April 26, 1949. G. R. ANDERSON 2,468,535

CONTROL SYSTEM FOR STEAM BOILER FURNACES

Filed Oct. 31, 1944 2 Sheets-Sheet 1

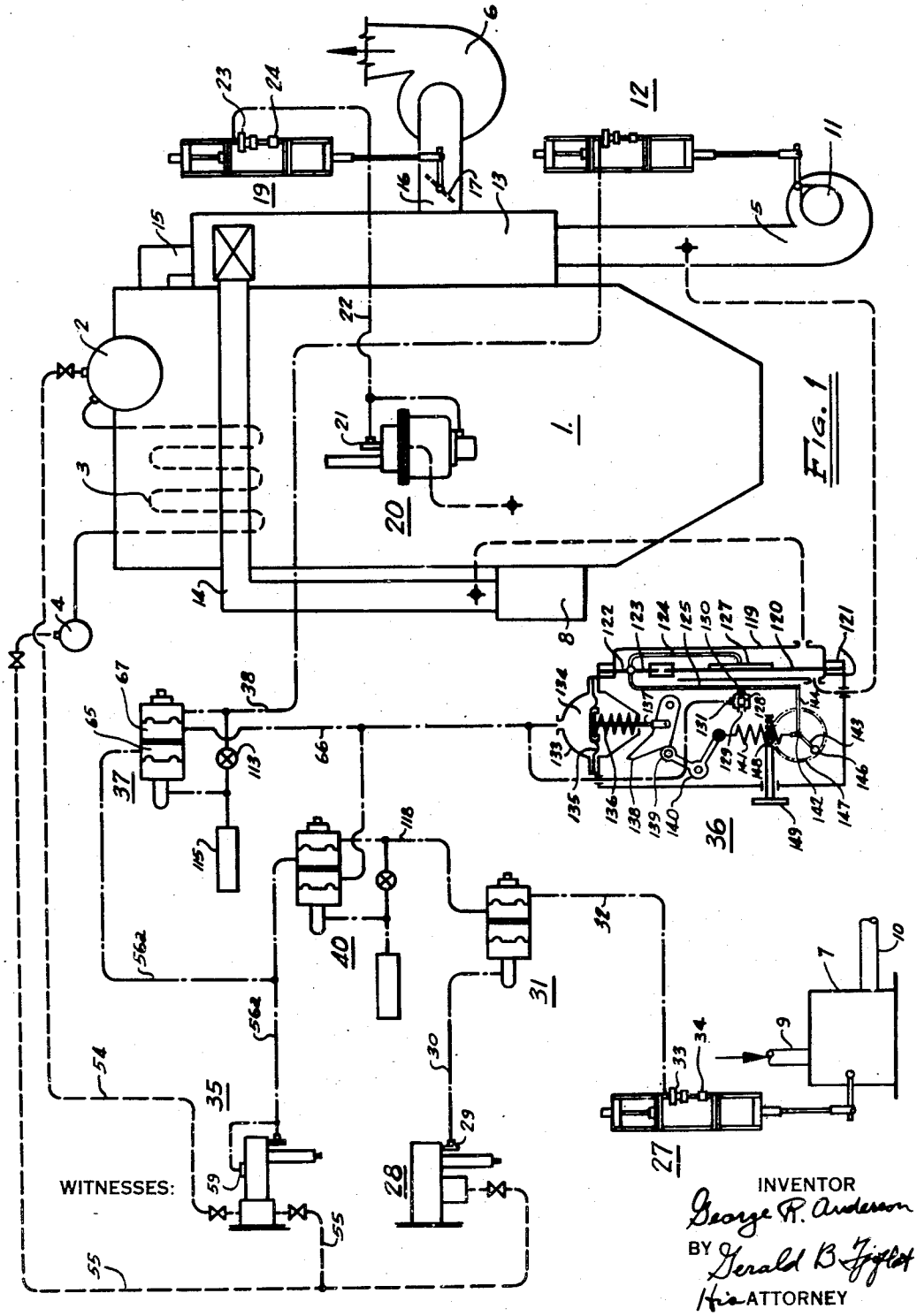


FIG. 1

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CONTROL SYSTEM FOR STEAM BOILER FURNACES

Filed Oct. 31, 1944 2 Sheets-Sheet 2

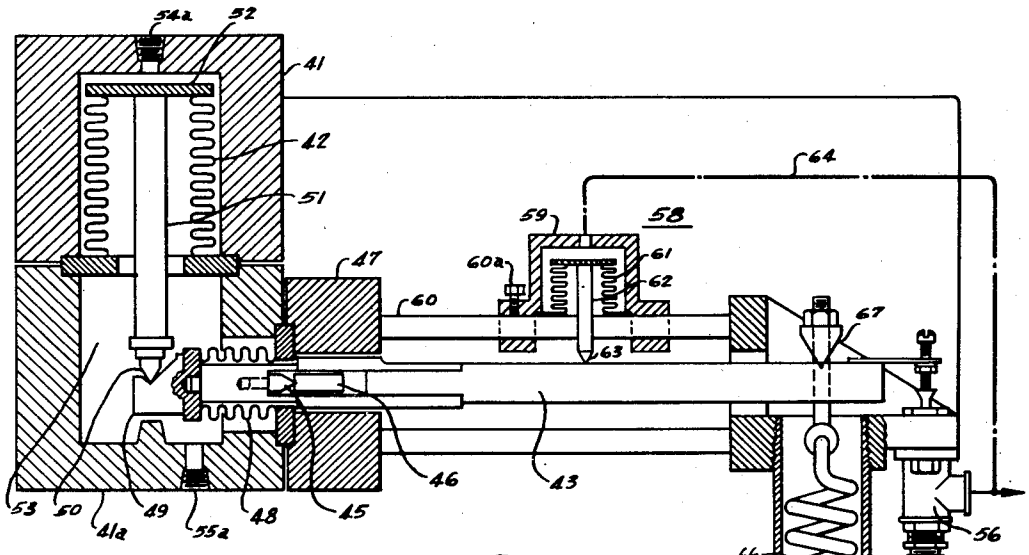


Fig. 2

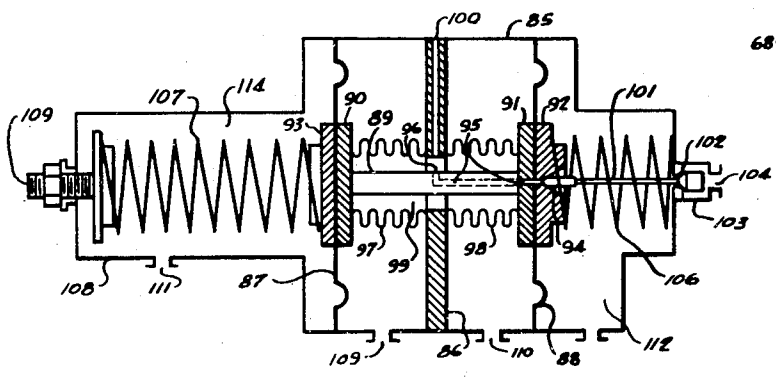


Fig. 3

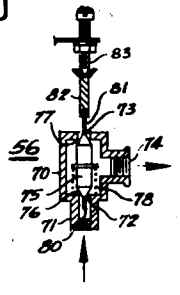


Fig. 2A

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UNITED STATES PATENT OFFICE

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CONTROL SYSTEM FOR STEAM BOILER FURNACES

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6 Claims. (Cl. 236—24.5)

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This invention relates to control systems for steam boiler furnaces in which either gaseous, liquid, or powdered solid fuels either alone or in admixture, are burned and more particularly to systems for maintaining a predetermined relationship between the rates of steam flow and the rate at which air is supplied to the combustion chamber or space of the boiler furnace.

An object of this invention is to provide an automatic control system for boiler furnaces which embodies means for measuring the rate of steam flow from a boiler and developing a force whose magnitude is a function of such steam flow rate, means for measuring the rate of flow of combustion air to the furnace and developing a second force whose magnitude is a function of such air flow rate, and means responsive jointly to said steam flow and air flow forces for so regulating the air supply that said control forces are maintained in balance with each other for all ratings at which the boiler is operated on automatic control.

A further object of the invention is to provide means for regulating the supply of fuel to the furnace in accordance with variations in steam pressure. Thus, the control system above set forth is designed and arranged to match the rate at which combustion air is supplied to the furnace with the rate of steam flow, and to cause fuel to be supplied to the furnace at a rate which will maintain the steam pressure at some predetermined desired value.

A still further object of the invention is to provide a control system that shall be simple, rugged, and yet sensitive and accurate in operation.

Other objects of the invention will, in part, be apparent and will, in part, be obvious from the following description taken in conjunction with the accompanying drawings in which

Fig. 1 is a more or less diagrammatic view of a steam boiler furnace provided with a control system embodying what now appears to be a preferred form of the invention;

Fig. 2 is a view in section of a steam flow measuring device embodied in the control system;

Fig. 2a is a cross sectional view of a sending valve; and

Fig. 3 is a more or less diagrammatic view in longitudinal section of a totalizer embodied in the control system.

Throughout the drawings and specification like reference characters designate like parts.

In Fig. 1 of the drawings, reference character 1 indicates a steam boiler furnace having a steam drum 2 and superheater 3 through which steam

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from drum 2 flows to a distribution header 4. The furnace is provided with a forced draft fan 5, an induced draft fan 6, and means 7, such as a pulverizer mill, for supplying fuel to burners 8.

The fuel supply means 7 may, for purposes of illustration, be considered as a coal pulverizer having a supply pipe 9 through which carrier air is supplied to the pulverizer for conveying pulverized coal through a pipe 10 to burners 8.

The forced draft air supply from fan 5 is controlled by means of a louvre type damper 11 which is operated by a positioning power cylinder 12. The forced draft air supply passes through a preheater 13 and a duct 14 to burners 8.

The induced draft fan 6 carries exhaust gases out of the furnace to a stack, not shown. The exhaust gases of the furnace pass out of the furnace through a conduit 15 into preheater 13 and discharge from the preheater through a pipe 16 into the suction or inlet of fan 6.

A damper 17 in the exhaust pipe 16 is provided to regulate the suction of the furnace so that the pressure within the combustion chamber of the furnace may be maintained at a predetermined substantially constant value, say at atmospheric pressure or at a value slightly below or slightly above atmospheric pressure, as desired. Damper 17 is operated by a power cylinder 19. Power cylinder 19 is caused to position damper 17 by means of a regulator 20 which responds to deviations in pressure in the combustion chamber of the furnace from the value desired to be maintained therein. Regulator 20 is designed, as stated above, to respond to changes in pressure within the combustion chamber of the furnace from that value which it is desired to be maintained therein and causes a control force to be sent from its control valve 21 through a sending line 22 to a diaphragm chamber 23 of a mechanism which operates a pilot valve 24 of power cylinder 19. The value of the control force delivered by valve 21 of regulator 20 to the diaphragm chamber 23 of power cylinder 19 is such as will cause cylinder 19 to so move damper 17 towards open or closed position that the pressure within the combustion chamber of the furnace will be maintained substantially constant at the desired value.

Power cylinders or operators 12 and 19 are, for convenience, illustrated as being of the same type and may be of the type shown in United States Patent 2,044,936. Regulator 20 may be of any type suitable for maintaining a balanced draft such, for example, as the regulator shown in Fig. 4 of United States Patent 2,243,944.

The rate at which carrier air is delivered to pulverizer 7 is controlled by a positioning power cylinder or operator 27 of the same type, for example, as power operators 12 and 19. Power cylinder 27 is controlled from a steam pressure responsive master regulator 28, which is of the type shown at 8 in United States Patent 2,220,837. This master regulator is responsive to the steam pressure of the boiler either as measured at the steam header 4 or, if desired, at drum 2. Master regulator 28 is designed to send out a control force from its valve 29 through a pipe 30 to a fuel cutback totalizer 31, which, in turn, transmits or repeats the control impulse of line 30 in and through line 32 to the diaphragm chamber 33 of the operator for pilot valve 34 of power cylinder 27. As the steam pressure in steam header 4 decreases, master regulator 28 responds causing the control force delivered to line 30, and as repeated in line 32, to decrease proportionately, and if the steam pressure rises, the control forces in pipes 30 and 32 are caused to increase proportionately. As the steam pressure in header 4 decreases and the control force delivered to the diaphragm chamber 33 of power cylinder 27 decreases, operator 27 causes more fuel to be delivered to the furnace. When the steam pressure in header 4 increases, the control forces delivered through pipes 30 and 32 increase, whereby operator 27 causes fuel to be delivered to the furnace at a decreased rate.

In order that a predetermined relationship may be maintained between the rate at which steam flows from the boiler drum 2 through steam superheater 3 to the steam header 4 and thence to the point where the steam is consumed, and the rate at which air is supplied for combustion to furnace 1, a steam flow measuring device 35, an airflow measuring device 36, and a totalizing regulator 37 are provided. Totalizing regulator 37 responds to a control force developed by the steam flow measuring device 35 and a control force developed by the air flow measuring device 36, and sends out a control force through pipe 38 to power cylinder 12 whereby power cylinder 12 so positions damper 11 that the air flow impulse developed by device 36 is caused to balance the control force developed by the steam flow measuring device 35.

The steam flow measuring device 35 and the totalizing regulator 37 are shown more or less in detail in Figs. 2 and 3, respectively, and will be described more particularly hereinafter.

In order to make provisions for the circumstance where, for some reason or other, the forced draft air supply to the furnace should fail or should become inadequate and fall behind the rate of steam flow from the boiler, means are provided for decreasing the rate at which fuel is delivered to the furnace in order that proper fuel-air ratio may be maintained. The means for reducing the fuel input or cutting back on the fuel input in case the air supply rate falls behind or below the rate at which steam flows from the boiler, consists of a totalizing device 40 which responds to the control forces developed by devices 35 and 36, respectively, and sends out a loading force to the cutback totalizer 31 thereby to so modify its operation that the impulse delivered through pipe 32 to the diaphragm 33 for the operator of pilot valve 34, reduces the fuel to a value corresponding to the rate at which air is supplied to the furnace. Devices 37, 40 and 31, respectively, are similar in construction, hence the detailed illustration of Fig. 3 hereinafter described will suffice for each of the devices.

The steam flow responsive device 35, as shown more particularly in Fig. 2, comprises a two-part housing 41 and 41*a* in which is disposed a flexible bellows 42 and the end of a beam 43 having a knife-edge 45 that bears against a knife edge bearing 46 rigidly supported in a bearing housing 47 secured to housing 41*a*. The inner end of beam 43 projects into the chamber of housing 41*a* but the opening through which the beam extends is sealed by means of a sealing bellows 48. The inner end of beam 43 is provided with a knife-edge bearing 49 which accomodates a knife-edge 50 carried at the lower end of a push rod 51 secured to the upper end of bellows 42.

It will be seen by inspection of Fig. 2 that bellows 42 divides the interior of housing 41 into two separated chambers 52 and 53. Chamber 52 is connected, see Fig. 1, by a pipe 54 at 54*a* to steam drum 2 and chamber 53 is connected by a pipe 55 at 55*a* to the steam header 4. Thus when the steam flow from the boiler is zero the pressures in chambers 52 and 53 will be equal, but as the steam flow increases from zero to higher and higher values the pressure in chamber 53 will be less than that in chamber 52 because of the pressure drop through superheater 3. This pressure drop will cause bellows 42 to be compressed in accordance with the steam flow and will have maximum compression at maximum steam flow and minimum compression at zero steam flow.

As the bellows 42 is flexed in accordance with the rate at which steam flows from the boiler to the distribution header 4, beam 43 is caused to rock on its knife edge 45 and to so actuate an escapement sending valve 56 that the pressure transmitted by this valve to its sending line 56*a* will be proportional to the pressure drop across superheater 3. Since the pressure drop across superheater 3 is proportional to the square of the flow of the steam through it, the value of pressure established in sending line 56*a* will therefore be proportional to the square of the rate of flow of steam through the superheater. The square root of the pressure drop or its indicated value, the pressure in line 56*a*, is a linear function of the steam flow.

Beam 43 is balanced by a pressure balancing device 58 which consists of a housing 59 slidably mounted on rods 60 to which it is secured by set screw 60*a*. A bellows 61 is mounted in the housing 59 and acts on fulcrum pin 62 having a knife edge 63 which rests on beam 43. One side of the bellows 61 is connected by line 64 to the sending port of valve 56 to balance the torque applied to the knife edge bearing 49.

Beam 43 is provided with an adjustable tension spring 66, the upper end of which is connected to a knife edge 67 bearing on the upper face of the beam near its free end, and the other end of which is connected to an adjusting screw 68 supported in a spring barrel 69. The tension in spring 66 is adjusted to compensate for the weight of the moving parts and the resistance of the sealing bellows 48.

Valve 56, Fig. 2*a*, comprises a body 70 having an inlet 71 connected to a supply of fluid, such as compressed air at constant pressure, an inlet seat 72, an exhaust seat 73, and a sending port 74 located between the inlet and exhaust seats. A valve member 75 having conical surfaces 76 and 77, respectively, is mounted within the body to coact with the inlet and exhaust ports 72 and

73. Valve 75 is urged towards its exhaust port 73 by means of a spring 78. Each end of valve 75 is provided with guides 80 and 81, respectively. Guide 81 coacts with a link 82, the upper end of which coacts with an adjustable screw 83 carried by beam 43 at its free end. As beam 43 rocks, the inlet ports 72 and 73 are opened or restricted, as the case may be, in such manner that the pressure of the compressed air issuing from port 74 will vary from a maximum, when the exhaust port 73 is closed, to a minimum when the inlet port 72 is closed, the values of pressures between the minimum and maximum varying with the position of valve 75 as determined by the position of beam 43, which, in turn, is determined by the pressure differential acting on bellows 42.

The totalizers 31, 37 and 40 are similar in construction and are represented by the showing of Fig. 3. This device comprises a housing 85 having a dividing partition 86 therein and flexible diaphragms 87 and 88 disposed on each side of the partition. The diaphragms are connected together by means of a rigid spacer post 89, the opposite ends of which carry clamping plates 90 and 91. A clamping plate 92 coacts with clamping plate 91, being secured thereto in any suitable manner, whereby the diaphragm 88 is held firmly between plates 91 and 92. A clamping plate 93 coacts with plate 90 to rigidly clamp the diaphragm 87 between plates 90 and 93. Plate 92 has a valve seat 94 that communicates with a passage 95 which extends through plate 91 and post 89 and terminates in a lateral passage 96. Bellows 97 and 98, respectively, are sealed to clamping plates 90 and partition 86 and plate 91 and partition 86 so as to provide a sealed space 99 about post 89. Partition 86 is formed with an exhaust passage 100 that communicates with passage 95 and lateral passage 96. These passages provide an exhaust for valve seat 94. A valve 101 is disposed to coact with valve seat 94 and an inlet valve seat 102. Valve seat 102 is disposed within a body 103 having an inlet 104 connected to a source of fluid pressure, such as compressed air at constant pressure. A light spring 106 tends to urge diaphragm 88 towards its neutral position, in which position the exhaust valve seat 94 and inlet port seat 102 are closed.

An adjustable compression spring 107 is disposed in a chamber 108 formed as part of body 85. As shown, this is a compression spring, the tension of which may be adjusted by means of a screw adjustment 109. The initial tension set up in spring 107 is determined by the values of the actuating pressures which may be supplied to act on diaphragms 87 and 88 when connected through the respective ports 109, 110 and 111.

If actuating pressures are connected to ports 109 and 110, these pressures will act in opposition to each other on diaphragms 87 and 88 and cause a pressure to be established in chamber 112 of the device which will cause the unbalance between the pressures acting in opposition to each other on these diaphragms to be balanced out. When in balance, the valve seats 94 and 102 will be closed. If a pressure is also introduced through port 111 as well as through ports 109 and 110, the pressure established in chamber 112 will be proportional to the alegbraic sum of the pressures acting on diaphragms 87 and 88 through ports 109 to 111 inclusive.

As shown in Fig. 1, sending line 56*a* is connected to port 109 of totalizer 37. Chamber 112 is connected to pipe 38, and pipe 38 is also connected through a needle valve 113 and suitable piping to port 111, so that the pressures acting in chamber 112 on diaphragm 88 and in chamber 114 on diaphragm 87 will balance out after a length of time as determined by the setting of the needle valve 113. A volume chamber 115 is connected to the piping leading from needle valve 113 to port 111 to give stability to the device.

The port 110 of totalizer 37 is connected to pipe 66 in which a variable pressure is established by device 36, the value or magnitude of this pressure being a function of the rate of air flow to the combustion chamber of the furnace.

The steam flow measuring device 35 will maintain a pressure as delivered through port 109 and acting on diaphragm 87 that is a function of the rate of steam flow, being proportional to the pressure drop across superheater 3. This pressure tends to move diaphragms 87 and 88 to the left as viewed in Fig. 3, whereby the inlet port 102 is closed and the exhaust port 94 uncovered, thereby decreasing the pressure in chamber 112 which is delivered to the forced draft damper power operator 12. In response to this decreased sending pressure sent to the pilot valve operator of power cylinder 12, damper 11 will be moved towards a wider and wider open position until the sending pressure delivered by device 36 through pipe 66 and port 110 is sufficient, when acting on the opposite face of diaphragm 88, to balance the force of the pressure in pipe 56*a* acting on diaphragm 87. When this balance is achieved the setting of damper 11 will be the setting required to cause the air flow to the combustion space of the boiler to match the steam flow out of the boiler. In other words, for any value of pressure introduced through port 109 by the steam flow device 35, the sending pressure from chamber 112 to operator 12 will continue to vary until the air flow impulse developed by device 36 and transmitted through pipe 66 is sufficient to balance the steam flow impulse and the initial bias imposed by spring 107. Thus the air flow will always be caused to bear a definite relationship to steam flow.

The effect of the needle valve 113 is to allow the pressures in chambers 112 and 114 to be equalized after a predetermined length of time, so that the only operative forces after such time period are those developed by the pressures connected to ports 109 and 110. For example, if it be assumed that the device is in balance and there is a decrease in steam flow resulting in a decreased pressure acting through port 109, then the pressure acting on diaphragm 88 through port 110 will tend to uncover the inlet valve seat 102, thereby increasing the pressure in chamber 112 which acts on diaphragm 88 in opposition to the pressure acting on the other side of this diaphragm to delay or resist a wide opening of the valve 102 thereby allowing power operator 12 to move towards its required position without overtravel. The needle valve 113, however, allows the increase in pressure in chamber 112 over the pressure existing in chamber 114 to be gradually equalized so that the resisting force of the pressure in chamber 112 is gradually wiped out, or balanced out.

Devices 31 and 40 coact to reduce the fuel supply delivered from the pulverizer 7 to the furnace when, for some reason or other, the supply of forced draft fails or is incapable of matching the steam flow from the boiler. Device 40 is con-

nected like device 37 is connected, except that the steam flow impulse from line 56a is connected to port 110 and line 66 is connected to port 109, that is, the opposite of the connections for device 37. Thus so long as the air flow impulses in lines 56a and 66 are equal or within predetermined limits of difference in value, the sending impulse from device 40 through line 118 to port 110 of device 31 will remain at a predetermined value which may range from zero gauge pressure to any high value, depending upon the minimum amount of fuel that is to be delivered to the boiler at some predetermined rating less than full rating.

Device 31 acts as a repeater of the pressure impulse in line 30, which pressure is proportional to the value of the steam pressure in header 4. Line 30 is connected to port 111 of device 31 so that the pressures acting through this port and the pressure acting through port 110 are in the same direction. Thus if the pressure in pipe 118 does not vary, the pressure in pipe 32 will merely be a repeat of the pressure in pipe 30, so that the amount of fuel delivered to the furnace will be proportional to the steam pressure in header 4. However, if the air flow for some reason or other falls behind the steam flow, then the pressure in pipe 118 will be increased, whereby the repeated impulse in line 32 will be increased, thereby causing power operator 27 to decrease the rate at which fuel is supplied to the furnace, whereby the ratio of fuel to air delivered to the furnace is maintained at that value required for efficient combustion.

Device 36 comprises a housing 119 in which a diaphragm 120 is disposed. The outer edges of this diaphragm are clamped between flanges 121 of the diaphragm housing. The diaphragm housing has an opening 122 which is closed by a fulcrum diaphragm 123 which acts as a fulcrum for beams 124 and 125, respectively. Beam 124 is connected by means of a clamping plate 127 to the middle portion of diaphragm 120 and beam 125 is disposed to actuate an escapement valve 128 which is similar in construction and operation to valve 56. Thus valve 128 will be positioned to control its inlet and exhaust ports 129 and 130, respectively, so that the pressure issuing from its outlet or sending port 131 will be a function of the position of diaphragm 120 as determined by the pressure drop across the forced draft air preheater. In order that the pressure transmitted from sending port 131 to line 66 may be caused to bear a definite relationship to the pressure drop across the air preheater, a loading device 133 is provided. This loading device comprises a diaphragm chamber 134 having therein a flexible diaphragm 135 that acts against a gradient spring 136 which resists the pressure in chamber 134. The diaphragm 135 is connected by a push rod 137 to a cam 138. Cam 138 coacts with a roller 139 on a bell crank 140, one arm of which is connected to a spring 141. Spring 141 is connected to a junction 142 between links 143 and 144 operatively connected to beam 125. Link 143 is connected at its outer end by a pin 146 to a gear wheel 147. The gear wheel coacts with a worm wheel 148 disposed to be actuated by a hand wheel 149 to vary the angle between links 143 and 144 to thereby vary the ratio between the pressure difference acting on diaphragm 120 and the pressure sent out by valve 128. If the pressure difference acting on diaphragm 120 changes so as to cause valve 128 to be moved, the pressure sent out by its sending port 131 will continue changing until the force of this pressure acting on diaphragm 135 is sufficient to position the cam 148 at a point where the force of spring 141, acting through links 143 and 144, balances the force of the pressure differential acting on diaphragm 120. Thus for every value of pressure differential acting on diaphragm 120 there will be a definite sending pressure in line 66 and acting in chamber 134.

It will be evident from the foregoing description that steam flow measuring device 35 and the air flow measuring device 36 each develop control forces that act on totalizer 37 in such a manner that the totalizer so controls the air flow regulator as to cause the air flow rate control force developed by device 36 to be in balance with the steam flow rate control force developed by device 35. Thus the rate at which air is supplied for combustion is caused to immediately follow and match the rate of steam flow from the boiler.

The control forces developed by devices 35 and 36 also act on totalizer 40 in such a manner that when a certain predetermined condition prevails in the air supply with respect to steam flow, it transmits a control force through line 118 to totalizer 31 which under these conditions modifies the rate of supply of fuel to the furnace to a value required by the available air supply.

Although one embodiment of the invention has been herein illustrated and described, it will be evident to those skilled in the art that various modifications may be made in the details of construction without departing from the principles herein set forth.

I claim:

1. A control system for steam boilers provided with regulatable supplies of combusion air and fuel and means responsive to steam pressure for regulating the fuel supply, said system comprising means responsive to the rate of steam flow from the boiler for developing a control pressure whose magnitude is a function of such steam flow rate, means responsive to rate of flow of combustion air for developing a control pressure whose magnitude is a function of such air flow rate, a regulator for controlling the rate of flow of air, and means responsive to the difference between said control pressures for transmitting a control pressure to said air flow regulator and causing the same to so regulate the rate of flow of combustion air that said air flow rate and steam flow rate control pressures are in equilibrium with each other.

2. A control system for steam boilers provided with regulatable supplies of combusion air and fuel and means responsive to steam pressure for regulating the fuel supply, said system comprising means for measuring the rate of steam flow from the boiler and developing a fluid pressure that is a function of the value of steam flow rate measurement, means for measuring the rate of flow of combusion air to the boiler furnace and developing a fluid pressure that is a function of the value of said air flow rate measurement, and pressure actuated means responsive to the difference between steam flow rate and air flow rate fluid pressures for so regulating the air supply that the air flow rate fluid pressure balances the steam flow rate fluid pressure.

3. A control system for steam boiler furnaces provided with regulatable supplies of fuel and combustion air, a fuel supply regulator and a regulator for adjusting the rate of supply of combustion air, comprising a rate of steam flow

responsive device having means for establishing a fluid pressure whose magnitude varies with and is a function of the steam flow rate, a device responsive to the rate of flow of combusion air to the furnace having means for establishing a fluid pressure whose magnitude varies with and is a function of the air flow rate, and pressure actuated means responsive differentially to said fluid pressure for so controlling the operation of said air flow regulator that the air flow rate fluid pressure is directly proportional in value to said steam flow rate fluid pressure.

4. A control system for steam boiler furnaces provided with regulatable supplies of fuel and combustion air, a fuel supply regulator and a regulator for adjusting the rate of supply of combustion air, comprising a rate of steam flow responsive device having means for establishing a fluid pressure whose magnitude varies with and is a function of the steam flow rate, a device responsive to the rate of flow of combustion air to the furnace having means for establishing a fluid pressure whose magnitude varies with and is a function of the air flow rate, pressure actuated means responsive differentially to said fluid pressures for so controlling the operation of said air flow regulator that the air flow rate fluid pressure is directly proportional in value to said steam flow rate fluid pressure, means responsive to steam pressure having means for establishing a control pressure adapted to so actuate the fuel supply regulator that the rate of combustion is adjusted to maintain said steam pressure at a substantially constant value, and means responsive to a predetermined difference between the steam flow rate fluid pressure and said air flow fluid pressure for modifying the operation of said fuel supply regulator to effect a reduction in the rate of supply of fuel to the boiler.

. In a control system for steam boiler furnaces including fuel and air supply means, said system comprising means for measuring the rate of steam flow from the boiler of said furnace and developing a fluid pressure whose magnitude is a function of such steam flow rate, means for measuring the rate of flow of combustion air to the furnace and developing a second fluid pressure whose magnitude is a function of such air flow rate, and means responsive to the difference between said steam flow rate and air flow rate fluid pressures or so regulating the air supply that the magnitude of said air flow rate fluid pressure is maintained in balance with the magnitude of said steam flow rate fluid pressure.

6. In a control system for steam boiler furnaces provided with regulatable supplies of combustion air and fuel, said system comprising means responsive to steam pressure for regulating the rate

of supply of fuel so as to increase the rate when the steam pressure decreases and to decrease the rate when the steam pressure increases, means traversed by steam flowing from a boiler producing a pressure drop varying in magnitude with the rate of flow of said steam, a pressure differential responsive device responsive to said steam flow pressure drop, said steam pressure differential responsive device having an escapement valve disposed to be positioned by said device in accordance with the magnitude of said steam flow pressure drop and to transmit a fluid pressure corresponding to said valve position, means traversed by the combustion air supplied to said boiler producing a pressure drop varying in magnitude with the rate of flow of said combustion air, a pressure differential responsive device connected to respond to said air flow pressure drop, said air flow responsive device being provided with an escapement valve disposed to be positioned thereby and to transmit a fluid pressure whose magnitude varies with the position of said valve, a pressure actuated relay having a valve for transmitting a fluid pressure of varying magnitude, said relay having diaphragm means responsive differentially to the fluid pressures transmitted by said steam flow and air flow pressure drop responsive devices and acting in opposition to each other so that the valve is actuated to vary the magnitude of the transmitted pressure in response to an unbalance between the transmitted pressures of said steam flow and air flow pressure-drop-responsive devices, and means responsive to said relay-transmitted pressure for so regulating the rate of flow of air that the said steam flow and air flow pressure drops are maintained in balance, whereby the rate of flow of air to the boiler is caused to correspond in magnitude to the rate of flow of steam from the boiler.

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