Oct. 13, 1942. A. C. GRANT 2,298,825

COMBUSTION CONTROL

Filed Jan. 23, 1939 2 Sheets-Sheet 1

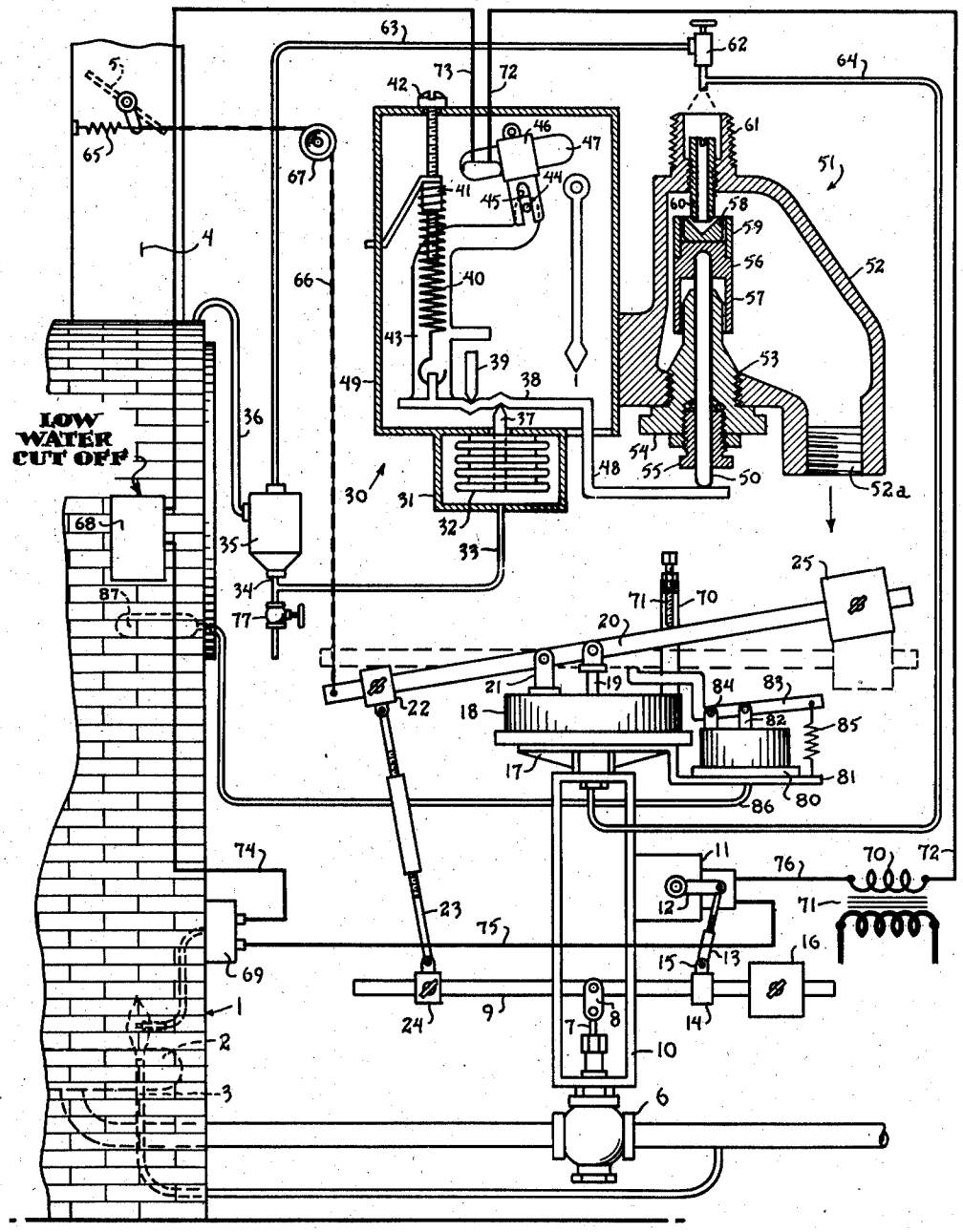


Fig. 1

Inventor
Arthur C. Grant
By
George H. Fisher
Attorney

Oct. 13, 1942. A. C. GRANT 2,298,825

COMBUSTION CONTROL

Filed Jan. 23, 1939 2 Sheets-Sheet 2

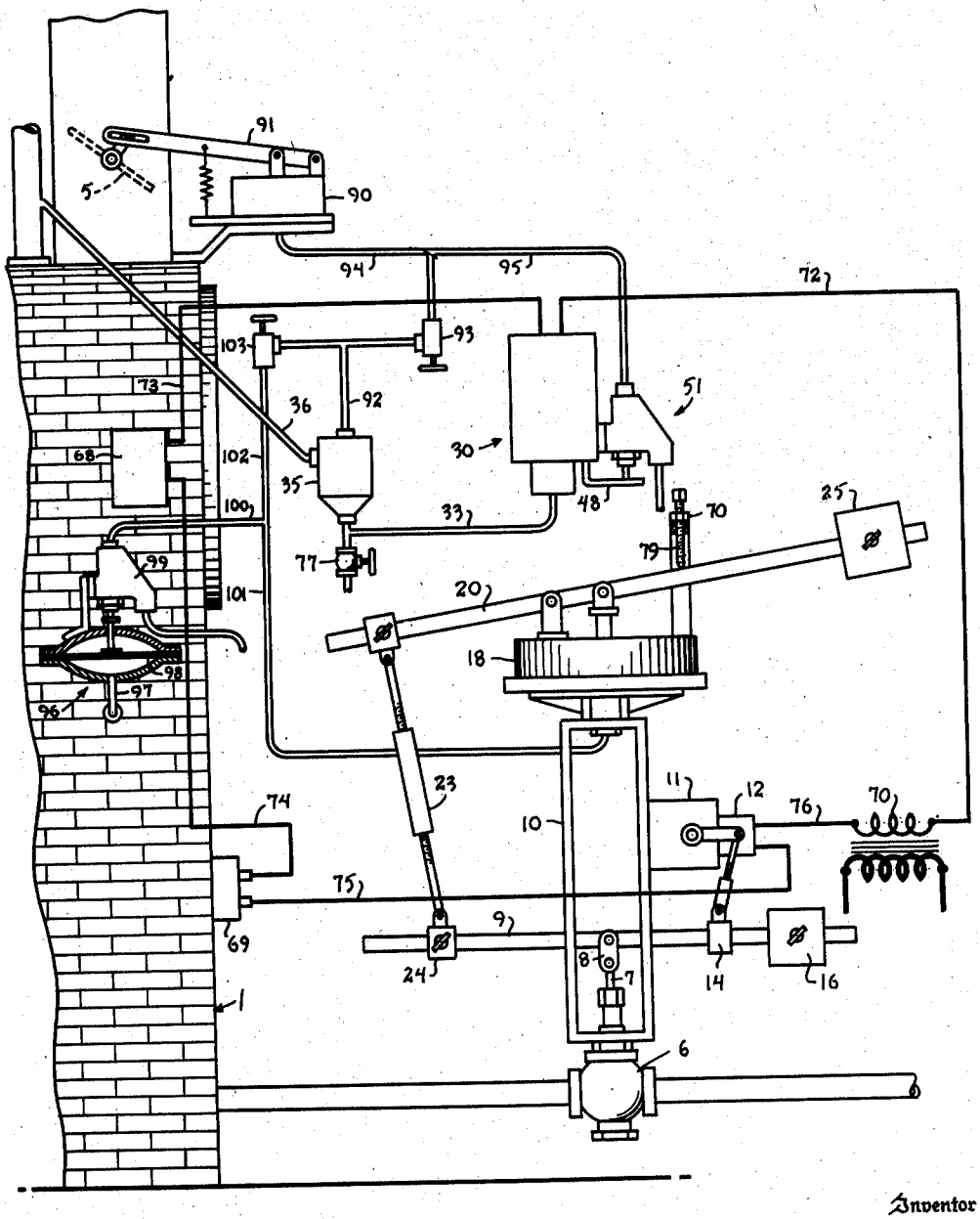


Fig. 2

Inventor

Arthur C. Grant

By

George H. Fisher

Attorney

Patented Oct. 13, 1942

2,298,825

UNITED STATES PATENT OFFICE

2,298,825

COMBUSTION CONTROL

Arthur C. Grant, St. Paul, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Application January 23, 1939, Serial No. 252,386

9 Claims. (Cl. 236—21)

This invention relates to combustion control for steam boilers.

It is an object of this invention to provide a combustion control which modulates the action of the boiler firing means in accordance with the load on the boiler, which is simple in construction, and which is accurate and dependable in operation.

More particularly, an object of this invention is the provision of a boiler combustion control which utilizes a pressure actuated motor for controlling the boiler firing means, this motor being subjected to steam pressure from the boiler which is controlled by means of a load responsive device so as to graduatingly vary the firing rate in accordance with the boiler load.

A further object of this invention is the provision of a control system of this general type in which the combustion rate is modulated in response to changes in boiler pressure within a predetermined range, and in which the combustion rate is positively and independently reduced when boiler pressure varies to a predetermined value above said modulating range.

Another object of this invention is the provision of a combustion control system of the type mentioned which provides modulating control of the boiler firing means in accordance with the load on the boiler, and in which the rate of firing is automatically and positively reduced or stopped upon the occurrence of an undesirable condition within or associated with the boiler.

A further object of this invention is the provision of a combustion control system which automatically limits the rate of firing of the boiler when it is cold so that the boiler is heated up to temperature slowly.

Other objects will appear from the following description and appended claims.

For a full disclosure of this invention reference is made to the following detailed description and to the accompanying drawings, in which:

Figure 1 diagrammatically illustrates a complete combustion control system embodying this invention, and

Figure 2 is a diagrammatic view of a modification.

Referring to Figure 1, reference character 1 indicates a boiler which may be provided with a gas burner 2 having a pilot 3. This boiler is also provided with an outlet flue or breeching 4 having a damper 5.

The flow of gas to the burner 2 is controlled by a valve 6. This valve is provided with the usual valve stem 7 which is connected by a link 8 with a floating lever arm 9. Mounted upon the bonnet of the valve 6 is a frame 10 which supports a power failure type electric motor 11. This motor may be of the type shown and described in the copending application of Sylvanus C. Shipley, Serial No. 65,274 filed February 24, 1936 and now Patent No. 2,169,168. This motor includes a lever arm 12 which is connected by an adjustable link 13 to a sleeve 14 which is secured to the lever arm 9. When the motor 11 is energized, the lever arm 12 rotates in a counter-clockwise direction to the position shown which raises the sleeve 14 thereby permitting the lever arm 9 to pivot about the pivot 15 which joins the link 13 to the sleeve 14. When motor 11 is de-energized however the lever arm 12 is caused to rotate clockwise or downwardly due to the weight 16 which is attached to the lever arm 9. This lowers the pivot 15 and causes lowering of the valve stem 7 so as to close the valve 6 and stop flow of gas to the burner.

Mounted on the top of the frame 10 is a stand 17 to which is secured a pressure actuated motor 18. Motors of this type are well known in the art and include a diaphragm or bellows (not shown) which actuates a push rod 19 which is pivotally connected to a lever arm 20 which in turn is pivoted to a bracket 21. Mounted upon the lever arm 20 is a sleeve 22 which is connected by an adjustable link 23 to a sleeve 24 carried by the lever arm 9. The lever arm 20 also carries an adjustable weight 25 which urges this lever arm in a direction tending to collapse the diaphragm or bellows of the pressure actuated motor 18. When the pressure applied to the motor 18 is increased, the push rod 19 rises thereby rotating the lever arm 20 in a counter-clockwise direction which through link 23 causes the lever 9 to rotate in a counter-clockwise direction about pivot 15 thus lowering the valve stem 7 for imparting closing movement to the valve. Conversely when the pressure applied to motor 18 is decreased, the weight 25 causes rotation of lever 20 in a clockwise direction thereby rotating the lever 9 in the same direction for imparting opening movement to the valve 6.

From the description thus far, it should be apparent that when the electric motor 11 is energized, the pivot 15 for the lever arm 9 is raised to a point wherein the pressure actuated motor can open the valve 6 and that the degree of opening of valve 6 will vary with the pressure applied to motor 18. Thus when the pressure applied to motor 18 is decreased the valve 6 is opened and

when the applied pressure is increased the valve 6 is actuated towards closed position. However, when the motor 11 is deenergized the pivot 15 about which the lever arm 9 rotates is lowered to such a point that the lever arm 20 is incapable of opening valve 6. Therefore deenergization of the motor 11 positively closes valve 6 irrespective of the pressure applied to the motor 18.

The motor 18 is controlled by means of a pressure controller generally indicated as 30. This controller may include a bellows chamber 31 which houses a bellows 32. This bellows chamber is connected by pipe 33 to the blow-off connection 34 of a filter 35 which is connected to the boiler by pipe 36. The bellows 32 is therefore subjected to boiler pressure. This bellows actuates a knife edge member 37 which in turn actuates a lever 38 which is pivoted to a stationary knife edge member 39. The lever 38 is also connected to a spring 40, the upper end of which is supported by a nut 41 threaded to an adjusting screw 42. The spring 40 therefore biases the lever 38 against the bellows 32. The lever 38 also includes an arm 43 which carries a pin 44 fitting into a slot 45 of a mercury switch carrier 46 which carries a mercury switch 47. When the boiler pressure increases, the bellows 32 will expand thereby causing counter-clockwise rotation of the lever 38 about its pivot 39 which causes movement of the pin 44 to be shifted to the left thereby rotating the mercury switch 47 to open position. When the boiler pressure is below a predetermined value depending upon the adjustment of spring 40, the switch 47 will remain closed as shown.

The lever arm 38 also includes a portion 48 which extends downwardly through the housing 49 of the instrument. This portion of lever 38 actuates a plunger 50 forming a part of the control valve 51 which may be secured to the housing 49. The control valve 51 includes a casing 52 which is provided with a condensate outlet 52a. This casing also has an opening 53 into which is threaded a nipple 54, this nipple being drilled to form a guide for the plunger 50. This nipple 54 is also provided with a suitable packing gland surrounding the plunger 50 so as to prevent any condensation from flowing out of the casing 52 at this point. The plunger 50 is secured to a plunger head 56. This plunger head is provided with a downwardly extending skirt portion 57 which surrounds the reduced upper portion of the nipple 54 for thereby tending to prevent flow of condensate to the top of the plunger. The plunger head 56 also carries a crater type valve element 58 which may be secured thereto by a sleeve 59. This valve member 58 cooperates with a bleed orifice member 60 which is threaded in an opening in the top of casing 52, this opening being surrounded by a pipe connection 61. This connection 61 is connected through a restricting device 62 and pipe 63 to the outlet of the filter 35 and thus receives a restricted flow of steam from the boiler. Restricting device 62 is also connected by a pipe 64 to the pressure actuated motor 18.

Due to the restricting device, the steam pressure in pipe 64 and motor 18 is considerably below boiler pressure. It will be apparent that the pressure applied to motor 18 will vary in accordance with the rate of bleed of steam through the bleed port member 60. For example, when the valve 58 is at its maximum distance from the bleed port member 60, the flow of steam through this member can be greater than the flow of steam through restriction 62 thereby causing the pressure applied to the motor 18 to be reduced to zero. However, as the valve 58 is raised the steam flow through port 60 will be restricted thereby progressively increasing the pressure applied to motor 18.

It will be noted that as the steam pressure within the boiler increases, the lever 38 causes the plunger 50 to be shifted upwardly thereby restricting the flow of steam through the bleed port for increasing the pressure applied to motor 18 which in turn causes closing of the valve 6, thus decreasing the flow of gas to the burner 2. Also due to the increasing of steam pressure, the flow through the restrictor 62 is increased which additionally causes the pressure applied to motor 18 to increase. This double action, namely, the rise in pressure within motor 18 due to increased steam flow through restriction 62 and due to closing movement of valve member 58 provides a very sensitive control arrangement for maintaining the boiler pressure within very close limits. It will be apparent that upon fall in boiler pressure the steam flow through restriction 62 will decrease and also the valve 58 will be lowered for increasing the flow through the bleed orifice, which will cause lowering of the pressure applied to motor 18 for increasing the opening of valve 6 to provide an increased supply of gas to the burner.

The motor 18 may also be utilized for automatically controlling the breeching damper 5. This may conveniently be done by providing a spring 65 for biasing the damper 5 towards open position. The actuating lever for damper 5 may then be connected by means of a chain 66 operating over suitable pulleys such as 67 to the lever arm 20. This arrangement will cause closing of the damper 5 simultaneously with closing of valve 6.

The power failure type motor 11 is controlled by means of the mercury switch 47 of pressure controller 30. This motor may also be controlled by means of a low water cut-off 68 and by means of a pilot flame responsive switch 69. The low water cut-off 68 is arranged so that it opens its switch whenever the water level within the boiler falls to the predetermined minimum value. Also the pilot flame responsive device 69 is arranged so that it opens its switch whenever the pilot is extinguished. The mercury switch 47, the low water cut-off 68, and the pilot responsive device 69 are connected in series with the motor 11 across the transformer secondary 70 of a transformer 71 by means of wires 72, 73, 74, 75, and 76. Therefore if either the boiler pressure is excessive, the water level is too low, or the pilot is out, the motor 11 will be deenergized for thereby closing the valve 6 for extinguishing or preventing operation of the burner 2.

It is important in controlling valve 6 to prevent this valve from being closed beyond a minimum value for if the flow of gas to the burner is throttled too far, the burner will not operate properly and is liable to "pop back." In order to prevent this from occurring the motor 18 is provided with a bracket 70 having an adjusting screw 71 adapted to engage the lever arm 20 and limit its counterclockwise travel. By properly adjusting the adjusting screw 71 the motor 18 may be prevented from closing the valve 6 beyond the desired minimum position and consequently as long as the valve 6 is under the modulating control of the motor 18, the gas supply to the burner will be sufficient to cause proper operation of the

burner. Under extremely light load conditions if this minimum position of the valve still provides too much heat supply, the boiler pressure will continue to increase which will cause opening of the mercury switch 47. This will deenergize the motor 11 and thus cause the valve 6 to pass abruptly from the minimum position to completely closed position. The burner 2 will then remain extinguished until the boiler pressure falls sufficiently to cause closing of the mercury switch 47 which will reenergize the motor 11 and open the valve 6 to its minimum position, provided that the pilot is burning and the water level is at the proper value.

From the foregoing description it will be apparent that under normal operation conditions for the boiler, the mercury switch 47 will be closed and the motor 11 energized thereby permitting the valve 6 to be graduatingly controlled by means of the control valve 51 which controls the pressure actuated motor 18, and that during such normal operation the valve 6 will not be closed beyond the position necessary for providing satisfactory burner operation. However, when the boiler load falls to such a value that the minimum burner operation is still too much, the boiler pressure will rise slightly above the normal operating range of control valve 51 for opening mercury switch 47 which deenergizes motor 11 for positively closing the valve. The control system therefore provides for a modulating control of the gas valve in accordance with boiler load conditions and provides for quickly opening or closing movement of the valve between closed and minimum positions. It will also be apparent that if the pilot fails or if the water level within the boiler falls too low then the valve will be closed regardless of what the boiler load happens to be, thereby protecting the boiler. Also in the event that modulating controls for the valve should fail to operate properly, the boiler pressure will be prevented from rising above the predetermined maximum value by the opening of the mercury switch 47.

Referring again to the control valve 52, it is important that this valve be prevented from completely stopping the bleed of steam, for this would permit full boiler pressure to be applied to the motor 18 which would cause damage to this motor. It is also important to properly adjust the restriction 62 with respect to the opening of the control valve so that the pressure applied to the motor never exerts a predetermined maximum value. It is important that the steam supplied to the valve 51 be perfectly clean at all times in order to obviate any possibility of clogging the restriction 62. For this reason the filter 35 is provided with a blow-off valve 77 to permit the filter to be blown down periodically.

When the boiler is being started up after a shut-down it is desirable to prevent the burner 2 from operating at full capacity for thereby causing the boiler to be slowly brought up to temperature in order to prevent any damage to the boiler and its setting. In order to prevent operation of the burner at full capacity when the boiler is cold, an auxiliary pressure actuated motor 80 may be mounted upon a bracket 81 which is secured to the stand 17. This motor 81 may include a bellows or diaphragm (not shown) which actuates a plunger 82 pivoted to lever 83 which in turn is pivoted at 84. This lever 83 is biased in a clockwise direction by means of a spring 85. The diaphragm or bellows of the motor is connected by a capillary tube 86 to a control bulb 87 which may be located within the boiler. The diaphragm, tube and bulb contain a suitable volatile fluid so that the pressure applied to motor 80 varies in accordance with boiler temperature. When the boiler is cold, the pressure applied to motor 80 will be low which permits spring 85 to rotate lever 83 in a clockwise direction which raises the left hand end of this lever thereby limiting the clockwise rotation of the lever 20. Therefore even if the pressure applied to the motor 18 is zero, the motor 80 will limit the movement of lever 20 and thus prevent complete opening of the gas valve 6. However as the boiler temperature rises, the pressure applied to motor 80 will increase thereby rotating the lever 83 in a direction for withdrawing it from the range of movement of lever 20, thereby permitting the valve 6 to be opened wide after the boiler is heated up.

Referring to Figure 2, this figure illustrates the application of my combustion control apparatus to a compensated type boiler control system. In this system the control valve 51 of the boiler pressure controller 30 instead of controlling the pressure applied to the gas valve motor 18 as in Figure 1, controls the breeching damper 5 by means of a damper motor 90. This damper motor may be of usual form and includes a lever arm 91 suitably attached to the damper lever arm so that an increase in pressure applied to motor 90 causes closing movement of damper 5. The filter 35 is provided with an outlet pipe 92 which is connected to the restriction 93 and the outlet of this restriction is connected to pipes 94 and 95 leading to the motor 90 and the valve 51, respectively. It will be apparent that upon increase in boiler pressure, the pressure controller 30 will adjust the control valve 51 so as to decrease the bleed therethrough thereby increasing the pressure applied to motor 90. This in turn shifts the damper 5 towards closed position.

The gas valve motor 18 is controlled by means of an overfire pressure regulator generally indicated as 96. This regulator may consist of a control valve 99 which is of exactly the same type as the control valve 51 and which is actuated by a diaphragm 98 subjected to overfire pressure by means of pipe 97. This control valve is connected by pipes 100, 101, and 102 to the motor 18 and to the restriction 103 which is in turn connected to the outlet of filter 35.

Upon an increase in overfire pressure the diaphragm 98 will adjust the control valve 99 so as to decrease the rate of bleed which will cause the pressure applied to valve motor 18 to increase for causing the valve 6 to be adjusted in closing direction.

The power failure type motor 11 of Figure 2 is controlled in exactly the same manner as in Figure 1 so that the valve may be closed by either the pressure controller 30, the low water cut-off 68, or the pilot responsive device 69.

The control arrangement just described will function as follows: assuming an increase in boiler load the boiler pressure will decrease and in response to this the pressure controller 51 will decrease the pressure applied to the breeching damper motor 90, thus causing this motor to open the damper 5 wider. This opening of damper 5 will decrease the pressure within the boiler combustion chamber which will cause lowering of the diaphragm 98 of the overfire regulator 96 thereby adjusting the control valve 99 so as to decrease the pressure applied to motor 18. This in turn will cause the valve 6 to be opened wider for thereby increasing the supply of gas to the burner

for carrying the increased load. Upon decrease in boiler load the opposite action will occur, namely, the boiler pressure will increase which will cause closing movement of damper 5 thereby increasing the overfire pressure which will cause the regulator 96 to increase the pressure applied to motor 18 for shifting valve 6 in closing direction to reduce the flow of gas to the burner. The remainder of the control system will function in exactly the same manner as in Figure 1. Thus if the pilot becomes extinguished or if the water level falls too low the power failure type motor 11 will be deenergized for completely closing valve 6. Also the stop 79 will prevent the modulating control motor 18 from closing the valve 6 beyond the predetermined minimum position and movement of the valve between closed position and this predetermined minimum position is effected entirely by the two-position motor 11. In Figure 2 just as in Figure 1, if the boiler pressure rises above the range of the modulating controls the pressure controller 30 will deenergize the motor 11 for instantly closing valve 6.

While I have shown and described two applications of my novel control system it will be apparent that the control system may be arranged in other manners for securing the desired results. Inasmuch as many modifications and adaptations of my invention will occur to those skilled in the art I desire to be limited only by the scope of the appended claims.

I claim as my invention:

1. In a combustion control system for a steam boiler, in combination, firing means for said boiler, a controller for graduatingly controlling said firing means, a pressure actuated motor for actuating said controller, said controller including a pivotally mounted lever, a two position type motor for moving the pivotal mounting for said lever, said two position type motor having a first position in which the pivotal mounting is positioned so that the pressure actuated motor is placed in control of said controller and a second position in which the pivotal mounting is positioned so that said controller is positioned for substantially reducing the rate of combustion irrespective of said pressure actuated motor, a source of fluid, control valve means actuated in accordance with boiler pressure for graduatingly controlling the application of said fluid to said pressure actuated motor for thereby graduatingly positioning said controller, and a control device actuated in accordance with boiler pressure for controlling said two position motor in a manner to cause said motor to assume its first position when boiler pressure is below a predetermined value while assuming its second position when boiler pressure rises above said value.

2. In a combustion control system for a steam boiler, in combination, firing means for said boiler, a controller for graduatingly controlling said firing means, a pressure actuated motor, connections by which said pressure actuated motor actuates said controller, a source of fluid, control valve means for controlling graduatingly the application of fluid from said source to said pressure actuated motor for thereby graduatingly posititoning said controller, pressure responsive means for actuating said control valve means in accordance with boiler pressure for thereby positioning said controller in accordance with boiler pressure, power failure type electric means associated with said connections and adapted when energized to place said controller under the control of said pressure responsive means, while causing actuation of said controller in a direction to reduce the rate of firing of said boiler independently of said pressure responsive means when deenergized, switching means responsive to an operating condition of the boiler for energizing said power failure type electric means when said operating condition is proper, while deenergizing said power failure type electric means when said operating condition becomes improper, and other switching means connected in series with said first mentioned switching means, said other switching means being normally closed but opened in response to a rise in boiler pressure above that normally maintained by said control valve means.

3. In a combustion control system for a steam boiler, in combination, firing means for said boiler, a controller for graduatingly controlling said firing means, a pressure actuated motor for actuating said controller, a second motor cooperating with said pressure actuated motor in positioning said controller, said second motor acting when in one position to place the pressure actuated motor in control of said controller while actuating said controller as said second motor approaches another position in a manner to reduce the rate of firing independently of said pressure actuated motor, a steam line connected to the boiler and having a restriction therein, said steam line being connected to said pressure actuated motor, a bleed orifice communicating with said steam line between said restriction and said pressure actuated motor, a valve member cooperating with said bleed orifice for controlling the flow of steam through said orifice to thereby vary the steam pressure applied to said pressure actuated motor, means responsive to the boiler pressure for varying the relationship between said valve member and said bleed orifice to thereby actuate said controller in accordance with boiler pressure, and means actuated by fall in water level within said boiler to a predetermined level for causing movement of said second motor to said other position for thereby preventing damage to said boiler.

4. In a combustion control for a steam boiler, in combination, a fluid fuel burner for the boiler, a valve for controlling the flow of fuel to the burner, ignition means for said burner, a pressure actuated motor for actuating said controller, a second motor cooperating with said pressure actuated motor in controlling said valve, said second motor acting when in one position to place the pressure actuated motor in control of said valve and when in another position to close said valve independently of said pressure actuated motor, a steam line connected to the boiler and having a restriction therein, said steam line being connected to said pressure actuated motor, a bleed orifice communicating with said steam line between said restriction and said pressure actuated motor, a valve member cooperating with said bleed orifice for controlling the flow of steam through said orifice to thereby vary the steam pressure applied to said pressure actuated motor, means responsive to the load on the boiler for varying the relationship between said valve member and bleed orifice to thereby actuate said fuel valve in accordance with the boiler load, and means responsive to operation of said ignition means for causing said second motor to close said valve upon failure to operate of said ignition means.

5. In a combustion control for a steam boiler,

in combination, a fluid fuel burner for the boiler, a valve for controlling the flow of fuel to the burner, ignition means for said burner, a pressure actuated motor for actuating said controller, a second motor cooperating with said pressure actuated motor in controlling said valve, said second motor acting when in one position to place the pressure actuated motor in control of said valve and when in another position to close said valve independently of said pressure actuated motor, a steam line connected to the boiler and having a restriction therein, said steam line being connected to said pressure actuated motor, a bleed orifice communicating with said steam line between said restriction and said pressure actuated motor, a valve member cooperating with said bleed orifice for controlling the flow of steam through said orifice to thereby vary the steam pressure applied to said pressure actuated motor, means responsive to the load on the boiler for varying the relationship between said valve member and bleed orifice to thereby actuate said fuel valve in accordance with the boiler load, means responsive to operation of said ignition means for causing said second motor to close said valve upon failure to operate of said ignition means, and means responsive to an operating condition of said boiler for also controlling said second motor in a manner to cause closing of said fuel valve when said condition varies to a predetermined value.

6. In a combustion control for a steam boiler, in combination, firing means for said boiler, a controller for graduatingly controlling said firing means, a pressure actuated motor for actuating said controller, a steam line connected to the boiler and having a restriction therein, said steam line being connected to said pressure actuated motor, a bleed orifice communicating with said steam line between said restriction and said pressure actuated motor, a valve member cooperating with said bleed orifice for controlling the flow of steam through said orifice to thereby vary the steam pressure applied to said pressure actuated motor, means responsive to the boiler load for varying the relationship between said valve member and said bleed orifice to thereby actuate said controller in accordance with boiler load, power failure type electric means associated with said pressure actuated motor and adapted when energized to place said controller under the control of said load responsive means, while causing actuation of said controller in a direction to reduce the rate of firing of said boiler independently of said load responsive means when deenergized, and means responsive to an operating condition of the boiler for deenergizing said power failure electric means when said operating condition varies to a predetermined value.

7. In a combustion control for a steam boiler, in combination, firing means for said boiler, a controller for graduatingly controlling said firing means, a pressure actuated motor for actuating said controller, a steam line connected to the boiler and having a restriction therein, said steam line being connected to said pressure actuated motor, a bleed orifice communicating with said steam line between said restriction and said pressure actuated motor, a valve member cooperating with said bleed orifice for controlling the flow of steam through said orifice to thereby vary the steam pressure applied to said pressure actuated motor, means responsive to the boiler pressure for varying the relationship between said valve member and said bleed orifice to thereby actuate said controller in accordance with boiler pressure, power failure type electric means associated with said pressure actuated motor and adapted when energized to place said controller under the control of said pressure responsive means, while causing actuation of said controller in a direction to reduce the rate of firing of said boiler independently of said pressure responsive means when deenergized, means responsive to an operating condition of the boiler for deenergizing said power failure electric means when said operating condition varies to a predetermined value, and means responsive to a predetermined maximum boiler pressure for deenergizing said power failure type electric means.

8. In a combustion control for a steam boiler, in combination, a fluid fuel burner for the boiler, a valve for controlling the flow of fuel to the burner, ignition means for said burner, a pressure actuated motor for actuating said controller, a steam line connected to said boiler and having a restriction therein, said steam line being connected to said pressure actuated motor, a bleed orifice communicating with said steam line between said restriction and said pressure actuated motor, a valve member for cooperating with said bleed orifice for controlling the flow of steam through said orifice to thereby vary the steam pressure applied to said pressure actuated motor, means responsive to boiler load for varying the relationship between said valve member and said bleed orifice to thereby actuate said fuel valve in accordance with boiler load, power failure electric means associated with said pressure actuated motor and adapted when energized to place said fuel valve under the control of said load responsive means, while causing closing of said fuel valve when deenergized, and means responsive to failure to operate of said ignition means for deenergizing said power failure type electric means to thereby prevent opening of said fuel valve.

9. In a combustion control system for a steam boiler, in combination, firing means for said boiler, a controller for graduatingly controlling said firing means, a pressure actuated motor for actuating said controller, a steam line connected to the boiler and having a restriction therein, said steam line being connected to said pressure actuated motor, a bleed orifice communicating with said steam line between said restriction and said pressure actuated motor, a valve member cooperating with said bleed orifice for controlling the flow of steam through said orifice to thereby vary the steam pressure applied to said pressure actuated motor, means responsive to the load on the boiler for varying the relationship between said valve member and said bleed orifice for causing actuation of said controller in accordance with the load on the boiler, and temperature responsive means for limiting the operation of said firing means to a predetermined maximum when the boiler is cold for thereby preventing the boiler from being heated up at an injurious rate.

ARTHUR C. GRANT.