Feb. 6, 1934. R. W. BAILEY 1,946,450

PRODUCTION OF METAL CASTINGS

Filed July 18, 1931 2 Sheets-Sheet 1

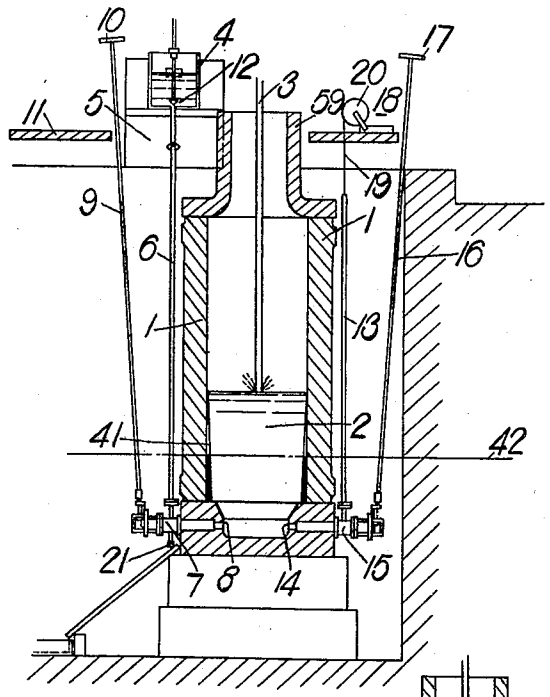


FIG. 1.

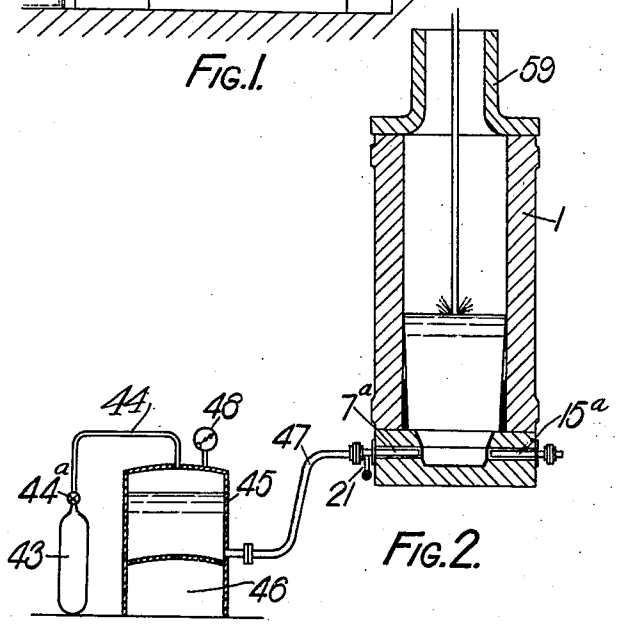


FIG. 2.

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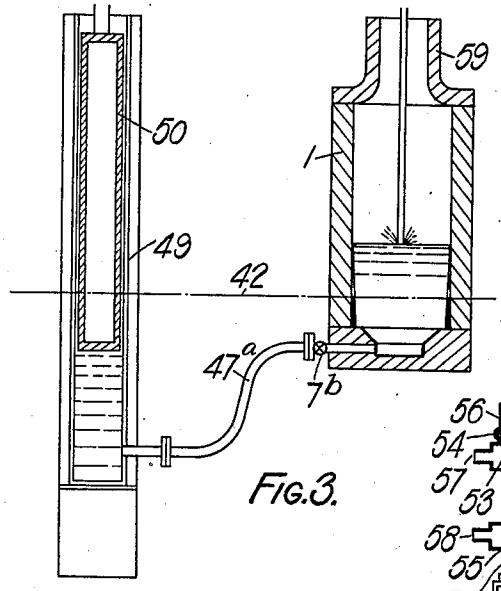


FIG. 3.

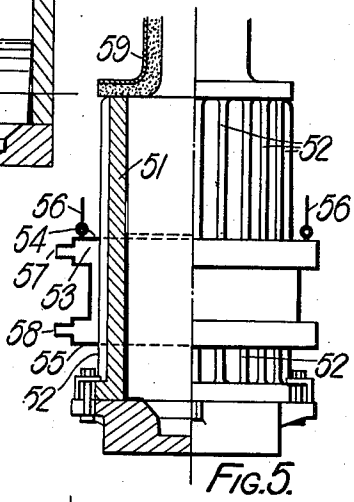


FIG. 5.

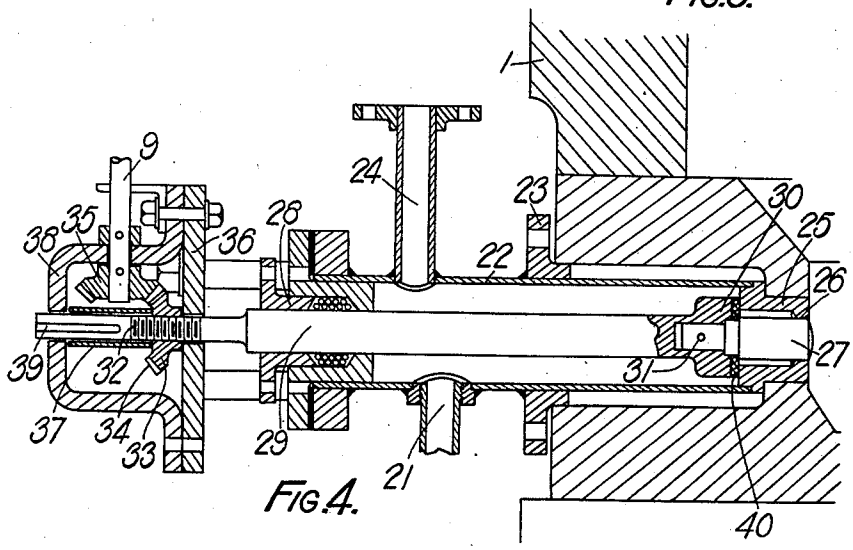


FIG. 4.

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1,946,450

PRODUCTION OF METAL CASTINGS

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Application July 18, 1931, Serial No. 551,769, and in Great Britain August 15, 1930

7 Claims. (Cl. 22—200)

This invention relates to the production of metal castings and particularly, though not exclusively, to the production of ingots of cast steel.

In the production of cast steel ingots, particularly of large size, variations in grain structure usually occur in various parts of the ingot. These may result in segregation and cracks in the outer parts of ingots of all shapes and of what are called ingot corner marks in the case of ingots of square and polygonal cross section. Defects also generally found in the axial region of an ingot, particularly in the upper part.

The object of the present invention is to reduce the liability for the formation of such defects and generally to produce an ingot of improved soundness and quality.

According to my invention I provide for the introduction, at a desired stage in the casting process or even after pouring is completed, of a suitable low melting point metal or alloy into the space formed between the mould and the casting by the contraction of the latter and/or the expansion of the mould. Means are also advantageously provided whereby the height of the free surface of the liquid filling metal thus introduced may be varied as desired. By this means the hydrostatic pressure of the still molten metal within the outer shell of the casting where solidification first occurs can be counteracted at any desired stage by the hydrostatic pressure of the liquid metal introduced between the shell and the mould, and, furthermore, the presence of metal between the casting and the mould will increase the rate of cooling of the casting so that, by varying the height of the metal introduced, the rate and manner of cooling of the casting can be controlled by varying the level of the liquid metal. When it is desired to remove the casting from the mould the metal introduced may be run out before lifting the casting.

In carrying out the invention in casting, for example, a large steel ingot, as soon as a certain amount of steel has been poured, molten metal, lead for example, is admitted near the bottom of the mould, preferably through an opening in the side of the mould, at a rate which maintains the level of the lead at an appropriate distance below the free surface of the steel as pouring is continued. When it is judged that the thickness of the shell of the ingot is such as to withstand the hydrostatic pressure of the still liquid steel in the interior of the ingot the level of the lead may be lowered so as to reduce the rate of cooling of the ingot. It is usually desired, in the case of steel ingots, that complete solidification of the lower part of an ingot shall take place well in advance of the solidification of the upper part and that solidification shall proceed in the upward direction, as this is found to result in fewer defects in the axial region of the ingot. This can readily be accomplished according to my invention by permitting the molten lead to remain in the lower part of the mould for a suitable time and by then raising its level either by stages or continuously. The rate of cooling may be varied at various parts of the ingot by raising and lowering the level of the lead in the mould. Variation of the rate and distribution of cooling of the ingot by the means described may be combined with heating or cooling of the mould whereby the rate and distribution of the cooling of the ingot may be more closely controlled. For example, in order to cool the mould, air may be blown over a part of the external surface of the mould which may, for greater effect, be formed with ribs; or the mould wall may otherwise be made to present an extended surface for the extraction of heat. Similarly, in place of cooling air, gaseous or other heating medium may be employed, and when it may be necessary, at a particular stage of the cooling, to accentuate the relative rates of solidification at different parts of an ingot, cooling of one part of a mould may be effected in conjunction with heating of another part. The molten filling metal may be introduced into the mould at a certain point in the casting process, in some cases after the pouring is completed, for the purpose only of controlling the rate of cooling, or the liquid metal may be introduced solely for the purpose of providing a counteracting hydrostatic pressure on the outside of the casting.

To provide for the introduction and withdrawal of the liquid filling metal, an opening or port of suitable size may be formed in the side of the mould near or at the bottom or even in the bottom itself; and, if necessary, means such as channels are provided for distributing the filling metal to the sides of the mould. In one arrangement, for example, said opening is provided with a plug with means for screwing same in and out so as to open and close the port for the admission and withdrawal of the liquid filling metal as required and to prevent access of the molten metal to be cast to the conduits or passages by which the filling metal is introduced. The outer side of the port communicates through a conduit with a reservoir for the liquid filling metal. The level of metal in the mould can be regulated by varying the height of molten metal in the reservoir or

the reservoir may be in the form of a cylinder containing a weight or a loosely fitted piston, the pressure of which can be varied, pressing on the upper surface of the metal therein, or there may be a sufficient space between the plunger, the axis of which would be substantially vertical, and the container to permit the former to act as a displacer causing the free surface of the liquid metal in the container and mould to rise or fall according as the plunger is moved. In another arrangement the level of the filling metal within the mould may be varied and controlled by means of the admission plug or valve referred to and means provided for running out the filling metal. Provision must be made for maintaining the whole of the metal to be introduced in a suitable liquid condition. In order to facilitate flow of the filling metal to all faces of the ingot one or more distributing conduits may be provided. These would be formed preferably by removing or displacing parts of the mould wall corresponding with the conduits, the said removal taking place after the commencement of pouring of the steel and before the liquid filling metal is admitted to the mould.

The accompanying drawings illustrate somewhat diagrammatically and by way of example various methods by which the invention may be carried out in practice.

Fig. 1 is an elevation, partly sectional, showing an ingot mould and means for delivering molten metal, such as lead, to the lower portion of the mould.

Figs. 2 and 3 are views similar to Fig. 1 showing other methods by which the melted lead may be caused to flow into the lower portion of the mould.

Fig. 4 is a sectional view, drawn to an enlarged scale, of a valve, such as is indicated in Fig. 1, for admitting the melted lead to the lower portion of the mould.

Fig. 5 is an elevation, the left-hand half being in section, showing a means for cooling the outside of the mould at different levels.

Referring now to Fig. 1, a mould for casting steel ingots is indicated in section at 1. The mould is illustrated as being about one-third filled with the molten steel indicated at 2, the stream of metal to be cast entering the mould being indicated at 3. 4 is a reservoir containing lead which is maintained in a melted condition by means of a furnace in the space 5 below the said reservoir. The reservoir 4 is situated at a level above that to which it is desired the liquid lead shall rise in the ingot mould. The lower end of the reservoir 4 communicates by a pipe 6 through a valve 7 with the lower portion of the mould as shown at 8. The valve 7 is operated through a shaft 9 rotated by means of a hand wheel 10 from a platform 11. The outlet from the reservoir 4 to the pipe 6 is regulated by a manually operable valve indicated at 12.

On the other side of the mould is shown a stand-pipe 13 which communicates with the lower portion of the mould as shown at 14 through a valve 15, which may be of a similar construction to the valve 7, said valve being operated by a shaft 16 and hand wheel 17.

18 is a device for indicating the level to which the metal rises in the stand-pipe 13 and thus the level to which the liquid lead has risen in the space between the casting and the side of the mould. Such an indication may be given in various ways. For example, as shown, a flexible wire 19 may be wound upon a metal drum 20, the position of the lower end of the wire in the stand-pipe being adjusted by rotating said drum. The wire and the metal in the stand-pipe are arranged to form part of an electric circuit including a suitable source of electricity and an alarm or signal device, so that when the metal in the stand-pipe rises to such a height as to touch the end of the wire the circuit is completed and a signal is given. It is obvious that many suitable devices can be employed, the one described being given merely as an example.

To permit the flow of melted lead from the lower part of the mould, an outlet 21 may be provided which is furnished with a shut-off cock of any suitable description. The outlet delivers on to a sloping trough and thence to a suitable container indicated at the bottom left-hand corner of the figure.

Referring now to Fig. 4, which illustrates by way of example a suitable construction of valve for permitting the liquid lead to flow into or out of the lower part of the ingot mould, 22 is a barrel constituting the main body of the valve which is secured to the base of the mould by means of a flange 23 and is provided with a branch 24 connected through a flange to the pipe 6 leading from the reservoir 4 and with an outlet 21. The barrel 22 terminates in an end piece 25 seated in an opening in the lower part of the mould and provided with an orifice 26 by which the interior of the barrel can communicate with the interior of the mould. Said orifice is fitted with a plug 27 by which it can be opened and closed. At the outer end of the barrel 22 is a terminal gland 28 furnished with packing and which may be of any suitable construction. The valve rod 29, which is adapted to slide in the gland 28, is connected to the plug 27 by a socket 30 in which the inner reduced end of the plug 27 is secured by a pin 31. The outer end of the valve rod 29 is reduced in diameter and is provided with a screw thread 32 engaging with a nut 33 provided with bevel teeth 34. The nut is rotatable on the screw thread 32 by means of a bevel gear 35 mounted on the end of the valve operating spindle 9. The nut 33 is maintained in position by means of a plate 36 supported from the barrel 22 and a sleeve 37, one end of which engages with the nut 33 and the other end of which engages with a bracket 38. The reduced portion of the valve rod 29 slides to and fro in an orifice in the bracket 38 and is provided with a key or feather 39 which slides in a groove in said orifice rotation of the valve rod when the nut 33 is rotated. It will be clear, without further description, that when the nut 33 is rotated in one or other direction by means of the operating rod 9 and hand wheel 10 the plug 27 will be moved in and out of the orifice 26. A gasket 40 of asbestos or other suitable material adapted to stand the temperature of the liquid lead may be provided between the socket 30 and the inner face of the end piece 25 of the valve barrel 22. The valve 15 (Figure 1), by which the bottom of the mould is connected to the stand-pipe 13, may be of similar construction to the valve 7.

Referring again to Fig. 1, the ingot is illustrated as being about one-third poured, and its lower portion as having solidified, so that a space 41 is formed between the lower portion of the ingot and the mould due to the contraction of the ingot and/or the expansion of the mould. During the initial stage of the pouring the valve 7 may be maintained closed so as to prevent the metal being poured from passing out of the mould. At a desired stage in the pouring the

valve 7 is opened and liquid lead from the reservoir 4 is permitted to flow into the pipe 6 by opening the valve 12 and thence into the space 41 between the lower part of the ingot and the mould. The level of the liquid in the space is regulated by operation of the valve 12. In the drawings the level is shown by the line 42. The valve 15 is also opened, permitting the liquid metal to flow into the stand-pipe 13 by which its level inside the mould is indicated as hereinbefore described. It will be understood that during the casting operation the pipe 6, the valve 7 and the stand-pipe 13, with its valve 15 will be maintained at such a temperature as will permit of the flow of the liquid lead from the reservoir 4 to the bottom of the mould, into the stand-pipe 13 or through the outlet 21 as desired. This may be done by external heating, for example by means of gas jets suitably applied, not shown in the drawings.

The liquid filling metal may be admitted to the mould in this manner at any desired stage in the pouring, or even after the pouring is finished, in order to regulate the cooling and/or to supply a suitable hydrostatic pressure to the outside of the ingot as desired.

Notwithstanding that the lower part of the ingot or casting is resting on the base of the mould it is found that the liquid filling metal will penetrate to the space between the ingot and the mould without difficulty. In some cases means such as channels, not shown in the drawings, may be provided for distributing the filling metal to the sides of the mould.

Referring now to Fig. 2, a mould 1, of which the lower portion is provided with valves such as valves 7^a and 15^a, which may be similar to the valves 7 and 15 hereinbefore described and illustrated in detail in Fig. 4, but which are of somewhat different external appearance, is shown. The liquid low-melting metal is supplied to the lower portion of the mould from a reservoir 45 which is located below the valve 7^a and connected to said valve by a pipe 47. The liquid low-melting metal is forced by pressure of a suitable gas from the reservoir 45 into the mould by way of the pipe 47 and valve 7^a. The gas, for example nitrogen, is supplied to the reservoir 45 from a gas bottle 43, connected to the upper end of the reservoir by a pipe 44 equipped with a regulating valve 44^a. The low melting point metal, for example lead, may be maintained in a molten condition by a furnace, not shown, located in the space 46 below the reservoir 45. The reservoir 45 is provided with a pressure gauge 48.

The stand-pipe in this instance may be dispensed with and the height to which the lead rises in the mould may be estimated from the pressure shown on the gauge 48. Instead of permitting the lead to escape through a pipe, such as the pipe 21, Figure 1, it may be permitted to run back into the reservoir 45 by reducing the pressure therein.

In Fig. 3 another method of supplying low melting point metal is indicated. In this case the ingot mould 1 and supply pipe 47 and a valve 7 may be arranged as before, but the reservoir, indicated at 49 and containing the liquid low melting point metal, is of considerable vertical height and is provided with a ram or plunger 50 of somewhat smaller cross-sectional dimensions than the reservoir so that metal may rise freely in the space between the plunger and the walls of the reservoir. It will be clear that, by raising and lowering the plunger 50 in the reservoir, the low melting point metal may be forced through the pipe 47 into and out of the lower portion of the mould between the ingot and the mould as desired. The level of the metal in the mould, as shown by the line 42, will obviously be the same as that in the reservoir 49. In this case also the standpipe for indicating the level may also be dispensed with.

In Fig. 5 means are shown for cooling the mould externally. For this purpose the mould 51, which may be of any desired form internally, is provided on its exterior with ribs or fins 52 to facilitate cooling. A muff 53, made of sheet metal, has its upper and lower plates 54, 55 shaped to cooperate with the ribs 52 and is adapted to be moved up and down the mould as desired by means of chains or wire ropes 56. The muff is provided with an inlet 58 and an outlet 57 for the admission and discharge of cooling air which is caused to flow, preferably in an upward direction, over the mould thereby causing a greater cooling effect at that portion of the mould to which the muff is applied than at other portions. The cooling effect will also be greater at the lower part of the muff or where the cold air is admitted. In some cases the upper plate 54 of the muff may be omitted and the air therein may discharge directly into the atmosphere. Arrangements such as shown in Fig. 5 for cooling the mould at some parts more than at others may, if desired, be employed in conjunction with arrangements for admitting liquid metal to the lower part of the mould as previously described.

In some cases means may be employed for heating the upper end of the ingot; for example the head part of the mould indicated at 59 in the drawings may be lined with a refractory material of low thermal conductivity supplemented by heating means. In one arrangement the head is made with double walls, the annular space between the walls constituting a heating chamber which may conveniently be heated by gaseous or liquid fuel. In some cases, for example in the case of very long ingots or castings, it may be desirable to apply heating means to the upper part of the ingot as distinct from the head.

In some cases after the wall of the ingot or casting has been solidified to a sufficient thickness it may be desirable to retard the rate of cooling of the upper part of the ingot while in the lower portion the rate of extraction of heat is intensified, for example by means such as above described with reference to Fig. 5. In this case above a cooling jacket such as shown in Fig. 5 a heat insulating jacket or muff may be employed which may be raised with the cooling muff during the operation of freezing the ingot or casting solid from the bottom upwards. Furthermore after the lower part of an ingot or casting has become solid it may be desired to retard the cooling to prevent the development of high internal stress. In this case heat insulating means or heating means may be applied below the cooling jacket or muff.

Although I have herein described various methods of carrying out the invention and illustrated various constructions in the drawings, it will be understood that the invention is not limited to any particular construction of mould or accessary apparatus. Furthermore it will be understood that the invention is not limited to the casting of ingots or pieces of simple shape, but may be employed for the purpose of increasing the soundness and quality of castings of other metals than steel and of larger or more complex

castings than those hereinabove particularly referred to.

I claim:

1. A process of producing metal castings, comprising pouring molten metal into a mold, permitting the poured metal to partially solidify, and introducing between at least a part of the solidified surface of the metal and the mold fluid metallic substance having a melting point lower than that of the metal being cast.

2. A process of producing metal castings, comprising pouring molten metal into a mold, and in introducing between at least a part of the metal and the mold, during the pouring operation and after partial solidification of a poured portion of the metal, fluid metallic substance having a melting point lower than that of the metal being cast.

3. A process of producing metal castings, comprising pouring molten metal into a mold, and in introducing between at least a part of the metal and the mold, after the pouring operation and partial solidification of the metal, fluid metallic substance, having a melting point lower than that of the metal being cast.

4. A process of producing metal castings, comprising pouring molten metal into a mold, permitting the poured metal to partially solidify, introducing between at least a part of the solidified surface of the metal and the mold fluid metallic substance having a melting point lower than that of the metal being cast, and varying the level of the metallic substance in the mold.

5. A process of producing metal castings, comprising pouring molten metal into a mold, permitting the poured metal to partially solidify and introducing molten lead between the mold and at least a part of the solidified surface of the metal being cast.

6. A process of producing metal castings, comprising pouring molten metal into a mold, permitting the poured metal to partially solidifiy, introducing between at least a part of the solidified surface of the metal and mold fluid metallic substance having a melting point lower than that of the metal being cast, and withdrawing the metallic substance from the mold before removing the casting.

7. A process of producing metal castings, comprising pouring molten metal into a mold, and forcing upwardly between the metal and the mold as the metal solidifies a molten metallic substance having a melting point lower than that of the metal being cast.

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