United States Patent

[11] 3,610,318

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[21] Appl. No. **701,723**
[22] Filed **Jan. 30, 1968**
[45] Patented **Oct. 5, 1971**
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[32] Priority **Aug. 23, 1967**
[33] **Great Britain**
[31] **38887/67**

[54] **ELECTROSLAG INGOT PRODUCTION**
6 Claims, 1 Drawing Fig.

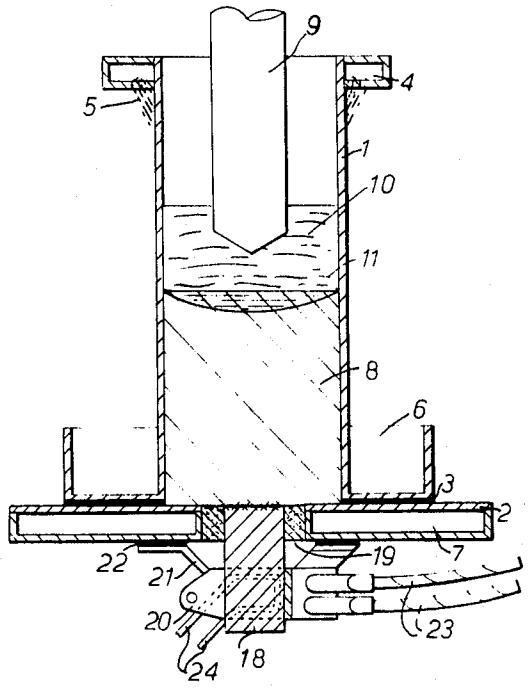
[52] **U.S. Cl.** **164/252,** 13/16
[51] **Int. Cl.** **B22d 27/02**
[50] **Field of Search** ..... 164/52, 252, 274, 282, 250, 48, 50, 273; 13/16, 17, 23, 23 X, 23 S

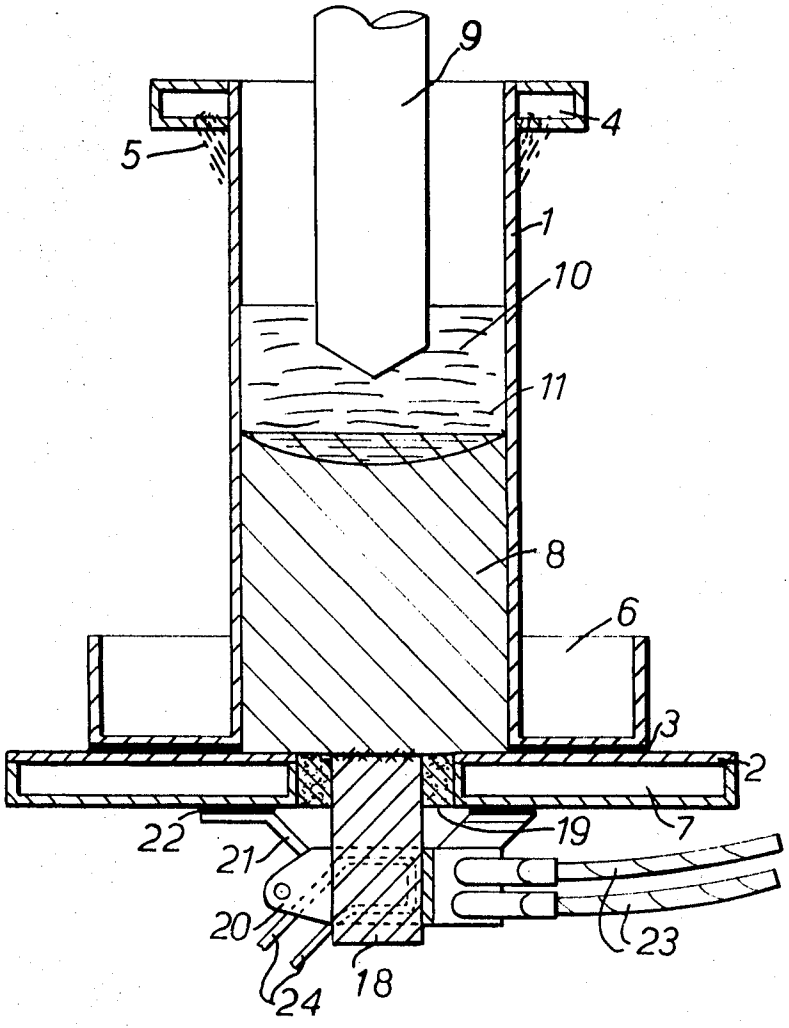
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ABSTRACT: The electroslag process of ingot production in a mold is improved by providing bottom contact to the forming ingot by means of a stub or spigot which is electrically insulated from the mold base and also has electrical connection made to it in a manner electrically insulated from the mold base.




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ELECTROSLAG INGOT PRODUCTION

CROSS-REFERENCE TO PRIOR PATENT

Application of even date of Peter Thomas Reginald Maskall Maskall application Ser. No. 629,746, now U.S. Pat. No. 3,448,790.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the so-called electroslag process of producing ingots of metal, which word is used herein as connoting not only elemental metals but also, in accordance with an important present day use of this process, metal alloys such for instance as various types of steel.

2. Description of Prior Art

In such an electroslag process, an electrode of metal from which an ingot is to be produced, or possibly of unalloyed constituents of an alloy to be produced as an ingot, is supported with its lower end depending into an ingot mold and there immersed in a blanket of molten slag over a pool of molten metal. The lower end of the electrode is spaced from the surface of this molten pool and is progressively fused off to enter the pool by heat which is generated by the passage of electric current through the slag. The slag not only shields the metal pool from contaminating gases but can also be so chosen that it acts to segregate and absorb impurities from the molten metal in its passage through the slag from the electrode to the molten pool. The mold wall, and usually also the mold base, are continuously cooled, so that, as the process proceeds, the molten metal solidifies progressively upwardly from the bottom and thereby forms a progressively lengthening ingot which is separated from the mold at the end of the process.

In single-phase operation of the electroslag process, (including the simultaneous formation of a number of ingots in individual molds with individual electrodes energized in parallel from a single-phase-line) and in multiphase, e.g., three-phase, operation with individual molds (as distinct from multiphase modes of operation in which, with at least three electrodes in a single mold, the operation proceeds by virtue of electrode-ingot-electrode current flow without requiring electrical contact to the bottom of the ingot) the operation is dependent on continuity of current flow through the slag and the ingot metal between the electrode in the (or each) mold and a bottom contact to the ingot. Where, as is common, the mold base is used for providing the bottom contact to the ingot, trouble is sometimes experienced due to loss of electrical conduction between the bottom of the ingot and the mold base. Such loss of conduction is liable to occur if any sticking occurs between the bottom of the ingot and the mold base. Such loss of conduction is liable to occur if any sticking occurs between the ingot and the mold walls, because shrinkage of the cooling ingot between the mold base and the sticking location tends to cause the bottom of the ingot to lift off the base. As it is undesirable for electric current to flow in the mold walls, it is common practice to insulate the mold walls from the base in order to prevent such current flow. Therefore the shrinkage effect just described can result in the interruption of the process current and consequent stopping of the process. Moreover, immediately before such interruption of the current a hot spot or local arcing may develop at the last point of contact with the mold base and this may seriously damage the mold base.

Loss of conduction may also occur due to the formation, between the ingot bottom and the mold base, of a thin layer or skin of solidified slag the conductivity of which, over the whole or part of its area, has become so attenuated by cooling as to impair the operation of the process. Provided the slag which forms such a layer remains sufficiently hot, its conductivity is sufficiently high for the process to continue. However, as the ingot solidifies upwardly as the process progresses, there is a tendency for the slag layer to become cooler and to lose its high conductivity except where it is locally heated by current passing through a restricted region or regions of its total area. Such region or regions may contract in size and/or reduce in number as the process continues, until either the current is interrupted or the localized heating produced by a high current flowing through a remaining region of relatively small area is sufficient to damage the mold base.

In the case of a multiphase operation in a single mold, the formation of the ingot can be concluded by a "hot-topping" procedure performed by withdrawing all but one of the electrodes and continuing the process in single-phase mode with the remaining electrode centralized in the mold, e.g. by appropriate sideways displacement of the latter on a wheeled support. In such a case, loss of bottom contact to the ingot during the multiphase operation could prevent the subsequent single-phase hot-topping step from proceeding. Moreover, loss of contact is more likely to occur with such multiphase operation than with single-phase operation, because in the latter the flow of current between the ingot bottom and the mold base has some tendency to keep a thin slag film between the ingot and mold base in an electrically conductive state.

SUMMARY OF THE INVENTION

According to the present invention maintenance of current connection to the bottom of the forming ingot is ensured by the provision at the bottom of the ingot of a stub or spigot which, extending through an opening in the mold base and being of material not incompatible with that of the ingot is electrically insulated from the mold base and has electrical connection made to it in a manner also electrically insulated from the mold base to provide bottom connection to the ingot, the cross section of the stub or spigot being smaller than the ingot cross section but being sufficiently great to carry the process current without fusing, taking into account any cooling effective on the stub or spigot.

In this way, bottom connection to the forming ingot is maintained directly via the connecting means and stub, so that lifting of the ingot bottom from the mold base due to shrinkage is no longer a problem. Also, because no current needs to pass through the mold base or between it and the bottom of the ingot, it is possible to make the mold base of a relatively cheap material, e.g., mild steel, which does not need to be suitable for carrying current. Additionally the elimination of current flow between the ingot and mold base reduces surface erosion.

By a material not incompatible with that of the ingot is meant one whose composition is the same as the ingot composition or at least is compatible with it.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE of the accompanying drawing is a somewhat schematic sectional elevation of an electroslag process mold showing the provision of an ingot bottom contact stub in accordance with the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

In the drawing, 1 represents the mold wall, (commonly but not necessarily cylindrical) insulated from the mold base 2 by insulating and sealing material 3. A water spray arrangement 4 round the top of the mold wall 1 produces a curtain 5 of cooling water which flows down the wall and is collected in a drainage trough 6 round the bottom of the wall. This trough 6 can with advantage be constructed as described in Maskall application Ser. No. 629,746 now U.S. Pat. No. 3,448,790. The mold base 2 has a cooling jacket 7. For forming an ingot 8 by the electroslag process an electrode 9 (or a number of such electrodes) depends into the mold with the lower end dipping into a layer of molten slag 10. Electric current is passed through the slag and the forming ingot between the electrode 9 and a bottom connection to the ingot. (The manner in which this bottom connection is ensured in the illustrated arrangement will be described later.) The passage of the current through the slag 10 keeps it in its molten state and causes the electrode 9 to be progressively melted off at its lower end. The molten electrode material falls through the slag into a molten

pool 11 at the top of the forming ingot. As the process proceeds the ingot progressively solidifies upwards from the bottom, due to the cooling of the mold. At the end of the process, the solidified ingot is separated from the mold.

In accordance with the invention, a preformed stub 18 (which becomes welded to the bottom of the ingot at the beginning of the process) projects through an opening for it in the mold base and is insulated from the mold base and its cooling jacket by an annulus 19 of heat-resisting, electrically insulating material such as alumina, accommodated round the stub within the stub opening in the mold base. The annulus 19 may be a preformed member or may be formed in situ (with the lower end of its accommodating space initially closed) by solidification of slag poured into the mold in molten state at the beginning of the ingot-forming process.

The stub 18 is gripped by a connecting clamp 20 which is supported beneath the mold base and is insulated from the latter. For this purpose the clamp 20 is indicated as being supported by brackets 21 with intervening electrical insulation 22. Supply return conductors 23 are connected to the clamp 20, which in this case is preferably provided with its own cooling circuit, as indicated at 24, because the intervening insulation 22 tends to isolate it from the cooling system for the mold base. The provision of insulation (3) between the mold wall 1 and mold base 2 could possibly be dispensed with because the mold base itself is now electrically isolated, but water sealing would, however, still be desirable.

When the ingot is ready for removal from the mold the clamp can be released and the stub can be withdrawn through the clamp by (upward) withdrawal of the ingot. The stub may then be cut off the bottom of the ingot and reused.

I claim:

1. An electroslag mold apparatus comprising, in combination:
   a. a mold base,
   b. a mold wall upstanding from said mold base and forming a mold cavity,
   c. an opening in said mold base, said opening having a cross section smaller than the internal cross section of said mold cavity,
   d. an annulus positioned in said opening, said annulus being formed of electrically insulative material,
   e. an electroconductive stub positioned within said annulus and electrically insulated from said mold base by said annulus,
   f. means for establishing electrical connection to said stub, and
   g. clamp means supported by said base.

2. The apparatus of claim 1 and including electrically insulating material between said clamp and said base.

3. The apparatus of claim 1 and including water-cooling means for said clamp.

4. The apparatus of claim 1 and including electrically conductive means mounted on said clamp.

5. The apparatus of claim 1 wherein said stub and said clamp are electrically connected.

6. The apparatus of claim 5 wherein said stub is formed in situ within said annulus.