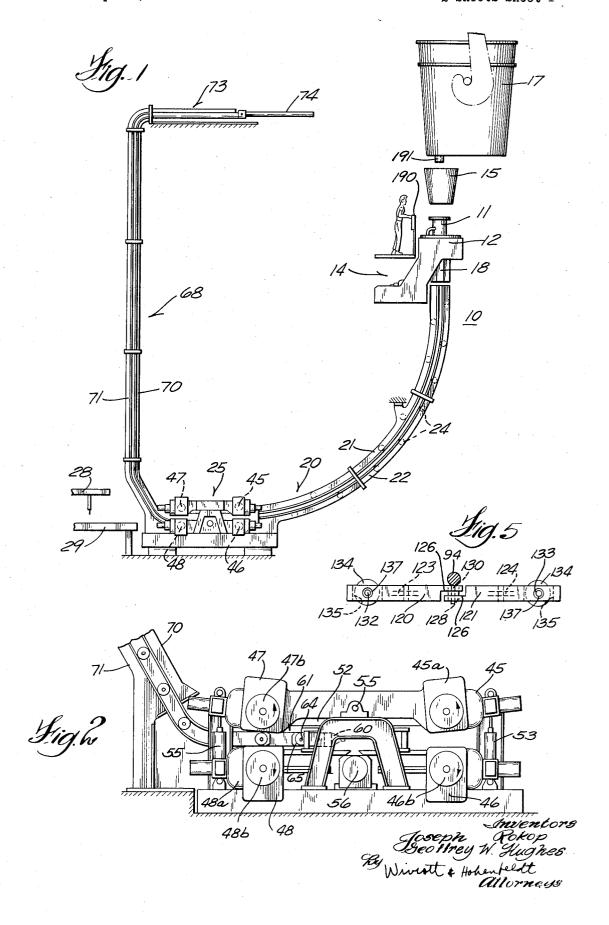
Nov. 7, 1972

3,702,154

J. ROKOP ET AL 3, CONTINUOUS CASTING MACHINE RECIPROCATION AND WITHDRAWAL CONTROL SYSTEM

Filed Sept. 3, 1970

2 Sheets-Sheet 1

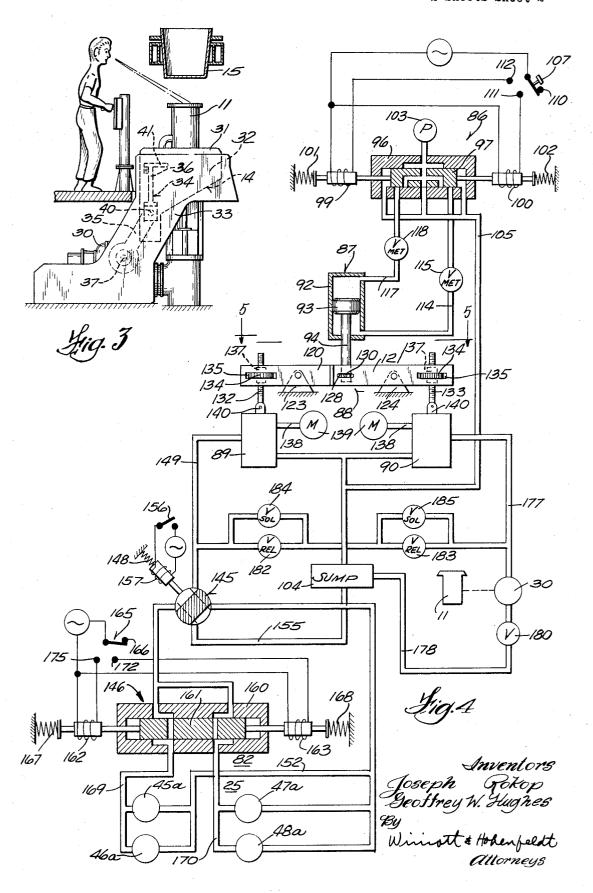


J. ROKOP ET AL 3,702,154
CONTINUOUS CASTING MACHINE RECIPROCATION AND

WITHDRAWAL CONTROL SYSTEM

Filed Sept. 3, 1970

2 Sheets-Sheet Z



United States Patent Office

3,702,154 Patented Nov. 7, 1972

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3,702,154 CONTINUOUS CASTING MACHINE RECIPROCA-TION AND WITHDRAWAL CONTROL SYSTEM Joseph Rokop and Geoffrey W. Hughes, Bethel Park, Pa., assignors to Pennsylvania Engineering Corporation Filed Sept. 3, 1970, Ser. No. 69,361 Int. Cl. B22d 11/12, 17/32

U.S. Cl. 164-

9 Claims

ABSTRACT OF THE DISCLOSURE

A continuous casting machine having a flow through mold, hydraulically driven withdrawal rollers for withdrawing a molded strand from the mold, and hydraulically tion parallel with that of strand withdrawal to insure separation of the strand therefrom during withdrawal. The withdrawal speed is selectively adjustable to correspond to the metal pouring rate and control means effects simultaneous changes in the speed of the oscillating mechanism according to a preselected proportionally constant.

BACKGROUND OF THE INVENTION

and more particularly to means for controlling the speed of strand withdrawal and mold oscillation.

Continuous casting machines generally include a flow through type mold which receives molten metal through its open intake end and shapes the same into the desired cross- 30 sectional configuration. Prior to the initiation of a casting operation, the discharge end of the mold is plugged with a head member attached to an elongate starting bar or chain, the other end of which is engaged by the withdrawal mechanism. The molten metal is transported to the casting 35 machine from a melting furnace by means of a ladle from which it is discharged into a tundish or molten metal transfer vessel disposed above the mold and having a discharge opening in its lower end positioned above the mold intake opening. After the molten metal had solidified around the head member, the latter is withdrawn from the mold by the withdrawal mechanism by acting through the agency of the starting bar. As the head member emerges from hte mold, it is followed by a continuously formed strand of $_{45}$ metal which consists of an outer skin of solidified metal which encloses a molten core. The flow of molten metal into the mold from the tundish should be compensated by a corresponding withdrawal of solidified metal from the discharge end of the mold. The pouring rate may not 50 remain uniform, however, since the molten metal tends to freeze around the tundish opening. If strand withdrawal is too slow, the molten metal in the mold will overflow onto the casting machinery which could result in damage or costly clean-up operations. On the other hand, if with- 55 drawal of the strand is too rapid, the skin of solidified metal will not be sufficiently thick whereby strand breakout is likely. It is accordingly necessary to co-ordinate the rate of strand withdrawal with the rate of metal solidification and feed rate of molten metal from the tundish.

The solidifying metal is separated from the mold by oscillating the latter rapidly in an axial direction. In order to prevent cracking, it is necessary that the separation occur when the mold is moving in the same direction as the strand and for this reason, the mold must move 65 more rapidly than the strand is being withdrawn by the withdrawal mechanism. For this reason, prior art casting machines set the oscillation rate at a value which was higher than the fastest expected withdrawal speed. This was not wholly satisfactory, however, because as the tun- 70 dish opening decreases to reduce the pouring rate, the withdrawal rate must be reduced accordingly to increase the

differences between oscillation and withdrawal rates which tends to cause undesirable skin effects on the strand.

An object of the invention is to provide a new and improved speed control means for the strand withdrawal and mold oscillating mechanisms of a continuous casting

A further object of the invention is to provide a continuous casting machine wherein strand withdrawal and mold oscillating speeds are co-ordinated.

Yet another object of the invention is to provide control means for simultaneously adjusting strand withdrawal and mold oscillating speeds in accordance with a predetermined relation.

These and other objects and advantages of the instant 15 invention will become apparent from the detailed description taken thereof with the accompanying drawings.

SUMMARY OF THE INVENTION

In a continuous casting apparatus having a mold for 20 receiving molten metal, withdrawal means for withdrawing at least partially solidified metal in a continuous strand from an opening in said mold and oscillating means for oscillating the mold to prevent the solidified metal from sticking thereto. First selectively operable control means This invention relates to continuous casting machinery 25 for controlling the speed of strand withdrawal, second control means for controlling the speed of mold oscillation and adjustment means coupled to each control means for simultaneously adjusting each in a common sense and a predetermined relation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view schematically illustrating a continuous casting machine incorporating the present invention;

FIG. 2 illustrates the strand withdrawal mechanism of FIG. 1 in greater detail;

FIG. 3 illustrates the mold oscillating mechanism of FIG. 1 in greater detail;

FIG. 4 is a schematic diagram illustrating the control mechanism according to the present invention; and

FIG. 5 is a fragmentary view taken along lines 5—5 of FIG. 4.

DESCRIPTION OF THE PREFERRED **EMBODIMENT**

Referring now to the drawings in greater detail, FIG. 1 shows a continuous casting apparatus 10 mounted on a suitable superstructure (not shown) and having a flow through mold 11. A frame 12 supports mold 11 and is coupled to an oscillating mechanism 14 for oscillating the mold 11 to prevent the strand (not shown) being cast from sticking to the mold surface as will be described more fully hereinbelow. In addition, a tundish or molten metal. transfer vessel 15 is disposed above the mold 11 for receiving molten metal from a ladle 17 and for discharging the same into the mold 11. An open ended spray chamber 18 may be mounted below and in axial alignment with the mold 11 and may include a plurality of nozzles (not shown) for spraying the strand of molten metal as it discharges from the lower end of the mold 11.

Normally, the metal strand has a relatively thin skin of solidified metal as it discharges from the mold 11 and the spray chamber causes the metal to solidify at a faster rate to form a relatively heavier skin prior to passage of the strand to a roller apron 20 positioned below the spray chamber 18. The roller apron 20 consists of a pair of spaced channel members 21 and 22 for supporting a plurality of spaced apart and staggered rollers 24 which define the curvillnear path for the strand being cast as it emerges vertically from the spray chamber 18 and enters horizontally into the withdrawal mechanism 25.

Referring now to FIG. 3, the oscillating mechanism is shown generally to include a hydraulic motor 30 of a type well known in the art and which is constructed and arranged to produce a rotational motion whose speed is governed by input flow. For example, the motion may be a fixed displacement, in-line piston motor, such as Vickers Model No. MFB20. In addition, a mold table 31 having depending sides 32 supports the mold 11 and is suitably mounted for vertical reciprocating movement on a support frame 33. A linkage assembly 34 couples the motor 30 to the mold table sides 32 and includes first and second pairs of parallel links 35 and 36. One end of links 35 are eccentrically connected to the motor output shaft 37 and are pivotally connected at their other ends to one end of links 36 by pins 40. The other ends of links 36 are suitably 15 secured at 41 to the mold table sides 32. It will be apparent that as the motor shaft 37 rotates, the mold 11 will oscillate vertically at a speed governed by the motor rotational

The withdrawal mechanism 25 is located at the lower end of the roller apron 20 for withdrawing the strand through mold 11 and discharging the same onto a work table 29 whereupon it may be cut into suitable lengths by any well known means, such as a torch 28. Assembly 25 includes a first pair of oppositely oriented entrance roller 25 the starting chain towards the entrance rolls 45b and assemblies 44 and 45 and a second pair of oppositely oriented exit roller assemblies 47 and 48. Each of the roller assemblies 45, 46, 47 and 48 includes an individually driven hydraulic motor 45a, 46a, 47a, and 48a, each of which is constructed and arranged to rotate drive rolls 30 45b, 46b, 47b, and 48b, respectively connected to their output shafts at a speed and in a direction governed by the . Ann an aite at a characht aigh a tha a charachta a chuir a charachta a chuir a charachta a chuir a charachta v Whene wilder & Did MVIFAO Middled spikeder cemt, it firlings of "I hould be revery ally a raised its disease asserbly by the facilities to be beginned to is inigialities especiation an experience direct Eurands chable there. t apper ersaenendels : 454 brand' l'Ana remount et le lafante une en el 1 o ic bipote a rarsi & 16 Luair & 15 Perpspeintely, yil (Filydralic io ipisto a an adr. dy bizhitede a sasocial losi e 505 à reu e copaç de dot al rea é o se naisc A (of teachers to first errors of 1.5 h acres 2 2 for operating the reassance a countried proportion in 1866 countries on their support the mater of 180. As att classel skielled nit belief to will i approcesses et de se pressere concerned to the second of the by the tensor such and and its divided on an diposton as abliques $\mathbf{s}_{i,j}$ SESA Australigationique orbite d'étaine vel·les bateile debannement les e i orkelnemas seebly lyzions estudois in avyavelny kyl dérécete desce a sotte nel i l to taxatralizantem choronal at sandras at at nongogous croat or arona de f a contration property and above a sees of the contration of the contration as a contration of the cont

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chain rollers 65 will engage the channel members 70 and 71 so that the starting chain 61 will be directed upwardly through the storage assembly 68 as the withdrawal mechanism 25 operates to draw the starting chain 61 and the end of the strand being formed from the mold 11. As will be more fully described in copending application Ser. No. 69,045, filed Sept. 2, 1970 and assigned to the assignee of the instant invention, as the starting member 61 approaches the exit rolls 47, the free end of the starting chain will be engaged by a latch assembly 73. A hydraulic mechanism 74 raises the end of the starting chain 62 away from the withdrawal mechanism 25 and the end of the chain 61 uncouples from the starting member 60 which then continues through an opening (not shown) in the storage mechanism 68 and onto the work table 28.

When it is desired to initiate a subsequent casting operation after the initial operation has been terminated, a new starting member 60 is suitably coupled to the end of the starting chain 61 and the latter is lowered by the hydraulic mechanism 74 until the chain 61 is between the exit rolls 47b and 48b whereupon their associated hydraulic cylinder 53 is pressurized to clamp chain 61. The chain latch assembly 73 is then disengaged and the exit rolls 47b and **48**b are operated in a reverse direction to move the end of 46b. When the starting chain is between rolls 45b and 46b, they are first clamped and then all of the rolls are operated in the reverse direction to move the starting chain 61 back up the roller apron 20 until the member 60 is in a position to close the lower end of the mold 11 whereupon a casting operation may commence.

The hydraulic control assembly according to the inven-. tincuits cabomatically villestrated in TIGS. A card Surviva at obertespecielacionaror alsaenand/th/03th, with throwave blicht marchi: HUR Bik force to to moutificial courts for kell will get each for kell in control in the figure acceptance of the court of general altraignes, it is period document as each it is in its constant to to a conditional teles peptie of other contributional and the management of the state of the sta 4 (46 A / 47 a reit A Ed Sanat Cart o solidaltation notote & R Unions ex A & r narranoment de satt de no socialitation en nocoto o rivi i de expetat entre situit 🖯 . Is tatatatilly, who is present an imposite the position of a secretar latter in v retkich dysaskar ordelder rozotor sl. Trêbes ishtdra serv alcidedeas asnobled y o countied 202 la ladse deficience cota anduse tel thickness con est out of hi e forther expense left introvers are the learnest expensional end reic->> t amo inferotionalar overement dieces f

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come to rest. Similarly when switch 107 is placed in contact 112, a solenoid 99 will be energized to move valve element 97 to the left and thereby couple pump 103 to the upper end of cylinder 92. This will cause the piston 93 to move downwardly until solenoid 99 is deenergized and the valve element 97 returned to its neutral position whereupon piston 93 will again come to rest.

The lever assembly 88 includes a pair of levers 120 and 121 which are respectively pivotally connected to intermediate their ends to fixed fulcrums 123 and 124. The proximate ends of levers 120 and 121 are formed with registrable opposed notches 126 between which the stem 94 is received for being pivotally coupled by means of a longitudinal slot 127 formed in each lever and a pin 130 extending through the end of stem 94 and each of the slots 127. The remote ends of the levers 120 and 121 are respectively coupled to threaded pump adjustment rods 132 and 133 by means of adjusting nuts 134 which are received in elongate slots 135 formed transversely through each of said levers. In addition, each of the pump adjusting rods 132 and 133 extends upwardly through openings 137 in each remote lever end and normal to the slots 135.

The pumps 89 and 90 may be of any well known type which are coupled for rotation at a constant speed by a shaft 138 to a constant speed motor 139 and whose outputs can be varied in accordance with longitudinal movement of an adjustment stem 140. One example of such a pump is the Vickers Variable Displacement Pump, Model PVB20. Each of the adjustment stems 140 is pinned to the end of one of the pump adjusting rods 132 or 133 whereby axial movement of either rod will modify the delivery of its respective pump.

The withdrawal roller assembly control 82 includes a first four-way solenoid operated valve 145 and a second double solenoid operated four-way valve 146. The valve 145 is normally held in its position shown in FIG. 4 by a spring 148 so that the pump 89 output conduit 149 is coupled to the input conduit 150 of a valve 146, and the motor return conduits 152 and 153 are coupled to conduit 155 which is connected to sump 104. When switch 156 is closed to complete an energizing circuit to solenoid 157, valve 145 is moved to an alternate position shown by the phantom lines in FIG. 4, wherein the motor return conduits 152 and 153 are coupled to pump 89 output conduit 149 and the valve 146 input conduit 150 is coupled to sump conduit 155.

Valve 146 includes a housing 160 and a reciprocating valve element 161 coupled for axial movement by solenoid 162 and 164 which are controlled by a switch 165. When switch 165 is on its neutral terminal 166, each of the solenoids 162 and 163 are deenergized and the ele- 50 ment 161 will be held in its position shown in FIG. 4 by springs 167 and 168. In this position, the motor input conduits 169 and 170 are each coupled by valve element 161 to the valve 146 input conduit 150. When switch 165 is moved to terminal 172, to energize solenoid 163, the 55 valve element 161 will move toward the right as viewed in FIG. 4 to uncouple the input conduits to motors 45a, and 46a from valve 146 input conduit 150, but as the result of the configuration of housing 160, the input conduit 170 to motors 47a and 48a will remain connected to 60 conduit 150. On the other hand, when switch 165 is moved to contact 175 to energize solenoid 162, the valve element 161 will be moved toward the left to disconnect motors 47a and 48a from conduit 150 while motors 45a and 46a will remain connected thereto.

Referring now to oscillation motor 30, its input is shown to be coupled by conduit 177 to the pump 90 output. The motor 30 return is coupled to the sump 104 by a conduit 178 and counterbalance valve 180. The latter valve imposes a back pressure on the motor 30 output which balances the pressure caused by the weight of the mold 11. Thus, the mold 11 is prevented from moving downwardly as a result of its own weight but must be driven by motor 30 so as to overcome the counterbalancing effect of valve 180. If the mold 11 were free to move down-75

wardly under its own weight, its speed in that direction could not be controlled. Valve 180 places a back pressure on the motor 30 which is greater than that produced by the mold 11 so that valve 80 will not open unless a pressure is delivered by the output of motor 30 which is greater than that resulting from the weight of the mold 11 alone.

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The system is protected by pressure relief valves 182 and 183 which are operative to shunt the withdrawal motors 45a, 46a, 47a and 48a or the oscillation motor 30, respectively, in the event of an over pressure in the system. Each of the pressure relief valves 182 and 183 are shunted by solenoid operated valves 184 and 185 respectively so that the pressure relief valves can be by-passed when the respective hydraulic motors are at rest but the pumps 89 and 90 are operating.

In operation, the operator determines the desired relative rates of speed of withdrawal mechanism 25 and the oscillation motor 30 in accordance with the casting speed and pouring rate so that the molten metal in the mold will be maintained at approximately an optimum height. The motor speeds may be adjusted initially by means of nuts 134 which are turned to position stems 140 such that the outputs of pumps 89 and 90 are at an optimum value when the piston 93 is centered. This adjustment will preferably set the oscillation motor 30 at a speed which is approximately 10% faster than the withdrawal rate of motors 45a, 46a, 47a, and 48a. This insures optimum strand skin conditions.

It will be recalled that initially, the starting chain 61 will be disposed in the storage assembly 68. To commence the operation, the operator stationed at control console 190 releases the hydraulic mechanism 74 so that the end of the starting chain will move into a position between the exit roll assemblies 47 and 48 which are then clamped. The operator then closes switch 156 and moves switch 165 to contact 172. This couples the return conduit 153 of exit roller motors 47a and 48a to the pump 89 output conduit 149 and disconnects entrance roller motors 45a and 46a from the system. The exit rolls 47b and 48b will be driven in the reverse direction to move the starter chain 61 toward the entrance rolls 45b and 46b. When the latter rolls have engaged chain '61, switch 165 is moved to contact 166 whereby entry roller motors 45a and 46a will also be coupled to the pump 89 through conduits 149 and 152 for reverse operation so that the starting chain will be driven up roller apron 20 and toward the mold 11.

When the starting member 60 is disposed in a position to plug the lower end of the mold 11, the solenoid valve 184 is opened to shunt the system whereby the withdrawal assembly 25 comes to rest. The metal pouring operation may then commence with the opening of a valve 190 on the lower end of ladle 17 (FIG. 1). As the molten metal within the mold 11 begins to rise and solidify, the operator opens switch 156 to return valve 145 to its forward position relative to motors 45a, 46a, 47a and 48a as shown by full lines in FIG. 4. Solenoid valves 184 and 185 are then opened to couple pumps 89 and 90 to drive their respective motors. The withdrawal assembly 25 will then begin withdrawing the starting member 60 out of the end of the mold 11 followed by the strand being formed as the motor 30 oscillates the mold 11 to prevent sticking.

In the event that withdrawal is too rapid, whereby the level of molten metal in the mold 11 begins to recede to an undesirably low level, the operator will move switch 107 to contact 112 thereby energizing solenoid 99 to move valve element 97 toward the left as viewed in FIG. 4. This couples the upper end of cylinder 92 to pump 103 whereby the piston will be moved downwardly as the stem 94 depresses the approximate ends of levers 120 and 121. This, in turn, moves the control rods 140 of each of the pumps 89 and 90 outwardly to proportionately decrease the output of each of the pumps 89 and 90 so that the rate of withdrawal and the rate of

oscillation of the mold 11 will decrease accordingly. As the result, the relative speeds of the strand and the mold 11 during oscillation will remain relatively constant. When the operator observes that the level of molten metal has returned to the desired level, he will move switch 107 to neutral contact 110 so that the valve 97 will return to its central position wherein pump 103 will be vented to the sump 104 and the piston 93 will come to rest. The withdrawal roller and oscillating speeds will then remain constant at the new level.

Similarly, should the operator note that the level of molten metal in mold 11 begins rising above a desired level, indicating the necessity for more rapid withdrawal, the switch 107 will be moved to contact 111. This energizes solenoid 100 to move valve element 97 toward 15 the right as viewed in FIG. 4 whereupon the lower end of the cylinder 92 will be connected to the pump 103. This piston 93 will then begin rising to move the control rods 140 toward their respective pumps 89 and 90 substantially uniformly whereby more rapid pump de-livery will be achieved. The withdrawal mechanism and oscillation motors will then begin operating more rapidly at the new withdrawal and oscillating speeds although the relative strand and mold speeds will remain relatively

When the operation is terminated and the end of the strand being cast moves past the entrance roller asemblies 45 and 46 whereby it is necessary to disconnect the latter assemblies so that power will remain on the exit roller assemblies 47 and 48, the switch 165 is moved 30 onto contact 172 to move the valve element 161 toward the right as viewed in FIG. 4 to disconnect the entry roller motors 45a and 46a from pump 89. The exit roller assemblies 47 and 48 continue to drive the chain 61 to its stored position and oscillation of the roller and oscillation motors is terminated.

In this manner, the withdrawal and oscillating speeds can be controlled to conform to mold pouring rates while maintaining their speed relation at a desired value to insure optimum strand skin conditions. While the in- 40 vention has been described in relation to a particular continuous casting apparatus, those skilled in the art will appreciate that it may be employed with other types of continuous casting apparatus. In addition, while particular hydraulic systems and components are illustrated in relation to the preferred embodiment of the invention, other systems and components capable of performing equivalent or analogous functions may also be employed. For example, functionally equivalent electrical components may be employed to provide an analogous 50 electrical system. Accordingly, while only a single embodiment of the invention has been shown and described, it is not intended to be limited thereby, but only by the scope of the appended claims.

We claim:

1. In a continuous casting apparatus, including a mold in which molten metal at least partially solidifies to form a strand means,

said mold having a first opening for receiving molten metal and a second opening for discharging said strand means.

withdrawal roller means engaging said strand means for withdrawing the same in a first direction outwardly of said second opening,

first drive means coupled to said roller means for driving the same to effect withdrawal of said strand

oscillating means coupled to said mold for reciprocally moving said mold in said first direction and in an opposite direction to prevent said strand means from 70 adhering thereto, and including second drive means independent of said first drive means,

first adjustable control means coupled to said first drive means for controlling the withdrawal speed of said strand means whereby the level of molten 75 first drive means includes at least two pair of reversible

metal within said mold may be maintained within desired limits.

second adjustable control means coupled to said second drive for controlling the speed of mold movement in said first direction,

said first and second control means being initially adjusted and arranged to move said mold in said first direction at a predetermined faster rate than that of said strand means,

adjustment means selectively operable in a first and second sense,

and proportioning means coupled to said adjustment means and to said first control means for adjusting the speed of the strand means withdrawal in response to the operation of said adjustment means and in the same sense to control the level of molten metal in said mold, said proportioning means also being coupled to said second control means for simultaneously and proportionately adjusting the speed of mold movement in said first direction,

said proportioning means being constructed and arranged to adjust the mold speed in the same sense and relation as that of said strand means to maintain a substantially constant speed ratio between said mold and strand means,

said proportioning means including first and second adjustable coupling means for respectively connecting the adjustment means to said first and second control means, each of such coupling means being simultaneously operable in the same sense by said adjustment means.

2. The apparatus set forth in claim 1 wherein said roller means includes at least two pair of reversible rollers, the rollers of each pair engaging the opposite sides of said strand means, and third control means for selectively or jointly coupling or uncoupling said pairs of rollers to said drive means independently of said proportioning means for selectively or jointly driving said pairs of rollers in a forward or reverse direction or for uncoupling the same.

3. The apparatus set forth in claim 2 wherein the first and second drive means each includes variable output pump means, the first and second control means each being operable to vary the output of its respective pump means.

4. The apparatus set forth in claim 3 wherein said withdrawal rollers each include hydraulic motor means, said third control means including valve means.

5. The apparatus set forth in claim 1 wherein said first and second coupling means are respectively adjustably connected to its respective control means to establish an initial operating speed relation between said mold and said withdrawal rolls and for corresponding increasing and decreasing the speed of each in accordance with said relation.

6. The apparatus set forth in claim 5 wherein coupling means include first and second linkage means, each linkage means being coupled to said adjustment means and to said first and second control means for simultaneously adjusting each control in a common sense and in accordance with said speed relation.

7. The apparatus set forth in claim 6 wherein each of said linkage means includes a link pivotally mounted intermediate its ends and each coupled on one side of its respective pivot to said adjustment means and each being adjustably coupled on the other side thereof to its respective control means.

8. The apparatus set forth in claim 7 wherein said adjustment means includes a hydraulic cylinder and piston coupled to each of said link means on one side of their respective pivots, and valve means selectively operable for moving said piston in opposite directions within said cylinder.

9. The apparatus set forth in claim 8 wherein said

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1	hydraulic roller means, said first and second drive means				3,040,397	6/1962	Haussner et al	_ 164—154	
(comprising variable output pump means, and valve means					3,344,841	10/1967	Rys 164—154 X	
for selectively coupling and uncoupling said pairs of						3,429,366 2/1969 Cruger et al 164-		_ 164—274	
hydraulic roller means to said first drive means in-						3,542,117	11/1970	Lemfer et al	16483 X
dependently of said proportioning means for driving					5	3,561,523	2/1971	Vertesi 1	64—154 X
said roller means in a forward or reverse direc									
for selectively uncoupling the same.						FOREIGN PATENTS			
			_			839,276	6/1960	Great Britain	164282
References Cited						, or 1700 Great Ellina 22222 211 212			
UNITED STATES PATENTS			10	R. SPENCER ANNEAR, Primary Examiner					
	2,135,183		Junghans Hessenberg et al	16483		U.S. Cl. X.R.			
	2,815,551			16483		164282		J.S. CI. A.K.	
	2,818,616	1/1958	Rossi	164260		104202			

UNITED STATES PATENT OFFICE CERTIFICATE OF CORRECTION

Patent No.	3,702,154	Dated_	November 7,	1972
Inventor(s)	Joseph Rokop and Geoff	rey W.	Hughes	
Inventor (b)_				

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the drawings, Sheet 1, Figure 5, reference numeral 128 should read 127. In the drawings, Sheet 1, Figure 2, the hydraulic motor attached to roller assembly 47 should be labeled 47a; numeral 45a should read 45; the hydraulic motor attached then to roller assembly 45 should be labeled 45a; the drive roll of roller assembly 45 should be labeled 45b; the hydraulic motor attached to roller assembly 46 should be labeled 46a; the support frame of roller assemblies 46 and 48, located in the center of the drawing and shaped like an inverted U, should be labeled 50; the right pivot arm between frame 50 and roller assembly 45 should be labeled 51; and the piston at the left side of the figure should be labeled 53 instead of 55. In the drawings, Sheet 2, Figure 4, the numeral 80 should be placed at the upper left of the drawings between the numerals 99 and 87 with an accompanying arrow pointing to the entire figure; the power source at the top center of the figure should be labeled 108; the numeral 128 should read 127; the numeral 83 should be inserted generally in the area between the numerals 183, 11 and 30; the numeral 153 should be applied to the pipe leaving valve 145 to the right; and the numeral 150 should be applied to the pipe leaving valve 145 to the left. At column 3, line 26, the numeral "44" should read --46--.

Signed and sealed this 3rd day of April 1973.

(SEAL) Attest:

EDWARD M.FLETCHER, JR. Attesting Officer

ROBERT GOTTSCHALK Commissioner of Patents