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METHOD OF CONTINUOUS AND SEMICONTINUOUS CASTING OF METALS AND A PLANT FOR SAME

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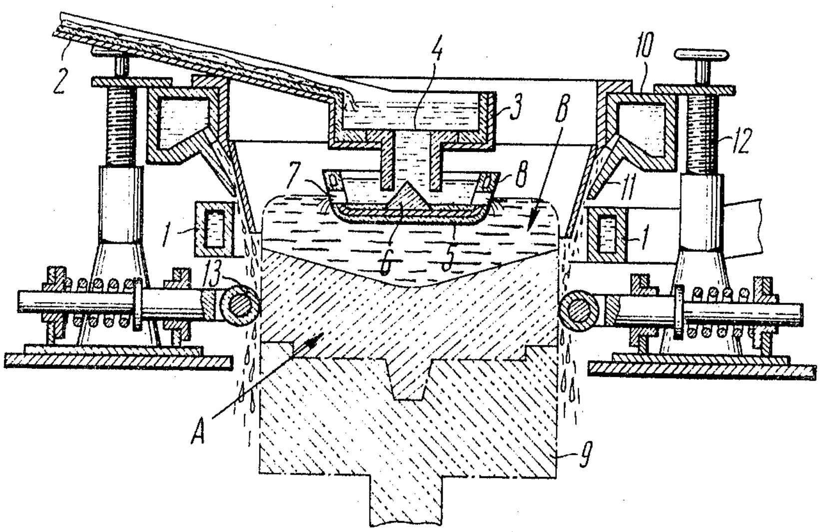

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METHOD OF CONTINUOUS AND SEMICONTINUOUS CASTING OF METALS AND A PLANT FOR SAME

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ABSTRACT OF THE DISCLOSURE

A method of, and an apparatus for, continuous or semi-continuous casting of molten metal into ingots by inducing an alternating electromagnetic field about the metal being cast so that the electromagnetic forces hold the molten metal in place as a cooling medium progressively cools the metal so its solidifies to form a skin for the ingot being cast.

The present invention relates to methods of continuous and semicontinuous casting of metals and plants for carrying the method into effect.

A method of continuous and semicontinuous casting of metals, is known wherein the molten metal from a device, ensuring its uniform supply, is directed into a mold, being in contact with cooled walls thereof, and partially solidifies. It is cooled on emerging therefrom and completely solidifies.

The known method employing moulds possesses a number of disadvantages. For instance, during the solidification of a moving ingot, it being in contact with the mold walls, various defects (blowholes, flashes) often form, while the formation of an air gap between the surface of the ingot and that of the mold will result in a decrease of the casting speed, the formation of surface flows, and a deterioration of the internal structure of the ingot. The presence of the surface defects requires an additional amount of machining ingots, thus considerably decreasing the yield of metal.

To decrease the friction between the mold and the moving ingot, in the known method, a lubricant is required, which is likely to impair the sanitary conditions of the work and to deteriorate the cultural level of the production process.

The molds employed in plants for effecting the existing methods of continuous and semicontinuous casting of metals are extremely expensive because of the requirements that must be met as to their quality of manufacture and heavy conditions of work.

An object of the present invention is to eliminate the foregoing disadvantages.

The principal object of the present invention is to provide a method of continuous and semicontinuous casting of metals, and a device for effecting the same, which allows increasing the production rate of casting units, reducing the expenses of manufacturing equipment, improving the structure of the ingots, obtaining an ingot surface which does not require machining, and improving the technical characteristics of the production process.

In conformity with the present invention, this is achieved when carrying into effect the continuous and semicontinuous methods of casting metals by use of an alternating electromagnetic field induced around the stream of molten metal, said electromagnetic field setting up forces in this stream that are directed inside the stream, and retain the metal from flowing off laterally, thus molding it into an ingot. A cooling medium is supplied on the surface of the forming ingot as it moves its crystallization zone.

In the plant for carrying said method into effect, an annular electromagnetical inductor is disposed under the tundish or other device for providing a uniform supply of the molten metal. In this plant, a device is provided for supplying the cooling medium into a gap between the inductor and the surface of the ingot thus formed.

The essential feature of the proposed method of continuous and semicontinuous casting of metal is as follows.

An alternating electromagnetic field is induced around the stream of molten metal. This field induces an alternating electromotive force and eddy currents in the molten metal (melt). The interaction of eddy currents with a magnetic field sets up electrodynamical forces (electromagnetical, mechanical, pondermomotive) directed inside the melt and compresses it. When compressed, the molten metal has imparted to it a definite shape in cross-sectional area and definite geometrical dimensions. The shape to be imparted to the melt depends upon the inductor shape, while its geometrical dimensions depend upon the intensity of the magnetic field on the metal surface.

For obtaining an ingot of the specified shape and dimensions, there is selected the frequency and current value of a generator setting up an alternating electromagnetic field. A uniform magnetic field along the ingot perimeter is also provided for inducing as well as for uniform cooling. The current frequency is selected in such a manner that the eddy currents induced in the melt flow along its surface layers, that is, there should occur the surface effect (so-called skin-effect). Hence, for cylindrical ingots, the frequency is selected with due account of a condition:

$$\frac{R_{\text{ingot}}\cdot\sqrt{2}}{\Delta e}\geq 10$$

where

R_{ingot} is the radius of ingot in cm.;

Δe is the equivalent depth of the current penetration into metal, in cm.

The electrodynamical forces mold the molten metal (melt) and completely prevent it from flowing off laterally during the entire process of the ingot formation.

A cooling medium is supplied on the surface of the ingot at it is formed, and passes into its crystallization zone, so that the ingot, when cooling down, undergoes a complete crystallization.

The nature of the present invention will become more fully apparent from a consideration of an exemplary embodiment of the proposed method, featuring the casting of aluminum to be carried into effect on a plant, represented in the accompanying drawing illustrating a preferred embodiment thereof.

The plant of the present invention is comprised of an annular electromagnetical inductor **1**; a supply of molten metal is poured through channel **2** to a box **3** on its end having a hole **4** to provide a uniform distribution of the melt to a cup or tundish **5** having a cone **6** in its center and holes **7** uniformly located around the perimeter of its walls **8**; a starter bar or dummy bar **9**; a collector **10** with an annular nozzle **11** whose position in the vertical plane is adjusted by screw-type lifting devices **12** provides coolant.

The process of casting aluminum is effected in the following manner. First, the appropriate frequency of the inductor current is selected. For obtaining an ingot 345 mm. in diameter, the frequency adopted is equal to 2500 hertz. The casting speed is equal to 120 mm./min.

The molten aluminum is supplied along the channel or trough **2** through the hole **4** of the box **3** on the starter bar **9**, inserted from below inside the inductor **1**. Water employed as a cooling medium is supplied from the collector **10** through the nozzle **11**, to impinge on the dummy bar and cools the molten metal on the dummy bar **9**, which begins to solidify.

The solidified portion of the melt is indicated in the drawing by the index A, while the non-solidified (or molten) portion thereof is shown by the index B.

The electromagnetic field, induced by the inductor **1**, sets up forces in the melt and thus the liquid portion of the ingot B is retained from flowing off, and solidifies in the shape desired.

As the height of the column of the molten metal increases, the column being partially solidified and resting on the starter bar **9**, the latter begins to descend. At the same time, the cup **5** is placed on the upper surface of the molten metal (portion B). The molten metal descends past the cone **6** of the cup **5**, flows over its bottom, and is uniformly supplied through the hole **7** into the magnetic field of inductor **1**. As the molten metal is supplied inside the inductor, the molten metal solidifies as it cools, thus forming the column of the solidified metal which descends together with the dummy bar. The ingot is maintained in the vertical position by rollers **13** provided under the inductor so as to be capable of being adjusted in the horizontal plane. The crystallization occurs due to water being supplied directly on the surface of the ingot. The water is supplied into a gap between the inductor and the surface of the ingot from the collector **10** by the annular nozzle **11** disposed inside the inductor **1** concentrically therewith and at a height approximately equal to the half of the inductor height.

As the molten metal is continuously supplied inside the inductor, the ingot is solidifying therein. The ingot, on being solidified with a continuous supply of the cooling medium (water), forms a continuous column of the solidified metal which, during its vertical movement, is cut into parts without interrupting the casting process. This continuous method may be employed for casting steel and alloys. As for aluminum, the casting process will be semicontinuous, because at the present time there are no methods available for its cutting, which would provide for the continuous casting process.

The described method of casting has been tested on an experimental plant.

The test ingots of aluminum thus obtained have a smooth surface free of defects and which requires no machining. The structure of the ingots was found to be fine-grained and sound. The ingots were employed for extrusion and forging. The mechanical testing of ingots and articles manufactured thereof has evidenced that they possess both a high plasticity and good mechanical properties.

What we claim is:

1. A method of continuous and semicontinuous casting of metals into an ingot, comprising the excitation of an alternating electromagnetic field around molten metal flowing onto the top of an ingot being cast, said electromagnetic field setting up forces inside the molten metal restraining the metal from flowing laterally off the ingot and supplying a cooling medium on to the surface of the metal to solidify it into an ingot and withdrawing the ingot downwardly as it solidifies.

2. A plant for continuous and semi-continuous casting of metals into ingots, comprising a device for a uniform supply of molten metal to the top of an ingot being poured; an annular inductor disposed below but adjacent said device for a uniform supply of the molten metal for providing a force to hold the molten metal on top of the ingot; a gap between said inductor and the surface of the ingot being cast; a means for supplying a cooling medium into said gap, and means for moving the metal progressively downwardly as it is cooled and solidifies.

3. A plant according to claim **2**, wherein a means for supplying the cooling medium is essentially an annular nozzle disposed concentrically with said inductor.

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