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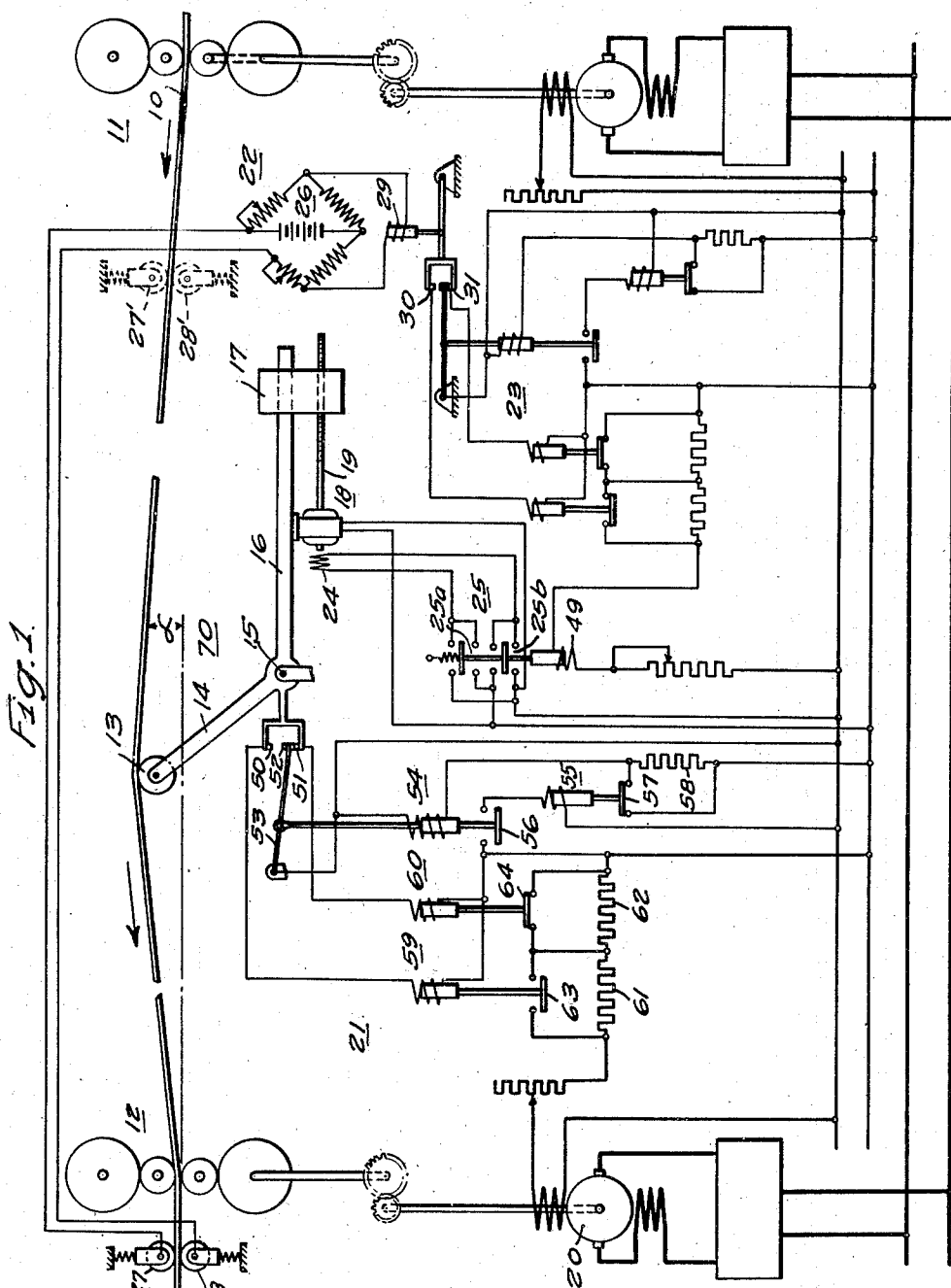
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2,268,217

TENSIOMETER FOR TANDEM MILLS

Filed July 1, 1937

3 Sheets-Sheet 1



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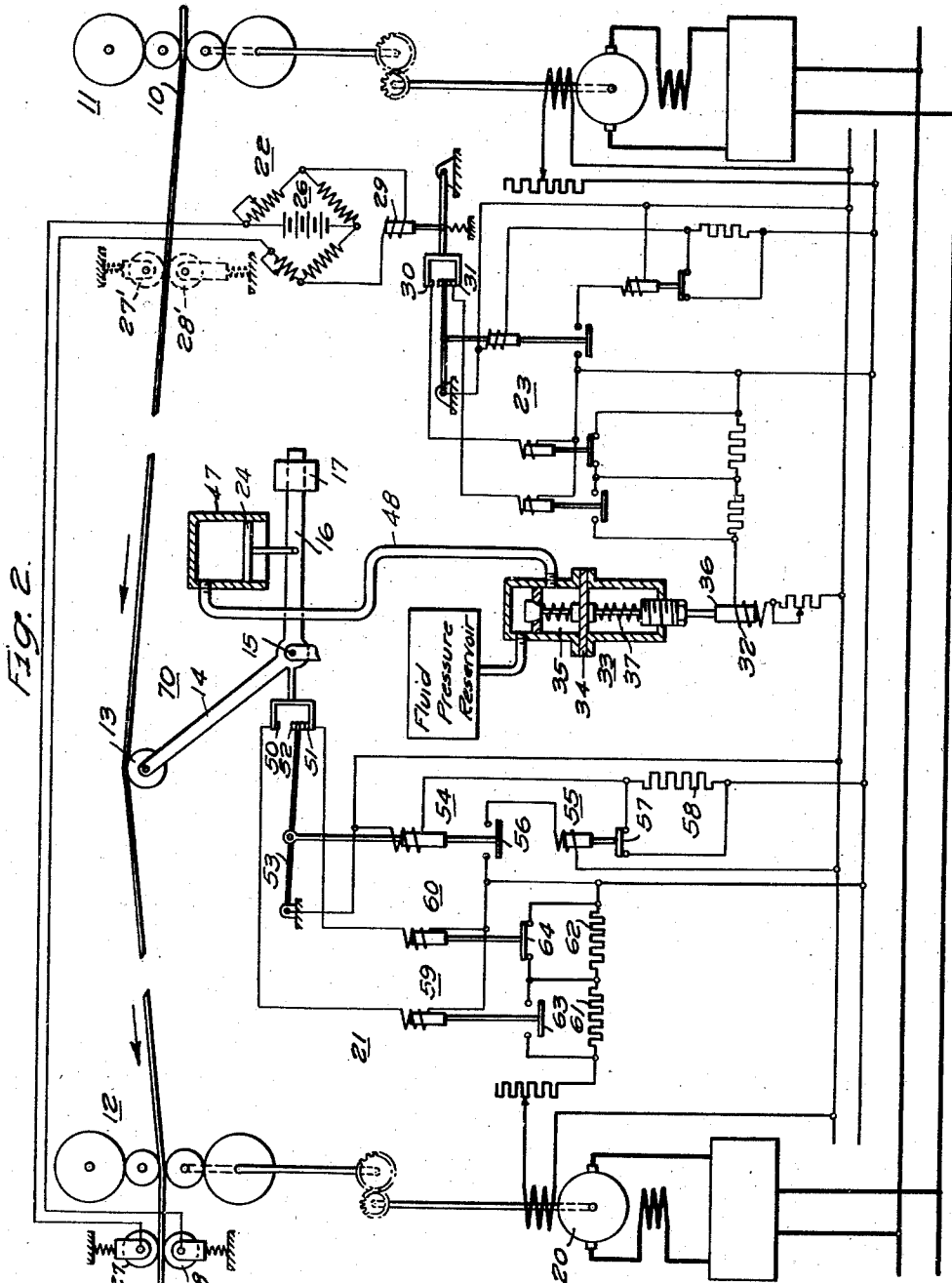
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TENSIOMETER FOR TANDEM MILLS

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3 Sheets-Sheet 2



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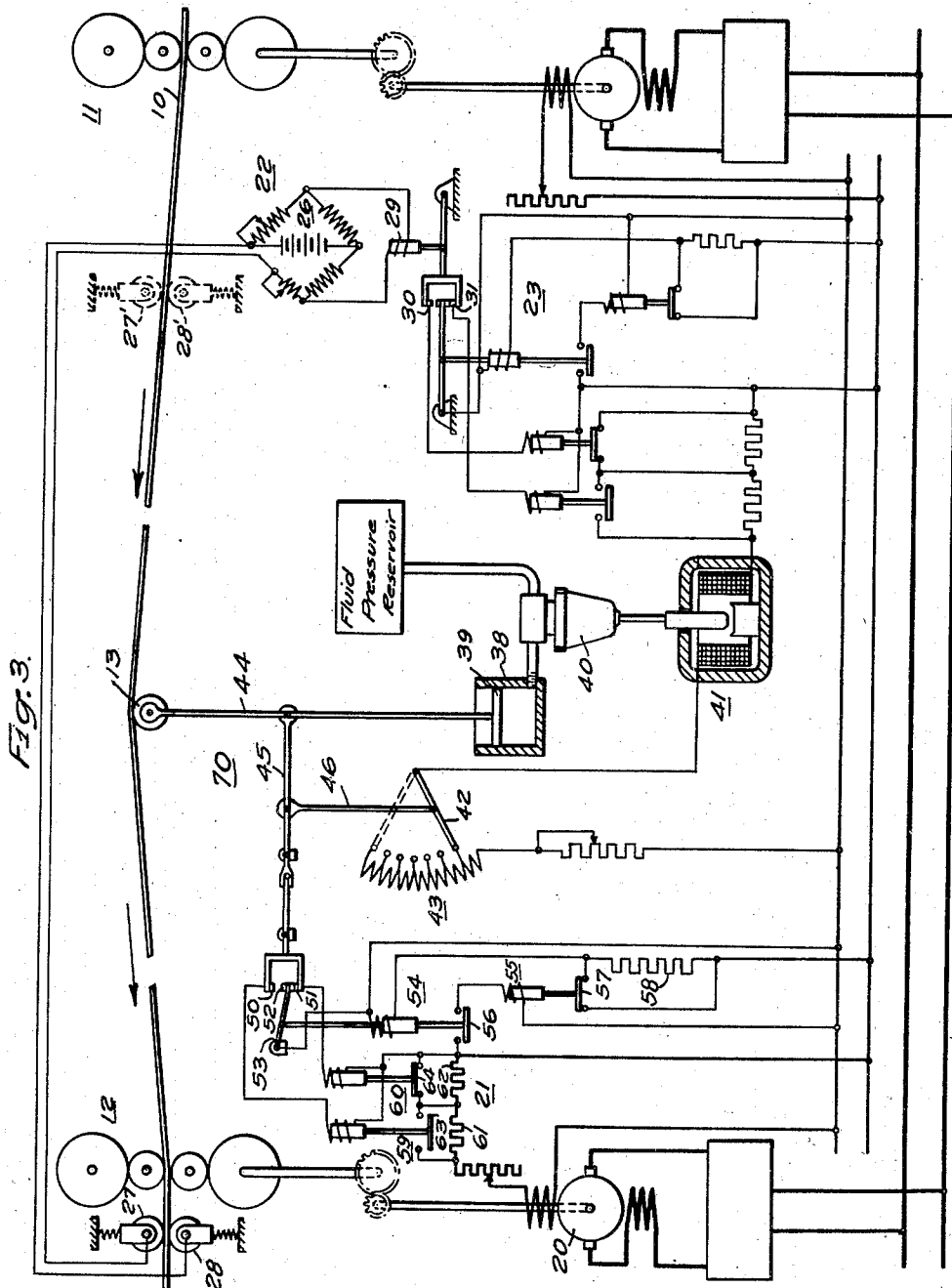
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TENSIOMETER FOR TANDEM MILLS

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3 Sheets-Sheet 3



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2,268,217

TENSIO METER FOR TANDEM MILLS

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Application July 1, 1937, Serial No. 151,483

24 Claims. (Cl. 80—35)

My invention relates, generally, to strip rolling mills, and, more particularly, to mechanism for so controlling the tension in the strip material as it passes between the roll stands as to secure uniform thickness of product.

In the operation of strip rolling mills it has been found desirable to maintain a tension on the strip as it passes between the roll stands. This tensioning of the material helps in the reduction of the material, the amount of reduction of the material being a function of the tension applied to the material. For a given tension, therefore, all other factors remaining constant, a given uniform thickness of strip would be produced.

However, due to variations of factors in the rolling process the thickness of the rolled strip may vary, resulting in a final product which is not of uniform thickness.

The object of my invention is to provide a tensioning device for a strip rolling mill which shall function to produce a strip of uniform cross-section or thickness.

Another object of my invention is to provide a strip tensioning device for a strip rolling mill which shall function to vary the tension on the strip in accordance with the thickness of the strip.

Another object of the invention is to provide a tensioning device for a strip rolling mill which shall function to vary the degree of reduction of the strip in the mill in accordance with variations in thickness of the strip.

Another object of the invention is to provide for controlling the operation of a strip tensioning device by means of a device responsive to the thickness of the strip whereby the tension on the strip is varied in accordance with the thickness thereof.

Another object of my invention is to provide a tensioning device for a strip rolling mill which shall be simple and reliable in operation and which may be readily manufactured and installed.

These and other objects and advantages of the invention will be apparent from the following detailed description of the invention taken in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration of the elements of the preferred embodiment of my invention and their cooperative relationships;

Fig. 2 is a diagrammatic illustration of another embodiment of my invention; and

Fig. 3 is a diagrammatic illustration of a third embodiment of my invention.

In practicing my invention I provide a strip tensioning device which normally functions to subject the strip to a substantially constant tension and control the operation of the tensioning device to vary the tension in accordance with any variation in the thickness of the strip from the desired thickness by means of a regulator device which is, in turn, controlled by a device responsive to the strip thickness. By means of this arrangement should the gauge or thickness of the strip vary for any reason, the tensioning device is immediately caused to subject the strip to an increased or decreased tension, as the case may be, to bring it back to the desired gauge.

Referring to the drawings, there is shown in Fig. 1 a tensioning device 70 which is similar to the tensioning device described in the copending application of Charles P. Croco, Serial No. 8,781, filed February 28, 1935, now Patent No. 2,185,836, issued January 2, 1940. In this figure of the drawings, a strip 10 is being passed through reducing roll stands 11 and 12 in the direction shown by the arrows. A roller 13 is caused to bear against the strip as it passes between the two roll stands. The roller 13 is mounted upon arm 14 of a bell crank which is pivoted at 15 and which has an arm 16 on which is slidably mounted a weight 17.

The turning moment of the bell crank may be varied by varying the distance of weight 17 from pivot point 15 and a motor 18 is provided for this purpose. The motor 18 operates a threaded shaft 19 which engages a correspondingly threaded opening in weight member 17 to slide the weight 17 along the arm 16.

The tensioning device 70 is so designed that it is self-compensating over a predetermined range of movement of the roller 13, that is, it automatically functions to subject the strip to a substantially constant tension throughout this predetermined range of movement by varying the transverse force exerted by the roller 13 in accordance with the degree of deflection of the strip from the normal pass line.

In order to maintain the roller 13 within its predetermined operating range and to hold the roller in as near the same position as possible at all times, a regulating means is provided and controlled in accordance with the position of the arm 14. The regulating means functions to control the excitation of the motor 20 of the mill stand 12 to so control the speed of the motor as to prevent deflection of the strip beyond a predetermined amount. This regulating means is shown generally at 21 and includes a pair of contact ele-

ments 50 and 51 which move in accordance with the movement of arm 14. These contact elements are spaced and are so positioned as to be alternately contacted by a movable contact element 52, the interval of contact between the movable contact element 52 and contact elements 50 and 51 being governed by the positioning of the arm 14 and thus the position of contact elements 50 and 51.

The movable contact element 52 is mounted on arm 53 which is caused to vibrate by the alternate energization and deenergization of relay 54 to which it is connected. Relay 54 controls the energization of relay 55 through its contact element 56 and relay 55 in turn controls the energization of relay 54 through its contact element 57 which is connected across a resistance 58 in the circuit of relay 54. Thus the relay 54 is intermittently energized to vibrate contact element 52.

The contact elements 50 and 51 govern the energization of relays 59 and 60 respectively. Relay 59, when energized, short circuits the resistance 61 through its contact element 63 to increase the field excitation of motor 20 to thus tend to decrease its speed. Relay 60, when energized, removes its contact element 64 from short circuit relation with resistance 62 to decrease the field excitation of motor 20 to thus tend to increase the motor speed. It will be seen that as the upward displacement of the arm 14 increases, contact element 52 will engage contact element 51 longer than it engages contact element 50 and this will result in increased motor speed since relay 60 will be energized longer than relay 59 and the excitation of the motor field will be decreased to increase the speed of the motor. This increase in motor speed will increase the rate at which the strip is passed through the roll stand 12 thereby reducing the slack in the strip between the roll stands and returning the roller to its normal position. In a like manner, the motor is governed by the regulator to prevent too great downward displacement of arm 14.

This regulating means will operate to keep the deflection of the strip from normal within predetermined limits regardless of the tension applied to the strip by the tensioning device which causes roller 13 to bear upon the strip.

In order to secure uniform thickness of the strip, means is provided for varying the tension on the strip in accordance with variations in strip thickness. This means comprises generally a thickness responsive device 22 which controls a regulator 23 to govern the operation of a reversing switch or relay 25 which in turn controls the operation of the weight adjusting motor 18 on the tensioning device.

The thickness responsive device 22 may be any mechanism which is sensitive to strip thickness and is shown as a Wheatstone bridge arrangement 26, one leg of which is connected in circuit with conducting rollers 27 and 28 which bear upon the strip as the strip passes between the two roll stands. Variations in thickness of the strip cause variations in the resistance in the leg of the Wheatstone bridge in which rollers 27 and 28 are connected and these variations in resistance cause variations in the energization of coil 29 of the regulator.

Coil 29 operates movable contact members 30 and 31, so that the positioning of these contact members depends upon the thickness of the strip. The position of the contact members 30 and 31 causes the regulator 23 to vary the energization

of coil 49 of the reversing switch 25. Regulator 23 is not described in detail here since it is substantially a duplicate of the regulator 21 described hereinbefore, both of which are of well known construction.

In the operation of the system of Fig. 1, while the strip 10 is being fed through the roll stands 11 and 12 its tension is being maintained substantially constant by the roller 13 and regulator 21 which operates in response to the displacement of roller 13 to govern the speed of motor 20 of roll stand 12. In this condition of normal operation, weight 17 has been placed at that position on arm 16 which will subject the strip to the desired tension.

If, now, for any reason there is an increase in the thickness of the strip, the resistance in the leg of the Wheatstone bridge 26 in which rollers 27 and 28 are connected will be increased which will cause the regulator to decrease the energization of coil 29. This decrease in the energization of the coil 29 will allow contact members 30 and 31 to be lowered and will cause the control regulator 23 to decrease the energization of coil 49 of the reversing switch 25. The reversing switch 25 closes its contact members 25a and 25b to so energize field 24 of motor 18 as to cause the motor 18 to move weight 17 further from the pivot point 15. This increase in the moment of arm 16 will increase the pressure of roll 13 upon the strip 10.

The increase in pressure on strip 10 resulting from the increased thickness of the strip will subject the strip to an increased tension to effect a greater reduction of the strip in the roll stand 11 and will allow greater deflection of the strip. This greater deflection, however, will immediately be decreased by the operation of regulator 21 as hereinbefore described.

In the event that the strip thickness decreases, the devices and circuits just described will function to cause motor 18 to operate in a direction as to move weight 17 toward the pivot point 15 to decrease the moment of arm 16 and thus decrease the tension on the strip. This decreased tensioning of the strip will decrease the reduction of the strip in the roll stand 11.

In Fig. 2 of the drawings, there is shown a system for maintaining a constant tension upon the strip which is similar to the one described in detail in my copending application Serial No. 133,419, filed March 27, 1937, now Patent No. 2,189,609, issued February 6, 1940, with a strip thickness responsive device similar to that just described in connection with the apparatus of Fig. 1 of the drawings employed therewith. Like reference characters refer to like elements in the several figures of the drawings.

In this modification roller 13 is caused to bear upon the strip by arm 14, which is pivoted at 15 and is connected to arm 16. A constant force is exerted upon arm 16 by a piston 24 which operates in cylinder 47. Fluid pressure is maintained in cylinder 47 through a fluid conductor 48 which is connected through a constant pressure regulating valve 33 to the fluid pressure reservoir, as shown. There is sufficient leakage past the piston 24 in the cylinder 47 to provide continuous fluid flow through the cylinder so that the pressure exerted by piston 24 will decrease when flow of fluid to cylinder is decreased.

The regulating valve 33 is so constructed as to automatically maintain a desired predetermined pressure in the cylinder 47 and will adjust this pressure when changes in deflection of strip 10

cause movement of piston 24. The operation of regulator 21 to control the speed of motor 20 to properly govern the speed of the rolls in roll stand 12 to limit the deflection of the strip 10 is the same as that described hereinbefore in connection with the operation of the apparatus in Fig. 1.

The pressure which valve 33 maintains in cylinder 47 is governed by the pressure on the lower side of diaphragm 34 which balances against the fluid pressure in the chamber 35 which bears on the upper side of the diaphragm 34. It will be seen that with an increase in pressure on the lower side of this diaphragm the valve will open to permit sufficient pressure to build up in the chamber 35 and, therefore, in cylinder 47 to counterbalance this increased pressure on the lower side of the diaphragm 34. Thus it will be seen that a decrease in the energization of coil 32 which operates on armature 36 to exert a downward force on diaphragm 34 will allow spring 37 to increase the upward force on diaphragm 34 and will permit the valve to increase the pressure in the cylinder 47 and thus so increase the moment of lever arm 16 as to increase the tensioning of the strip 10.

In this instance the strip thickness responsive device 22 and regulator 23 function to so vary the energization of coil 32 to operate valve 33, which in turn, will cause such increases or decreases in fluid pressure in the cylinder 47 as are necessary to increase or decrease the tensioning on the strip to increase or decrease the reduction of the strip in the roll stand 11 to maintain the desired thickness of strip.

In Fig. 3 of the drawings there is shown a strip tensioning device similar to the one disclosed and fully described in my copending application Serial No. 133,418, filed March 27, 1937, now Patent No. 2,221,592, issued November 12, 1940 with a strip thickness responsive device similar to that described hereinbefore in connection with the operation of the apparatus of Fig. 1 of the drawings employed therewith. In this modification the device described in connection with Fig. 3 of the drawings of my hereinbefore referred to Patent No. 2,221,592 is modified by applying to it the strip thickness responsive device.

In this modification roller 13 is caused to bear upon and tension strip 10 by fluid pressure in the cylinder 38 which acts upon piston 39 to force the roller 13 against the strip. The fluid pressure in cylinder 38 is controlled by a regulating valve 40, which in turn, is governed by solenoid 41, and in the normal operation of the mill, the energization of solenoid 41 is constant and the pressure in cylinder 38 is maintained constant to in turn maintain a constant pressure upon the strip. Cylinder 38 and piston 39 operates similar to cylinder 47 and piston 24. In the event that the deflection of the strip increases greater pressure in cylinder 38 will be necessary to maintain the predetermined desired tension on the strip and this is secured by a decrease in the energization of solenoid 41 caused by increased resistance in the circuit of its coil. This increased resistance is effected by movement of arm 42 of rheostat 43 as a result of movement of the roller 13 which is connected through linkage 44, 45 and 46 with arm 42.

In the event that the deflection of the strip increases beyond a predetermined amount regulator 21 will vary the speed of motor 20, as hereinbefore described, to decrease the slack in the

strip and return the roller 13 to its normal position.

Thickness responsive device 22 will act in response to variations in thickness of the strip through regulator 23 to so vary the energization of the regulator solenoid 41 as to vary the pressure in cylinder 38 and thus so adjust the tension on the strip as to cause the necessary variation in the reduction of the strip to maintain a constant strip thickness. The detailed operation of this thickness responsive device and the regulator which it controls has been described hereinbefore.

While, in practice, it is preferable to position the rollers 27 and 28 of the thickness responsive device so as to be responsive to the thickness of the strip after it has passed through the second of the adjacent roll stands as shown in the drawings, it may be so positioned as to be responsive to the thickness of the strip after it has passed through the first of the adjacent roll stands as shown by the broken line positioning of the rollers 27' and 28' in the several figures of the drawings, or these rollers may be positioned to bear on the strip before it passes through the first roll stand.

It is understood that the thickness responsive device described is merely illustrative and any thickness responsive device which has the proper sensitivity may be used. Likewise, the regulating devices described in connection with this application and my hereinbefore referred to patents are illustrative and any suitable regulator may be used.

Thus it will be seen that I have provided a mechanism which is simple in operation, inexpensive to manufacture and easy to install, which will function to so control the tension on a strip of material as it passes between adjoining reducing roll stands as to secure the proper reduction in strip to produce a strip of uniform thickness.

In compliance with the requirements of the patent statutes, I have shown and described herein the preferred embodiments of my invention. It is understood, however, that the invention is not limited to the precise constructions shown and described, but is capable of modification by one skilled in the art, the embodiments herein shown being merely illustrative of the principles of my invention.

I claim as my invention:

1. In a system for reducing the cross-sectional area of a length of material, adjacent work devices through which the material is passed for reducing the cross-sectional area of the material, tensioning means bearing on the material for tensioning the material as it passes between the work devices, and means whereby said tensioning means automatically varies the tension on the material in response to variations in the thickness of the material.

2. In a system for reducing the cross-sectional area of a length of material, a series of work devices through which the material is passed for reducing the cross-sectional area of the material, means engaging the material between pairs of adjacent work devices for tensioning the material as it passes between said work devices, and means for causing the tensioning means to vary the tension on the material automatically in response to variations in the thickness of the material, whereby variations in the amount of reduction of the material are made automatically

in accordance with variations in the thickness of the material.

3. In a strip rolling mill having adjacent reducing roll stands, means for tensioning the strip as it passes between the stands comprising a pivoted arm, a member supported by the arm over which the strip travels in passing between the adjacent stands, said arm being so disposed as to tension the strip when a force tending to rotate said arm about its pivot is applied to the arm, means for applying a rotational force to the arm and means responsive to the strip thickness for varying said rotational force automatically in accordance with the variations in the thickness of the strip.

4. In a strip rolling mill having adjacent reducing stands, means for tensioning the strip as it passes between the stands comprising a member over which the strip travels in passing between adjacent stands, a pivoted arm supporting said member, said arm being so disposed as to tension the strip when a force tending to rotate said arm about its pivot is applied to the arm, means for applying a rotational force to said arm comprising a lever arm having a variable turning moment, and means responsive to the strip thickness for automatically varying the turning moment of said lever arm in accordance with variations in the thickness of the strip.

5. In a strip rolling mill having adjacent reducing stands, means for tensioning the strip as it passes between the stands comprising a member over which the strip travels in passing between the stands, a pivoted arm supporting said member, said arm being so disposed as to tension the strip when a force tending to rotate said arm about its pivot is applied to said arm, means for applying a rotational force to said arm comprising a pivoted lever arm carrying a weight, and means for varying the distance of said weight from the pivot of said lever arm in response to variations in the thickness of the strip.

6. In a strip rolling mill having adjacent reducing stands, means for tensioning the strip as it passes between the stands comprising a member over which the strip travels in passing between the stands, a pivoted arm supporting said member, said arm being so disposed as to tension the strip when a force tending to rotate the arm about its pivot is applied to the arm, means for applying a rotational force to said arm comprising a pivoted lever, means for applying a force to said lever to give it a turning moment, and means responsive to the strip thickness for automatically varying said force in accordance with variations in the thickness of the strip.

7. In a strip rolling mill having adjacent rolling stands, means for tensioning the strip as it passes between the stands comprising a member over which the strip travels in passing between the stands, a pivoted arm supporting said member, said arm being so disposed as to cause tensioning of the strip in accordance with the turning moment applied to the arm, means for varying the turning moment of the arm in accordance with variations in the thickness of the strip comprising a fluid pressure operated piston, and means responsive to variations in strip thickness for varying the fluid pressure applied to said piston.

8. In a strip rolling mill having adjacent reducing stands, means for tensioning the strip as it passes between the stands comprising a member over which the strip travels in passing

between the stands, means for causing said member to exert a varying force against the strip in accordance with variations in strip thickness comprising a fluid pressure operated piston, and automatic means responsive to the strip thickness for varying the fluid pressure on said piston in accordance with variations in strip thickness.

9. In a strip rolling mill having adjacent reducing stands, roller means for tensioning the strip comprising roller means over which the strip travels in passing between the stands, a fluid pressure operated piston for actuating said roller means against the strip to tension the strip, a regulator valve for controlling the fluid pressure acting on said piston, and means responsive to strip thickness for controlling the operation of said valve.

10. In a strip rolling mill having adjacent reducing stands, a tensioning device for the strip having a pivoted lever arm and a weight on said arm for providing tensioning moment for the tensioning device, electrical means for moving said weight along said arm to vary the turning moment of said arm, and means responsive to the thickness of the strip for controlling said electrical weight moving means, whereby the tensioning of the strip is controlled by the thickness of the strip.

11. In a strip rolling mill having adjacent reducing stands, means for tensioning the strip comprising roller means over which the strip travels in passing between the stands, a fluid pressure operated piston for actuating said roller means against the strip to tension the strip, a regulator valve for controlling the fluid pressure acting on said piston, means responsive to strip thickness for controlling the operation of said valve, and means responsive to the degree of displacement of said roller by said piston for so regulating the relative speeds of the rolls in the adjacent reducing stands as to limit the displacement of said roller means.

12. In a strip rolling mill having adjacent reducing stands, means for tensioning the strip as it passes between the stands comprising a member over which the strip travels in passing between adjacent stands, a pivoted arm supporting said member, said arm being so disposed as to tension the strip when a force tending to rotate said arm about its pivot is applied to the arm, means for applying a rotational force to said arm comprising a lever arm having a variable moment, means for varying the turning moment of said lever arm in accordance with variations in the thickness of the strip, and means responsive to the amount of turning movement of said arm for so regulating the relative speeds of the rolls in the adjacent rolling stands as to limit the amount of turning movement of said arm.

13. In a strip rolling mill, means for tensioning the strip as it passes between two adjacent roll stands, and means responsive to the thickness of the strip after it has passed through the second of the roll stands for automatically varying the tension on the strip in accordance with variations in strip thickness.

14. In a strip rolling mill, means for tensioning the strip as it passes between two adjacent roll stands, and means responsive to the thickness of the strip after it has passed through the first of the roll stands for automatically varying the tension on the strip in accordance with variations in strip thickness.

15. In a strip rolling mill having adjacent re-

ducing stands, means for tensioning the strip comprising roller means over which the strip travels in passing between the stands, a fluid pressure operated piston for actuating said roller means against the strip to tension the strip, a regulator valve for controlling the fluid-pressure acting on said piston, automatic means for controlling said regulator valve comprising means responsive to strip thickness and means responsive to the degree of displacement of the strip by said roller.

16. A control system for rolling mill apparatus and the like having a pair of rolls for reducing the thickness of a length of moving material comprising in combination, an electric motor for driving said rolls, and electric gauge means responsive to variations in the thickness of said material for controlling the speed of said motor thereby to vary the tension of said material so as to decrease the variations in thickness.

17. A control system for material modifying apparatus and the like having an element for performing an operation on a length of moving material and a succeeding element for performing an operation on the material after it is delivered from said first element comprising in combination, a first dynamo-electric machine mechanically coupled to said first element, a second dynamo-electric machine mechanically coupled to said succeeding element, and means responsive to variations in the thickness of said material between said elements for controlling said first dynamo-electric machine to vary the tension of said material to reduce the variations in thickness of said material.

18. A control system for material modifying apparatus and the like having an element operating on a length of moving material and a succeeding element operating on the material after it is delivered from said first element comprising in combination, a first dynamo-electric machine mechanically coupled to said first element, a second dynamo-electric machine mechanically coupled to said succeeding element, and electric gauge means responsive to variations in the thickness of the material for controlling the excitation of said first dynamo-electric machine to vary the tension of said material to reduce the variations in thickness of said material.

19. A control system for material modifying apparatus and the like having an element operating on a length of moving material, a succeeding element operating on the material after it is delivered from said first element comprising in combination, individual electric motors mechanically coupled to drive said elements, and means responsive to variations in the thickness of the material between said elements for varying the speed of the motor connected to said first element to vary the tension of said material to reduce the thickness variations of said material.

20. A control system for rolling mill apparatus and the like having an element operating on a length of moving material and a succeeding element operating on said material after it is delivered

from said first element comprising in combination, individual dynamo-electric machines mechanically coupled to said elements, and means responsive to variations in the thickness of said material between said elements for controlling the dynamo-electric machine connected to said first element to vary the tension of the material supplied to said first element to decrease the thickness variations of said material.

21. A control system for rolling mill apparatus and the like having a plurality of elements operating successively on a length of moving material and individual electric motors connected to drive said elements comprising in combination, electric gauge means responsive to variations in the thickness of the material between one of said elements and a succeeding element operating on said material after delivery from said first element, and means controlled by said gauge for controlling the motor connected to said one element to vary the tension of said material between said one element and a preceding element to decrease the variations in thickness of said material.

22. A control system for rolling mill apparatus and the like having an element operating on a length of moving material and a succeeding element operating on said material after it is delivered from said first element comprising in combination, a dynamo-electric machine mechanically coupled to the first of said elements, a device for measuring the tension of said material and means responsive to operation of said device for controlling said dynamo-electric machine to maintain said tension substantially constant, and means responsive to variations in the thickness of the material for varying the setting of said regulator thereby to vary said tension to decrease the variations in thickness of said material.

23. A control system for rolling mill apparatus and the like having an element operating on a length of moving material, a succeeding element operating on said material after it leaves said first element and a dynamo-electric machine mechanically coupled to said first element comprising in combination, a device having a member movable in response to variations in the tension of the material and means responsive to movement of said member for controlling said dynamo-electric machine to decrease said tension variations thereby to maintain said tension substantially constant at a value corresponding to the setting of said device, and electric gauge means responsive to variations in the thickness of said material between said elements for varying the setting of said device to vary said tension so as to decrease the variations in thickness of said material.

24. In a mill for rolling strip, a gauging device on the exit side of said mill, a movable roller on the entrance side of said mill bearing against the strip, and means for varying the force with which said movable roller is moved against said strip in response to variations in gauge determined by said gauging device.

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