United States Patent [19]

Paton et al.

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[45] **July 17, 1973**

[54] **ELECTROSLAG SYSTEM FOR THE PRODUCTION OF METAL CASTINGS**

[76] Inventors: **Boris Evgenievich Paton,** ulitsa Kotsjubinskogo, 9, kv. 21; **Boris Izrailevich Medovar,** Bulvar Lesi Ukrainki 2, kv. 8; **Jury Vadimovich Latash,** Vozdukhoflotsky prospekt, 87, kv. 14; **Vitaly Mikhailovich Baglai,** ulitsa Semashke 10, kv. 54/3, all of Kiev, U.S.S.R.

[22] Filed: **June 29, 1970**

[21] Appl. No.: **60,168**

Related U.S. Application Data

[62] Division of Ser. No. 707,088, Feb. 21, 1968.

[30] **Foreign Application Priority Data**

Feb. 25, 1967	U.S.S.R.	1,136,880
Feb. 25, 1967	U.S.S.R.	1,136,881
Apr. 20, 1967	U.S.S.R.	1,150,103
July 17, 1967	U.S.S.R.	1,173,639

[52] **U.S. Cl.** **164/252,** 13/18

[51] **Int. Cl.** **B22d 27/02**

[58] **Field of Search** 164/252, 250, 52, 164/48, 50

[56] **References Cited**

UNITED STATES PATENTS

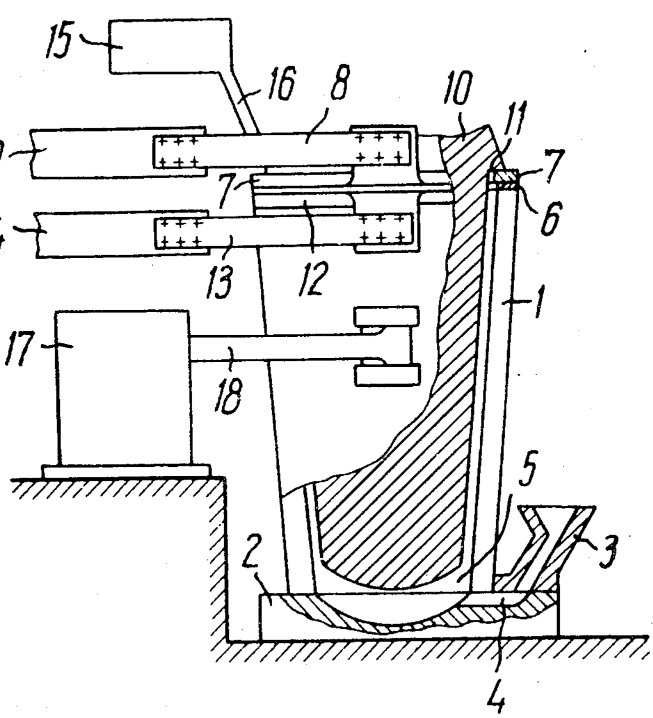
2,907,807	10/1959	Noesen	164/252
3,193,889	7/1965	Lane et al.	164/252
2,385,989	10/1945	Hopkins	164/252 X
2,385,136	9/1945	Hopkins	164/252
2,127,239	8/1938	Stoody	164/252 X
2,759,034	8/1956	Southern	164/252 X
2,307,001	12/1942	Johnson	164/252
2,761,002	8/1956	Laird et al.	164/252 X

Primary Examiner—J. Spencer Overholser
Assistant Examiner—V. K. Rising
Attorney—Waters, Roditi, Schwartz and Nissen

[57] **ABSTRACT**

In an electroslag remelting system, a consumable electrode is immersed in a bath of molten slag formed in a mold. The electrode is maintained fixed relative to the mold and slag is added to the bath of molten slag to maintain the process of melting of the consumable electrode as the electrode melts.

33 Claims, 5 Drawing Figures



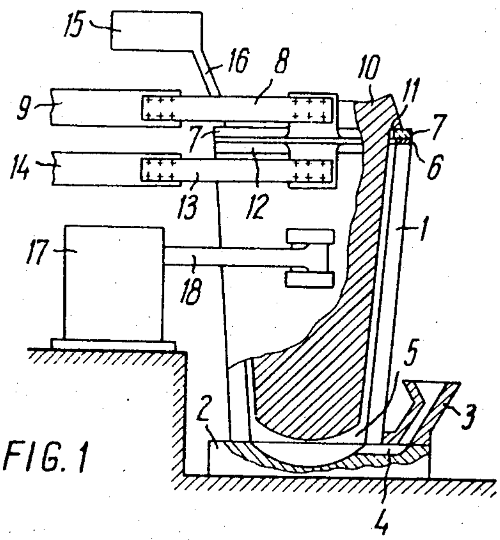

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FIG. 1

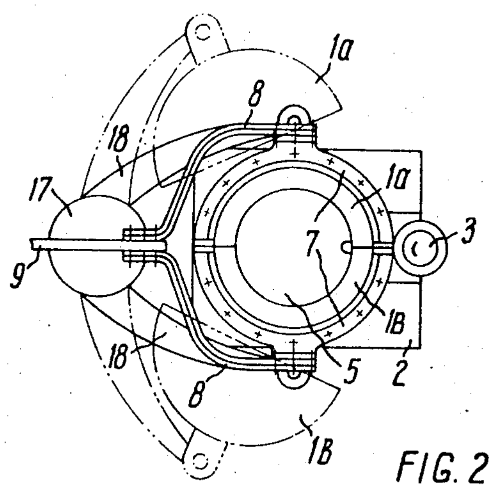
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FIG. 2

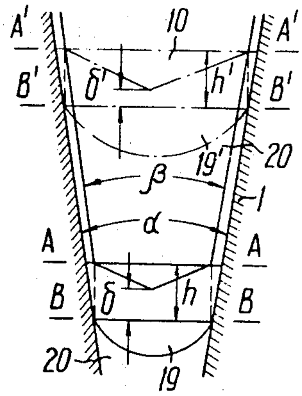

FIG. 3

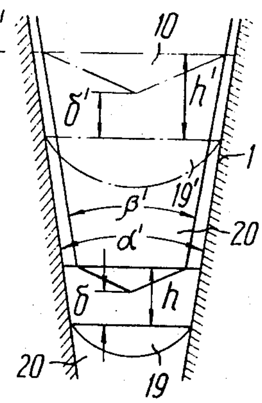

FIG. 4

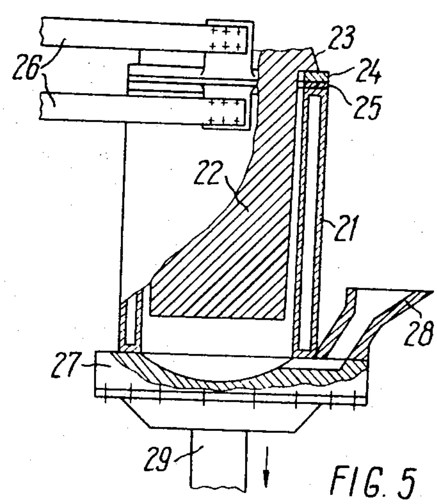

FIG. 5

ELECTROSLAG SYSTEM FOR THE PRODUCTION OF METAL CASTINGS

This application is a division of copending application Ser. No. 707,088, filed Feb. 21, 1968.

The present invention relates to plants for the production of metal castings.

More particularly, the invention relates to a plant for the electroslag remelting of consumable electrodes and can be used, in particular, to produce ingots from ball-bearing, heat-resistant and high-strength construction steels and alloys.

Known in the prior art is a process of electroslag remelting, consisting in that a pool of liquid slag is created in a cooled ingot mold, into which the lower ends of one or several metal blanks are immersed serving as a consumable electrode, an electric current being passed through the electrode and the slag pool. The electric current causes the heat necessary for melting of the metal blank to be liberated in the slag pool; the metal melted off the blank is given the required shape in the ingot mold, forming a casting.

As a rule, the cross section of the consumable electrode is much less than that of the mold space, and for this reason the height of the ingot obtained is much less than the length of the electrode being remelted. To maintain the electrode melting process, the mold or the electrode must be moved so as to preclude breaking of the electric circuit which would take place if the electrode leaves the slag pool.

The known plants, in particular, those described in Soviet Inventor's Certificate No. 195,482, have mechanisms for moving the electrode or mold, which comprise carriages with an electrode holder or a platform with the mold, travelling along guide columns. The guide columns are usually cumbersome and have a considerable height, especially in plants for casting ingots weighing over 10 tons, and the mechanisms for moving the electrode or mold must have a large lifting capacity. It can therefore be stated that such plants are of a complicated design, require considerable working area and high shop structures.

An object of the present invention is to eliminate the above disadvantages and difficulties.

The specific object of the invention is to provide and a plant for the production of metal castings by electroslag remelting of a consumable electrode, in which, according to the invention, no mutual movement of the mold and the electrode is required to maintain the process of melting of the consumable electrode.

Disclosed in the present invention is an improved plant for producing metal castings by electroslag remelting of a consumable electrode in a cooled ingot mold. According to the invention, remelting is run with the electrode in a fixed position relative to the mold, and with slag being added to the slag pool to maintain the process of melting of the consumable electrode as it is used up.

It is good practice to use solid pulverized slag and fill the space between the electrode and the mold with it, so as to provide a layer of solid slag above the slag bath in the process of melting which would gradually enter the slag pool as the electrode is consumed.

This ensures uniform feeding of the slag pool in the mold and protection of the pool from the surrounding atmosphere; at the same time the layer of solid slag above the bath serves as an adsorbent for the gases liberated in the process of melting the metal.

In addition, in the proposed plant the slag pool can be constantly refreshed as new portions of the solid slag are melted, whereby refining of the metal is improved.

It is also possible to pre-fill the space between the electrode and the mold with liquid slag beforehand and let it solidify; the solid slag will replenish the slag pool as the electrode melts under its own weight.

It is also possible to run the plant by periodically adding liquid slag to the slag pool as the electrode melts, the slag being poured in from above through the gap between the electrode and the mold.

It will sometimes be expedient to use a tapered consumable electrode and place it into a conical mold with its greater base upward. With the taper of the electrode and the mold being the same, notwithstanding the addition of slag, the depth of the slag pool can be insured to remain constant, while its volume will increase as the mold widens upward.

It will be preferable to have the taper of the electrode somewhat greater than that of the mold space to ensure that the height of the built-up ingot will be less than the length of the remelted portion of the electrode, and that with the slag pool moving in accordance with the ingot growth along the height of the mold, the depth of said pool should increase and insure the optimal ratio between the depth of the slag pool and the diameter of the mold space at the place of the slag pool location at the given moment.

The advantage of using tapered electrodes consists in that such electrodes can be produced by casting the metal in cast iron molds, whereas they were previously manufactured by forging, rolling or in continuous metal-casting plants.

Practice has also proved that the tapered shape of the mold, widening upward, results in a more favorable crystallization of the ingot, the crystallization proceeding upward.

To produce untapered ingots it is desirable to use prismatic or cylindrical electrodes and remelt them in untapered molds or in molds slightly widening downward. In this case the cross sectional dimensions of the electrode should be at least nine-tenths of the respective dimensions of the internal cross section of the mold. This is done to ensure that the depth of the slag pool at the end of melting should not exceed technologically tolerable limits.

When using tapered, prismatic and cylindrical electrodes it is desirable to make them with a shoulder in the upper portion, so as to make it possible to do without an electrode holder and place the electrode in the mold by arranging its shoulder directly on the current-feeding contact device. In the plant for effecting the process, according to the invention, this contact device is installed in the upper portion of the mold and is electrically insulated from it.

In a plant for the production of tapered castings the mold is made of at least two parts split along a vertical plane, which can be connected to a mechanism for moving them apart when the ingot is being extracted.

An advantage of the invention as a whole resides, first of all, in the simplification and lower cost of the plants for electroslag remelting, and also in the simplification of their operation.

Another advantage stems from the high electrotechnical characteristics of the plants owing to the current conductors from the source of power to the plants having a comparatively short length and being arranged parallel to each other at a close distance (bifilarly). This, in turn, made it possible to reduce the resistance and inductive reactance of the electric circuit of the plant.

The invention made it possible to appreciably reduce the height of the plants and, accordingly, the height of the shop structures accommodating them, and also to reduce the floor space used.

The nature of the present invention will become more fully apparent from a consideration of the following description of exemplary embodiments thereof, taken in conjunction with the accompanying drawings, in which:

FIG. 1 represents a schematic view of a plant according to the invention, with a tapered mold, used for effecting the process of producing metal castings;

FIG. 2 is a top view of the same plant, without the consumable electrode, the phantom lines showing the separated condition of the split mold;

FIG. 3 shows schematically the mutual arrangement of the consumable electrode and the mold, when the electrode and the mold have the same taper;

FIG. 4 shows schematically the mutual arrangement of the consumable electrode and the mold, when the taper of the electrode is greater than that of the mold;

FIG. 5 is a schematic view of a plant according to the invention, with a cylindrical mold, used for effecting the process of producing metal castings.

In one of the possible embodiments, shown in FIGS. 1 and 2, the plant comprises a cooled tapered mold 1 widening upward and installed on a base 2 with a siphon device 3, which communicates by means of a duct 4 in the base 2 with a space 5 of the mold and serves for pouring liquid slag into the mold. The top edge of the mold 1 carries current-feeding contact devices 7, insulated from the mold edge by means of a dielectric gasket 6, said contact devices 7 being made as two half-rings (see FIG. 2), connected via feeders 8 to a busbar 9, the latter being connected to a source of alternating or direct current (not shown).

A consumable tapered electrode 10 (an ingot cast in a cast iron mold being usable for the purpose), with a cross section close to the internal cross section of the mold 1, is so placed in the latter that its lower end is immersed in the slag pool (not shown), said electrode bearing with its shoulder 11 that is in the upper portion thereof, against the contact devices 7.

In the upper part of the mold 1 two current-feeding contact devices 12 are also secured connected via feeders 13 to a busbar 14, connected to the same source of current. The electrode 10 can have the same taper as the mold, or a greater one.

Solid pulverized slag, which is fed into the slag pool as the electrode 10 melts for stabilizing the process, is charged into the space between the electrode 10 and the mold 1 from a bin 15 along a chute 16 via a hole (not shown) in the shoulder 11 of the electrode 10.

For extracting the finished ingot (not shown) from the mold 1 the latter is made of two parts 1A and 1B, split along a vertical plane, each said part carrying said contact device 7 made as a half-ring. The parts 1A and 1B of the mold 1 are moved apart for extracting the ingot by means of a mechanism 17, provided with turning levers 18 in a plane perpendicular to the axis of the mold 1. The levers 18 are connected to the parts 1A and 1B of the mold. An open mold is shown by the phantom lines in FIG. 2.

Thus a novel feature of the plant described hereinabove is the design of the electrode 10 and the mold 1 which are made tapered, widening upward, with identical or close tapers, and also the fixed position of the electrode 10 relative to the mold 1.

The principle of operation of the plant and the process for producing ingots in this plant are described herein below for embodiments when the tapers of the electrode 10 and the mold 1 are equal, and when the taper of the electrode 10 is greater than that of the mold 1.

By switching on the source of current, voltage is applied to the electrode 10 and mold 1. Preliminarily melted slag is poured into the mold 1 through the device 3 in such an amount, as indicated above, that the lower end of the electrode 10 should be immersed in the slag. When this takes place the process of melting the electrode 10 commences. The space between the electrode 10 and the mold 1 is filled with solid slag. It is desirable that in the process of melting the slag pool be covered by a layer of solid slag, which would gradually drop into it as the electrode 10 melts; this also contributes to better refining of the metal.

The volume of the slag pool can be maintained by periodically feeding liquid slag into the gap between the electrode 10 and the mold 1. It is also possible to prefill this space with liquid slag and let it solidify owing to the intensive removal of heat through the walls of the mold 1 and the electrode 10. As the electrode 10 melts, the solidified slag will also drop into the slag pool under its own weight.

The diagrams presented in FIGS. 3 and 4 show the relation between the length of the melted portion of the electrode, the height of the built-up ingot and the depth of the slag pool in the process of remelting, depending on the taper of the electrode 10 and the mold 1.

In case the angles α and β of taper of the mold 1 (FIG. 3) and of the electrode 10, respectively, are equal and the depth h of the slag pool is specified, it is possible to insure, in the process of melting, the equality of the cross sectional areas of the electrode 10 at the place where its melting begins (levels AA or A'A' along the surface of the slag pool at the beginning and the end of the melting process, respectively) and of the surface of a metal bath 19 and 19' (levels BB or B'B') of an ingot 20 being built up.

Under these conditions in the process of melting with the addition of solid slag in the space between the electrode 10 and the mold 1 the depths h and h' of the slag pool are constant, but the ratio between the depth of the slag pool and the diameter of the mold (at the place where the slag pool is located) decreases, whereby the discharge gap δ' between the electrode 10 and the surface of the metal bath 19 at the end of the process becomes less than the discharge gap δ at the beginning of the process, and an arc may strike between the electrode 10 and the metal bath 19.

When the taper of the electrode 10 exceeds that of mold 1 (FIG. 4) so that during the entire process of melting the ratio between the depth of the slag pool and the diameter of the mold remains constant, with $\beta > \alpha$ we have $h' > h$ and $\delta' > \delta$.

Since in these instances the volume of the slag pool continuously grows, it is good practice to increase the power supplied by raising the voltage.

Upon completion of the melting process the stub of the electrode is removed and the ingot **20** is extracted from the mold.

It is most expedient to use conical ingots thus produced for forging on hammers and presses.

In another embodiment of the invention (FIG. 5), in contrast to the first one, the plant comprises a prismatic or cylindrical mold **21**, in which a prismatic or tapered electrode **22** is similarly installed, said electrode **22** bearing with its shoulder **23** against an annular current-feeding contact device **24** installed on the upper edge of a mold **21** and electrically insulated from it by means of a gasket **25**.

The plant is supplied from a source of alternating or direct current (not shown) by means of feeders **26**.

The internal cross section of the mold **21** may somewhat increase toward the bottom for the extraction of the ingot to be facilitated.

A base **27** and a siphon device **28** are similar to those described above. For the extraction of the ingot from the mold the base **27** is made vertically movable on a bed-plate **29** connected to a lowering mechanism (not shown).

A condition prereguisite for the operation of this plant is that the cross sectional dimensions of the electrode **22** must be at least nine-tenths of the corresponding dimensions of the internal cross section of the mold **21**.

This is done to insure that the difference between the linear rates of electrode melting and ingot building up should be minimum, and that the depth of the slag pool at the end of melting should not exceed the appropriate tolerances.

In the process of melting the volume of the slag pool also increases with melting of the electrode **22**, and the power supplied to the plant must be increased. The ingots produced in this plant are designed mainly for processing in rolling mills.

Described herein are the most easily realizable exemplary embodiments of the invention with one consumable electrode. It is also possible, however, to remelt two or three electrodes connected correspondingly in series (a bifilar circuit), or with a star or delta connection. Here the total cross section of the electrodes should then approach the internal section of the ingot mold.

The invention is not limited to the exemplary embodiments described herein and may have modifications within the scope of the following claims.

We claim:

1. An electroslag remelting system for the production of a metal ingot by the melting of at least one consumable electrode in a molten slag bath, comprising a cooled base and a mold in which said consumable electrode is placed; a source of electric power; contact device means for connecting said mold and said consumable electrode to said source of power, a portion of said contact device means with insulation means being installed directly on the top of said mold and electrically insulated from said mold; and means including said consumable electrode, said mold, and said portion of said contact device means for maintaining said consumable electrode vertically stationary and incapable of being advanced with respect to said mold during remelting.

2. A system as defined by claim **1**, wherein while using a tapered mold the latter consists of at least two parts and is split in a vertical plane.

3. A system as defined by claim **2**, wherein a mechanism is provided for moving apart the parts of said mold for extraction of the ingot.

4. An electroslag remelting system as defined by claim **1**, wherein said means for maintaining said consumable electrode vertically stationary includes the upper portions of said consumable electrode and said mold.

5. An electroslag remelting system as defined by claim **1**, wherein said means for maintaining said consumable electrode vertically stationary with respect to said mold includes said portion of said contact device means.

6. An electroslag remelting system as defined by claim **1**, including means for pouring liquid slag into the base portion of said mold enabling pouring with said consumable electrode in place within said mold.

7. An electroslag remelting system as defined by claim **1**, including means for adding additional slag to said molten slag bath from the space between said consumable electrode and said mold during the remelting of said consumable electrode.

8. An electroslag remelting system as defined by claim **7**, wherein said means for adding slag during remelting of said consumable electrode provides molten slag for introduction into said molten slag bath.

9. An electroslag remelting system as defined by claim **7**, wherein said means for adding slag during remelting of said consumable electrode provides pulverized slag for introduction into said molten slag bath.

10. An electroslag remelting system as defined by claim **1**, including a layer of slag positioned in the space between said consumable electrode and said mold.

11. An electroslag remelting system as defined by claim **1**, wherein the inner sidewalls of said mold are tapered vertically downward and wherein said consumable electrode placed in said mold has a vertical taper which approximately corresponds to the vertical taper of said mold.

12. An electroslag remelting system as defined by claim **1**, wherein said consumable electrode is tapered vertically downward and wherein the inner sidewalls of said mold are tapered vertically downward, with the vertical taper of said consumable electrode being greater than that of said mold.

13. An electroslag remelting system as defined by claim **1**, wherein the cross sectional dimensions of said consumable electrode in a horizontal plane are at least nine-tenths of the corresponding dimensions of the internal cross section of said mold.

14. An electroslag remelting system as defined by claim **1**, wherein said consumable electrode has an integral outer shoulder at the upper portion thereof, said shoulder designed to bear directly against said portion of said contact device means.

15. An electroslag remelting system as defined by claim **14**, wherein the weight of said consumable electrode presses it into electrical contact with said portion of said contact device means.

16. An electroslag remelting system as defined by claim **14**, wherein said portion of said contact device means consists of a metal ring in contact with said shoulder for supplying electric power to said electrode and a dielectric member preventing contact of said metal ring with the upper portion of said mold.

17. An electroslag remelting system as defined by claim 16, wherein said contact device means includes a second metal ring interposed between said dielectric member and in contact with said mold for supplying electric power to said mold.

18. An electroslag remelting system as defined by claim 1, wherein at least two consumable electrodes are melted simultaneously in said mold.

19. An electroslag remelting system as defined by claim 1, wherein said consumable electrode has outer surfaces parallel to its vertical axis.

20. An electroslag remelting system as defined by claim 1, wherein said outer surfaces of said electrode are substantially parallel to the inner sidewall surfaces of said mold.

21. An electroslag remelting system as defined by claim 1, including means to move said cooled base relative to said mold to facilitate removal of said formed ingot.

22. An electroslag remelting system as defined by claim 1, wherein said mold has inner sidewall surfaces parallel to the vertical axis of said mold.

23. An electroslag remelting system as defined by claim 1, including means to move at least a portion of the mold sidewall away from the formed metal ingot to facilitate removal of said ingot from said mold.

24. An electroslag remelting system as defined by claim 23, wherein said mold is formed in two parts, and means are provided to move said two parts relative to one another away from said ingot to facilitate removal of said ingot from said mold.

25. An electroslag remelting system as defined by claim 24, wherein said mold is formed in two parts which are moved apart to facilitate removal of said ingot and wherein said mold parts are joined one to another along lines parallel to the vertical axis of said mold when closed.

26. An electroslag remelting system as defined by claim 1, wherein said contact device means comprises two half-rings connected through feeder elements to a bifurcated bus bar.

27. An electroslag remelting system as defined by claim 1, wherein said contact device means includes at least one bus bar connected to said mold and at least one bus bar connected to said electrode, and said bus bars positioned closely spaced and parallel to one another to reduce inductive loss.

28. An electroslag remelting system as defined by claim 1, wherein the cross-sectional area of the lower end of said consumable electrode is substantially equal to the cross sectional area of the upper end of said ingot.

29. An electroslag remelting system for the production of a metal ingot by the melting of at least one consumable electrode in a molten slag bath, comprising a cooled base and a mold in which said consumable electrode is placed; a source of electric power; a contact device means for connecting said mold and said consumable electrode to said source of power, a portion of said contact device means with insulation means being installed directly on the top of said mold and electrically insulated from said mold; said consumable electrode having an integral outer shoulder at the upper portion thereof designed to bear directly against said portion of said contact device means; means including said consumable electrode, said mold, and said portion of said contact device means for maintaining said consumable electrode vertically stationary and incapable of being advanced with respect to said mold during remelting; means for adding additional slag to said molten slag bath from the space between said consumable electrode and said mold during the remelting of said consumable electrode; and means to move at least a portion of the mold sidewall away from the formed metal ingot to facilitate removal of said ingot from said mold.

30. An electroslag remelting system as defined by claim 29, including means for pouring liquid slag into the base portion of said mold enabling pouring with said consumable electrode placed within said mold.

31. An electroslag remelting system as defined by claim 29, wherein the inner sidewalls of said mold are tapered vertically downward and wherein said consumable electrode placed in said mold has a vertical taper which approximately corresponds to the vertical taper of said mold.

32. An electroslag remelting system as defined by claim 29, wherein the cross-sectional dimensions of said consumable electrode in a horizontal plane are at least nine-tenths of the corresponding dimensions of the internal cross section of said mold.

33. An electroslag remelting system as defined by claim 29, wherein said mold is formed in two parts, and means are provided to move said two parts relative to one another away from said ingot to facilitate removal of said ingot from said mold.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,746,075 Dated July 17, 1973

Inventor(s) BORIS E. PATON et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 44, cancel "and"

Column 7, line 48, insert --are-- after "bars".

Signed and sealed this 22nd day of January 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

115

UNITED STATES PATENT OFFICE

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