Oct. 25, 1949. C. K. STROBEL 2,486,340

SAFETY CONTROL AND IGNITION SYSTEM FOR FUEL BURNERS

Filed Dec. 19, 1946 2 Sheets-Sheet 1

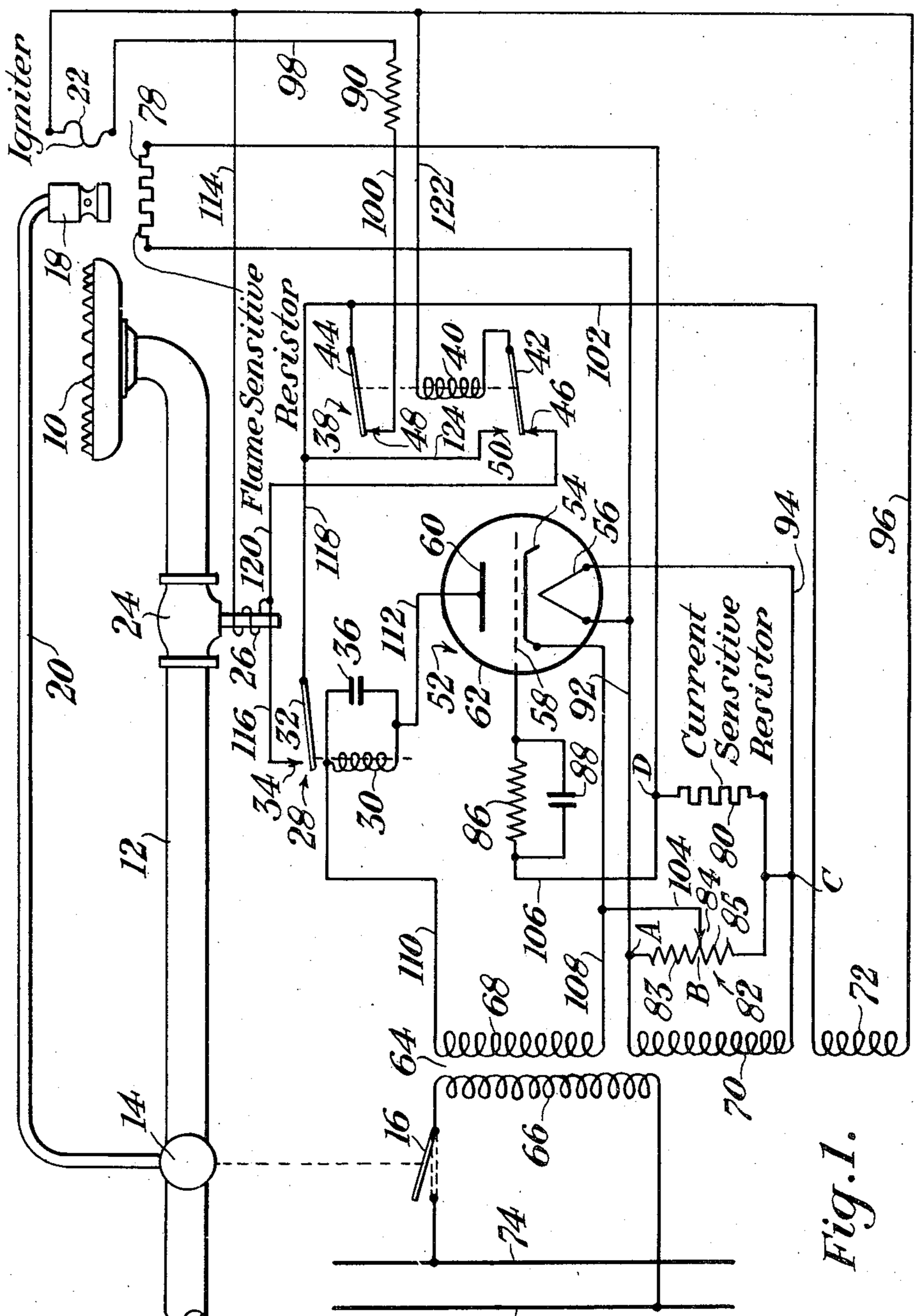

Fig. 1.

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

Oct. 25, 1949. C. K. STROBEL 2,486,340

SAFETY CONTROL AND IGNITION SYSTEM FOR FUEL BURNERS

Filed Dec. 19, 1946

2 Sheets-Sheet 2

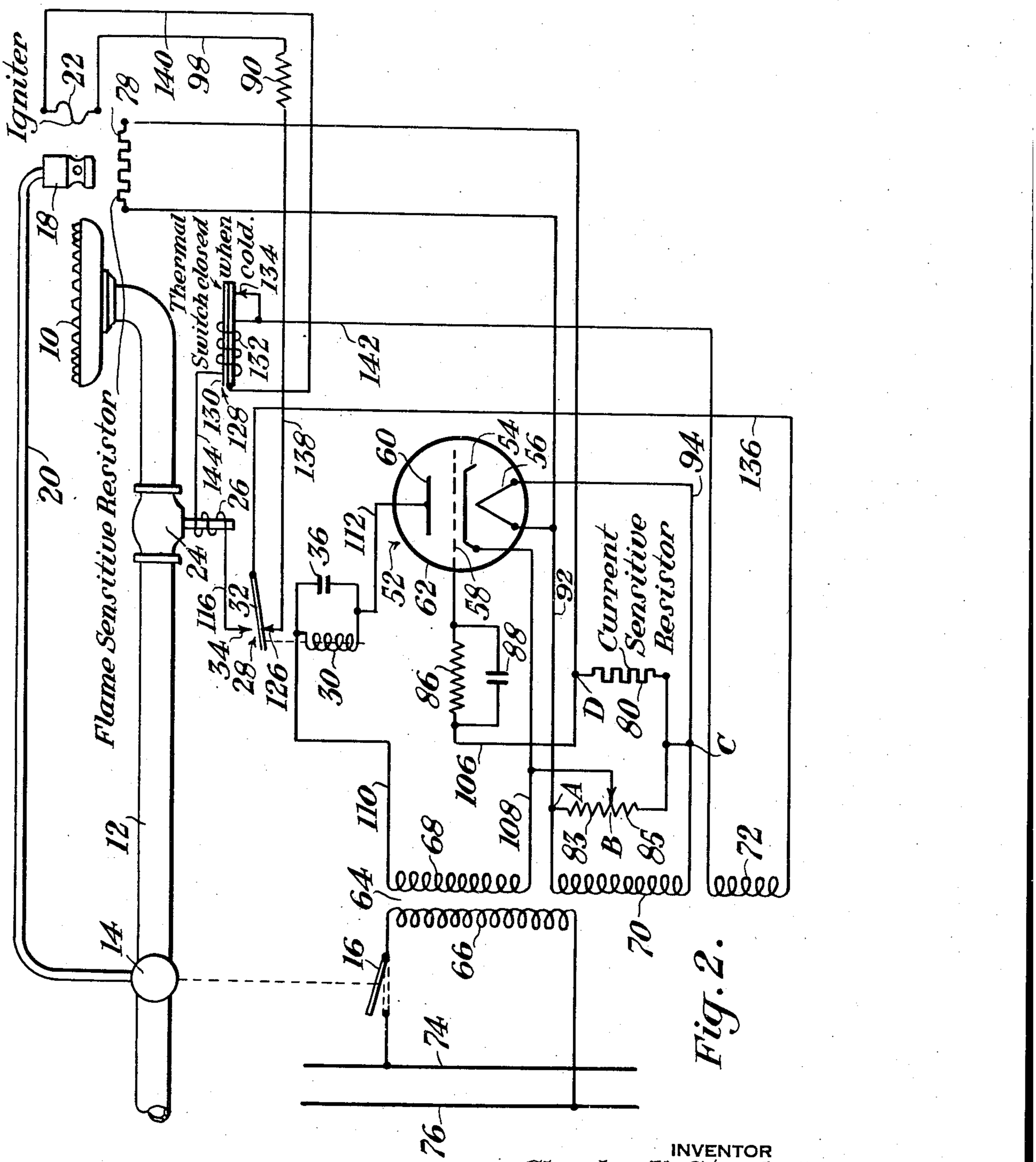

Fig. 2.

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

Patented Oct. 25, 1949

2,486,340

UNITED STATES PATENT OFFICE

2,486,340

SAFETY CONTROL AND IGNITION SYSTEM FOR FUEL BURNERS

Charles K. Strobel, Pittsburgh, Pa., assignor to Robertshaw-Fulton Controls Company, a corporation of Delaware

Application December 19, 1946, Serial No. 717,183

14 Claims. (Cl. 158—117.1)

1

This invention relates to control systems for fuel burning apparatus and, more particularly, to electrically operated safety control and ignition systems.

Gaseous fuel burners have been controlled by means responsive to the presence of a flame at the burner so that whenever the flame is extinguished the supply of fuel is automatically cut-off. In order to start the burner in operation it is necessary to supply fuel thereto while the flame is non-existent. The common method of providing for such supply is by the use of a timing device which operates during a limited period to permit the supply irrespective of the condition of the flame responsive means. At the end of the timing period the fuel supply is again cut-off unless the flame responsive means has become responsive to a flame at the burner.

An object of this invention is to simplify existing systems by eliminating special timers and utilizing equivalent characteristics inherent in a simple control device of the electronic type.

Another object of the invention is to adapt the system for electronic control to effect the timing function and also improve the general safety features thereof.

Another object of the invention is to preserve existing parts of the safety control system which have proved reliable while improving the performance thereof in the modified system.

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

Fig. 1 is a schematic view of the improved control system for controlling the flow of fuel to a fuel burning apparatus; and

Fig. 2 is a similar schematic view of a modification of the improved control system.

Referring more particularly to Fig. 1 of the drawings, the main burner 10 is shown as being supplied with fuel from a main fuel pipe 12 under control of a main fuel valve or cock 14 which, if desired, may also incorporate a thermostatic device (not shown) responsive to temperatures caused by operation of the main burner 10. The main fuel cock 14 also includes a main switch 16 which is operated to closed position when the main fuel cock is opened and is normally open when the main fuel cock is closed.

A pilot burner 18 is located in proximity of the main burner 10 to ignite the fuel flowing therefrom and is supplied with fuel by a conduit 20 under control of the main fuel cock 14. Electric igniting means 22, preferably in the form

2

of a coil of resistance wire, is located in lighting proximity to the pilot burner 18 to ignite the fuel issuing therefrom.

Electrically operable means is provided for controlling the flow of fuel to the main burner 10 and may take the form of a solenoid valve 24 normally biased to closed position by gravity, springs or the like to prevent the supply of fuel to the main burner 10. The valve 24 has an energizing coil 26 operatively associated therewith for causing it to open when energy of sufficient value is supplied to the coil 26. As will be apparent, the supply of fuel to the main burner 10 is under control of both the main fuel cock 14 and the solenoid valve 24 while the supply of fuel to the pilot burner 18 is under control of the main fuel cock 14 only.

A control device comprising a first relay 28 is employed for controlling the operation of the valve 24 by controlling the energization of the coil 26. This first relay 28 includes a coil 30 and the usual control elements including a movable armature means 32 adapted to engage a fixed contact means 34 when the coil 30 is supplied with energy of sufficient value. The relay coil 30 has a capacitor 36 of suitable size connected in parallel circuit therewith to smooth the current flow in the coil 30.

A second relay 38 is provided for controlling the igniting means 22 and includes a coil 40 and a pair of movable armature means 42 and 44. The armature means 42 and 44 are normally biased into engagement with contact means 46 and 48 respectively. Upon energy of sufficient value being supplied to the coil 40, the armature means 42 and 44 become disengaged from the contact means 46 and 48 and the armature means 42 thereby becomes engaged with contact means 50.

An electronic device 52 of the triode type is provided for controlling the operation of the relays 28 and 38. The cathode 54 of this device 52 is indirectly heated by a heating element 56 and these elements are housed, together with the control grid 58 and anode 60, within the usual envelope 62.

A step-up, step-down transformer 64 controls the energization of the electronic device 52 as well as the various other electrical elements referred to. The transformer 64 comprises a line voltage primary 66, a high voltage secondary 68 and low voltage secondaries 70 and 72. The line voltage primary 66 is connected at one end through the main switch 16 to a line wire 74 and at the opposite end to a line wire 76. While any

suitable voltage may be employed, depending on the voltage of the power source available and the operating characteristics of the electronic device **52**, the primary winding **66** in this instance is connected to a 110-volt source of energy and the windings **68**, **70** and **72** may be designed to operate at voltages of 250 volts, 6 volts and 4 volts, respectively. In this preferred embodiment of the invention the transformer **64** constitutes the source of energy and is so named for the purposes of description and definition, although some primary source of energy must be connected therewith as has been described. As far as the present invention is concerned, the construction of the transformer **64** and the connections for supplying energy at various potentials to the control system can be varied, it being understood that the step-up winding may be omitted if an appropriate electronic device is used and connected directly to a suitable primary power source.

As previously indicated, the safety control system to which this invention pertains includes flame responsive means of a known type which operates in conjunction with cooperating elements to control the flow of fuel to the main burner **10** should the pilot burner **18** become extinguished. Thus, the flame responsive means comprises a variable resistor **78** in the form of a coil of wire of material having normally a relatively low resistance and a positive temperature coefficient of resistance. The resistor **78** is located in proximity of a flame from the pilot burner **18** and is adapted to increase appreciably in resistance value when heated thereby. It will be apparent, however, that the passage of electrical energy through the resistor **78** will also cause it to become heated to some extent but it is the heating thereof by the flame of the pilot burner **18** which is primarily responsible for its usefulness in the disclosed system.

A second variable resistor **80** is provided for cooperation with the resistor **78** and is also formed from a coil of wire having normally a relatively low resistance and a positive temperature coefficient of resistance. This second resistor **80** is not, however, exposed to the flame of any burner and is adapted to vary its resistance only due to the passage of electrical energy therethrough.

A potential divider **82** is provided for cooperation with the resistors **78** and **80** in the operation of the electronic device **52**. The potential divider **82** consists of the usual resistance means **83** and **85** in series and provided with a tap **84** forming part of a connection between the circuit of the secondary **70** and that of the secondary **68** as will hereinafter be apparent.

A timing circuit of conventional form is provided for producing the necessary time delay for operation of the system. This timing circuit comprises a resistor **86** and a capacitor **88** in parallel and connected to the circuit of the grid **58** of the electronic device **52**. The various elements of the system are completed by the provision of a resistor **90** for adjusting the value of the energy supplied to the igniting means **22**.

In the subsequent description of the operation of the system the various circuit connections for the described elements will be outlined together with the cooperation between the various elements to produce the required results. Generally, the resistor **78** cooperates with the resistor **80** and the potential divider **82** to control the grid bias of the electronic device **52** in response to flame conditions at the pilot burner **18**. The variations in grid bias, in turn, control the current supply to the relays **28** and **38** so that the control elements of the relay can function to control the operation of the igniting means **22** and the solenoid fuel valve **24**. It should be noted that the electronic device **52** acts as its own rectifier and no separate D.-C. supply is necessary for operation of the system.

With the various elements in the position shown in Fig. 1 of the drawings and the system inoperative, the fuel supply and the 110-volt supply to the primary **66** of the transformer **64** are turned on simultaneously by operation of the main fuel valve **14**. Thus, fuel will flow in the conduit **20** to the pilot burner **18** and the transformer **64** will be energized.

As the solenoid valve **24** is biased closed there is no flow of fuel in the main fuel pipe **12** to the main burner **10** at this time. In accordance with the known characteristics of electronic devices, there is a time delay before any energy flows from the output circuit of the device until the heating element **56** reaches operating temperature and the circuit potentials are stabilized. When the electron flow in the device **52** is established there is an initial output current which is insufficient for operation of the system so that the movable circuit elements, such as armatures **42** and **44**, remain in the biased positions shown in Fig. 1. This holding of the energy in the output circuit below the effective energizing value is due to a negative bias being applied to the grid **58** as long as the resistor **78** is unheated by a flame from the pilot burner **18**.

Thus, on one-half of the alternating current cycle the anode potential is positive with respect to the cathode **54** and there is an electron flow between the cathode **54** and the anode **60**. On the succeeding half-cycle, the anode potential becomes negative with respect to the cathode potential and no electron flow occurs between these elements. During this second half-cycle the capacitor **36** supplies energy to the coil **30** of the relay **28**. However, when the anode potential is positive as described the electron flow depends upon the amount and sign of the potential at the grid **58**. As this grid potential changes in a negative direction with respect to the potential of the cathode **54**, the electron flow to the anode **60** is reduced.

Under the circumstances described, the cathode **54** becomes heated by the heating element **56** of the control device **52** which is connected to the 6-volt secondary **70** of the transformer **64** by a wire **92** from one terminal of the secondary **70** to one end of the heating element **56** and by a wire **94** from the other terminal of the secondary **70** to the opposite end of the heating element **56**. Meanwhile, the igniting means **22** is energized through a circuit from the lower terminal of secondary **72**, wire **96**, igniter **22**, wire **98**, resistor **90**, wire **100**, contact means **48**, armature means **44** and wire **102** to the upper terminal of the transformer secondary **72**. The fuel issuing from the pilot burner **18** is thus ignited and the flame produced thereby serves to heat the resistor **78** and cause it to increase in resistance value.

The heating and increase in resistance value of the resistor **78** is effective for causing the desired shift in the biasing of the input circuit of the electronic device **52** sufficiently to render the same conductive. The input circuit of the electronic device **52**, comprising control grid **58**

and cathode 54, is connected as the detector branch of a bridge circuit in which the resistors 78 and 80 and resistance means 83, 85 of potential divider 82 each form one of the other four branches. This circuit is connected across the 6-volt supply as follows: Upper terminal of secondary 70, wire 92, bridge junction A, resistance means 83, junction B, resistance means 85, junction C, resistor 80, junction D and resistor 78 back to junction A, it being noted that wire 94 completes the connection of junction C back to the lower terminal of secondary 70. The detector branch of this bridge is connected at junction B by tap 84 and wire 104 to cathode 54, grid 58, resistor 86 and capacitor 88 in parallel and wire 106 to junction D.

The lower terminal of the 250-volt secondary 68 is connected to the wire 104 to cathode 54 by a wire 108 and the upper terminal of secondary 68 is connected by wire 110 to one terminal of the relay coil 30, the opposite terminal of which is connected by a wire 112 to the anode 60. The capacitor 36 in parallel circuit with the relay coil 30 serves to smooth the half-wave rectified current of this outut circuit of the electronic device 52, as will be apparent. It is further apparent that the current in the 6-volt secondary 70 be approximately 180 degrees out of phase with the current in the 250-volt secondary 68.

When the resistor 78 is sufficiently heated by the flame from the pilot burner 18, the elements of the foregoing described bridge circuit cooperate to shift the bias of the grid 58 in a positive direction sufficiently to increase the output current of the electronic device 52 above that required to effectively energize the relay coil 30. The relay armature means 32 then engages contact means 34. A circuit for the solenoid valve 24 is then established as follows: lower terminal of transformer secondary 72 to wire 96, wire 114, solenoid valve 26, wire 116, contact means 34, armature means 32, wire 118 and wire 102 back to the upper terminal of the transformer secondary 72. The solenoid valve 24 is thus actuated to open position to supply fuel to the main burner 10 where it is ignited by the flame from the pilot burner 18.

It is apparent that once the main burner 10 is in operation, it is no longer necessary for the igniting means 22 to be energized. Consequently, means are provided to automatically deenergize the igniting means 22 at this time. This igniter deenergizing means includes a lock-out circuit for the second relay 38. Thus, when the first relay 28 is energized and engagement between armature means 32 and contact means 34 occurs, the second relay 38 becomes energized through a circuit which may be traced as follows: upper terminal of transformer secondary 72, wire 102, wire 118, armature 32, contact means 34, wire 116, wire 120, contact means 46, armature 42, second relay coil 40, wire 122, and wire 96 back to the lower terminal of the transformer secondary 72. The establishment of this circuit will serve to cause the armature means 42 and 44 of the second relay 38 to move out of engagement with the contact means 46 and 48, respectively, and the armature means 42 will thus be moved into engagement with the contact means 50. In the latter event, the circuit of the igniting means 22 will be opened and the energization of the igniting means 22 will cease. The locking arrangement for the auxiliary relay 38 is now effective to maintain the coil 40 energized until the system is manually shut-off by

operation of the main switch 16. The circuit now established by the foregoing operation of the second relay 38 may be traced as follows: from the upper terminal of transformer secondary 72, wire 102, wire 124, contact means 50, armature means 42, relay coil 40, wire 122 and wire 96 back to the lower terminal of the transformer secondary 72.

The system will remain in the steady state operation described until manually shut-off by operation of the main fuel valve 14 or until the flame at the pilot burner 18 is extinguished. In the latter case, the potential drop across the resistor 78 is decreased as soon as this element starts to cool. The rate of decrease of this potential is augmented by the action of the resistor 80 which is also responsive to temperature changes therein, as described. The bias of the grid 58 in finally changed in a negative direction so as to cause the output current of the electronic device 52 to decrease sufficiently to cause effective deenergization of the relay coil 30. The armature means 32 then moves under its bias out of engagement with the contact means 34 and the system returns to its initial condition with the solenoid valve 24 closed to shut-off fuel flowing to the main burner 10. As previously described, the second relay 38 remains in energized condition to maintain the circuit to the igniting means 22 open. Consequently, the system must be manually restarted by manipulation of the main fuel valve 14 and is not recycling.

If a rapid on-off-on operation of the main fuel valve 14 is conducted when starting, or if a rapid off-on operation is made during steady state running, then there is a substantial delay in rendering the electronic device 52 conductive due to the time required to stabilize the circuit potentials. Hence, the starting conditions appropriate for systems of this nature are provided for.

Should a recycling system be required instead of the non-recycling system of Fig. 1, a system similar to that disclosed in Fig. 2 may be employed. This arrangement is similar to that previously described except that the second relay is dispensed with. Accordingly, in Fig. 2 similar reference numerals have been applied for corresponding parts in the two arrangements.

Referring now more particularly to Fig. 2, the relay 28 has the armature means 32 thereof initially biased into engagement with a contact means 126 which is utilized in conjunction with a thermal switch 128 for delaying energization of the igniting means 22 when the initial biasing of the electronic device 52 is resumed upon failure of the flame at the pilot burner 18. This feature is of importance in recycling systems inasmuch as a purge period for dissipation of unburned fuel at the burner should be provided before another igniting operation is established.

The thermal switch 128 in this embodiment comprises a bimetal strip 130 having a heater coil 132 associated therewith and contact means 134 with which the strip 130 engages when the heater coil 132 is deenergized. As the remaining elements of the system disclosed in Fig. 2 are identical with those disclosed in the embodiment of Fig. 1, further description of the parts is considered unnecessary.

In the operation of the embodiment shown in Fig. 2, the closing of the main switch 16 by operation of the fuel valve 14 serves to energize the igniting means 22 through the following circuit:

from lower terminal of transformer secondary 72, wire 136, armature means 32, contact means 126, wire 138, resistor 90, wire 98, igniting means 22, wire 140, bimetal strip 130, contact means 134 and wire 142 back to the upper terminal of transformer secondary 72.

After the resulting flame from the pilot burner 18 has heated the resistor 18 sufficiently to render the electronic device 52 conductive, as previously explained, the coil 30 of the relay 28 becomes effectively energized. The armature means 32 then moves into engagement with the contact means 34 and opens the circuit of the igniting means 22 by its consequent disengagement from contact means 126. A circuit is then established for the solenoid valve 24 and also for the heater coil 132 as follows: from the upper terminal of the transformer secondary 72, wire 142, heater coil 132, wire 144, relay coil 26, wire 116, contact means 34, armature means 32 and wire 136 back to the lower terminal of transformer secondary 72.

Upon establishment of the foregoing circuit, the solenoid valve 24 is caused to open and admit fuel to the main burner 10 where it is ignited by the flame from the pilot burner 18. Moreover, the heater coil 132 becomes energized and causes the bimetal strip 130 to warp and disengage itself from the contact means 134. The apparatus is then in steady state operation until the fuel supply is shut-off by operation of main valve 14 or the pilot burner 18 becomes extinguished.

Upon extinguishment of the pilot burner 18, the resistor 78 will cool and cause a shift in the grid bias of the electronic device 52 as previously described and the relay 28 will operate to open the circuit of valve coil 26 and cause the solenoid valve 24 to close. Such action will serve to engage the armature means 32 of the relay 28 with its contact means 126 but, as the bimetal strip 130 is disengaged from the contact means 134, the igniting means 122 will not immediately be energized. It is apparent that the thermal switch 128 will be so designed that its cooling period is longer than that of the resistor 78 so as to allow a suitable period between the time of closing of the solenoid valve 24 and complete reenergizing of the igniting means 22 to permit any unburned fuel from the main burner 10 to flow away.

When the heater coil 122 and the bimetal strip 130 cool off sufficiently to cause engagement of the strip 130 with the contact means 134, then the igniting means 22 will again be energized through the described igniter circuit. Another cycle of the system would thus be initiated and the sequence of operation would be as previously described.

While a preferred embodiment of the invention and a modification thereof have been shown and described, it is apparent that many other modifications will occur to those skilled in the art. For example, the separate 4-volt secondary has been employed to indicate that the power consumption may be reduced by this expedient instead of using the 6-volt secondary for all the low voltage circuits. Hence, the invention is not to be deemed limited to the form shown and described or otherwise than as defined by the scope of the claims appended hereto.

I claim:

1. In a control system for fuel burning apparatus having a source of fuel supply, the combination of electrically operable means movable between positions for controlling the fuel supply to be burned, an electronic device having the output circuit thereof connected to said means for supplying operative energy thereto, a bridge circuit comprising a branch connected to the input circuit of said device, and a plurality of resistance means in at least two other branches of said bridge, one said resistance means being responsive to temperature changes caused by the burning fuel for varying in resistance value and being cooperable with the other said resistance means for varying the potential across said input circuit and causing variations in the output energy supplied to said electrically operable means sufficient for movement thereof between said positions.

2. In a control system for fuel burning apparatus having a source of fuel supply, the combination of electrically operable means movable between positions for controlling the fuel supply to be burned, an electronic device having the output circuit thereof connected to said means for supplying operative energy thereto, a bridge circuit comprising a branch connected to the input circuit of said device, and a plurality of resistance means in at least two other branches of said bridge, one said resistance means being responsive to temperature changes caused by the burning fuel and another said resistance means being responsive to the passage of energy therethrough for varying in resistance value, said plurality of resistance means being cooperable for varying the potential across said input circuit and causing variations in the output energy supplied to said electrically operable means sufficient for movement thereof between said positions.

3. In a control system for fuel burning apparatus having a source of fuel supply, the combination of electrically operable means movable between positions for controlling the fuel supply to be burned and including an energizing coil, an electronic device having the output circuit thereof connected to said coil for supplying operative energy thereto, a bridge circuit comprising a detector branch connected to the input circuit of said device, and a plurality of resistance means in at least two other branches of said bridge, one said resistance means being responsive to temperature changes caused by the burning fuel for varying in resistance value and being cooperable with the other said resistance means for varying the potential across said input circuit and causing variations in the output energy supplied to said coil sufficient for movement of said electrically operable means between said positions.

4. In a control system for fuel burning apparatus having a source of fuel supply, the combination of electrically operable means movable between positions for controlling the fuel supply to be burned and including an energizing coil, an electronic device having the output circuit thereof connected to said coil for supplying operative energy thereto, a bridge circuit comprising a detector branch connected to the input circuit of said device, and a plurality of resistance means in at least two other branches of said bridge, one said resistance means being responsive to temperature changes caused by the burning fuel and another said resistance means being responsive to the passage of energy therethrough for varying in resistance value, said plurality of resistance means being cooperable for varying the potential across said input circuit and causing variations in the output energy supplied to said coil sufficient for movement of said electrically operable means between said positions.

5. In a control system for fuel burning apparatus having a source of fuel supply, the combina-

tion of electrically operable means movable between positions for controlling the fuel supply to be burned and including an energizing coil, an electronic device having the output circuit thereof connected to said coil for supplying operative energy thereto, a bridge circuit comprising a detector branch connected to the input circuit of said device, and a plurality of resistance means in the other branches of said bridge, said resistance means including potential divider means and a pair of variable resistors, one said resistor being responsive to temperature changes caused by the burning fuel and the other said resistor being responsive to the passage of energy therethrough for varying in resistance value, said plurality of resistance means being cooperable for varying the potential across said input circuit and causing variations in the output energy supplied to said coil sufficient for movement of said electrically operable means between said positions.

6. In a control system for fuel burning apparatus having a source of fuel supply, the combination of electrically operable means for controlling the fuel supply to be burned and including a relay coil and armature means operable thereby between different positions relative to cooperating contact means, an electronic device having the output circuit thereof connected to said coil for supplying energy thereto, electric igniting means for the fuel having an energizing circuit controlled by cooperation between said armature means and said contact means, a bridge circuit comprising a branch connected to the input circuit of said device, and a plurality of resistance means in at least two other branches of said bridge, one said resistance means being responsive to temperature changes caused by the burning fuel for varying in resistance value and being cooperable with the other said resistance means for varying the potential across said input circuit and causing variations in the output energy supplied to said coil sufficient for operation of said armature between said positions, said igniting means being energized in one thermal condition of said one resistance means and being deenergized in another said condition thereof.

7. In a control system for fuel burning apparatus having a source of fuel supply and main and pilot burners, the combination of electrically operable means for controlling the fuel supply to the main burner, a control device including a relay coil and one set of contact means disposed to be opened and another set of contact means disposed to be closed upon energization of said coil, an electronic device having an input circuit and an output circuit, a source of electrical energy, electric igniting means for the pilot burner, means connecting said output circuit, said source, and said coil, means for biasing said input circuit so as to hold the energy in said output circuit below the value necessary to energize said coil, said last means including a resistance means responsive to temperature changes caused by operation of the pilot burner and adapted to vary in resistance value in one thermal condition to cause a shift in said biasing sufficiently to energize said coil, means for connecting said igniting means to said source and said one set of contacts for energization of said igniting means only when said coil is deenergized, and means for connecting said electrically operable means to said source and said other set of contacts for energization of said electrically operable means only when said coil is energized.

8. In a control system for fuel burning apparatus having a source of fuel supply and main and pilot burners, the combination of electrically operable means for controlling the fuel supply to the main burner, a control device including a relay coil and one set of contact means disposed to be opened and another set of contact means disposed to be closed upon energization of said coil, an electronic device having an input circuit and an output circuit, a plurality of sources of alternating energy, electric igniting means for the pilot burner, means connecting one of the sources of energy to said output circuit and said coil, means for biasing said input circuit so as to hold the energy in said output circuit below the value necessary to energize said coil, said last means including a resistance means responsive to temperature changes caused by operation of the pilot burner and adapted to vary in resistance value in one thermal condition to cause a shift in said biasing to increase the output energy sufficiently to energize said coil, connections between a second of said sources of energy and said last means, and connections between a third of said sources of energy, said igniting means and said electrically operable means, said last connections including both one and the other sets of said contact means for energization of said igniting means and said electrically operable means alternatively.

9. In a control system for fuel burning apparatus having a source of fuel supply, the combination of electrically operable means for controlling the fuel supply to be burned and including an energizing coil, an electronic device having a cathode, anode and control grid, a source of electrical energy, a bridge circuit having opposite junctions connected to said source, a detector branch of said bridge having one terminal connected to said cathode and the opposite terminal connected to said grid, said one terminal being also connected to said source, said coil and said anode in series, said detector branch normally maintaining said control grid at a potential such that said coil is effectively deenergized, and a plurality of resistance means in the other branches of said bridge including a pair of variable resistors, one said resistor being responsive to temperature changes caused by the burning fuel for varying in resistance value and cooperating with the other said resistance means to maintain said control grid at a different potential such that said coil is effectively energized whenever said one resistor is in one thermal condition.

10. In a control system for fuel burning apparatus having a source of fuel supply and main and pilot burners, the combination of electrically operable means for controlling the fuel supply to the main burner, a control device including a relay coil and one set of contact means disposed to be opened and another set of contact means disposed to be closed upon energization of said coil, an electronic device having a cathode, anode and control grid, an electric igniter for the pilot burner, a source of electrical energy, a bridge circuit having opposite junctions connected to said source, a detector branch of said bridge having one terminal connected to said cathode and the opposite terminal connected to said grid, said one terminal being also connected to said source, said coil and said anode in series, said detector branch normally maintaining said control grid at a potential such that said coil is effectively deenergized, a plurality of resistance means in the other branches of said bridge

including a pair of variable resistors, one said resistor being responsive to temperature changes caused by operation of the pilot burner for varying in resistance value and cooperating with the other resistance means to maintain said control grid at a different potential such that said coil is effectively energized whenever said one resistor is in one thermal condition, and means for connecting said igniter and said electrically operable means to said source including both one and the other sets of said contact means for energization of said igniter and said electrically operable means alternatively.

11. In a safety control for fuel burning apparatus having main and pilot burners and means for supplying fuel thereto, comprising electrically operable means responsive to variations in the current value supplied thereto for controlling the supply of fuel for operation of the main burner, an electronic device having the output circuit thereof connected to said means for supplying current thereto, electric igniting means for the pilot burner controlled by said electrically operable means for energization only when the main burner is not operating, means for initially biasing the input circuit of said device so as to hold the current value in said output circuit below that necessary to cause operation of the main burner, said last means including means responsive to a flame at the pilot burner to cause a shift in said biasing sufficiently to cause operation of the main burner, and means electrically connected to said igniting means for delaying energization thereof when said initial biasing is resumed upon failure of the flame at the pilot burner.

12. In a safety control for fuel burning apparatus having main and pilot burners, comprising electrically operable means responsive to variations in the current value supplied thereto for controlling the operation of the main burner, an electronic device having the output circuit thereof connected to said means for supplying current thereto, electric igniting means for the pilot burner controlled by said electrically operable means for energization only when the main burner is not operating, means for initially biasing the input circuit of said device so as to hold the current value in said output circuit below that necessary to cause operation of the main burner, said means including a thermal resistor responsive to a flame at the pilot burner for varying in resistance value to cause a shift in said biasing sufficiently to cause operation of the main burner, and thermally responsive means having a cooling period longer than that of said thermal resistor electrically connected to said igniting means and controlled by said electrically operable means, said thermally responsive means being effective for delaying energization of said igniting means when said initial biasing is resumed upon failure of the flame at the pilot burner.

13. In a control system for fuel burning apparatus having a source of fuel supply and main and pilot burners, the combination of electrically operable means for controlling the fuel supply to the main burner, a first relay for controlling the operation of said electrically operable means, an electronic device, a second relay adapted to be controlled by said first relay, igniting means for the pilot burner controlled by said second named relay, a transformer having a plurality of secondary windings, connections between one

of said secondary windings, said first-named relay and said electronic device constituting the output circuit of said electronic device and controlling the energization of said first-named relay, resistance means connected to a control grid of said electronic device constituting with another of said windings the input circuit of said electronic device, said resistance means including flame responsive means adapted upon the presence of a flame at the pilot burner to shift the grid bias sufficiently to energize the first-named relay for operation of said electrically operable means, connections between another of said windings, said second-named relay and said igniting means to energize said igniting means prior to said operation of said electrically operable means, and further connections between another of said windings and said second named relay to energize said second-named relay independently of the first-named relay and maintaining said igniting means deenergized after said operation of said electrically operable means.

14. In a control system for fuel burning apparatus having a source of fuel supply and main and pilot burners, the combination of electrically operable means for controlling the fuel supply to the main burner, a first relay having control elements for controlling the operation of said electrically operable means, an electronic device, a second relay having control elements and connected to said first-named relay to be controlled thereby, igniting means for the pilot burner controlled by certain of the control elements of said second-named relay, a transformer having a plurality of secondary windings, connections between one of said secondary windings, said first-named relay and said electronic device constituting the output circuit of said electronic device and controlling the energization of said first-named relay for operation of its control elements, resistance means connected to a control grid of said electronic device constituting with another of said windings the input circuit of said electronic device, said resistance means including flame responsive means adapted upon the presence of a flame at the pilot burner to shift the grid bias sufficiently to energize the first-named relay for operation of said electrically operable means, connections between another of said windings, said certain control elements of said second-named relay and said igniting means to energize said igniting means prior to operation of said electrically operable means, and further connections between another of said windings, said second-named relay and other of its control elements to energize said second-named relay independently of the first-named relay and maintain said igniting means deenergized after said operation of said electrically operable means.

CHARLES K. STROBEL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,170,497	Gille	Aug. 22, 1939
2,260,977	Jones	Oct. 28, 1941
2,327,690	Ackerman	Aug. 24, 1943
2,343,001	Cohen	Feb. 29, 1944
2,380,125	Strobel	July 10, 1945
2,397,311	Eskin et al.	Mar. 26, 1946