the ingot. Either before starting the electric current flow or just after the electric current flow is started the depression in the top of ingot 16 is filled, or partly filled, with a blanket of flux 18 which may be either solid or molten. Preferably the flux 18 is heaped over the top of ingot 16, in such a case a proper dam 15' is employed to maintain flux 18 on ingot 16.

Electrode 17 should be of such composition that the fusing metal deposited from it is of substantially the same analysis as that of the metal of ingot 16. Since there is generally a loss of electrode constituents the analysis of electrode 17 may vary from that of the metal of ingot 16 as required to compensate for the losses. Electrode 17 may be covered or bare; electrode 17 may be solid or hollow. All of the required constituents of electrode 17 may be incorporated in the metallic portion thereof, or some of them may be included in the metallic portion and the remainder included in the coating of the electrode, if one is used, or passed to the region of the gap through which the current flows in any suitable way as for instance, by making electrode 17 hollow or at least trough-like and passing the remainder of the constituents through the hollow center, or also by passing said remainder of the constituents separately from the electrode as for instance through a hollow body which may be non-consumable or made of the same material as the electrode.

The flux 18 should be such that it is substantially non-gassing and will not remove substantial quantities of desired ingredients from the molten metal but will flux out impurities. A wide variety of fluxes may be used satisfactorily. Silicates in general either simple silicates or mixtures thereof, or complex silicates or mixtures thereof, are satisfactory fluxes. Tantalates and similar compounds are likewise satisfactory. The flux need not be composed of reacted materials but may be made up of the unreacted components thus, for instance, in the case of manganese silicate the flux may be made up of MnO and SiO₂. At present, silicates, either simple or complex of the alkaline earth metals, manganese, aluminum and iron are preferred. Of these, manganese silicate is preferred as it predominates in the desired characteristics. With any of the materials of the classes mentioned unreacted components that generate an excessive amount of gas either in reacting or at the temperature of the arc should be excluded. Thus, uncombined iron oxides, carbonates, etc., and water are undesirable. Flux 18 may also include constituents de-

sired in the final deposited metal or constituents such as ferro-silicon, etc., that facilitate the production of the final desired deposited metal. The slag produced during the manufacture of chrome-iron alloys is also a preferred flux. This material compares favorably in required characteristics with the best of the materials above noted and has the additional advantage that it is self disintegrating so that it does not require any comminuting to prepare it for use. The finishing slag used in making the molten metal that is cast into mold 15 may also be used as the flux. This may be done by ladling molten slag directly from the steel finishing furnace or by cooling the slag and then breaking it up into fine enough particle size to permit the formation of the protective blanket 18.

The electrode 17 is preferably fed to the gap at a predetermined rate and a predetermined voltage and amperage maintained. This is accomplished by means of the usual welding head 19. Welding head 19 controls feed wheel 20 that drives electrode 17 toward ingot 16. Welding head 19 may include a welding current generator or the current may be supplied to it from a separate source. In any event, welding head 19 is provided with the usual arrangements for controlling the voltage and amperage of the welding current. One side of the welding current supply is connected to ingot 16 by cable 21 and the other side is connected to a contact nozzle 22, through which electrode 17 passes, by cable 23. Contact nozzle 22 may be of any preferred construction but should be such as to assure the continuous passage of current to electrode 17.

The discharge of welding current through the gap between the end of electrode 17 and the metal of ingot 16 generates heat which causes the progressive melting of electrode 17. The heat generated by the current discharge will also cause the fusion of some of the metal of ingot 16 so that the metal melted from electrode 17 commingles with and becomes part of the metal of ingot 16. The passage of current is continued and electrode 17 consumed until the pipe cavity is completely filled.

The heat generated by the current discharge remelts or renders more fluid, some of the metal of ingot 16. The metal thus effected is the metal in which segregation of unwanted materials is greatest. The action of the heat thus releases the segregated material so that it can come into contact with the supernatant molten flux and be absorbed. Thus, the metal of ingot 16 is further refined and purified by the action of the heat generated by the current discharge.

The flux 18, as above stated, is introduced into the pipe cavity and covers or blankets the deposition of metal from electrode 17 so that it as well as the metal at the sides of the pipe cavity is protected from the atmosphere. The flux 18 however is also progressively melted by the heat of the current discharge, or when introduced in the molten condition rendered more fluid, so that in any case after the operation has gone on a short time a molten layer of flux covers the molten metal. The molten flux is at a high temperature and, since it is not of high heat conductivity, prevents the rapid dissipation of the heat generated and assures the fusion and further refinement of the metal at and adjacent the sides of the pipe cavity even though such metal may not come into direct contact with the discharge of current. As the deposition of metal continues the progressive melting of the flux, when it is in-

roduced in the solid condition, reduces the volume of the flux so that it may be necessary from time to time to add flux in order to maintain a proper blanket.

While the current input is largely determined by the amount of metal to be deposited and by the time available for its deposition, it is at present preferred to initiate the operation at high current inputs and gradually reduce the current input as the deposition progresses. Thus, for instance, the operation may be started at an amperage in the vicinity of 8000 amperes per inch diameter of electrode and finished at an amperage in the vicinity of 2000 amperes per inch of electrode. The amperage values just given are illustrative only and higher or lower values may be employed as required to obtain the desired results, thus, the initial amperage may be as high as 10,000 amperes or more and is limited only by the amount that the electrode can safely carry. The high initial current input is desirable since it provides for the generation of heat at a rate high enough to assure fusion of the bulk of the metal at the end of the primary pipe and the metal at the situs of the secondary pipe. The tapering off in current input on the other hand assures the solidification of the metal deposited at the upper end of the primary pipe at a rate that approaches the rate of deposition with the result that there is very little molten metal in the cavity at the end of the deposition of metal from electrode 17 and piping, segregation and porosity is avoided. The current may be tapered off to the value above given or to a much lower value as required to obtain the results just mentioned.

To further assure complete fusion of the metal deposited from electrode 17 with the metal that forms the walls of the pipe cavity, electrode 17 may be given an oscillatory and/or rotary motion relative to ingot 16 so that the region of the current discharge will come into contact with or closely approach all portions of the sides of the pipe cavity. For this purpose either ingot 16 or electrode 17 may be moved. Thus, ingot 16 may be supported on a turntable and rotated at a desired speed, also welding head 19 may be rotated and/or provided with any of the usual electrode oscillating devices.

The method of this invention may also be employed to fill the pipe cavities of ingots, or cavities in metal bodies of whatsoever character, such as castings, and the like, after all of the metal of the metal bodies is solidified, or solidified and cooled to room temperature. In the cases just mentioned, the procedure is the same as that just above described however care should be taken to employ a sufficiently high initial welding current input to assure the melting of a substantial portion of the metal at the bottom of the primary pipe so that the metal at the situs of the secondary pipe may be melted and this source of imperfect metal removed.

The novel method may also be employed in

connection with a hot top or similar device, however, if a hot top is employed the relative volume thereof may be materially reduced below that of the best present practice. Thus, in Fig. 3 mold 30 is provided with a hot top 31 that contains about 5% more or less of the metal of ingot 16'. In applying the method of my invention to this form of mold either of the procedures described above may be employed, however, the pipe cavity need only be filled to the crop line.

While the novel method of the invention has been disclosed in connection with ingots either prior to complete solidification or after complete solidification; the novel method is of much broader application; thus, it may equally well be used in connection with cast bodies in general. Also, the method of the invention is not limited to cast metal bodies as it may well be used in the repair of wrought or otherwise worked bodies. Thus, the method may be used in the repair of imperfections such as porous areas, seams, cracks, etc. Therefore, the above description and in the following claims the terms ingots and pipes should be taken as referring respectively to metal bodies of whatsoever character, and to holes, cracks, seams, porous areas, etc.

It is my present belief that in the operations above described the heat is generated by an arc discharge of the electric current. However, since the fluxes mentioned are current conductors when molten it has been advanced that the heat is generated by the flow of the current through the molten flux. Since the present application is a disclosure of fact it is to be understood that I do not wish to be bound or limited by any theory advanced and that the appended claims are to be interpreted and construed in the light of the factual disclosure and the prior art regardless as to the correctness of the theory underlying the generation of heat.

I claim:

1. A method of forming pipeless cast ingots comprising the steps of casting molten metal in a mold incorporating additional metal by electric energy and a fusible electrode, the energy input being so controlled during the final portion of the deposition of the added metal that said added metal is deposited at a rate less than that at which the molten metal solidifies whereby at the end of said deposition only a small quantity of molten metal is present in the pipe cavity.

2. A method of casting pipeless ingots which comprises casting a molten metal in an ingot mold and depositing by electric energy weld metal from a fusible electrode into the pipe cavity formed in said cast metal and maintaining a flux blanket over the fused metal during the welding operation, the energy input being progressively diminished during the adding of the metal whereby the final portion of said deposition is effected at a rate which is less than the rate of solidification of the molten metal in the ingot.

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