June 26, 1945. J. J. KLINKER 2,379,008

COMBUSTION REGULATION

Filed Dec. 19, 1942 3 Sheets-Sheet 1

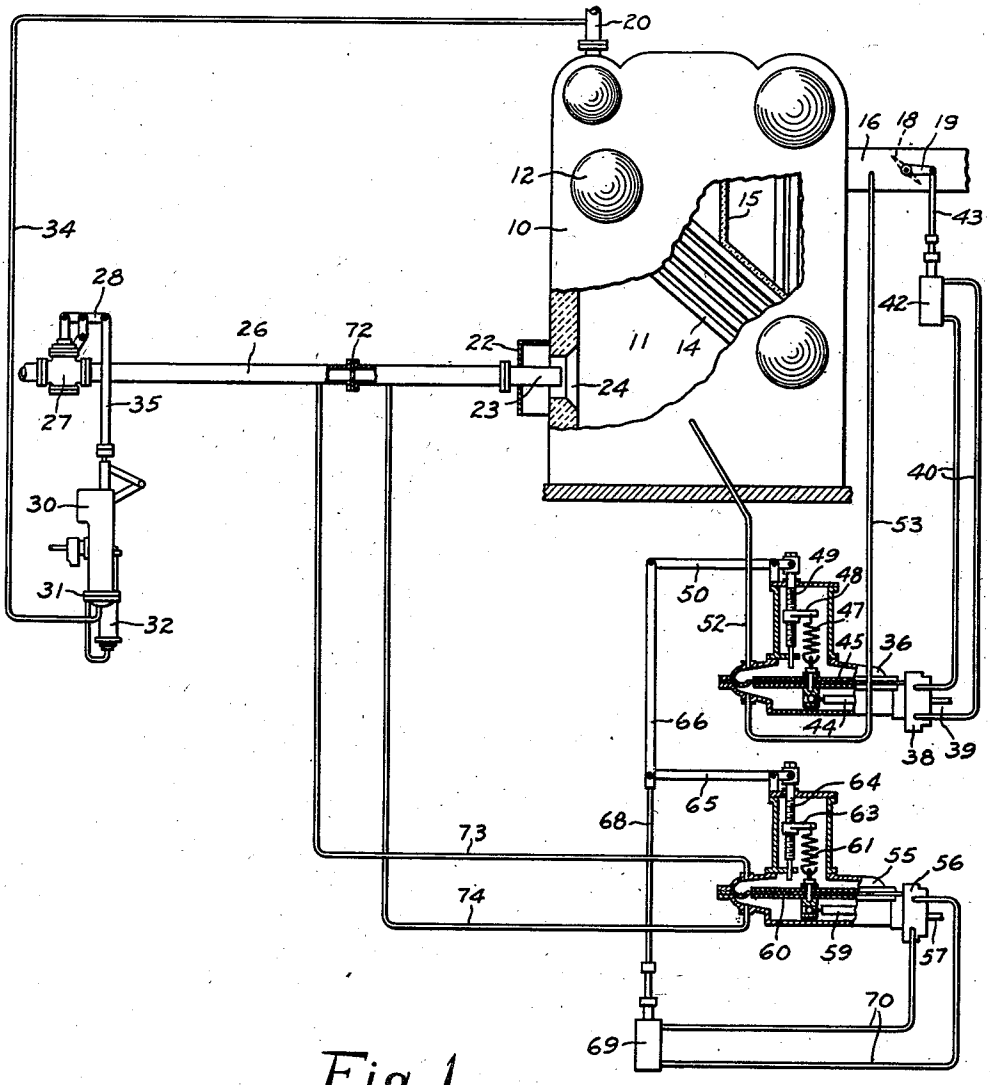


Fig. 1

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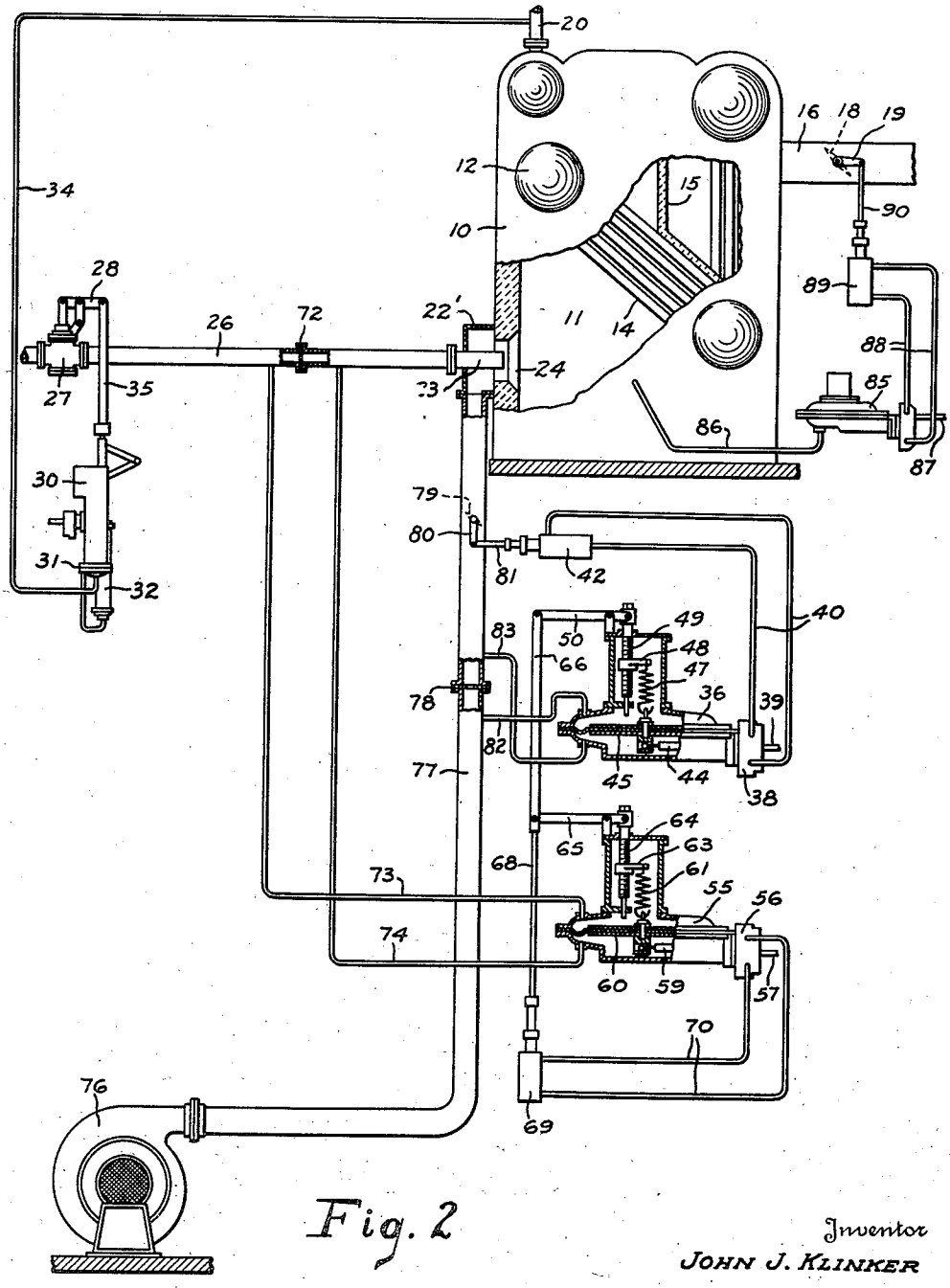


Fig. 2

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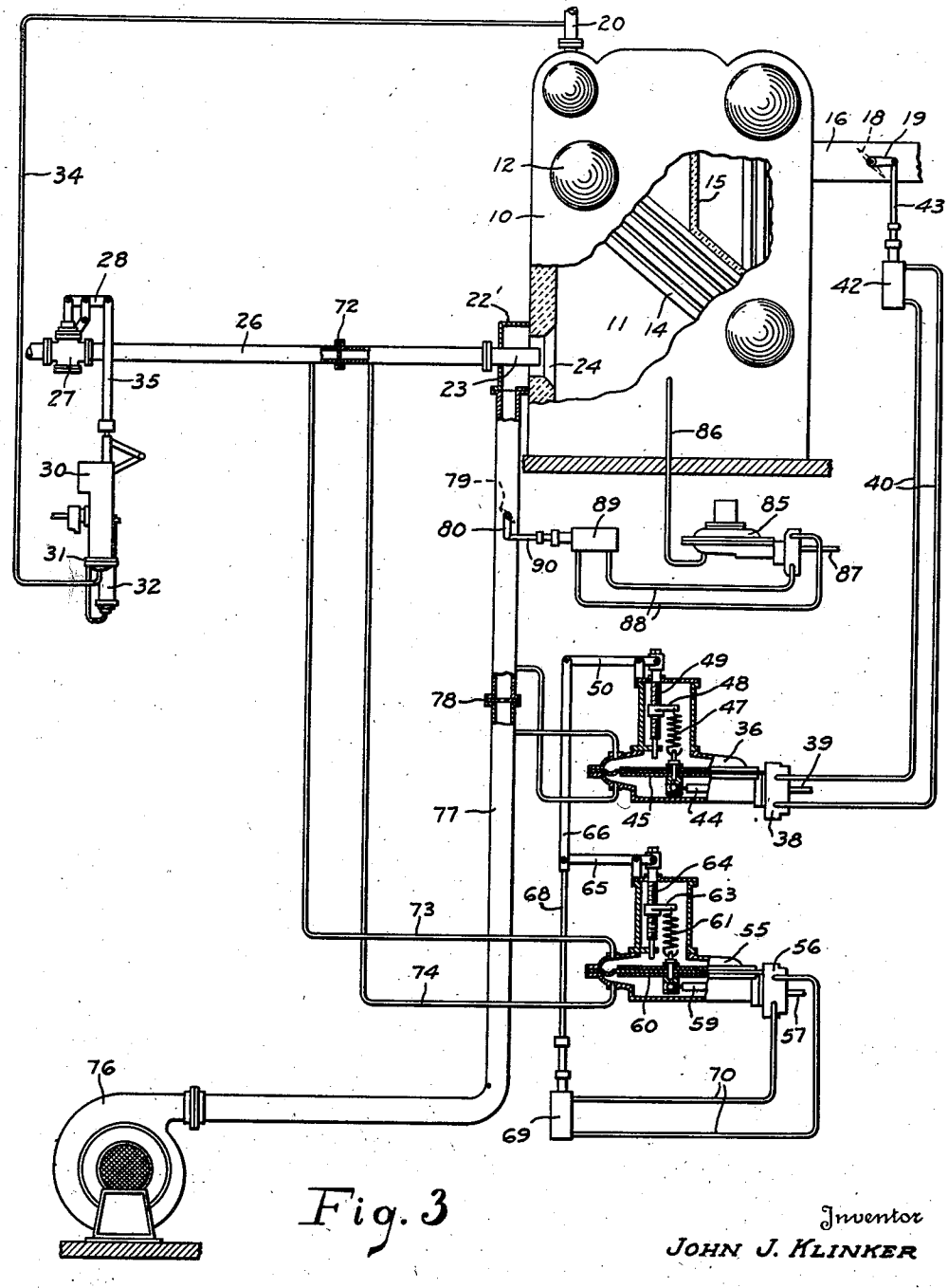


Fig. 3

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2,379,008

COMBUSTION REGULATION

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Application December 19, 1942, Serial No. 469,527

2 Claims. (Cl. 137—164)

This invention relates to combustion regulation, and more particularly to the construction and arrangement of apparatus for regulating the combustion of fluent fuels, such as gas or oil.

Since these fluent fuels are burned in suspension in a furnace, and the combustion gases travel rather rapidly through the furnace, it is of great importance to maintain at all times the proper relationship between the rate of fuel supply and the rate of air supply. Otherwise there may be periods during which combustion is proceeding in an inefficient manner. Particularly, when the supply of fuel is varied frequently to follow an erratic load, it is important that the air supply should be changed promptly and accurately in accordance with the changes in fuel supply.

It is accordingly one object of the invention to provide a combustion regulating system of a simple and dependable construction which will maintain the correct relationship between the supply of a fluent fuel and the supply of combustion air.

It is a further object of the invention to provide a relatively inexpensive and thoroughly reliable apparatus for regulating the combustion of fluent fuel and applicable to either natural draft or forced draft furnaces.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

Referring to the drawings illustrating one embodiment of the invention, and in which like reference numerals indicate like parts,

Fig. 1 is a diagrammatic elevation of a natural draft steam boiler furnace and associated combustion regulating apparatus, certain parts being shown in section for clearness of illustration;

Fig. 2 is a view similar to Fig. 1, but showing the furnace supplied with air under forced draft; and

Fig. 3 is a view similar to Fig. 2, but showing a modification of the apparatus.

The embodiment illustrated in Fig. 1 comprises a furnace 10 arranged to form a combustion chamber 11, and a steam boiler 12 associated therewith. The boiler is provided with banks of water tubes 14 and a baffle 15 of usual construction, this baffle serving to direct the hot gases from the combustion chamber into proper contact with the water tubes and thence to a gas outlet duct 16, which may lead to a suitable stack or induced draft fan (not shown). The outlet duct 16 is provided with a damper 18 having an operating arm 19. The boiler 12 is provided with the usual steam delivery pipe 20.

On the front of the furnace 10 there is mounted a burner 22 having a central fuel nozzle 23 arranged to direct a stream of fuel rearwardly into the combustion chamber 11 through an opening 24 in the furnace wall. A suitable fluent fuel, such as a combustible gas, is supplied to the nozzle 23 at a pressure above atmospheric through a pipe 26 provided with a valve 27 having an operating lever 28. The burner 22 is of the "natural draft" type, the air for combustion being forced therethrough by the pressure of the atmosphere, a sub-atmospheric pressure being maintained in the combustion chamber 11. The combustion chamber pressure, and hence the rate of air flow through the burner, is controlled by means of the damper 18.

The fuel control valve 27 is regulated in accordance with the demand for heat, and for this purpose I preferably utilize an automatic regulator 30 of the type disclosed in the United States patent to Temple No. 2,049,549. This regulator comprises a diaphragm chamber 31 and a motor 32. The diaphragm chamber 31 is connected by a pipe 34 to the steam delivery pipe 20, and the motor 32 is connected by a rod 35 to the valve lever 28. The regulator thus serves to control the valve 27 in accordance with variations in the pressure of the steam in the pipe 20.

In order to control the damper 18 there is provided a regulator 36 of the type disclosed in the United States patent to Temple No. 1,992,048. This regulator comprises a pilot valve mechanism 38 supplied with fluid under pressure from a suitable source through a pipe 39, the valve mechanism being connected by tubes 40 to a hydraulic motor 42 which is connected by a rod 43 to the arm 19 of the damper 18. The pilot valve mechanism is actuated by a lever 44 which in turn is controlled by a flexible diaphragm 45, the diaphragm being loaded by means of a coiled tension spring 47. The upper end of the spring is supported by a nut 48 mounted on a vertical screw 49 which can be raised and lowered by means of a lever 50. The pressure in the combustion chamber 11 is transmitted to the upper side of the diaphragm 45 by means of a pipe 52, and the pressure in the gas outlet duct 16 is transmitted to the lower side of the diaphragm by means of a pipe 53. The diaphragm is thus subjected to an effective fluid pressure which is a function of the rate of flow of gases past the

boiler 12 and the rate of flow of air into the combustion chamber. Hence the regulator 36 will control the damper 18 and maintain a predetermined rate of air flow corresponding to the loading afforded by the spring 47. This loading may be adjusted by moving the lever 50 or by manually turning the screw 49.

The lever 50 is moved automatically in accordance with variations in the rate of fuel flow in the pipe 26. For this purpose there is provided a regulator 55 which is similar to the regulator 36 and comprises a pilot valve mechanism 56 supplied with fluid under pressure from a suitable source through a pipe 57. This pilot valve mechanism is actuated by a lever 59 which in turn is controlled by a flexible diaphragm 60, the diaphragm being loaded by means of a coiled tension spring 61. The upper end of the spring is supported by a nut 63 mounted on a vertical screw 64 which can be raised or lowered by means of a lever 65. This lever is connected to the lever 50 by a link 66. This link is connected by a bar 68 to a hydraulic motor 69 from which tubes 70 lead to the pilot valve mechanism 56. A suitable restriction, such as an orifice plate 72, is provided in the fuel supply pipe 26 to provide a slight pressure differential for regulating purposes. A pipe 73 leads from the pipe 26 anterior to the orifice plate to the space above the diaphragm 60, and a pipe 74 leads from the pipe 26 posterior to the orifice plate to the space below the diaphragm 60. Thus the diaphragm is subjected to an effective fluid pressure which is a function of the rate of flow of fuel to the furnace.

The operation of this embodiment will now be apparent from the above disclosure. Fuel flows to the burner nozzle 23 through the pipe 26, and the rate of flow is controlled by the valve 27, which is actuated by the regulator 30 in accordance with the demand for steam from the boiler 12. Any variation in the rate of fuel flow will change the pressure differential transmitted through the pipes 73—74 to the diaphragm 60. The resultant movement of the diaphragm will cause the pilot valve 56 to admit pressure fluid to the motor 69, which will thereupon adjust the levers 50 and 65 to new positions. The movement of the lever 65 will readjust the tension of the spring 61 until the forces on the diaphragm 60 are balanced and the pilot valve 56 has been restored to neutral, whereupon the motor 69 will come to rest. The movement of the lever 50 will readjust the tension of the spring 47, which will throw the diaphragm 45 out of balance and cause the pilot valve 38 to admit pressure fluid to the motor 42. This will readjust the damper 18 and change the rate of air flow through the burner 22, thereby changing the pressure differential which is transmitted through the pipes 52—53 to the diaphragm 45. When the forces on this diaphragm are again in balance, the pilot valve 38 will be restored to neutral and the motor 42 will bring the damper 18 to rest. Thus the rate of air supply to the furnace will be changed to a new value corresponding to the new rate of fuel supply. Any change in the stack draft will affect the regulator 36 through the pipes 52—53, and the regulator will adjust the damper 18 to maintain the correct rate of air flow regardless of the variation in draft.

The regulator 36 is of the non-compensating type, there being no mechanical connection through which its motor 42 will restore its pilot mechanism 38 to neutral position. Consequently, this regulator has no definite operating range, and even the slightest change in the pressure differential effective on its diaphragm will cause a full stroke of its motor, if such full stroke should be required to restore the desired rate of air flow. The regulator 55, on the other hand, is of the compensating type, its motor 69 being mechanically connected to its pilot mechanism 56 by means of the bar 68, lever 65, screw 64, nut 63, spring 61, and lever 59 to restore the pilot mechanism to neutral position. Consequently, this regulator has a definite operating range through which the pressure differential effective on its diaphragm must vary in order to cause full stroke movement of its motor. Within this operating range, the motor 69 will assume and maintain a definite predetermined position for each value of the pressure differential effective on the diaphragm, thereby adjusting the regulator 36 for a predetermined rate of air flow for each value of the rate of fuel supply. This rate of air flow will be maintained with great accuracy despite variations in draft.

In Fig. 2 there is shown a modified form of the invention in which the natural draft burner 22 of Fig. 1 has been replaced by a forced draft burner 22' which is supplied with air under pressure by a fan 76 through a duct 77. This duct is provided with an orifice plate 78 to produce a slight pressure differential for regulating purposes, and with a damper 79 having an operating arm 80 to control the rate of air flow. This arm 80 is connected by a rod 81 to the motor 42. The air pressure anterior to the orifice plate 78 is transmitted to the upper side of the diaphragm 45 of the regulator 36 by means of a pipe 82, and the air pressure posterior to the orifice plate is transmitted to the lower side of the diaphragm by means of a pipe 83. The gas outlet damper 18 is preferably controlled to maintain a substantially constant pressure, slightly below atmospheric, in the combustion chamber 11, and for this purpose I may use a regulator 85 of the type disclosed in the patent to Temple No. 1,992,048. This regulator is connected to the combustion chamber by a pipe 86. Pressure fluid is supplied to the regulator 85 by a pipe 87, and tubes 88 lead from the regulator to a hydraulic motor 89 which is connected by a rod 90 to the operating arm 19 of the damper 18.

The operation of this embodiment of the invention will now be apparent from the above disclosure. The regulator 30 will control the valve 27 and adjust the rate of fuel flow in accordance with the demand for steam. Any change in fuel flow will cause the motor 69 of the compensating regulator 55 to assume a new position, thereby readjusting the non-compensating regulator 36 by means of the lever 50. This will cause the regulator 36 to move the forced draft damper 79 and change the rate of air supply to correspond to the new rate of fuel supply. Changes in air flow will vary the pressure differential transmitted through the pipes 82—83 to the diaphragm 45, so that the regulator 36 will maintain a predetermined rate of air flow dependent upon the position of the lever 50. Under all conditions the regulator 85 will control the damper 18 to maintain a substantially constant pressure in the combustion chamber 11.

In Fig. 3 there is shown a still further modification of the invention. This embodiment is the same as that shown in Fig. 2 except that the motor 42 of the regulator 36 is connected to the uptake damper 18 instead of to the forced draft damper 79, and the motor 89 of the regulator 85

is connected to the forced draft damper 79 instead of to the uptake damper 18. With this construction, any change in fuel flow will cause the compensating regulator 55 to adjust the lever 50 on the non-compensating regulator 36, and the motor 42 will thereupon change the position of the uptake damper 18, which will tend to change the pressure within the combustion chamber 11. As soon as the combustion chamber pressure starts to change, the regulator 85 will respond and adjust the forced draft damper 79 until this pressure has been restored to its normal value by the resultant change in air flow. The new rate of air flow will correspond to the new rate of fuel flow, thus ensuring efficient combustion conditions.

The invention provides a comparatively simple and thoroughly dependable apparatus for controlling the combustion of fluent fuels, and adapted for both natural draft and forced draft installations.

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

1. Control apparatus for a combustion system utilizing a fluent fuel and air as the elements of combustion comprising an adjustable device to control the rate of air flow, a first regulator and a second regulator each including as parts thereof a motor, a pilot mechanism to control the motor and having a neutral position, a fluid pressure responsive device connected to the pilot mechanism to actuate the same, and adjustable loading means for the fluid pressure responsive device to urge the same in opposition to the fluid pressure effective thereon, means connecting the motor of the first regulator to the air flow control device to adjust the same, means to subject the fluid pressure responsive device of the first regulator to an effective fluid pressure which is a function of the rate of air flow and thereby cause the first regulator to control the rate of air flow in accordance with the adjustment of its loading means, means to subject the fluid pressure responsive device of the second regulator to an effective fluid pressure which is a function of the rate of fuel flow, and means connecting the motor of the second regulator to the loading means of both regulators to adjust the same and increase the loading of both regulators upon an increase in the effective fluid pressure on the fluid pressure responsive device of the second regulator, the various parts being so constructed and arranged that any change in the effective fluid pressure on the fluid pressure responsive device of the second regulator will cause the corresponding pilot mechanism to effect movement of the associated motor in such a direction as to adjust the loading means of the second regulator to restore the corresponding pilot mechanism to its neutral position, whereby the first regulator will change the rate of air flow in accordance with changes in the rate of fuel flow.

2. Control apparatus for a combustion system utilizing a fluent fuel and air as the elements of combustion comprising an adjustable device to control the rate of air flow, a first regulator and a second regulator each including as parts thereof a hydraulic motor, a pilot valve mechanism to control the motor and having a neutral position, a flexible diaphragm connected to the pilot valve mechanism to actuate the same, and a spring connected to the diaphragm to urge the same in opposition to the fluid pressure effective thereon, means connecting the motor of the first regulator to the air flow control device to adjust the same, means to subject the diaphragm of the first regulator to an effective fluid pressure which is a function of the rate of air flow and thereby cause the first regulator to control the rate of air flow in accordance with the force provided by its spring, means to subject the diaphragm of the second regulator to an effective fluid pressure which is a function of the rate of fuel flow, and means connecting the motor of the second regulator to the springs of both regulators to adjust the same and increase the force thereof upon an increase in the effective fluid pressure on the diaphragm of the second regulator, the various parts being so constructed and arranged that any change in the effective fluid pressure on the diaphragm of the second regulator will cause the corresponding pilot valve mechanism to effect movement of the associated motor in such a direction as to adjust the spring of the second regulator to restore the corresponding pilot valve mechanism to its neutral position, whereby the first regulator will change the rate of air flow in accordance with changes in the rate of fuel flow.

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