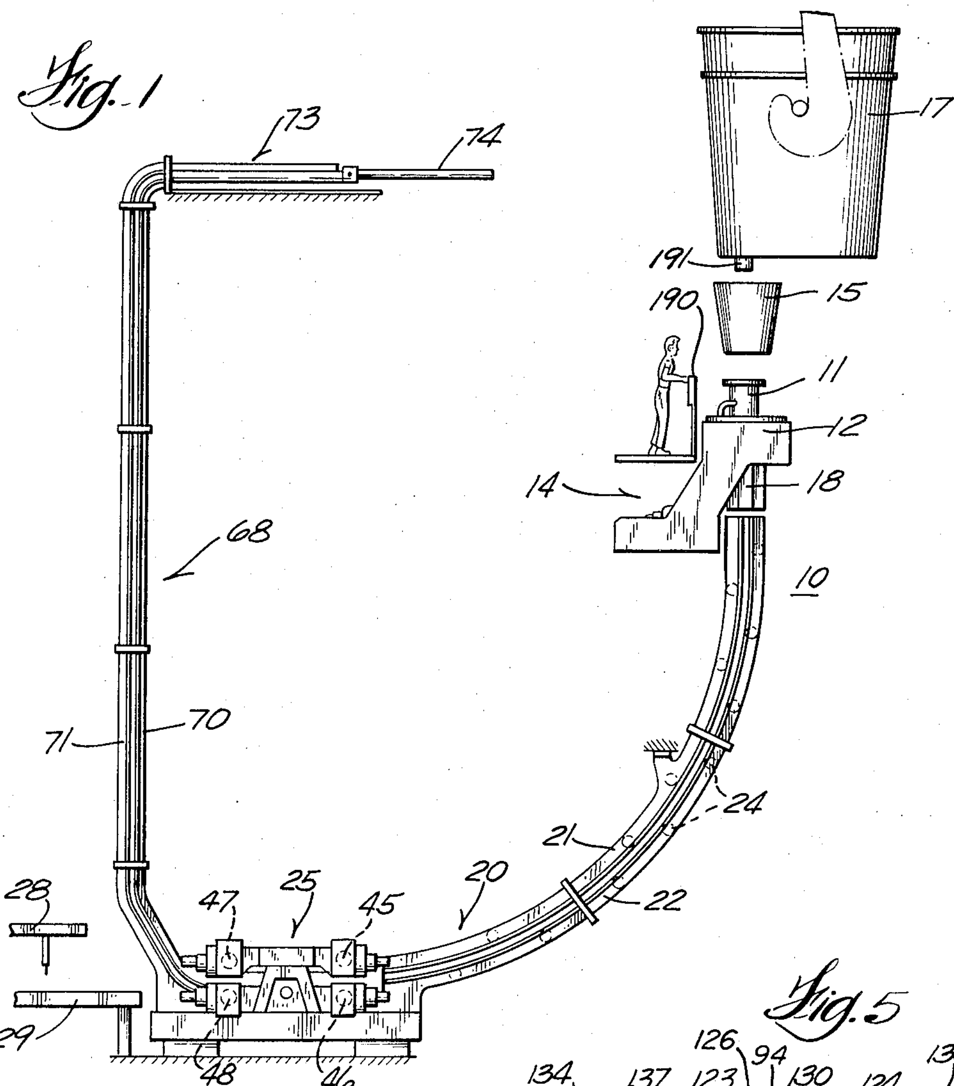
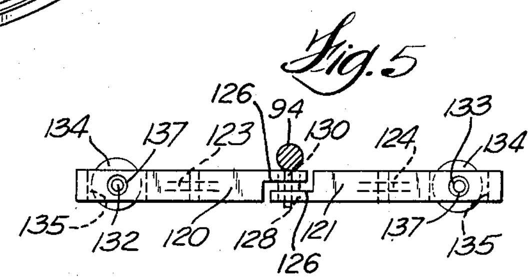
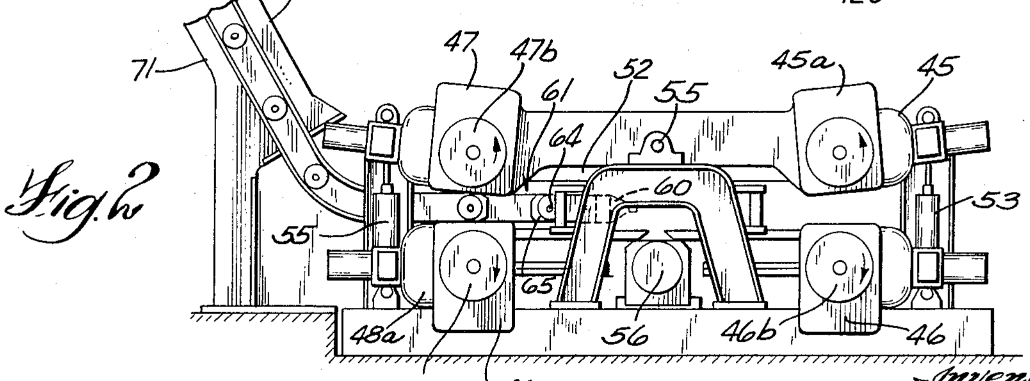
CONTINUOUS CASTING MACHINE RECIPROCATION AND WITHDRAWAL CONTROL SYSTEM

Filed Sept. 3, 1970 2 Sheets-Sheet 1







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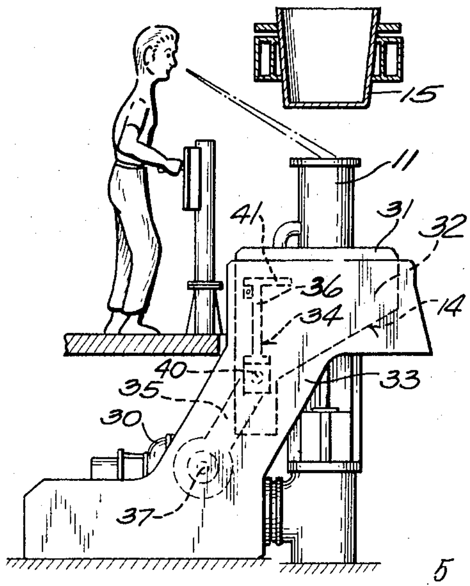

Fig. 3

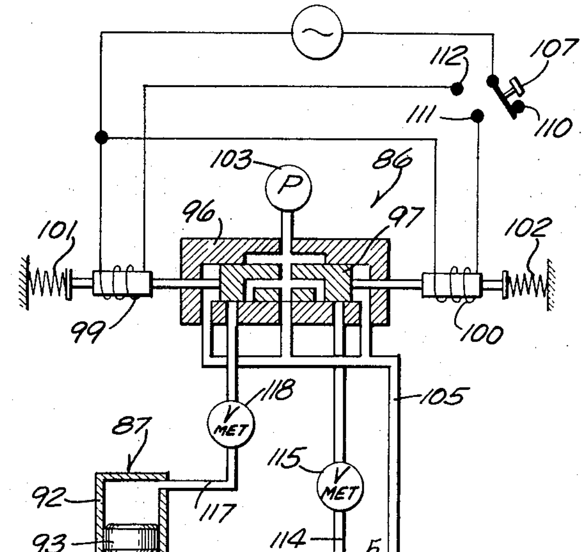
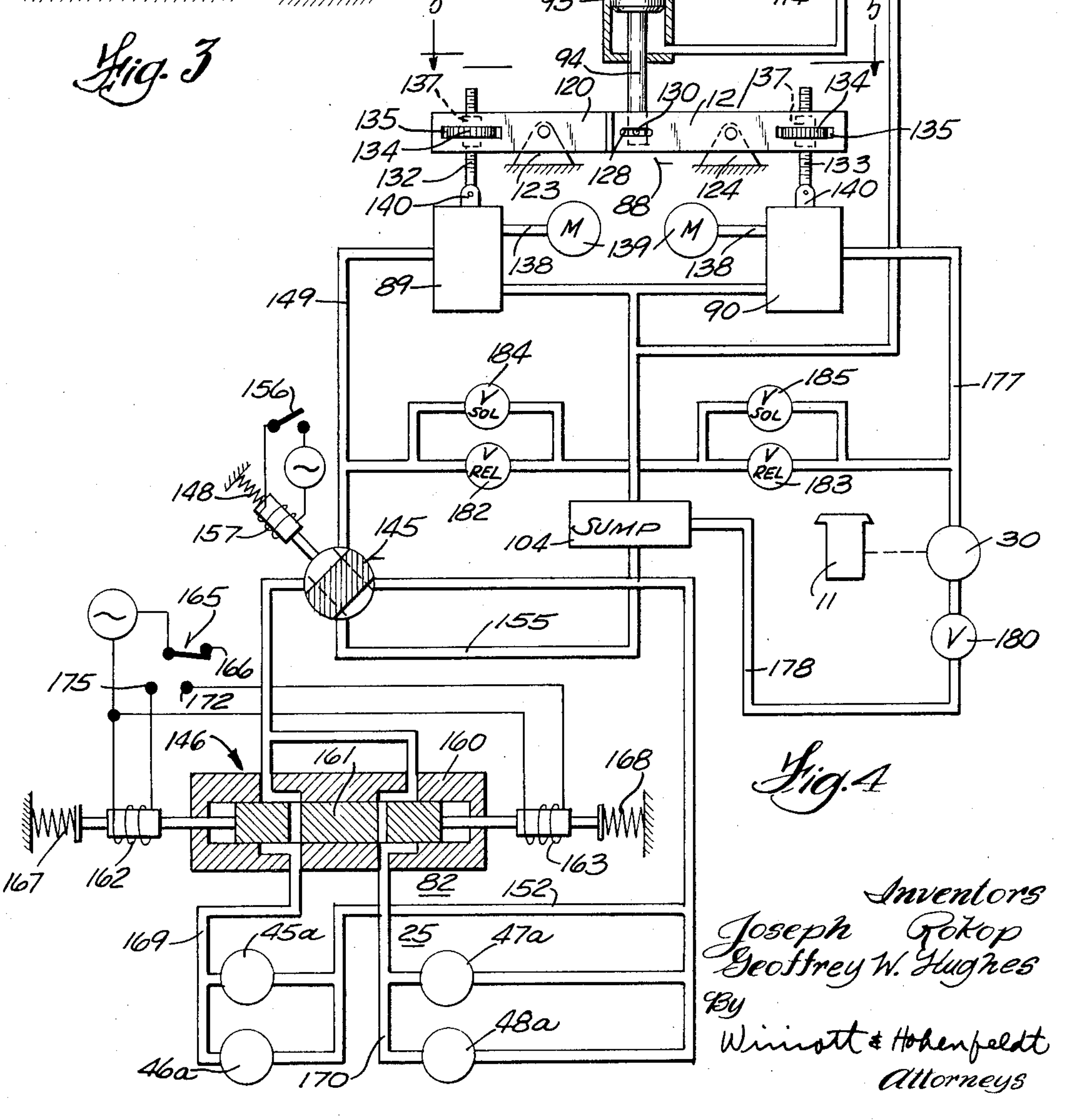

Fig. 4

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3,702,154
CONTINUOUS CASTING MACHINE RECIPROCATION AND WITHDRAWAL CONTROL SYSTEM
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Filed Sept. 3, 1970, Ser. No. 69,361
Int. Cl. B22d *11/12, 17/32*
U.S. Cl. 164—154 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

This invention relates to continuous casting machinery 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-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 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 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 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 withdrawal 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 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 tundish opening decreases to reduce the pouring rate, the withdrawal rate must be reduced accordingly to increase the

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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 machine.

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 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 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 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 illusrates 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 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 speed.

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 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 **45*a***, **46*a***, **47*a***, and **48*a***, each of which is constructed and arranged to rotate drive rolls **45*b***, **46*b***, **47*b***, and **48*b***, respectively connected to their output shafts at a speed and in a direction governed by the [illegible]

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 **47*b*** and **48*b*** whereupon their associated hydraulic cylinder **53** is pressurized to clamp chain **61**. The chain latch assembly **73** is then disengaged and the exit rolls **47*b*** and **48*b*** are operated in a reverse direction to move the end of the starting chain towards the entrance rolls **45*b*** and **46*b***. When the starting chain is between rolls **45*b*** and **46*b***, 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- [illegible] 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 element **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 valve element **161** will move toward the right as viewed in FIG. 4 to uncouple the input conduits to motors **45***a*, and **46***a* from valve **146** input conduit **150**, but as the result of the configuration of housing **160**, the input conduit **170** to motors **47***a* and **48***a* will remain connected to 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 **47***a* and **48***a* from conduit **150** while motors **45***a* and **46***a* 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 downwardly 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.

The system is protected by pressure relief valves **182** and **183** which are operative to shunt the withdrawal motors **45***a*, **46***a*, **47***a* and **48***a* 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 **45***a*, **46***a*, **47***a*, and **48***a*. 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 **47***a* and **48***a* to the pump **89** output conduit **149** and disconnects entrance roller motors **45***a* and **46***a* from the system. The exit rolls **47***b* and **48***b* will be driven in the reverse direction to move the starter chain **61** toward the entrance rolls **45***b* and **46***b*. When the latter rolls have engaged chain **61**, switch **165** is moved to contact **166** whereby entry roller motors **45***a* and **46***a* 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 **45***a*, **46***a*, **47***a* and **48***a* 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 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 delivery 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 constant.

When the operation is terminated and the end of the strand being cast moves past the entrance roller assemblies **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 onto contact **172** to move the valve element **161** toward the right as viewed in FIG. 4 to disconnect the entry roller motors **45*a*** and **46*a*** 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 invention 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 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 means,

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 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

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 first drive means includes at least two pair of reversible hydraulic roller means, said first and second drive means comprising variable output pump means, and valve means for selectively coupling and uncoupling said pairs of hydraulic roller means to said first drive means independently of said proportioning means for driving said roller means in a forward or reverse direction or for selectively uncoupling the same.

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R. SPENCER ANNEAR, Primary Examiner

U.S. Cl. X.R.

164—282

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,702,154 Dated November 7, 1972

Inventor(s) Joseph Rokop and Geoffrey W. Hughes

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

FORM PO-1050 (10-69)

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