Jan. 6, 1953 F. L. RUNNINGER 2,624,868

PRESSURE CONTROLLER

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FIG. 1.

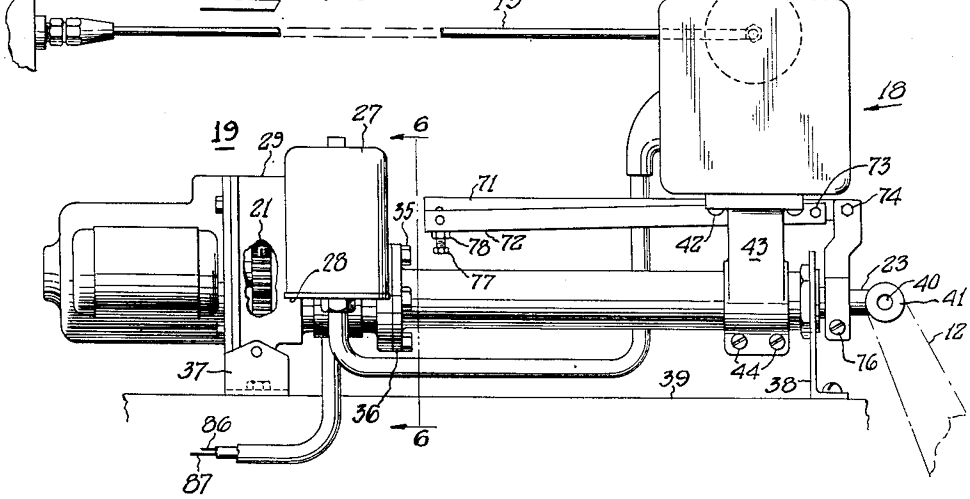

FIG. 2.

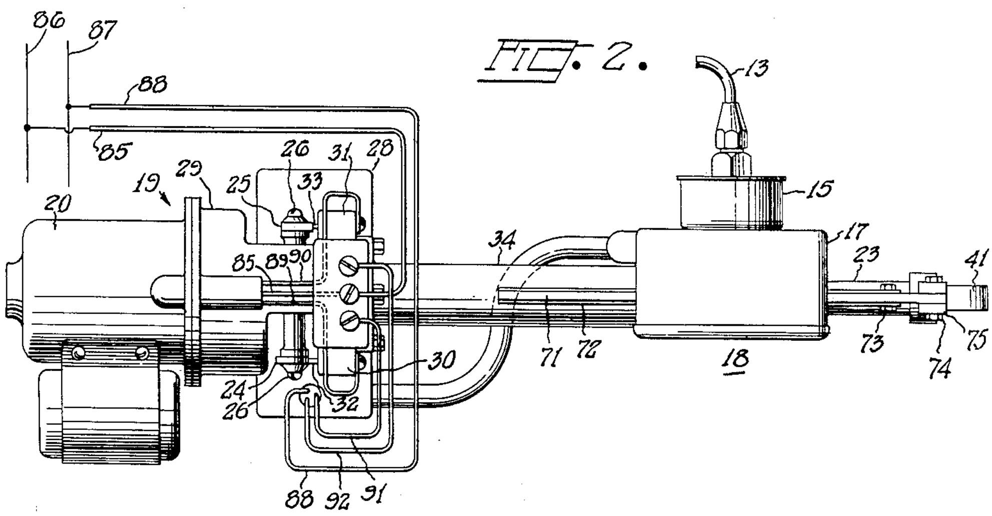

FIG. 9.

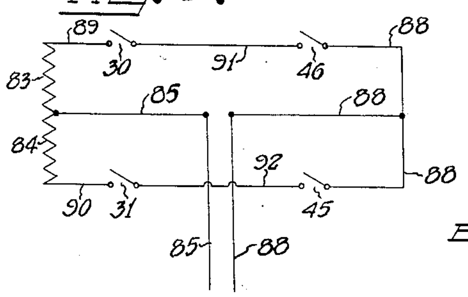

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FIG. 7.

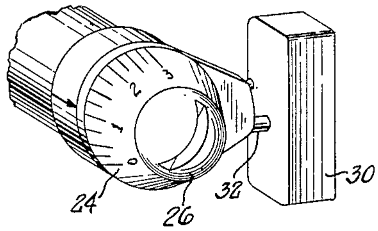


FIG. 8.

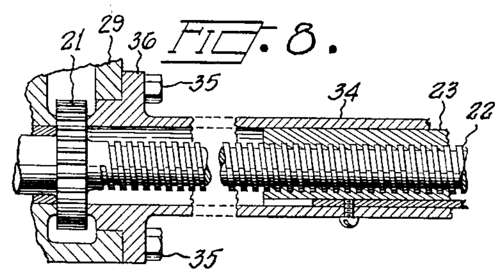
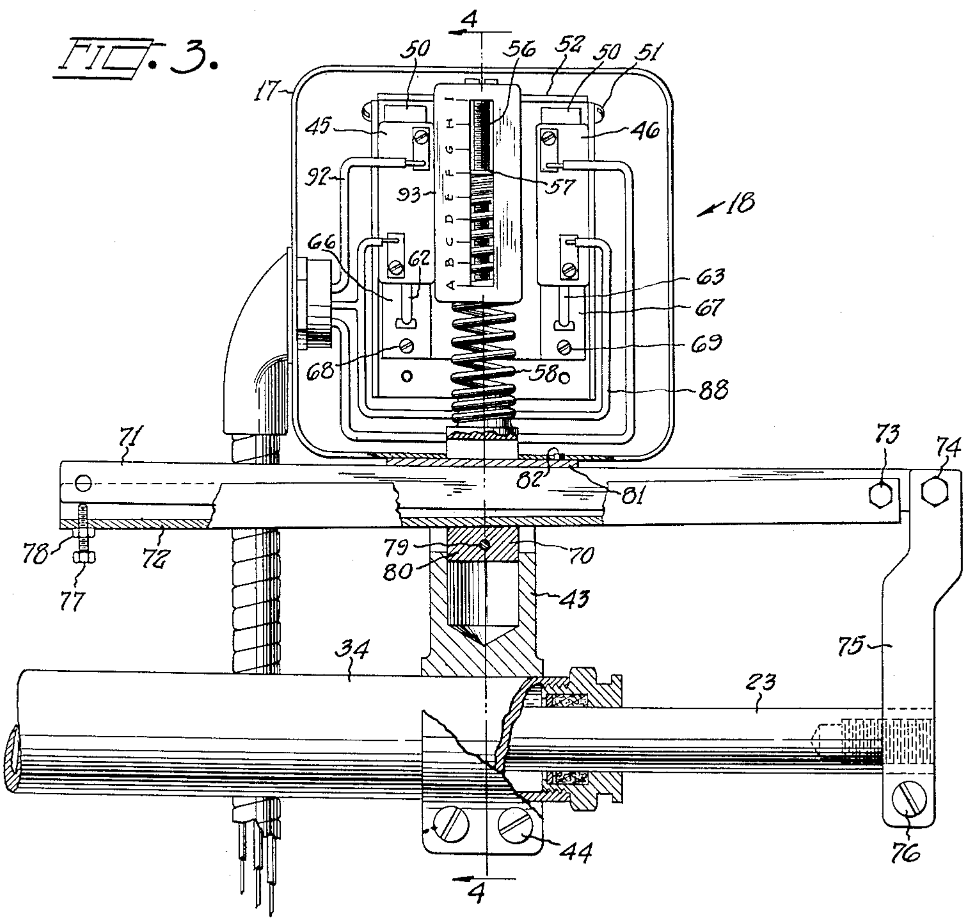


FIG. 3.



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PRESSURE CONTROLLER

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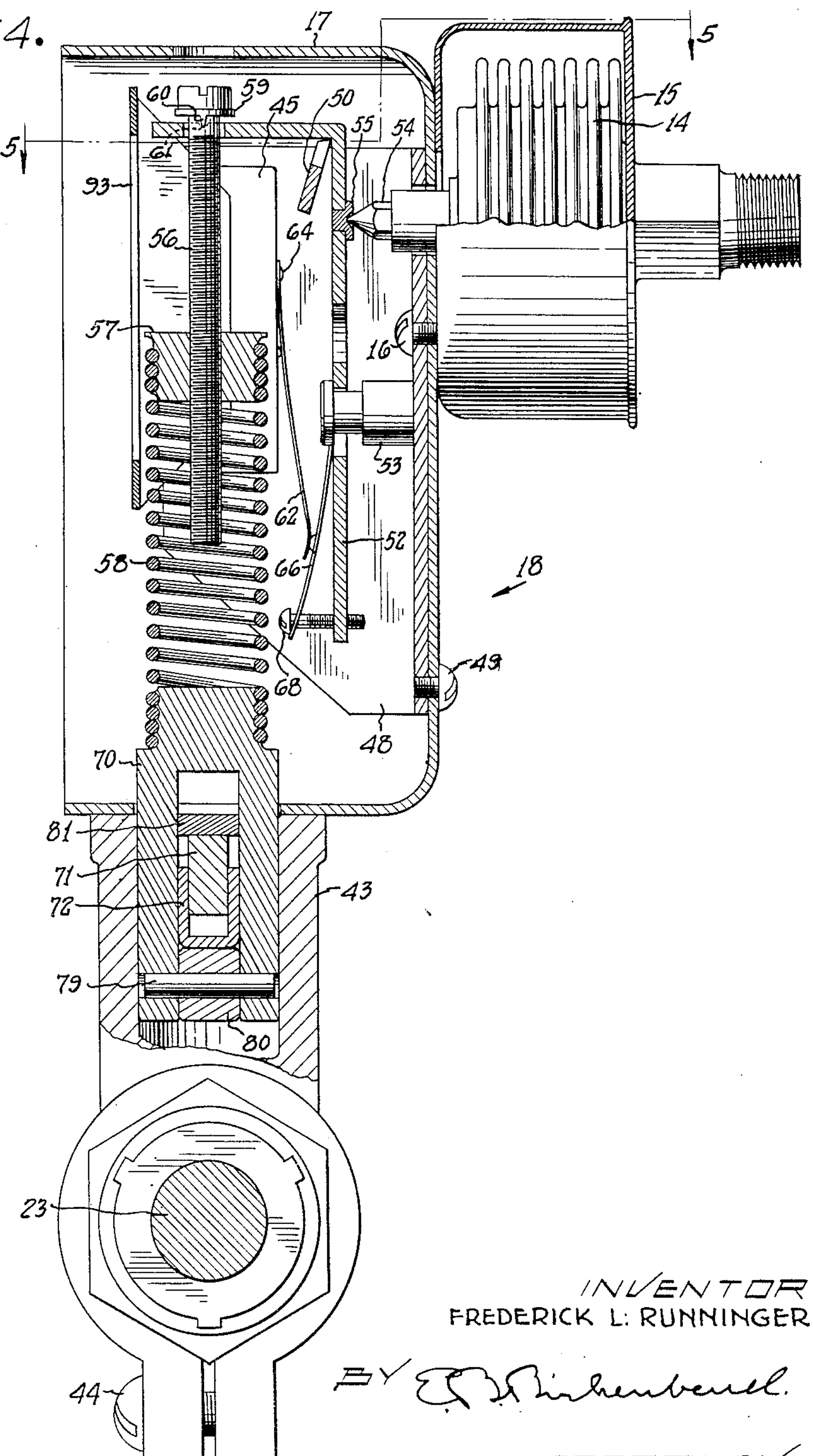
FIG. 4.



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PRESSURE CONTROLLER

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FIG. 5.

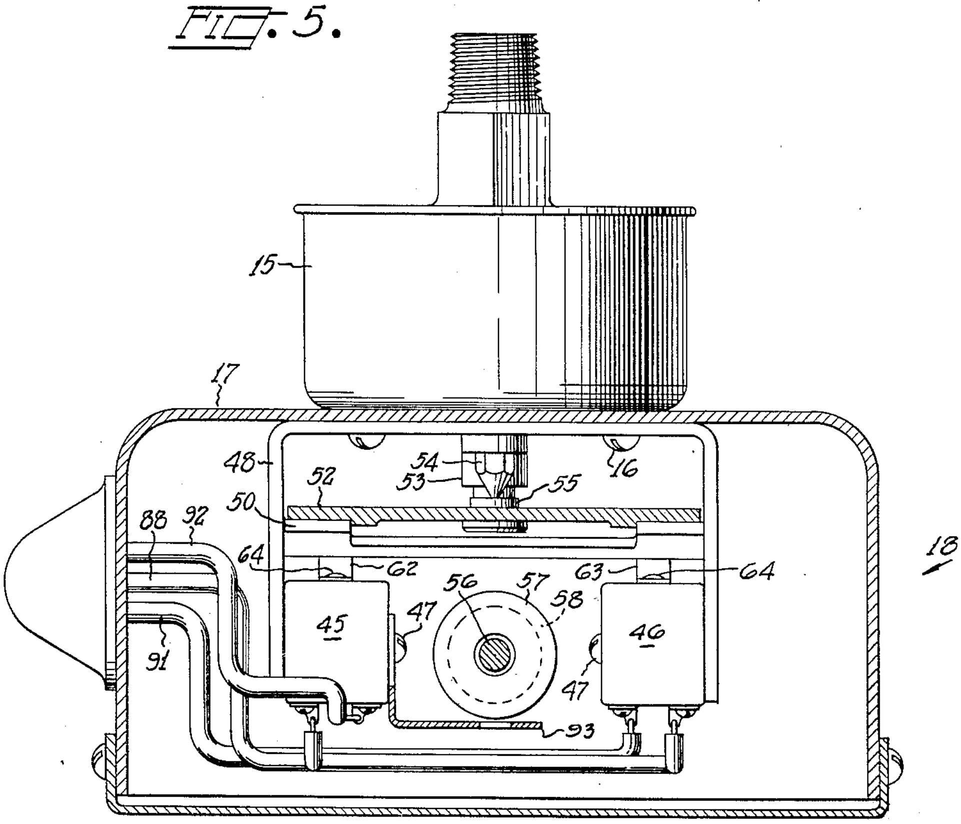
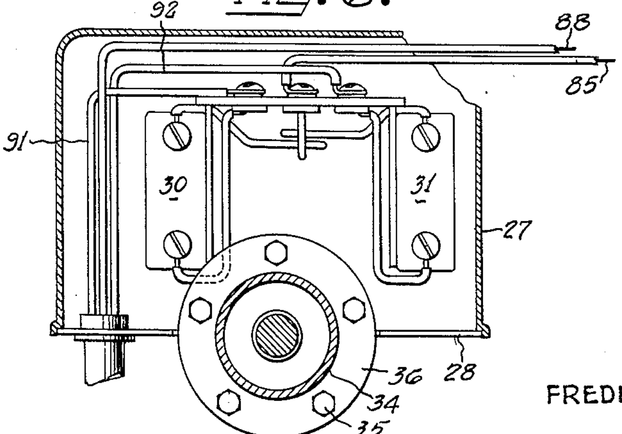


FIG. 6.



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UNITED STATES PATENT OFFICE

2,624,868

PRESSURE CONTROLLER

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Application January 10, 1950, Serial No. 137,694

5 Claims. (Cl. 318—32)

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This invention relates generally to fluid pressure controllers and more particularly to a device for controlling the operation of a mechanically operated fuel burner of the modulating or full-floating type applied to a steam boiler furnace for the purpose of maintaining a desired steam pressure in the boiler even though the rate of steam withdrawal from the boiler may be continuously varying.

It is a common practice in the art of steam generation to equip a steam boiler with a furnace fired by a continuously operating fuel burner having a single lever, or other means, the movement of which in one direction will increase the rate of fuel flow to the burner and the movement of which in the other direction will decrease the rate of fuel flow to the burner, and to control the movement of the regulating lever or other means from a pressure sensitive pilot device communicating with the steam space in the boiler. Such burners are usually variable in rate of flow of fuel to the furnace from a maximum taking full advantage of the boiler capability to a minimum less than any operating load likely to be applied to the boiler. As a safety measure the boiler will be equipped with a second steam pressure sensitive instrument set at a pressure within the safe pressure limit of the boiler but higher than the pressure setting of the operating control.

It is the duty of this second pressure instrument or limit control to shut down the fuel supply means entirely if for any reason the pressure rises to the pressure setting of the limit instrument. Also it is a practical necessity and usually a legal requirement that the boiler be equipped with a pressure operated steam release valve set to discharge steam rapidly from the boiler should the pressure rise to its setting.

One of the problems met in providing an operating control for the modulating fuel feed type of burner is caused by the time required for the various pieces of mechanism to act, and also by the time required for the effect of the increased fuel feed to be felt in the change of steam pressure of the boiler. Without some method of compensation of the controller there would be a continuous cycling of the burner controller due to this lack of instantaneous response of the fire to the demands of the pilot instrument. And different boiler plant installations will require different rates of application of compensation effects. In the pressure controller of the present invention "over-shooting" and "under-shooting" of the fuel supplied to the boiler is prevented by providing the pilot control with mechanism which regularly lowers the pressure setting of the

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instrument as the load on the boiler is increased and, conversely, regularly increases the pressure setting of the instrument as the load on the boiler is reduced. In the present invention this mechanism is made adjustable so that the rate of change of steam pressure setting of the instrument with respect to change of boiler load, or fuel feed, can be adjusted to suit the requirements of the particular steam generation system to which it is applied.

In the prior art, the operating control mechanism for a modulating fuel feeder of the class described has usually been a pneumatic or hydraulic system of considerable size and cost and therefore such equipment has only been economically available to large installations where its use could be justified.

It is the principal object of the present invention to provide a modulating or full floating controller having such precise operating characteristics and being of such rugged construction as to make it desirable for use with even the largest boilers, and yet being relatively so simple, small and economical, that it is adapted to use with medium and small size industrial and commercial boiler installations.

A second object has been to provide in one unit an operating controller having the pressure sensitive pilot instrument combined with the drive mechanism, which in response to the pilot instrument changes the position of the lever, or other means, which modulates the fuel supply to the burner.

A third object has been to provide a drive mechanism comprising a reversing electric motor operatively connected to a driving arm having a straight line motion and to so mount the pilot instrument with respect to the drive mechanism that the mechanically operated compensating mechanism of the pilot instrument can be directly driven by the driving arm of the drive mechanism.

A fourth object has been to provide a pressure responsive pilot instrument of the electrical contact making and breaking type combined with a mechanically operated pressure setting compensator.

A fifth object has been to provide such a pilot instrument with a compensating mechanism that is adjustable in its rate of compensation in relation to compensator movement.

How these and other objects are attained will be made clear by the following description of the invention which refers to the accompanying drawings, in which:

Fig. 1 is a side elevation of the combined pilot instrument and drive mechanism of this invention.

Fig. 2 is a plan view of the mechanism showing in Fig. 1.

Fig. 3 is a fragmentary and enlarged view, partly in section, of the right hand half of Fig. 1.

Fig. 4 is a vertical section along the line 4—4 of Fig. 3.

Fig. 5 is a plan view in partial section along the line 5—5 of Fig. 4.

Fig. 6 is an elevation of the mechanism of Fig. 1 as viewed from the section line 6—6.

Fig. 7 is a perspective view of one of the limit switches of the drive mechanism shown also in Figs. 2 and 6, but showing also one of the adjustably positioned cams operatively connected to the drive mechanism to stop the drive motor at one limit position of the driving arm.

Fig. 8 is a fragmentary view partially in section showing the screw and gear operatively connecting the reversing motor to the driving arm of this controller.

Fig. 9 is an elementary schematic showing of the electric circuit of the controller.

Referring now to the drawings there is indicated at 11 a boiler the steam pressure of which is to be controlled and at 12 a lever the movement of which in one direction will increase the rate of fuel feed to the boiler furnace (not shown) and the movement of which in the other direction will decrease the rate of fuel feed to the furnace. Hollow metallic tubing 13 of any required length opens at one end to the interior of boiler 11 and at the other end with the interior of sealed bellows 14 enclosed in cup 15 attached by screws 16 to case 17 of the pilot instrument 18 of the controller, the driving mechanism of which is indicated generally by the numeral 19.

Driving mechanism 19 which is made by others and included here as a necessary part of the combination of this invention is well known in the art and includes generally a reversible electric motor 20 operatively connected by gearing 21 to screw shaft 22 which engages the internal threads of driving arm 23 and as motor 20 is energized to rotate in one direction arm 23 is extended while if motor 20 is energized to rotate in the other direction arm 23 is retracted. Limit switch cams 24 and 25 are adjustably positioned by screws 26 on a cam shaft (not shown) operatively connected with screw shaft 22 to rotate as arm 23 extends or retracts and positions cams 24 and 25 in accordance with the extended or retracted position of arm 23. Protected by cover 27 and supported on a base 28 secured to frame 29 of drive mechanism 19 are single pole, single throw, limit switches 30 and 31 of the unit switch type well known in the art. The operating stems 32 and 33 of limit switches 30 and 31 are biased by their respective switch mechanisms to follow the faces of cams 24 and 25 respectively. Arm 23 is protected and supported as shown in tube 34 supported on frame 29 by cap screws 35 through flange end 36 of tube 34. Drive mechanism 19 is supported by brackets 37 and 38 on any suitable base 39. Lever 12 is engaged by pivot pin 40 to operatively connect lever 12 with driving arm 23 through screw eye 41 threaded into the end of arm 23.

Case 17 of pilot instrument 18 is secured by screws 42 to post 43 clamped to tube 34 by screws 44. Single pole, single throw operating switches 45 and 46 of pilot instrument 18 are secured by screws 47 to bracket 48 held to case 17 by screws 16 and 49. Knife edge bar 50 secured to bracket

48 by screws 51 fulcrums angle lever or bell crank 52 limited in movement by headed stud 53 secured to bracket 48. Pointed strut 54 secured to bellows 14 presses against conical bearing button 55 inset into bell crank 52 with a pressure proportional to the pressure of steam in the boiler 11.

Pressure adjusting screw 56 threaded into end fitting 57 of tension spring 58 has its head bearing on washer 59 whose knife edged extensions 60 mate with depressed bearing grooves 61 of bell crank 52 causing calibrated spring 58 to oppose the rotation of bell crank 52 about pivot bar 50 due to the steam pressure in bellows 14 acting on strut 54.

The basic steam pressure for which the controller is set is indicated by the graduations on scale 93 opposite the upper edge of spring end fitting 57. Adjustment of the steam pressure setting is made by turning screw 56 to the right or left.

Switch operating resilient blades 62 and 63 each secured at one end by one of the screws 64 to the case of one of the operating switches 45 and 46 are biased away from contact respectively with switch operating pins 65 but are respectively constrained into position against the respective pins 65 by contact with resilient calibrating blades 66 and 67 each secured at one end to bell crank 52. The other end of each of the blades 66 and 67 is biased away from bell crank 52, its respective biasing effect being limited by calibrating screws 68 or 69. In practice calibrating screws 68 and 69 are so adjusted that the electric circuits of both switches 45 and 46 will be open when the tension of spring 58 just balances the pressure of strut 54 on bell crank 52, but so that a slight increase in steam pressure will close one of the switches or a slight decrease in steam pressure will close the other of the switches.

Secured to the lower end of tension spring 58 is clevis end fitting 70 journalled for vertical movement in post 43.

Extending through the clevis end of fitting 70 are the mating compensating bars 71 and 72. At one end bar 72 is hinged to bar 71 by cap screw 73 and bar 71 is hinged by cap screw 74 to one end of arm 75 which at its other end is secured to driving arm 23 by screw 76. The other ends of bars 71 and 72 are adjustably spread by cap screw 77 and lock nut 78 to give pilot instrument 18 the amount of compensation found desirable for the particular installation.

Pinned by rocking pin 79 between the forks of clevis 70 is bearing metal slider 80 which, bearing against the under side of bar 72, maintains spring 58 in tension and varies the tension of spring 58 as bars 71 and 72 are moved forward or backward with the movement of driving arm 23. Bearing on the top of bar 71 is bearing metal slider 81 held upward against case 17 by bar 71 and held against lateral movement by pin 82 extending into a close fitting hole in case 17.

One end of each of the reversing windings 83 and 84 is connected by wire 85 to electric supply line 86. The other supply line 97 is connected by wire 88 to one terminal of each of the operating switches 45 and 46. The other ends of reversing windings 83 and 84 are connected respectively to one terminal of limit switches 30 and 31 by wires 89 and 90. The remaining terminals of limit switch 30 and operating switch 46 are connected by the wire 91, while the remaining terminals of limit switch 31 and operating switch 45 are connected by the wire 92.

In making an installation of this equipment the complete controller unit is mounted on brackets 37 and 38 in a convenient position adjacent the fuel feed control of the burner. A position of the controller unit is chosen where driving arm 23 is extended to approximately its mid-position when lever 12 is in approximately its mid-position. The electric circuit of the controller is then connected to the electric supply line as described above and shown on the drawings. Bellows 14 of the pilot instrument is connected to boiler 11 by tubing 13. A separate indicating pressure gauge on the boiler is referred to, to note the steam pressure of the boiler and adjusting screw 56 is turned to bring the upper edge of fitting 57 opposite the graduations on scale 93 corresponding to the known boiler pressure. Calibrating screws 68 and 69 are then adjusted so that neither switches 45 nor 46 are closed but so that a slight turn of screw 56 in one direction will close one of the switches and a slight turn of screw 56 in the other direction from its original setting will close the other of the switches. Then with driving arm 23 extending to approximately its midposition, pin 41 is inserted to engage lever 12 and arm 23, thus putting lever 12 under control of arm 23. Steam is then allowed to discharge from the boiler, thus reducing the boiler pressure, and pilot instrument 18 will operate to drive mechanism 19 to cause arm 23 to move lever 12 toward its full feed position. When lever 12 has moved to a desired limit in the full feed position the appropriate limit switch cam 24 or 25 is set to open the appropriate limit switch 30 or 31 to stop the drive mechanism from further advancing in that direction. The discharge of steam from the boiler is then gradually shut off and, as steam pressure builds up, pilot instrument 18 will start drive mechanism in the opposite direction to move lever 12 toward its minimum fuel feed position. When the desired minimum fuel feed position of lever 12 is reached the other limit switch cam is set to open the other limit switch and thus prevent further movement of lever 12 in the fuel feed reducing direction. The boiler valves are then adjusted to their normal load positions and the fuel feed will be continuously modulated in accordance with the steam pressure fluctuation caused by variations in the amount of steam discharged by the boiler.

During this installation and adjustment period, cap screw 77 has been in approximately its mid-position of spread of the free ends of compensating bars 71 and 72. If it is found by observation of the boiler load and the operation of the controller that variations of load are relatively low in frequency and moderate in rate of change as indicated by two or more successive operations of the driving mechanism occuring to move lever 12 in the same direction, then screw 77 can be adjusted to decrease the spread of bars 71 and 72 until the controller makes a more complete response to a change in boiler load. If, however, it is found that load fluctuations are rapid and of greater magnitude, then the controller is adjusted to handle as indicated by frequent reversal of drive mechanism 19 or by the controller making several consecutive reverse operations before settling down after a load change in one direction, then screw 77 is adjusted to spread compensating bars 71 and 72 enough to overcome this hunting characteristic of operation. In the usual or average installation smooth operation will be obtained with the controller set for a boiler regulation of about 5 per cent or when the compensating bars are spread enough to cause the steam pressure of the boiler to be about 5% higher at light load than at full load.

Having thus described a preferred form of the mechanism of my invention and explained its operations, I claim:

1. A compensated condition responsive electric circuit controller comprising a first electric switch, a second electric switch, means biasing one of said switches towards its closed position and the other of said switches towards its open position, a condition responsive means adapted to oppose said biasing means with a force varying as a function of the value of a condition and means operable when one of said switches is closed to increase the effect of said biasing means and to decrease the effect of said biasing means when the other of said switches is closed, said operable means comprising a first stationary abutment means, a second abutment means secured to one end of said biasing means, a tapered wedge adapted to engage both said abutment means whereby the longitudinal movement of said wedge in one direction will increase the bias of said biasing means and the longitudinal movement of said wedge in the other direction will decrease the bias of said biasing means, and a reversible electric motor operable to move said wedge longitudinally in one direction when one of said switches is closed and to move said wedge longitudinally in the other direction when the other of said switches is closed.

2. A compensated condition responsive electric circuit controller comprising an electric motor, a first circuit for energizing said motor to rotate in one direction, a second circuit for energizing said motor to rotate in the other direction, a first electric switch in said first circuit, a second electric switch in said second circuit, means biasing one of said switches towards its closed position and the other of said switches towards its open position, means responsive to a variable condition for opposing said biasing means, and means operably connecting said motor and said biasing means whereby the effect of said biasing means will be increased as said motor rotates in one direction and decreased as said motor rotates in the opposite direction, said operably connecting means including a first stationary abutment means, a second abutment means secured to one end of said biasing means, a tapered wedge adapted to engage both said abutment means, and means operably connecting said wedge with said motor, whereby said wedge will be moved longitudinally in one direction as said motor rotates in one direction and said wedge will be moved longitudinally in the other direction as said motor rotates in the other direction.

3. A compensated condition responsive electric circuit controller comprising a normally closed circuit opening switch, a normally open circuit closing switch, an electric motor, a first circuit for energizing said motor to rotate in one direction, a second circuit for energizing said motor to rotate in the other direction, a first limit switch, a second limit switch, said first circuit including said circuit opening switch and said first limit switch, said second circuit including said circuit closing switch and said second limit switch, means biasing said normally closed switch toward its closed position and said normally open switch toward its open position, a condition responsive means adapted to overcome said biasing means to

open said normally closed switch at one value of said condition and to close said normally open switch at another value of said condition, and means operably connecting said motor and said biasing means to increase the biasing effect of said biasing means as said motor rotates in one direction and to decrease the biasing effect of said biasing means as said motor rotates in the other direction, said operably connecting means including a first stationary abutment means, a second abutment means secured to one end of said biasing means, a tapered wedge adapted to engage both said abutment means, and means operably connecting said wedge with said motor whereby said wedge will be moved longitudinally in one direction as said motor rotates in one direction, and said wedge will be moved longitudinally in the other direction as said motor rotates in the other direction.

4. A mechanically compensated condition control comprising a reversible electric motor driven arm arranged to advance or retract as the motor is rotated in one or the other direction of rotation, said arm being operatively connected to a means for varying said condition between maximum and minimum values determined by a pair of adjustable limit switches in the circuit of said motor and operably connected with said arm, an additional pair of electric switches in the circuit of said motor the closing of one of which switches will cause the motor to rotate in one direction while the opening of said one switch and the closing of the other of which switches will cause the motor to rotate in the other direction, a coil spring biasing a bell crank to turn in one direction about a pivot and close one of said additional switches, means responsive to said condition adapted to bias said bell crank to move in the other direction and close the other of said additional switches, means interposed between said bell crank and said spring for adjusting the biasing effect of said spring and thereby adjusting the values of said condition at which said additional switches will be closed, terminal means for the end of said spring opposite said bell crank, and adjustable means operatively connecting said terminal means with said arm whereby when the position of said arm is changed by the rotation of said motor the biasing force of said spring on said bell crank will be changed as a function of said position of said arm, said adjustable means comprising a first stationary abutment means, a second abutment means formed on said terminal means, and a tapered wedge adapted to engage, both said abutment means, said wedge being operatively attached to said arm for longitudinal movement therewith.

5. A compensated condition responsive electric circuit controller comprising: a stationary structure; a first bar supported on said structure for axial reciprocation; a reversible electric motor supported on said structure and means operable by said reversible motor to reciprocate said bar; a first limit switch mounted on said structure, a second limit switch mounted on said structure, means operable to open said first limit switch on movement of said bar to a pre-set position in one axial direction, and means operable to open said second limit switch on movement of said bar to a pre-set position in its other axial direction; a lever pivotally mounted on said structure, a resilient means adapted to bias said lever towards movement in one direction of rotation, a condition responsive means adapted to oppose the biasing force of said resilient means on said lever, a first operating switch, a second operating switch, and means adapted to open said first operating switch and to close said second operating switch on movement of said lever in one direction of rotation and to close said first operating switch and to open said second operating switch on movement of said lever in its other direction of rotation; a source of electric power, a first circuit means connecting one of said limit switches and one of said operating switches in series with said source of power and one directional winding of said motor, and a second circuit means connecting the other of said limit switches and the other of said operating switches in series with said source of power and the other directional winding of said motor; and means adapted to vary the biasing forces of said resilient means on said lever as the axial position of said first bar is varied by the operation of said motor, said last mentioned means comprising a second bar conconnected to said first bar for movement therewith, a third bar carried on said second bar at an angle thereto, abutment means on said structure adapted to slidbly support said third bar and abutment means on said resilient means adapted to be positioned by said second bar in accordance with the axial position of said first bar.

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