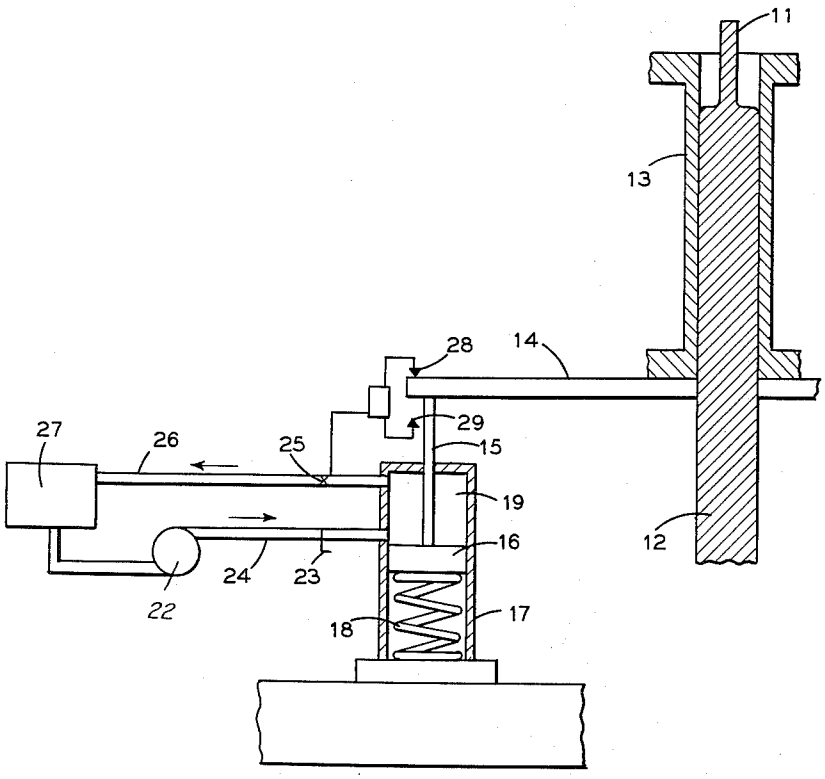
March 20, 1962 G. LITTLEWOOD 3,025,579

CONTINUOUS CASTING OF METALS

Filed June 16, 1959



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United States Patent Office 3,025,579
Patented Mar. 20, 1962

3,025,579

CONTINUOUS CASTING OF METALS

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Filed June 16, 1959, Ser. No. 820,744
Claims priority, application Great Britain June 17, 1958
1 Claim. (Cl. 22—57.2)

This invention relates to improvements in continuous casting apparatus.

U.S. Patent 2,815,551 describes a system of moving the mold used for continuously casting steel in such a manner so as to prevent or minimize the effects of friction between the mold and the ingot. In this specification the mold is water cooled and open at both ends and is used to solidify or partly solidify the liquid metal which is poured in at one end and withdrawn as a solid or partly solidified casting or ingot at the other end.

Frictional forces acting at or near the meniscus level in the mold often cause transverse tears in the ingot skin, and said patent describes several methods of overcoming this tearing. One of these methods consists of supporting the mold on springs, so that when the ingot adheres to the mold wall, the mold is moved downwardly with the ingot and against the restoring force of the springs. When the mold has travelled a short distance, a force is exerted on the mold to move the mold in the direction of ingot withdrawal at a speed in excess of that of the ingot, so that the friction causing the sticking is overcome by compressing the ingot skin, so inhibiting transverse ruptures. This force is produced by mechanical or pneumatic means.

In the present application the compressive releasing force is applied by hydraulic means. Hydraulic means are preferred because they can produce a superimposed mold movement of uniform speed and almost instantaneous acceleration, and thereby fully inhibit transverse ruptures of the ingot skin.

In accordance with the present invention, apparatus for preventing tearing in ingots being cast by continuous casting molds comprises a hydraulic system regulated by a control system which causes operation of the hydraulic system when sticking occurs, to move the mold faster than, and in the same direction as, the withdrawal of the ingot, and springs or like means being arranged, when permitted by the control system, to act upon the mold to return the mold to its original position after the mold has passed through a predetermined distance.

The invention will be more readily understood by way of example from the following description, reference being made to the accompanying drawing which is a part sectional and part diagrammatical view of the apparatus.

A stream of molten metal, as indicated at **11**, is poured into the open upper end of a water cooled mold **13** from suitable molten metal delivery means (not shown) with the casting or ingot **12** formed in the mold withdrawn downwardly from the open lower end thereof by a withdrawal mechanism (not shown). The rate of molten metal delivery to and the rate of ingot withdrawal from the continuous casting mold **13** are coordinated for the proper solidification of the molten metal.

A platform **14** is attached to the mold **13** and is connected at each end to a hydraulic means for lowering the platform **14** and mold **13** when sticking of the ingot occurs. Only one such means is shown in the drawing and, as there illustrated, comprises a piston rod **15** secured to the platform **14** and attached to a piston **16** located in a cylinder **17** which contains a spring **18** and a fluid **19**, acting on opposite sides of the piston **16**. The fluid **19** is continuously pumped into the cylinder **17** by a pump **22** from a storage tank **27** through a metering valve **23** in a delivery tube **24** and is discharged through an electro-

magnetic valve **25** in a second delivery tube **26** to a storage tank **27**, the latter tube **26** being of larger bore than the tube **24**. The piston **16** is mounted on the spring **18**, thereby supporting the mold **13**.

Above and below the platform are two spaced limit switches, such as micro-switches **28** and **29** respectively. Switch **28**, while operated by contact with the platform **14** prevents the valve **25** from closing, but on becoming inoperative through downward movement of the platform **14** (breaking contact with switch **28**) causes the valve **25** to close, resulting in an immediate build up of pressure until the switch **29** is contacted by the platform **14** moving downwardly and causes the valve **25** to reopen.

When sticking of the ingot **12** to the mold **13** occurs, the mold **13** is drawn downward a short distance by the ingot **12**, which is being withdrawn by the withdrawal mechanism. Movement of the mold **13** and hence the platform **14**, causes the switch **28** to close the valve **25** which then prevents flow of the fluid **19** from the cylinder **17**. The downward movement of the piston **16** is initiated by movement of the platform **14** and mold **13** as caused by adhesion between the ingot and the mold wall. As soon as the contact between switch **28** and the platform **14** is broken, closing the valve **25**, the hydraulic fluid entering the cylinder **17** will force the piston **16** downward at a rate dependent upon the flow regulating position of the metering valve **23**. In accordance with the invention, the rate of flow through the tube **24** will be sufficient to force the piston **16** in a downward direction at a greater rate than that caused by adhesion of the ingot to the wall of the mold. Thus the mold will also move downward at a greater rate than the ingot to break the adhesion therebetween.

The piston **16** moves downward under the force exerted by the hydraulic fluid and compresses the spring **18** until the switch **29** reopens the valve **25**. With the release of fluid from the cylinder **17** through the line **26**, the piston with platform **14** and mold **13** thereon will rise to its upper position with the platform again in its usual position in contact with switch **28**. When the friction between the ingot and the mold again rises the cycle will be repeated. The storage tank **27** provides a means for containing excess fluid until such time as it is again required. The flow rate through the metering valve **23** may be kept in adjustment manually, or automatically in coordination with the ingot withdrawal speed by well known electrical or mechanical means.

It will be understood that the apparatus described should be duplicated in order that the vertical movement of the mold is maintained coaxial with respect to the ingot. However, it will also be understood the apparatus may be applied by connecting one end of a lever to the piston **16** and attaching the other end of the lever to the mold **13**, in which case only one cylinder would be necessary.

Alternatively, the use of springs such as **18** may be dispensed with by admitting a continuous flow of hydraulic fluid through the lower chamber of cylinder **17**, maintaining sufficient pressure therein just to hold the mold in its uppermost position. Upon the friction level rising between mold and ingot, the mold will be moved downward and so trip limit switches which will simultaneously: (1) Stop fluid entering the lower chamber of cylinder **17**, (2) Stop fluid leaving the top chamber **19**. Thus the mold will be forced down at a rate proportional to the the rate of flow of fluid which is controlled by valve **23**.

After travelling a certain distance, the valve **25** is opened allowing fluid to flow out of chamber **19**, and simultaneously fluid is re-admitted to the lower chamber to force the mold to its uppermost position.

In such a system, whereby the relative speeds of mold and ingot are not of great importance, so long as the

downward speed of the mold exceeds that of the ingot, the operating fluid may conveniently be compressed air and the system may be run from any available supply of compressed air.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

In apparatus for the continuous casting of metal having an upright open ended mold and means for delivering molten metal to the upper end and withdrawing an ingot from the lower end of said mold, the combination comprising means guiding said mold for vertical movement in coaxial relationship to the withdrawn ingot including a closed cylinder, a piston in said cylinder arranged to support said mold, spring means for supporting said piston in said cylinder, conduit means for continuously delivering a hydraulic fluid to said cylinder, a second conduit means of greater flow area than said first

conduit means for the discharge of said hydraulic fluid from said cylinder, a cut-off valve in said second conduit means, and valve operating means for closing said valve when said mold initially moves downwardly from an upper position against said spring means in response to an increase in friction between said mold and ingot, said valve operating means closing said valve to force said mold downwardly at a substantially uniform rate greater than the withdrawal rate of said ingot, under the influence of the incoming flow of said hydraulic fluid, said valve operating means being arranged to open said valve after a predetermined downward movement of said mold to release hydraulic fluid from said cylinder at a flow rate greater than said fluid delivering rate and thereby causing said mold to return to its said upper position at a substantially uniform rate under the influence of said spring means.

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