United States Patent

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[54] **POURING SPOUT FOR CONTINUOUS CASTING OF MOLTEN METALS**
6 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **222/146,** 222/564, 222/566
[51] **Int. Cl.** **B67d 5/62,** B65d 5/72
[50] **Field of Search** 222/146, 566, 567, 564, 76

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ABSTRACT: A pouring spout for use in the continuous casting of molten metal is described. It comprises as major components a nozzle body, heating means and antivortexing means.

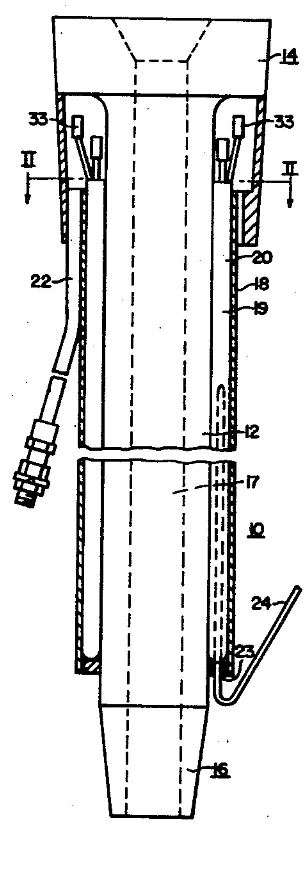

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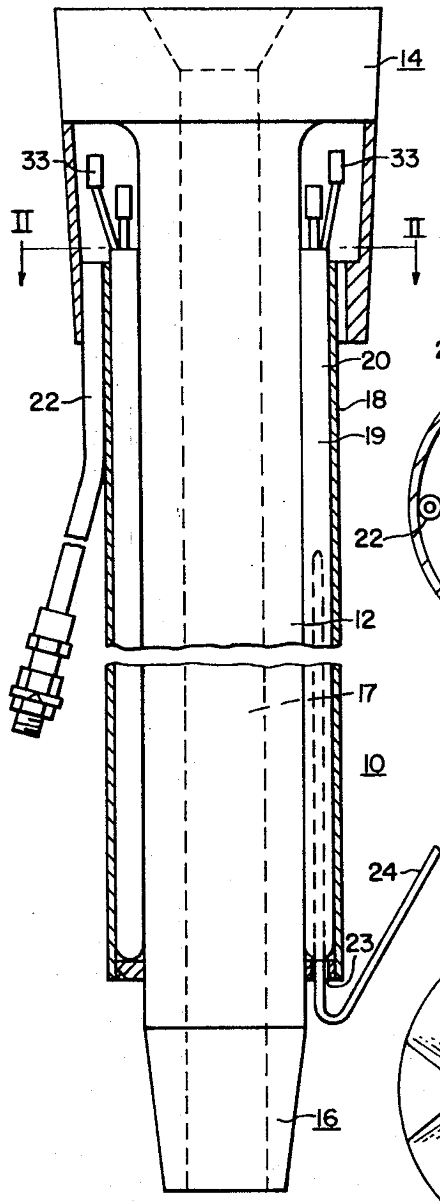
FIG. 1.



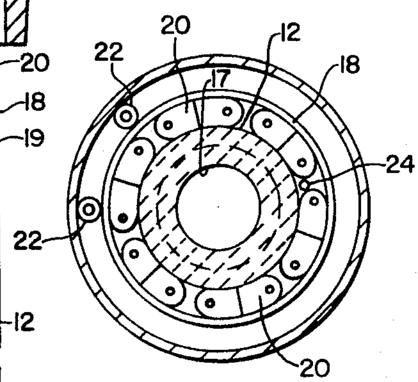


FIG. 2.

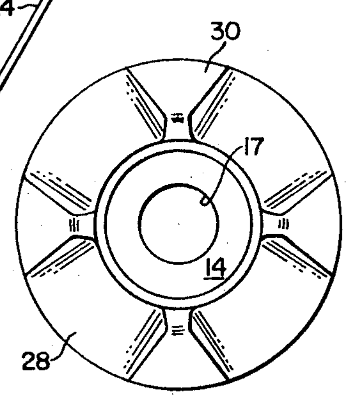


FIG. 4.

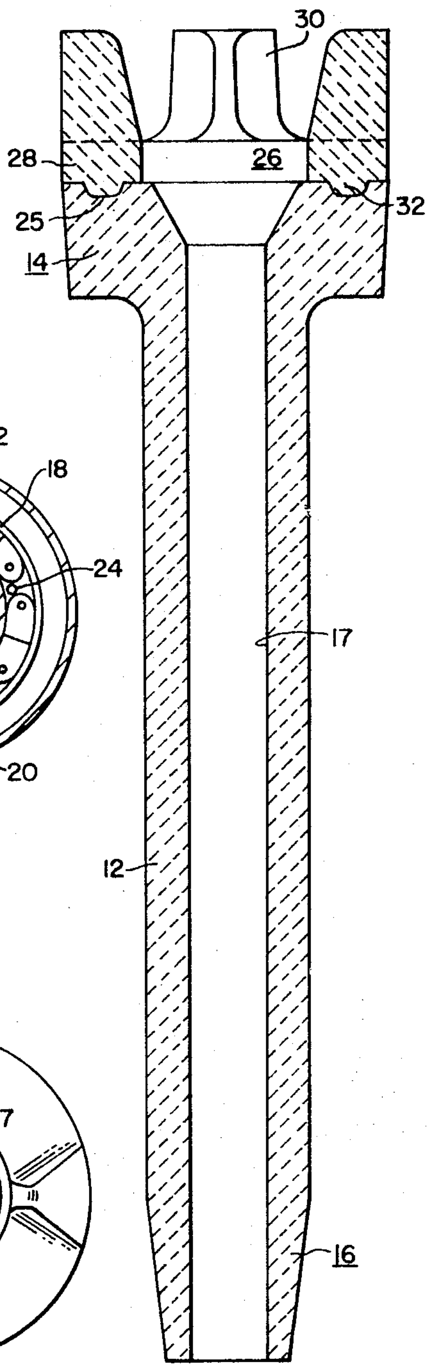


FIG. 3.

WITNESSES

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POURING SPOUT FOR CONTINUOUS CASTING OF MOLTEN METALS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a pouring spout which is suitable for use in the continuous casting of molten metals and in particularly to the continuous casting of molten copper.

2. Description of the Prior Art

In the past, an apparatus employed in the continuous casting of molten metals such as aluminum or copper included the use of a rotatable drum having a grooved periphery thereabout and around the portion of the drum a steel endless belt is applied to fit tightly to the periphery to close said groove to retain molten metal in the groove until the metal solidifies, the bent being of greater length than the circumference of the drum and diverging therefrom upon opposite sides. This arrangement is best illustrated by reference to various patents issued to Ilario Properzl and the patents assigned to the Southwire Company, such as U.S. Pat. No. 3,322,184; No. 3,279,000; and No. 2,865,067.

In such apparatus molten metal is fed from a tundish through a pouring spout into the groove contained in the periphery of the continuous casting wheel at the point where it matches the steel endless belt. In the past, such substances as graphite have been used for the pouring spout since graphite is not subject to thermal shock, is nonwetting, and preheatable and is relatively inexpensive. In addition graphite is easily machined to the required shape and dimensions. However, at molten metal temperatures encountered and, in particular, the temperatures encountered in the continuous casting of copper, graphite oxidized and in time ablates to change the internal and external geometries such that the spout will become inoperative in a relatively short period of use. Continuous casting economies are largely influenced by the length of run and when pouring copper through a graphite spout the run length was limited to about 3 to 4 hours. Moreover, with the aspect of the continuous ablation of both the internal and external geometries, automation of such continuous casting process was impractical because of the continuous changing geometry of the interior dimensions thereby varying the flow rates through the nozzle without control. It was also found that with the use of graphite pouring spouts, icicles of the metal being poured tended to form at the end of the pouring spout until a uniform heat distribution was obtained and upon this result large chunks or masses of the metal would fall off the end of the spout and become embedded within the continuously cast material, thereby producing a flaw in the bar being cast.

It is noted that pouring spouts, which are utilized in a bottom of the tundish, assures a continuous slag-free supply of molten metal since the slag will flow to the top of the pouring pot. However, it was noted that molten metal exhibits true fluid phenomena including the incidents of whirlpool or vortex flow. In this respect a vortex can "pump" or "drain" to gas atmosphere above the liquid level by an entrapping mechanism into the metal stream and into the casting without obvious evidence to this gas entrapping activity being present, that is, when the static head above the pouring spout is high vortexing is obscured and can be of extremely small diameter. However, when the static head is low, vortexing is obvious and gross casting defects can be associated with this last condition.

SUMMARY OF THE INVENTION

The present invention contemplates a novel pouring spout for use in the continuous casting of molten metals. Essentially, the pouring spout comprises a nozzle having a central opening therein and a sheath disposed about the nozzle in spaced relation thereto defining an annular compartment. Within the compartment a heating means is disposed in order to control the quantity of heat supplied to the nozzle body. In the preferred embodiment, an antivortexing means is disposed on the top of the nozzle body in seating engagement therewith for preventing vortex or whirlpool formation during the continuous casting of molten metals.

The pouring spout of the present invention having its own heating means contained therein is particularly advantageous during the startup of the continuous casting operation. A predetermined quantity of heat can be supplied to the nozzle body to cause it to reach a desired temperature thereby eliminating all external torch heating and, by controlling the heating thereof a spout at the proper temperature is available at any time almost instantaneously for programmed operation. Moreover, by controlling the temperature within the nozzle body during shutdown the pouring spout will drain completely, consequently, there is no solidification in the bore thus making restarts much easier whether the process has been temporarily interrupted or whether the continuous casting process is being shut down for an extended period of time. In addition, since the nozzle body is readily nonwetting, any momentary interruptions will not prevent the immediate restart and the resumption of casting operations on a programmed basis. Since the nozzle body retains the required temperature, "icicle" formation on the end of the continuous casting tube is greatly reduced thereby improving the quality of the casting obtained.

Accordingly, it is an object of the present invention to provide a pouring spout suitable for use in the continuous casting of molten metal.

Another object of the present invention is to provide a pouring spout for use in the continuous casting of molten metal which pouring spout contains a regulated heat supply thereto thereby minimizing any abnormalities in the flow rate resulting from startup and shutdown.

A more specific object of the present invention is to provide a pouring spout formed from a material which exhibits an exceedingly low degree of ablation when used at elevated temperatures and which contains a programmed heating source for minimizing irregularities from a desired flow pattern.

Other objects of the present invention will become apparent to those skilled in the art when read in conjunction with the following description and the drawings in which:

FIG. 1 is a view in section of the assembled pouring spout;

FIG. 2 is a view along line II–II.

FIG. 3 is a view in section of the nozzle body with an antivortexing means in position on the top thereof; and

FIG. 4 is a top view illustrating some of the details of the antivortexing means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and to FIG. 1 in particular, there is illustrated a pouring spout shown generally at **10**. The pouring spout **10** comprises an elongated nozzle body **12** having a head portion **14** and a tail portion **16** and a central opening **17** extending substantially throughout the length of said nozzle body **12**. In the embodiment illustrated in FIG. 1 and as also shown in FIGS. 3, the head portion **14** is formed to the shape of a frustum of a cone which facilitates seating of the assembled pouring spout within the bottom of a metal tundish (not shown). To substantially the same effect, the external geometry of the tail portion **16** is also in the shape of a frustum of a cone and the tail portion is disposed to extend in close proximity to the cavity from by the groove of the continuous casting wheel where it is matched with the endless belt, the latter apparatus not being shown.

As stated previously, when graphite is used as the nozzle body it is subject to serious ablation during use. Accordingly, the material from which the nozzle body is formed must be carefully selected. In the preferred embodiment of this invention it has been found that silicon carbide such as recrystallized silicon carbide, and in particular silicon nitride doped silicon carbide has proved to be quite advantageous from the standpoint that the internal and external geometry of the nozzle body is unaffected by the temperatures and atmospheres employed. For example, in the continuous casting of molten copper while silicon carbide has a high degree of thermal shock sensitivity, a composition containing about 80 percent by weight of silicon carbide, about 2 percent by weight of carbon, about 16 percent by weight of silicon nitride, about 1 percent by weight of silica, about 0.5 percent by weight of iron oxide and 0.5 percent by weight of aluminum oxide has been utilized with outstanding success. Such doped silicon carbide materials exhibit a narrow range of thermal shock sensitivity and as a result careful heating through the sensitive range can be readily accomplished as will be explained more fully hereinafter without any fear of cracking of the nozzle body itself.

The nozzle body **12** is disposed to be surrounded by a sheath **18** in predetermined spaced relation thereto thereby defining an annular cavity **19** the function of which will be explained hereinafter. The sheath **18** extends up to and terminates adjacent to the heat portion **14** and the top portion of the sheath **18**, usually, although not necessarily, continues at the same slope as the sides of the head portion as described hereinbefore. The sheath **18** extends a predetermined distance along the length of the nozzle body and terminates at a predetermined distance above the tail portion of the nozzle body **12**. Preferably, the sheath **18** completely encloses and is in tight engagement with the nozzle body **12**. A heating means **20** is disposed to reside in the annular cavity **19** formed between the sheath **18** and the nozzle body **12**. In the embodiment illustrated the heating means comprises a plurality of kidney-shaped electrical resistance heating elements which are disposed in the annular compartment **19**. Preferably, the heating elements are of the sheath type resistance elements with the wires hermetically terminated from magnesia powder encapsulation. These elements **20** are connected to spaced insulated bus bars **32**, thereby permitting the connection of the individual elements in series, parallel or combination. As a result greater design flexibility and necessary functions that is to provide two terminals to the AC power supply is accomplished. Power thereto is supplied by means of leads **22** connected to bus bars **32** and extending from the annular cavity formed between the sheath **18** and the nozzle body **12**.

As stated previously, it is preferred to use for the spout a material of the class known as silicon nitride bonded silicon carbide. This material is particularly advantageous from the standpoint that it has a limited range of thermal shock sensitivity and is not subject to ablation by reason of the temperatures of operation and the environmental conditions involved. Thus the heating element **20** may be programmed by controlling the current supplied through bus leads **22** such that from room temperature to about 800° F. The nozzle body is heated to provide a temperature rise at a rate of about 200° F. per hour. Since the thermal shock sensitivity range for the nozzle material is from about 800° to 1,000° F. the current is regulated so that the heating rate does not exceed 100° F. in this temperature range. It is seldom during the continuous casting of molten copper that the temperature will drop as low as 1,000° F. Consequently the risk of thermal shock to the nozzle body is greatly reduced. Thereafter, once the thermal shock sensitivity range has been exceeded the current is then programmed to heat the nozzle at a rate of about 200° F. per hour until a temperature of about 1,600° F. is reached. Control of the temperature is maintained by monitoring the temperature of the nozzle body **12** by means of a thermocouple **24** inserted through opening **23** in the sheath **18** and disposed in close proximity to the nozzle body **12**. On cooling the nozzle from the pouring temperature the temperature programmed control is reversed.

It will be appreciated that the use of silicon nitride bonded silicon carbide is advantageous from the standpoint that the material is relative nonwetting with respect to the molten copper being cast. By the utilization of a separate heat source of controlled heat input the temperature of the pouring spout can be maintained with in relatively narrow limits. Accordingly, once the continuous casting process has begun there is no tendency for any material to adhere to the inner bore of the pouring spout by reason of momentary interruptions of the flow of molten metal nor for that matter during a brief shutdown, since the controlled heat input to the nozzle body will maintain the nozzle body at a temperature in excess of the melting point of the copper. In addition, it will be appreciated that since there is no ablation due to the nonwetting aspect of the copper with respect to the material of the nozzle body, as well as its relative inertness to the operational environment, good maintenance of the original geometry of the central opening is established thereby making the pouring spout ideally suited for mechanized or computerized control of the continuous casting operation. While the embodiment illustrated demonstrates the use of an electrical resistance heating element, it will be appreciated that other sources of heat such as a combusted gas can be employed so long as the heat source can be controlled to maintain the desired temperature of operation as well as the desired rate of heat input especially when the material is being heated through the thermal shock sensitivity range.

Referring now to FIG. 3 in particular, there is illustrated a preferred modification to the embodiment shown in FIGS. 1 and 2. In this respect, the nozzle body **12** is composed of the same material and is formed to substantially the same internal geometries and external with the exception of the heat portion **14**. In the embodiment illustrated in FIG. 3, the head portion **14** is provided with a circumferential groove **25** which is disposed concentric to the central opening **17** and in the top part of the head portion **14**, the function of which will be described hereinafter. Disposed for seating engagement on the heat portion **14** is an antivortexing device shown generally at **26** which comprises annular ring member **28** upon which a plurality of upwardly extending vanes **30** are situated and disposed radially about the central opening **17** in the head portion **14** of the nozzle body **12**. Preferably, the antivortexing device **26** is also formed of the same silicon nitride bonded silicon carbide and the annular ring **28** is provided on the side opposite the vanes **30** with a tongue portion **32** which is matched to fit the circumferential groove **25** to be found in the head portion **14** of the nozzle body **12**. The tongue **32** and groove **25** aspect of the heat portion **14** and the annular ring **28** are employed for maintaining the antivortexing device **26** concentric to the opening **17** in the nozzle body **12** and to provide extra shear strength for the antivortexing device **26** and the top portion **14**. It will be appreciated however that while in the embodiment illustrated in FIG. 3, the antivortexing device **26** is shown as being a separate unit, the antivortexing device **26** can be molded and fires as a single integral unit with the nozzle body **12** or it may be formed as a separate unit and thereafter cemented into place.

As another alternative to the tongue **32** and groove **25** method it will be appreciated that integral tabs and dimples can be utilized in the various component to substantially obtain the same effect.

As more clearly illustrated in FIG. 4, the vanes **30** are formed usually integrally with the annular ring member **28**. The vanes **30** are generally upwardly extending and have a general wedge-shaped thereto and are disposed radially about the central opening **17** in the head portion **14** of the nozzle body **12**. By thus disposing the antivortexing device **26** on top of the head portion **14**, the whirlpool flow of the molten metal through the nozzle body **12** is greatly reduced thereby inhibiting any pumping or draining of the gas atmosphere above the liquid level through the stream and into the casting. In addition, the antivortexing device **26** better regulates the flow of the molten metal through the pouring spout thereby lending itself ideally to automated operation of the entire continuous casting process.

In operation, the pouring spout **10** is secured into the bottom of a tundish (not shown) and the bus leads **22** are connected to a suitable source of energy. The heating element is programmed to control the temperature of the nozzle body **12** for a controlled heating rate through the thermal shock sensitivity range namely 800° F. to about 1,100° F. Thereafter, the nozzle body is heated to a temperature of about 2000° F. and maintained at this temperature throughout the operation. Control of the program is maintained by monitoring the temperature of the nozzle body **12** by thermocouple **24**. By thus maintaining the temperature at about 1,600° F. the nozzle body is maintained at a temperature in excess of the freezing temperature of the metal being continuously cast, in the present instance, said metal being copper. For aluminum an appropriate lower nozzle temperature will be used. Upon the completion of the casting the nozzle can be maintained at temperature for prolonged periods of time without any danger of ablation due to reaction with the atmosphere. If it is desired to discontinue the continuous casting operation for an extended period of time, the heating element can be controlled by an appropriate schedule to bring it back to room temperature by natural cooling by radiation and convection, the same being controlled in the reverse manner through the thermal shock sensitivity range to that described upon heating it to the pouring temperature. The apparatus thus described has been successful in the use, in the continuous casting of copper for prolonged periods of time and has proved to be advantageous in eliminating the decrepancy which have been encountered heretofore with the use of graphite type pouring spouts.

It will be understood by those skilled in the art that although the invention has been described with respect to two specific embodiments, modifications and variations may be employed without departing from the underlying spirit and scope of the invention.

I claim:

1. A pouring spout for use in continuous casting of molten metals, the combination comprising, a thermally sensitive elongated nozzle body having heat and tail portions and a central opening extending through the length of said nozzle body, a sheath disposed about the nozzle body in spaced relation thereto defining an annular compartment, said sheath extending from the head portion and terminating at a predetermined distance above the tail portion, means disposed in the annular compartment for supplying a predetermined quantity of heat to the nozzle body programmed means cooperating with the heating means for providing a predetermined control of the temperature of the thermally sensitive nozzle body including a high rate of temperature rise in the region of low thermal sensitivity, a low rate of temperature rise in the region of high thermal sensitivity and maintenance of any predetermined selected temperature, and means disposed on the heat portion of the nozzle body for inhibiting vortex movement of the molten metal through the opening in the nozzle body.

2. The pouring spout of claim 1 in which the means disposed within the annular compartment comprises an electrical resistance heating element.

3. The pouring spout of claim 1 in which the vortex inhibiting means comprises a plurality of upwardly extending generally wedge-shaped vanes disposed radially about the central opening in the head portion of the nozzle body and in seating engagement thereon.

4. A pouring spout for use in the continuous casting of molten metals, the combination comprising, a silicon nitride bonded silicon carbide thermally sensitive elongated nozzle body having head and tail portions and a central opening extending throughout the length of said nozzle body, said thermal sensitivity occurring at a temperature within the range between about 800° F. and about 1,000° F., said heat portion of the nozzle body having a circumferential groove concentric with the central opening in the nozzle body and spaced radially therefrom, a sheath disposed about the nozzle body in spaced relation thereto defining an annular compartment, said sheath being disposed in engagement with the head portion of the nozzle body and terminating a predetermined distance above the tail portion of the nozzle body electrical resistance heating means disposed within the annular compartment for supplying a predetermined quantity of heat to the nozzle body programmed means cooperating with the heating means for providing a predetermined control of the temperature of the thermally sensitive nozzle body both on heating and cooling including a high rate of temperature rise or fall between room temperature and about 800° F. a temperature rise or fall not in excess of 100° F. per hour through the temperature range between 800° F. and about 1,000° F. and maintenance of any predetermined selected temperature and an antivortexing assembly comprising an annular ring member disposed concentric with the central opening and having a tongue on one surface thereof and a plurality of upwardly extending vanes disposed on the opposite surface and radially extending about the central opening, said tongue and said annular ring member being secured in seating engagement in the circumferential groove of the head portion of the nozzle body.

5. A pouring spout for use in the continuous casting of the molten metals, the combination comprising, a thermally sensitive elongated nozzle body having a central opening extending throughout the length of said nozzle body, heating means disposed about at least a portion of the nozzle body for controlling the temperature thereof, programmed means cooperating with the heating means for providing a predetermined control of the thermally sensitive nozzle body including a high rate of temperature rise in the region of low thermal sensitivity, a low rate of temperature rise in the region of high thermal sensitivity and maintenance of any predetermine selected temperature and means disposed on at least one end of the nozzle body for inhibiting vortex movement of the molten metal through the opening in the nozzle body.

6. The pouring spout of claim 5 in which the nozzle body is formed of silicon nitride bonded silicon carbide having a range of thermal shock sensitivity between about 800° F. and 1,000° F., the rate of high temperature rise is about 200° F. per hour and the rate of low temperature rise is not greater than about 100° F. per hour.