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P. J. AMUNDSON

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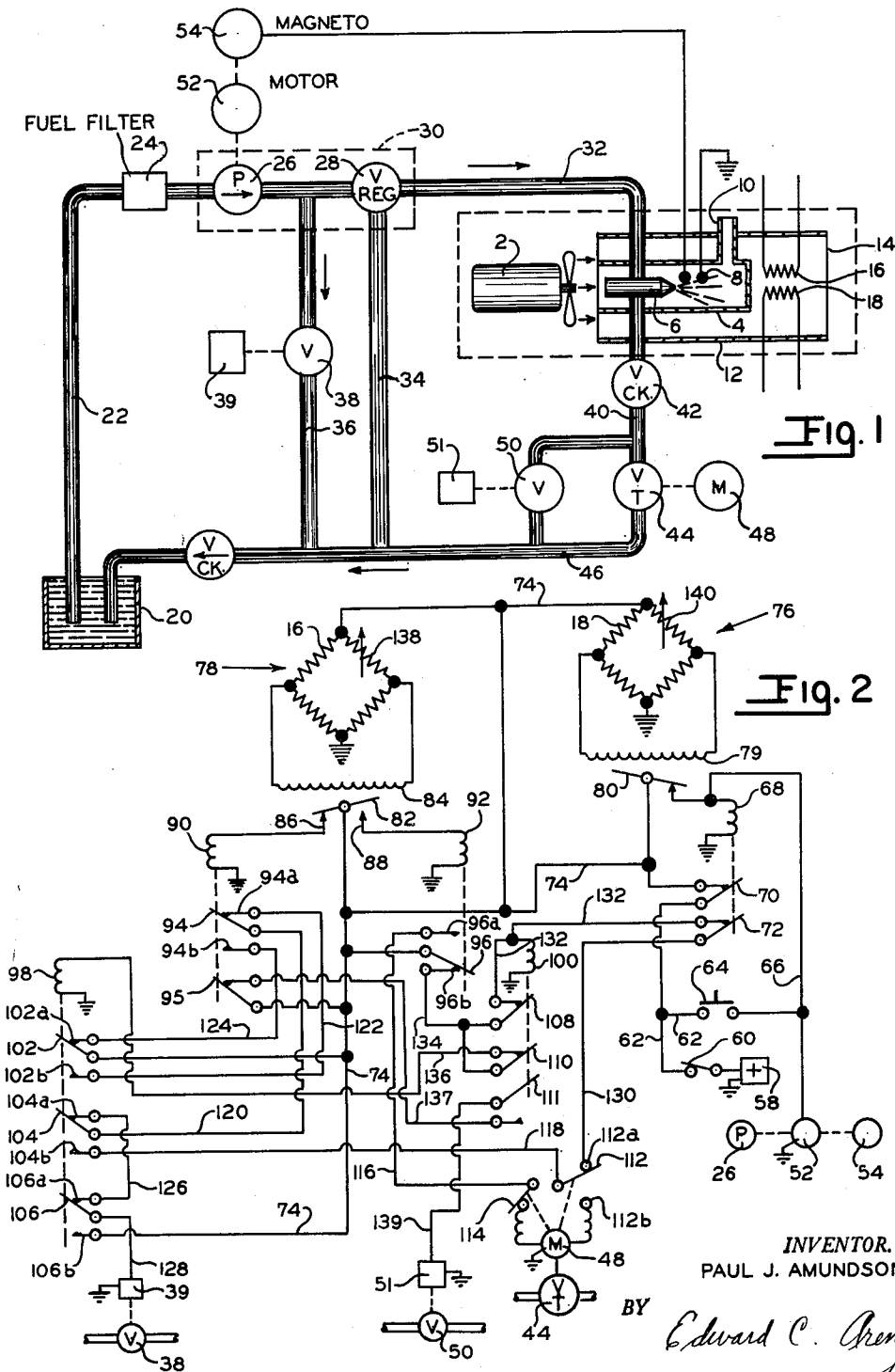


Fig. 1

Fig. 2

INVENTOR.
PAUL J. AMUNDSON

BY *Edward C. Aron*
ATTORNEY

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AIR HEATER FUEL CONTROL SYSTEM

Paul J. Amundson, Moline, Ill., assignor to American Air Filter Company, Inc., Louisville, Ky., a corporation of Delaware

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This invention relates to portable air heaters employing liquid fuel and relates particularly to a fuel control system for such a heater.

Hubbard U.S. Patent 2,758,591, issued August 14, 1956, exemplifies a portable space heater used extensively for supplying heated air for a multitude of purposes. The present invention is directed to a fuel control system for an air heater of this general type.

Such heaters conventionally include: a burner or combustor to which liquid fuel is supplied and ignited; a heat exchanger to which ventilating air is delivered for tempering; an outlet for the tempered ventilating air; a ventilating air temperature sensing element for sensing the tempered air; and means for controlling the flow of fuel to the burner in accordance with the differential between a selected air temperature and sensed air temperature.

Under fortuitous firing conditions, the control system may hunt as a result of the time lag between the sensing by the controls of an incorrect outlet temperature and a change or correction of the temperature condition of the heat exchanger. Such hunting may occur, for example, where the fuel is being fired at a rate producing an outlet temperature exceeding the selected temperature, and consequently, the sensing element signals or demands a decreased fuel discharge rate into the combustor. Before this decreased fuel discharge rate is manifested at the sensing element, however: (1) the flow controlling means must respond; (2) the mass of the heat exchanger must decrease in temperature; and, (3) the decreased ventilating air temperature resulting from the foregoing must be sensed by the sensing element. While these successive steps are occurring, it frequently happens that the flow control means "overshoots" a position which would have provided the correct fuel discharge rate. In other words, the firing rate in the combustor becomes lower than the rate which would have satisfied the sensing element at the outlet of the heater. As a result, a reverse situation prevails (outlet temperature sensed is below selected temperature), and the same steps occur in an effort to increase the outlet temperature to the selected value. This hunting situation may cause undesirable swings in outlet temperature.

The present invention has, as one of its objects, the provision of a control system which substantially minimizes hunting of the control system when the system responds to an outlet temperature exceeding the selected temperature.

A more specific object is the provision of valve means operative to rapidly reduce the rate at which fuel is discharged into the combustor whenever the control means calls for a decreased fuel rate in response to a sensed temperature exceeding the selected temperature.

It is a further object of this invention to provide a control system having such valve means with means for rendering the valve means inoperative with the system as a whole is operating under conditions where the main fuel control valve is in a minimum fuel flow position and fuel flow to the combustor is being controlled in an on-off method of operation as opposed to a modulating control of fuel flow.

Another object is the provision of a fuel control system in which the valve means for rapidly reducing the fuel discharge rate into the combustor is arranged in parallel

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with the main fuel control valve and which is operative to restore fuel flow control to the main fuel flow control valve when the air temperature sensitive means are apparently satisfied.

These and other objects are attained in accordance with the invention by providing a system which includes a main fuel flow control valve operative in a modulating type of operation in response to the differential between a sensed and selected temperature and a valve in parallel with the main valve for permitting the flow of fuel around the main valve and thereby rendering the main valve control ineffective when the parallel valve is open. The parallel valve is arranged to be operated to an open position whenever the air temperature sensitive means controlling the main valve demands a lower fuel rate. As a result, when such lower fuel rate is demanded, the fuel is bypassed through the open parallel valve and the fuel discharged into the combustor is rapidly reduced so that the decreased outlet temperature is obtained more quickly than if the main valve alone controlled the rate of fuel discharge into the combustor. The system of control also serves to compensate for the overshooting tendency of the main valve due to heat transfer lag factors.

Additionally, in accordance with this invention, this system is readily adapted for utilization in connection with a fuel control system of the type disclosed and claimed in Robson U.S. patent application Serial No. 760,359, filed September 11, 1958, of the same assignee and wherein provision is made for modulating control of fuel flow in a relatively higher temperature range, and, on-off control in a lower range. In the adaptation of the present invention to such a system means are provided to maintain the parallel valve in a closed position in response to a condition of the control system calling for the on-off control.

The invention will be described in connection with the accompanying drawing illustrating a preferred embodiment of the invention by way of example, and wherein:

FIGURE 1 is a diagrammatic view illustrating the heater fuel flow system and certain elements associated therewith for controlling fuel flow and heater operation;

FIGURE 2 is a diagram of an electrical circuit adapted to provide the control for that part of heater operation to which this invention is directed.

The combustion and air heating system is of the general type illustrated in Hubbard U.S. Patent 2,758,591, issued August 14, 1956, and as shown diagrammatically in FIGURE 1 comprises: forced air blower means 2 to provide ventilating air and combustion air; a combustion chamber or burner 4 adapted to receive combustion air from the blower 2 and liquid fuel from jet nozzle 6, the burner also containing igniting spark electrodes 8 and communicating with an exhaust stack 10 for discharging the exhaust gases; an outer jacket 12 defining a heat exchanging passageway between the combustion chamber and the outer jacket so that the ventilating air may be heated in its passage therethrough, the outer jacket terminating in an air outlet 14 through which ventilating air is discharged into suitable conveying ducts for delivery to the serviced space; and a temperature control sensing element 16, and a temperature overheat sensing element 18, both of which are associated with Wheatstone bridge circuits to be hereinafter described in some detail.

The fuel flow system will now be described. Fuel is drawn from tank 20 through conduit 22 and the fuel filter 24 by pump 26. A regulating valve 28 on the discharge side of pump 26 is a conventional balanced regulating type valve within housing 30 and is adapted to open and to supply fuel at a predetermined pressure to nozzle supply conduit 32. When the regulating valve 28 opens, fuel flows at that predetermined pressure (e.g., 150 p.s.i.) through conduit 32 to nozzle 6. Secondary by-pass con-

duit 34 returns fuel, in excess of that required to maintain a steady 150 p.s.i. in nozzle conduit 32, back to tank 20. Primary by-pass conduit 36 contains a two-position (open-closed) valve 38 controlled by solenoid 39.

Burner nozzle 6 is of the by-pass type which permits an operation wherein the rate of fuel discharged into the burner through nozzle 6 is controlled by throttling on the downstream side of the nozzle. Such a burner nozzle is illustrated and described in detail in Hubbard U.S. Patent 2,758,591 and includes a supply chamber into which fuel from conduit 32 flows, a combustion jet orifice through which some of the fuel escapes as a spray or jet into the burner, and a by-pass chamber which receives the rest of the fuel. With fuel supplied by conduit 32 at a constant pressure to the nozzle, part of the fuel will be discharged through the jet orifice into the burner chamber and part of it will by-pass to the by-pass chamber. The by-pass chamber connects to the nozzle by-pass conduit 40 which contains a check valve 42 and a throttling valve 44. Thus, in operation, the more the nozzle by-pass conduit is throttled by valve 44, the more fuel is discharged through the nozzle jet orifice; and conversely, the less the nozzle by-pass conduit is throttled, the less fuel issues through the nozzle jet orifice. The downstream side of the throttling valve 44 is connected to pass excess fuel back to the tank 20 by way of return conduit 46. The throttling valve is modulated between end travel limits by reversible motor 48 which, in turn, is controlled in a manner to be described hereinafter.

Valve 50 is a two position (open-closed) valve connected in parallel with throttling valve 44 between the downstream side of check valve 42 and return conduit 46 and controlled by solenoid 51. Valve 50 is biased by conventional means to a closed position when solenoid 51 is not energized, and is actuated to an open position by energization of the solenoid. It will be apparent that while the valve 50 is closed, control of the fuel discharge rate into the burner will be effected wholly by the throttling valve. However, when valve 50 is actuated to an open position, most of the fuel will by-pass valve 44 and flow to return conduit 46 by way of the relatively unrestricted path through open valve 50—the exact division of flow between the two valves depending upon the degree to which valve 44 is open at the time valve 50 is actuated to an open position. However, it is to be understood that valve 50 is sized to provide a substantial reduction in fuel back pressure to the nozzle 6 when the valve is opened so that a correspondingly substantial reduction of fuel discharged into the burner occurs upon opening of the valve.

Fuel pump 26 is driven by electric motor 52 which also drives the ignition magneto 54 electrically connected to supply power for the igniting spark between electrodes 8 at the nozzle orifice. This insures an igniting arc at the nozzle at all times when the fuel pump is operating.

As will be apparent hereinafter from the description of the circuit utilized to control the fuel flow system, the solenoid operated valve 38 is maintained in a closed position by energization of solenoid 39 while the throttling valve 44 is being modulated between its end travel positions. Valve 38 is biased to an open position when the solenoid 39 is de-energized. Thus, while the valve 38 is closed and the throttling valve 44 is between its end travel limits, the rate of fuel discharge from nozzle 6 into the burner is entirely under the control of the throttling valve 44 and parallel valve 50.

Referring now to FIGURE 2, a suitable power source 58 is connected through main switch 60 to provide power through line 62 to one side of normally open, manually closable switch 64. Closure of switch 64 energizes line 66, relay winding 68, and motor 52 which drives fuel pump 26 and ignition magneto 54. Energization of relay winding 68 operates both relay actuated switches 70 and 72 to the position illustrated in FIGURE 2 and thus through switch 70 line 74 serves to energize overheat

bridge circuit 76 and temperature control bridge circuit 78. Energization of overheat bridge 76 causes current to flow through polarized winding 79 in a direction causing closure of overheat switch 80 and thereby completes the alternate circuit for energizing relay winding 68. Thus, when switch 64 is released by the heater operator, relay winding 68 remains energized through the overheat cut-off switch 80 and relay actuated switch 70, and motor 52 remains energized through line 66.

Switch 82 is controlled by current flow from temperature control bridge 78 through polarized relay 84. Switch 82 is biased towards a neutral position and is out of contact with its contact 86 and heating contact 88 when current flow through polarized relay 84 in either direction is below a predetermined value. Current flow in one direction above this predetermined value will cause switch 82 to close to cooling contact 86 and thereby energize relay winding 90. It is noted that contact 86 and relay winding 90 will be characterized as "cooling" contact and "cooling" relay respectively since the effect of their operation is to reduce the rate of heating. The use of the word "cooling" in this connection is not meant to imply that any means for refrigeration or the like is brought into operation. Current flow in the opposite direction above the predetermined value will cause switch 82 to close to heating contact 88 and thereby energize relay winding 92.

Energization of relay winding 90, which may be characterized as the cooling winding, actuates switch 94 to its 94a position and closes switch 95 as shown in FIGURE 2 and indicates the bridge circuit 78 is demanding a lower ventilating air discharge temperature. Energization of relay winding 92, which may be characterized as the heating winding, actuates switch 96 to its 96a position or opposite to the position shown in FIGURE 2 and indicates the bridge circuit 78 is demanding a higher ventilating air discharge temperature. It will be apparent that both windings 90 and 92 cannot be energized at the same time and that while bridge 78 is in substantial balance, thereby indicating the ventilating air discharge temperature is relatively close to the desired temperature, neither winding 90 nor 92 will be energized.

Relay windings 98 and 100 may be characterized as holding relay windings normally energized only during the time that on-off fuel flow control is being employed. Energization of relay winding 98 actuates switches 102, 104 and 106 to their "a" contact positions. Energization of relay winding 100 actuates switches 108 and 110 to their closed positions and switch 111 to its open position as illustrated in FIGURE 2.

Switches 112 and 114 in the circuit to motor 48 are limit switches which are actuated by travel of motor 48 to its end travel limits. Switch 112 is actuated from its 112b position to its 112a position when motor 48 is driven to its end travel position corresponding to a maximum open (minimum stable flame-supporting fuel rate) position of throttle valve 44. Switch 114 opens when motor 48 is driven to its opposite end travel position corresponding to a maximum closed (maximum fuel rate to burner) position of throttle valve 44.

One side of switch 114 is connected by line 116 to contact 96a of switch 96. Since the actuated element of switch 96 is connected to power line 74, when switch 96 is operated to its 96a contact by energization of heating relay winding 92, the motor 48 will be energized and operated in a direction to closes throttle valve 44 and consequently throttle nozzle by-pass conduit 40.

When switch 112 is in its 112b contact position, and cooling relay winding 90 is energized and holding relay winding 98 is de-energized, the motor 48 is connected by line 118, switch 104 in its 104b position, line 120, switch 94 in its 94a position, line 122, and switch 102 in its 102b position to power line 74 and the motor 48 will be energized and driven in a direction to open throttle valve 44

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and consequently increase the quantity of fuel by-passed through nozzle by-pass conduit 40.

Contact 94b is connected by line 124 to contact 102a, contact 104a is connected by line 126 to contact 106a and operable arm of switch 106 is connected by line 128 to solenoid 39 which controls primary by-pass valve 38.

Contact 112a of limit switch 112 is connected by line 130 to one side of switch 72 which has its other side connected to holding relay winding 100 by line 132. Line 132 is also connected to one side of switch 108 which has its other side connected by line 134 to terminal 96b of switch 96 and to one side of switch 110. The other side of switch 110 is connected by line 136 to holding relay winding 98.

Switch 95 has one side connected to power line 74 and its other side connected by line 137 to switch 111. Switch 111 is connected to solenoid 51 by line 139. Thus, when switch 95 is closed by energization of cooling winding 90, and switch 111 is in a closed position due to non-energization of holding relay 100, the circuit to solenoid 51 is complete and it is energized. If either switch 95 or 111 is open, solenoid 51 is de-energized.

Bridge circuit 78 includes the air discharge temperature sensing resistor 16 in one leg of the bridge and a variable temperature selection resistor 138 in another leg of the bridge. Overheat bridge 76 includes the overheat air discharge temperature sensing resistor 18 in one leg of the bridge and an overheat temperature selection resistor 140 in another leg of the bridge. Both bridges 76 and 78 operate in a conventional manner wherein the direction and magnitude of current flow through the polarized relay windings 79 and 84 is dependent upon the resistance differential between the sensing and the selection resistors.

Operation

The operation of the heater and control of fuel flow will now be described. After ventilation and combustion air flow is initiated, closure of switch 60 delivers power to one side of switch 64 which is then momentarily closed to energize relay windings 68 and the motor 52. Energization of relay winding 68 actuates switches 70 and 72 to their positions shown in FIGURE 2 so that relay winding 68 will remain energized through overheat safety switch 80 after switch 64 is released. With switches 70 and 72 closed, power is delivered by line 74 to both of the bridges, to the temperature control switch 82 and to various other switches as shown in FIGURE 2.

For purposes of explanation, it is assumed that motor 48 and valve 44 are in an intermediate position, that limit switch 114 is closed, and limit switch 112 is in its contact 112b position so that the motor 48 may be energized for movement in either direction. While a slow fire start of the heater may be accomplished through utilization of additional circuitry described and claimed in Aubrey H. Robson's co-pending application Serial No. 764,170, filed September 29, 1958, now Patent No. 2,979,264, it has been deleted from this specification to simplify explanation of this system.

It is assumed that the desired discharge air temperature has been selected by adjusting resistor 138, and that the temperature sensed by resistor 16 is considerably below this value. Thus, current flow through polarized relay 84 will be of a magnitude and in a direction to close switch 82 to its heat contact 88. This energizes relay winding 92 which thereby actuates switch 96 to its 96a position so that power is delivered from line 74 to motor 48 through line 116 and motor 48 is driven in a direction to close throttling valve 44 and thereby increase the fuel discharged from nozzle 6 into the burner. After the heated air discharged from the heater has reached a temperature corresponding to that selected by the resistor 138, switch 82 will break from heating contact 88 and move towards its neutral position since the resistance of element 16 and element 138 will be nearly equal and current flow through

polarized relay winding 84 will be insufficient to maintain switch 82 in contact with either the heating or cooling contact 88 or 86. Motor 48 is then in a de-energized condition and throttle valve 44 will remain in that particular position until conditions change. Since switch 95 has remained open during this period, valve 50 has consequently remained closed.

If the temperature sensed by resistor 16 exceeds that temperature selected by resistor 138, current flow through polarized relay winding 84 will be in a direction to tend to close switch 82 to its cooling contact 86. Closure of switch 82 to cooling contact 86 results in energization of cooling relay winding 90, actuation of switch 94 to its 94a position, and closure of switch 95. Motor 48 is then energized in a cooling direction (opening throttle valve 44) from line 74 by way of switch 102 at its 102b contact, line 122 to switch 94 at its 94a contact, line 120 to switch 104 at its 104b contact, line 118 and limit switch 112 in its 112b position.

However, while throttle valve 44 is being progressively opened to cause a decrease in discharge of fuel into the burner chamber, closure of switch 95 has completed the circuit including line 137, switch 111 and line 139 so that solenoid 51 is energized and valve 50 is opened. This results in an immediate and substantial decrease of fuel discharge into the burner chamber due to reduction in fuel back pressure at the nozzle. The temperature of the heat exchanger consequently decreases more rapidly than if the progressively opening throttle valve were alone effecting the reduction in fuel back pressure at the nozzle.

When the temperature sensed by resistor 16 closely approaches the selected temperature, switch 82 breaks from cooling contact 86, cooling relay winding 90 is de-energized, and consequently switch 94 is actuated to its 94b contact and switch 95 opens. Thus, motor 48 and solenoid 51 are de-energized so that valve 50 is closed and fuel flow into the burner chamber is again entirely under control of throttle valve 44. If the fuel rate into the burner is then sufficiently close to the rate which continues to produce the selected temperature, the throttle valve 44 will remain in that particular position.

If by chance the throttle valve has had sufficient time, before switch 82 opens from contact 86, to open to a position resulting in an insufficient fuel rate, the switch 82 will close to heating contact 88 and the throttle valve will be operated in a closing direction as explained hereinafore.

If the throttle valve 44 has not had sufficient time to open to the proper position while valve 50 is open, the switch 82 will again close to cooling contact 86 and valve 50 will be re-opened to by-pass fuel while the throttle valve opens farther.

It will be apparent then that one result of the operation of the valve 50 in "dumping" fuel is to dampen the amplitude of outlet temperature variations. In effect, its operation gives the heat exchanger a "head start" in cooling down when a decreased outlet temperature is required by the control system.

If the temperature sensed by overheat sensing resistor 18 exceeds that selected by overheat selection resistor 140, current flow through polarized relay winding 79 associated with overheat bridge 76 will cause switch 80 to open. Thus, relay winding 68 is de-energized, switches 70 and 72 open, and combustion is terminated.

In the operation of the heater of the present invention, it is sometime necessary to furnish a heated air discharge having a temperature only slightly above the temperature of the ambient air drawn into the heater. In the attempt of the control to decrease fuel flow into the burner to a sufficiently small quantity to only slightly heat the air, the motor 48 will be driven to a position wherein throttling valve 44 is at its maximum open position. The limit switch 112 will be actuated automatically to its 112a position when motor 48 reaches this end travel position. Actuation of switch 112 to its 112a position coupled with

switch 82 being in its cooling contact 86 position (thus indicating that the air discharged from the heater still exceeds the desired temperature even though the motor 48 has driven throttle valve to its maximum open position) is used to trigger the method of operation wherein by-pass valve 38 is alternately opened and closed in accordance with the discharge air temperature demands.

Thus, when switch 112 operates to its 112a position and switch 82 remains in its cooling contact 86 position, power is delivered to energize relay 100 by way of the following path. Line 74 delivers power to switch 102 in its 102b contact position, through line 122 to switch 94 in its 94a position, through line 120 to switch 104 in its 104b position, through line 118 to switch 112 in its 112a position, through line 130, switch 72 and line 132 to energize holding relay winding 100. Energization of relay winding 100 operates switches 108 and 110 to a closed position and opens switch 111. Opening of switch 111 de-energizes solenoid 51 and thus insures that valve 51 will remain closed while fuel discharge is being controlled by by-pass valve 38.

When switches 108 and 110 are actuated to their closed positions, holding relay winding 98 is also energized through switch 96 in its 96b position, line 134, switch 110, and line 136. When relay winding 98 is energized, switches 102, 104 and 106 are all actuated to their "a" positions. As soon as 106 is actuated to its 106a position, the circuit to solenoid 39 is opened and valve 38, which is biased to an open position when solenoid 39 is de-energized, moves to an open position which by-passes all fuel from regulating valve 28 through primary by-pass conduit 36 back to the tank. In other words, when by-pass valve 38 opens, fuel flow to the nozzle 6 through supply conduit 30 is terminated and combustion ceases.

With no fire in the burner, the outlet air temperature decreases and this decrease is sensed by resistor 16. When the resistance of the resistors 16 and 38 tends to balance because of the decreased outlet air temperature, current flow through the polarized relay 84 decreases sufficiently to cause switch 82 to open from cooling contact 86, relay winding 90 is de-energized and switch 94 moves to its 94b position. When switch 94 moves to its 94b position, the solenoid 39 is again energized through line 128, switch 106 in its 106a position, line 126, switch 104 in its 104a position, line 120, switch 94 in its 94b position, line 124, switch 102 in its 102a position, and power line 74. Thus, minimum burner fire is re-established in the heater by causing a fuel discharge from the nozzle which is just sufficient to maintain the lowest stable flame.

If the minimum burner fire again causes the discharge air temperature to increase above the selected value, switch 82 will again close to cooling contact 86, and through the circuits heretofore described, will cause the by-pass valve 38 to again open, by-pass all fuel and extinguish burner flame. This alternate open-closed operation of by-pass valve 38 will continue as long as the temperature demanded by the control system can only be maintained by this type of operation.

It will be apparent that since switch 111 is maintained in an open position as long as holding relay winding 100 is energized, the valve 50 will remain closed irrespective of opening and closing of switch 95 which is controlled by opening and closing of switch 82 to cooling contact 86. One purpose of this arrangement for rendering valve 50 ineffective to control fuel discharge during by-pass valve 38 control conditions is to prevent unnecessary operation of this valve 50 during this period.

If the alternate open-closed operation does not suffice to provide the desired air outlet temperature, this will be sensed by bridge 78 and switch 82 will be operated by the current flow through polarized relay 84 to its heating contact position 88. This will energize relay winding 92 and and actuate switch 96 to its 96a position. When so actuated, the motor 48 is moved from its cooling end travel position by power delivered from line 74 through switch 96, through line 116 and limit switch 114. As soon as

motor 48 is driven from its cooling end travel position, limit switch 112 is thereby operated to its 112b position, the holding relay winding 100 is de-energized, and consequently holding relay winding 98 is also de-energized by opening switch 108. Closure of switch 111 in response to de-energization of holding relay winding 100 provides that upon subsequent closure of switch 95 in response to a cooling demand, the dump valve 50 will again be operable to dump fuel. Since solenoid 39 is energized as soon as switch 82 opens from cooling contact 86, it is insured that by-pass valve 38 is closed and a minimum burner fire is established before switch 82 is moved to its heating contact position 88. When holding relay winding 98 is de-energized, switch 106 moves back to its 106b position and solenoid 39 is again energized directly from line 74 through the switch 106. This insures that when the switch 82 moves away from its heating contact 88 (which occurs when the temperature control bridge is again satisfied) the by-pass valve 38 will remain in a closed position as motor 48 modulates throttle valve 44 back and forth in accordance with temperature demands manifested by the temperature control bridge 78.

By means of the described arrangement, it will be noted that switch 82 operates to control fuel flow by means of dump valve 50 and by actuating motor 48 whenever modulation of motor 48 and valve 44 between end travel positions will serve to satisfy the demands of the system, and also serves as the control for on-off fuel flow control to the burner when the temperature demands of the system cannot be satisfied by a modulating type of operation.

Having described my invention, I claim:

1. A fuel control system for an air heater, comprising a burner having a return conduit; means for supplying fuel to said burner; a throttle valve in said return conduit from said burner for varying in direct relation the fuel back pressure in said return conduit and the rate of fuel discharge into said burner; a normally closed solenoid operated dump valve in parallel with said throttle valve; first electrical switch means actuated one way or another for energizing said throttle valve for movement in one direction or another; air temperature responsive means for actuating said first electrical switch means said one way or another for energizing said throttle valve in a direction to increase and decrease fuel discharged into said burner in response to a sensed outlet air temperature produced by said burner respectively below and above a selected temperature; and, electrical means including circuit means having second electrical switch means actuated to a closed position for energizing said solenoid operated dump valve to an open position to substantially reduce said fuel back pressure in response to actuation of said first switch means said other way resulting from a condition of said air temperature sensitive means demanding a decreased rate of fuel discharge into said burner.

2. A fuel control system for an air heater, comprising: a burner having a nozzle; a main conduit for carrying fuel to said burner nozzle; pump means for supplying fuel under a predetermined pressure to said main conduit; return conduit means connected to said burner nozzle for returning excess fuel; a throttle valve in said return conduit means for controlling the rate of fuel discharge into said burner; air temperature responsive means for controlling said throttling valve, said means being operable to open and close progressively said throttling valve in response to a sensed outlet air temperature produced by said burner respectively above and below a selected temperature; a dump valve in parallel to said throttling valve in said return conduit means; and means for opening said dump valve in response to a sensed air temperature above said selected temperature to substantially reduce fuel flow into said burner while said sensed temperature produced by said burner exceeds said selected temperature.

3. The system of claim 2 including: a bypass conduit connecting said main conduit to said return conduit means; a valve in said bypass conduit; means for opening said by-

pass conduit valve in response to a maximum open position of said throttling valve with a coincidental condition of said air temperature responsive means corresponding to said sensed temperature being produced by said burner above said selected temperature; and means for maintaining said dump valve in a closed position while said throttling valve is in said maximum open position.

4. A fuel control system for an air heater, comprising: a burner having a bypass type nozzle; conduit means for supplying fuel to said burner nozzle; fuel return line means connected to said burner nozzle; a modulating valve in said return line means operable in a first direction to increase progressively the rate of fuel discharge into said burner, and in the opposite direction to decrease progressively the rate of fuel discharge into said burner; air temperature responsive means for operating said modulating valve in said first direction in response to a sensed air temperature produced by said burner below a desired air temperature, and in said opposite direction in response to a sensed air temperature produced by said burner above said desired air temperature; a solenoid valve in said return line means in parallel with said modulating valve; a circuit for energizing said solenoid valve; and switch means operative in response to a condition of said air temperature responsive means causing operation of said modulating valve in said opposite direction, for completing said circuit to open said solenoid valve for reducing the rate of fuel discharge into said burner independently of the position of said modulating valve.

5. The fuel system specified in claim 4 wherein: said

solenoid valve includes means biasing it to a closed position when said solenoid valve is not energized.

6. The fuel system specified in claim 5 including: second switch means operative, in response to a maximum open position of said modulating valve, to open said solenoid valve circuit.

7. A fuel control system for an air heater, comprising: a burner; supply conduit means for supplying fuel to said burner; return conduit means connected to said burner for fuel bypassing said burner, said return conduit means including parallel fluid flow paths; a throttle valve in the first of said parallel flow paths; air temperature responsive means operative to modulate said throttle valve towards an open position in response to an air temperature produced by said burner above a desired air temperature, and towards a closed position in response to an air temperature produced by said burner below said desired air temperature; a two-position valve in the second of said parallel flow paths; and means for operating said two-position valve to an open position when said throttle valve starts to modulate in an opening direction, and maintaining said open position while said modulation continues.

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