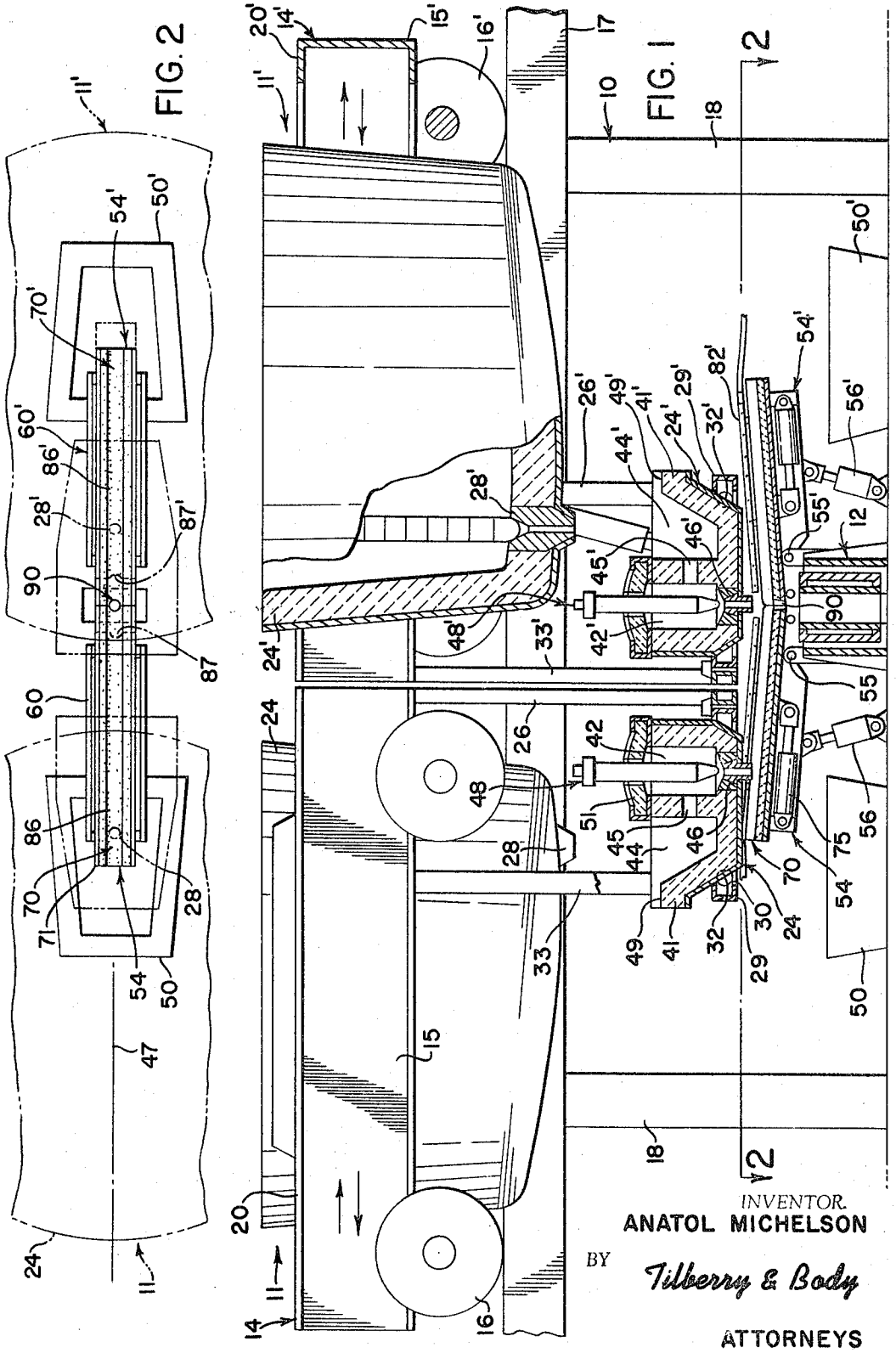
May 14, 1968 A. MICHELSON 3,382,913

APPARATUS FOR UNINTERRUPTED CONTINUOUS CASTING

Filed Aug. 25, 1965 2 Sheets-Sheet 1



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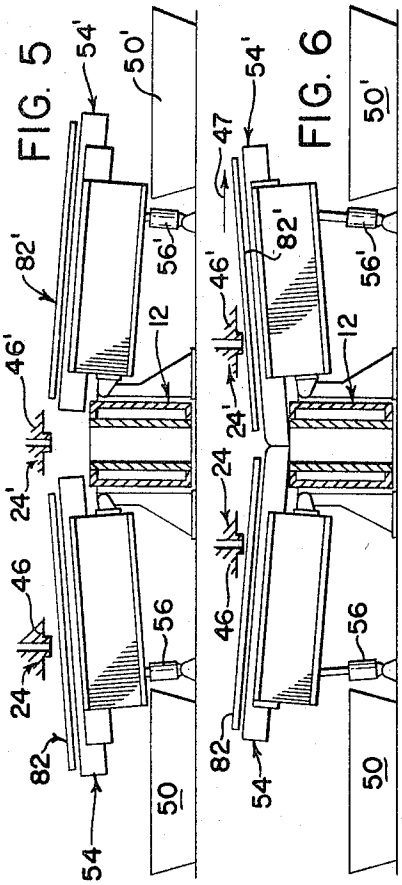

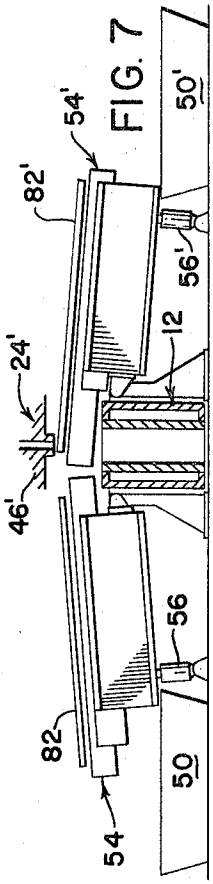

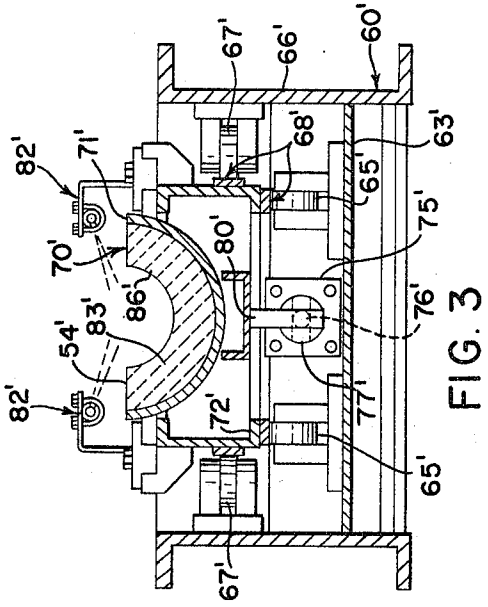

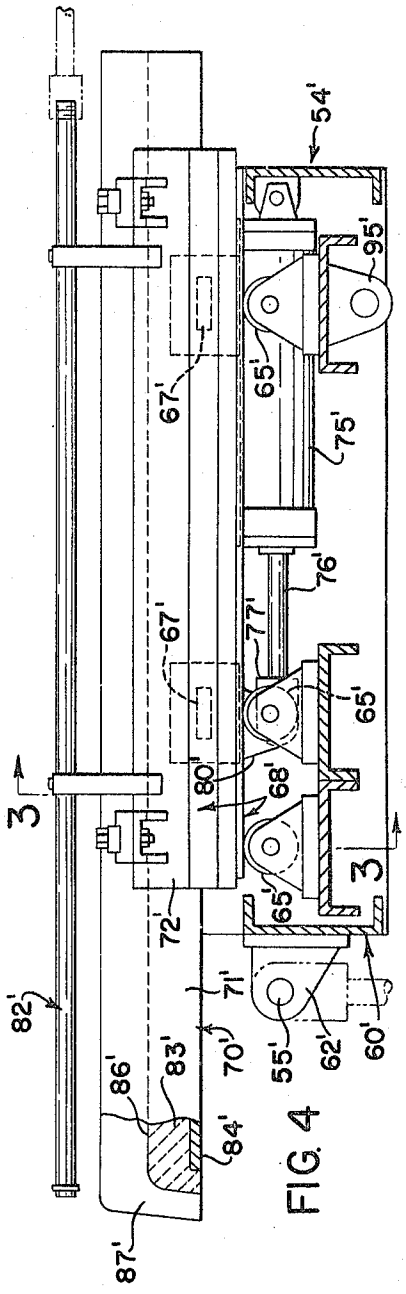

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United States Patent Office 3,382,913 Patented May 14, 1968

3,382,913

APPARATUS FOR UNINTERRUPTED CONTINUOUS CASTING

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Filed Aug. 25, 1965, Ser. No. 482,360
5 Claims. (Cl. 164—281)

ABSTRACT OF THE DISCLOSURE

This disclosure pertains to the art of continuous casting and more particularly to apparatus for supplying molten metal to a casting mold without interruption. In the disclosure a pair of tundishes is adapted to contain a quantity of molten metal to be cast. Each tundish is movable along a common line of movement intercepting the mold. The line of movement extends from a pouring location above the mold in opposite directions to idle positions on either side thereof. As one tundish is in the pouring location supplying metal to the mold, the other, a full one, is in an idle position alongside. An open trough extends outwardly from the mold axis along the line of movement above the mold. The trough is inclined toward the mold so as to direct the flow of metal into the mold. During the transition movement of the tundishes, the full for the empty between the idle and pouring positions, the molten metal is conducted to the mold from the full tundish by the trough until such time as its location coincides with the pouring position vacated by the empty tundish. The disclosure further contemplates a trough extending outwardly in opposite directions on each side of the mold so that pouring may commence from either tundish from the idle position. Also, either or both troughs may be pivoted adjacent the mold so that its outer end can be tilted below the top of the mold or extended laterally to interrupt flow to the mold so as to discard metal from either tundish when desired.

The invention will be described with particular reference to a method and apparatus for pouring molten ferrous metals such as steel into a continuous casting mold, however, it should be appreciated that it has much broader applications and is equally applicable to the gravity feeding of other liquid substances where the procedure is to hold the liquids in reserve in batch form until intended for use and then to sequentially feed individual batches without interruption of flow.

In continuous casting installations ladles of molten metal are usually not poured directly into the mold. Instead they are tapped into an intermediate vessel referred to in the trade as a tundish located between the ladle and the mold. From the tundish, molten metal is metered into the top of the mold at a rate approximately equal to the rate an ingot is withdrawn from the bottom.

In the casting of ferrous metals such as steel for example, the combination of a high casting temperature, chemical attack and physical erosion on the refractory parts of the ladles and tundish permit a continuous run of only about one hour before the casting cycle is interrupted. The interruption occurs mainly because the nozzle and stopper head of the tundish must be replaced. Their service life usually does not exceed 60 minutes with existing refractory materials. This short service life causes interruptions in the continuous casting process which consumes about 50 percent of the available time.

The present invention contemplates a method and apparatus for overcoming this problem by permitting an interval during the casting cycle in which the ladle and tundish may undergo repairs without interrupting casting operations.

In accordance with the broadest aspect of the invention, the method proceeds by metering a stream of liquid at a fixed pouring location from a substantially full container and associated intermediate vessel, shifting the container and vessel together relative to the pouring location before they become empty, conducting the liquid stream to the previous pouring location by gravity flow means and starting a metered flow of liquid from another full container and intermediate vessel shortly before flow diminishes from the first container and vessel so as to supplement the diminishing liquid stream therefrom, whereby the total metered flow requirements are maintained while the first container and intermediate vessel are allowed to become empty.

More particularly, where the liquid is a molten metal and the containers and intermediate vessels are refractory lined ladles and tundishes and the pouring location is a continuous casting mold, the arrangement is such that one ladle and tundish is in a discharge position directly supplying the mold while the other is in an idle position alongside and the ladles and tundishes are supported for movement relative to the mold so as to be shifted in tandem back and forth above the mold.

Further in accordance with the invention, in combination with the tundishes is an apparatus for conducting the liquid stream of molten metal to the mold by gravity flow means which includes refractory trough members mounted between the mold and tundishes and extending outwardly in alignment with the path of movement of the tundishes, the trough members being inclined so that their lower ends are at the pouring location over the mold while their upper ends extend beneath one or both of the tundishes.

Further in accordance with the invention, the trough members include two inclined trough sections each of which extends from adjacent the mold outwardly in opposite directions along the line of movement of the tundishes, the inner adjacent ends of each section having a mating cutout portion to define a circular pouring opening aligned with the pouring location of the mold.

Where it is desirable to divert a portion of the metered flow entirely away from the mold, a trough section is pivotally mounted adjacent the mold so that its outer end can be tilted below the top of the mold.

It is also desirable to conduct metal through the trough members when a fresh ladle and tundish are initially tapped to carry away refractory debris which may be present and therefore in addition to being pivotally mounted, the trough sections are mounted on trackways so as to be movable rectilinearly beneath the pouring location.

The principal object of the invention is to provide a method and apparatus for continuously feeding a metered stream of liquid from a liquid source that is constituted as a plurality of separate containers.

Another object is to provide a new and improved method for feeding a continuous casting mold whereby part of the refractory pouring apparatus is idle while another part is supplying the mold and the parts alternate positions so as to permit replacement and repair without halting the casting cycle.

These and other objects will be more fully appreciated by referring to the following description and drawings wherein:

FIGURE 1 is a partial sectional view showing a tandem tundish and ladle arrangement as embodied in the invention and as applied to the pouring of a continuous casting mold;

FIGURE 2 is a plan view taken along line 2—2 of FIGURE 1 showing the principal pouring position of the apparatus in FIGURE 1;

FIGURE 3 is a cross-sectional view of a portion of

the apparatus in FIGURE 1 taken along line 3—3 of FIGURE 4 showing a trough member used to feed the mold during the transition of the apparatus between pouring positions;

FIGURE 4 is a side view of the trough member;

FIGURE 5 is a schematic view depicting the relative pouring positions of the apparatus when one tundish is supplying the full mold requirements;

FIGURE 6 is a schematic view similar to FIGURE 5 depicting the relative positions when the apparatus is shifted in accordance with the invention; and

FIGURE 7 is a view which illustrates the position of the apparatus when a portion or the entire flow to the mold is to be diverted.

Referring to the drawings wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only and not for the purpose of limiting same, FIGURE 1 shows the upper portion only of a continuous casting installation **10** utilizing standard bottom pour ladles **11, 11'** to supply molten metal to a conventional water cooled continuous casting mold **12**. While not shown, it will be appreciated that the casting installation **10** extends vertically below the mold **12** and would include the usual guide rolls, pulling mechanism, cooling apparatus, and cutting equipment for handling the cast ingot being withdrawn from the bottom of the mold **12**.

The ladles **11, 11'** are held in separate pouring sections **14, 14'** each of which is movable along rails **17** supported on stanchions **18** above the mold **12**. Preferably the pouring sections are connected together for movement in unison, however they may be separated if desired and their movements correlated. Since the sections **14, 14'** are substantially the same in construction a description with respect to one will be understood as applying equally to the other and like parts will be identified by like numerals with the addition of a prime mark. With respect to the pouring section **14**, on the left as viewed in FIGURE 1, a carriage **15** is provided having bogies **16** guided on rails **17** for movement toward and away from the mold **12**. The carriage **15** has an upper platform **20** adapted to support the ladle **11** in a bottom dropped position. The ladles are of the off-center pour type. A tundish **24** is postiioned below ladle nozzle **28** and is supported on a hanger **26** depending from the carriage **15**. The hanger **26** includes a floor **29** having an opening **30** over which the tundish **24** is pivotally mounted as indicated at **32**. The tundish **24** has a refractory lining **41** which defines a closed pouring chamber **42** and an open basin **44** communicating with each other through a port **45**. Basin **44** is positioned directly below the ladle nozzle **28**. Pouring chamber **42** has a nozzle **46** for discharging a metered flow of molten metal into the mold **12** as controlled by a stopper **48**. A lip **49** in the edge of basin **44** is aligned with a slag pot **50** for draining off accumulations of slag so the level of pure metal is always above the port **45**.

In accordance with the invention, with the pouring sections **14, 14'** in substantially abutting relationship as shown in FIGURE 1, the tundish nozzles **46, 46'** have a given spacing along the line of movement **47** such that when one nozzle is over the mold in a discharge position, the other one is in an idle position adjacent the mold. Associated with each pouring section **14, 14'** is a trough member **54, 54'** pivoted adjacent opposite sides of mold **12** at **55, 55'** and extending outwardly from the mold in opposite directions along the line of movement **47**. The trough sections **54, 54'** are operated on hydraulic cylinders **56, 56'** in connection with the tundishes **24, 24'** to conduct molten metal to the mould **12** in a manner to be described hereinafter. Since the trough members **54, 54'** are substantially similar, a description as to one will be understood as applying equally to the other and as before, like parts will be identified by like numerals with the addition of a prime mark.

Referring now to FIGURES 3 and 4, trough member **54'** includes a generally rectangular frame **60'** carrying a bracket **62'** for pivotal mounting of the trough member at **55'** adjacent the mold as shown in FIGURE 1. The frame **60'** supports bottom guide rollers **65'** and side guide rollers **67'** which cooperate to define a longitudinal trackway, generally indicated by numeral **68'**, within the frame **60'**. A refractory chute **70'** is constructed on a channel **71'** supported by a box member **72'** adapted to be reciprocally guided in the trackway **68**. Supported within the frame **60'** is a fluid cylinder **75'** having an operating rod **76'** pivotally connected to a bracket **80'** carried by the box member **72'** for extending or retracting the chute **70'** on the trackway **68'**. A semicircular cutout portion **87'** at the inner end of chute **70'** mates in a complementary fashion with a semicircular cutout portion **87** of the companion chute **70** of trough member **54** to define a circular pouring opening **90** (FIGURE 2) aligned with the mold axis when the chutes **70, 70'** are in extended position as shown in FIGURES 1, 2 and 6. A pair of gas burners **82'** extend longitudinally along each side of chute **70'** and are connected to a suitable source of combustible gas, such as natural gas, to heat the metal stream and prevent excessive oxidation. The fluid cylinders **56, 56'** raise or lower the trough members **54, 54'** so that the outer ends of the chutes **70, 70'** are above the top of the mold **12** in one position as shown best in FIGURES 1 and 6 or are lowered below the mold in a second position as shown in FIGURES 5 and 7.

A more complete understanding of the operation of the invention may be had by referring to the following description. Briefly, the method of operation involves pouring from one ladle until it is nearly empty and before its supply of metal is exhausted, bringing up a fresh ladle and beginning to pour from it so as to continue supplying the total requirements. The change from one ladle to the next is accomplished without interrupting the metered flow of metal to the mold.

Starting at some time while casting is in progress with the position of the apparatus as shown in FIGURE 1, let it be assumed that ladle **11'** has nearly exhausted its supply of metal and ladle **11** which is substantially full of metal, has just been brought up and placed on carriage **15** but has not yet been tapped. The chutes **70, 70'** are in the extended and elevated position as shown in FIGURE 1. The circular pouring opening **90** formed by the mating inner ends of the chutes **70, 70'** is slightly larger than the full flow cross section of the molten metal stream being emitted from the tundish nozzle **46'** and when aligned with the nozzle, the metal enters the mold directly.

Before the metal supply from ladle **11'** is completely exhausted, pouring sections **14, 14'** are moved in tandem slowly to the right, as viewed in FIGURE 1, relative to the mold **12** such that the tundish nozzles **46, 46'** are displaced along the line of movement **47** as depicted in FIGURE 6. Due to the fact that the outer ends of the chutes **70, 70'** are elevated above the mold, the stream of metal from nozzle **46'** will continue to flow to the mold **12** at the original pouring location as presently maintained by the opening **90**.

When the flow diminishes from nozzle **46'**, ladle **11** is tapped and initial flow from nozzle **46** is begun to supplement the diminishing flow from nozzle **46'**, so as to maintain the total metered flow requirements of the mold. Gas burners **82, 82'** are ignited as metal begins to flow in the chutes **70, 70'** to keep the casting temperature of the metal streams at the proper level and to provide a reducing blanket of gas to prevent oxidation of the molten metal. As the metal supply diminishes from ladle **11'** the slag level in basin **44'** of tundish **24'** reaches port **45'**. At this point, stopper **48'** is closed. To compensate, the stopper **48** of tundish **24** is opened sufficiently wide to continue supplying the total mold requirements. The pouring sections **14, 14'** continue to move to the right until tundish nozzle **46** occupies the original pouring location vacated by nozzle **46'**. Now gas to the burners **82, 82'** is shut off

and the cylinders 75, 75' and 56, 56' are retracted moving chutes 70, 70' to the retracted and lowered position shown in FIGURE 5. Tundish 24' may then be pivoted on hanger 26' at 32' so as to empty any remaining metal and slag into the slag pot 50'. The empty ladle 11' is picked up and carried to a melting furnace to receive a fresh batch of metal or is taken to a repair area where it is reconditioned. With the tundish 24' in the idle position a fresh tundish can be installed or relining and reconditioning carried on while casting proceeds from tundish 24.

If during any portion of the casting cycle an emergency arises while nozzle 46 or 46' is in the pouring location directly over the mold, either chute 70 or 70' can be extended completely under the tundish nozzle to divert the entire stream of metal from the mold and into a slag pot 50 or 50' as depicted in FIGURE 7.

As may be appreciated from the above description, the process continues by bringing a full ladle with new tundish to replace the empty one and moving the pouring sections 14, 14' in the opposite direction before the flow diminishes thus supplying an uninterrupted metered flow of metal to the mold 12.

Having thus described a preferred embodiment of the invention and its method of operation it will be appreciated that various modifications and changes may be made which would be obvious to those skilled in the art without departing from the invention as defined by the appended claims except insofar as they are limited by the prior art.

I claim:

1. A continuous casting installation comprising

a mold adapted to receive a continuous supply of molten metal,

a pair of pouring vessels each containing a supply of molten metal to be cast movable on a common line of movement intercepting the mold, which line of movement extends from a pouring location above the mold in opposite directions to idle positions on either side thereof such that as one vessel is in the pouring location supplying a metered flow of metal to the mold, the other is in an idle position alongside and

elongated means extending outwardly from adjacent the mold along the line of movement beneath the pouring vessel in the idle position, said means opening upwardly along said line of movement and inclined toward the mold for receiving and directing the flow of metal from said vessel into the mold during movement thereof relative to the elongated means whereby the mold is continuously supplied with a metered flow of molten metal during the transition of vessels between the idle and pouring locations.

2. A continuous casting installation according to claim 1 wherein the elongated means comprises a pair of trough members extending outwardly in opposite directions along the line of movement from adjacent the mold whereby pouring from either vessel may commence in the idle position.

3. A continuous casting installation according to claim 2 wherein one of said trough members is pivotally mounted adjacent the mold so that its outer end can be tilted below the top of the mold for discarding any portion of the flow from the vessel.

4. A continuous casting installation according to claim 2 wherein the adjacent inner ends of each trough member are in abutting relationship above the mold and have complementary semicircular openings to define a gravity flow pouring opening coinciding with the mold axis.

5. A continuous casting installation according to claim 2 wherein one of said trough members comprises

guide means defining a longitudinal trackway intersecting with the mold which is pivoted adjacent thereto for movement in a vertical plane and

a refractory channel is received on said guide means and is longitudinally movable thereon beyond the mold axis, the opposite end being tiltable below the top of the mold on said pivot whereby the metal flow may be diverted away from the mold.

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