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[54] **CONTINUOUS CASTING METHOD**
2 Claims, 1 Drawing Fig.

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[50] **Field of Search** 164/73, 86, 64, 149, 83

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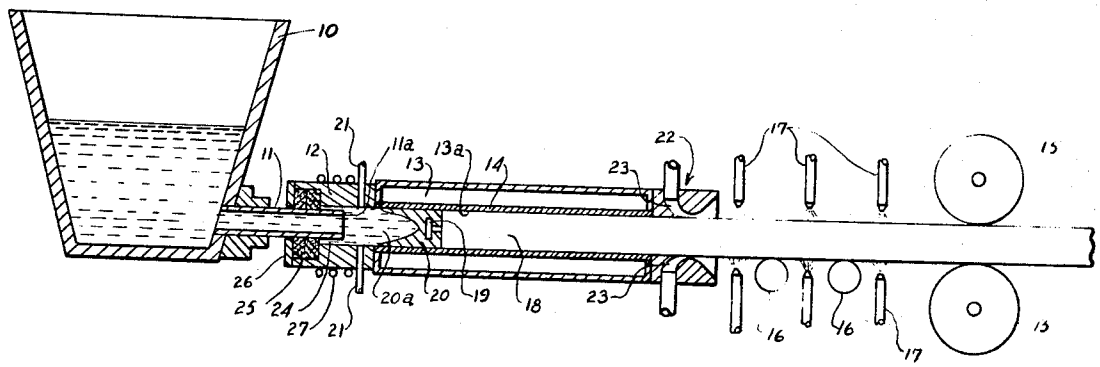
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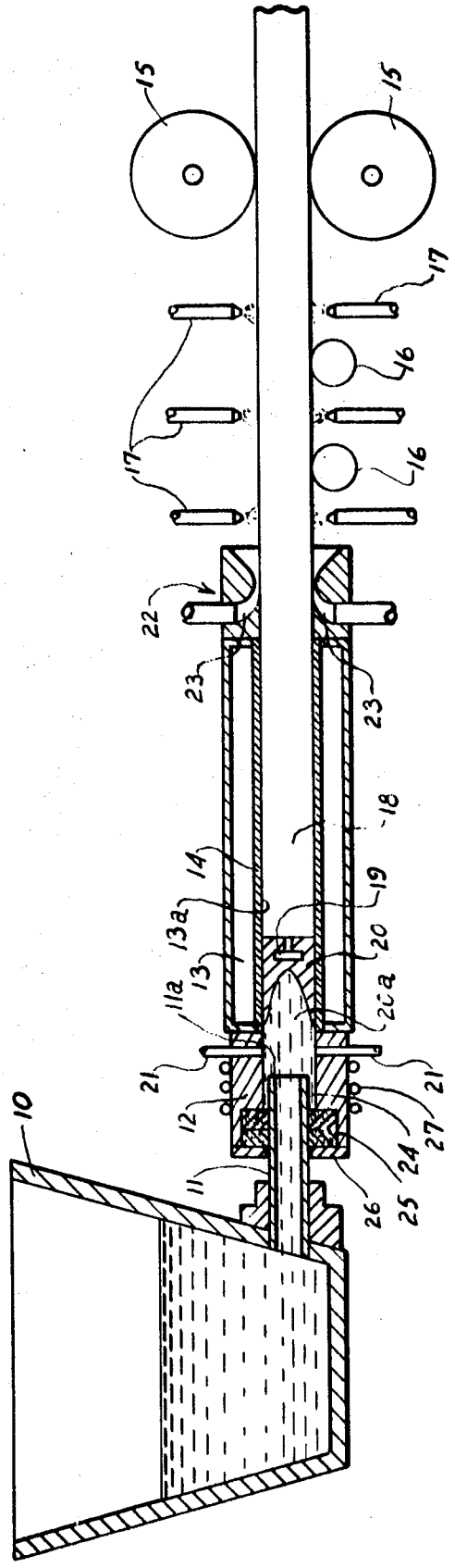
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ABSTRACT: In apparatus which is particularly adapted for continuous casting in a horizontal direction lubrication is provided by feeding a lubricating material to the peripheral edge of the entrance end of the mold cavity and applying a pulsating vacuum at the periphery of the exit end of the mold cavity. Structure producing a venturi effect is utilized for producing the vacuum.

Molten metal from a supply is fed to the mold cavity through a feed spout extending into a duct of refractory material which is connected to the entrance of the mold cavity. Heat is applied to metal in the duct for melting metal which has solidified on the end of the feed spout and for keeping the metal molten in the duct. The high heat required is suitably applied by induction heating coils around the duct.





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CONTINUOUS CASTING METHOD

The present invention relates to apparatus for the continuous casting of metal, such as steel, wherein molten metal is fed into the entrance end of an open-ended mold, which is cooled to solidify the periphery of metal in the mold to form a cast strand, and wherein a cast strand thus formed is withdrawn from the other, exit, end of the mold. In particular the invention is apparatus that is especially adapted for continuously casting metal in a horizontal direction.

Continuous casting in a horizontal direction—wherein the longitudinal axis of the mold cavity is substantially horizontal—creates two special problems. One is lubrication; the other is the feeding of molten metal into the entrance end of the mold cavity.

An object of the present invention is to provide an improved method and means for lubricating the interface between the wall of the mold cavity and metal therein, which method and means are particularly adapted to provide the lubrication required for casting with a generally horizontal mold cavity.

In accordance with the present invention the lubrication is accomplished by feeding a lubricating material, such as slag powder or other flux material, to the peripheral edge of the entrance end of the mold cavity and applying a pulsating vacuum around the mold cavity at its exit end for the purpose of drawing the lubricating material into the mold cavity, and for withdrawing gases which are released from the metal in the mold. The vacuum is suitably created by having the exit end flared outward and introducing a fluid, such as air, humidified air or water, into the base of the flare through a passage so that a venturi effect is generated. The vacuum is suitably pulsated by varying the pressure of the fluid introduced, and is preferably pulsated in repetitive cycles from approximately atmospheric pressure to maximum vacuum and back. The pulsating vacuum could also be generated by other means such as conventional vacuum pumps operated to produce a cyclically variable vacuum.

Also, for casting with a generally horizontal mold cavity, the entrance end of the mold cavity opens in a horizontal direction so that a closed conduit must be provided to conduct molten metal into the mold cavity from a source of supply. In addition, it is desired to be able to oscillate the mold along its longitudinal axis in a manner known in the art. The conduit is suitably provided by a feed spout, from a tundish or other source of supply of molten metal, extending slidably into a duct which is attached or otherwise supported in fluid flow communication with the entrance end of the mold cavity. The feed spout and duct are coaxial with the longitudinal axis of the mold cavity, and the cross-sectional configuration and diameter of the duct preferably correspond to those of the mold cavity. There is a tendency, however, for the molten metal emerging from the feed spout to solidify on the end of the feed spout and build up a false tube which may eventually extend into or even through, the mold cavity, thereby disrupting the casting process.

It is therefore a further object of the present invention to provide an improved duct means which provides for remelting any metal that has solidified on the end of the feed spout and which serves to keep metal in the duct molten.

In accordance with this aspect of the invention the duct is made of a refractory material and is provided with means for applying sufficient heat to metal in the duct for melting metal which may have solidified in the duct—particularly on the portion of the feed spout in the duct. In a preferred form the duct is made of refractory material with low heat conductivity which prevents heat loss from metal in the duct, and the desired heating effect is provided by electrical induction heating coils around the duct.

Further objects, advantages and features of the method and apparatus of this invention will be apparent from the following detailed description of an illustrative form of the invention shown in the accompanying schematic drawing which is a cross-sectional view longitudinally through horizontal continuous casting apparatus embodying the invention.

Referring to the drawing, in the continuous casting process molten metal from a source of supply, such as a tundish **10**, is fed through a feed spout **11** into duct **12** which is attached to the end of a mold **13** having an open-ended horizontally aligned mold cavity **13***a* defined by a lining **14** of appropriate material, such as copper. The duct **12** preferably has substantially the same cross-sectional configuration and diameter as the mold cavity **13***a*, and is connected coaxially in fluid flow communication therewith.

The mold **13** is cooled by conventional means, not shown, such as by circulating water through a jacket around the mold or through passages in the mold walls, and molten metal from the duct flows into the mold cavity **13***a* where the periphery of the metal solidifies to form a strand. The strand is withdrawn from the exit end of the mold cavity **13***a* by a pair of driven rollers **15** which are spaced from the exit end. The driven rollers **15**, in addition to serving to withdraw the strand, are suitably utilized to apply pressure for shaping and reducing the dimension of the strand. At this point the interior of the strand is still molten or soft and the pressure applied by the rollers **15** also consolidate the strand, eliminating pipes and pockets. Between the exit end of the mold cavity **13***a* and the driven rollers **15**, the strand is supported by idler rollers **16** and cooled by water sprays **17**.

In order to start a casting run the mold cavity **13***a* is plugged by a dummy bar **18** which has a protruding head **19** around which molten metal fed into the mold solidifies to attach the dummy bar to the lead end of a strand forming in the mold cavity. In the drawing the solidified lead end and periphery of the strand is indicated at **20**; the still molten core is indicated at **20***a*. The body of the dummy bar **18** extends out the exit end of the mold cavity **13***a* and between the driven rollers **15**. When sufficient metal has accumulated in the mold cavity for a strand to form, and for some of the metal to have solidified around the head **19**, the driven rollers **15** are operated to withdraw the dummy bar **18** and strand from the mold cavity. Thereafter molten metal is fed into the entrance end of the mold cavity to replace the metal withdrawn as a continuous strand.

The interface between the lining **14** of the mold cavity **13***a* and metal therein is lubricated by feeding lubricating material to the peripheral edge of the entrance end of the mold cavity through pipes **21**. These pipes **21** are shown at the entrance end of the mold cavity **13***a* but they could be upstream therefrom, so long as the lubricating material is applicable to the periphery of the metal at the entrance of the mold cavity. The lubricating material may be any suitable flux material, such as slag powder, and may be applied in molten or fluid form, or as a powder which will melt as soon as it comes in contact with the molten metal.

A pulsating vacuum is generated at the periphery of the strand emerging from the exit end of the mold cavity **13***a* by creating a venturi effect in a fluid fed to the interior of the exit end. For this purpose the end of the mold cavity **13***a*—or an extension thereof provided by a casing **22**—is flared outward as shown and a suitable fluid such as air, humidified air, or water is fed into the base of the flared portion through a passage or passages **23**. Thus, the fluid flows through the passage or passages **23**, through the throat between the periphery of a strand and the base of the flared portion of the mold cavity, and then out the flared portion producing a venturi effect which generates a maximum vacuum in the throat. In accordance with the invention the vacuum is pulsated to be most effective for drawing the lubricating material into the mold cavity, and to withdraw gases, which are released from the metal in the mold, out from the exit end of the mold, and the desired pulsations are suitably produced by repetitively varying the pressure of the fluid fed into the passage or passages **23**. These changes in fluid pressure are suitably accomplished by conventional means (not shown), such as pressure-reducing valves in feedlines for the fluid. In the preferred method of practicing the invention the vacuum is pulsated in repetitive cycles from approximately atmospheric pressure to

maximum vacuum and back. The length of the pulses and the relative length of time of maximum vacuum and of approximate atmospheric pressure may be adjusted to determine the most effective lengths for the particular situation, the provision of some cyclic variation in the amount of vacuum being the most important aspect.

At the entrance end of the mold cavity **13***a* the feed spout **11** of the tundish **10** extends coaxially into the duct **12**, and the clearance **24** between them is sealed by asbestos or other heat resistant packing **25** around the feed spout, held in place by a packing ring **26**. The feed spout **11** and duct **12** are coaxially aligned and fitted together to enable the duct **12** to oscillate in a horizontal direction relative to the feed spout **11** when the mold **13**—to which the duct **12** is attached—is oscillated in a horizontal direction in accordance with a casting method known in the art.

Molten metal tends to solidify and build up on the end **11***a* of the feed spout within the duct, particularly at the start of a casting run when the feed spout and duct are relatively cold. Therefore, it is desirable to be able to apply heat to the interior of the duct, and to metal therein, for melting the solidified metal on the feed spout and in general to prevent solidification of metal in the duct. High heat is required and for this purpose the duct **12** is suitably made of a refractory material and has an electrical induction coil **27** around it.

What is claimed is:

1. In a continuous casting method wherein molten metal fed into the entrance end of an open-ended mold cavity peripherally solidifies to form a strand which is withdrawn from the other, exit, end of the cavity, a method of lubricating the interface between the wall of the mold cavity and metal therein comprising: feeding a lubricating material to the peripheral edge at the entrance end of the mold cavity, creating a vacuum at the exit end of the mold cavity between the wall of the mold cavity and the periphery of a strand therein for removing gases from the mold cavity and for drawing said lubricating material into the mold cavity, and pulsating said vacuum, said lubricating material being a flux material.

2. The method of claim **1** in which the flux material is slag powder.