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[54] **ELECTRIC SLAG REMELTING PROCESS AND APPARATUS FOR PRODUCING METAL INGOTS HAVING A CHANGE IN TRANSVERSE DIMENSION**

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[58] **Field of Search** 164/52, 133, 136, 252, 129, 164/130

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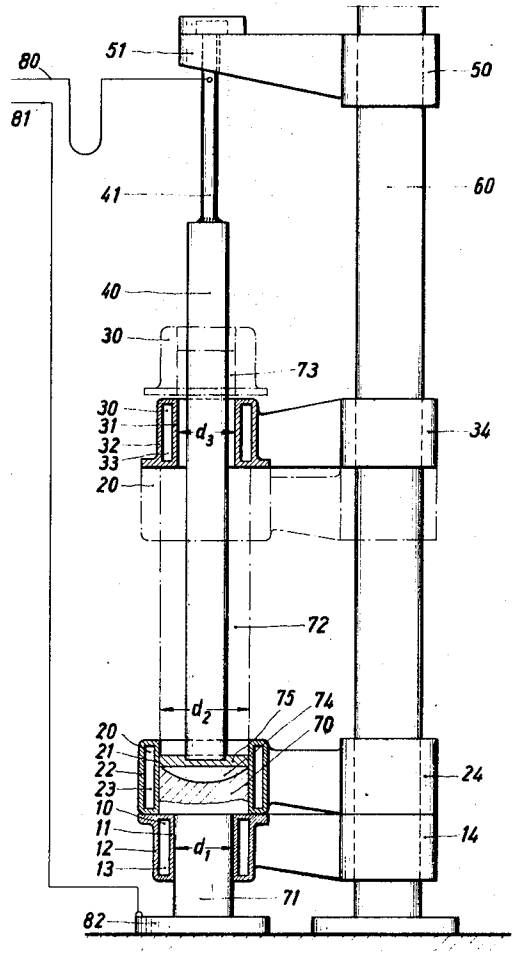
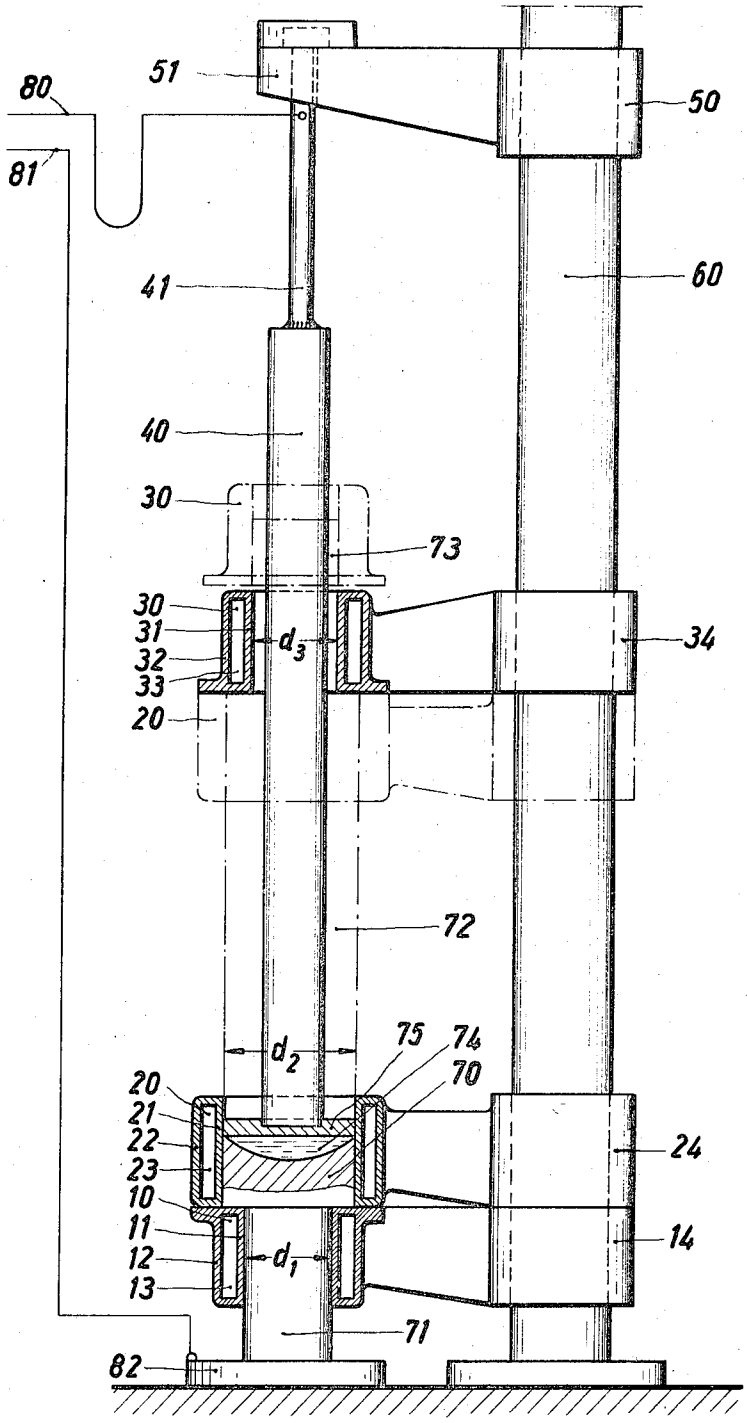
[57] **ABSTRACT**

A plurality of superimposed ingot molds are provided, which have open ends and differ in at least one inside transverse dimension. A slag layer is provided in said ingot molds. Electrode means which consist of a metal from which an ingot is to be formed are maintained dipped in said slag layer in each of said ingot molds for a period of time while electric current is passed through said electrode means to generate heat and thus fuse down said electrode means in each of said ingot molds to form molten metal therein. Said molten metal is solidified in each of said ingot molds, whereby an integral, rigid ingot is formed.

15 Claims, 1 Drawing Figure





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ELECTRIC SLAG REMELTING PROCESS AND APPARATUS FOR PRODUCING METAL INGOTS HAVING A CHANGE IN TRANSVERSE DIMENSION

This invention relates to a process of producing ingots which consist of metal, preferably steel, and have considerable changes in cross section or transverse dimensions, which process comprises an electric slag remelting step, and a plant for carrying out such process. Such ingots may serve, e.g., as workpieces to be forged or as workpieces from which rolls are made.

It is an object of the invention to enable a production of ingots which consist of metal, preferably steel, and have considerable changes in cross section or transverse dimensions in a continuous operation by electric slag remelting. In a process of the kind defined first hereinbefore, this object is accomplished in that one or more electrodes, consisting of the metal to be remelted and disposed under a slag layer, have current conducted therethrough, and under the action of the heat which is generated by said current, are fused down in succession in two or more superimposed ingot molds, which are open at both ends and have cross sections and transverse dimensions which correspond to those of the ingot to be made. The molten metal is cooled in the ingot mold in which it has been formed so that the molten metal solidifies to form a single, rigid ingot.

The present process will now be fully described in connection with a plant for carrying out the process. Said plant is diagrammatically shown on the accompanying drawing partly in elevation and partly in section.

An electrode **40** to be fused down is coaxial with cylindrical inner shells **11**, **21** and **31** of three superimposed ingot molds **10**, **20** and **30**. Each ingot mold **10**, **20** or **30** is secured to a separate mold-lifting carriage **14**, **24** or **34**, respectively. An extension rod **41**, connected to the top end of the electrode **40**, is secured to an arm portion **51** of an electrode-lifting carriage **50**. The mold-lifting carriages **14**, **24** and **34** and the electrode-lifting carriage **50**, disposed over the mold-lifting carriages **14**, **24** and **34**, are vertically displaceable independently of each other on the square-section column **60** with the aid of tension cables, which are not shown. As the electrode **40** is fused down, it can be adjusted in height so that the electrode **40** dips into the slag layer **75**, which floats on the molten metal **74** and serves to purify and shield the molten steel, and the end of the electrode **40** is spaced the correct distance apart from the surface of the molten metal **74**. At the same time, the elevation of the ingot molds **14**, **24** and **34** may be changed as follows: During the initial phase of the melting operation, the lowermost ingot mold **10** rests on the liquid-cooled bottom plate **82** until the surface of the molten metal **74** in that ingot mold **10** has reached a predetermined level. The ingot mold **10** is then raised at such a speed that the relation of the surface of molten metal **74** to the ingot mold **10** remains unchanged. The upward movement of the mold **10** is continued until it contacts the second ingot mold **20**, which is disposed over the ingot mold **10**. The two ingot molds **10** and **20** now remain at rest until the surface of the molten metal **74** in the second ingot mold **20** has reached a certain level. The second ingot mold **20** is much larger in inside diameter than the lowermost, first ingot mold **10**. The second ingot mold **20** is then raised at such a speed that the relation of the surface of the molten metal **74** to the ingot mold **20** remains unchanged. The operation which has just been described is then repeated with the uppermost, third ingot mold **30**, which is smaller in inside diameter than the second ingot mold **20**. The remelting operation which has been described thus results in a single ingot **70**, which consists of three cylindrical portions **71**, **72**, and **73**. The two end portions **71** and **73** of the ingot are much smaller in diameter (d_1 and d_3, respectively) than the intermediate portion **72** having a diameter d_2. The complete metal ingot **70** is indicated with dash-dot or dotted lines. The positions assumed by the ingot molds **20** and **30** at the end of the remelting operation are indicated with dash-dot lines. An electric lead **80** leads from one terminal of the source of power which is employed to the extension rod **41** of the electrode **40**.

The other terminal of the source of power is connected by an electric lead **81** to the horizontal bottom plate **82**, which consists of metal, preferably copper. The source of power is not shown and may consist, e.g., of the secondary winding of a transformer. The bottom of the solidified ingot **70** rests on the bottom plate **82**.

For the sake of completeness, it may be stated that the ingot molds **10**, **20** and **30** are cooled with water, which flows respectively through the jacket space **13**, **23** or **33** defined between the cylindrical inner shell **11**, **21** or **31** and the outer shell **12**, **22**, and **32** of each ingot mold **10**, **20** or **30**. Flexible tubes, not shown, are used to conduct cooling water to and from these jacket spaces **13**, **23** and **33**.

When the melting operation in one of the ingot molds has been terminated, warm cooling water may be used to avoid an excessive cooling of the previously solidified ingot portion. Alternatively, split ingot molds may be used, which are swung open and thus separated from the ingot to avoid a continued cooling of the sides of the solidified ingot portion. The solidified ingot portion may be additionally maintained at a predetermined temperature by the application of split insulation, which may be heated or unheated.

The mold-lifting carriages, on the one hand and the electrode-lifting carriage, on the other hand, may be mounted on separate columns.

The ingots, which are made in the plant which has just been described, are circular in cross section. The present process may also be used, however, to make ingots having other cross sections, which may be, e.g., rectangular or square, provided that suitably shaped ingot molds are employed.

The process according to the invention enables the production of ingots which consist of metal, preferably steel, and which have considerable changes in cross section and are of high purity, by electric slag remelting. Where the plant according to the invention is used, the length of these ingots may be as long as desired within wide limits.

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

We claim:

1. A process for casting metal ingots, having at least one change in cross-sectional area dimensions, by electroslag remelting electrode means, comprising the steps of

movably suspending at least two molds of different cross-sectional area dimensions from a vertical column,

providing a liquid slag layer in said molds,

movably suspending said electrode means from said vertical column into said slag layer,

maintaining said electrode means in said slag layer while passing an electric current through said electrode means, thereby remelting said electrode means by generating heat,

moving a first lower mold of said two molds upwardly jointly with said electrode means along said vertical column until said lower mold comes into contact with the second upper mold of said two molds while the molten metal in said first mold solidifies, and

moving thereafter said second mold upwardly jointly with said electrode means along said vertical column, whereby a solid unitary ingot is formed having at least one change in cross-sectional area dimensions.

2. A process as set forth in claim **1**, in which said metal is steel.

3. A process as set forth in claim **1**, in which said two molds have inner cylindrical surfaces of different diameters.

4. A process as set forth in claim **1**, in which said electrode means consist of a single electrode.

5. A process as set forth in claim **1**, in which at least three molds are movably suspended from said vertical column.

6. A process as set forth in claim **1**, which comprises removing said electrode means from one of said molds,

cooling said molten metal in said one mold at a first rate until said molten metal in said one mold has solidified to form an ingot portion, and

cooling said ingot portion at a second rate, which is lower than said first rate.

7. A process as set forth in claim 6, in which

cold water is used to cool molten metal in said one mold at said first rate, and

warm water is used to cool said ingot portion at said second rate.

8. A process as set forth in claim 1, which comprises

removing said electrode means from one of said molds,

cooling said molten metal in said one mold until said molten metal in said one mold has solidified to form an ingot portion, and

maintaining said ingot portion at a predetermined temperature.

9. A process as set forth in claim 8, which comprises applying split insulation to said ingot portion to maintain it at said predetermined temperature.

10. A process as set forth in claim 9, which comprises heating said insulation while it is applied to said ingot portion.

11. A process as set forth in claim 1, which comprises removing said electrode means from one of said molds,

cooling said molten metal in said one mold until said molten metal in said one mold has solidified to form an ingot portion, and

applying unheated, split insulation to said ingot portion.

12. In an apparatus for casting molten metal derived from metallic electrode means extending into a liquid slag layer through which an electric current is passed, an arrangement comprising a vertical column, at least two molds movably suspended for independent movement on said vertical column, said two molds having different cross-sectional area dimensions, means for moving said metallic electrode means movably mounted on said column and supporting said electrode means so that it extends into said liquid slag layer, means for moving said two molds comprising means for moving a first lower mold of said two molds upwardly jointly with said electrode means along said vertical column until said lower mold comes into contact with the second mold of said two molds while the molten metal in said first lower mold solidifies and means for moving said second mold upwardly jointly with said electrode means along said vertical column whereby a solid unitary ingot is formed having at least one change in cross-sectional area dimensions.

13. The arrangement as set forth in claim 12, which comprises

a bottom plate disposed under said molds,

said means for moving said molds including a plurality of mold-lifting carriages, each of which carries one of said molds,

said means for moving said electrode means including an electrode-lifting carriage disposed over said mold-lifting carriages and carrying said electrode means, and

tension cable means operable to control the vertical movement of said mold-lifting carriages and said electrode-lifting carriage independently of each other along said vertical column

14. The arrangement as set forth in claim 13, including cooling means which are operatively mounted on said two molds and which are operable to cool said molds with a liquid.

15. The arrangement as set forth in claim 12, in which at least one of said molds is split and adapted to be swung open.

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