Aug. 13, 1940. E. B. HUDSON 2,211,658

GAUGE AND CAMBER CONTROL

Filed Sept. 15, 1938 4 Sheets-Sheet 1

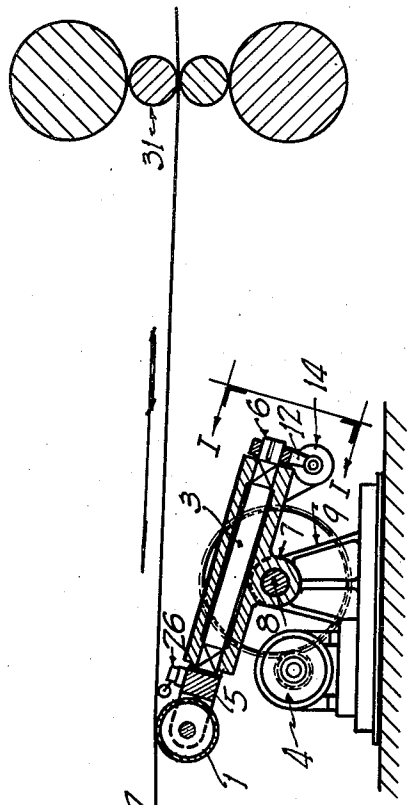


FIG. 1.

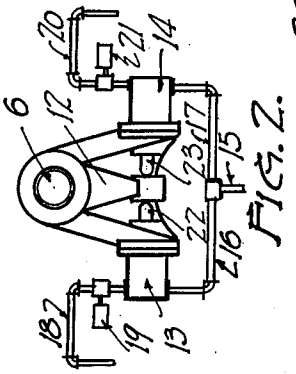
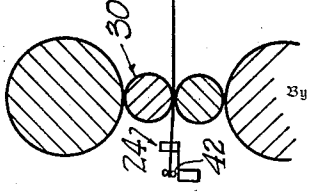


FIG. 2.



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GAUGE AND CAMBER CONTROL

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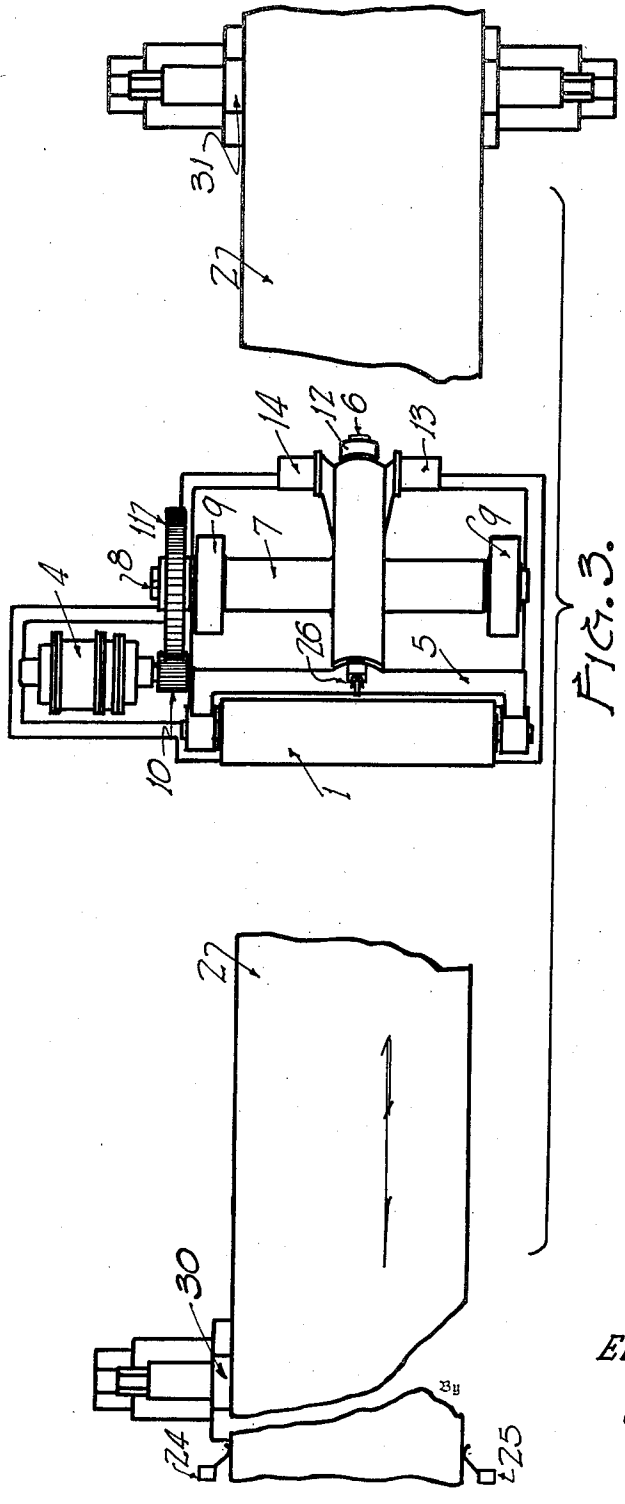


FIG. 3.

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GAUGE AND CAMBER CONTROL

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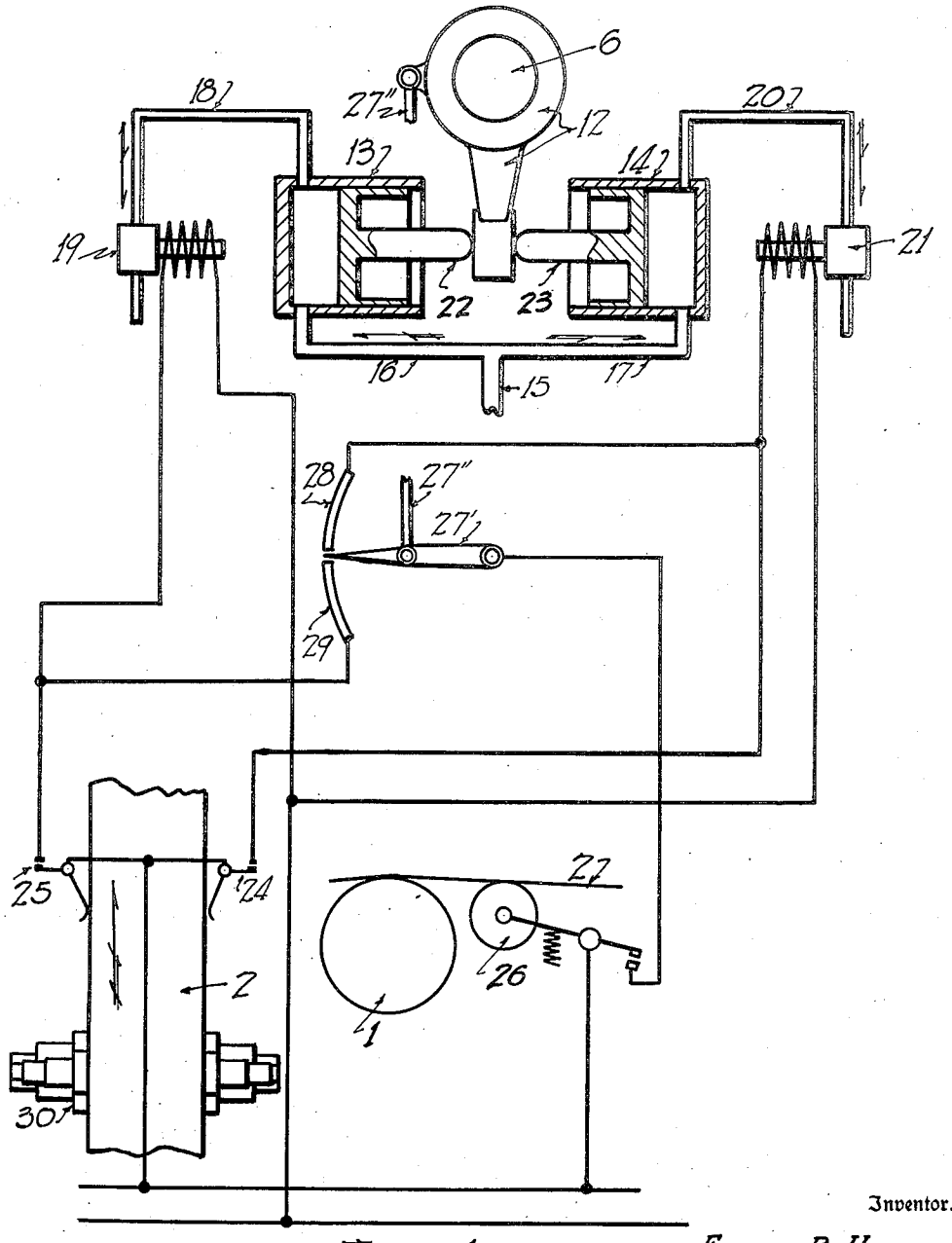


FIG. 4.

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GAUGE AND CAMBER CONTROL

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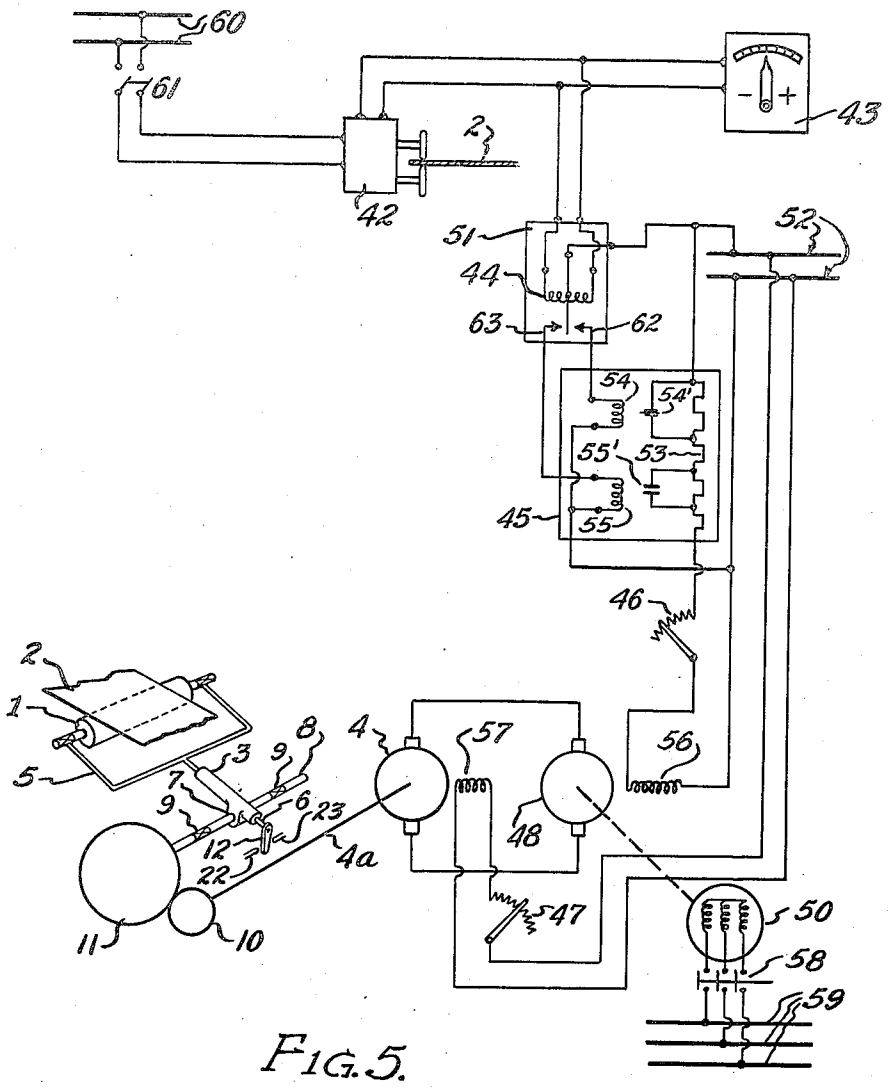


FIG. 5.

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UNITED STATES PATENT OFFICE

2,211,658

GAUGE AND CAMBER CONTROL

Edwin B. Hudson, Middletown, Ohio, assignor to The American Rolling Mill Company, Middletown, Ohio, a corporation of Ohio

Application September 15, 1938, Serial No. 230,069

8 Claims. (Cl. 80—35)

This invention relates to the control of gauge and camber in the rolling of metal strip and is an improvement upon the invention disclosed and claimed in a copending application in the name of Edwin B. Hudson and Ernest G. Schlup, Serial No. 200,155, filed April 5, 1938.

In that application a method and apparatus for controlling gauge were disclosed according to which the strip was passed over a roller, which roller was provided with means for exerting more or less pressure against the strip automatically in accordance with variation in gauge being produced by the mill. If the gauge being produced increased greater pressure was exerted by the roll so as to increase the tension on the entering side of the mill. If the gauge being produced became smaller less pressure was exerted by the roll so that tension on the entering side of the mill was decreased.

Another variation in rolled strip which it is desirable to overcome in addition to variation in gauge, is a variation in camber. It is well known that if the working rolls are not absolutely parallel so that the strip along one edge is slightly thicker (even .0001 inch), the strip will be delivered with curved edges and the thicker edge will be the shorter radius, and the thinner edge will be the longer radius. It has been attempted in the past to control this camber by means of the screw down mechanism, but this has proved impracticable on account of the extremely small differences in gauge between the two edges of the strip.

It is well known that slight changes in gauge may easily be made by varying the tension in the strip while it is being rolled. For example, an increase in tension on the entering side of the mill brings about a thinner delivered gauge and vice versa. As long as the strip having a uniform gauge and cross section is being rolled and the stress is uniformly distributed over the strip section, the strip will run true through the mill remaining on the center line thereof. However, when this ideal condition is upset so that one edge is rolled thicker, for example, on the right edge, the strip will begin to move to the right on account of the shorter right edge.

With the above considerations in mind it is an object of my invention to provide a method of controlling the camber of a metal strip being rolled in a rolling mill. It is another object of my invention to provide an apparatus which will serve to control the camber and do so automatically. It is another object of my invention to provide an arrangement whereby gauge and camber can be controlled simultaneously if desired.

These and other objects of my invention which will be discussed more in detail hereinafter or which will be apparent to one skilled in the art upon reading these specifications, I accomplish by that certain construction and arrangement of parts and by that series of method steps of which I shall now describe exemplary embodiments.

Reference is now made to the drawings forming a part hereof and in which:

Figure 1 is an elevational view of the control device showing its relation to a tandem train of rolling mills.

Fig. 2 is an end elevation of a portion of the mechanism taken from the viewpoint I—I of Fig. 1.

Fig. 3 is a plan view of the machine.

Fig. 4 is a wiring diagram for controlling the camber.

Fig. 5 is a wiring diagram for controlling the gauge.

Briefly, in the practice of my invention, I provide a roll 1 which is adapted to bear upwardly on the under side of the strip, and this roll is mounted not only for movement toward and away from the strip, but also for rocking motion about an axis 3. Thus, for example referring to Fig. 1 in which the strip is shown as passing from right to left, if the near edge of the strip is being rolled thicker than the far edge so as to produce a camber which would cause the strip to travel toward the observer, I provide means for causing the roll 1 to be rocked about an axis 3 to raise the near end thereof and thus increase the tension on the near edge of the strip, whereby the elongation of the near edge will be increased and the camber will be eliminated. I cause this action to be brought about automatically by means of feeler switches contacting the edges of the strip, and by appropriate mechanical or other linkages.

In Fig. 1 I have shown mills 30 and 31 by which a strip 2 is being rolled. The roll 1 contacting the strip is mounted in a forked member 5 which is preferably an integral part of the shaft 6 disposed on the axis 3. The shaft 6 is carried by a frame member 7 mounted on a shaft 8, carried in bearings 9, as shown. The shaft 8 is rotated by means of a torque motor through a pinion 10 and gear 11 independently of the rotation of the shaft 6. The torque motor 4 is controlled by means of a thickness gauge in contact with the strip beyond the second mill.

The control of the torque output of the motor 4 is accomplished in the follpwing manner:

Referring to Fig. 5, the strip gauge being produced is measured by an electro-limit gauge 42, having an indicator 43, which is preferably of the under and over type. The gauge and indicator do not form any part of my invention, and since they are well known commercial instruments, I shall not describe them further, except to state that variation in strip thickness resulting in variations in voltage output from the gauge 42, cause the pointer of the indicator 43 to move to one side or the other of the zero position. A sensitive relay of known construction is connected across the terminals of the indicator 43, so that the variations in voltage output of the gauge 42 will affect the moving contactor of the sensitive relay 51, by means of the relay coil 44. The function of the sensitive relay and its contactor will be described hereinafter.

A motor generator set comprising a motor 50 and generator 48 is provided, the motor 50 being fed through the starter 58 from a power source 59. The armature of the generator 48 is electrically connected to the armature of the torque motor 29, which as above described, actuates the roller 1. The torque motor 4, which is designed to have a low inertia of its moving parts, is provided with a shunt field 57, which is fed from an external power source 52 through a shunt field rheostat 47. The generator 48 is provided with a shunt field 56 in the circuit of which is placed a field rheostat 46, and a regulating resistor 53 which will be described in more detail hereinafter.

From the foregoing it will be clear that an increase in the field current of the generator shunt field coil 56, will result in a higher voltage output on the armature of the generator 48, whereby the armature voltage of the torque motor 4 is increased, thus producing an increase of torque on the shaft 4a of the torque motor 4. As previously described, such torque increase results in the application of greater tension by means of the roll 1. Conversely if the field current of the generator shunt field coil 56 is decreased, a lower voltage output of the armature of the generator 48 will result in a lower impressed armature voltage on the torque motor 4, so that the torque on the shaft of the torque motor 4 is reduced. It is to be noted that the direction of the torque, whether it be increased or reduced, remains the same.

The regulating resistor 53 in the shunt field circuit of the generator 48, includes contactor coils 54 and 55, with their respective contacts 54', and 55'. The contacts 54' and 55' respectively shunt out portions of the regulating resistor 53. The coils 54 and 55 are respectively in circuits with the contacts 62 and 63 of the sensitive relay 51. As will be clear from the drawings, this entire portion of the system is fed from an external source 52.

It will be noted that in the de-energized condition of the coils 54 and 55, the contact 54' is normally closed and the contact 55' is open. This condition obtains when contact is not being made either at 62 or at 63. Thus contact 54' serves to short circuit a portion of the regulating resistor 53. Now if the strip thickness increases so as to require greater back tension, the sensitive relay 51 actuated from the gauge 42 causes contact circuit 63 to close energizing the coil 55, and closing the contact 55'. An additional portion of the coil 53 has thus been short circuited out whereby an increased field current for the generator shunt field coil 56 is provided. As hereinabove described, this will result in causing the roller 1 to exert increased back tension on the strip 2.

If the strip thickness decreases, the sensitive relay 51 causes the contact 62 to be closed, energizing the coil 54 and opening the contact 54'. In the meantime of course, the coil 55 has been de-energized and the contact 55' is again open. The opening of the contact 54', adds a portion of the regulating resistor 53 into the field circuit of the generator 48, whereby as previously described, the torque of the motor 4 is reduced, whereby the back tension on the strip 2 is reduced.

In practice and in setting up, the motor generator set and the motor 4 are running, the shunt field rheostat 46 is in its "all in" position, resulting in a relatively low output voltage on the armature of the generator 48. By a certain adjustment of the generator field rheostat 46 and the torque motor field rheostat 47, the torque motor 4 is caused to develop a certain torque so as to cause the roll 1 to be pressed upwardly against the moving strip 2, thereby bringing the strip 2 under tension. The desired amount of tension for the particular rolling conditions such as mill screw setting, gauge, etc., are then established. The gauge head 42 is placed on the strip, and the switch 61 is closed, whereby the gauge 42 is energized from a power source 60. From this point on the system is fully automatic, as has been previously described.

I have described only the basic elements of the torque regulator which I indicated generally at 45, and it is to be understood that various refinements such as anti-hunting coils, quick make and quick break contacts, are desirable, but have not been described since they form no part of this invention.

In order to bring about a rocking of the shaft 6 I provide an arm 12 keyed to said shaft and engaged on opposite sides by piston rods 22 and 23, operating in the cylinders 13 and 14. The cylinders 13 and 14 are supplied with oil under pressure by means of pipes 15, 16 and 17. The cylinders 13 and 14 are provided respectively with discharge lines 18 and 20 in which are installed respectively the normally closed solenoid valves 19 and 21. It will thus be clear that if the solenoid valve 19 is open a rocking of the shaft 6 in a clockwise direction as seen in Fig. 2 will be produced, while an opening of the valve 21 will produce a rocking in a counterclockwise direction. Of course, when both valves 19 and 21 are closed the shaft 6 is held non-rotatably.

Referring now particularly to Fig. 4, I have shown feeler switches 24, (right) and 25 (left) engaging the edges of the strip. It will be seen that the switch 24 is so connected as to energize the solenoid switch 21 to open its valve when the switch 24 closes, and that the switch 25 upon closing will energize the solenoid valve 19 to open the latter. The closing of the switches 24 and 25 is, of course, brought about by lateral movement of the strip due to the camber. The action of the cylinders 13 and 14 with respect to the shaft 6 has already been described. Thus, for example, if the strip moves to the right it closes the switch 24, causing the solenoid valve 21 to open, thus permitting the piston 23 to move toward the right whereby the shaft 6 is rocked in a counterclockwise direction. This rotation, of course, causes the right end of the roll 1 to be raised, increasing the tension on the right hand side of the strip

so that the camber will be eliminated. Of course, if the strip moves toward the left closing the switch 25, a reverse action will take place involving the solenoid valve 19 and the piston 22.

For the purpose of leveling the roll 1 after the rear end of a strip has entered the mill 30, I provide a switch 26 which is normally open and only closes when no strip is passing over the roll 1. Should the left end of the roll 1 be high, the arm 27' will contact the segment 28, energizing the solenoid 21 allowing oil to escape from the cylinder 14, causing the shaft 6 to rotate in a counter clockwise direction. Through the linkage indicated at 27'' this rotation is transmitted to the arm 27' so that the latter will also rotate until it reaches the gap between the segments 28 and 29 at which point the valve 21 will close because its solenoid will be de-energized. Similarly, contact between the switch 27' and the segment 29 will cause the shaft 6 to rotate in a clockwise direction until the arm 27' reaches the gap between the segments 28 and 29. The switch 27' of course can ouly function when the switch 26 is closed, which occurs only when no strip is passing over the roller 1.

It is to be understood that various modifications may be made in my preferred embodiment and that I do not intend to limit myself as to the use of any particular type of power whether mechanical, electrical, pneumatic or hydraulic or the like, and that the invention generally is not limited in any way other than as pointed out in the claims which follow.

Having now fully described my invention what I claim as new and desire to secure by Letters Patent is:

1. In a mill for rolling strip, elements on the exit side of said mill operative upon lateral movement of the strip, a roller on the entrance side of said mill, said roller occupying normally a position parallel to the working rolls, and means operative in response to the operation of said elements for causing said roller to be tilted in one direction or the other depending upon whether the lateral movement of the strip is toward the left or right.

2. In a tandem train of rolling mills for rolling strip, elements positioned to be actuated upon lateral movement of the strip produced by said train, a roller positioned to bear against the strip between said mills and occupying a position normally parallel to the working rolls, and means operative in response to the operation of said elements for causing said roller to be tilted in one direction or the other depending upon whether the lateral movement of the strip is toward the left or the right.

3. In a mill for rolling strip, a gauging device, and elements operative upon lateral movement of the strip, all disposed on the exit side of said mill, a roller on the entrance side of the mill bearing against the strip, means for varying the force with which said roller is pressed against the strip in response to variations in gauge determined by said gauging device, and means operative in respones to the operation of said elements for causing said roller to be tilted in one direction or the other depending upon whether the lateral movement of the strip is toward the left or right.

4. In a tandem train of rolling mills for rolling strip, a gauging device, and elements operative upon lateral movement of the strip, all disposed to be actuated by the strip produced by said train, a roller positioned to bear against the strip between said mills, and occupying a position normally parallel to the working rolls, means for varying the force with which said roller is pressed against the strip in response to variations in gauge determined by said gauging device, and means operative in response to the operation of said elements for causing said roller to be tilted in one direction or the other depending upon whether the lateral movement of the strip is toward the left or the right.

5. In combination with a rolling mill for rolling strip, a roll positioned to bear against the strip on the entering side of the mill, said roll being mounted for movement in a direction substantially normal to the strip, and for oscillatory movement about an axis which is coplanar with the center line of the strip and closely parallel thereto, means for producing said normal movement in response to variation in gauge being produced by said mill, and means for producing said oscillatory movement to the right or left in response to cambering of the strip being produced by said mill toward the left or right respectively.

6. In combination with a rolling mill for rolling strip, a supporting frame positioned on the entering side of said mill and below the path of the strip, a member mounted on said frame for rocking movement in a vertical plane, a roller support mounted on said member for oscillation about an axis which is coplanar with the center line of the strip, a roller mounted on said roller support, a crank arm on said roller support, and opposed hydraulic cylinders having pistons and rods in operative relation with said crank, means for supplying fluid under pressure to said cylinders, exhaust means for said cylinders and control valves for said exhaust means, switches positioned adjacent the edges of the strip beyond said mill and adapted to be actuated alternatively by lateral movement of said strip due to camber, and connections between said switches and said control valves whereby one of said valves is actuated in response to actuation of one of said switches, and the other valve in response to the actuation of the other of said switches.

7. In a gauge and camber controlling device for use in connection with a rolling mill for rolling strip, a supporting frame positioned on the entering side of said mill and below the path of the strip, a member mounted on said frame for rocking movement in a vertical plane, a roller support mounted on said member for oscillation about an axis which is coplanar with the center line of the strip, a roller mounted on said roller support, a crank arm on said roller support, and opposed hydraulic cylinders having pistons and rods in operative relation with said crank, means for supplying fluid under pressure to said cylinders, exhaust means for said cylinders and control valves for said exhaust means, switches positioned adjacent the edges of the strip beyond said mill and adapted to be actuated alternatively by lateral movement of said strip due to camber, and connections between said switches and said control valves whereby one of said valves is actuated in response to actuation of one of said switches, and the other valve in response to the actuation of the other of said switches, and leveling means for said roller comprising a switch member connected to said roller for tilting movement therewith, and spaced segments operatively disposed with respect to said switch member and arranged so that said switch member rests between said segments when said roller is in a level position, and connections between said switch member, segments and control valves whereby contact of said switch member with one of said segments

will cause actuation of the appropriate valve, and contact of said switch member with the other segment will cause actuation of the other valve, and an enabling switch permitting operation of said leveling device only when no strip is passing over said roller.

8. In a gauge and camber controlling device for use in connection with a rolling mill for rolling strip, a supporting frame positioned on the entering side of said mill and below the path of the strip, a member mounted on said frame for rocking movement in a vertical plane, a roller support mounted on said member for oscillation about an axis which is coplanar with the center line of the strip, a roller mounted on said roller support, a crank arm on said roller support, and opposed hydraulic cylinders having pistons and rods in operative relation with said crank, means for supplying fluid under pressure to said cylinders, exhaust means for said cylinders and control valves for said exhaust means, switches positioned adjacent the edges of the strip beyond said mill and adapted to be actuated alternatively by lateral movement of said strip due to camber, and connections between said switches and said control valves whereby one of said valves is actuated in response to actuation of one of said switches, and the other valve in response to the actuation of the other of said switches, and leveling means for said roller comprising a switch member connected to said roller for tilting movement therewith, and spaced segments operatively disposed with respect to said switch member and arranged so that said switch member rests between said segments when said roller is in a level position, and connections between said switch member, segments and control valves whereby contact of said switch member with one of said segments will cause actuation of the appropriate valve, and contact of said switch member with the other segment will cause actuation of the other valve, and an enabling switch permitting operation of said leveling device only when no strip is passing over said roller, said enabling switch comprising a fixed element and a movable element, said movable element being associated with a roller adjacent said first mentioned roller, and having spring means urging it against the strip, whereby when no strip is passing over said first mentioned roller said movable element may contact said fixed element.

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