This invention relates to improvements in burner control apparatus, and particularly to an improved control for maintaining substantially constant the ratio between the rates of supply of fuel and air to a power-type fluid fuel burner.

Throughout the following description and in the appended claims, the term "power burner" is used to refer to burners of the type in which combustion-supporting air is supplied by a fan, blower, ram or the like, as distinguished from so-called "natural draft" burners.

In certain power burner installations, as in aircraft and the like, difficulties frequently are encountered in maintaining the proper ratio between the supply of fuel and the supply of air to the burner to maintain best combustion efficiency. In the case of aircraft installations, for example, a change in altitude of the aircraft, with its accompanying change in air density, will alter any preset adjustment of the fuel-air ratio, requiring readjustment either of the fuel supply or of the air supply if the correct ratio is to be maintained.

In accordance with a preferred embodiment of the present invention, the fuel-air supply ratio of a power burner is maintained at a preselected value by continuously monitoring the length of the flame issuing from the burner. Upon deviation of the flame length beyond predetermined limits, the fuel supply to the burner is automatically adjusted to reestablish the preselected ratio.

A more complete understanding of the invention can be had by reference to the following description of an illustrative embodiment thereof, when considered in connection with the accompanying drawing, the single figure of which is a schematic diagram of a burner control embodying the invention.

In the apparatus shown in the drawing, there is included a power-type liquid fuel burner 10 arranged to discharge into an elongated space 12 defined by a cylindrical casing 14. The burner 10 may, for example, be of the high-velocity type, as described in U.S. Patent 2,488,548 by MacCracken, comprising an inner sleeve 16 defining a combustion chamber 17 and surrounded by a coaxial outer sleeve 18. Air is supplied to the burner under pressure by a blower (not shown) to flow into the space 20 between the sleeves 16, 18 and thence into the combustion chamber 17 through holes 22 in the inner sleeve 16, to support the combustion of liquid fuel sprayed into the chamber from a nozzle 24 and ignited by an igniter 27.

The fuel nozzle 24 in the embodiment of the invention being described is of the so-called return-flow type, an example of which is to be found in U.S. Patent 2,567,818 by MacCracken. In a return flow type nozzle system, the fuel is supplied to the nozzle at a substantially constant rate through a pump 25 from a supply line 26. At the nozzle, two paths are available to the fuel; one through the nozzle discharge orifice into the combustion chamber 17 and the other back to the supply source (not shown) through a return line 28 and a regulator 30.

The rate of delivery of fuel from the nozzle into the combustion chamber is controlled by the amount bled off through the return line 28, which, in turn, is controlled by the setting of the regulator 30. An example of a suitable regulator is given in U.S. Patent 2,590,112 by MacCracken et al.

It will be understood, of course, that the burner 10 may be adapted to burn gaseous rather than liquid fuel, in which case a conventional gas regulator would be used.

In the apparatus being described, the setting of the regulator that adjusts the nozzle output is controlled by a reversible motor 32. The motor, in turn, is controlled by an electrical system (described hereinafter) which includes a pair of so-called flame electrodes 34a, 34b extending into the combustion space 12.

The flame electrodes 34a, 34b comprise rods of suitable heat-resisting and current-conducting material which are mounted in and project through sleeves 36 of insulating material, such as porcelain. As is well known, ignition accompanying combustion makes it possible to pass electric current through a flame between a pair of "electrodes" contacted by the flame. Of course, the chamber wall 14 can constitute one such electrode. Thus, if the chamber wall and either of the electrode rods (34a or 34b) is connected to a suitable electric circuit, current will flow between wall and rod when a flame impinges thereon.

In the present case, the flame electrodes are spaced apart along the path of flame propagation in the combustion space 12. With this arrangement, a short flame will not contact either of the electrodes, a somewhat longer flame will play over the upstream electrode 34a but not the downstream electrode 34b, while a still longer flame will impinge on both electrodes. This relationship is utilized for control purposes, as will be explained shortly.

The electrical system for controlling the regulator 30 includes power supply lines 38 adapted to be connected to the usual power supply source (not shown). One of the power supply leads is connected directly to the motor 32, while the other is connected to the movable contact 40 of a relay 42. The relay has two fixed contacts 44, 46, one of which (44) is connected to the motor 32 to complete a circuit for driving the motor in such a direction as to cause a decrease in the fuel output from the nozzle 24. The other fixed contact 46 is connected to the movable contact 48 of a second relay 50, which has a fixed contact 52 for completing a circuit to drive the motor 32 in the opposite direction, so as to increase the output of fuel from the nozzle.

Also connected across the power supply lines 38 are a pair of amplifier circuits 54 for energizing the relays. Among the many suitable relay amplifiers that can be used, a specific example is the "type R-187 Minneapolis-Honeywell" relay circuit. Each of the circuits 54 is connected with the casing 14 and with one of the electrodes 34a, 34b, the arrangement being such that when flame from the burner contacts either of the electrodes 34a, 34b, the relay in the circuit connected with the contacted electrode will be energized. Both relays are shown in the drawing in deenergized position.

In considering the operation of the apparatus shown in the drawing, it should be noted that for a given supply of air to the burner 10, an increase in the amount of fuel supplied will cause an increase in the flame length, while a fuel supply decrease will decrease the flame length. Also, a decrease in the quantity of air supplied, or an air density decrease, will cause an increase in the flame length, while an air quantity or air density increase will have the opposite effect. The reason for this is, of course, that an excess of fuel for a given quantity of air will cause the combustion area to extend further down-
stream in the direction in which the fuel-air mixture is flowing. An excess of air, on the other hand will allow completion of combustion well upstream in the combustion space.

In preparing the apparatus for normal operation, the fuel and air supply first will be adjusted so that, at optimum combustion efficiency, the burner flame will contact and extend slightly beyond the upstream electrode 34a, but not contact the downstream electrode 34b. Thereafter, the control system will automatically adjust the fuel supply through the medium of the motor and the regulator to maintain the same fuel-air ratio. Thus, if the fuel supply becomes excessive due to a decrease in the rate or density of the air supply, the flame length will increase until the flame impinges on the downstream electrode 34b. This will allow current to flow through the circuit of the electrode 34b, resulting in energization of the relay 42. At the same time, of course, the other relay 50 also will be energized, so that the movable contactor 48, 46 will be in the position shown in dotted lines in the drawing. This will energize the motor 32 to readjust the regulator 30, thereby decreasing the flame length until the relay 42 drops out. The motor circuit will now be open, and the new fuel setting will hold until there is some change in the air supply. If the air supply becomes deficient, the flame will gradually falling away from the upstream electrode 34a. This will cause the relay 50 to drop out, completing a circuit to drive the motor in such fashion as to increase the fuel output from the nozzle.

It can be seen, therefore, that the flame length continuously is monitored by the control system, with the flame electrodes supplying control signals to the relay energizing circuits to indicate and correct for deviations from optimum fuel-air ratio.

What is claimed is:

1. A control system for maintaining substantially constant the ratio between the rates of delivery of air and fuel to a power-type fluid fuel burner, in combination, means to control the rate of supply of fuel to said burner, a pair of electric circuits, flame detecting electrodes spaced along the path of flame discharge from said burner and connected to said circuits to pass current therethrough upon impingement of flame of said electrodes, means connecting said circuits to said control means to decrease the fuel supply rate upon a predetermined increase in length of said flame and to increase said fuel supply rate upon a predetermined decrease in length of said flame.

2. A control system for maintaining substantially constant the ratio between the rates of delivery of air and fuel to a power-type fluid fuel burner, in combination, means to control the rate of supply of fuel to said burner, said last-named means including a reversible motor and a circuit for supplying current to said motor, a pair of electric circuits, flame detecting electrodes spaced along the path of flame of said burner and connected to said circuits to pass current therethrough in response to flame impingement of said electrodes, and means connecting said circuits to said control means to energize said motor for rotation in one direction upon a predetermined increase in length of flame and for rotation in the opposite direction upon a predetermined decrease in length of flame.

3. In a control system for maintaining substantially constant the ratio between the rates of delivery of air and fuel to a power-type fluid fuel burner, a pair of electrically conductive electrodes spaced along and extending into the path along which flame is discharged from said burner, a pair of electric circuits connected one to each said electrode and each adapted to conduct current upon impingement of flame on its associated electrode, a relay connected in each said circuit to be energized by current flow therein, and means to control the rate of supply of fuel to said burner, said last-named means including a reversible motor and a circuit for supplying current to said motor, relays having contacts connected in said last-named circuit to energize said motor for rotation in one direction upon simultaneous energization of both said relays and in the opposite direction upon simultaneous de-energization of both said relays.

4. In a control system for maintaining substantially constant the ratio between the rates of delivery of air and fuel to a power-type fluid fuel burner, a pair of electrically conductive electrodes spaced along and extending into the path along which flame is discharged from said burner, a pair of electric circuits connected one to each said electrode and each adapted to conduct current upon impingement of flame on its associated electrode, a relay connected in each said circuit to be energized by current flow therein, and means to control the rate of supply of fuel to said burner, said last-named means including a control circuit, said relays having contacts connected in said last-named circuit to actuate said control in accordance with the energization of said relays.

5. In a control system for maintaining substantially constant the ratio between the rates of delivery of air and fuel to a power-type fluid fuel burner, a pair of electrically conductive electrodes spaced along and extending into the path along which flame is discharged from said burner, a pair of electric circuits connected one to each said electrode and each adapted to conduct current upon impingement of flame on its associated electrode, a relay connected in each said circuit to be energized by current flow therein, and means to control the rate of supply of fuel to said burner, said last-named means including a control circuit, said relays having contacts connected in said last-named circuit to actuate said control in accordance with the energization of said relays.

6. In a control system for maintaining substantially constant the ratio between the rates of delivery of air and fuel to a power-type fluid fuel burner, means defining an elongated combustion space into which said burner discharges, a pair of electrically conductive electrodes spaced along and extending into said space, a pair of electric circuits connected one to each said electrode and each adapted to conduct current upon impingement of flame on its associated electrode, a relay connected in each said circuit to be energized by current flow therein, and means to control the rate of supply of fuel to said burner, said last-named means including a regulating, a reversible motor coupled to said regulator, a circuit for supplying current to said motor, said relays having contacts connected in said last-named circuit to energize said motor for rotation in one direction upon simultaneous energization of both said relays and in the opposite direction upon simultaneous de-energization of both said relays.

7. In a control system for maintaining substantially constant the ratio between the rates of delivery of air and fuel to a power-type fluid fuel burner, a pair of electrically conductive electrodes spaced along and extending into the path along which flame is discharged from said burner, a pair of relays, means connecting said electrodes one to each said relay to energize said relays upon flame impingement on said electrodes, and means to control the rate of supply of fuel to said burner, said last-named means including a reversible motor and a circuit for supplying current to said motor, relays having contacts connected in said last-named circuit to energize said motor for rotation in one direction upon simultaneous energization of both said relays and in the opposite direction upon simultaneous de-energization of both said relays.

8. In a control system for maintaining substantially constant the ratio between the rates of delivery of air and fuel to a power-type fluid fuel burner, a pair of
electrically conductive electrodes spaced along and extending into the path along which flame is discharged from said burner, a pair of electric circuits connected one to each said electrode and each adapted to conduct current upon impingement of flame on its associated electrode, means to vary the rate of fuel supply to said burner, said last-named means including a reversible motor and a circuit for supplying current to said motor, and switch means connected in said last-named circuit and controlled by said pair of circuits to energize said motor for rotation in one direction upon simultaneous current flow in said pair of circuits and in the opposite direction in the absence of current flow in both said circuits.

References Cited in the file of this patent

UNITED STATES PATENTS

2,052,181 Krogh ------------ Aug. 25, 1936
2,336,232 Doran ------------ Dec. 7, 1943
2,538,642 Gardiner et al. -- Jan. 16, 1951
2,589,074 Goodwin ---------- Mar. 11, 1952
2,715,815 Malick et al. ------- Aug. 23, 1955
2,742,756 De Boisblanc ------- Apr. 24, 1956
2,799,136 De Boisblanc ------- July 16, 1957

FOREIGN PATENTS

683,391 Great Britain ------- Nov. 26, 1952