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[54] **ELECTRIC SLAG REFINING PROCESS AND APPARATUS**

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[51] **Int. Cl.** **H05b 3/60**

[58] **Field of Search** .... 13/9, 12, 9 ES, 13, 13/34

[56] **References Cited**

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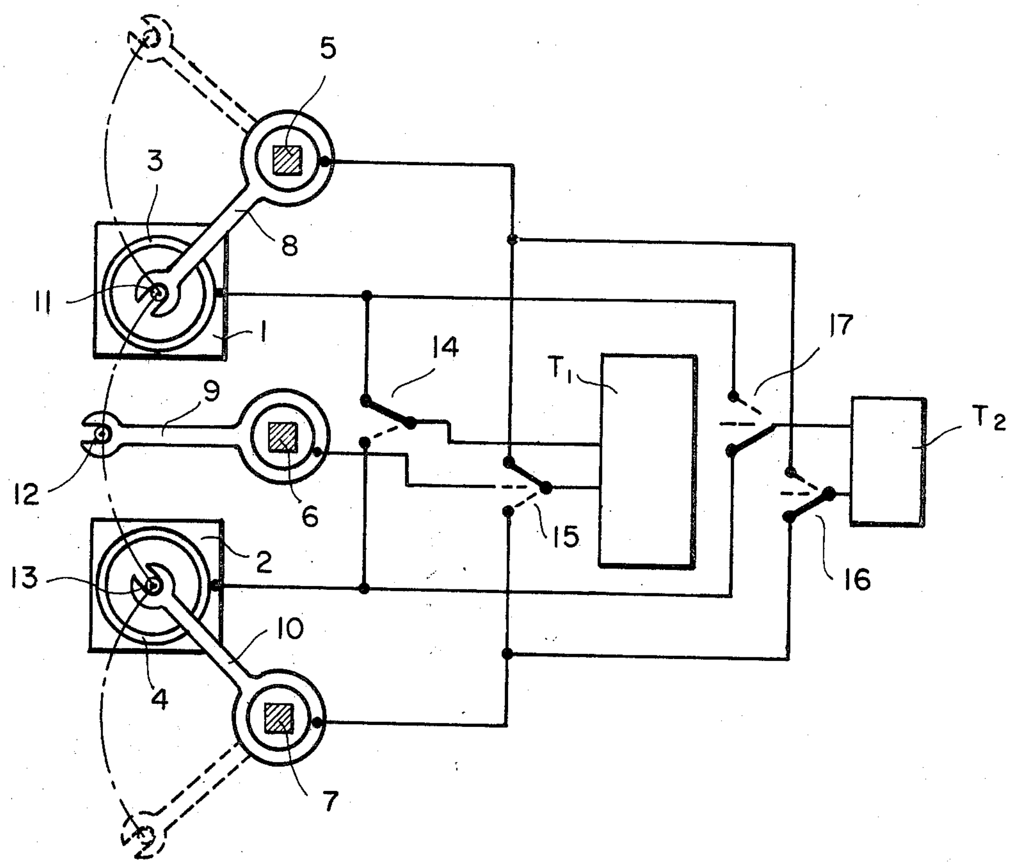
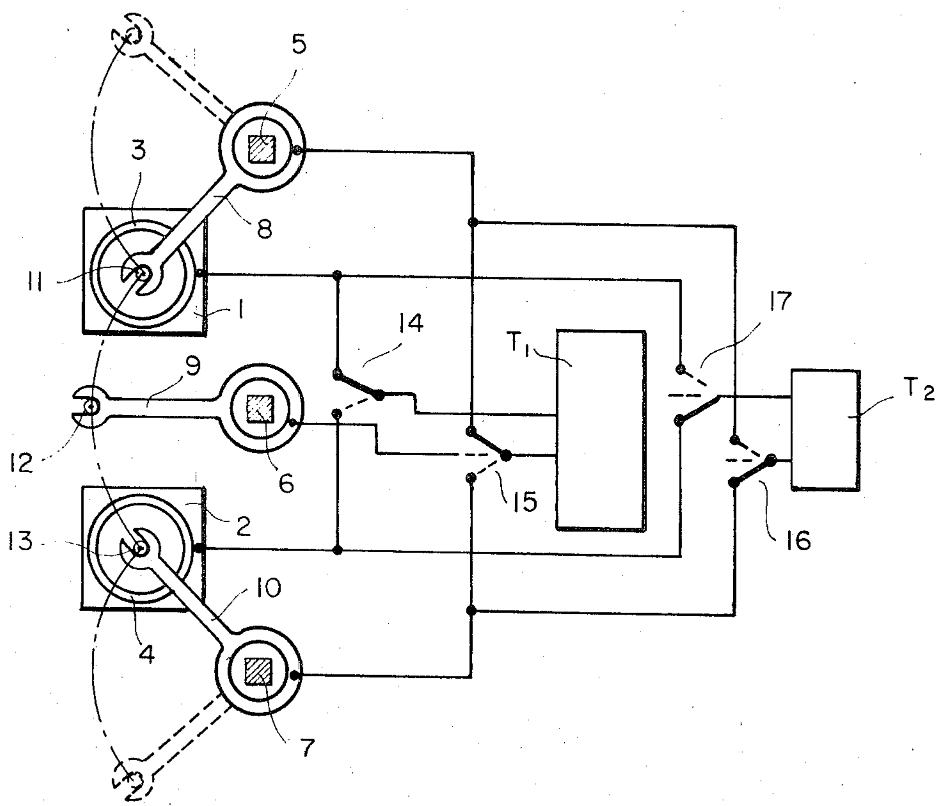
[57] **ABSTRACT**

To produce an ingot consisting of a metal alloy, substantially the entire ingot is formed in an ingot mold by fusing down remelting electrode material in a liquid slag bath contained in said mold while electric a.c. power is supplied to said slag bath from first a.c. transformer means. The ingot in said mold is subsequently subjected to top end heating in that electric a.c. power is supplied to said liquid slag bath from second a.c. transformer means having a lower nominal power than said first transformer means.

3 Claims, 1 Drawing Figure

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ELECTRIC SLAG REFINING PROCESS AND APPARATUS

This invention relates to an electric slag refining process for making ingots from metal alloys, particularly steel alloys, and an apparatus for carrying out the process.

In the known process, an ingot is produced in that a consumable electrode which is similar in kind is continuously fused down in a slag layer, which is heated by electric resistance heating by means of alternating current which is passed through the layer. As a result, the electrode immersed into the slag is fused down and the dripping metal is collected in a water-cooled ingot mold, where the molten metal is continuously solidified. The resulting ingot has a main direction of crystallization from bottom to top. This results in a particularly good structure of the ingot. The ingot grows at a velocity of only a few millimeters per minute, and there is always a liquid sump during the remelting operation. That sump has a depth which is about one-half of the diameter of the ingot. When the ingot has grown to the desired height, the voltage applied to the slag is reduced so that the power supplied to the slag is lowered to about one-sixth to one-eighth of full power. The slag is held at a temperature above the liquidus temperature of the metal, and metal is melted from the electrode only in the amount required to compensate the contraction. This part of the operation is described as top end heating and serves to ensure a solidification of the top end of the ingot without formation of a pipe.

Considerable time is required for said top end heating, particularly in the production of ingots of large diameter. With ingots which are, e.g., 1,000 millimeters in diameter, the top end heating takes 3–4 hours and this time increases to more than 30 hours with ingots which are about 3,000 millimeters in diameter. As a result, the production rate of such apparatus in the production of ingots having such diameters is reduced by 10–30 percent or even more, depending on the diameter and length of the ingots which are produced.

It is an object of the invention to avoid said disadvantage. To accomplish this object it is proposed according to the invention to produce an ingot by a remelting operation in which two a.c. transformers having different rated powers are used and to use the transformer having the lower rated power for the top end heating. Hence, the process according to the invention requires an apparatus having a second transformer. The costs of such a second transformer is relatively low because it requires only a nominal power of 10–20 percent of the nominal power of the actual remelting transformer. On the other hand, the production rate of the plant is increased to such an extent that the expenditure involved in providing the additional transformer is insignificant. For instance, during the production of an ingot which is 3,000 millimeters in diameter, the top end of said ingot may be heated by means of the additional transformer and another ingot can be formed up to a height of about 2 meters at the same time by means of the now free main transformer.

An electric slag refining apparatus for carrying out the process according to the invention thus comprises two a.c. transformers having different rated powers and comprises apparatus for switching the power supply from the transformer having a high rated power to the transformer having the lower rated power. The means used to change the power depend on the type of the

plant and may be of various types. If the smelting apparatus is designed to remelt a single electrode so as to form a single ingot, the two transformers and the associated electrode feeder are arranged one beside the other, and the water-cooled bottom plate and the water cooled ingot mold are mounted on a carriage which is movable on wheels between the two electrode feeders. When the ingot has grown to the desired height, the carriage with the bottom plate and ingot mold is moved under that electrode feeder which is fed by the transformer having the lower rated power. If the plant is designed, however, to produce higher ingots and for this purpose is provided with a so-called liftable ingot mold, additional means are required to hold the ingot mold in position on the carriage during the movement to the electrode feeder for top end heating. Those means may comprise special supports for the ingot mold of clamping jaws, which are applied to the lower edge of the ingot mold and operable to clamp the ingot mold on the ingot. If the ingot is produced from a plurality of electrodes fused down in succession, the electrode feeders associated with the transformer having the higher rated power and those associated with the transformer having the lower input power comprise the known means for a rapid replacement of the consumed electrode by a new one, e.g., each feeder may comprise two columns provided with pivoted electrode-lifting device.

In that case, a preferred embodiment of the apparatus according to the invention may be used, in which no carriage is used to move the ingot under the electrode feeder fed by the transformer having the lower rated power, but two stations for supporting the bottom plate and ingot are provided. The electrode feeder which is fed by the transformer having the higher power may selectively serve two stations. In this case, the electrode feeder for top end heating, which feeder is fed by the transformer having the lower rated power, is either movable on wheels between the two stations so that it can be selectively used at each station, or each station is provided with an electrode feeder for top end heating, and each of said feeders can be connected to the transformer having the lower power.

The economy of the remelting apparatus according to the invention may be further increased in that the electrode feeder connected to the transformer having a lower power is used for remelting smaller ingots during the time in which said apparatus is not required for top end heating.

Finally, a remelting plant for a simultaneous production of a plurality of large ingots may be provided with a single electrode feeder for top end heating in a plurality of remelting units. In this case, the large ingots may be made in succession with such timing that a top end heating of two or more ingots at the same time is not required.

It is apparent that the invention may be used in numerous variations with economically desirable results.

A preferred embodiment of apparatus according to the invention will now be explained by way of example with reference to the drawing showing the apparatus in a top plan view.

The remelting plant comprises two supports for bottom plates **1** and **2**, on which ingot molds **3** and **4** are mounted, and also comprises electrode feeders and transformers **T1** and **T2**. The electrode feeders comprise three columns **5**, **6**, and **7** and electrode arms **8**, **9**, and **10**, which are mounted on said columns to be movable vertically along and pivotally about the axis of the respective columns. Each electrode arm **8, 9,** and **10** carries at its outer end an electrode clamp, which carries an electrode and its support rod. The paths of the pivotal movement of the axes of the electrodes and their support rods **11** and **12** and **12** and **13** intersect each other. The ingot molds **3** and **4** are arranged at and below the intersection. The electrode arms and their clamps are connected by flexible cables to a transformer T1 having a high nominal power and to a transformer T2 having a lower nominal power. Electric leads connect also the bottom plates **1** and **2** to the transformers T1 and **T2.** The means for changing the energy supply comprise switches **14, 15, 16,** and **17.**

The remelting apparatus shown on the drawing is operated as follows. Using the electrode arms **8** and **9,** remelting electrodes are first fused down in the ingot mold **3.** In this operation, the ingot mold **3** may be raised in known manner as the ingot grows. The mold-lifting means, not shown, may be guided along the column **5.** At the beginning of the remelting operation, it must be ensured that the last electrode to be fused down in producing the ingot is to be fed with the arm **8.** For this reson, the first electrode to be fused down is carried by the arm **8** if the ingot is to be formed from an even number of remelting electrodes, and by the arm **9** when the ingot is to be formed from an odd number of remelting electrodes. During the remelting operation using the electrode arms **8** and **9,** the switch **14** constantly connects the transformer T1 to the bottom plate **1** whereas the switch **15** is operated to connect the transformer to that electrode arm **8** or **9** and to that electrode clamp which is in remelting position over the ingot mold at any time. The switches **16** and **17** are in their intermediate position. When the electrode arm **8** carrying the last electrode to be used in forming the block has been swung to its remelting position, the first electrode for the ingot to be formed in the ingot mold **4** on the bottom plate **2** is hung into the arm **9** or **10.** The arm is again selected so that the last remelting electrode to be used in forming the ingot is fed with the arm **10.** Because the top end heating is carried out with a lower power and with a lower fusing-down rate, only part of the last remelting electrode is generally required for this operation. As soon as the top end heating of the first ingot is to be initiated, the switches **14** and **15** are shifted to connect the bottom plate **2** and the electrode arm **9** or **10** and the associated electrode clamp to the transformer **T1.** The remelting to form the new ingot on the bottom plate **2** may now be initiated. At the same time, the switches **16** and **17** are moved to the upper position shown on the drawing so that the power required for the top end heating of the first ingot is supplied from the transformer **T2** having a lower nominal power. When the top end heating of the first ingot has been terminated, the same is removed from the plant and the bottom plate **1** and the ingot mold **3** are prepared for the remelting to form the third ingot. The remelting to form the second ingot is effected as has been described for the first ingot. It will be understood that the various switches must be moved to the positions required for this purpose.

Although the invention is illustrated and described with reference to a plurality of preferred embodiments thereof, it is to be expressly understood that it is in no way limited to the disclosure of such a plurality of preferred embodiments, but is capable of numerous modifications within the scope of the appended claims.

What is claimed is:

1. An electric slag refining process of producing ingots consisting of a metal alloy, which comprises

building substantially an entire ingot in an ingot mold by fusing down remelting electrode material in a liquid slag bath contained in said mold while supplying electric a.c. power to said slag bath from first a.c. transformer means, and

subsequently subjecting said ingot in said mold to top end heating by supplying electric a.c. power to said liquid slag bath from second a.c. transformer means having a lower nominal power than said first transformer means.

2. A process as set forth in claim **1,** in which remelting electrode material consisting of an alloy steel is fused down.

3. Electric slag refining apparatus for producing ingots consisting of metal alloys, which comprises

at least one ingot mold adapted to contain a liquid slag bath,

holding means for holding remelting electrode material adapted to be fused down in said liquid slag bath to form in said mold an ingot under said liquid slag bath,

first a.c. transformer means,

second a.c. transformer means having a lower nominal power than said first transformer means, and

switch means adapted to alternatively connect said first and second transformer means to supply electric a.c. power to said slag bath.

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