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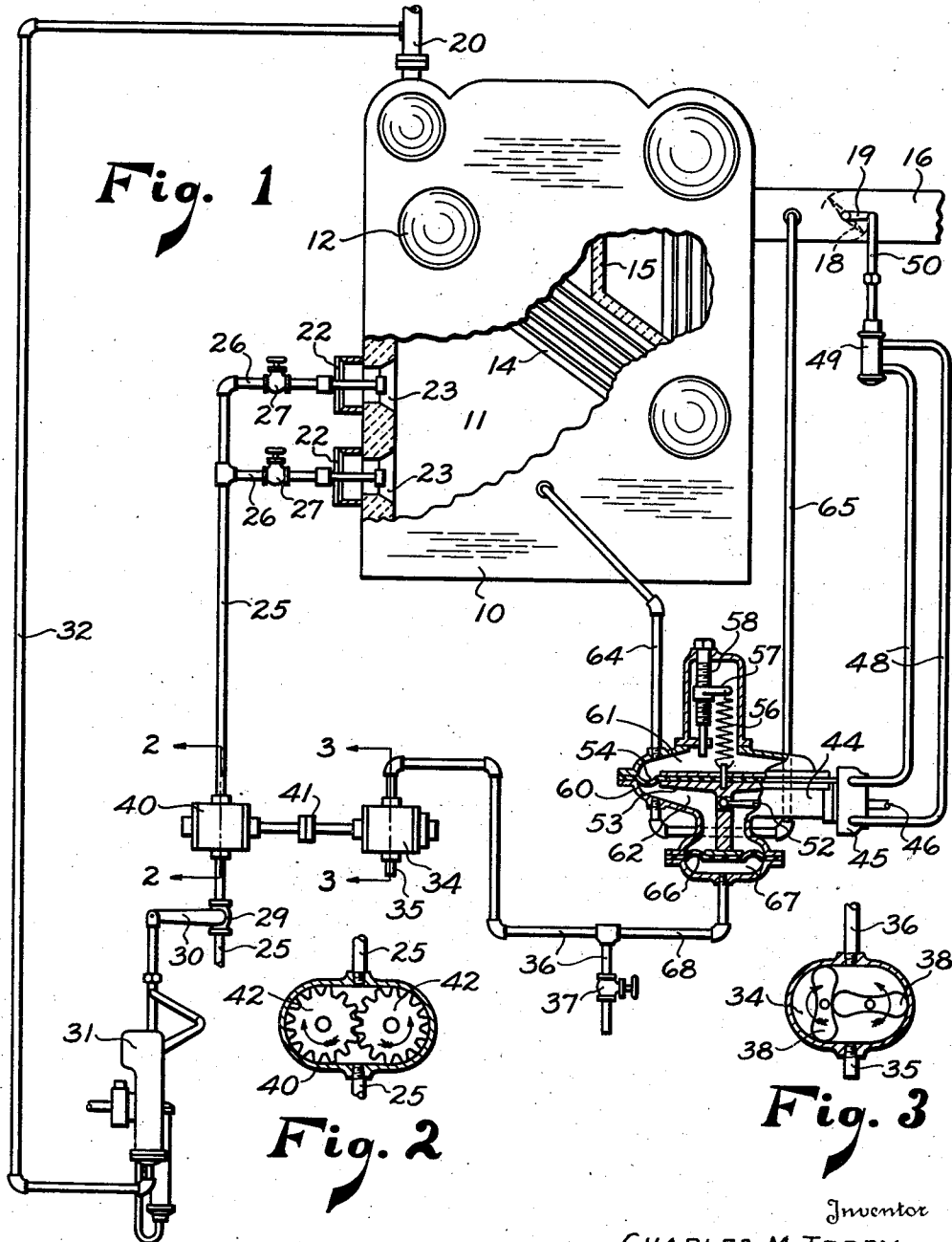
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2,197,904

COMBUSTION CONTROL

Filed July 27, 1937

2 Sheets-Sheet 1



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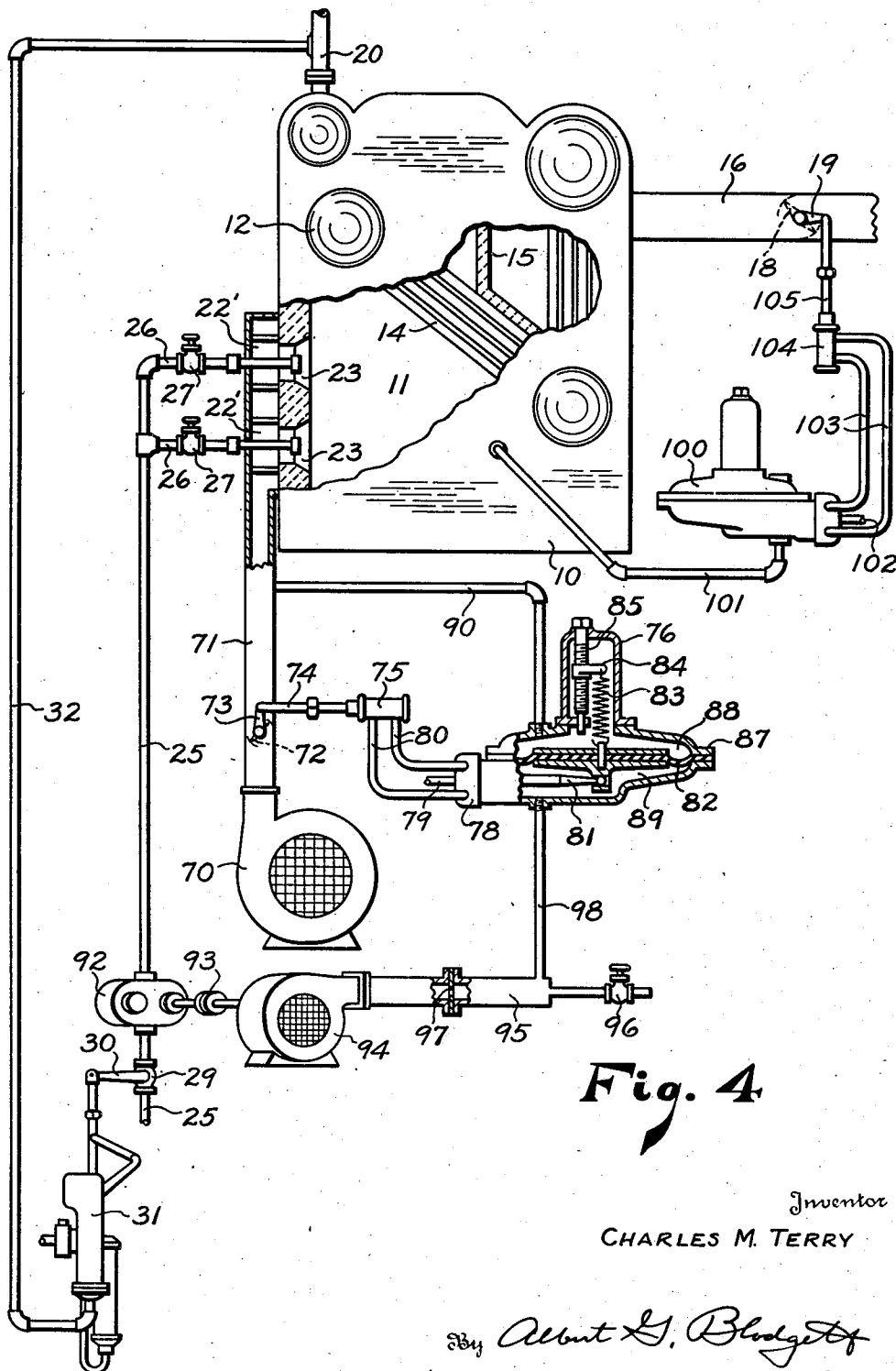


Fig. 4

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UNITED STATES PATENT OFFICE

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COMBUSTION CONTROL

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9 Claims. (Cl. 158—1)

This invention relates to combustion control, and more particularly to the control of the combustion of fluent fuels, such as oil and gas.

It is customary to vary the supplies of fuel and air in accordance with the demand for heat, but difficulties have been encountered in maintaining the correct proportions between the rate of fuel supply and the rate of air supply. Unless this fuel-air ratio is maintained at the proper value, it will be impossible to obtain efficient combustion conditions. It is also important to provide means whereby the fuel-air ratio can be adjusted to compensate for changes in the quality or heating value of the fuel. While attempts have been made to solve this problem, no thoroughly satisfactory solution has heretofore been disclosed.

It is accordingly one object of the invention to provide a comparatively simple and dependable method and apparatus for controlling the combustion of fluent fuel and maintaining the fuel and air supplies in the correct proportions at all times.

It is a further object of the invention to provide a comparatively simple and dependable method and apparatus for burning fluent fuel and for adjusting the fuel-air ratio.

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 and the steps of the process set forth in the specification and covered by the claims appended hereto.

In accordance with my invention in its preferred form, I cause a fluid, such as air, to flow in a stream at a rate dependent upon the rate of supply of fuel for combustion, and I control the supply of air for combustion in accordance with pressure characteristics of the fluid stream. The fluid is preferably compelled to flow in a conduit from which it is allowed to escape at a rate which can be adjusted to vary the fuel-air ratio. The fluid is preferably forced into the conduit by a pressure-generator driven by a motor, the latter being actuated by the stream of fuel flowing to the furnace.

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

Fig. 1 is a diagrammatic view, partly in section, showing a furnace to which air is supplied for combustion by natural draft;

Fig. 2 is a section on the line 2—2 of Fig. 1;

Fig. 3 is a section on the line 3—3 of Fig. 1; and

Fig. 4 is a view similar to Fig. 1, showing an

arrangement in which the furnace is supplied with air for combustion by forced draft.

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 are mounted two oil burners 22 of the natural draft type. These burners are arranged to discharge oil in the form of a spray rearwardly into the combustion chamber through openings 23 in the furnace wall. Air for combustion enters the combustion chamber through these openings at a rate controlled by the damper 18. Fuel oil is supplied under pressure from any suitable source through a pipe 25 having branches 26 which lead to the burners 22. Each branch 26 is shown provided with a valve 27 which is normally open but which can be closed when it is desired to shut down the corresponding burner. The pipe 25 is provided with a valve 29 having an operating lever 30 which is controlled by an automatic regulator 31 of the type disclosed in the patent to Temple, No. 2,049,549, granted August 4, 1936. This regulator is connected to the boiler steam pipe 20 by means of a pipe 32. These parts are so constructed and arranged that the regulator 31 will control the valve 29 (and hence the supply of fuel oil to the burners) in accordance with variations in the demand for heat as indicated by changes in the boiler steam pressure transmitted through the pipe 32.

In order to maintain the correct ratio between the supply of fuel and the supply of combustion air, I have shown a pressure-generator in the form of a positive-displacement blower 34 arranged to receive air at atmospheric pressure through a pipe 35, and deliver this air to a conduit in the form of a pipe 36 having a valve 37 therein through which the air may escape to the atmosphere. As shown in Fig. 3, the blower 34 may be of a well known type having a pair of oppositely rotating impellers 38.

Means is provided to vary the air pressure in the pipe 36 in accordance with variations in the rate of supply of the fuel oil to the furnace. For

this purpose the blower 34 is driven by means of a motor 40 which is connected to the blower by a coupling 41, this motor being mounted in the pipe line 25 and arranged to be actuated by the fuel oil flowing therethrough. As shown in Fig. 2, the motor 40 may be of a well known construction having a pair of intermeshing spur gears 42 which are rotated by the fuel oil at a speed varying substantially in direct proportion with variations in the rate of fuel flow. Any change in the rate of supply of the fuel oil will thus vary the speed of the motor 40 and of the blower 34, thereby varying the rate at which air is delivered to the pipe 36 and causing a change in the air pressure in this pipe.

These variations in the pressure of the air in the pipe 36 are utilized to control the rate at which air is supplied for combustion of the fuel. For this purpose there is shown an automatic regulator 44 of a construction similar to that disclosed in the patent to Temple, No. 1,992,048, granted February 19, 1935. This regulator 44 comprises a pilot valve 45 supplied with a suitable fluid under pressure by a pipe 46 and connected by tubes 48 to a fluid motor 49, this motor being connected by a link 50 to the arm 19 of the damper 18. The pilot valve 45 is controlled by a lever 52 which is connected to a pressure plate 53 located beneath and in contact with a flexible diaphragm 54. The diaphragm is connected to the lower end of a coiled tension spring 56 having its upper end secured to a nut 57 mounted on a vertical adjusting screw 58. The edge portions of the diaphragm are supported by a casing 60 shaped to provide a chamber 61 above the diaphragm and a chamber 62 beneath the diaphragm. A pipe 64 connects the chamber 61 with the combustion chamber 11, and a pipe 65 connects the chamber 62 with the gas outlet duct 16 anterior to the damper 18. In addition to the main diaphragm 54 the regulator 44 is provided with a second and preferably somewhat smaller diaphragm 66 having a chamber 67 therebeneath. The two diaphragms are connected centrally to move as a unit, and they jointly control the lever 52 and the pilot valve 45. The chamber 67 beneath the lower diaphragm 66 is connected by a pipe 68 to the pipe 36 anterior to the valve 37.

The operation of this embodiment will now be apparent from the above disclosure. Under steady load conditions, the regulator 31 will hold the valve 29 in the proper position to supply fuel oil to the burners 22 at the rate necessary to maintain the boiler steam pressure constant, and the regulator 44 will hold the damper 18 in the proper position to ensure the correct supply of air for combustion. The fuel oil will actuate the motor 40 at a constant speed, and the motor will drive the blower 34 at the same speed, thus maintaining a uniform air pressure in the pipe 36 and chamber 67. With a steady flow of gases past the boiler water tubes, a constant differential pressure will be transmitted to the diaphragm 54 by the pipes 64 and 65, and the regulator 44 will be in balance, with its pilot valve 45 in neutral position. If now the demand for steam increases, the steam pressure transmitted through the pipe 32 will decrease, and the regulator 31 will open the valve 29 and increase the flow of the fuel oil to the burners. This will cause the motor 40 and blower 34 to operate at a higher speed, increasing the air pressure in the pipe 36 and chamber 67. This increased air pressure on the diaphragm 66 will throw the regulator 44 out of balance, causing its pilot

valve 45 to admit operating fluid to the motor 49 and thus open the damper 18 to increase the flow of combustion air through the burners. As soon as the rate of air flow has increased sufficiently, the resulting increased pressure differential transmitted to the diaphragm 54 through the pipes 64 and 65 will restore the regulator to balance, and the damper 18 will be brought to rest. Similarly, a decrease in the demand for steam will cause the steam pressure to increase, and the regulator 31 will close the valve 29 to decrease the flow of fuel oil. This will reduce the speed of motor 40 and blower 34, decreasing the pressure in the chamber 67. The regulator 44 will thereupon close the damper 18 until a balanced condition is again obtained. If the heating value of the fuel oil is changed, or if for any other reason it is desirable to change the fuel-air ratio in order to maintain proper combustion conditions, it is merely necessary to adjust the valve 37 which controls the rate at which air escapes from the pipe 36. Opening this valve will produce a richer mixture, since it will decrease the pressure in the chamber 67 for a given rate of fuel flow, and a decreased flow of combustion air will be required to maintain the regulator 44 in balance. Similarly, closing the valve 37 will produce a leaner mixture by increasing the flow of combustion air for a given rate of fuel supply.

In Fig. 4 there is illustrated a slightly modified form of the invention, in which the combustion air is supplied to the furnace under forced draft. In this modification the burners 22 of Fig. 1 are replaced by burners 22' of the forced draft type, these burners being supplied with air at a pressure above atmospheric by means of a fan 70 connected to the burners by a duct 71. This duct is provided with a damper 72 having an operating arm 73 which is connected by a link 74 to the motor 75 of a regulator 76. This regulator is of the type disclosed in the patent to Temple, No. 1,992,048, granted February 19, 1935, and comprises a pilot valve 78 supplied with fluid under pressure from a suitable source through a pipe 79 and connected with the motor 75 by means of tubes 80. This pilot valve is actuated by means of a lever 81 which is controlled by a flexible diaphragm 82 connected to the lower end of a coiled tension spring 83. The upper end of the spring 83 is secured to a nut 84 mounted on a vertical adjusting screw 85. The edge portions of the diaphragm 82 are supported by a casing 87 shaped to provide a chamber 88 above the diaphragm and a chamber 89 beneath the diaphragm. A pipe 90 connects the chamber 88 with the duct 71 posterior to the damper 72.

The pressure in the chamber 89 is varied in accordance with changes in the rate of flow of the fuel oil in the pipe 25. For this purpose there is mounted in the pipe 25 a motor 92 similar to the motor 40 of Fig. 1 and connected by means of a coupling 93 to a pressure-generator in the form of a rotary fan 94. This fan receives air from the atmosphere and delivers it under pressure to a conduit in the form of a duct 95 having a valve 96 connected thereto through which the air may escape to the atmosphere. The duct is preferably provided with an orifice plate 97. A pipe 98 serves to connect the chamber 89 with the duct 95 posterior to the orifice plate 97.

The gas outlet damper 18 in Fig. 4 is preferably controlled to maintain a substantially constant pressure, slightly below atmospheric, in the com-

bustion chamber 11, and for this purpose there is shown a regulator 100 of the same type as the regulator 76. This regulator 100 is connected to the combustion chamber by a pipe 101. Pressure fluid is supplied to the regulator by a pipe 102, and tubes 103 lead from the regulator to a fluid motor 104 which is connected by a link 105 to the operating arm 19 of the damper 18.

The operation of the embodiment illustrated in Fig. 4 will now be apparent from the above disclosure. Under steady load conditions, the regulator 31 will hold the valve 29 in the proper position to supply fuel oil to the burners 22' at the rate necessary to maintain the steam pressure constant, and the regulator 76 will hold the damper 72 in the proper position to ensure the correct supply of air for combustion. The fuel oil will actuate the motor 92, and the motor will drive the fan 94 at a constant speed, thus maintaining a uniform air pressure in the duct 95 and chamber 89. A constant pressure will be transmitted through the pipe 90 to the chamber 89, and the regulator 76 will be in balance, with its pilot valve 78 in neutral position. If now the demand for steam increases, the steam pressure transmitted through the pipe 32 will decrease, and the regulator 31 will open the valve 29 and increase the flow of the fuel oil to the burners. This will cause the motor 92 and fan 94 to operate at a higher speed, increasing the air pressure in the duct 95 and chamber 89. This increased air pressure will throw the regulator 76 out of balance, causing its pilot valve 78 to admit operating fluid to the motor 75 and thus open the damper 72 to increase the flow of combustion air through the burners until the pressure transmitted through the pipe 90 to the diaphragm 82 has increased sufficiently to restore the regulator to balance, whereupon the damper 72 will be brought to rest. Similarly, a decrease in the demand for steam will cause the steam pressure to increase, and the regulator 31 will close the valve 29 to decrease the flow of fuel oil. This will reduce the speed of the motor 92 and fan 94, decreasing the pressure in the chamber 89. The regulator 76 will thereupon close the damper 72 until a balanced condition is again obtained. By adjusting the valve 96 the fuel-air ratio can be varied as desired in a very simple manner. The orifice plate 97 improves the pressure characteristics of the fan 94 in relation to its speed, and makes it possible to obtain a wider range of adjustment by means of the valve 98 without requiring an excessively large valve. Regardless of changes in the rate of combustion, the regulator 100 will control the gas outlet damper 18 in such a way as to maintain a predetermined pressure in the combustion chamber 11.

It will be understood that the positive displacement blower 34 of Fig. 1 can be utilized in place of the fan 94 and orifice plate 97 of Fig. 4, and vice versa.

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

1. The method of controlling the combustion of fluent fluid in a furnace comprising the steps of delivering a stream of fuel to the furnace, supplying air to the furnace for combustion of the fuel, deriving power from the fuel stream, utilizing said power to cause a separate control fluid to flow in a continuous stream at a rate unaffected by the rate of air supply, and varying

the rate of air supply in accordance with variations in pressure characteristics of the stream of control fluid.

2. The method of controlling the combustion of fluent fuel in a furnace comprising the steps of delivering a stream of fuel to the furnace, supplying air to the furnace for combustion of the fuel, deriving power from the fuel stream, utilizing said power to force a separate control fluid into a confined space at a rate unaffected by the rate of air supply, allowing the control fluid to escape from said space at a controlled rate, and varying the rate of air supply in accordance with variations in the fluid pressure in the confined space.

3. The method of controlling the combustion of fluent fuel in a furnace comprising the steps of delivering a stream of fuel to the furnace, supplying air to the furnace for combustion of the fuel, deriving power from the fuel stream, utilizing said power to force a separate stream of air into a confined space at a rate unaffected by the rate at which combustion air is supplied, allowing air to escape from the confined space at a controlled rate, and varying the rate of supply of the combustion air in accordance with variations in the air pressure in the confined space.

4. Combustion control apparatus comprising a furnace, means to deliver a stream of fluent fuel to the furnace, means to supply air to the furnace for combustion of the fuel, means actuated by the fuel stream to produce a continuous stream of a separate control fluid which flows at a rate unaffected by the rate of air supply, and means to vary the rate of air supply in accordance with variations in pressure characteristics of the stream of fluid.

5. Combustion control apparatus comprising a furnace, means to deliver a stream of fluent fuel to the furnace, means to supply air to the furnace for combustion of the fuel, a motor actuated by the fuel stream, means driven by the motor to produce a continuous stream of a separate control fluid which flows at a rate unaffected by the rate of air supply, and means to vary the rate of air supply in accordance with variations in pressure characteristics of the stream of fluid.

6. Combustion control apparatus comprising a furnace, means to deliver a stream of fluent fuel to the furnace, means to supply air to the furnace for combustion of the fuel, a motor actuated by the fuel stream, a conduit, a pressure-generator driven by the motor and arranged to force a continuous stream of a separate control fluid into the conduit at a rate unaffected by the rate of air supply, a valve through which the control fluid may escape from the conduit, and means to vary the rate of air supply in accordance with variations in the fluid pressure in the conduit.

7. Combustion control apparatus comprising a furnace, means to deliver a stream of fluent fuel to the furnace, means to supply air to the furnace for combustion of the fuel, a motor actuated by the fuel stream, a conduit, a pressure-generator driven by the motor and arranged to force a separate stream of air into the conduit at a rate unaffected by the rate at which combustion air is supplied, a valve through which air may escape from the conduit, and means to vary the rate of supply of the combustion air in accordance with variations in the air pressure in the conduit.

8. Combustion control apparatus comprising a furnace, means to deliver a stream of fluent fuel to the furnace, means to supply air to the furnace for combustion of the fuel, a motor actuated by the fuel stream, a conduit, a pressure-generator driven by the motor and arranged to force a separate stream of air into the conduit at a rate unaffected by the rate at which combustion air is supplied, a valve through which air may escape from the conduit, and a regulator arranged to control the rate of flow of the combustion air, the regulator being responsive both to changes in the rate of flow of the combustion air and to changes in the air pressure in the conduit.

9. Combustion control apparatus comprising a furnace, means to deliver a stream of fluent fuel to the furnace, means to supply air to the furnace for combustion of the fuel, a rotatable motor actuated by the fuel stream at a speed substantially in direct proportion to the rate of fuel flow, a conduit, a pressure-generator driven by the motor and arranged to force a separate stream of air into the conduit at a rate unaffected by the rate at which combustion air is supplied, a valve through which air may escape from the conduit, and means to vary the rate of supply of the combustion air in accordance with variations in the air pressure in the conduit.

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