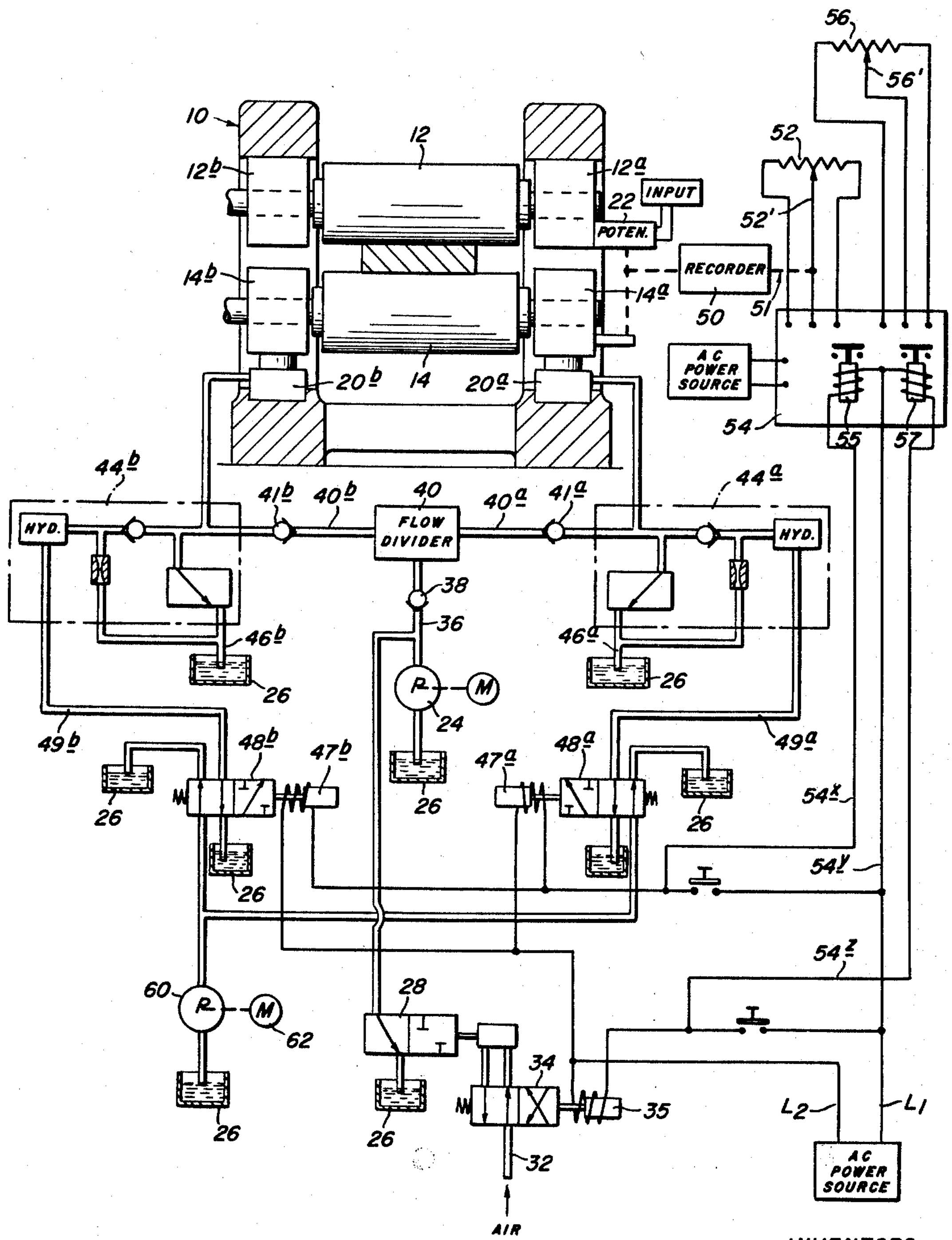
APPARATUS FOR CONTROLLING THE POSITION OF WORK ROLLS

Filed March 9, 1965



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United States Patent Office

3,389,588
Patented June 25, 1968

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3,389,588
APPARATUS FOR CONTROLLING THE POSITION OF WORK ROLLS

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Filed Mar. 9, 1965, Ser. No. 438,274
3 Claims. (Cl. 72—8)

ABSTRACT OF THE DISCLOSURE

An apparatus for controlling the position of work rolls in a mill is disclosed which includes means to obtain a signal related to the spacing between the work rolls, means to provide a command signal proportional to desired roll spacing and means to operate a fluid system responsive to a signal related to the deviation between actual and desired roll spacing so as to adjust the roll spacing.

The present invention relates to an apparatus for controlling the position of work rolls in a rolling mill. More particularly, the invention involves adjusting the spacing between the work rolls so as to maintain an approximate desired roll gap.

In recent years, there has been emphasis on improving the quality of rolled products. As a result, greater efforts have been made to more accurately control product thickness during rolling. Conventionally, the thickness of the product has been determined by measuring the product after rolling and making mill adjustments as needed. The present invention contemplates maintaining continuous surveillance of the roll gap and making instantaneous mill adjustments to compensate for undesirable deviations.

An outstanding advantage of the invention is the relative simplicity of the equipment to measure the position of work rolls in a rolling mill. The invention is particularly useful in slab mills and in other mills where relatively thick product is rolled. The system employed for measuring and controlling the roll position can maintain roll spacing within a tolerance of ±0.025″. Although not sufficiently accurate for thin gauge strip, the system according to the invention is well-suited for use on rolling mills in which relatively thick product such as slabs are rolled.

In addition to the above, the invention is particularly useful in conjunction with continuous metal casting operations. In continuous casting, a continuous metal column of metal is produced which is passed through rolls which should be maintained at a preselected roll spacing. In spite of continual variation in the roll separating forces caused by changes in the thickness and temperature of the metal column entering the rolls, the present invention can be employed to maintain the preselected roll gap with sufficient accuracy to produce a more uniform product.

Other advantages of the invention will be made more apparent by the following description in conjunction with the drawing which is a schematic diagram illustrating a preferred embodiment of the invention.

In the drawing, a 2-high rolling stand is shown, comprising top and bottom rolls **12** and **14**, respectively, having shafts mounted in roll chocks **12***a* and **12***b* and **14***a* and **14***b*, respectively. The roll chocks in turn are supported in a mill housing **10** wherein they may be moved vertically to adjust the roll gap, i.e. spacing, between the rolls **12** and **14**. In the preferred embodiment illustrated, the position of top roll **12** is fixed within the mill housing **10**, but the roll chocks **14***a* and **14***b* of the bottom roll are supported by fluid-operated assemblies **20***a* and **20***b* to raise and lower the bottom roll.

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The spacing between the rolls is controlled by means of an electrical system which measures the roll gap and energizes the hydraulic system to affect movement of bottom roll **14** as needed (up or down) so as to maintain the desired roll spacing. This is accomplished in the preferred embodiment by means of a transducer **22** connected to a recorder **50** whose indicator arm **51** is mechanically linked to the slider arm **52′** of a retransmitting potentiometer **52** which is in turn connected to a device **54** which compares the magnitude of two electrical signals and energizes the proper fluid system to raise or lower the bottom work roll to maintain the desired roll gap. Also connected to device **54**, which may be a bridge-balance relay as herein after described, is a set-point potentiometer **56** whose slider arm **56′** may be manually set to issue a signal to device **54** proportional to the desired roll spacing.

The roll gap is varied by moving roll **14** by means of the fluid-operated cylinder-ram assemblies **20***a* and **20***b*. To operate the cylinder-ram assemblies, a pump **24** continuously circulates fluid to the storage reservoir **26** through a control valve **28** which is positioned in fluid line **30**. The control valve **28**, which is preferably an air-actuated valve produced by Republic Mfg. Co., model No. 831–1, is normally open to permit the circulation of fluid to the reservoir **26** and is closed by introducing air through line **32** via solenoid valve **34** (connected to an air supply not shown). The air-actuated control valve **28** may be closed by solenoid-operated valve **34**. The solenoid valves used herein may be model CC20025A made by Hannifin. When valve **28** is closed, fluid from pump **24** is forced to flow through line **36** and through check valve **38** into the flow divider **40** which distributes the fluid flow into two equal components which are diverted to the two fluid-operated ram assemblies **20***a* and **20***b* to cause the roll **14** to move upwardly and thereby decrease the roll gap.

The bottom roll is lowered by energizing solenoid-operated valves **48***a* and **48***b* thereby permitting pump **60** to force pilot fluid through lines **49***a* and **49***b* thereby applying force to hydraulic actuators which in turn open decompression valves **44***a* and **44***b* to allow fluid from ram assemblies **20***a* and **20***b* to escape through lines **46***a* and **46***b* to the reservoir **26**, thus lowering roll **14**. The solenoids **47***a* and **47***b* of solenoid-operated valves **48***a* and **48***b* together with the solenoid **35** of solenoid-operated valve **34** are energized and de-energized by control relays **55** and **57** which are contained within the bridge-balance relay **54**. Relays **55** and **57** are energized by power from a transistorized amplifier also contained within bridge-balance relay **54**.

In operation, the roll gap measuring device **22** which may be any suitable transducer but in the preferred embodiment is a spring-loaded reel-type precision potentiometer, with its wire connected between the roll chocks, receives a constant input signal and produces an output signal approximately proportional to the existing roll gap. The signal sent by device **22** is only approximately proportional to the roll spacing because it actually measures the spacing between the roll chocks which may be slightly different than the spacing between the rolls. Spacing between the rolls will vary largely due to rolling forces which change the relative positions of the roll chocks which changes are proportional to changes in the roll gap but, in addition, because of roll wear, deflection, etc.; these latter changes will not be reflected in the signal issued by the potentiometer **22**. However, it has been found that an arrangement as illustrated can be satisfactorily operated within ±0.025″ of actual roll spacing. This tolerance is more than satisfactory for a relatively large roll gap such as would be used in rolling slabs. The signal issued from potentiometer **22** which is therefore approximately proportional to the roll gap, is received by a strip recorder **50** which provides a continuous record of changes in the roll spacing. Any suitable recorder may be employed such as the Minneapolis-Honeywell continuous-balance potentiometer type. As the roll gap and the relative positions of the roll chocks **12***a* and **14***a* vary, the reel of the potentiometer **22** is likewise rotated by the wire connection between the chocks to change the valve of the signal to the recorder. Simultaneously actuated is a circuit comprising a set-point potentiometer **56** and a retransmitting potentiometer **52** both of which are connected to a suitable device **54** for comparing values and algebraically summarizing two electrical signals. One preferred such device for comparing values of two electrical signals is a bridge-balance relay produced by the Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., identified as R7103C and described in a publication by the manufacturer identified as 95–5420.

The set-point potentiometer **56** has an adjustable slider arm and dial **56′** to permit a manual setting of potentiometer **56** so as to provide an electrical signal to the bridge-balance relay **54** proportional to the desired roll spacing. The potentiometer is properly calibrated for this purpose. The retransmitting potentiometer **52** has a slider arm **52′** that is mechanically linked with the arm or pen of the recorder **50** so that it assumes a position in accordance with the existing roll gap as indicated on the recorder. Any suitable recorder may be used such as the continuous-balance potentiometer type made by Minneapolis-Honeywell. In this way, the potentiometer **52** provides a signal to the relay **54** approximately proportional to the existing roll gap. The bridge-balance control relay contacts receive an input from a power source through lines L_1 and L_2 and compare the signal from the set-point potentiometer **56** to the signal from the retransmitting potentiometer **52**. These signals are of equal value when the roll spacing conforms with the desired roll gap. In that event, the bridge-balance relay **54** will have both of its control relays, **55** and **57** and their respective circuits **54***x* and **54***z*, each of which include common line **54***y* de-energized, thereby causing no change in the roll gap. If, however, the roll gap is greater than that desired, the bridge-balance relay will be unbalanced and will energize control relay **57** which, when closed, connects the solenoid **35** associated with solenoid-operated valve **34** with the line source and the solenoid is energized to operate the valve. When valve **34** is opened, it permits air to enter through line **32** closing the air-actuated control valve **28**. Fluid is then forced by pump **24** through line **36**, passed the spring-loaded check valve **38** into the flow divider **40** and then into lines **40***a* and **40***b*. The fluid passes check valves **41***a* and **41***b* to enter the cylinder-ram assemblies **20***a* and **20***b*, thereby raising roll chocks **14***a* and **14***b* and work roll **14**. This action continues until the desired roll gap is achieved at which time the slider arm **52′** of the retransmitting potentiometer **52** is at a setting such that the signals from this potentiometer and the set-point potentiometer will balance in the relay **54** and the control relay **57** becomes de-energized. De-energizing control relay **57** causes the solenoid-operated valve **34** to shift, permitting air to open valve **28** and resumes the flow of fluid through line **30** to the reservoir **26**, thereby halting the flow of fluid into the cyinder-ram assemblies **20***a* and **20***b*.

If the existing roll gap is less than the desired roll spacing established by the slider arm of the set-point potentiometer **56**, the bridge-balance relay energizes the normally opened relay **55**. In so doing, solenoids **47***a* and **47***b* of solenoid-operated valves **48***a* and **48***b* are electrically connected with the line source and the valves **48***a* and **48***b* are operated to open pilot-operated decompression valves **44***a* and **44***b*. This, as previously described, causes fluid to be exhausted from the cylinder-ram assemblies **20***a* and **20***b*, thereby causing the cylinder-rams and bottom roll to lower and increase the roll spacing. This action continues until the selected roll gap is achieved as indicated by the slider arm of the retransmitting potentiometer **52**. The signals from the retransmitting potentiometer and set-point potentiometer then balance in the bridge-balance relay, and no signal is produced across **54***x* and **54***z*. As these signals become equal, bridge **54** is balanced and relay **55** is opened and the solenoids **47***a* and **47***b* are de-energized, closing valves **48***a* and **48***b*. This directs pilot flow from motor-operated pump **60** to the reservoir and allows lines **49***a* and **49***b* to drain and stops the flow of fluid from the cylinder-ram assemblies **20***a* and **20***b* to the reservoir **26** and the roll gap is thereby maintained at the preselected setting.

It is apparent from the above that various changes and modifications may be made without departing from the invention. The fluid-operating system employed in conjunction with the circuitry for sensing the approximate position of the work rolls with respect to each other has been found to be effective for instantaneous mill adjustments. The term "fluid-operated system," of course, refers generally to hydraulic systems. Although one type of valve responsive to electrical signals has been shown, i.e. the solenoid-operated valves, other valves operating under the same principle may be similarly employed, preferably other low torque rotary directional valves. In this connection it should be noted that alternate equipment performing similar functions may be readily substituted throughout the system described herein. Thus, for example, summing or bi-stable amplifiers may be used in lieu of the bridge-balance relay. Similarly other transducers, or indeed, any device which translates mechanical displacement into a proportional signal, electrical or otherwise, may be used in place of the spring-loaded potentiometer **22**.

In the preferred embodiment described herein, a recorder is used to maintain a record of roll changes. However, it is apparent that the recorder may be omitted and, moreover, the potentiometer **22** may be directly connected to the bridge-balance relay **54**, thereby also omitting, if desired, retransmitting potentiometer **52**.

We claim:

1. Apparatus for controlling the position with respect to each other of work rolls in a rolling mill comprising means to obtain a first signal approximately proportional to the spacing between work rolls in a rolling mill, means to provide a command signal proportional to the desired roll spacing, means to compare said first signal and said command signal, a fluid-operated system responsive to said last-named means for increasing and decreasing roll spacing so that a desired approximate roll spacing may be maintained.

2. An apparatus for controlling the position with respect to each other of work rolls in a rolling mill comprising upper and lower work rolls, support means for said work rolls, fluid-operated rams positioned at the supports of at least one work roll in said rolling mill adapted to raise and lower said roll, means to provide a controlled supply of fluid to said fluid-operated rams, means to evacuate a controlled quantity of fluid from said fluid-operated rams, means to obtain a signal approximately proportional to the spacing between the rolls, means responsive to said signal for energizing and de-energizing said means to supply fluid to said rams and said means to evacuate fluid from said rams whereby a desired roll spacing is maintained.

3. An apparatus for controlling the position with respect to each other of work rolls in a rolling mill having upper and lower work rolls with the roll ends mounted in roll chocks and supported in a mill housing comprising a fluid-actuated cylinder-ram assembly positioned beneath the roll chock at each end of the bottom roll for raising and lowering said roll chocks and roll, first means to supply a controlled quantity of fluid to said cylinder-ram assemblies to raise said bottom roll and second means to withdraw a controlled quantity of fluid from said cylinder-ram assemblies to lower said bottom roll, means to obtain a first signal proportional to the spacing between the roll chocks of the top and bottom rolls, means to provide a command signal proportional to the desired roll spacing, means to compare said first signal and said command signal and to energize one of said first means and said second means to raise or lower the

bottom work roll until said first signal and said command signal balance.

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