

July 13, 1937.

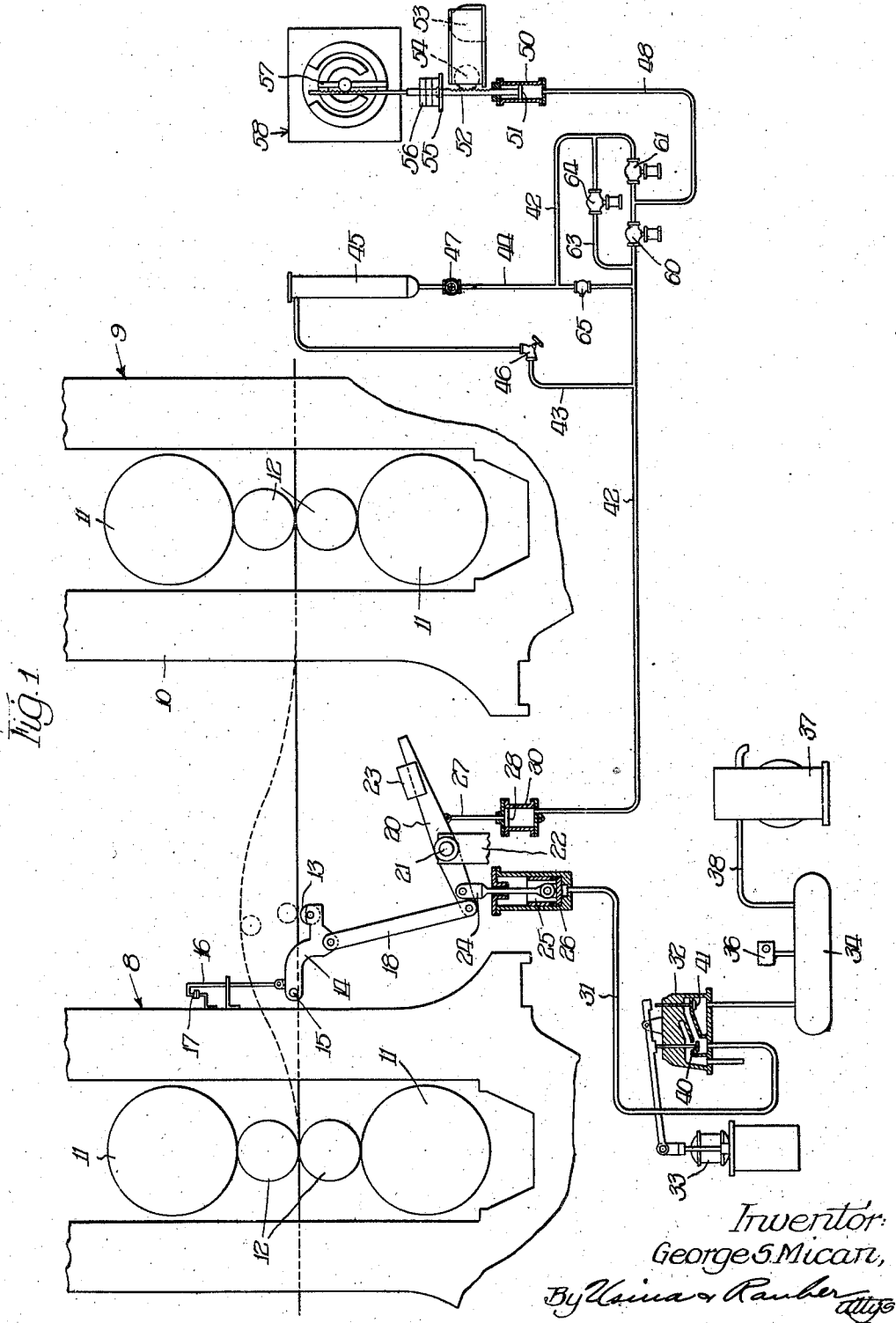
G. S. MICAN

2,087,040

SPEED CONTROL FOR CONTINUOUS STRIP MILL

Filed Jan. 13, 1936

2 Sheets-Sheet 1



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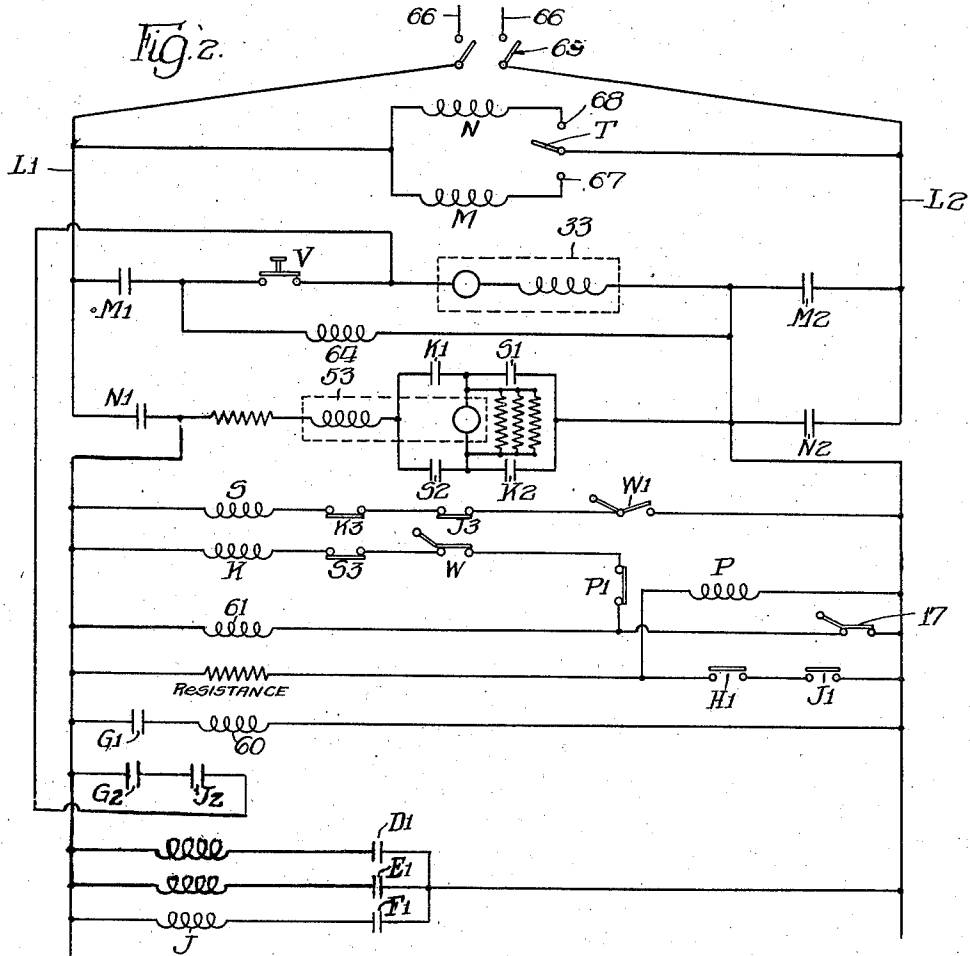
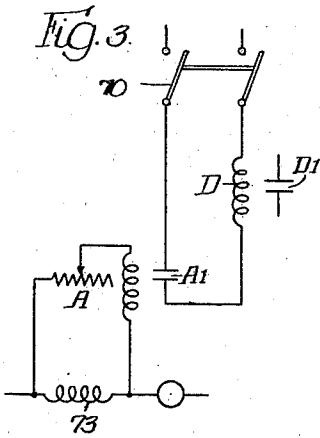
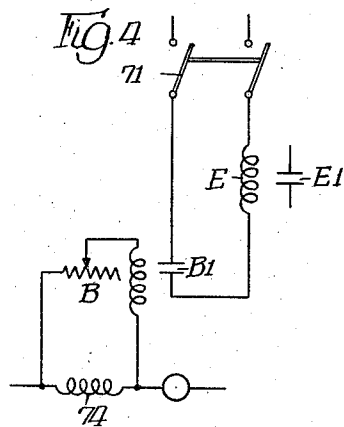
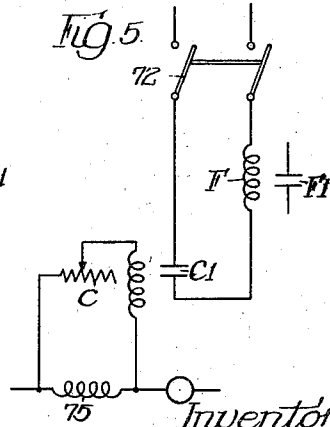
G. S. MICAN

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SPEED CONTROL FOR CONTINUOUS STRIP MILL

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,087,040

SPEED CONTROL FOR CONTINUOUS
STRIP MILL

George S. Mican, Chicago, Ill.

Application January 13, 1936, Serial No. 58,934

11 Claims. (Cl. 80—35)

The invention relates to improvements in apparatus for controlling the speed of continuous rolling mills and has reference particularly to improved apparatus for applying and maintaining a predetermined amount of tension on the material between the roll stands of a continuous hot strip rolling mill.

Heretofore the desired respective speeds of the successive roll motors of the individual stands of a continuous rolling mill have been obtained approximately by the method of manually setting field rheostats for the roll motors respectively. The speed settings of the successive stands are based on the speed of the initial or entering stand of the mill, on the respective reduction in each stand and on the intent to maintain a degree of tension between stands. After the material enters the successive stands speed adjustments are made by the aforementioned manual method to correct the initial discrepancies in setting, for degree of tension or for lack of tension and for temperature variables.

It is an object of the invention to provide apparatus that will automatically perform all the desired speed control functions after the initial speed setting and which will maintain a predetermined amount of tension on the material between roll stands.

Another object of the invention is to provide improved means for automatically regulating the speeds of continuous mills by means of predetermined tension between stands and which will incorporate safety means for automatically regulating the speed of the various roll stands as the material enters and leaves said stands respectively.

With these and other objects in view the invention may consist of certain novel features of construction and operation, as will be more fully described and particularly pointed out in the specification, drawings and claims appended hereto.

In the drawings which illustrate an embodiment of the invention and wherein like reference characters are used to designate like parts—

Figure 1 is a schematic illustration of two successive roll stands of a continuous rolling mill and which are shown equipped with the speed control apparatus of the present invention;

Figure 2 is a wiring diagram illustrating the electrical connections for the speed control mechanism; and

Figures 3, 4 and 5 are wiring diagrams showing the connections between the speed control mechanism and the motor for number 7 stand, number 8 stand and number 9 stand, respectively.

In Figure 1 the apparatus of the invention is

shown in association with successive mill stands of a continuous rolling mill and which stands may perform the last rolling operation on the material, although it is of course understood that the invention is not limited in this respect. For purposes of description the stand to the left may be considered as number 8 and the stand to the right as number 9, each comprising vertically extending spaced uprights 10 which journal the upper and lower backing-up rolls 11 and the working rolls 12. The material travels from left to right, entering number 8 stand where it is reduced in thickness and correspondingly elongated and thereupon enters number 9 stand which further reduces and elongates the material. In practice the speed of the working rolls of a forward stand is somewhat greater than that of the rolls of the next adjacent rearward stand in order to compensate for the elongation in length of the material and since it is desirable to maintain a certain amount of tension on the material between successive stands.

The speed control mechanism of the invention automatically regulates the speed of the forward working rolls responsive to the tension of the material between stands. The same consists of a looping roll 13 carried by the member 14 suitably pivoted at 15 to supporting structure. To the upper end of member 14 is pivotally connected an upright 16 which actuates a limit switch 17, said switch being closed when the looping roll 13 is positioned even with or below a horizontal plane represented by the material when the same travels between the stands with the proper tension thereon. Said switch is accordingly opened when the looping roll travels upwardly which takes place when the material between the stands becomes slack. Pivoted to the member 14 is a link 18 connecting at its other end with a counterbalancing arm 20 suitably journaled at 21 to the vertical standard 22 and carrying on one end thereof the weight 23. Said arm to the left of the pivot point connects with rod 24 joined to the piston 25 adapted to have vertical reciprocating movements within the air cylinder 26. To the other side of the pivot 21 the arm connects with rod 27 which in turn actuates piston 28 having reciprocating movement in the oil cylinder 30.

The air line 31 connects the valve housing 32 with the air cylinder 26. The valves of said housing are in turn actuated by a motor operated thruster 33 and said housing is supplied with air under pressure from the air receiver 34 through pipe line 35. The air receiver is equipped with a pressure governor 36 and con-

nects with the air compressor 37 through the pipe line 38. With the thruster 33 in the position shown in the drawings the exhaust valve 40 is open and therefore the air cylinder 26 communicates with the atmosphere. With the thruster in its other position of operation the exhaust 40 will be closed and the pressure valve 41 will be opened, admitting air from receiver 34 to the connection 31 and eventually to the air cylinder 26 to produce upward movement of the looping roll 13.

The oil cylinder 30 is joined by pipe line 42 and branch lines 43 and 44 with an oil reservoir 45. Line 43 is provided with a relief valve 46 and line 44 with a shut-off valve 47. The oil cylinder 30 also connects through line 42 and line 48 with a second oil cylinder 50 provided with piston 51 and connecting rod 52 in the form of a rack, whereby said rod can be elevated or lowered by operating an electric motor 53 operatively connecting with the rack through gearing 54. The rack 52 extends upwardly through a stop plate 55 which supports counterweights 56. Said weights are elevated by the rod 52 when the same is forced upwardly either by actuation of the electric motor 53 or through pneumatic pressure existing within the oil cylinder 50. At its extreme upper end rod 52 provides a rack operatively connecting with a rheostat sweep arm 57 forming part of the rheostat which is electrically connected in the field of the roll motor of number 9 stand and therefore functions to control the speed of the working rolls of said stand. The oil line 48 joins with oil line 42 between the solenoid operated valves 60 and 61, the former being normally closed and valve 61 being normally open. A by-pass 63 is provided around said valves 60 and 61, said by-pass containing a third solenoid operated valve 64. During manual actuation of the mechanism described the solenoid valve 64 is open so as to connect the oil cylinder 30 with the reservoir 45, thus allowing actuation of the counter-balance arm 20 without effecting corresponding actuation of the rheostat sweep arm 57. For manual operation speed regulation and adjustment are obtained by means of an independent rheostat, not shown. When valves 61 and 64 are closed and the normally closed valve 60 is open the oil cylinders 30 and 50 are joined in a closed system and pneumatic pressure induced in cylinder 30 is communicated to cylinder 50.

Referring to Figure 2, the various elements comprising the control apparatus above described are shown as connected in parallel to conductors L1 and L2 which are electrically connected by means of a single throw double pole switch 69 with the power lines 66 providing the source of power for operating the apparatus. For manual control the switch 69 is first closed and then the selector switch T is closed on the lower contact 67, energizing coil M which actuates to close the contactors M1 and M2. Closing of these contactors energizes the coil of solenoid valve 64 to cause opening of said valve. The circuit to the thruster motor 33 can then be closed by actuation of push button V to result in operation of the motor. Opening and closing the circuit to the thrust motor will alternately open and close the valves 40 and 41 and therefore air under pressure can be admitted to the air cylinder 26 to raise the looping roll 13 or air can be exhausted from said air cylinder to lower said looping roll as desired.

For automatic control the switch T is closed

on the upper contact 68, breaking the circuit to coil M and energizing coil N which effects closing of the contactors N1 and N2, as a result of which the coil of solenoid valve 61 will be energized to open the valve since the looping roll 13 will normally assume its lowermost position, thus maintaining the limit switch 17 closed. The coil P of a time relay will also be energized upon closing of the contact N1 and N2 which will have the effect of opening the contacts P1.

The above operations take place before the material enters the rolls of stand number 7. Referring to Figure 3, which shows certain electrical connections with the interpole field of the motor of stand number 7, it will be understood that the switch 70 is first closed, which would result in energization of coil D except for the fact that the contacts A1 are normally open. When the material enters stand number 7 a voltage drop occurs across the interpole field 73, energizing coil A, closing the contacts A1, which energizes coil D to effect closing of the contacts D1. Referring again to the wiring diagram of Figure 2, it will be observed that contacts D1 are in circuit with the coil G and thus closing of these contacts will energize coil G to cause closing of contacts G1 and G2. With the closing of contacts G1 the coil of solenoid valve 60 is energized and accordingly said valve is opened.

The preliminary operations above described must take place before the material enters the rolls of stand number 8. When this occurs a voltage drop is likewise produced across the interpole field 74 of its respective roll motor. Coil B, Figure 4, is thereupon energized to close contacts B1 which energizes coil E since it is understood that switch 71 has been previously closed. Energization of coil E effects a closing of contacts E1 which as shown in Figure 2 is in circuit with coil H, the same being thus energized, closing the butterfly contacts H1. The material thereupon enters number 9 stand and produces a voltage drop across the interpole field 75 of the motor of said stand, energizing coil C, closing contact C1, energizing coil F, closing contacts F1. F1 is in circuit with coil J which is thereupon energized to cause closing of contactor J2 and the butterfly contacts J1. Energization of this coil also effects opening of the butterfly contacts J3. It will be observed that closing of the contacts H1 and J1 will short-circuit the time relay coil P, which allows the contacts P1 to again close. Closing of the contactor J2 completes the circuit to the thruster motor which is thereupon energized, with the result that the exhaust valve 40 is closed and valve 41 is opened and air under pressure is admitted to the air cylinder 26. Opening of butterfly contact J3 prevents any possibility of motor 53 actuating the rheostat sweep arm 57 to speed up the motor of number 9 stand.

By admitting air under pressure to the air cylinder 26 the looping roll 13 will be forced upwardly. If slack exists in the material between stands 8 and 9 upward movement of the looping roll 13 will be sufficient to open the limit switch 17. As shown in Figure 2 this switch is in circuit with the coil of solenoid valve 61 and as a result said coil is deenergized, closing the valve. The oil cylinder 30 and the oil cylinder 50 are now connected in a closed circuit and any further upward movement of the looping roll will induce pneumatic pressure in oil cylinder 30 which will be communicated to cylinder 50 to effect actuation of the rack 52 and sweep arm 57. As the looping roll 13 travels upwardly, rack 52

likewise has upward movement, rotating the sweep arm 57 in a direction to speed up the roll motor of number 9 stand to take up the slack in the material. The mechanism will now continue to operate automatically to maintain the proper tension on the material between stands.

In the event that the looping roll 13 does not have initial upward movement to open the limit switch 17, which would indicate that the material is under tension greater than that desired, the following operations take place. As the limit switch 17 remains closed and since contacts P1 are closed, the coil K will be energized, closing the contactors K1 and K2, which results in operation of motor 53 in a direction to turn rheostat sweep arm 57 to lower the speed of number 9 roll motor. This immediately causes slack in the material which allows the looping roll 13 to rise, thereupon opening limit switch 17 which breaks the circuit to coil K and also the coil of the solenoid valve 61. As a result the oil cylinders 30 and 50 are placed in the closed circuit and actuation of the mechanism takes place automatically as described.

When the material leaves stand number 7 the voltage drop across the interpole field of its respective motor diminishes, deenergizing coil A, coil D and coil G. The contacts G1 and G2 are accordingly opened which opens the circuit to the thruster motor 33 and to the coil of the solenoid valve 60, whereupon said valve closes and the thruster valve 32 is opened to exhaust. If piston 28 moved upward after valve 60 had closed and no other means of oil feed to cylinder 30 was provided, the possibility of air binding would be encountered. In order to avoid this check valve 65 is incorporated in the system.

As the material leaves stand number 8 the drop in voltage across the interpole field of its respective motor also diminishes, deenergizing relay P, coil E, coil H, and thus opening butterfly contact H1. This permits the time relay coil P to reenergize, whereupon contacts P1 are opened, which by deenergizing coil K, has the effect of preventing the rheostat motor from slowing up the motor of number 9 stand which would take place in the event limit switch 17 closes while the material is still between number 8 and number 9 stands.

When the material leaves number 9 stand the drop in voltage across the interpole field of its respective motor likewise diminishes deenergizing coil C, coil F and coil J, which effects opening of the butterfly contact J1, contactor J2 and closing of butterfly contact J3. The butterfly contact J3 is in circuit with coil S and a limit switch W1 which limits the travel of the rheostat motor in a direction of speeding up the motor of number 9 stand. In circuit with coil K is another limit switch W which limits travel of the rheostat motor in the direction of slowing down the motor of number 9 stand. The circuit to the thruster motor 33 was opened as previously explained when the material left stand number 7 and accordingly air will be exhausted from cylinder 26 to allow the looping roll to descend to its lowermost position, whereupon limit switch 17 will be closed. Closing of this switch energizes the coil of solenoid valve 61, opening the valve to connect oil cylinder 50 with the oil reservoir 45, allowing the counterweights 56 to descend and return the rheostat sweep arm to its normal position which will slow down the motor of number 9 stand.

Limit switch W is closed when the rheostat sweep arm is in the normal or mid-position. It opens only to limit the travel of the rheostat motor in the direction of slowing down number 9 roll motor. When coil K is energized, butterfly K3 is opened, the rheostat motor rotates moving rack 52 downward, closing limit switch W1 at the beginning of its downward motion. If rack 52 is still below normal or mid-position when coil K is de-energized by the opening of either limit switch W or 17, W1 will be closed and butterfly K3 will be closed by the opening of contactors K1 and K2. If the material is still in number 9 stand, J3 will be open. When the material leaves number 9 stand, J3 will close, coil S will be energized, closing contactors S1 and S2 and opening butterfly S3 causing rheostat motor 53 to rotate to return rack 52 to mid-position. At mid-position, limit switch W1 is opened and the rheostat motor is stopped. The return of the rheostat arm to normal position may be summarized as follows: If when the material leaves number 9 stand, the rheostat arm is in a position to speed up number 9 roll motor, it is returned to a normal position by the counterweights alone. If when the material leaves number 9 stand, the rheostat arm is in a position to slow up number 9 roll motor, it is returned to a normal position by the rheostat motor.

From the foregoing, it will be understood that the speed control apparatus of the invention is automatically actuated in response to the slack in the material between stands and therefore maintains a predetermined tension on the material. In the event the material is slack the looping roll is permitted to rise, which results in the actuation of certain instrumentalities to speed up the motor of the forward stand, which takes up the slack and applies proper tension on the material. In case the material is stretched by the initial speeds of the motors, then other elements are actuated to cause a reduction in the speed of the motor of the forward stand, thereupon producing some slack in the material. The invention further makes provision for proper control of the various instrumentalities as the material leaves the several stands having electrical connection with the control apparatus. Thus, as the material leaves stand number 7 of the apparatus disclosed the circuit to the thruster motor is opened so that the looping roll is permitted to descend and simultaneously therewith solenoid valve 61 is energized to open, breaking the closed oil circuit between cylinders 30 and 50. These operations and others which take place as the material leaves stand number 8 counteract the normal tendency of the motor of number 9 stand to speed up. The invention is not limited to the particular form of looping roll disclosed as any mechanism embodying a freely rotating roller mounted and guided in a motion, some component of which is perpendicular to the plane of travel of the material could be substituted therefore. Also the invention would be operative if instead of speeding up or slowing down the motor of stand 9, the motor of stand 8 were operated in a reverse manner, that is, in place of speeding up motor of stand 9 the motor of stand 8 could be reduced in speed.

What is claimed is:

1. In a continuous rolling mill, the combination with successive roll stands, of movable means located between a pair of stands and having motion some component of which is perpen-

dicular to the plane of travel of the material, pneumatic pressure means operatively connecting with said movable means for maintaining the same in contact with said material, control apparatus including a field rheostat adapted to regulate the speed of one roll stand of said pair of stands between which said movable means is located, and a pneumatic pressure line connecting said movable means and said field rheostat whereby said rheostat is actuated responsive to the motion of said movable means, said pressure line being automatically connected to a reservoir as the end of the material leaves the stand immediately forward of said pair of stands, thereby rendering inoperative the connection between said movable means and field rheostat.

2. In a continuous rolling mill, the combination with successive roll stands, of movable means located between a pair of stands and having motion some component of which is perpendicular to the plane of travel of the material, pneumatic pressure means operatively connecting with said movable means for maintaining the same in contact with said material, control apparatus including a field rheostat adapted to regulate the speed of one roll stand of said pair of stands between which said movable means is located, a pressure cylinder operatively connecting with said movable means, a second pressure cylinder operatively connecting with the field rheostat, and a pressure line connecting said cylinders whereby said field rheostat is actuated responsive to the motion of said movable means, said pressure line being automatically established by the initial travel of the material between stands provided said movable means is permitted to move in a direction indicating the existence of slack in said material.

3. In a continuous rolling mill, the combination with successive roll stands, of movable means located between a pair of stands and adapted to have motion some component of which is perpendicular to the plane of travel of the material, means operatively connecting with said movable means for maintaining the same in contact with said material, control apparatus including electrical means adapted to regulate the speed of one roll stand of the pair of stands between which said movable means is located, a pressure cylinder operatively connecting with said movable means, a second pressure cylinder operatively connecting with the electrical means, a pressure line connecting said cylinders and being joined at a mid-point to a reservoir containing a pressure medium, a valve for closing the connection between said pressure line and reservoir rendering said pressure line operative whereby said electrical means is actuated responsive to the motion of said movable means, and means actuated by the movement of said movable means in a direction indicating the existence of slack in the initial travel of the material between the stands and effective to cause said valve to close.

4. In a continuous rolling mill, the combination with successive roll stands, of movable means located between a pair of stands and adapted to have motion some component of which is perpendicular to the plane of travel of the material, means operatively connecting with said movable means for maintaining the same in contact with said material, control apparatus including electrical means adapted to regulate the speed of one roll stand of the pair of stands between which said movable means is located,

a pressure cylinder operatively connecting with said movable means, a second pressure cylinder operatively connecting with the electrical means, a pressure line connecting said cylinders and being joined at a mid-point to a reservoir containing a pressure medium, a valve for closing the connection between said pressure line and reservoir rendering said pressure line operative whereby said electrical means is actuated responsive to the motion of said movable means, and a limit switch actuated by movement of said movable means in a direction indicating slack in the material between the stands and effective to render said pressure means operative, whereby said field rheostat is actuated responsive to the motion of the movable means.

5. In a continuous rolling mill, the combination with successive roll stands, of movable means located between a pair of stands and adapted to have motion some component of which is perpendicular to the plane of travel of the material, pressure means operatively connecting with said movable means for maintaining the same in contact with the material, control apparatus including a field rheostat adapted to regulate the speed of one roll stand of the pair of stands between which said means is located, pressure means connecting said movable means with the field rheostat whereby said field rheostat is actuated responsive to the motion of the movable means, and an electric motor operatively connecting with said field rheostat, said motor providing auxiliary means for actuating said rheostat.

6. In a continuous rolling mill, the combination with successive roll stands, of movable means located between a pair of stands and adapted to have motion some component of which is perpendicular to the plane of travel of the material, pneumatic pressure means operatively connecting with said movable means for maintaining the same in contact with the material, control apparatus including a field rheostat adapted to regulate the speed of one roll stand of the pair of stands between which said means is located, pressure means connecting said movable means with the field rheostat, means actuated by movement of said movable means in a direction indicating slack in the initial travel of the material between said stands and effective in rendering said pressure means operative, whereby said field rheostat is actuated responsive to the motion of the movable means, an electric motor operatively connecting with the field rheostat, said motor being operative to actuate the rheostat in the event slack does not exist in said material preventing motion of said movable means.

7. In a continuous rolling mill, the combination with successive roll stands, of movable means located between a pair of stands and adapted to have motion some component of which is perpendicular to the plane of travel of the material, pneumatic pressure means operatively connecting with said movable means for maintaining the same in contact with the material, control apparatus including a field rheostat adapted to regulate the speed of one roll stand of the pair of stands between which said means is located, pressure means connecting said movable means with the field rheostat and constructed and arranged to actuate the field rheostat responsive to the motion of said movable means, an electric motor connected to said field rheostat for actuating the same, and means controlling the operation of said motor, said means being rendered operative during the initial travel of the mate-

rial between stands in the event slack does not exist in said material and also being rendered operative as the end of said material leaves the forward roll stand of said pair.

5 8. In a continuous rolling mill, the combination with successive roll stands, of a motor for driving the rolls of each stand, a movable member located between a pair of stands and adapted to contact the material, a valve for regulating the move-
10 ment of said member to cause the same to move into contact with the material or recede therefrom, control apparatus including electrical means adapted to regulate the speed of one roll stand of said pair of stands between which said
15 movable member is located, pressure means connecting the movable member and said electrical means whereby said electrical means is actuated responsive to the motion of said movable member, and an electrical connection between said regu-
20 lating valve and the motor of the last roll stand of said pair of stands, said electrical connection being constructed and arranged to effect actuation of said valve when the material enters said last roll stand to produce movement of the mov-
25 able member into contact with the material.

9. In a continuous rolling mill, the combination with successive roll stands, of a motor for driving the rolls of each stand, a movable member located between a pair of stands and adapted to
30 contact the material, a valve for regulating the movement of said member to cause the same to move into contact with the material or recede therefrom, control apparatus including electrical means adapted to regulate the speed of one roll
35 stand of said pair of stands between which said movable member is located, pressure means connecting the movable member and said electrical means whereby said electrical means is actuated responsive to the motion of said movable
40 member, and an electrical connection between the regulating valve and the motor of the roll stand preceding said pair of stands, said electrical connection being constructed and arranged to effect actuation of said regulating valve when
45 the material leaves said preceding roll stand to produce movement of the movable member out of contact with the material.

10. In a continuous rolling mill, the combination with successive roll stands, of a motor for
50 driving the rolls of each stand, a movable mem-

ber located between a pair of stands and having motion some component of which is perpendicular to the plane of travel of the material, pressure means for producing movement of said movable member, motor actuated regulating
5 valves for regulating said pressure means to cause movement of said member, whereby said member may be caused to move into contact with the material or recede therefrom, control apparatus including electrical means adapted to regulate the
10 speed of one roll stand of said pair of stands between which said movable member is located, a pressure line connecting the movable member and said electrical means, whereby said electrical means is actuated responsive to the motion
15 of said movable member, and an electrical connection between the motor of said regulating valves and the motor of the last roll stand of said pair of stands, said electrical connection being constructed and arranged to effect actuation of
20 said valves when the material enters said last roll stand to produce movement of the movable member into contact with the material.

11. In a continuous rolling mill, the combination with successive roll stands, of a motor for
25 driving the rolls of each stand, a movable member located between a pair of stands and having motion some component of which is perpendicular to the plane of travel of the material, pressure means for producing movement of said movable
30 member, motor actuated regulating valves for regulating said pressure means to cause movement of said member, whereby said member may be caused to move into contact with the material or recede therefrom, control apparatus includ-
35 ing electrical means adapted to regulate the speed of one roll stand of said pair of stands between which said movable member is located, a pressure line connecting the movable member and said electrical means, whereby said electrical
40 means is actuated responsive to the motion of said movable member, an electrical connection between the motor of the regulating valves and the motor of the roll stand preceding said pair of stands, said electrical connection being con-
45 structed and arranged to effect actuation of said valves when the material leaves said preceding roll stand to produce movement of the movable member out of contact with the material.

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