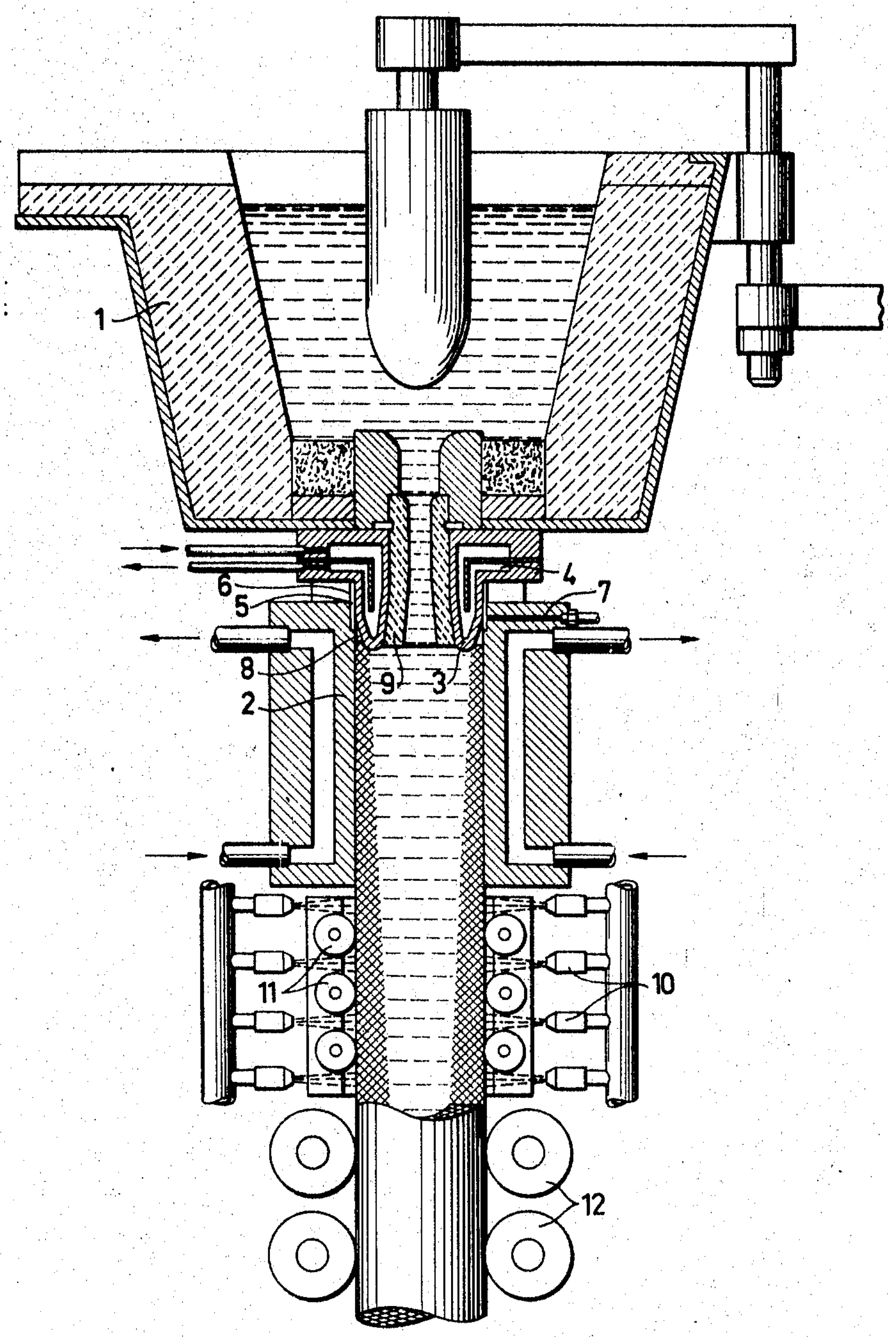
Aug. 12, 1969

E. A. OLSSON

3,460,609

NOZZLE FOR SUPPLYING MELT TO A MOULD IN A CONTINUOUS CASTING MACHINE

Filed July 23, 1965



INVENTOR

Erik Allan Olsson

BY Christy, Parmelee & Strickland

ATTORNEYS

United States Patent Office

3,460,609
Patented Aug. 12, 1969

3,460,609

NOZZLE FOR SUPPLYING MELT TO A MOULD IN A CONTINUOUS CASTING MACHINE

Erik Allan Olsson, Oerlikonerstrasse 88, Zurich, Switzerland

Filed July 23, 1965, Ser. No. 474,280
Claims priority, application Sweden, July 23, 1964, 8,980/64
Int. Cl. B22d *11/04, 11/10, 11/12*
U.S. Cl. 164—281 4 Claims

ABSTRACT OF THE DISCLOSURE

This application discloses a continuous casting apparatus wherein metal is delivered from a receptacle through a nozzle into the upper end of a reciprocating mould. The mould is arranged for the introduction of lubricant into its upper end and the nozzle slidably projects into the upper end of the mold. The nozzle has a water-cooled metal exterior portion in the form of a hollow annulus for sliding engagement with the mould. Provision is made for the escape of gas generated by the lubricant upwardly between the nozzle and the mould, and in addition the nozzle has a lower terminal portion of decreasing overall diameter so as to taper away from the mould wall. The water-cooled metal annulus has a refractory sleeve passing therethrough which insulates the molten metal passing through the nozzle from the water-cooled surfaces and prevents premature cooling of this metal.

In vertical continuous casting, the molten metal is supplied to one end of an open-ended mould while the solidified or at least partly solidified material is simultaneously withdrawn from the opposite end of the mould. When iron or steel or other high-melting metals are cast, complete solidification occurs outside of the mould, because the heat conductivity of the metal is too low to enable it to solidify completely within the mould at the rate of withdrawal of the strand which is required to obtain an economically satisfactory casting capacity. The casting strand is usually advanced by means of driving rolls disposed below a cooling zone. Having passed the driving roll, the casting strand can be cut to desired lengths directly or bent to a substantially horizontal direction, whereupon it is straightened out again and then cut to desired lengths. Systems wherein driving and bending are achieved by means of the same apparatus have also been proposed as well as casting in a curved mould, in which case the cooling zone beyond the mould is formed as a circular arc. After the casting strand has been brought to a substantially horizontal direction, it is straightened by means of a combined straightening and driving mechanism.

In all the cases mentioned above, the rate of supply of molten metal and the rate of withdrawal of the casting strand must be coordinated so as to keep the level of molten metal in the mould substantially constant. Too great a rate of supply of molten metal in relation to the rate of withdrawal will, of course, result in overflowing of the mould, and too rapid withdrawal of the strand in relation to the rate of supply of molten metal will result in a lowering of the metal level in the mould, possibly to an extent such that breakthrough occurs below the mould.

In horizontal or inclined continuous casting plants wherein open-ended moulds are used, the molten metal must, of course, be supplied in some other manner, usually by means of some kind of closed system. When casting low-melting metals, the molten metal will usually be supplied by inserting the mould, which is preferably made of graphite, into a wall of the receptacle for molten metal,

whereby the metal flows automatically into the mould in a rate determined by the rate of withdrawal of the solidified casting strand. Attempts have been made to cast high-melting metals in the same way but it was found highly difficult to avoid bridging at the mould edges in the entrance opening. While several different horizontal continuous casting machines are in operation for non-ferrous metals, no horizontal casting machine for iron or steel has found practical use, due to the above and other difficulties.

The present invention relates to a nozzle for supplying molten metal to the casting passage of a continuous casting mould, enabling molten metal to be supplied to a horizontal or inclined mould as well as to the moulds of conventional vertical continuous casting plants. In the latter case, the use of the invention reults in an automatic supply of molten metal at a rate adapted to the rate of withdrawal to which the machine is adjusted. This makes it unnecessary to employ an operator for controlling the level of the metal surface by adjusting the supply of molten metal and/or the rate of withdrawal of the casting strand. The invention is further applicable to the casting of iron and steel as well as other high melting metals in machines having a horizontal or inclined mould.

Several suggestions for solving the problem referred to have been made, but have found no practical use, at least for the casting of iron or steel. One difficulty resides in the necessity of lubricating the mould in the area of the casting passage opening where molten metal strikes the mould wall. To achieve an efficient lubrication of this mold portion the mould is usually subjected to an oscillating or reciprocating movement, whereby the mould surface is periodically exposed for efficient lubrication. The lubricating oils used for this purpose are partly vaporized and partly burnt. A closed system for supplying molten metal will of course make it difficult to lubricate the mould wall efficiently, and in addition the vaporization of lubricant which occurs as the lubricant contacts the molten metal may cause dangerous explosions or at least result in a high gas pressure at the supply end of the mould so that too little or no metal flows after the strand as it is withdrawn.

When nozzles of ceramic material are used and the nozzle is in close contact with the wall, further difficulties occur, such as bridging of the strand skin over the joint between the nozzle and the mould and rupture of the nozzle in consequence of mechanical and thermal stresses.

The metal supplying nozzle of this invention which is characterized in that it is made from metallic material preferably copper, and has coolant passages, withstands said thermal and mechanical stresses. By making the front nozzle end, which enters the mould, conical or at least such that a rearwardly tapering clearance is formed between the nozzle and the mould wall, sticking of solidifying metal is prevented. Due to the fact that the clearance narrows rearwardly and the metal entering it is cooled from two sides, the entrance into the clearance will not be deep, since the surface tension of the molten metal increases strongly with decreasing temperature. Since the pouring opening widens toward the mould, bridging of any solidifying metal skin which may be present in this portion, is prevented. The nozzle engages the mould wall with an easy sliding fit, which per se would not permit a sufficiently rapid removal of vapors or gases formed by the lubricant. Therefore, orifices or passages for venting such gases are provided along the circumference of the nozzles. These passages or orifices may be bores or longitudinal grooves in the sliding surfaces, said grooves defining passages together with the mould wall as outer defining surfaces. The greater the number of grooves, the better is the possibility of the gases formed of rapidly leaving through the mould opening. However, the cross-sectional area of said orifices should not be so great that molten metal may enter them. Thus, the cross-sectional area of each individual groove should not exceed 2 mm.^{2}, whereby the surface tension and the relatively rapid cooling of the molten metal prevent entry of the metal. The gas pressure occurring as a result of vaporization of the lubricant through particular passages, in the nozzle contributes to the same action, said passages being adapted to open in the sliding surfaces as close to the front edge of the nozzle as possible.

It will of course be difficult to position the nozzle and mould so that sliding between the mould wall and the nozzle is not prevented. Even the best possible positioning when the apparatus is cold, may result in jamming at the start of the casting operation or during the casting operation when various thermal stresses are set up in the system. Therefore, the sliding surfaces of the nozzle should be made as short as possible and slightly spherical, whereby an exact parallelism between the axes of the mould and the casting nozzle will not be so highly critical as when the sliding surfaces are long and straight.

For a better understanding of the invention, reference is made to the accompanying drawing, wherein the single figure shows a vertical central cross-section through a continuous casting machine having a nozzle in accordance with this invention.

Referring to the drawing more in detail, there is shown a receptacle **1** adapted to hold molten metal, a water-cooled open-ended mould **2** and a nozzle **3** according to this invention provided in a bottom opening of the metal receptacle **1** and extending into the top end of the mould **2** to allow metal to flow from the receptacle into the mould. Passages for supplying coolant to the nozzle are shown at **4**, and the sliding surfaces **5** of the nozzle are formed with grooves **6**, forming passages for allowing gases and vapors to leave. A lubricant is supplied through bores **7** in the top end of the mould preferably above the uppermost portion of clearance **8** and will gasify or vaporize as it contacts the hot metal whereby a gas pressure is built up in a rearwardly tapering clearance **8** defined by the forwardly tapering front end of the nozzle and the top inner wall of the mould said gas pressure preventing entrance of metal into the grooves **6** provided for the flow of gases or vapors out of the mould. Each groove **6** has one end communicating with the space or clearance **8** and the other end communicating with the exterior of the mould. The angle between the mould wall and outer wall of the lower end of water cooled annulus **4** within the space or clearance **8** is preferably acute. Fitted into the pouring orifice of the nozzle is a ceramic sleeve **9**, the bore of which widens conically similar to the nozzle so that a satisfactory admission of metal is obtained even if a tendency for the metal to solidify in this region obtains. The nozzle is conically flared over a substantial portion of the length of the tubular ceramic or refractory sleeve **9** in contact with the hollow annulus **4**, and the conically flared portion terminates at the lower end or terminal of the sleeve **9**. During the casting operation, the mould **2** is moved in a reciprocating manner, whereby the lubrication of that portion of the mould inner wall which is struck by molten metal is improved and the same mould portion obtains intermittently a short recovery period. The alternation of the molten metal contacting surfaces of the mould wall can also be achieved by vertical oscillation of the nozzle **3** and the receptacle **1**, but the method of oscillating the mould has been found more satisfactory in practice.

In some cases it has been found more advantageous to lubricate the front end of the nozzle, before the casting operation is started, with a composition which reduces the tendency of the molten metal to adhere.

The embodiment shown in the figure comprises a cooling zone having water-spraying nozzles **10** and roller sets **11** provided between the mould and driving rollers **12** for the casting strand. When a nozzle according to this invention is attached to a receptacle and extends into the mould opening in the manner disclosed, the rate of withdrawal can be adjusted to any desired value, molten metal flowing automatically into the mould **2** from the receptacle **1** at a corresponding rate. This constant rate of withdrawal enables the cooling intensity in the cooling zone to be kept at a constant value. Thus, the invention eliminates the necessity of providing either manual or automatic means for controlling the rate of supply of molten metal to the mold or the withdrawal of the strand and for controlling the cooling intensity.

From the foregoing it will be seen that the outer part of the nozzle is a hollow water-cooled metal annulus for sliding contact with the mould, this annulus at its free terminal decreasing the overall outside diameter providing a clearance space of upwardly-decreasing diameter between said terminal and the mould wall, molten metal flowing out of the nozzle and into the exterior space between the mould wall and annulus **4** will be reduced in temperature by cooling both the water cooled mould **2** and the water cooled annulus **4** to reduce the temperature of the molten metal and prevent further penetration of the metal into the space **8**, but will not be reduced sufficiently to solidify. The refractory sleeve **9** lining the passage through the annulus keeps the molten metal from prematurely cooling by insulating it from contact with the water-cooled annulus.

Although the invention has been exemplified as employed in a continuous casting machine having a straight vertical mould, it will be obvious for those skilled in the art that the invention is not limited thereto, the same advantages being obtainable when using the nozzle of this invention in continuous casting machines having inclined or horizontal moulds as well as in those having curved molds. The invention is not limited to the embodiment disclosed but can be varied in many ways without departing from the spirit and scope of the invention.

What is claimed is:

1. Continuous casting apparatus comprising in combination:

(a) a metal holding receptacle,

(b) an open-ended mould with inlet and discharge ends,

(c) a nozzle for conducting molten metal from the receptacle to the mould, the nozzle having its upper end connected with a vessel and its lower terminal portion projecting into and slidably fitted into the inlet end of the mould,

(d) the mould having means at its inlet end for introducing lubricant into the mould,

(e) the nozzle having a water-cooled annulus forming the exterior thereof and having a tubular refractory sleeve passing therethrough through which the molten metal flows from the receptacle into the mould and out of direct contact with the water-cooled annulus,

(f) the lower terminal portion of the annulus inside the mould being of decreasing external diameter providing a space of upwardly-diminishing section between said terminal portion and the surrounding mould wall, and

(g) elongated gas escape passages disposed at intervals around the nozzle, each having one end communicating with the exterior of the mould.

2. Continuous casting apparatus as defined in claim **1** wherein each of said elongated gas escape passages do not substantially exceed 2 mm.^{2} in section.

3. Continuous casting apparatus as defined in claim **1** wherein the angle between said surrounding mould wall and said lower terminal portion of the annulus is acute, whereby molten metal flowing out of the nozzle and entering said space of upwardly-diminishing section between the mould wall and annulus will be reduced in temperature by cooling from both said mould and said water-cooled annulus to reduce the temperature and increase the surface tension of said molten metal to thereby prevent further penetration of said metal into said space while effectively preventing premature cooling of the molten metal within said tubular refractory sleeve by contact with the water-cooled annulus.

4. Continuous casting apparatus as defined in claim 1 wherein said means for introducing lubricant into said mould are disposed at a higher elevation than the uppermost portion of said space of upwardly-diminishing section.

References Cited

UNITED STATES PATENTS

3,040,396	6/1962	Hudson	164—173

FOREIGN PATENTS

1,208,851	9/1959	France.
509,012	2/1952	Belgium.
134,401	8/1960	U.S.S.R.
688,955	3/1953	Great Britain.
1,290,962	3/1962	France.
1,140,675	12/1962	Germany.

J. SPENCER OVERHOLSER, Primary Examiner

ROBERT D. BALDWIN, Assistant Examiner

U.S. Cl. X.R.

164—73, 283