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[54] THRUSTING ARRANGEMENT FOR A ROLLING MILL

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[51] **Int. Cl.**...**B21b 37/08**

[58] **Field of Search**.......................72/245, 246, 8, 20, 21, 10

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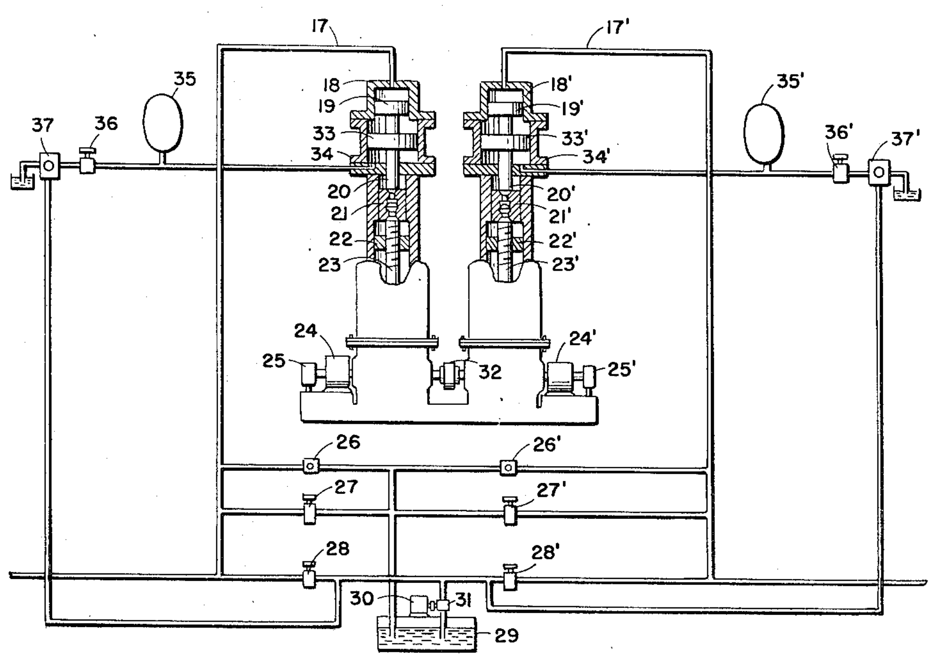
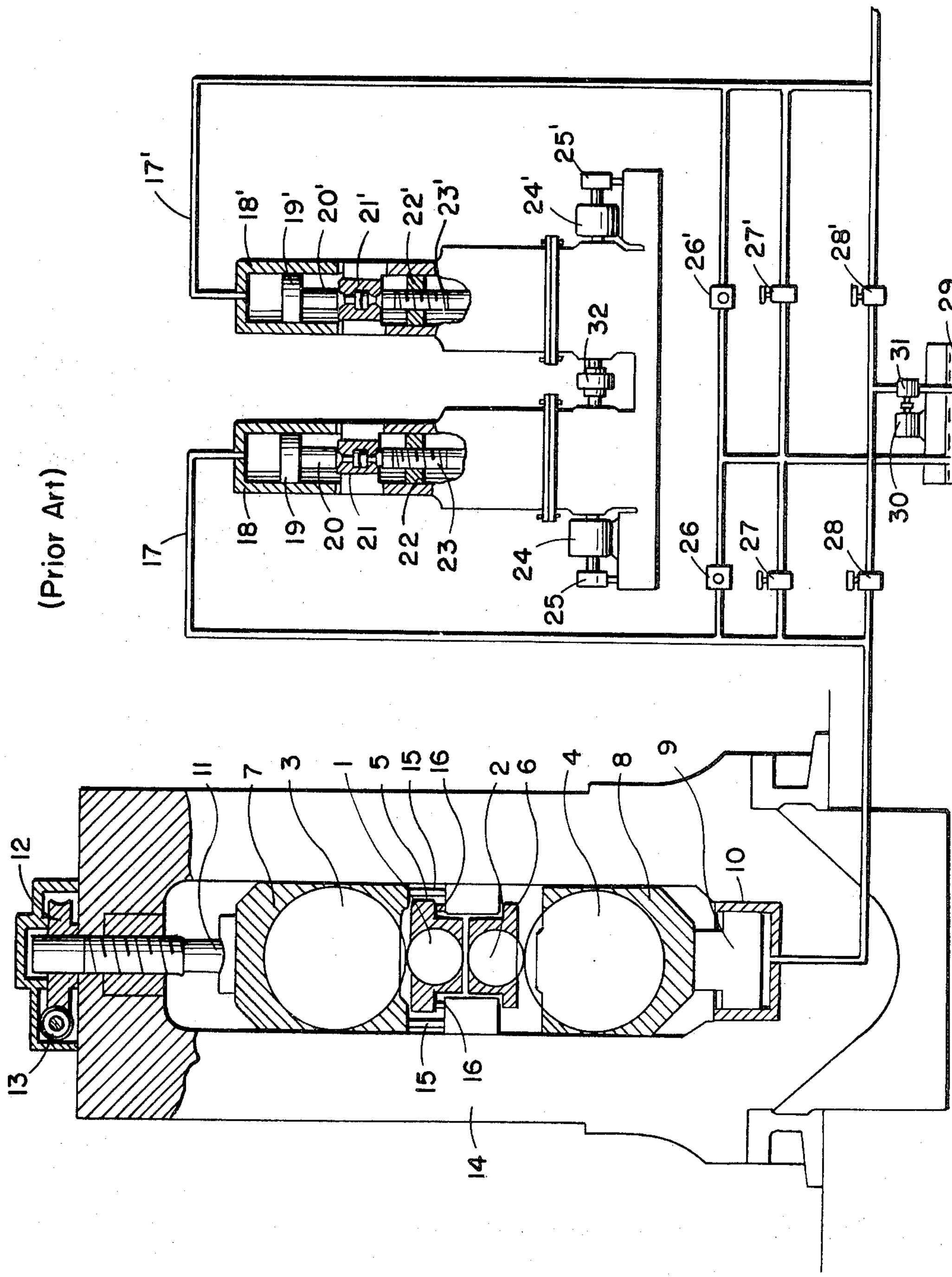
[57] **ABSTRACT**

A thrusting arrangement for a rolling mill which has a large diameter hydraulic piston maintaining pressure on the working rolls to maintain the roll gap includes a hydraulic device hydraulically coupled to the large diameter piston and including relatively small diameter piston means displaceable in cylinder means and connected to piston rod means. The arrangement includes means operable to apply, to the small diameter piston means, a back pressure opposing the pressure thereon resulting from the hydraulic coupling to the large diameter piston and due to the rolling force exerted by the work on the working rolls. Mechanical means are connected to the piston rod means to displace the small diameter piston means, and may comprise a screw and nut arrangement driven by either an electric motor or a hydraulic motor.

4 Claims, 3 Drawing Figures





(Prior Art)

FIG. 1

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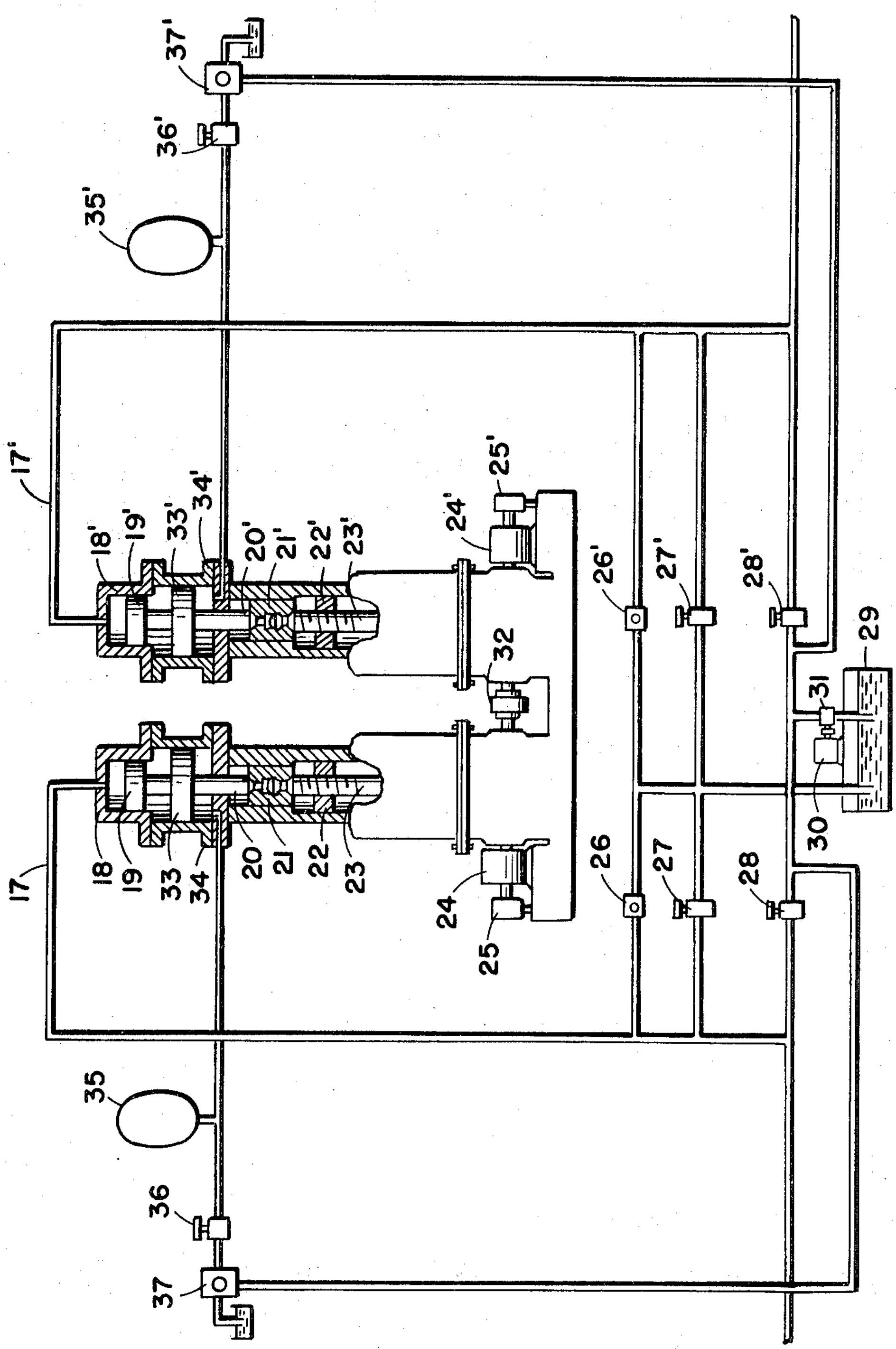

FIG. 2

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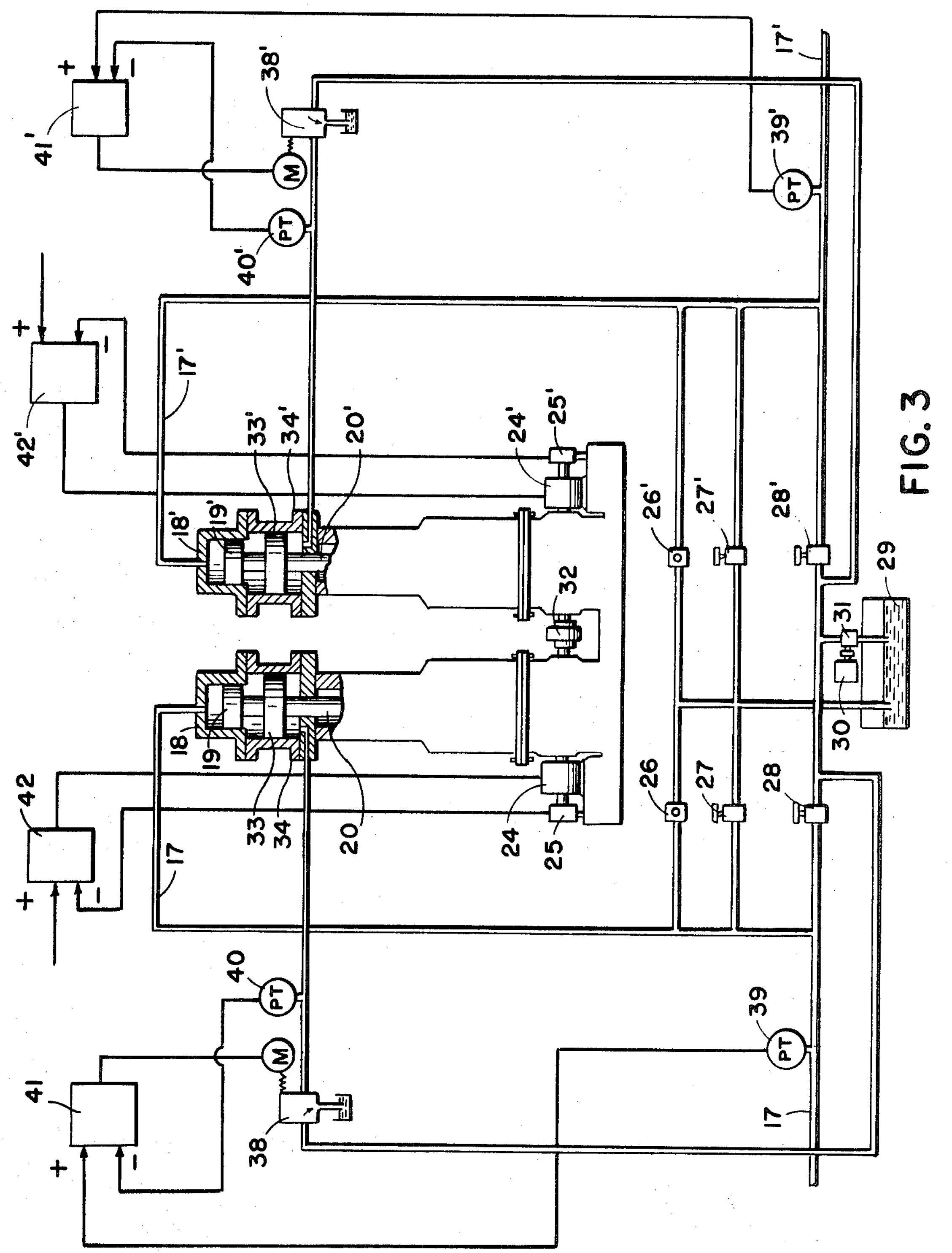

FIG. 3

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THRUSTING ARRANGEMENT FOR A ROLLING MILL

BACKGROUND OF THE INVENTION

There are known thrusting arrangements, for a rolling mill, operable to regulate and set the rolling gap, between the working rolls, through a hydraulic system. Known arrangements have usually been either of the electromechanical type or of the hydraulic type, the hydraulic type being more usually employed.

In known electromechanical thrusting arrangements, pressing has been effected by driving a pressing screw through an electric motor and associated reduction gearing. Consequently, the mechanical efficiency has been low, requiring a high-capacity electric motor, and the response to control signals has been slow.

Known hydraulic arrangements have included restoring means including a pilot valve for positioning the device and means including a servo valve operating as a control valve for accelerating the response to control signals. The efficiency of these hydraulic arrangements has been higher than that of the electromechanical systems or arrangements. However, continuous operation of the hydraulic pressure generating means and the control valve is necessary, and high reliability of the hydraulic system is essential. The maintenance and checking of the arrangement has been complex and troublesome. In addition, in the case of hydraulic arrangements including an especially precise servo valve, there are complexities and troubles due to the fact that the requirement for maintenance and checking has been so severe that the working hydraulic fluid, as well as the filter employed therewith, must be replaced frequently.

To overcome the deficiencies of the electromechanical and hydraulic thrusting arrangements, there has been proposed a hydromechanical thrusting arrangement. This hydromechanical arrangement includes a first hydraulic device for regulating the roll gap and a second hydraulic device, having a smaller diameter than the first hydraulic device, the two devices being coupled to each other. A piston rod of the hydraulic device of smaller diameter is mechanically positioned by means of an electric motor, a hydraulic motor or the like. Thereby, the roll gap may be regulated and set by positioning a ram of the larger diameter hydraulic device by controlling the hydraulic pressure applied to the ram.

This hydromechanical arrangement represents a very substantial improvement in that the mechanical efficiency is enhanced in comparison with electromechanical arrangements, and thus the size or capacity of the electric motor can be made small resulting in improved response to control signals. Another advantage is that maintenance and checking is easier because the hydraulic system is simpler than that used in known hydraulic thrusting arrangements.

Although the hydromechanical arrangement represents an improvement in mechanical efficiency as compared with electromechanical arrangements, it is subjected to the same condition as the latter that, during the rolling operation, thrusting must be carried out continuously against a force proportional to the rolling pressure. The effective work required for thrusting is likewise the same as that required by electromechanical thrusting arrangements, and there is no reduction in the required effective work.

Consequently, the size of the electric motor used with the hydromechanical thrusting arrangement cannot be reduced substantially below the size or capacity of motor required with electromechanical arrangements. An additional disadvantage is that the hydromechanical arrangement cannot obtain a response time equal to that of a hydraulic arrangement employing a servo valve and a pilot valve. Thus, this known hydromechanical thrusting arrangement is not capable of meeting the response time requirements resulting from increases in speed of modern rolling mills.

SUMMARY OF THE INVENTION

This invention relates to thrusting arrangements for rolling mills and, more particularly, to a novel and improved hydromechanical thrusting arrangement in which the operating power requirements are very substantially reduced as compared to known prior art arrangements.

In accordance with the invention, hydraulic ram means, adapted to regulate a roll gap, and a hydraulic device provided with a piston having a diameter smaller than that of the hydraulic ram means, are hydraulically coupled with each other and a back pressure is applied to the smaller diameter piston in opposition to the pressure generated in the hydraulic ram means and due to the rolling force exerted by the work on the working rolls. The piston rod of the smaller diameter piston is mechanically displaced by means of an electric motor, or a hydraulic motor, whereby the roll gap may be regulated or set.

Stated another way, the thrusting arrangement of the present invention represents a substantial improvement upon the known hydromechanical arrangement mentioned above in that the arrangement of the present invention contemplates applying a selected back pressure on the piston rod side of the smaller diameter piston in opposition to the rolling pressure. Thereby, various advantages are obtained, particularly a reduction in the size or power of the electric motor or hydraulic motor, so that these motors can be smaller in size than those required for known electromechanical thrusting arrangements. In addition, the mechanical components, such as the reduction gearing, are greatly reduced in size, resulting in further improvements in the response time. The high-pressure type precise hydraulic control valve, required for known hydraulic thrusting arrangements, is not required in the arrangement of the pressing invention, while the reliability of operation is enhanced and maintenance is facilitated.

An object of the invention is to provide an improved thrusting arrangement for rolling mills.

Another object of the invention is to provide such thrusting arrangement which is of a hydromechanical type.

A further object of the invention is to provide such a thrusting arrangement which is free of the disadvantages of known prior art arrangements of the electromechanical, hydraulic, and hydromechanical types.

Another object of the invention is to provide such an arrangement in which the size and power requirements of mechanical components are very substantially reduced.

A further object of the invention is to provide such an arrangement which has increased reliability and greatly reduced maintenance requirements.

Another object of the invention is to provide such an arrangement in which a back pressure is opposed to the pressure resulting from the rolling force exerted by the work on the working rolls of the mill.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a somewhat schematic part elevational and part sectional view of a known hydromechanical thrusting arrangement for a rolling mill; and

FIGS. 2 and 3 are views, similar to FIG. 1, but omitting illustration of the rolling mill, and illustrating two different embodiments of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In order to facilitate an understanding of the invention, a known hydromechanical thrusting arrangement, illustrated in FIG. 1, will first be described. Referring to FIG. 1, a rolling mill includes upper and lower working rolls 1 and 2, respectively, for direct contact with the work to be rolled. Working rolls 1 and 2 are backed up or reinforced by reinforcement rolls 3 and 4, respectively, which are in rolling contact with the working rolls 1 and 2. Working rolls 1 and 2 are mounted in respective bearing chocks 5 and 6, and reinforcing rolls 3 and 4 are mounted in respective bearing chocks 7 and 8.

Adjustment and maintenance of the rolling gap is effected by a relatively large diameter ram 9 operating in a cylinder 10 and engaging bearing chock 8 for lower reinforcement roll 4. The roll gap between working rolls 1 and 2 can be regulated by displacement of ram 9 in the vertical direction. A screw 11, for adjusting the pass line, is driven from an AC electric motor (not shown), through the medium of a worm gear 12 and a worm 13, for displacement of the rolls in a vertical direction. The mentioned parts are mounted in a mill stand 14 whose base is fixed securely to a supporting structure, such as the floor of a rolling mill.

In addition, the rolling mill stand includes a piston rod 15, of a reinforcing roll-balancing cylinder, and a piston rod 16, of a working roll-balancing cylinder, and piston rods 15 and 16 serve to support the weight of upper reinforcement roll 3, through its bearing chock 7, and the weight of upper working roll 1, through its bearing chock 15, when no work is positioned between working rolls 1 and 2.

A hydraulic line or conduit 17 connects cylinder 10 with a smaller diameter cylinder 18, and a hydraulic line or conduit 17′ connects a cylinder 10′ (not shown) on the opposite ends of the rolls, with a smaller diameter cylinder 18′. Small diameter pistons 19 and 19′ are movable in cylinders 18 and 18′, respectively, and have secured thereto respective piston rods 20 and 20′. Respective couplings 21 and 21′ connect piston rods 20 and 21′ with screws 23 and 23′, respectively, and also prevent rotation of the connected piston rods. Nuts 22 and 22′ are threadedly engaged with screws 23 and 23′, respectively, and are fixed against rotation. Screws 23 and 23′ are rotatable by respective electric motors 24 and 24′ through suitable reduction gearing, whereby to displace pistons 19 and 19′, respectively, in the vertical or axial direction.

Respective transducers 25 and 25′ sense the angular displacements of motors 24 and 24′, respectively, and provide corresponding electric output signals. A clutch 32 is provided to couple the output shafts of motors 24 and 24′. Safety valves 26 and 26′ are connected to lines 17 and 17′, respectively, to relieve excessive pressure applied to cylinder 10, or to its associated cylinder 10′ (not shown), or to cylinders 18 and 18′. Valves 27 and 27′ are provided for rapidly lowering rams 9 and 9′, the ram 9′ not being shown. This is done upon replacement of the rolls. Valves 28 and 28′ are provided to effect rapid elevation of the rams and, upon opening of valves 28 or 28′, hydraulic fluid is delivered into the ram cylinders by means of a hydraulic pump 31 driven by an electric motor 30 and connected to a hydraulic fluid reservoir 29 into which valves 26 and 26′ as well as valves 27 and 27′ discharge.

In the known thrusting arrangement shown in FIG. 1, during rolling operation, valves 27, 27′ and 28, 28′ are closed. When it is desired to regulate the roll gap between working rolls 1 and 2, the rams are displaced vertically through hydraulic lines 17 and 17′, respectively, by energizing electric motors 24 and 24′ to displace cylinders 19 and 19′, respectively, through the medium of the associated screws and nuts, so that the roll gap may be freely regulated. As the change in the roll gap is proportional to the number of revolutions of electric motors 24 and 24′, and since pistons 19 and 19′ have smaller diameters than the respective rams, a fine adjustment of the roll gap can be obtained to obtain a precise amount of pressure to be exerted on the work by working rolls 1 and 2. In addition, by coupling clutch 32, a precisely parallel pressure may be attained, similarly to the known electromechanical pressing arrangements.

FIG. 2 illustrates a thrusting arrangement embodying the invention and which is an improvement on the arrangement shown in FIG. 1. In FIG. 2, the same reference numbers as used in FIG. 1 have been used to indicate identical parts. The rolling mill stand 14 and its associated components has been omitted for clarity.

In FIG. 2, pistons 33 and 33′ are mounted in cylinders 34 and 34′, respectively, and are either rigidly or integrally united with the respective pistons 19 and 19′. The cross-sectional areas of cylinders 34 and 34′, less the cross-sectional areas of the respective piston rods 20 and 20′, are equal to the cross-sectional areas of cylinders 18 and 18′, respectively. Thus, if the pressure effective in cylinders 18 and 18′ above the respective pistons 19 and 19′ is maintained equal to the pressure in cylinders 34 and 34′ below the respective pistons 33 and 33′, the loads applied to the respective piston rods 20 and 20′ are substantially zero. Thereby, the capacity of driving electric motors 24 and 24′ may be made very small. The thrusting arrangement shown in FIG. 2, further includes hydraulic pressure accumulators 35 and 35′, reducing valves 37 and 37′ and shutoff valves 36 and 36′.

In operation of the arrangement shown in FIG. 2, initially clutch 32 is disengaged when not under load, and electric motors 24 and 24′ are operated to reduce the roll gap exactly to zero. When the roll gap is exactly zero, clutch 32 is reengaged and electric motors 24 and 24′ are energized to adjust working rolls 1 and 2 to predetermined roll gap, while observing the electrical signals at the outputs of the transducers 25 and 25′. After the roll setting has been completed, a pressure, corresponding to the expected rolling pressure, is applied beneath pistons 33 and 33′ by operation of the respective reducing valves 37 and 37′ with the associated shutoff valves 36 and 36′ open.

Since the variation of the rolling pressure during a rolling operation is small, either stop valves 36 and 36′ may be closed when a predetermined pressure has been obtained beneath pistons 33 and 33′ upon operation of reducing valves 37 and 37′ to apply a substantially constant pressure from accumulators 35 and 35′, or shutoff valves 36 and 36′ may remain open while reducing valves 37 and 37′ are continuously operable. Under these conditions, when the work to be rolled is pinched between working rolls 1 and 2, the reaction force exerted on pistons 19 and 19′, due to the rolling pressure, becomes substantially equal to the pressure exerted beneath pistons 33 and 33′, respectively, due to the preset back pressure. Thus, the stress exerted on screws 23 and 23′ is substantially zero.

Under these conditions, electric motors 24 and 24′ are actuated in accordance with AGC (automatic gap control) signals, and the roll gap, under the loaded condition, is controlled so as to be maintained constant. Therefore, as the load upon motors 24 and 24′ during rolling is very small, the capacity of these motors likewise may be made very small and, as a result, the motors can be reduced in size. Also, the reduction gearing, including a worm and a worm gear, can also be designed to be small. This greatly improves the response of the thrusting arrangement and thus enables obtaining a rolled workpiece having an accurately uniform thickness.

FIG. 3 illustrates another preferred embodiment of the invention in which the same reference numerals as used in FIGS. 1 and 2 have been applied to identical parts, and in which the rolling mill itself has been omitted, as in FIG. 2.

The embodiment of the invention shown in FIG. 3 includes electromechanical reducing valves 38 and 38′ operated by motors M and controlled through the medium of pressure transducers 39 and 39′ operable to convert pressure in the line 17 and 17′ into electrical signals. Similar pressure transducers 40 and 40′ convert the pressure in the back pressure line into other electrical signals. The electrical signals from pressure transducers 39 and 40 are applied to a controller 41, and those from pressure transducers 39′ and 40′ are applied to a controller 41′, controller 41 controlling operation of electromechanical reducing valve 38 and controller 41′ controlling operation of electromechanical reducing valve 38′. Controllers 42 and 42′ are provided for controlling electric motors 24 and 24′, respectively, and are effective to control motors 24 and 24′ in accordance with signals from the automatic gap control (AGC).

In operation of the arrangement shown in FIG. 3, clutch 32 is disconnected when the rolling mill is not under load and, after the roll gap has been reduced accurately to zero through independent operation of electric motors 24 and 24', clutch 32 is reengaged and electric motors 24 and 24' are actuated through controllers 42 and 42' to set a predetermined roll gap. The setting value of the roll gap, under no-load conditions, is assured through the feedback transducers 25 and 25'.

After the roll gap thus has been set, and when the work is passed between working rolls 1 and 2, the pressure in hydraulic lines 17 and 17' will increase, and pressure is converted, by pressure transducers 39 and 39', into a set value signal for electromechanical reducing valve controllers 41 and 41'. Thus, electromechanical reducing valves 38 and 38' are operated responsive to this signal.

The output pressures of electromechanical valves 38 and 38' are detected by the respective pressure transducers 40 and 40' and converted into a feedback signal for the respective electromechanical reducing valve controls 41 and 41'. Thereby, reducing valves 38 and 38' are operated until the outputs signals from the respective controllers 41 and 41' eventually become zero, that is, until the output signals from pressure transducers 39 and 39', and the output signals from the associated pressure transducers 40 and 41', coincide with each other.

Under these conditions, the force exerted on pistons 19 and 19', and the force exerted on the associated pistons 33 and 33', become exactly equal to each other so that the forces exerted on the respective piston rods 20 and 20' are zero. Consequently, the work required to regulate the roll gap, during a rolling operation, is only that due to friction at the cylinder packings and frictions in the reduction gearing. Thus, the power of electric motors 24 and 24' can be greatly reduced, the size of the motors can be reduced, and the size of the reduction gearings can also be reduced. The value of GD^2, with respect to the output torques of the motors, can be made relatively small, so that an excellent response, having a good rising characteristic, is obtained.

Thus, during rolling operations, the same signals from AGC (moment of oscillation) are applied to controllers 42 and 42', as setting value signals, while feedback signals are obtained from transducers 25 and 25', respectively, to achieve automatic control. Thereby, it is possible to maintain the roll gap continuously constant and to carry out precise rolling.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A thrusting device, for rolling mill including roll stands rotatably mounting a pair of working rolls having a work-rolling gap therebetween during operation and a large diameter ram operable to maintain pressure on the working rolls to maintain a preset rolling gap during operation, comprising, in combination, a piston, having a diameter smaller than that of said ram, movable in a cylinder communicating, through a hydraulic pressure line, with the larger diameter cylinder containing said ram; whereby one side of said smaller diameter piston is subjected to the pressure in said ram cylinder; a piston rod coupled to said small diameter piston; mechanical driving means coupled to said piston rod; a motor connected to said driving means to actuate the same to adjust said small diameter piston in its cylinder; and means operable to apply, to the opposite side of said piston, a back hydraulic pressure opposing the hydraulic pressure exerted on said small diameter piston due to the rolling force.

2. In a rolling mill including roll stands rotatably mounting a pair of working rolls having a work-rolling gap therebetween during operation, hydraulic means, including a large diameter ram, operable to maintain pressure on the working rolls to maintain a preset rolling gap during operation, and a source of hydraulic fluid under pressure connected to the hydraulic means; an improved thrusting arrangement for controlling the pressure applied to said hydraulic means, said arrangement comprising, in combination, a hydraulic device hydraulically coupled to said hydraulic means and having a piston whose effective diameter is substantially smaller than that of said ram, and a piston rod connected to said piston; means operable to apply, to said piston, a back pressure opposing the pressures thereon resulting from the hydraulic coupling of said device to said hydraulic means and due to the rolling force exerted by the work on said working rolls; mechanical means connected to said piston rod to displace said piston to adjust the pressure effective on said ram; and a motor means operable to drive said mechanical means; said hydraulic device comprising a first relatively small diameter cylinder in communication with said hydraulic means; said piston comprising a first piston in said first relatively small diameter cylinder and having the entire area of one face exposed to the pressure effective on said ram, and a second piston connected to said first piston by said piston rod and having said piston rod extending therethrough; said second piston being disposed in a relatively larger diameter cylinder; said means operable to apply a back pressure communicating with said relatively larger diameter cylinder beneath said second piston; the area of said second piston less the area of said piston rod being equal to the area of said first piston.

3. In a rolling mill including roll stands rotatably mounting a pair of working rolls having a work-rolling gap therebetween during operation, hydraulic means, including a large diameter ram, operable to maintain pressure on the working rolls to maintain a preset rolling gap during operation, and a source of hydraulic fluid under pressure connected to the hydraulic means; an improved thrusting arrangement for controlling the pressure applied to said hydraulic means, said arrangement comprising, in combination, a hydraulic device hydraulically coupled to said hydraulic means and having a piston whose effective diameter is substantially smaller than that of said ram, and a piston rod connected to said piston; means operable to apply, to said piston, a back pressure opposing the pressures thereon resulting from the hydraulic coupling of said device to said hydraulic means and due to the rolling force exerted by the work on said working rolls; mechanical means connected to said piston rod to displace said piston to adjust the pressure effective on said ram; and a motor means operable to drive said mechanical means; said means operable to apply a back pressure comprising a hydraulic fluid conduit connected to said hydraulic device and to a source of fluid under pressure; and a pressure-reducing valve connected in said hydraulic fluid conduit; said pressure-reducing valve being an electromechanically operated pressure reducing valve; and a controller controlling operation of said pressure reducing valve responsive to the pressure differential between the pressure effective on said ram and said back pressure.

4. In a rolling mill, an improved pressing arrangement as claimed in claim 3, including a first electrohydraulic pressure transducer connected to said hydraulic means and to said controller; and a second electrohydraulic pressure transducer connected to said hydraulic fluid conduit and to said controller.

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