Aug. 9, 1960 R. EASTON 2,948,030

METHOD AND APPARATUS FOR THE CONTINUOUS CASTING OF MOLTEN METAL

Filed March 13, 1957

3 Sheets-Sheet 1

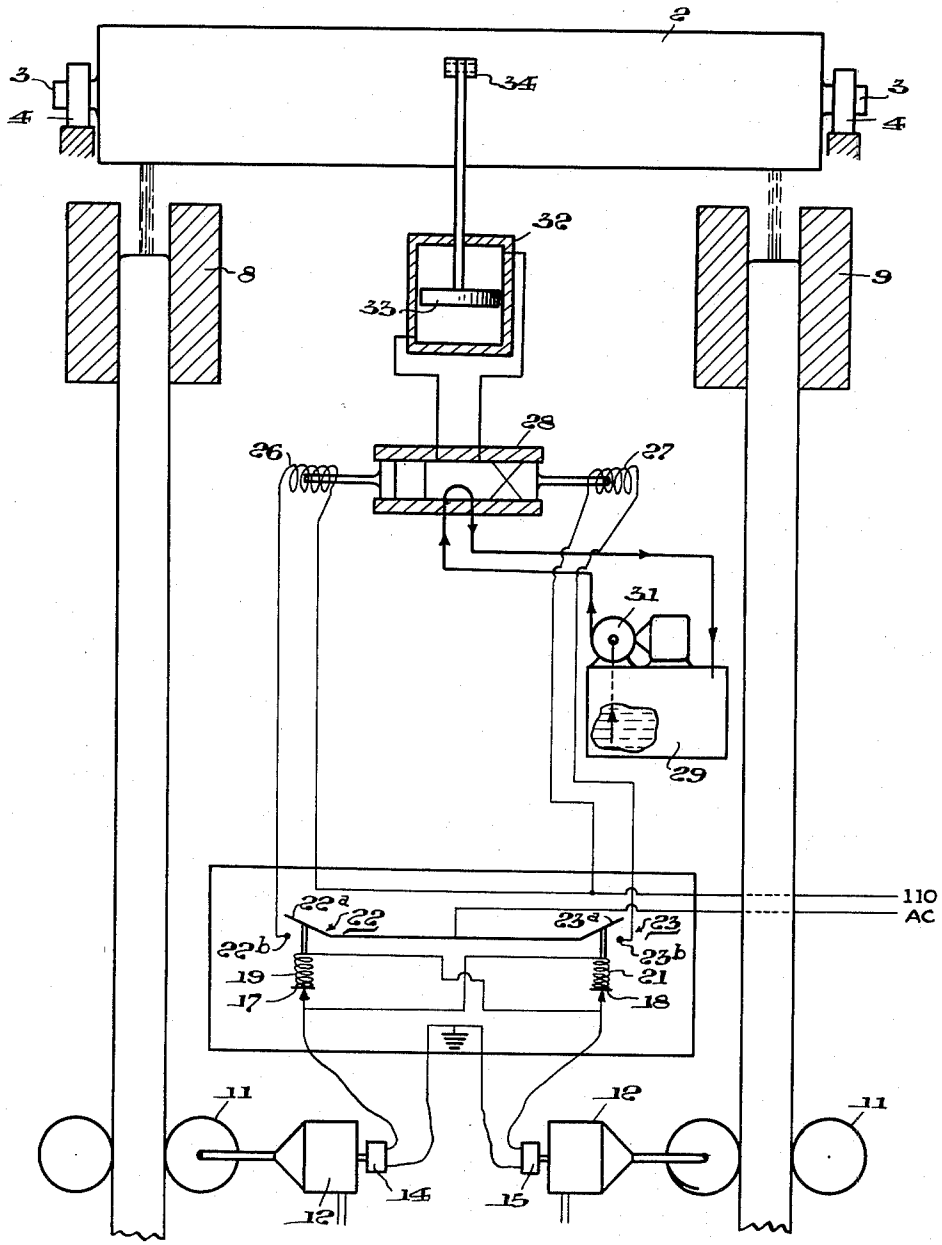


Fig. 1.

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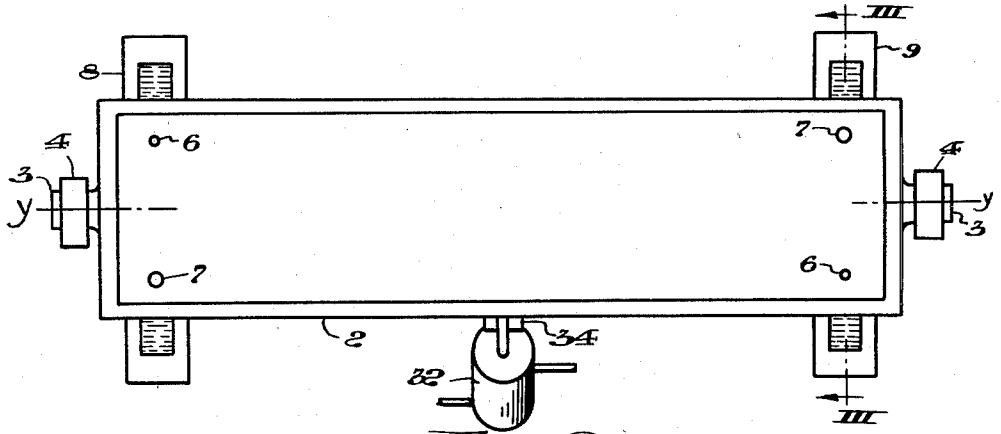


Fig. 2.

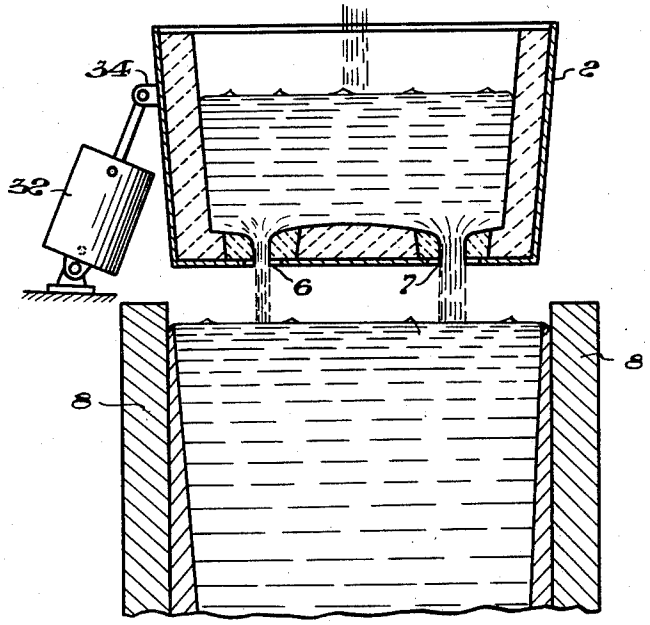


Fig. 3.

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METHOD AND APPARATUS FOR THE CONTINUOUS CASTING OF MOLTEN METAL

Filed March 13, 1957 3 Sheets-Sheet 3

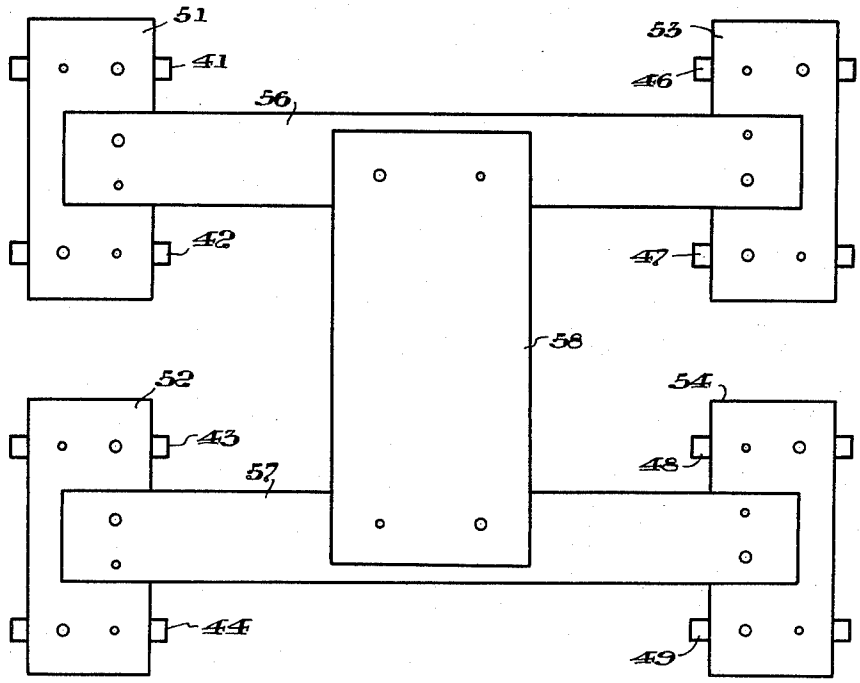


Fig. 4.

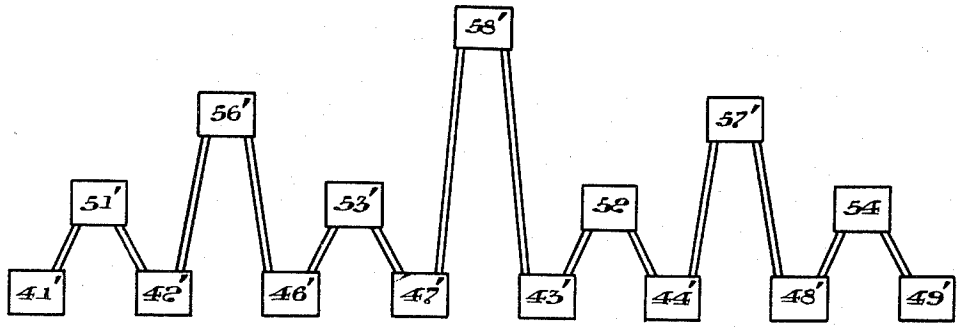


Fig. 5.

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2,948,030

METHOD AND APPARATUS FOR THE CONTINUOUS CASTING OF MOLTEN METAL

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3 Claims. (Cl. 22—57.2)

This invention relates to continuous casting and more particularly to a method and apparatus for the continuous casting of molten metal in two or more strands simultaneously.

In the continuous casting of multiple strands of molten metal, it is desirable to cast the strands from the tundish means into molds at controlled rates of speed and it is frequently desirable to cast the strands at identical rates of speed to facilitate the subsequent cutting of the strands into billets and the discharge of such cutoff billets. In the past, the frequently occurring and uncontrolled deviations in the sizes of the strand pouring outlets of the tundish means from their initial pouring sizes have caused the strands to run at uncontrolled relative rates of speed, resulting in subsequent cutting and discharging difficulties. Further, the distribution of the proper amount of molten metal to each of the strands, which has been accomplished by means of manually controlled tilting launders, runners, or tundishes, has become increasingly difficult with increased casting speeds, and the required constant attention of the operators to metal distribution has resulted in either the neglect of other duties or necessarily the costly addition of further operators to a specific work force.

The present invention avoids the abovementioned disadvantages, providing an efficient and accurate apparatus and method for automatically controlling the distribution of molten metal in the continuous casting of two or more metal strands.

The present invention further provides a method and apparatus wherein the continuous casting of two or more strands of molten metal can be accomplished from a single tundish without a sudden flow of metal from one end of the dundish to the other, thus permitting a safer and more accurate means of making small metal flow adjustments during casting operations.

Various other features of the present invention will become obvious to one skilled in the art upon reading the disclosure set forth hereinafter.

More particularly, the present invention provides a method of continuously casting molten metal comprising pouring molten metal strands from spaced pouring stations having regulatable rates of metal pour into spaced open-ended mold zones beneath the pouring stations, withdrawing the solidifying metal strands from each of the mold zones, sensing the rate of metal withdrawal from each of the mold zones, comparing the sensed rates of metal withdrawal, and regulating the rates of metal pour from the pouring stations in accordance with the rates of withdrawal from the mold zones to provide a selected relative rate of casting from the mold zones. The present invention further provides apparatus for continuously casting molten metal which comprises tiltable tundish means, spaced pouring outlet means in the tundish means, spaced open-ended mold means positioned beneath the outlet means, strand withdrawal means positioned beneath each of the open-ended mold means, sensing means for sensing the rate of strand withdrawal, power means connected to the tundish means to tilt the same, and control means connecting the sensing means with the power means for tilting the tundish in accordance with the sensed rates of strand withdrawal.

It is to be understood that various changes can be made in the arrangement, form and construction of the apparatus set forth herein and in the several steps of the method set forth herein without departing from the scope or spirit of this invention.

Referring to the drawings:

Figure 1 is a schematic elevation view of an apparatus for continuously casting molten metal which incorporates an advantageous embodiment of the present invention;

Figure 2 is an enlarged top plan view of the tundish and mold arrangement schematically disclosed in Figure 1;

Figure 3 is an enlarged cross-sectional, elevation view of the tundish and mold arrangement of Figure 2 taken in a plane passing through line 3—3 of Figure 2;

Figure 4 is a schematic plan view of a multiple arrangement of tundishes and molds like that disclosed in Figures 1–3;

Figure 5 discloses a schematic arrangement of control mechanism for the multiple arrangement of Figure 4;

Referring to Figures 1–3 of the drawings, tiltable tundish 2 is disclosed supported from trunnions 3 which are journaled for rotation in bearing boxes 4. As can be seen more fully in Figure 2, the tundish 2 has a substantially oblong shaped horizontal cross-sectional area and the trunnions 3 are located along the shorter sides of the tundish so that the tundish is tiltable about its major axis Y—Y.

Tundish 2 is provided with metal pouring outlet means arranged to provide pouring outlets on opposite sides of axis Y—Y. The outlet means includes two small outlets or nozzles 6 and two large outlets or nozzles 7 with a large and small outlet being positioned on each side of axis Y—Y. It is to be noted that each of the large outlets 7 on either side of the tilting axis is substantially in alignment with one of the small outlets 6 on either side of the tilting axis to thus form two sets of aligned large and small outlets. With such an arrangement, the longitudinal axes of the aligned large and small outlets in each set fall in a common plane, which plane is substantially normal to the tilting axes Y—Y of the tundish 2. In the advantageous embodiment of the invention disclosed, small outlets 6 are of equal size to each other and large outlets 7 are of equal size to each other.

Situated beneath the outlet means of tundish 2 are two spaced open-ended molds 8 and 9. These molds can be any one of several types well known in the art and are so positioned that each receives molten metal strands simultaneously from one of the sets of aligned small and large outlets 6 and 7 of the tundish 2. With the arrangement described, any small variations in the rate of flow of metal into the molds can be obtained by tilting the tundish about its axis Y—Y, such tilting motion increasing the flow of metal to one mold while decreasing the flow of metal to the other mold. Since the tilting is effected about the major axis Y—Y of the tundish, no sudden and lengthy flow of metal from one end of the tundish to the other occurs and, with the resulting freedom from sloshing, a steadier and more accurate manner of making slight adjustments in casting speeds is provided.

In a typical example of apparatus incorporating the features of the invention described above, a tundish can be provided having a capacity of about five (5) tons of molten metal with the bottom cross sectional dimensions of the tundish being approximately 30" by 100" and with the tundish having large outlets or nozzles of 1⅛" in diameter and small outlets or nozzles of ⅞" in diameter. The aligned large and small outlets on either side

of the tilting axis can be spaced 24" apart from each other with a distance of approximately 96" between outlets on the same side of the axis.

In operation, the metal level in the tundish can be maintained at about 12" above the outlets when the tundish is level, the metal flow from each set of aligned large and small outlets into each mold being about 2405 lbs. of metal per minute under such conditions. When the tundish is tilted 10° one way, the one mold would receive 2400 lbs. of metal per minute and the other mold 2500 lbs. of metal per minute.

When the tundish is tilted 10° the other way, the first mold would receive 2500 lb. of metal per minute and the second strand would receive 2400 lb. of metal per minute, the tundish being tilted one way or the other in varying amounts in accordance with the rates of withdrawal of the strands issuing from the molds to effect a balanced pouring into the molds. It will be obvious that such a method of balancing is difficult to accomplish manually, particularly when the speed of casting is great. Accordingly, the present invention provides, in addition to the tundish and casting features aforedescribed, an automatically controlled system for tilting the tundish in accordance with the rates of withdrawal of the solidifying metal strands from their respective molds.

As can be seen in Figure 1 of the drawings, the strand withdrawal means for each mold 8 and 9 includes a separate set of pinch rolls 11, each set being driven by a variable speed motor 12 connected thereto. Separate sensing means is connected to each of the variable speed motors, such sensing means including a tachometer-generator set 14 responsive to the speed of the motor for the pinch rolls positioned under mold 8 and a tachometer-generator set 15 responsive to the speed of the motor for the pinch rolls positioned under mold 9. The tachometer-generator sets 14 and 15 are connected to each other in selective series through rectifiers 17 and 18 and solenoids 19 and 21. Solenoids 19 and 21, in turn, are arranged to control normally open switches 22 and 23 respectively, the switches having armatures 22*a* and 23*a* respectively and contacts 22*b* and 23*b* respectively. The switches 22 and 23 are included in a circuit in such a manner as to be connected in series respectively with the parallel connected solenoids 26 and 27. Accordingly, the closing of switch 22 is effective to actuate solenoid 26 and the closing of switch 23 is effective to actuate solenoid 27. The solenoids 26 and 27 are connected to opposite ends of a hydraulic selector valve 28, the position of valve 28 being determined by energization of one of the solenoids 26 and 27. This selector valve 28 serves to control the direction of fluid flow in a fluid circuit which includes fluid supply tank 29, motor driven pump arrangement 31 and power cylinder 32. The power cylinder 32 has a movable piston 33, one end of piston 33 being attached to lug 34 integral with one side of tundish 2.

In a typical operation of the apparatus described above, assuming that the strand through the open-ended mold 8 is moving faster than the strand in the open-ended mold 9, the tachometer-generator 14 will have a greater voltage output than tachometer-generator 15. As a result, current flows through rectifier 17 to energize solenoid 19 and close normally open switch 22. When this occurs, solenoid 26 is actuated and the selector control valve 28, which is normally centered, is moved to a position which causes fluid to be directed to the lower end of hydraulic cylinder 32. This causes piston 33 in cylinder 32 to move upwardly and tilt tundish 2 about trunnions 3 to lower the smaller outlet 6 and raise the larger outlet 7 of the aligned outlet set over mold 8, resulting in a greater head of metal over small outlet 6 and a lesser head of metal over the larger outlet 7 of the outlet set. Accordingly, there is a slowing down of metal pour to mold 8. At the same time the larger outlet 7 of the outlet set over mold 9 is lowered and the small outlet of such set is raised to increase the metal head over the larger outlet of the set and decrease the metal head of the small outlet of this set. As a result, there is an increase of metal pour to mold 9. With such an arrangement, tundish 2 is automatically tilted one way or the other, keeping the rate of speed of strand withdrawal from molds 8 and 9 substantially equal.

It is to be understood that the automatic control arrangement described herein is not limited in its use to the specific tundish set forth in Figures 1–3 of the drawings. For example, the automatic control system disclosed can be used with a single, conventional, tiltable bottom pouring tundish having only single molten metal outlets on either side of the tilting axis or with separate tundishes of the well known lip pouring type, each of which tundishes cooperates with its own mold positioned therebelow. It also is to be understood that the automatic control system itself can be varied depending upon the circumstances involved. For example, in instances where the pinch rolls are driven by motors having electronic speed controls, the basic sensing for the tundish tilting control can be accomplished directly from the electronic speed controls to eliminate possible time lags created by motor inertia. Further, the automatic control arrangement can be employed in multiple casting operations where more than just two strands are involved, as is set forth hereinafter.

Referring to Figure 4, a multiple strand casting arrangement is schematically disclosed as embodying eight strands and advantageously utilizing tiltable tundishes of the aligned large and small outlet type as disclosed in Figures 1–3. To receive the eight molten metal strands, eight (8) separate and spaced molds are employed, these molds being designated by the reference numerals 41, 42, 43, 44, 46, 47, 48, and 49. Positioned above the molds are four tiltable tundishes 51, 52, 53, and 54, tundish 51 cooperating with molds 41 and 42, tundish 52 with molds 43 and 44, tundish 53 with molds 46 and 47, and tundish 54 with molds 48 and 49. Tundishes 51 and 53, in turn, are positioned below a larger tundish 56 and tundishes 52 and 54 are positioned below a like tundish 57. Finally the largest tundish 58 is positioned above tundishes 56 and 57.

Referring to Figure 5, it can be seen that to tilt tundish 58 it is only necessary that the power and control system 58′ for this tundish, which system can be like that disclosed in Figure 1, be connected to sensing devices for two of the strands. In this connection, it is preferable that system 58′ be connected to two sensing devices, one of which sensing devices cooperates with a strand which receives its metal from tundish 56 and the other of which devices cooperates with a strand which receives its metal from tundish 57. In the advantageous embodiment of the invention disclosed, 58′ is shown connected to sensing devices 43′ and 47′ for strands emanating from molds 43 and 47 respectively. In like manner, it is only necessary that the power and control systems 56′ and 57′ for tundishes 56 and 57 respectively be connected to sensing devices for two of the strands, the control systems 56′ and 57′ also being like that disclosed in Figure 1. For control system 56′, it is preferable that one of the sensing devices to which it is connected be one co-operating with a strand which receives its metal from tundish 51 and the other be a device cooperating with a strand which receives its metal from tundish 53. For control 57′ it is preferable that one of the sensing devices to which it is connected be one cooperating with a strand which receives its metal from tundish 52 and the other be a device cooperating with a strand which receives its metal from tundish 54. Accordingly, it can be seen in Figure 5 that control 56′ is connected to sensing device 42′ for the strand emanating from the mold 42 and to sensing device 46′ for the strand emanating from the mold 46. Control system 57′ is connected to sensing device 44′ for the strand emanating from the mold 44 and sensing device 48′ for the strand emanating from the mold 48.

Finally, to tilt tundishes 51, 52, 53, and 54 power and control systems 51′, 52′, 53′, and 54′ respectively are

provided. These systems also can be like that disclosed in Figure 1. System 51' is connected to sensing device 41' and 42' for strands emanating from molds 41 and 42 respectively, system 52' is connected to sensing devices 43' and 44' for strands emanating from mold 43 and 44 respectively, system 53' is connected to sensing device 46' and 47' for strands emanating from molds 46 and 47 respectively, and system 54' is connected to sensing devices 48' and 49' for strands emanating from molds 48 and 49 respectively.

With the above described system, it is possible to obtain an efficient and economical arrangement for casting multiple molten metal strands at selected relative rates of speed with a minimum of equipment and in a minimum of time.

The invention claimed is:

1. In apparatus for continuously casting molten metal, a tiltable tundish having a substantially uninterrupted molten metal compartment and having a substantially oblong horizontal cross sectional area, said tundish compartment providing a single source of molten metal for simultaneously forming a plurality of individual castings, said tundish being tiltable about its major axis and having metal pouring outlet means on opposite sides of said tilting axis for simultaneously pouring molten metal into said molds, said outlet means on such opposite sides of said tilting axis each including spaced small and large outlets with the large outlets on one side of said tilting axis substantially aligned with the small outlets on the other side of said tilting axis so that the axes of aligned large and small outlets lie in a common plane substantially normal to said tundish tilting axis, and spaced open-ended mold means positioned beneath said outlet means so that each mold means receives molten metal strands simultaneously from aligned large and small outlets.

2. In apparatus for continuously casting molten metal, a tiltable tundish having a substantially uninterrupted molten metal compartment and having a substantially oblong horizontal cross sectional area, said tundish compartment providing a single source of molten metal for simultaneously forming a plurality of individual castings, said tundish being tiltable about its major axis and having metal pouring outlet means on opposite sides of said tilting axis for simultaneously pouring molten metal into said molds, said outlet means on such opposite sides of said tilting axis each including spaced small and large outlets with the large outlets on one side of said tilting axis substantially aligned with the small outlets on the other side of said tilting axis so that the longitudinal axes of aligned large and small outlets lie in a common plane substantially normal to said tilting axis, said small outlets being of substantially equal size to each other and said large outlets being of substantially equal size to each other, and spaced open-ended mold means positioned beneath said outlet means so that each mold means receives molten metal strands simultaneously from aligned large and small outlets.

3. In apparatus for continuously casting molten metal, a first tiltable tundish, said first tiltable tundish providing a single source of molten metal for simultaneously forming a plurality of individual castings, said tundish having a first tiltable axis and having metal pouring outlet means on opposite sides of the tilting axis of said tundish, said outlet means on such opposite sides of said tilting axis each including spaced small and large outlets with the large outlets on one side of said tilting axis substantially aligned with the small outlets on the other side of said axis, second and third tiltable tundishes having tilting axes normal to said first tilting axis having metal pouring outlet means like said first tiltable tundish, said second and third tundishes positioned under said first tiltable tundish so that each receives molten metal strands simultaneously from aligned large and small outlets of said first tundish, and spaced pairs of open-ended mold means positioned beneath the outlet means of said second and third tundishes so that each mold means of said pairs simultaneously receives molten metal strands from aligned large and small outlets of each of said second and third tundishes.

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CERTIFICATE OF CORRECTION

Patent No. 2,948,030 August 9, 1960

Rufus Easton

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 7, for "2405" read -- 2450 --.

Signed and sealed this 4th day of April 1961.

(SEAL)

Attest: ERNEST W. SWIDER

XXXXXXXXXXX

Attesting Officer

ARTHUR W. CROCKER

Acting Commissioner of Patents