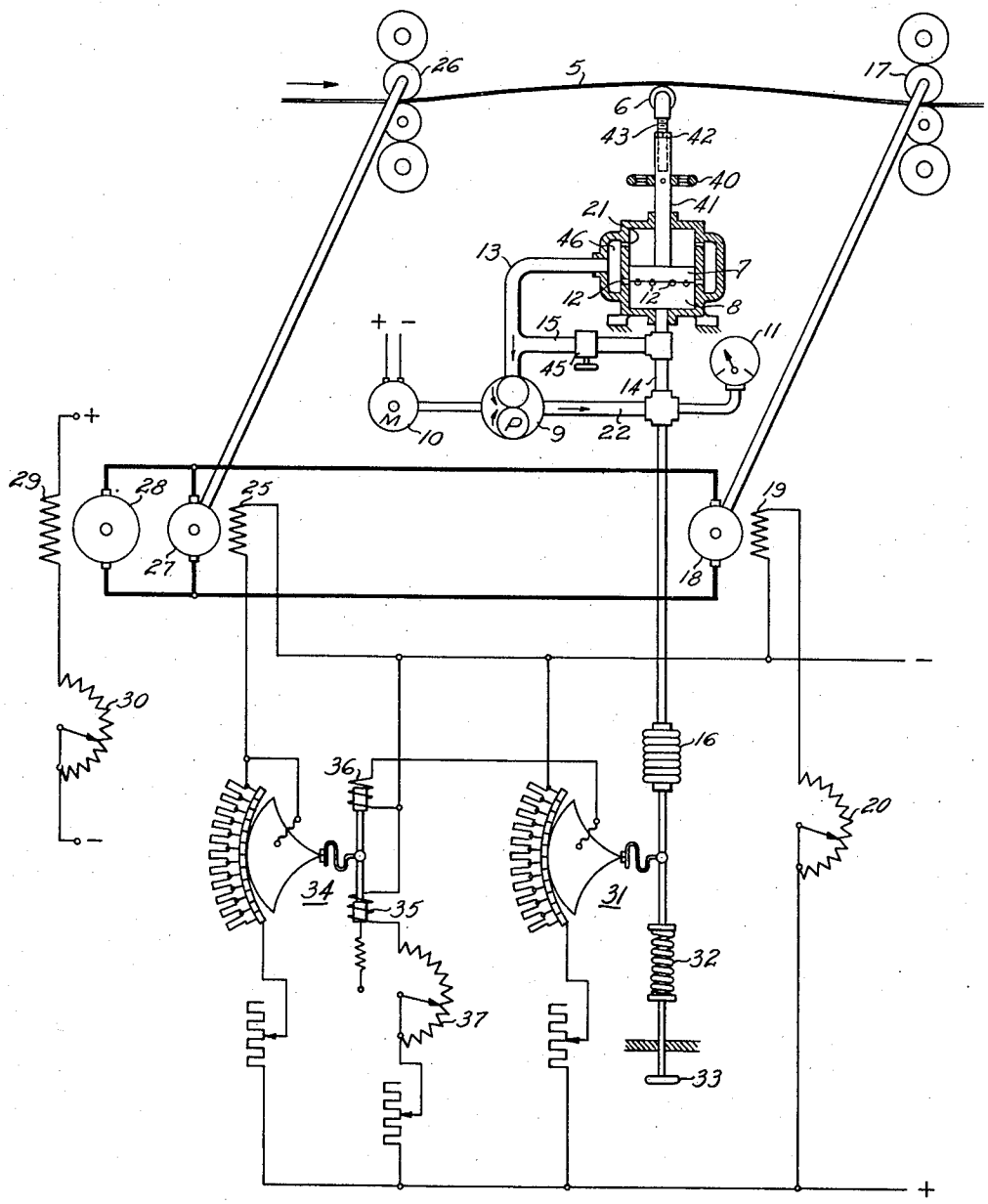
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TENSION INDICATOR AND CONTROL

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TENSION INDICATOR AND CONTROL

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This invention relates in general to a system and apparatus for regulating and indicating the tension in a strip of material moving between sets of operation performing rolls in a strip mill.

Prior art control systems and apparatus of this type have included an idler roll disposed to apply a force transverse to the path of movement of the strip. The force has been applied to the idler roll by counterweights, springs or a fluid pressure operated piston acting on a bell crank supporting the idler roll. The pressure of the idler roll against the strip, however applied, has been regulated responsively to movement of the idler roll up or down due to changes in strip tension.

Movement of the idler roll up or down involves a change in the angle of deflection of the strip from the pass line. Such movement changes the value of the downward component of force on the idler roll by the strip relative to the tension in the strip. Therefore, in order to utilize the force biasing the piston against the strip for purposes of accurately indicating or controlling the strip tension, a compensation of this force was provided to take care of the changed angle of deflection upon movement of the idler roll up or down.

Such compensating devices were more or less delicate and intricate, expensive, subject to inaccuracies and often failed to function properly.

It is therefore a general object of the present invention to provide a fluid pressure operated idler roll that needs no compensation or pressure regulation, in that the angle of deflection is not changed upon changes in tension, and the roll at all times maintains the strip a predetermined distance above the pass line.

It is also an object of the present invention to provide in a system of the above type a tension indicating and regulating device in which the hydraulically operated roll maintains substantially the same position independently of the varying tension in the strip.

It is a further object of the present invention to provide a tensiometer device which will maintain a given position during normal operation and also in the event of strip breakage or when no strip is in the mill.

It is also an object of the present invention to provide a tensiometer device utilized to indicate and regulate the tension in a moving strip of material, which device maintains a substantially constant angle between the strip of material and the pass line of the mill.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawing, in which the single figure is a schematic diagram of a strip mill embodying the present invention.

In the drawing, a strip 5 is shown as being moved in the arrow direction through rolls 17 and 26 of a tandem rolling mill. A hydraulically operated tensiometer is utilized to regulate and indicate the tension in the strip 5. This tensiometer consists generally of a cylinder 8 in which a piston 7, holding a roll 6 against the strip 5, is supported by fluid pressure. This fluid pressure can be utilized for tension indication by connecting an ordinary pressure gauge 11 to the pipe 14 and for tension control by connecting an expansible bellows 16 to the pipe 14.

To more clearly understand the fundamentals of operation of piston 7, the operation of piston 7 in a closed fluid pressure system will be considered. Consider that the cylinder 8 is entirely closed except for the inlet pipe 14, and that the pipe 14 connects with gauge 11 and bellows 16 to form a closed pressure system filled with oil to the bottom of piston 7. The pipes 15 and 22 and the openings 12 in the cylinder 8 will be considered plugged.

Under these conditions, the downward force of the strip 5 on the roll 6 is transmitted through the oil to all parts of the closed system. The gauge 11 will accurately register this pressure and movement of the bellows 16 can be utilized to control the relative speeds of motors 27 and 16. As the piston 7 would float on surface of the oil, and as the oil is substantially non-compressible, the piston 7 and roll 6 would remain in the same position, relative to the strip pass line, independently of changes in strip tension.

The above considered operation would continue only in the event of no leakage of oil past the piston or anywhere in the closed pressure system. In a practical working device such leakage would occur and the level of oil in cylinder 8 and therefore the angle of deflection of the strip would change.

In order to maintain the angle of deflection constant and provide for piston leakage, the device as shown in the drawings is utilized. Leakage openings 12 are provided in the cylinder 8 circumferentially in a plane parallel to the plane of the face of the piston 7. The distance of these holes from the bottom of the cylinder 8 is made equal to the predetermined distance the strip 5 is to be above the pass line. These openings 12 are relatively small and a large number of

them are provided. In one embodiment where the cylinder 8 was six inches in diameter, the openings 12 were one-tenth of an inch in diameter and about forty openings were provided.

A small pump 9 pumps the leakage oil from a reservoir 46 surrounding the cylinder 8, through pipes 13, 22 and 14 to the cylinder 8 beneath the piston. The leakage of oil through the openings 12 is controlled by very slight movement of the piston 7, which opens or restricts these openings so that the pressure in the oil beneath the piston is always equal to the pressure of the strip 5 on the roll 6. The space above the piston 7 is opened to the reservoir 46 by ports 21.

The movement of piston 7 in opening or restricting the leakage openings 12 is negligible as to its effect on the angle of deflection of the strip and therefore on the accuracy of the device. Error due to leakage flow of oil through openings 12 is negligible as these openings are very small and the flow of liquid is also very small. As the pump 9 supplies only this small leakage flow, such pump may be of low capacity.

As the piston 7 maintains substantially the same position regardless of the tension in the strip 5, the fluid pressure in the cylinder 8 is an accurate measure of the tension on the strip 5. This pressure is indicated by the gauge 11 which is calibrated in pounds tension in the strip. If the strip 5 should break, the tensiometer piston 7 is maintained in the position shown, for the pressure of the oil in the cylinder 8 is immediately relieved, due to absence of pressure on the roll 6. Similarly when the strip 5 is being threaded into the mill the tensiometer piston has no downward force other than gravity acting thereon and it therefore maintains its normal position.

The amount of fluid pressure in the cylinder 8 is also utilized to regulate the tension in the strip 5 by regulating the relative torques of the motors 18 and 27 driving the stands of rolls 17 and 26, respectively. The pressure in the cylinder 8 is transmitted to a bellows 16, which supplies movement to a regulator shown generally at 31. This movement is dependent upon the amount such pressure is in excess of a biasing force supplied by spring 32. The spring 32 may be adjusted by means of an adjusting member 33. The speed of the motor 18 is maintained at the desired constant value by means of a rheostat 20 in the circuit of field 19 of the motor 18. The regulator 31 is utilized to control the current in a control coil 36 of a regulator 34 which controls the current in the field 25 of the trailing motor 27.

The adjusting coil 35 of the regulator 34 has the current therein set by a rheostat 37 so that the torque of the motor 27, relative to the speed of the motor 18, is such as to give the desired tension. If, after this setting is made, the tension in the strip 5 increases a slight amount, the piston 7 is moved downward slightly to restrict the ports 12 to permit the increase of pressure in the cylinder 8. This pressure extends the bellows 16 downward, moving the regulator 31 against the action of spring 32 to decrease the amount of resistance in circuit with the coil 36 thereby increasing the current in such coil. The increase of current in the coil 36 moves the regulator 34 to increase the resistance in series with the field 25 thereby reducing the current therein and increasing the torque of trailing motor 27. This increase in torque, relative to the constant speed of motor 18, decreases the tension in the strip 5 until it is at the desired normal value.

A generator 28 supplies both motors 27 and 18 and is shown as provided with a field 29 which may be varied by a rheostat 30 to change the speed of the mill. The roll 6 is shown mounted in a supporting member having a threaded portion 43 cooperating with a similarly threaded portion of the piston rod 41. A hand wheel 40 is rigidly mounted on the rod 41 so as to rotate therewith. The position of the roll 6 above the pass line is therefore adjustable for roll wear by adjusting the relative position of piston rod 41 and the supporting member 43 by turning of the hand wheel 40 while the roll 6 is supported against movement by the roll guides (not shown). A lock nut 42 holds the relative position of the rod 41 and member 43.

In order to adjust the tensiometer roll 6 to the proper position prior to rolling the strip 5, a bypass valve 45 is opened in the pipe 15 permitting the piston 7 to come to rest at the bottom of cylinder 8. The hand wheel 40 is then moved so that the roll 6 is just at the pass line. This makes a simple adjustment as the pass line may change dependent upon the diameter of the particular rolls 17 and 26 being utilized. The roll 6 is therefore above the pass line a distance equal to that from the bottom of the cylinder to the ports 12.

The ports 12 have been shown as illustrative of any valve means in the cylinder 8 whereby the leakage oil pumped through pipes 22 and 14 by the constant volume pump 9 may be controlled so that the piston 7 is always at a predetermined level in cylinder 8. Any suitable valve means operated by or in accordance with a very slight movement of piston 7 may be utilized to provide the function of ports 12.

An embodiment of the invention has been illustrated in connection with a tandem strip mill. This invention is applicable to any plurality of work devices arranged in spaced relation for simultaneously working a piece of material extending between such work devices.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. In a system for tensioning a strip of material, an idler roll, a piston supporting said idler roll in contact with said strip, means comprising a cylinder for supplying fluid under pressure to said piston, and valve means providing for and controlling leakage of said fluid from said cylinder when said piston is at a predetermined point intermediate the ends of said cylinder.

2. In a system for tensioning a strip of material, an idler roll, a piston supporting said idler roll in contact with said strip, means comprising a cylinder for supplying fluid under pressure to said piston, valve means providing for and controlling leakage of said fluid from said cylinder when said piston is at a predetermined point intermediate the ends of said cylinder, and means for indicating said pressure.

3. In a strip tensioning system, an idler roll, a piston supporting said idler roll in contact with said strip, a cylinder cooperating with said piston, an inlet in said cylinder connected to a constant

flow source of fluid under pressure, an outlet in said cylinder, and means operable in accordance with slight movement of said piston for controlling the effective area of said outlet.

4. In a strip tensioning system, an idler roll, a piston supporting said idler roll in contact with said strip, a cylinder cooperating with said piston, an inlet in said cylinder connected to a constant flow source of fluid under pressure, an outlet in said cylinder, means operable in accordance with slight movement of said piston for controlling the effective area of said outlet, and means for indicating said pressure in said cylinder.

5. In a strip tensioning system, an idler roll, a piston supporting said idler roll in contact with said strip, a cylinder cooperating with said piston, an inlet in said cylinder connected to a constant flow source of fluid under pressure, and means comprising an outlet opening in said cylinder whereby said piston is maintained at a substantially constant level in said cylinder and the pressure in said fluid is directly proportional to the tension in said strip.

6. In combination, a plurality of work devices arranged in spaced relation for simultaneously working a piece of material extending therebetween, an idler roll, a piston supporting said idler roll, a cylinder cooperating with said piston to maintain a fluid under pressure thereon tending to hold said roll in contact with said strip, and means comprising a valved outlet opening in said cylinder operable upon slight movement of said piston for regulating the torque supplied to one of said plurality of work devices.

7. In combination, a plurality of work devices arranged in spaced relation for simultaneously working a piece of material extending therebetween, an idler roll, a piston supporting said idler roll, a cylinder cooperating with said piston to maintain a constant flow of fluid under pressure to said piston tending to hold said roll in contact with said strip, means comprising a valved outlet opening in said cylinder operable upon slight movement of said piston for maintaining said piston substantially at a predetermined level in said cylinder independently of the tension in said strip, and means responsive to said pressure for regulating the torque supplied to one of said work devices relative to the speed of another of said work devices.

8. In a tension indicating device, an idler roll, a piston supporting said idler roll, a cylinder cooperating with said piston to maintain fluid under pressure thereon tending to support said roll against a downward force acting thereon, a chamber adjacent said cylinder, a communicating passageway between said chamber and said cylinder controlled by movement of said piston, a second passageway between said chamber and said cylinder, a fluid pump connected in said second passageway to move fluid under pressure from said chamber to said cylinder, and a pressure gauge connected responsive to the pressure in said cylinder.

9. In combination, an idler roll, a piston supporting said idler roll, a cylinder cooperating with said piston, an inlet opening in said cylinder, a constant volume pump connected to supply liquid to said inlet opening, a chamber adjacent said cylinder, a plurality of small outlet openings in said cylinder circumferentially arranged in a plane parallel to the face of said piston and opening into said chamber, means connecting the intake of said pump to said chamber, and a pressure translating device connected to said cylinder.

10. In a system for tensioning a strip of material, a roll, a cylinder, a piston reciprocable in said cylinder and provided with a projection supporting said roll in contact with said strip, means for supplying fluid under pressure to said cylinder on one side of said piston, and a plurality of pressure releasing openings in the wall of said cylinder arranged circumferentially in a plane parallel to the face of said piston at a predetermined point intermediate the ends of said cylinder.

11. In combination, a roll, a cylinder, a piston reciprocable in said cylinder and provided with a projection supporting said roll, means comprising a substantially constant volume pump for supplying fluid under pressure to said cylinder on one side of said piston, and pressure releasing means rendered operative when said piston is at a predetermined point intermediate the ends of said cylinder for maintaining a substantially constant volume flow of fluid through said cylinder.

12. In combination, a plurality of work devices arranged in spaced relation for simultaneously working a piece of material extending therebetween, a cylinder, an idler roll, a piston reciprocable in said cylinder and provided with a projection supporting said idler roll in contact with said piece of material between said work devices, means for supplying fluid under pressure to said cylinder on one side of said piston, and a pressure releasing opening in the wall of said cylinder at a distance from the fluid entering end of said cylinder equal to the distance said idler roll is supported away from a straight line through said piece of material at said work devices.

13. In a strip tensioning system, a roll, a cylinder, a piston reciprocable in said cylinder and provided with a projection supporting said roll, an opening in the wall of said cylinder at a predetermined point intermediate the ends thereof, and means comprising a closed pressure system for supplying fluid under pressure to said cylinder at one side of said piston and receiving fluid under pressure from said opening.

14. In a strip tensioning system, a roll, a cylinder, a piston reciprocable in said cylinder and provided with a projection supporting said roll, an opening in the wall of said cylinder at a predetermined point intermediate the ends thereof, means comprising a closed pressure system for supplying fluid under pressure to said cylinder at one side of said piston and receiving fluid under pressure from said opening, and means connected to said closed pressure system for indicating the fluid pressure therein.

15. In a system for tensioning a strip of material, an idler roll, a piston supporting said idler roll in contact with said strip, means comprising a cylinder for supplying fluid under pressure to said piston, and valve means operably dependent upon the position of said piston in said cylinder for controlling the quantity of leakage of said fluid from said cylinder.

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