July 2, 1946. C. K. STROBEL 2,403,411

CONTROL SYSTEM FOR FUEL BURNERS

Filed Aug. 23, 1944

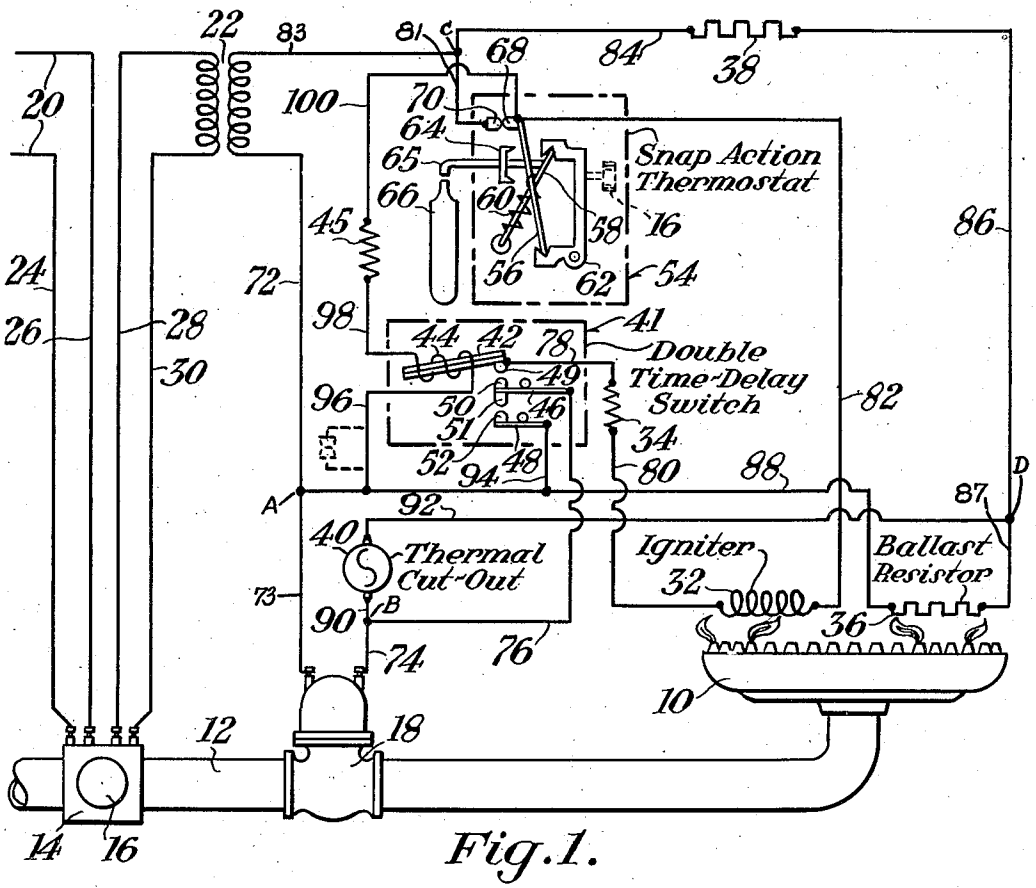


Fig. 1.

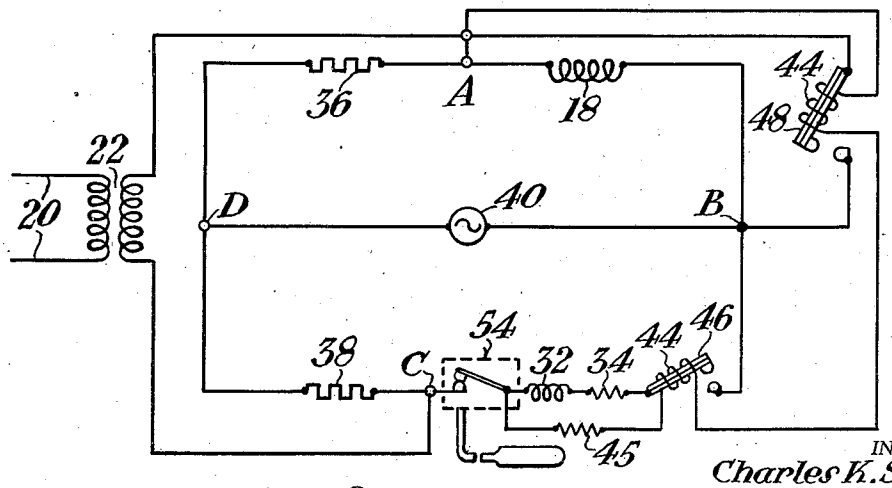


Fig. 2.

INVENTOR
Charles K. Strobel.
BY
Albert J. Henderson
HIS ATTORNEY

Patented July 2, 1946 2,403,411

UNITED STATES PATENT OFFICE

2,403,411

CONTROL SYSTEM FOR FUEL BURNERS

Charles K. Strobel, Pittsburgh, Pa., assignor to Robertshaw Thermostat Company, Youngwood, Pa., a corporation of Pennsylvania

Application August 23, 1944, Serial No. 550,757

10 Claims. (Cl. 158—117.1)

1

This invention relates to control and ignition systems for fuel burners and, more particularly, to systems for domestic gas water heaters embodying water temperature and safety controls.

An object of this invention is to control ignition and fuel flow in conjunction with a burner under a number of different conditions including flame failure and water temperature.

Another object of the invention is to achieve economy in operation by eliminating a constant burning gas pilot.

Another object of the invention is to prolong the life of the electrical ignition device by deenergizing it as soon as the burner is ignited.

Another object of the invention is to utilize an electrical bridge type of control circuit in which very little power is consumed during off periods of the burner.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawing, wherein

Fig. 1 is a schematic view of a safety control apparatus and ignition system for a gaseous fuel burner embodying the temperature control features of this invention; and

Fig. 2 is a circuit diagram showing the electrical connections.

Referring more particularly to the drawing, a gaseous fuel burner 10 is supplied with fuel by a main fuel pipe 12. The fuel supply is controlled by a main valve 14 which, in this instance, is arranged for manual operation by a suitable knob or handle 16 but which may be arranged for thermostatic operation if desired. Interposed in the fuel supply pipe 12 between the main valve 14 and the burner 10 is an electromagnetic or solenoid gas valve 18 of any known type which is arranged to be opened by energization of the solenoid and closed by gravity, spring or other bias upon deenergization or reduction of the current value thereto below holding value.

Electric current for the operation of the apparatus is supplied by the line wires 20 which may carry commercial current at a voltage variation from 105 to 125 volts. In this embodiment, the main valve 14 has a main switch (not shown) combined therewith which is of the double-pole type having two terminals connected in series circuit with the line wires 20 by wires 24 and 26. The other two terminals of the double-pole switch are connected by wires 28—30 in series circuit with the primary of a transformer 22.

An electrical igniter 32, preferably of the resistance coil type, is provided for the burner 10

2

and a series resistor 34 is associated therewith to facilitate adjustment of the current values in the secondary circuit. A ballast resistor 36 having normally a relatively low resistance and a positive temperature coefficient of resistance is positioned to be exposed to the flame of the burner 10 for causing, either directly or in cooperation with other devices to be described, operation of the solenoid valve 18 under certain conditions. It will be understood that although the ballast resistor 36 is thermally responsive to the passage of current therethrough, it is primarily the heating thereof by the burner flame which causes the variation in resistance relied upon in this embodiment.

As indicated hereinbefore, a control resistor 38 is provided for cooperation with the ballast resistor 36 to control operation of the solenoid valve 18 and serves to render the adjustment of the circuit constants less critical. In order to accelerate the operation of the solenoid valve 18 upon a change in the value of the current supplied thereto, the control resistor 38 may also vary appreciably in resistance value upon thermal changes and have normally a relatively low resistance and a positive temperature coefficient of resistance, as in the case of the ballast resistor 36. The resistor 38 is not, however, exposed to the heat of any flame but is adapted to become heated upon passage of electric current therethrough and will vary in resistance value in accordance with changes of temperature caused by changes in the value of the current flowing through it. A cut-out 40 is also included in the secondary circuit and is preferably of the thermal type having time-delayed operation for a purpose which will be apparent hereinafter. Such devices are constructed with predetermined time-current characteristics and usually contain a heater element in addition to and affecting a fusible member which opens the circuit by passage of overcurrent.

The operating coil of the solenoid valve 18 is arranged to be short-circuited by switching means of any suitable type for a predetermined period of time following operation of the main switch of valve 14. Moreover, after the expiration of a second and longer predetermined period of time, the igniter 32 is deenergized and remains inoperative during the remainder of the running period of the burner 10. A thermal timing switch generally designated 41 is provided for these purposes and includes a bimetal switch arm 42 having a heater coil 44 and resistor 45 associated therewith; a long time-delay switch arm

46 and a short time-delay switch arm 48 both of which are resilient and movable in response to warping of switch arm 42. The long delay arm 46 carries contacts 50—51 on opposite sides thereof which are movable into and out of operative engagement with contacts 49 and 52 carried on bimetal arm 42 and switch arm 48, respectively.

Both switch arms 46 and 48 are initially positioned with their contacts 51 and 52 engaged and with contacts 50 and 49 also engaged, and are adapted to open their contacts upon warping of the bimetal arm 42 due to the heat of the coil 44. Suitable stops may be provided to limit movement of switch arms 46—48 during the opening movement. In this embodiment of the invention the switch arm 46 has the longer time delay before opening of the contacts 49—50 and this delay period may be eighteen seconds after the main switch of valve 14 is closed. The switch arm 48 has the shorter time delay before opening of the contacts 51—52 following the closing of the main switch of valve 14 and this period may be five seconds.

Means responsive to a condition caused by operation of the burner 10 are provided for controlling operation of the thermal timing switch 41 through its heater coil 44 and may comprise a temperature regulator 54 of the snap-acting type. As indicated in broken lines in Fig. 1 of the drawing, the knob or handle 16 for operating the combined valve and switch 14 could be utilized for setting the temperature regulator 54 to operate at a desired temperature. As indicated schematically in this figure, the temperature regulator 54 may comprise a pair of levers 56—58 connected by an overcenter spring 60 and supported at opposite ends for snap-action in knife-edge bearings carried on a pivoted frame 62. The lever 58 is adapted to be engaged by the actuating portion of a thermally sensitive element 64, the other portions of the thermal element comprising the usual capillary tube 65 and bulb 66 which is located in the space to be heated by the main burner 10. As previously indicated herein this space could well be the water tank of a domestic water heater and the temperature could be regulated by operation of the thermostat 54 in accordance with the setting of the handle 16. The lever 56 carries, at the end opposite the knife-edge bearing therefor, a contact 68 adapted for movement into and out of engagement with a stationary contact 70 to open and close the circuit as hereinafter described. It will be apparent that the snap-acting thermostatic regulator 54 disclosed herein is in schematic form only and various modifications could be made in the details of construction and operation for commercial use.

The description of the operation of the device, which now proceeds, includes a description of the electrical connection for the various parts of the apparatus and reference may be had to Fig. 2 of the drawing for a clearer understanding of the precise form of electrical circuit. It will be apparent from the diagram shown in Fig. 2 of the drawing that upon initial closure of the main switch of valve 14 the various elements are connected in a bridge type of circuit, except insofar as the heater coil 44 and the short time-delay switch arm 48 and associated contacts are concerned. It will further be observed that the thermal timing element 41 which is shown as a unit in Fig. 1 of the drawing has been separated into two switching devices in Fig. 2 of the drawing to

facilitate illustration of the circuit connections but without otherwise altering the essential character of this timing device or the circuit wherein it is connected.

The thermostatic or manual opening of the main valve 14 by its handle 16 permits fuel to flow in the main fuel pipe 12 as far as the electromagnetic or solenoid valve 18 which is initially closed. As the main switch combined with the main fuel valve 14 is also operated to closed position when the main fuel valve is opened the electrical bridge circuit is established as follows with reference to Fig. 1 of the drawing: From the lower terminal of the secondary of the transformer 22, wire 72 to junction A, wire 73, solenoid valve 18, wire 74 to junction B, wire 76, switch arm 46, contacts 50—49, wire 78, resistor 34, wire 80, igniter 32, wire 82, contacts 68—70, wire 81 to junction C, wire 84, resistor 38, wire 36 to junction D, and wire 87, resistor 36, wire 88 to junction A. Wire 83 connects junction C to the upper terminal of the secondary of transformer 22.

The cut-out 40 is connected as the detector arm of the bridge in this initial or starting period circuit by a wire 90 connecting one terminal thereof to junction B and a wire 92 connecting the other terminal thereof to junction D. The temporary short-circuiting of the solenoid valve 18 is established by a shunt path across junctions A and B by a wire 88 from junction A, wire 94, switch arm 48, contacts 52—51, switch arm 46 and wire 76 to junction B. The heater coil 44 for the bimetal switch is connected at one end by a wire 96 to the wire 88 and the opposite end thereof is connected by a wire 98 to one end of resistor 45 the opposite end of which is connected by a wire 100 to contact 68.

By referring to Fig. 2 of the drawing it will be apparent that the bridge consists of the valve coil 18 in one arm in series with the adjacent arm formed of the long time-delay switch 46, resistor 34, igniter 32 and the thermostatic switch 54. The other two arms in parallel with the foregoing consist individually of resistor 38 and resistor 36 in series. Thus, the current from the secondary of transformer 22 enters the bridge at junctions A and C while the cut-out 40 is connected as the detector arm at junctions B and D. The short-circuiting of the valve coil is shown as being established by switch arm 48 connected at junctions A and B. The heater coil 44 and resistor 45 are shown as connected in parallel with all the elements of the first two bridge arms except the thermostatic switch 54 which is in series circuit therewith.

In Figs. 1 and 2 the parts are shown in the running position with the thermostat calling for heat. Upon initial closing of the main switch of valve 14 the elements comprising the bridge circuit are unheated and the coil of the solenoid valve 18 is short-circuited by the short time-delay switch comprising switch arm 48 and contacts 51—52. It will be apparent, therefore, that at this time the bridge network is considerably unbalanced so that the current through the wires 90—92 to the cut-out 40 is large until the circuit elements heat up and the bridge balance is improved. However, due to the time lag of the cut-out 40 the large inrush current upon initial closing of the main switch of valve 14 is ineffective to cause operation of the cut-out. Upon expiration of the specified five seconds time-delay the short time-delay switch opens and causes re-

moval of the short-circuit from the coil 18 of the solenoid valve.

During this preliminary period the igniter 32 is preheated before any fuel flows from the burner 10 and reaches igniting temperature. The solenoid valve 18 is now actuated to open position through the circuit previously traced and the fuel flowing from the burner 10 is ignited to produce a flame. It will be understood that the current supplied to the coil of the solenoid valve 18 to cause the pick-up from closed position may be of greater value than that required to maintain this valve in open position. As the igniter 32 is still connected in the circuit when the pick-up occurs and is establishing a relatively low impedance therein, it is apparent that the required value of the current is available even if the ballast resistor 36 is unheated by the burner flame and is of relatively low resistance.

It may be assumed that the ballast resistor 36 and the control resistor 38 have now become heated, the former due to the flame from the burner 10 and the passage of current therethrough and the latter due to the passage of current therethrough only. Consequently, the bridge balance is improved to such an extent that current through the cut-out 40 is reduced to a value insufficient to cause operation thereof regardless of whether the main switch of valve 14 is manipulated in on-off-on cycles at this period of starting operation. The cut-out will now operate only on passage of overcurrent and thus protects the circuit against failure of the ballast resistor 36 during the running operation.

At the expiration or the eighteen-second time-delay of the long time-delay switch comprising switch arm 46 and contacts 50 and 49, the igniter 32 and series resistor 34 become deenergized by operation of the long delay switch to open position. The bridge nature of the circuit is thus eliminated unless the network is considered a bridge with infinite impedance in one arm. This operation of the switch having the longer time-delayed action to open position is entirely automatic and occurs regardless of whether the ballast resistor 36 is heated by the burner flame or even whether the burner has become ignited. As previously indicated, the current to the coil of the solenoid valve 18 is now reduced below pick-up value and need be only at the predetermined minimum value sufficient to retain the valve in open position.

When the contacts 49—50 of the long time-delay switch become disengaged the ballast resistor 36 should have become heated by the burner flame and its resistance have increased sufficiently to cooperate with resistor 38 and raise the resistance of the shunt established thereby around the coil of the solenoid valve 18 and cut-out 40 to compensate for the increase in total circuit resistance. Unless this increase in resistance has occurred then the current to the solenoid valve coil will decrease below the predetermined minimum value for holding purposes and the valve 18 will be released to closed position. It will be understood that the predetermined minimum current value referred to herein is established by adjustment of the circuit constants and takes into account the fluctuations in the line voltage. Such action of the resistors 36 and 38 is accelerated by providing that resistor 38 be subject to the heating effects of the current passing therethrough and the valve closing time is generally short.

In addition to the provision for closing of the solenoid valve 18 at the end of the starting period if the ballast resistor 36 has not become heated, a similar provision is made for such valve closure during the running period. Thus, if at any time during the operation of the apparatus the flame of the burner 10 ceases, then the ballast resistor 36 will cool and its resistance be lowered in consequence so that the current through the coil of the solenoid valve 18 is rendered insufficient to maintain the valve in open position whereupon closure will occur.

The heater coil 44 of the bimetallic time-delay switch, together with the coil of the solenoid valve 18, remains energized until the contacts 68—70 of the thermostat are opened due to the thermostat becoming satisfied. When this occurs, the heater coil 44 in series circuit with these contacts becomes deenergized causing bimetal arm 42 to return toward its initial position closing first the long delay switch contacts 49—50 and then the short delay switch contacts 51—52. The coil 18 of the solenoid valve continues to receive current above release value during this switch closing action and the fuel continues to flow from the burner 10 until the contacts 51—52 of the short time-delay switch close and cause the coil to be short-circuited. When the temperature of the water in the tank falls below that for which the thermostat has been set then the contacts 68—70 again close and the sequence of operations previously described will commence.

It will be apparent that the introduction of the high resistance branch circuit in parallel with the coil of the solenoid valve 18 upon engagement of the contacts 49—50 of the long time-delay switch during the shutting-off period of the burner does not affect the operation of any part of the system as this branch only carries a fraction of an ampere of current. However, this small current can be eliminated if desired by substituting a double-pole thermostat for the single-pole type disclosed herein. Such substitution would also eliminate the small amount of current which flows through the igniter 32 during part of the time the thermostat contacts 68—70 are open. It will be apparent that the substitution of the double-pole thermostat would merely involve the introduction of an extra pair of contacts in the circuit of the heater coil 44 as indicated in the broken lines, Fig. 1 of the drawing.

It will be seen that a complete condition and safety control system has been provided in conjunction with ignition means for the main burner of a water heater or like appliance. While a preferred embodiment has been disclosed herein, it will be apparent that many changes can be made in the arrangement and combination of parts and in the details of construction herein disclosed within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. In a control system for fuel burners, an electrical igniter, an energizing circuit for said igniter, a thermal switch having contacts operable for opening and closing said circuit, a heater for said switch, and a control switch having contacts operable for controlling said heater and being cooperable with said thermal switch contacts for controlling said circuit.

2. In a control system for a fuel burner, an electrical igniter, an energizing circuit for said igniter, a thermal switch having contacts oper-

able for opening and closing said circuit, a heater connected in parallel circuit with said igniter and thermal switch and causing operation of said thermal switch contacts for supplying heat to said thermal switch, a control switch having contacts operable for opening and closing said heater circuit and being cooperable with said thermal switch contacts for controlling said energizing circuit, and means responsive to the demand for heat from the burner for actuating said control switch.

3. A safety control and ignition system for fuel burners comprising in combination an electrical bridge circuit having a plurality of resistors in two arms thereof; a pair of bridge arms in parallel circuit with said resistor arms and including an electrically operable fuel control device in one of said pair of bridge arms, an igniter in another of said pair of bridge arms, and a pair of switches having contacts in said other pair of bridge arms and in series circuit with said device and igniter; and means operable in one contact position of one of said switches for operating the other to open its contacts and thereby deenergize said igniter.

4. A safety control and ignition system for fuel burners comprising in combination an electrical bridge circuit having a plurality of resistors in two arms thereof; a pair of bridge arms in parallel circuit with said resistor arms and including an electrically operable fuel control device in one of said pair of bridge arms, an igniter in another of said pair of bridge arms, and a pair of switches having contacts in said other pair of bridge arms and in series circuit with said device and igniter, one of said switches being thermally operable with time delayed action; and heating means controlled by the contact position of the other said switch for operating said thermal switch to open its contacts and thereby deenergize said igniter.

5. A safety control and ignition system for a fuel burner comprising in combination an electrical bridge circuit having a plurality of resistors in two arms thereof; a pair of bridge arms in parallel circuit with said resistor arms and including an electrically operable fuel control device in one of said pair of bridge arms, an igniter in another of said pair of bridge arms, and a pair of switches having contacts in said other pair of bridge arms and in series circuit with said device and igniter, one of said switches being thermally operable with time delayed action, heating means controlled by the contact position of the other said switch for operating said thermal switch to open its contacts and thereby deenergize said igniter, and means responsive to the demand for heat from the burner for actuating said other switch to change said contact position.

6. In a safety control system for fuel burners having a source of electrical energy, an electrically operable fuel control device in circuit with the source, a control switch having contacts operable for opening and closing a second circuit from the source, a thermal switch having contacts adapted in one position to short-circuit said control device, and a heater for said thermal switch controlled by the contact position of said control switch.

7. In a safety control system for a fuel burner having a source of electrical energy, an electrically operable fuel control device in circuit with the source, a control switch having contacts operable for opening and closing a second circuit from the source, a thermal switch having contacts adapted in one position to short-circuit said control device, a heater for said thermal switch controlled by the contact position of said control switch, and means responsive to the demand for heat from the burner for actuating said control switch.

8. A safety control system for fuel burners, comprising in combination, an electrical bridge circuit having a plurality of resistors in two arms thereof, one of said resistors being exposed to the burner flame and adapted to vary in resistance value when heated thereby; an electrically operable fuel control device and a control switch in the other two arms respectively, said other two arms being in parallel circuit with said resistor arms, the current value to said control device being varied according to said resistance value to control operation of said device; means affording a current path across intermediate points of said bridge circuit to maintain said device energized irrespective of said switch position; a thermal switch adapted in one position to short-circuit said control device; and a heater for said thermal switch controlled by said control switch.

9. A safety control and ignition system for a fuel burner, comprising in combination, an electrical bridge circuit having a plurality of resistors in two arms thereof, one of said resistors being exposed to the burner flame and adapted to vary in resistance value when heated thereby; a pair of bridge arms in parallel circuit with said resistor arms and including an electrically operable fuel control device in one of said pair of bridge arms, an igniter in another one of said pair of bridge arms, and a pair of switches having contacts in said other one of said pair of bridge arms and in series circuit with said device and igniter, the current value to said control device being varied according to said resistance value to control operation of said device; means affording a current path across intermediate points of said bridge circuit to maintain said device energized irrespective of said switch contact position; a third switch having contacts adapted in one position to short-circuit said control device; means controlled by one of said pair of switches for causing operation of the other one of said pair and said third switch; and means responsive to the demand for heat from the burner for actuating said one switch.

10. A safety control and ignition system for a fuel burner, comprising in combination, an electrical bridge circuit having a plurality of resistors in two arms thereof, one of said resistors being exposed to the burner flame and adapted to vary in resistance value when heated thereby; a third arm of said bridge including an electrically operable fuel control device; a fourth arm of said bridge including an igniter, a control switch and a thermal switch, said switches having contacts in series circuit with said device and igniter, the current value to said device being varied according to said resistance value to control operation of said device; means affording a current path across intermediate points of said bridge to maintain said device energized irrespective of said switch contact position; a second thermal switch having contacts adapted in one position to short-circuit said control device; heating means for said thermal switches controlled by the contact position of said control switch; and means responsive to the demand for heat from the burner for actuating said control switch to change said contact position.

CHARLES K. STROBEL.