

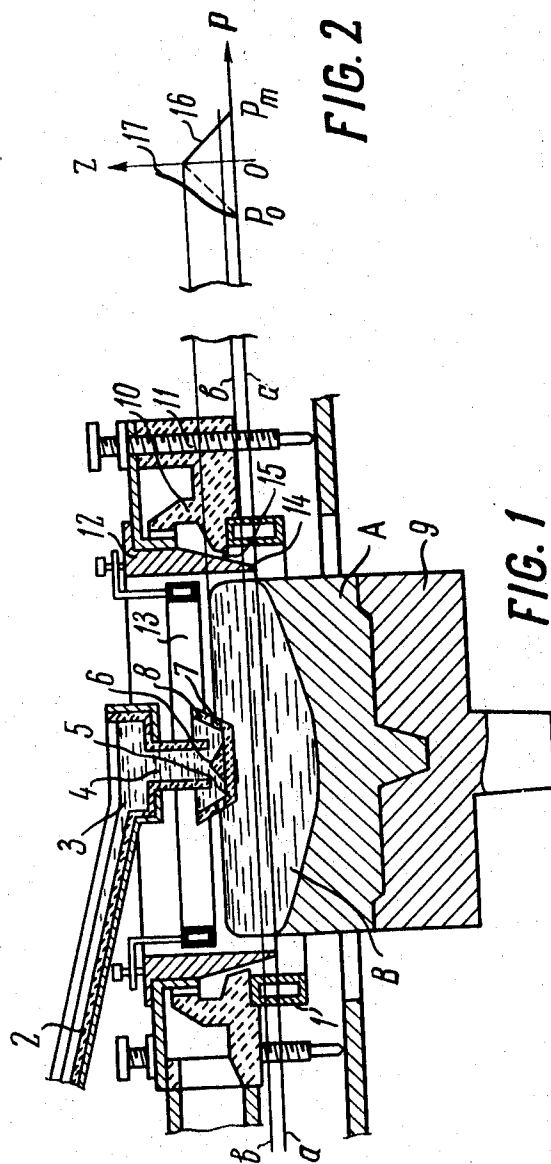
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CONTINUOUS CASTING APPARATUS WITH ELECTROMAGNETIC SCREEN

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CONTINUOUS CASTING APPARATUS WITH ELECTROMAGNETIC SCREEN

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2 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for continuous and semicontinuous casting of metals permitting ingots to be produced without any surface defects due to the fact that a magnetic field is provided in the apparatus distributed in the axial direction so as to ensure the quality of the hydrostatic and electromagnetic pressures. This is achieved by means of an electromagnetic screen mounted within the ring-shaped inductor. The electromagnetic screen consists of a closed ring of a non-magnetic metal whose thickness increases upwardly while the lower edge is disposed at approximately half of the height of the inductor.

The present invention relates to apparatus for continuous and semicontinuous casting of metals.

Known in the art are apparatus provided with a ring-type electromagnetic inductor, a device for uniformly feeding molten metal into this inductor and a device for feeding a cooling medium into the gap between the inductor and the lateral surface of the ingot being cast.

The ring-shaped inductor is employed for exciting an alternating electromagnetic field around the molten metal fed into the ingot-forming zone, the said electromagnetic field developing forces directed into the molten metal and preventing it from spreading, thus forming this metal. In this case the molten metal acquires a required shape in the cross section as well as required overall dimensions. A cooling liquid is applied onto the lateral surface of the column of molten metal formed by the electromagnetic field and, as a result, the metal being cooled completely solidifies during the movement and forms an ingot.

In the process of forming the ingot defects often appear on the surface thereof due to a distortion of the shape and dimensions of the ingot, for example, longitudinal pleats and transverse waves.

The above defects take place in the case of disparity between the hydrostatic pressure of the molten metal and the electromagnetic pressure on the lateral surface of the molten zone of the ingot.

Furthermore, the longitudinal pleats may result from a high intensity of movement of the molten metal caused by the electromagnetic forces shaping the ingot.

The object of the invention is to provide an apparatus for continuous and semicontinuous casting of metals, in which the distribution of the magnetic field in an axial direction is such that the hydrostatic pressure on the lateral surface of the liquid zone of the ingot is equal to the electromagnetic pressure, while the magnetic field in the upper portion of the liquid zone is such that it does not lead to an intensive movement of the metal inside of the liquid zone of the ingot, and this makes it possible to produce ingots without defects on their surface.

This and other objects of the invention are attained by providing an apparatus for continuous and semicontinuous casting of metals in which, according to the invention, arranged inside the ring-shaped electromagnetic inductor coaxially therewith is an electromagnetic screen comprising a closed ring of non-magnetic metal featuring an upwardly increasing thickness, whereas the lower edge

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of the screen is located at approximately half of the height of the inductor.

In some cases a ring made of a metal having high electric conduction is preferably positioned inside the electromagnetic screen concentrically and close thereto, said ring being arranged near the upper portion of the screen and being capable of moving along a vertical line.

Further objects and advantages of the invention will be apparent from the following description of the invention, reference being made to the accompanying drawings, in which:

FIG. 1 shows a longitudinal section of the apparatus for continuous and semicontinuous casting of metals; and

FIG. 2 shows a diagram of distribution of the electromagnetic and hydrostatic pressures on the lateral side of the ingot within the liquid zone.

The apparatus shown in the drawings consists of a horizontally arranged ring-shaped electromagnetic inductor 1 (FIG. 1), a feed tray 2 communicating with a tank 3, in the bottom of which there is provided a hole 4 of a device disposed under the tank 3 and employed for a uniform distribution of an aluminium melt, which device consists of a cup 5 with a cone 6 in the centre of the bottom and with openings 7 uniformly distributed over its side walls 8, a pan 9 located under the cup 5, a collector 10, screw elevators 11 for moving the apparatus in a vertical direction, an electromagnetic screen 12 located inside the inductor 1 and arranged coaxially therewith, a ring 13 made of a material having high electric conduction and located inside the screen 12.

The electromagnetic screen 12 is a closed ring whose cross section is featured by an upwardly increasing thickness, said screen being made of a non-magnetic metal. The conduction of the screen material is selected depending on the current frequency. For example, at a frequency of 1000 to 2500 c./s., the screen is to be made of non-magnetic steel having a high specific resistance, while at a frequency of 50 to 500 c./s. the screen is to be made of aluminium or copper. The lower edge 14 of the screen 12 is located approximately at the level of half of the height of the inductor and has a minimum thickness of 1 to 1.5 mm.

The thickness of the screen 12 is changed along the height depending on the distribution of the magnetic field of the inductor 1 in an axial direction.

The ring 13 is located in the upper portion of the screen 12 concentrically and close thereto.

The ring 13 is made of a copper tube having a rectangular cross section and is capable of moving along a vertical line. The ring 13 is cooled by water.

The above-described apparatus operates as follows.

The molten aluminium is fed through the tray 2 and opening 4 in the tank 3 into the pan 9 inserted into the inductor 1 from below. The water used as a cooling medium and fed from the collector 10 through the annular nozzle 15, formed by the electromagnetic screen 12 on one side and by the wall of the ring-shaped collector 10 on the other side, is fed into the pan 9 along the outer surface of the screen 12 and cools the molten metal located on this pan so that the metal begins to solidify.

In the drawing A stands for the solidified portion of the melt and B stands for non-solidified (liquid) portion of the melt.

The electromagnetic field produced by the inductor 1 develops forces in the melt due to which the liquid portion B of the ingot is prevented from spreading and in its form assumes the shape of the inductor in cross section.

Together with an increase in the column of the metal shaped, partially solidified and disposed on the pan 9, the latter starts to move down. At this moment the cup 5 is set on the upper surface of the molten metal (portion B).

The molten metal occurring on the cone 6 of the cup 5 spreads along its bottom and through openings 7 is uniformly supplied into the inductor 1.

The molten metal fed into the inductor is shaped and solidified forming a column of a solid metal which moves down together with the pan. The solidification takes place when the water is fed directly on the lateral surface of the ingot.

In the process of casting due to unavoidable changes in the rate of casting, intensity of cooling, position of the cooling band and deflection of the ingot from a vertical axis, the boundary between the liquid portion B and solid portion A of the ingot can be displaced over the surface of the ingot (along the axes $a-a$ and $b-b$ in FIG. 1).

The displacement of this boundary always occurs at the beginning of the process of casting.

As known, the hydrostatic pressure P_m of the liquid portion B within the metal melt is changed linearly (a straight line 16 in FIG. 2). At the same time, the calculations and experiments have shown that according to the character of distribution of the magnetic field, the electromagnetic pressure P_o acting on the surface of the liquid portion B along the axis O-Z at all points exceeds the hydrostatic pressure P_m (curve 17). In this case, the more distant is any point of the surface of the liquid portion of the ingot from the boundary between the liquid and solid portions of the ingot, the greater is the difference between the above-said pressures.

The disparity between the hydrostatic and electromagnetic pressures on the lateral surface of the liquid portions of the ingot results in the fact that at any displacements of the boundary between the liquid B and solid A portions of the ingot (axis $a-a$ in FIG. 1), the transverse dimensions of the liquid portion, that is of the ingot, are changed. For example, if this boundary is displaced upwards due to the fact that the electromagnetic pressure exceeds the hydrostatic pressure, the shaped portion of the ingot tends to squeeze and this results in a reduction of the transverse dimensions of the ingot.

Due to the reduction of the diameter of the ingot during its downward movement in the process of casting, the cooling band is displaced below its initial position.

In this case the boundary between the liquid and solid portions of the ingot is also lowered, i.e. it will occupy the position close to the initial position, whereas the diameter of the ingot will assume the dimensions close to the initial size. Due to such variations in the transverse dimensions, the surface of the ingot becomes wave-shaped while the dimensions exceed the permissible value.

Owing to the fact that the screen 12 is ring-shaped with upwardly directed thickening, the rate of attenuation of the magnetic field of the inductor 1 is increased upwardly. In this case the magnetic field is distributed so that the electromagnetic pressure is changed linearly along the height of the liquid portion of the ingot and this provides for the equality between the hydrostatic and electromagnetic pressures.

The equality of these pressures on the surface of the liquid portion B of the ingot being cast makes it possible to avoid any disturbance of its shape, e.g. formation of transverse waves and a change of the dimensions of the ingot.

In the process of shaping the ingot there may be observed intensive movement of metal within the liquid portion B of the ingot due to the electromagnetic forces excited by the inductor 1.

In this case the flows of metal carry the solidified crystals from the transition zone (zone of volume solidification) onto the surface of the ingot. These crystals are concentrated on the lateral surface of the ingot under the action of the hydrostatic and electromagnetic forces, and this results in the layers of the liquid portion of the ingot adjacent the surface acquiring a semi-liquid (pulpy) state.

In the process of shaping the metal in such a state, longitudinal pleats are formed on the surface of the metal. After the solidification of the metal, the pleats remain on the surface of the ingot.

The ring 13 employed in the apparatus herein proposed eliminates the above mentioned defects. The electromagnetic field of the inductor 1 induces within this ring eddy currents whose magnetic field, when interacting with the inductor field, lowers the intensity of the magnetic field in the upper portion of the ingot. This results in a decrease in the intensity of movement of the flows of metal, thus eliminating the possibility of formation of defects on the ingot surface.

The above-described apparatus has been tested in industrial conditions.

The produced ingots have had predetermined dimensions and shape and a smooth even surface.

What is claimed is:

1. An apparatus for continuous and semicontinuous casting of metals comprising in combination: a device for uniform supply of molten metal, a ring-shaped electromagnetic inductor located under said device for maintaining a column of molten metal, an electromagnetic screen located inside said inductor and arranged coaxially therewith, said screen consisting of a closed ring of a non-magnetic metal and having an upwardly increasing thickness while the lower edge thereof is located at approximately half of the inductor height, said increasing thickness being such as to distribute the magnetic field of said inductor to provide substantial equality between the hydrostatic and electromagnetic pressures exerted along said column of molten metal, means for supplying a cooling medium into the gap between said inductor and the lateral surface of said column, and means for supporting and progressively lowering said column as it cools and solidifies.

2. An apparatus as claimed in claim 1, comprising a ring made of a metal having high electric conduction located inside the electromagnetic screen in its upper portion, said ring being disposed concentrically with said screen, close to it, and with means for moving it along a vertical line.

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ROBERT D. BALDWIN, Primary Examiner

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