

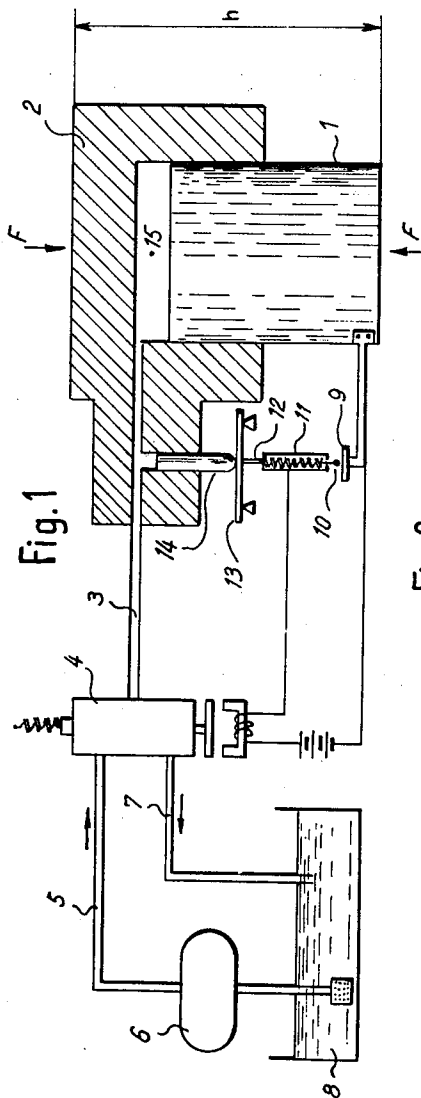
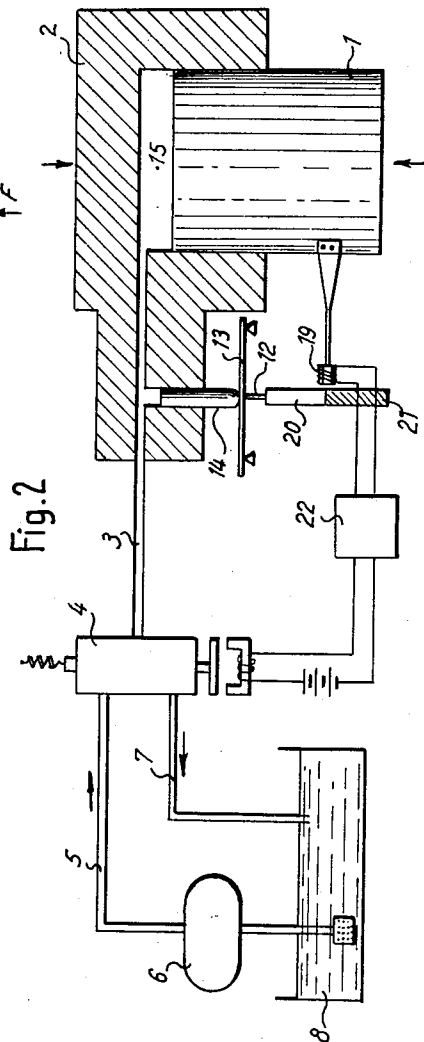
Jan. 29, 1963

P. BLAIN
HYDRAULIC ARRANGEMENT FOR ADJUSTING THE SPACING
OF THE ROLLS IN ROLLING MILLS AND
FOR COMPENSATING MILL SPRING

3,075,417

Filed Oct. 26, 1959

5 Sheets-Sheet 1



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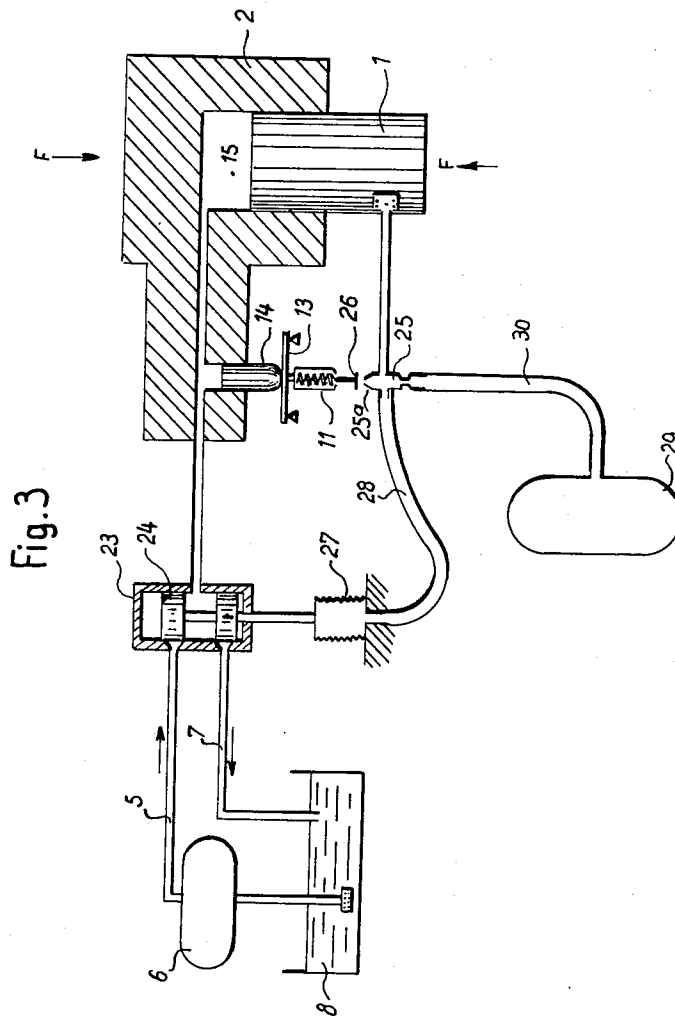
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Fig. 5

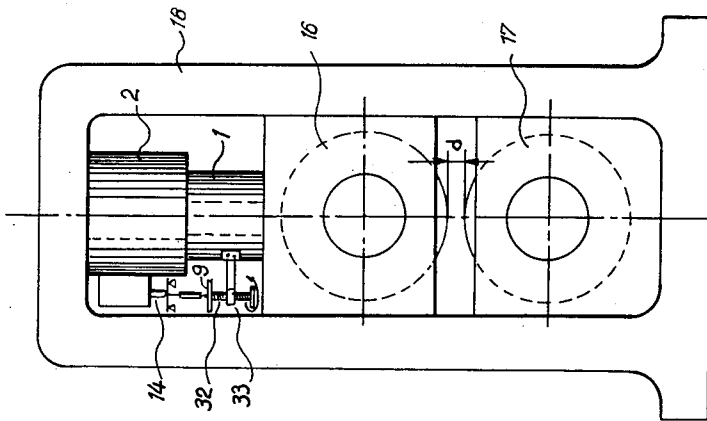
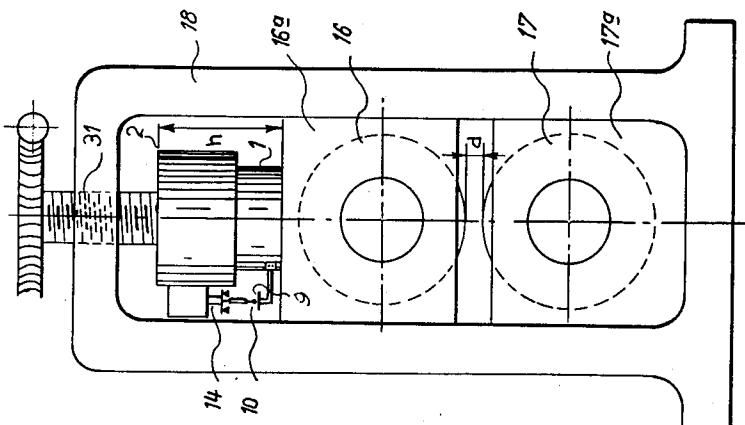


Fig. 4



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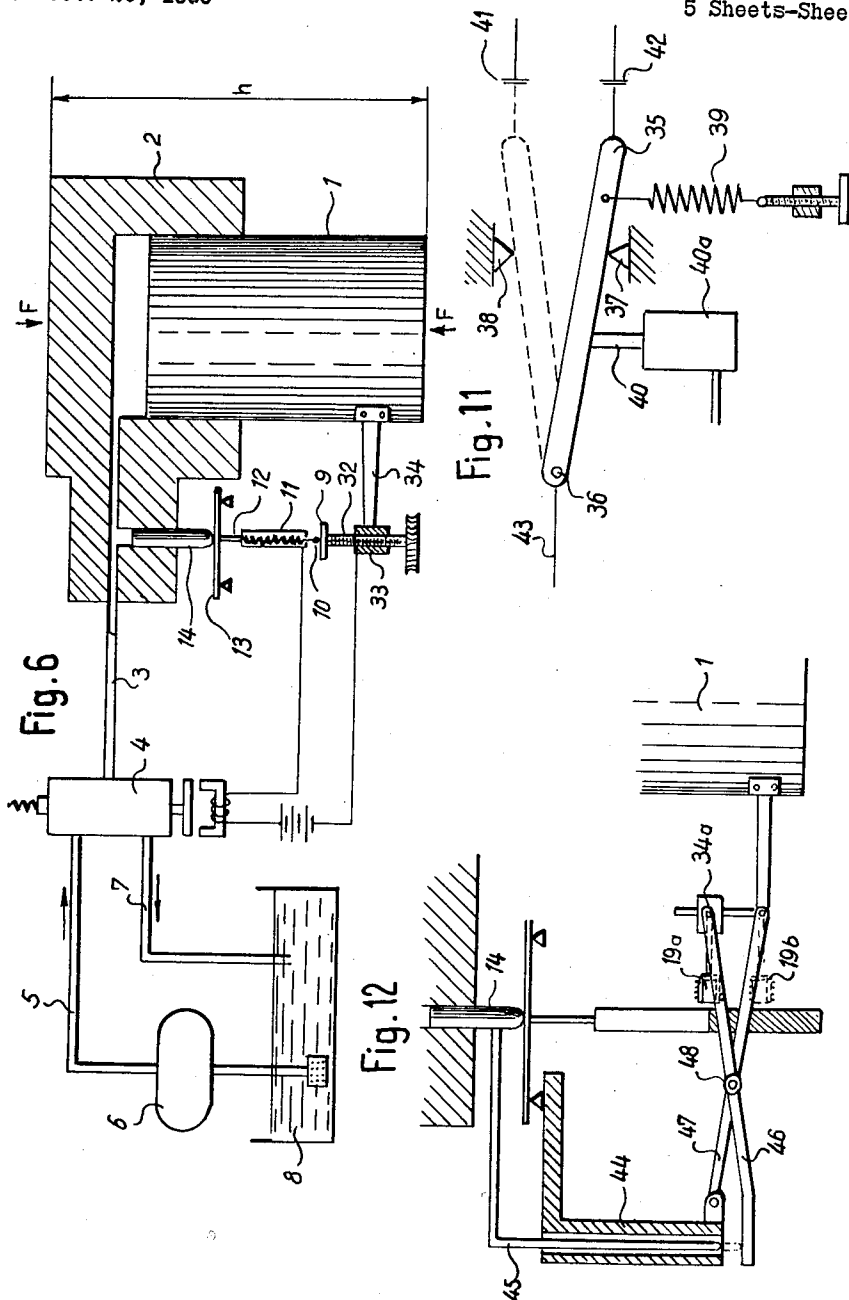
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5 Sheets-Sheet 4



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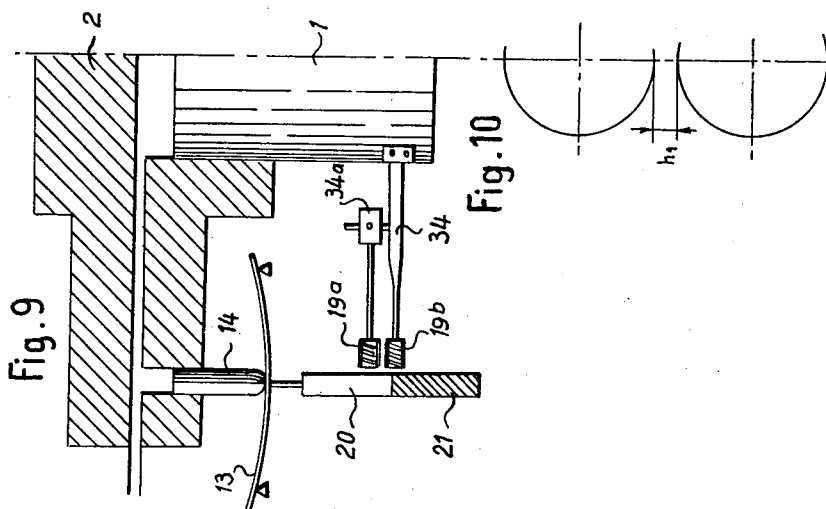
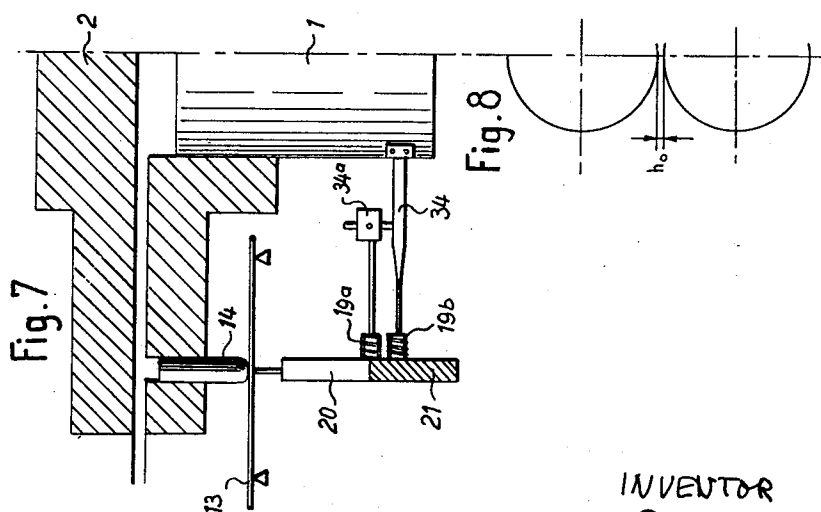
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5 Sheets-Sheet 5



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3,075,417

HYDRAULIC ARRANGEMENT FOR ADJUSTING THE SPACING OF THE ROLLS IN ROLLING MILLS AND FOR COMPENSATING MILL SPRING

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5 Claims. (Cl. 80—56)

The thickness of rolled material is subject to variations at a predetermined adjustment of the screw-down mechanism of the rolling mill when the input thickness of the material and its hardness vary and these variations are the result of mill spring, that is, the elastic deformations of the rolling mill under the action of the forces developed by the reduction of the thickness of the rolled material.

According to certain known methods, it has been attempted to make up for such deformations by correcting the adjustment of the rolling mill through an automatic action on the tightening screws, the tightening or releasing impulses being controlled either by the thickness as measured at the output end of the rolling mill, or else by the separating force applied to the mill. These methods show the usual drawback of providing the desired correction only with a substantial lag, due to the inertia of the power unit and of the mechanical means controlling the screws.

Adjusting means are also known which act on the rolls independently of the tightening screws. These adjusting means which resort to different control mechanisms dependent for instance of the distance of the roll necks or on the value of the separating force show certain advantages, but also certain drawbacks and deficiencies. Thus, the arrangements controlled by the modifications of the distance between the necks do not take into account the bending of the rolls. Other arrangements lead to considerable lags in the case of mechanical control systems, or else they are of a very difficult execution when designed for commercial purposes.

Lastly, arrangements have been proposed which also take into account the elastical deformation of the rolls, but these arrangements act on the screw-operating power unit, which leads, as mentioned hereinabove, to a substantial lag, which is detrimental to the actual rolling operation.

Now, the present invention has chiefly for its object an arrangement which does not show the above drawbacks and which resorts to hydraulic control means capable of a very speedy response, said arrangement providing at the same time an automatic compensation for the elastic deformations of the rolling mill.

To this end, my invention provides a hydraulic adjusting device for rolling mills including a jack, the total height of which increases with the pressure applied to it and a control mechanism for said jack including a component, the position of which depends on the operative pressure and cooperating with a further component, the position of which depends on that of the plunger piston of the jack, said components being inserted in a control circuit for adjusting the application and release of pressure on said jack.

According to another feature of the invention, the component, the position of which depends on the operative pressure exerted on the jack, and the component the position of which depends on the plunger piston of the jack are combined to form a displacement transducer of any type, which cooperates with auxiliary means arranged and adapted to control the pressure on the jack.

According to a still further feature of the invention, the component, the position of which depends on the operative pressure exerted on the jack, is constituted by one contact-

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piece of a switch, secured to a plunger piston subjected to the operative pressure which is balanced by a spring while the other contact-piece secured to the plunger piston of the jack forms the other component of said switch.

The rolling mill, the compensation of which is obtained by this invention, as will become apparent herein-after, shows no difficulty in cold rolling because, in reversing mill operation or in continuous rolling the starting of the next rolling pass or the engagement of the material is performed at a greatly reduced speed. The compensating means have therefore ample time for responding to the sudden increase of the stress, without the differences in thickness appearing during the transitory period leading to any noticeable disturbance.

The case is different with hot rolling mills, chiefly with continuous hot strip rolling mills into which the material is introduced at the normal speed of rolling. As a matter of fact, at the moment of engaging the material, the separating force rises suddenly from zero value to the normal value corresponding to the pass to be performed. Before the elastic displacement obtained at the moment of engagement is compensated by the action of the correcting mechanisms, a more or less considerable time elapses, which varies according to the arrangement used between a fraction of a second and more than one second. The speed of the strip being high and reaching in certain cases seven meters per second and more, it is apparent that the leading end portion of the strip may be too thick over a length of several meters, which is not acceptable.

According to yet a further feature of this invention, it is possible to eliminate the serious drawbacks appearing in hot rolling by mill spring compensation; to this end, the hot rolling mill is provided with adjusting means including a double control member, of which one section controls idle operation and the other controls operation under load, said control member being associated with means for shifting operation from the first section to the second section at the moment of the engagement of the material to be rolled by the rolling mill. Said shifting may be obtained automatically through the agency of a lever adapted to assume two positions corresponding respectively to idle operation and to operation under load and actuated either by the suddenly increasing pressure in the jack at the moment of the introduction of the material in the case of hydraulic compensating means or else, for instance, through the sudden increase of the armature current in an electric motor controlling the mill, in the case of mechanical means compensating the mill spring. The above-mentioned lever carries a switch adapted to set the adjusting means selectively in a condition corresponding to either of the positions referred to. It is apparent that if the difference between the two settings of the adjusting means corresponds exactly to the mill spring during the pass, the rolling mill will be automatically and correctly adjusted immediately after the introduction of the material. There is no longer any transitory period, the part played by the adjusting means consisting solely in maintaining during operation the previously established compensation for the mill spring. On the other hand, if the difference between the two adjustments does not correspond exactly to the mill spring produced by the pass, a short transitory period is obtained but, since the above-referred to correspondency has been at least partly provided, this transitory period will be much shorter than that which would appear in the absence of the improved arrangement according to the invention.

The difference between the adjustments may be modified by hand, so as to take into account the mill spring observed during the successive passes or else it may be adjusted automatically during one pass for the next pass.

In order to allow my invention to be properly understood, several embodiments thereof are described herein-

after by way of example without limiting the invention to these embodiments, reference being made to the accompanying drawings, wherein:

FIG. 1 is a partly diagrammatic illustration of a first embodiment of the adjusting and compensating arrangement according to the invention including a jack shown in elevational section.

FIG. 2 is a similar view of a modified arrangement of the invention.

FIG. 3 illustrates a further modification incorporating a hydraulic distributor.

FIG. 4 illustrates a conventional rolling mill equipped with the arrangement of FIG. 1 in an elevational view.

FIG. 5 is an elevational view of a rolling mill of a different type from that illustrated in FIG. 4 and equipped with a modified compensating arrangement.

FIG. 6 is a partly diagrammatic view of the compensating arrangement of FIG. 5.

FIG. 7 is a partial view of yet another compensating and adjusting arrangement in the position assumed during idle operation of the associated mill.

FIG. 8 shows the rolls of the rolling mill associated with the arrangement of FIG. 7.

FIG. 9 shows the apparatus of FIG. 7 in the position assumed when the rolls of the mill are under load.

FIG. 10 shows the rolls associated with the device of FIG. 9 in a corresponding position.

FIG. 11 shows a switch cooperating with the device shown in FIGS. 7 and 9.

FIG. 12 illustrates automatic adjustment means for use with the apparatus of FIGS. 7 to 11.

The arrangement illustrated in FIG. 1 is constituted chiefly by a jack including a plunger piston 1 and a cylinder casing 2, the inner chamber 15 of which is connected through a pipe 3 with an electrically actuated three-way valve 4 of a conventional type, which valve opens into an input channel 5 connected with a pump 6 and with an output channel 7 opening into a vat 8 filled with a suitable liquid and adapted to feed the pump 6. The piston and the casing of the jack may, for instance, be positioned inside a rolling mill stand between the bearings and a fixed member of the stand. The circuit controlling the valve 4 passes through a switch, of which one contact-piece 9 is rigid with the plunger piston 1, while the other contact-piece 10 is connected, through the agency of a positioning spring 11, with a rod 12 rigid with a transverse blade spring 13. Said blade spring is subjected through a small plunger 14 to the action of the pressure prevailing inside the cylinder 15 of the jack, which pressure balances the outer force F acting on the jack.

It will be readily understood that if the jack 1—2 is fitted inside a rolling mill stand, as described hereinabove, the switch 9—10 opens and closes alternately. When the switch is closed, the fluid contained inside the vat 8 is sent into the chamber 15 of the jack, so that the plunger piston 1 sinks and, thereby, breaks the valve circuit at the switch 9—10. The switch being opened, the chamber 15 is now connected with the exhaust through the pipe 7 and, under the action of the outer force F exerted on the jack 1—2, the fluid is fed towards the outlet channel 7, this producing a rising of the plunger piston 1 which closes again the switch between 9 and 10. The switch thus opens and closes intermittently.

The alternating opening of the inlet and outlet channels for the jack fluid leads to a final stabilization of the level reached by the jack piston with negligible fluctuations in said level which remains thus at the desired value corresponding to a height h of the entire jack, for which height the switch 9—10 remains in a position for which it closes or opens alternatively.

Now, the position of the upper contact-piece 10 of the switch depends on the pressure prevailing in the chamber 15 and, consequently, on the outer force exerted on the jack. If said force F increases, the fluid pressure

in the jack increases also and the small plunger 14 exerts on the spring 13 a larger stress, so that the upper contact-piece 10 sinks by a corresponding amount and, consequently, the position of equilibrium is modified and the height h increases. Thus, the total height of the jack 1—2 increases with the pressure applied to it.

The bending of the spring 13 being proportional to the pressure prevailing in the chamber 15 and, consequently, proportional to the force F , it is possible to write the following equation for the total height h of the jack: $h = h_0 + KF$, h_0 being the height of the jack before the application of any stress F , while K is a coefficient depending directly on the resilience of the spring 13.

If such an arrangement is inserted in the kinematic chain connecting the two rolls 16 and 17 in a rolling mill housing 18, as illustrated in FIG. 4 and if the coefficient K is suitably selected, it is apparent that it is possible to compensate accurately through an increase in the total height h of the jack matching the rolling stress to be exerted for the elastic deformation of said kinematic chain. If said condition is satisfied, the distance d separating the two rolls 16 and 17 (FIG. 4) will remain constant, whatever may be the stress produced by a reduction in the thickness of the rolled material. Said rolled material will finally be reduced to a uniform thickness after rolling, even if its thickness at the input of the mill or its hardness varies.

FIG. 1 illustrates a switch 9—10 for sensing the height h of the adjusting jack 1—2. This is, of course, only one of the numerous embodiments of the arrangement according to the invention and any other position indicator may be used for acting on the electrically actuated valve 4.

FIG. 2 illustrates diagrammatically another embodiment of the invention. In said FIG. 2, a winding 19 carried by a part rigid with the plunger piston 1 of the jack moves along a vertical rod including an upper section 20 made of a non-magnetic material and a lower section 21 made of a ferro-magnetic material. The winding 19 is connected through suitable leads to an amplifier 22 in such a manner that the winding, when horizontally aligned with the non-magnetic section 20, produces a signal setting the electrically actuated valve for delivery of liquid from the pump to the jack, whereas when the winding 19 is aligned with the ferro-magnetic section 21, the signal obtained sets the valve 4 for connecting the pipe with the channel 7.

It is also possible to resort to a luminous beam acting on a photo-cell, the luminous beam being cut off by a screen to a varying extent according to the relative position of the elements positioned in the manner described for the contact-pieces 9 and 10 and illustrated in FIG. 1. Obviously, any other means for indicating the relative position of the jack elements may be used.

FIG. 3 illustrates diagrammatically a further arrangement of the invention, wherein the pressure acting inside the jack is adjusted continuously and gradually by a hydraulic distributor including a sleeve 23 and a double slide valve 24 inside the latter. Said slide valve 24 may be shifted by a known pneumatic control system including a nozzle 25 rigid with the plunger piston 1 of the jack, a plate 26 connected through a positioning spring 11 with the blade spring 13 subjected in turn to the action of the piston 14 and bellows 27 subjected to the pressure acting in the nozzle 25 and transmitted to it through the agency of the hose 28. The nozzle 25 is supplied continuously with compressed air from a container 29 through a further hose 30, said air escaping through the port 25a at the end of the nozzle. The jet passing out of said port 25a impinges at right angles on the plate 26 which is located at a small distance from said port; the pressure prevailing in the nozzle 25 depends consequently on the position of the blade 26 with reference to the nozzle 25.

It is apparent that if a sheet of material is urged into

the gap between the rolls of the rolling mill, the force F applied to the jack increases the pressure inside the jack chamber 15. The blade 26 urged forwardly by the piston 14 is lowered and increases the pressure in the nozzle 25 and produces thereby an expansion of the bellows 27, which shifts the slide valve 24 inside the distributor, whereby fluid is admitted to balance the pressure generated between the rolls, and to lower the plunger piston 1 of the jack.

If the force F is eliminated or reduced, the valve 24 is shifted in the opposite direction and allows some fluid to escape out of the jack.

FIG. 4 illustrates a rolling mill including the jack 1, 2 arranged to compensate for the spring of the mill, said jack being inserted in the kinematic chain of the other-wise conventional rolling mill in which the roll spacing may be adjusted by screws 31. A housing 18 carries the movable elements of the mill including the tightening screw 31, the jack 2—1, the roll 16 in its chock bearing 16a and the roll 17 in its chock bearing 17a. It is also possible to use the jack for adjusting a rolling mill not equipped for adjustment through screws, as illustrated in FIGS. 5 and 6. FIG. 5 shows the arrangement of the jack inside housing 18, while FIG. 6 illustrates with further detail the arrangement for adjusting the height h of the jack, which arrangement differs from that described hereinabove with reference to FIG. 2 only by the fact that the lower contact-piece 9 associated with the upper contact-piece 10 is adjustably secured to the jack plunger piston 1 by a screw 32 engaging a nut 33 fixedly fastened to the support 34 which is mounted on the plunger piston 1. Upon manual turning of said screw 32 or upon operation of said screw by a small motor which is not illustrated, the height h of the jack 1—2 is caused to vary, since the plunger piston 1 assumes always a position such that the switch 9—10 is in an intermediate position ensuring cyclic closing and breaking of the circuit.

This arrangement permits adjusting the spacing of the rolls without the tightening screws of conventional rolling mills. However, hydraulic control means associated with detecting means adapted to be adjusted through a very light mechanical control system, when compared with conventional adjusting means, have the advantage of a much lower inertia. It should be noted that the switch 9—10 and, consequently, the height h of the jack 1—2 also is controlled by the location of the small plunger piston 14 sensitive to the actual rolling stress, whereby it is possible to obtain during the rolling a compensation of the mill spring already referred to.

FIGS. 7 to 10 show the application of an arrangement of the type illustrated in FIG. 2, to a hot rolling mill. In FIGS. 7 and 9 are shown two windings 19a and 19b replacing the winding 19 of FIG. 2, the position of the winding 19a with reference to the winding 19b being adjusted by changing the position of a block 34a adjustably secured to the support 34. In the drawings, the two windings have been illustrated on the same side of the rod 20—21 for sake of clarity of the drawings, but, in practice and for reasons of bulk, it may be preferred to locate the windings 19a and 19b on opposite sides of the rod without any modification whatever in the operation of the arrangement. The winding 19a corresponds to the adjustment prior to the introduction of the material into the gap between the rolls, and the winding 19b to the adjustment during the pass.

In FIG. 7, the arrangement is illustrated prior to operation, the winding 19a controlling the operation, while the jack enters the position illustrated for which said winding 19a lies in accurate registry with the line of separation or junction between the non-magnetic and the ferro-magnetic sections of the rod, the junction constituting a first control member of a control arrangement which includes the windings 19a and 19b as a second and third member respectively. FIG. 8 illustrates diagrammatically the relative position of the rolls spaced by a

height h_0 prior to operation, i.e. prior to engagement of the strip by the rolling mill.

Upon engagement of the strip by the rolling mill, the pressure rises suddenly inside the jack, the small plunger 14 depresses the spring 13, and the rod 20—21 is shifted downwardly. Simultaneously with the downward movement of the rod, a switch to be described hereinafter energizes the winding 19b. Now, if the spacing of the two windings has been correctly adjusted, the winding 19b will at this moment accurately register with the line of separation between the non-magnetic and the ferro-magnetic section of the rod, as shown in FIG. 9. The corresponding relative position of the rolls which are now spaced by a height h_1 is illustrated in FIG. 10.

The jack 1—2 without further movement is in its accurate position and no transitory period will occur. The case would have been otherwise if there had been only one winding, for instance the winding 19a, since the jack would have moved to compensate for the spring of the mill through the distance separating the windings 19a and 19b in FIGS. 7 and 9 which obviously requires a substantial lapse of time.

The switch energizing the winding 19b is illustrated in FIG. 11. In this embodiment, which is given solely by way of example and by no means in a limiting sense, the controlling element is constituted by a lever 35 pivotally secured at one end 36 to a stationary element of the mill and adapted to move its other end between two stationary stops 37 and 38. It is urged downwardly by a helical spring 39 and upwardly by a small plunger 40 subjected to the pressure prevailing inside the jack chamber 15 and moving inside a cylinder 40a. When the rolling mill is idle, the lever 35 engages its lower stop 37 under the predominant action of the spring 39. When material engages the rolling mill, the action of the small plunger 40 predominates and the lever engages its upper stop 38. The free end of the lever carries the contact-pieces 41—42 adapted to close the circuit 43 energizing the valve respectively over the windings 19a and 19b according to the position assumed by the lever.

It will now be shown how the spacing between the windings 19a and 19b may be adjusted automatically during a predetermined pass for the next pass. The spacing between the two windings should obviously be equal in this case to the sag of the spring 13 between the period during which the rolling mill was running idle and the period during which the pass is being performed. This sag corresponds to a movement of the measuring plunger 14 from its original position into the position occupied by it during the pass. This shifting of the plunger 14 between a fixed position and a transient position may be sensed and the sensed length of the movement may be conveyed to a remote control system so as to provide a shifting of the winding 19a with reference to the winding 19b.

In FIG. 12, 44 designates a tube which is secured through means which are not illustrated to the body of the jack. A rod 45, the upper end of which is secured to the small plunger 14, extends longitudinally inside said tube. The adjustment of said tube 44 and of the rod 45 is such that the lower end of the rod registers with the lower end of the tube when the rolling mill is idle. Two clamping levers 46—47 the center portions of which are pivotally connected at 48 are pivotally secured to the respective supports of the windings 19a and 19b. The lever 47 corresponding to winding 19b is pivotally secured to the lower section of the tube 44. During the rolling pass, the rod 45 sinks and projects out of the tube 44 by a length corresponding to the rolling mill spring to shift the lever 46. It is sufficient for automatic adjustment of the spacing between the windings to provide means for temporarily releasing, during the pass, the block 34a defining the position of the winding 19a with reference to the winding 19b, so that the lever 46 may engage the end of the rod 45. The block 34a is then fastened again, which

produces an accurate positioning of the winding 19a on said lever 46 with reference to the winding 19b.

Obviously, the lever-controlled arrangement is mentioned solely by way of a non-limiting example and any other automatic adjustment method may be resorted to within the scope of the present invention as defined in the accompanying claims.

In the embodiments of the invention illustrated in FIGS. 7 to 12, the operation of the valve 4 is thus controlled by the relative positions of three control members. The first control member is constituted by the portions of the rod sections 20, 21 contiguously adjacent their line of separation. The second control member is constituted by the winding 19a, and the third control member constituted by the winding 19b. The first control member moves toward and away from the cylinder casing 2 in response to changes in the fluid pressure in the chamber 15 of the casing, as transmitted by the plunger 14. The second and third control members are fastened to the plunger 1 of the jack and move with it. During idling of the mill rolls 16, 17 the second control member is adjacent the first control member, and the third control member is remote therefrom. During the rolling operation, the positions of the second and third control members relative to the first control member are interchanged.

It will be understood that it is possible without departing from the scope of this invention to design modifications in the several arrangements described.

What I claim is:

1. In a rolling mill, in combination, two rolls rotatable about respective, substantially parallel axes; two bearing means movable relative to each other transversely of said axes, said bearing means rotatably supporting respective ones of said rolls; jack means including a cylinder element and a piston element jointly defining a pressure space in said jack means, said elements being connected to respective ones of said bearing means for joint movement therewith; a source of pressure fluid; valve means communicating with said source and said pressure space and movable for alternatively admitting fluid to said space from said source, and for releasing said fluid from said space; and control means for actuating movement of said valve means, said control means including a first control member movable in a direction toward and away from a predetermined position relative to a first one of said elements in response to changes in the fluid pressure in said pressure space, a second control member and a third control member spacedly arranged and each connected to the second element of said jack means for joint

movement therewith relative to said first element between two positions in which one of said second and third control members is respectively adjacent said first control member whereas the other one of said second and third control members is remote from said first control member, and actuating means responsive to the relative position of said first control member and the adjacent one of said second and third control members for actuating movement of said valve means.

2. In a rolling mill as set forth in claim 1, adjusting means for adjusting the relative spacing of said second and said third control member in response to the pressure in said pressure space.

3. In a rolling mill as set forth in claim 2, said adjusting means being responsive to a pressure increase in said pressure space to increase the relative spacing of said second and third control members.

4. In a rolling mill as set forth in claim 1, movement of said valve means being electrically actuated, at least one of said second and third control members being responsive to a position thereof relative to said first control member to generate an electrical signal, and said actuating means including electric circuit means responsive to the signals of said one control member to actuate said valve means.

5. In a rolling mill as set forth in claim 4, said circuit means including switch means responsive to the pressure in said pressure space for connecting a respective one of said second and third control members with said circuit means when the pressure in said pressure space differs from a predetermined value.

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