METHOD OF HANDLING AND REPLACING POURING TUBES OF A CONTINUOUS CASTING APPARATUS

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References Cited

UNITED STATES PATENTS

3,430,644 3/1969 Lyman........................................ 137/329.06
3,499,587 3/1970 Brock........................................ 222/545 UX
3,743,007 7/1973 Simons et al. ......................... 164/281

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ABSTRACT

A method of handling and replacing pouring tubes used for pouring molten metal from a supply vessel into a mold of a continuous casting machine wherein a pouring tube is positioned beneath and in alignment with an outlet of the supply vessel and beneath the surface of a pool of metal in the mold for the purpose of conducting molten metal from the supply vessel into the mold. A replacement pouring tube is positioned at a location removed from the outlet of the vessel and in a position preparatory for exchange of the aforementioned pouring tube located in casting position beneath the outlet of the vessel. Upon the need to replace the pouring tube located in casting position beneath the outlet of the vessel the pouring tubes are displaced along a path such that as the pouring tubes are moved the pouring tube which is beneath the outlet of the vessel is moved out of alignment with said outlet and the replacement pouring tube is moved into alignment with such outlet.

9 Claims, 6 Drawing Figures
METHOD OF HANDLING AND REPLACING POURING TUBES OF A CONTINUOUS CASTING APPARATUS

CROSS-REFERENCE TO RELATED CASE

This is a divisional of our commonly assigned, co-pending U.S. application, Ser. No. 82,750, filed Oct. 21, 1970, now U.S. Pat. No. 3,743,007, and entitled "Continuous Casting Apparatus with Inter-Changeable Pouring Tubes".

BACKGROUND OF THE INVENTION

The present invention broadly relates to the continuous casting art, and in its more specific aspects concerns a new and improved method of handling and replacing pouring tubes used for pouring molten metal from a supply vessel into a mold of a continuous casting machine or apparatus without interrupting the continuous casting operation.

When operating such continuous casting machines, it is known to feed molten metal into a tundish from which location the molten metal then flows into the mold cavity of the continuous casting mold. The metal is supplied to the tundish from a ladle. In the continuous casting of steel, the molten metal may be poured into the mold by submerging the lower end of the pouring tube into the molten metal bath within the continuous casting mold. This procedure has been found to be very advantageous, particularly in reducing oxidation of the molten steel.

With the trend towards increasing weights per heat, and with the introduction of sequential casting, casting times have been substantially prolonged with consequently greater wear on the pouring tubes. As a result, signs of erosive destruction at the pouring tube within the bore and in the region of the outlet, are found after relatively short casting times. This is especially prevalent when manganese-alloy steel is cast. Additional erosion is found — when the immersible pouring tubes penetrate through the surface of the molten metal in the mold and when the surface is covered with a layer of casting powder — in the regions of contact of the pouring tube with the surface of the molten metal.

It is hardly necessary to emphasize the disadvantageous nature of such erosion effects. Frequently, the pouring tubes will break at the thus-weakened regions with resultant entrainment of contaminants into the liquid core of the cast strand and oxidation of the steel. Furthermore, the flow pattern of the molten metal becomes changed when such breaks occur — irrespective of whether they are partial or total — and this leads to the conveyance of contaminants into deeper regions of the liquid core.

Desirably, therefore, it should be possible to replace weakened or fractured pouring tubes in a simple and rapid manner, in order to avoid the problems which result from such fracture while at the same time avoiding expensive downtime of the casting apparatus to the maximum extent possible.

SUMMARY OF THE INVENTION

It is, accordingly, an object of the invention to overcome the above disadvantages and to provide the desirable advantages which have been outlined.

More particularly, it is an object of the invention to provide an improved method of handling and replacing pouring tubes in continuous casting apparatus of the type under discussion which affords these advantages for the continuous casting apparatus while not being possessed of the listed disadvantages.

Another object of the present invention is to provide a method of handling and replacing pouring tubes used for pouring molten metal from a supply vessel into a mold of a continuous casting machine in a manner permitting replacement of a weakened or defective pouring tube with another pouring tube, without requiring any shutdown of the casting apparatus so that for all practical purposes the continuous casting operation proceeds without interruption.

Yet a further object of the present invention is to provide a method of handling and replacing pouring tubes of continuous casting apparatus in a manner wherein it is not only possible to exchange the pouring tubes in an extremely efficient and reliable manner, but simultaneously components of the flow-regulating device controlling the flow of molten metal out of a supply vessel into the continuous casting mold.

Now in order to implement these and still further objects of the invention, which will become more readily apparent as the description proceeds, the method aspects of this development for handling and replacing pouring tubes used for pouring molten metal from a supply vessel into a mold at a continuous casting machine contemplates positioning a pouring tube beneath and in alignment with an outlet of the supply vessel and beneath the surface of a pool of metal in the mold for conducting molten metal from the supply vessel into the mold. A replacement pouring tube is positioned at a location removed from the outlet of the vessel and in a position preparatory for exchange of the pouring tube located in casting position beneath the outlet of the vessel. Upon the need to replace the pouring tube located in casted position beneath the outlet of the vessel, the pouring tubes are displaced along a path such that as the pouring tubes are moved, the pouring tube which is beneath the outlet of the vessel is moved out of alignment with said outlet and the replacement pouring tube is moved into alignment with such outlet.

According to the invention, the pouring tubes are moved substantially in unison along the aforementioned path. Since the pouring tube which is beneath the outlet of the supply vessel can be moved out of alignment with such outlet and the replacement pouring tube moved into alignment with such outlet, it will be appreciated that accordingly one pouring tube can be exchanged for another without interrupting the actual casting operation. It is, in fact, possible to automate the exchange operation and the individual steps involved may be made to overlap in time, so as to further shorten the period required for completing the exchange, necessitating an interruption of metal flow into the mold for less than 30 seconds, and thus making it possible to carry out normally the exchange without having to interrupt the continuous casting process.

Connecting and disconnecting of the pouring tubes and the outlet of the supply vessel, typically a tundish, can be facilitated by making both the pouring tubes and the tundish movable relative to one another, particularly in the direction of metal outflow. To prevent the occurrence of leaks between the pouring tube and tundish, and to assure reliable sealing engagement of one with the other, independently of possible tolerances in their relative movements, resilient means, typically
spring means, may press the relevant pouring tube towards the outlet of the tundish.

It is desirable that the pouring tube being removed (as defective, weakened, etc.) be withdrawn quickly to make room for its replacement. To facilitate this, the pouring tube may be mounted in or on a guide track which advantageously rises from the level of the tundish outlet. It is particularly advantageous to connect the track with the tundish.

When slabs are cast in the apparatus, and when therefore the slab mold has a correspondingly large-dimensioned width, the pouring tubes may be guided in a path — for movement into and out of the mold inlet with their respective lower portions — which is accurately curved in an upright plane. It is then advantageous to connect the correspondingly curved guide track provided for this purpose, with the stationary steel structure and to mount the tundish so that it can be raised and lowered with reference to the mold.

According to a further aspect of the invention, there can be provided means for regulating the outflow of the molten metal through the outlet of the tundish. In conventional manner, this can be accomplished by varying the unobstructed cross-sectional area of the outlet. However, according to the invention, this means is not necessarily provided on the tundish, but instead may be displaceable as a unit with the pouring tube relative to the outlet. In this manner all components of the apparatus which are subject to weakening or damage under the afore-described conditions, can be readily replaced to thus further increase the number of sequential casts obtainable with the tundish.

The path in which the pouring tubes move to and from the operating position in which they communicate or are in alignment with the outlet of the supply vessel, may be determined by providing a mounting means with arms which are turnable about an upright — usually vertical — axis and which each carries a holding arrangement for holding one of the pouring tubes. It is especially advantageous to mount the arms on a pin or shaft which is journaled on the supply vessel itself, for example the tundish, and also can be adjusted to raise and lower the arms with reference to the outlet. The holding arrangements themselves may, however, be turnable with reference to the respective arms and may be arrestable against turning when the longitudinal axis of a pouring tube which they hold has a horizontal or substantially horizontal orientation. This makes it possible to keep the vertical displacement of the supply vessel or tundish within very small limits, or even to avoid it entirely.

If a pouring tube is moved into operating position in cold state, with the term here being used in its relative sense as is obvious when one considers that the apparatus operates with molten metal, deleterious thermal stresses may occur in the fire and heat-resistant material of the pouring tubes. Also, the molten metal, such as steel, may solidify and block their interior passage, especially when the inner diameter is small. To avoid this, the invention also contemplates the provision of pre-heating means for pre-heating the pouring tube which is in standby position, in other words, a replacement pouring tube which is located remote from the outlet of the supply vessel or tundish prior to placing such into casting position beneath such outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and objects other than those set forth above, will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings showing various exemplary embodiments of apparatus useful for the practice of the method aspects of this development and wherein:

FIG. 1 is a view in vertical section through one embodiment of apparatus designed according to the invention for practicing the inventive method;

FIG. 2 is a similar view, but through another embodiment of the invention;

FIG. 3 is a section taken on line III—III of FIG. 2;

FIG. 4 is a view similar to that of FIG. 1, but of yet an additional embodiment;

FIG. 5 is a section taken on line IV—IV of FIG. 4;

and

FIG. 6 is a section taken on line VI—VI of FIG. 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing firstly the embodiment of FIG. 1, it will be seen that reference numeral 1 identifies a supply vessel, such as typically a tundish, which can be raised and lowered as indicated by the double-headed arrow. The tundish 1 possesses an outlet 2 which is provided with a flow-regulating device, here shown as a slide valve 3, by means of which the flow of molten metal, such as steel, — shown within tundish 1 but not particularly identified with a reference numeral — can be varied and stopped as desired. A pouring tube 5, which may also be called an immersible pouring tube or casting nozzle, is in operative position in which it conducts the steel from the outlet 2 of tundish 1 into the illustrated continuous casting mold 4 to a point below the surface of the molten steel within such mold. In addition, the pouring tube protects the steel against oxidation during travel from the tundish 1 to the mold 4, and the lateral outlets or outlet passages 6 which are immersed below the level of metal in the mold and through which metal can flow out, provide for improved flow patterns in the liquid core.

It can be seen from the drawing that the outlets 6 of pouring tube 5 are located below the surface of the molten steel. In this manner, molten steel can be conveyed into the mold 4 without being affected or contaminated by the ambient air.

A holding element 7 is turnable about the pivot axis or shaft 8 and holds the pouring tube 5 which is retained, as shown, by a conically tapering inner surface 9 of the holding or holder element 7 which prevents it from downward movement, and by outwardly pivotable retaining arms 10 which prevent it from upward movement.

A resilient means, for instance spring 11, urges or biases the pouring tube holding element 7 with the retained pouring tube 5 towards the outlet 2 of the supply vessel or tundish 1, pressing this pouring tube 5 thereagainst when the holding element 7 and the pouring tube 5 are in the illustrated operative position where the pouring tube 5 communicates with the inlet of the continuous casting mold 4 below the surface of the metal. The spring 11 assures proper sealing between pouring tube 5 and outlet 2 even during play in the lifting or descending movement of the tundish 1. Such
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movement, incidentally, can be accomplished with any known means suitable for the purpose and known to those skilled in the art.

In addition to the pouring tube 5, there is provided another pouring tube, identified with numeral 5'. This other pouring tube 5' is to be rapidly substituted at such time as weakening of pouring tube 5 makes this desirable, or when fracture of pouring tube 5 makes this step imperative.

For this purpose, the replacement pouring tube 5' is retained in a holder or holding element 7' which is turnable or rotatable about a pivot axis or shaft 8'; it is shown in FIG. 1 in its standby position. The holding elements 7 and 7', and therefore the pouring tubes 5 and 5', are connected by conveyor chain means 12 having runs provided with rollers 13 and located at opposite lateral sides of the elements 7 and 7'. A guide arrangement or guide means 14 is provided which defines a path in which each chain 12 can travel. As the drawing shows, the path rises upwardly from a level below the outlet 2 of tundish 1.

Reference numeral 15 identifies a portion of a frame or otherwise stationary component of the apparatus, and the guide arrangement 14—composed of two substantially U-profiled elements of the type shown—is made fast with component 15 at opposite lateral sides of tundish 1. It is emphasized that such rigid connection is possible only when the inlet of the mold is wide so that the lower end of the pouring tube can move into and out of the mold 4—see the broken line arrow—without requiring lifting of the guide arrangement 14. Of course, no problem exists if the lower end of the pouring tube does not actually extend into the liquid core.

When the pouring tube 5 is to be replaced with the replacement pouring tube 5', the slide valve 3 is first operated to cut-off the flow of metal. The tundish 1 is raised to separate the outlet 2 from the pouring tube 5 and a non-illustrated conventional drive of a suitable type, for example mechanical or hydraulic, is operated to advance the chain structure and to thereby displace the pouring tubes 5 and 5' in unison in the curved path defined by guide arrangement 14, as indicated by arrow 16. As a result of this, pouring tube 5 moves out of operating position while pouring tube 5' moves into operating position and can be placed into alignment or flow communication with the outlet 2 of the tundish 1. This takes place during and without interruption of the casting process, i.e., while there is still liquid molten steel moving through the mold 4. Thereupon the tundish 1 is lowered until outlet 2 sealedly engages pouring tube 5', and the outlet is reopened via slide 3. The defective pouring tube is removed from its holding element 7 and replaced with a new one, so that the replacement action can be repeated when pouring tube 5' requires substitution except that the movement will then be in the opposite direction from the direction shown by arrow 16.

In the embodiment of FIGS. 2 and 3, a supply vessel, namely tundish 21, is connected with an arcuate guide track or track arrangement 22 via cylinder and piston units 23. This permits raising and lowering of track arrangement 22 relative to tundish 21 in the direction of outflow of the molten metal. In operative position, the pouring tube 5 is again pressed against outlet 2, but here by the units 23. The tundish 21 itself may be raised and lowered to permit insertion and removal of the lower end of pouring tube 5 in the mold 28. Means for raising and lowering of tundish 21 may be of any known type and are therefore not shown.

Here also a replacement pouring tube 5' is provided for standby purposes. A carriage 29 is movable on rolls 33 in guide track arrangement 22 and is provided with cylinder and piston units 26 which hold the pouring tube 5' in place.

In addition, there is provided a preheating device 24 which is movable in the direction of arrow 27 and which is also only shown in diagrammatic form inasmuch as such is well known to those active in this field and having routine knowledge. The preheating device 24 is associated with and serves for heating of the replacement pouring tube 5'. Of course, if more than one standby pouring tube is provided, more than one preheating device 24 may also be provided, if desired. Its purpose has been discussed earlier, and the device 24 is primarily useful when the pouring tubes are thick-walled and consist, for example, of clay graphite. In this manner, the standby or replacement pouring tube, in this case the pouring tube 5', can be preheated to a desired uniform temperature before it is mounted on carriage 29, or—and in certain circumstances this may be advantageous—the heating can take place while the pouring tube 5' is already connected with the carriage 29.

In this embodiment, exchange of pouring tube 5' for pouring tube 5 is initiated by closing outlet 2 via a stopper or plug 38 which may be manipulated in known manner from outside the tundish 21. Now the units 23 are operated to lower track arrangement 22 in order to separate pouring tube 5 from outlet 2, while at the same time the tundish 21 is raised (together with the track arrangement 22) in order to lift the lower end of pouring tube 5' from the mold 28.

Once this is done, the carriage 29 is advanced in the direction of arrow 30 through 90° by suitable non-illustrated mechanical, hydraulic or other means. The units 23 now lift the track arrangement to sealingly press pouring tube 5 against outlet 2, and it is parenthetically pointed out that suitable dimensioning of the units 23 makes it possible to pre-select this pressure so that the units 23 can additionally act as hydraulic springs. Now the tundish 21 together with track 22 is lowered until pouring tube 5' is immersed in the liquid core of mold 28 to the desired depth below the surface of the molten steel, whereupon plug 38 is removed and metal flows again to the mold. Of course, if the inlet is wide, or if the pouring tube does not extend into the metal bath, raising and lowering of the tundish 21 and of the track arrangement 22 is not necessary, although the movement in track arrangement 22 alone is still needed.

Details of the track arrangement 22 are shown in the sectional view of FIG. 3 where it will be seen that two stationary track ring portions 31 are each provided with four rollers or wheels 32 which serve to retain and guide carriage 29 in guides 33. The carriage 29 is composed of two angle-profiled rings 34, connected by ribs 35 which not only serve to provide carriage 29 with the requisite strength and stability, but also support the units 26 for the pouring tubes 5, 5'.

Coming, finally, to the embodiment of FIGS. 4—6, it will be seen that here the pouring tubes 5 and 5' can be displaced in unison with respective flow-regulating de-
vices for the outlet 63 of a supply vessel, for instance the tundish 61.

Reference numeral 64 identifies a guide which supports pouring tube 5 in operative position, together with an apertured sliding plate 65. A similar plate 65' and the standby or replacement pouring tube 5' are in standby position, held in a guide 64' which is pivotally connected with guide 64 as shown.

As Figs. 5 and 6 show, pouring tube 5 is mounted in a plate 72 which is pivotable on guides 73 about a pivot shaft or axis 74, with reference to plate 65. The purpose of this arrangement, in which movement of plate 72 can be caused, for instance, by means of a laterally mounted cylinder and piston unit 76 which can be coupled to a transmission lever 75, is to permit regulating the flow of steel through the outlet 63.

When the unit consisting of plate 65 and pouring tube 5 is to be replaced, then plate 72 is pivoted to close the outlet 63. Now the tundish 61 is raised and the guides 64' and 64'' are swung downwardly about the pivot axes or shafts 68 so that they move to positions in which they are horizontally aligned with the guide 64. A cylinder and piston unit 66 pushes the pouring tube 5' and plate 65' from the guide 64 into the guide 64, and simultaneously displaces pouring tube 5 and plate 65 from guide 64 into guide 64'. Therefore, the guides 64' and 64'' are swung upwardly to the position shown in Fig. 4 (with the new position of pouring tube 5 shown in broken or phantom lines) and the flow of molten metal through the outlet 63 is restored.

Of course, it should be understood that individual features of one of the embodiments could be provided for other embodiments to the extent that the same are compatible. Thus, for instance, the preheating means for heating the replacement pouring tube, as indicated in the embodiment of Fig. 2, could also be provided for any of the other embodiments. With the teachings of the invention, it will be recognized that the pouring tube which is beneath the outlet of the vessel, and for instance which must be replaced because it is damaged or otherwise defective, can be moved out of alignment with the outlet of the supply vessel and the replacement pouring tube can be moved into alignment with such outlet, without the need to interrupt the continuous casting operation. Furthermore, the damaged pouring tube can then be replaced for a new one during such time as the casting operation proceeds, and therefore the system is again ready to quickly carry out a new replacement operation for the pouring tube located in casting position beneath the outlet of the supply vessel when the need arises.

While there is shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto, but may be otherwise variously embodied and practiced within the scope of the following claims.

Accordingly, What is claimed is:

1. A method of handling and replacing pouring tubes used for pouring molten metal from a supply vessel into a mold of a continuous casting machine without interrupting the continuous casting operation, comprising the steps of positioning a pouring tube beneath and in alignment with an outlet of the supply vessel and beneath the surface of a pool of metal in the mold for conducting molten metal from the supply vessel into the mold, positioning a replacement pouring tube at a location removed from the outlet of the supply vessel and in a position preparatory for exchange of the first-mentioned pouring tube located in casting position beneath the outlet of the supply vessel, and upon need to replace the pouring tube located in casting position beneath the outlet of the supply vessel, displacing the pouring tubes along a path such that as the pouring tubes are moved, the pouring tube which is beneath the outlet of the supply vessel is moved out of alignment with said outlet and the replacement pouring tube is moved into alignment with such outlet.

2. The method as defined in claim 1, further including the step of moving such pouring tubes substantially in unison along said path.

3. The method as defined in claim 1, wherein displacement of the pouring tubes is carried out in unison with respective flow-regulating devices for the outlet of the supply vessel.

4. The method as defined in claim 1, further including the step of briefly interrupting the flow of molten metal from the vessel into the mold prior to displacement of the pouring tubes.

5. The method as defined in claim 1, further including the step of briefly interrupting the flow of molten metal from the vessel into the mold prior to displacement of the pouring tubes.

6. The method as defined in claim 1, further including the step of replacing the pouring tube which has been moved out of alignment with the outlet of the supply vessel with a new pouring tube after such time as the other pouring tube has moved into a position beneath the outlet of the supply vessel.

7. The method as defined in claim 1, further including the step of preheating the pouring tube which is located removed from the outlet of the supply vessel prior to placing such into casting position beneath the outlet of the supply vessel.

8. The method as defined in claim 1, further including the step of resiliently biasing the pouring tube which is beneath the outlet of the supply vessel in the direction of such outlet.

9. The method as defined in claim 1, further including the steps wherein upon said need to replace the pouring tube located in casting position beneath the outlet of the supply vessel, during a first step closing the outlet of the supply vessel, then during a second step carrying out said displacing of the pouring tubes along a path such that as the pouring tubes are moved, the pouring tube which is beneath the outlet of the supply vessel is moved out of alignment with said outlet and the replacement pouring tube is moved into alignment with said outlet, then during a third step again opening the outlet of the supply vessel, and during a fourth step carrying out the aforesaid replacing of the pouring tube which has been moved out of alignment with the outlet of the supply vessel by a new pouring tube after such time as the replacement pouring tube has moved into a position beneath the outlet of the supply vessel.