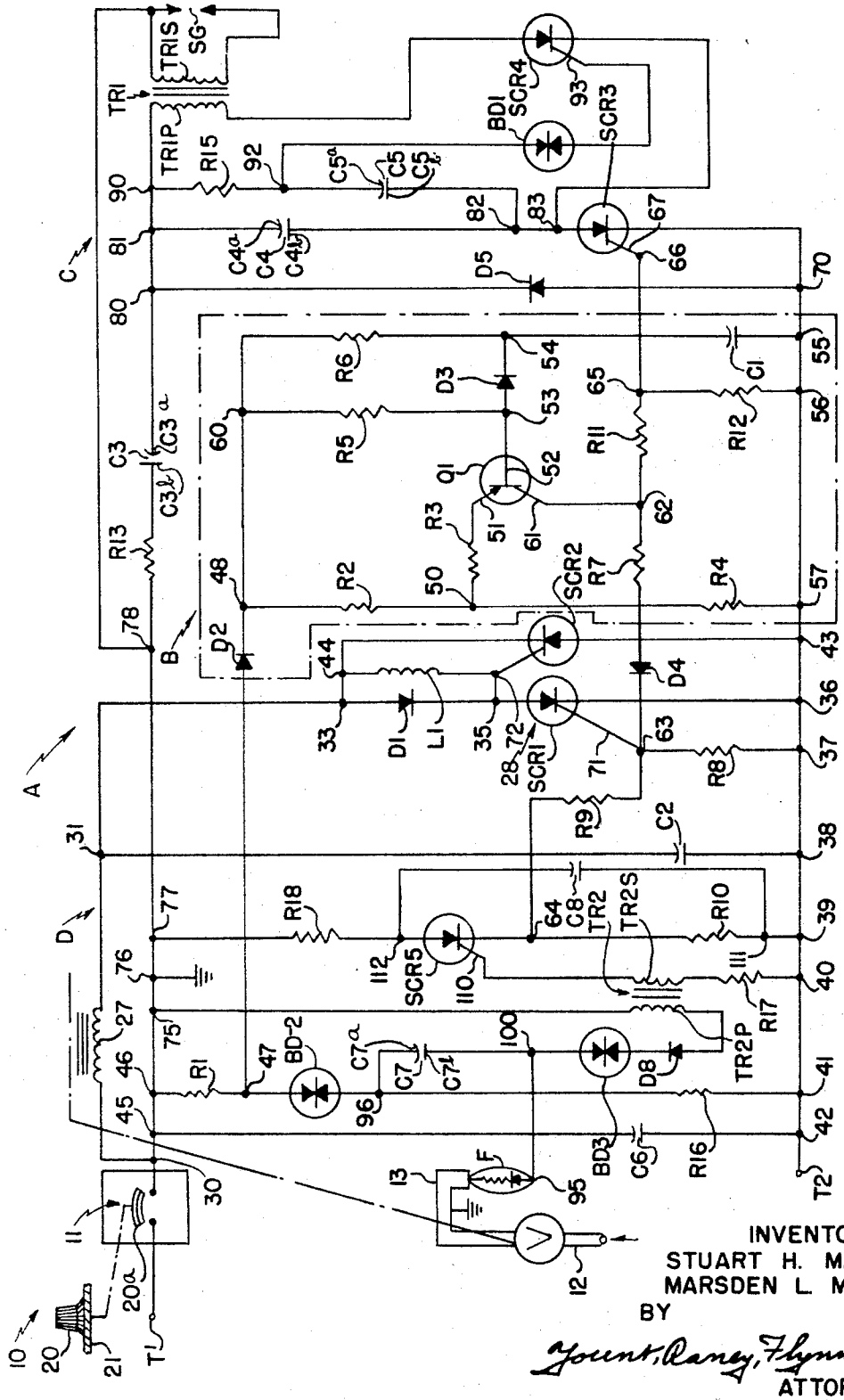
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BURNER CONTROL APPARATUS

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BURNER CONTROL APPARATUS

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ABSTRACT OF THE DISCLOSURE

Burner control apparatus including a burner and an electrically energized valve in a fuel supply conduit therefor, circuitry including a control switch, a pulsing circuit, an igniter circuit and a flame detector circuit which cooperate when the circuit is energized through the switch to produce a supply of fuel to the burner, ignite the fuel, and maintain the supply of fuel to the burner in response to the presence of a flame produced by burning of the fuel. The control switch is a thermostatic switch which opens when a medium heated by the burner reaches a predetermined temperature, closing the valve and resetting the circuitry. In the event that the fuel supply to the burner is not ignited, the fuel supplied thereto is automatically cut off until such time as the control circuitry is reset.

BACKGROUND OF THE INVENTION

(1) *Field of the invention*

The present invention relates to flame control apparatus and more particularly relates to electronic control apparatus for establishing and maintaining a flame at a burner.

(2) *The prior art*

The prior art has proposed electrical systems for supervising flame at a main or pilot burner; however these proposals have required the use of high cost components which are not suitable for use in connection with consumer items such as household stoves, furnaces or the like, by reason of their cost alone.

The use of semiconductor elements in flame control apparatus has resulted in costs which are low enough to permit use in household appliances, but in many instances these elements have not assured fail-safe operation. For example: semiconductor devices can become short circuited without warning and such malfunctions have tended to cause dangerous conditions to obtain. This is particularly so when a malfunctioning semiconductor maintains a fuel supply valve open in the absence of flame at the burner.

SUMMARY OF THE INVENTION

The present invention provides flame control apparatus which is of a relatively low cost due to use of semiconductor circuit elements, but in which malfunctions, such as shorting out of semiconductors, do not cause accumulations of unburned fuel at the burner.

An object of the present invention is the provision of a new and improved burner control operable to provide a flow of fuel to a burner, produce an igniting spark at the fuel burner, sense the presence or absence of a flame produced by burning of the fuel and maintain or discontinue the flow of the fuel to the burner in response to the presence or absence, respectively, of such flame.

Another object of the present invention is the provision of a new and improved burner control including circuitry connected to a AC power supply through a control switch and which circuitry comprises pulsing circuit means effective to produce cyclic pulses for a predetermined, relatively short, period of time after the control switch is closed, first and second switch means connected to the pulsing circuit means and rendered conductive in response to impulses therefrom, a first of the switch means conducting to effect operation of a normally closed fuel supply valve for the burner and the second switch means rendered conductive to initiate operation of a flame ignition circuit, and flame sensing means operable to detect the presence of flame produced by ignition of fuel and to maintain the first mentioned switch means in a conductive state in response to burning of fuel and after the pulsing circuit means is ineffective to produce pulses.

Another object of the present invention is the provision of a new and improved burner control as set forth in the next preceding paragraph wherein the flame detecting circuitry includes a charging circuit connectable to ground through a flame produced by burning of the fuel and a circuit rendered conductive in response to charging of the charging circuit, and wherein the second mentioned circuit is coupled to the first mentioned switch means through transformer means whereby the first switch means is maintained conductive in response to the presence of a flame at the burner.

Another object of the invention is the provision of a new and improved burner control apparatus of the type referred to wherein the ignition circuit means includes a spark gap at the burner, a charging circuit which is charged in response to operation of the pulsing circuit and a triggering circuit for effecting rapid discharging of the charging circuit to produce a fuel igniting spark in the gap and wherein the trigger circuit includes a second charging circuit coupled to a switch means with the switch means rendered conductive when a voltage level in the second charging circuit exceeds a predetermined level.

Other objects and advantages of the present invention will become apparent from a consideration of the detailed description thereof which follows and from the accompanying drawing wherein a burner control embodying the present invention is illustrated.

The burner control **10** illustrated in the drawing includes control circuitry A connected across terminals T1, T2 of an alternating current power supply through a suitably constructed thermostatic switch means **11** and which circuitry A is effective to control operation of a valve V in a fuel conduit **12** which supplies fuel to a burner **13**. As will become apparent from the following description, the circuitry A may be utilized in conjunction with a great number of devices employing burners, however the preferred embodiment of the invention is utilized in conjunction with an oven of a domestic gas fired range to provide controlled, preselected temperatures therein and will be described in reference to such an environment.

The circuitry A is energized in response to manual operation of an oven control knob **20** which is suitably mounted on the chassis **21** of the range, which range has not been illustrated. As is conventional, the knob **20** is associated with suitable indicia for permitting rotation of the knob to a position wherein a desired temperature is to be manitained in the oven. The control knob **20** is drivingly connected to the switch means **11** so as to close contacts of the switch means and complete an energization circuit for the control circuitry A when the oven is to be initially heated, or when the temperature of air in the oven is to be elevated. The switch means **11** may be of any suitable construction, but preferably includes a temperature responsive member **20***a* connected to the knob **20** so that the energization circuit for the circuitry A is completed at sensed oven temperatures below the preselected desired temperature, and interrupted when oven temperatures are above the desired temperature. The switch means **11** additionally includes parts for providing a positive "off" position of the knob **20**, and which parts are not illustrated. The control circuit A is preferably

coupled to a standard 117 volt AC domestic power supply through a suitable transformer, not illustrated, to provide the circuitry with 24 volt, 60 cycle AC power at its power terminals T1, T2. For purposes of description, the terminal T1 is assumed positive with respect to the terminal T2 during positive half cycles of the power supply and the terminal T2 is positive with respect to the terminal T1 during negative half cycles of the power supply.

When the knob 20 is rotated from its "off" position to a position wherein the oven is to be heated, the switch means 11 is closed to effect opening of the valve V. The valve V, which in the illustrated embodiment is a normally closed solenoid operated valve, is opened in response to energization of an AC solenoid 27 connected in the circuitry A through the switch means 11 and in series with a switch means 29 including silicon-controlled rectifiers, SCR1, SCR2. During a positive half cycle of the power supply, an energization circuit for the solenoid 27 can be traced from the positive terminal T1 of the power supply through the switch means 11, a junction 30, the solenoid coil 27, a junction 31, a junction 33, the anode and cathode electrodes of a diode D1, a junction 35, the anode and cathode electrodes of the SCR1, junctions 36–42, and to the negative terminal T2 of the power supply. During a negative half cycle of the power supply an energization circuit for the solenoid coil 27 can be traced from the terminal T2 through junctions 42–36, a junction 43, the anode and cathode electrodes of the SCR2, a junction 44, the junctions 33, 31, the solenoid 27, junction 30, the switch means 11 and to the terminal T1 of the power supply. It will be apparent that the valve V can be operated by means other than a solenoid, for example, a bimetallic member could be utilized to open the valve V in response to conduction of SCR1 and SCR2 to establish a heater circuit for the bimetal.

Immediately after the control knob 20 is actuated to render the oven operative, the switch means 28 is rendered conductive by the operation of a pulsing circuit generally indicated by broken lines at B, and which is effective to provide pulses to the control electrode of the SCR1 during positive half cycles of the power supply, which pulses are produced during a relatively short period after the energization circuit for the control circuitry A has been completed through the switch means 11. The pulsing circuit B includes a PNP transistor Q1 having an emitter-base circuit connected to the terminal T1 during positive half cycles of the power supply through the switch means 11, junction 30, junctions 45, 46, a resistor R1, a junction 47, the anode and cathode electrodes of a diode D2, a junction 48, a resistor R2, a junction 50, a resistor R3, the emitter electrode 41 and base electrode 52 of the transistor Q1, a junction 53, the anode and cathode electrodes of a diode D3, a junction 54, a capacitor C1, junctions 55–57, 43, 36–42, and to the negative terminal T2 of the power supply. A forward voltage is provided across the emitter and base electrodes 51 and 52, respectively, of the transistor Q1 by a voltage divider formed by the resistor R2 and a resistor R4 connected in series therewith, which resistors govern the voltage at the junction 50 connected to the emitter 51, and a resistor R5 which is connected to the base electrode 52 at the junction 53 and to the junction 48 by a junction 60. The voltage drop across the resistor R4 is larger than the voltage drop across the resistors R2, R3 so that the emitter electrode 51 tends to be positive with respect to the base 52 during positive half cycles of the power supply. The cathode electrode of the diode D3 is connected to a series circuit formed by the capacitor C1 and a resistor R6 which are connected between the junctions 48, 56 so that the forward voltage across the diode D3 is dependent upon the charge on the capacitor C1. A charging circuit for the capacitor C1, through the resistor R6 can be traced from the terminal T1 through the switch means 11, junctions 30, 45, 46, resistor R1, junction 47, the diode D2, junction 48, junction 60, the resistor R6, junction 54, the capacitor C1, junction 55, and to the terminal T2 of the power supply. During negative half cycles of the power supply it should be apparent from the construction of the circuitry that the capacitor C1 is not being charged.

When the switch means 11 is effective to complete the energization circuit for the circuit B, the capacitor C1 charges during positive half cycles of the power supply but initially the charge on the capacitor C1 is not sufficient to render the diode D3 non-conductive so that the aforementioned emitter-base circuit of the transistor Q1 is established. When the emitter-base circuit of the transistor Q1 is established, an emitter-collector, or output, circuit thereof is completed due to transistor action of the transistor Q1 and which emitter-collector circuit can be traced, during a positive half cycle of the power supply, from the terminal T1 through the switch means 11, the junctions 30, 45, 46, resistor R1, junction 47, diode D2, junction 48, resistor R2, junction 50, resistor R3, emitter 51 and collector 61 of the transistor Q1, a junction 62, through a resistor R7, a diode D4, a junction 63, a resistor R8, the junction 37, and to the negative terminal T2 of the power supply. The junction 63 is also connected to the terminal T2 through a resistor R9, a junction 64, a resistor R10 and the junction 39. During a negative half cycle of the power supply the emitter-collector circuit of the transistor Q1 is not conductive.

It should be apparent that the capacitor C1 continues to be charged during positive half cycles of the power supply, in the manner described above, and after a predetermined period of time, which is determined by the values of the resistor R6 and of the capacitor C1, the voltage at the junction 54 in the emitter-base circuit of the transistor Q1 is sufficiently high to prevent forward conduction through the diode D3, which has the same effect as if the base 52 of the transistor Q1 is positive with respect to the emitter 51 thereof. In the preferred embodiment, approximately four seconds are required for the capacitor C1 to charge sufficiently to render the diode D3 non-conductive. When the capacitor C1 is so charged, the transistor Q1 no longer conducts during positive half cycles of the power supply. It should be recognized that the diode D3 protects the transistor Q1 from reverse conduction in its emitter-base circuit which might otherwise damage the transistor.

An additional emitter-collector circuit of the transistor Q1 can be traced from the terminal T1 to the junction 48, resistor R2, junction 50, resistor R3, emitter 51, collector 61, junction 62, through a resistor R11, a junction 65, a junction 66 at the gate, or control, electrode 67 of a silicon-controlled rectifier SCR3 to a junction 70 and through junctions 55–57, 43, 36–42 and to the terminal T2 of the power supply. The purpose and function of this additional circuit will be described in greater detail presently.

The first mentioned emitter-collector circuit of the transistor Q1 provides a pulsating voltage at the control, or gate, electrode 71 of the SCR1 to render that SCR conductive during a positive half cycle of the power supply and to establish an energizing circuit through the solenoid 27. Establishment of the energizing circuit through the solenoid 27 opens the valve V as described above and also produces a slight voltage across an inductor coil L1 which is connected between the junction 44 and a junction 72 and in parallel with the diode D1. At the beginning of a succeeding negative half cycle of the power supply the SCR1 becomes non-conductive since the cathode electrode thereof is rendered positive with respect to its anode electrode and the magnetic field established about the inductor L1 due to current flow therethrough collapses to provide an inductive pulse or signal to the gate, or control, electrode 75 of the SCR2, which signal renders the SCR2 conductive. Conduction of the SCR2 maintains the solenoid coil 27 energized and the valve V open during negative half cycles of the power supply as noted. Thus, it is seen that SCR1 and SCR2 of the switch means 28 maintain the solenoid 27

energized and the valve V open in response to operation of the pulsing circuit B so that fuel is supplied to the burner 13 upon closing of the switch means 11.

A capacitor C2 is connected in parallel with the switch means 28 between the junctions 31, 38 and is effective to suppress transients in the SCR circuits.

The fuel supply to the burner 13 is ignited by an igniter circuit, generally designated at C, of the control circuit A. The igniter circuit C includes a spark gap SG located adjacent the burner 13, and circuit means for producing an electric spark across the gap SG to ignite the fuel at the burner in response to operation of the pulsing circuit B. The igniter circuit C is rendered operative by conduction of the SCR3 in response to signals received at the gate electrode 67 thereof from the emitter-collector, or output, circuit of the transistor Q1 in the pulsing circuit B. More specifically, the pulsing circuit B provides a signal at the control electrode 67 of the SCR3 which is positive with respect to the voltage at the cathode thereof during a positive half cycle of the power supply by virtue of a resistor R12 connected between the junction 65 in the output circuit of the transistor Q1 and the junction 56 connected to the terminal T2 of the power supply. The signal thus received at the gate electrode 67 of the SCR3 is effective to render that SCR conductive during positive half cycles of the power supply from the terminal T1 of the power supply through the switch means 11, junctions 30, 45, 46, junctions 75–78, resistor R13, a capacitor C3, junctions 80, 81, a capacitor C4, junctions 82, 83, the anode and cathode electrodes of the SCR3, the junction 70, and to the negative terminal T2 of the power supply.

When the SCR3 is rendered conductive the capacitor C4 is charged in steps, during positive half cycles of the power supply, up to twice the peak voltage at the terminal T1 through a charging circuit from the terminal T1, through the capacitor C3, junctions 80, 81, the capacitor C4, junctions 82, 83, SCR3, and to the terminal T2. When the capacitor is charged as described, the voltage at the plate C4*a* thereof is positive with respect to the voltage at its plate C4*b*.

The aforementioned charging voltage for the capacitor C4 is provided by a voltage doubler circuit including the capacitor C3 and a diode D5 which is connected between the junctions 80, 70 and in parallel with the SCR3. The diode D5 is oriented to conduct during negative half cycles of the power supply to effect charging of the capacitor C3 so that the plate C3*a* thereof is positive with respect to its plate C3*b*. During positive half cycles of the power supply the diode D5 is not conductive and the voltage at the plate C3*b* increases in a positive sense and since the voltage across the capacitor C3 tends to remain constant the voltage at the plate C3*a* is also increased to a peak value of approximately twice the peak value of the voltage at the terminal T1 during a positive half cycle. Thus the peak voltage applied to the plate C4*a* of the capacitor C4 during charging thereof through the SCR3 is approximately twice the peak value of the voltage at terminal T1.

The igniter circuit C additionally includes a trigger circuit for effecting rapid discharging ofthe capacitor C4 through the primary winding TR1P of a transformer TR1, the secondary winding, TR1S, of which is connected in series with the spark gap SG so that the pulse in the primary TR1P induces a voltage in the secondary TR1S of sufficient magnitude to produce an igniting spark across the gap. The discharge path for the capacitor C4 can be traced from the plate C4*a*, through the junction 81, a junction 90, primary TR1P of the transformer TR1, the anode and cathode electrodes of an SCR4, junctions 83, 82 and to the plate C4*b* of the capacitor C4.

The trigger circuit for discharging the capacitor C4 includes the SCR4, a break-down or avalanche type diode BD1, a resistor R15, and a capacitor C5. The resistor R15 and capacitor C5 are connected in series between the junctions 90, 82 and in parallel with the capacitor C4. The capacitor C5 is charged during positive half cycles of the power supply, concurrently with the capacitor C4, by a charging circuit through the junction 90, resistor R15, a junction 92, the capacitor C5, junction 82, SCR3 and to the terminal T2 of the power supply. The rate at which the capacitor C5 charges is lower than the charging rate of the capacitor C4 due to the current limiting effect of the resistor R15, as is well known, and the voltage at the junction 92 rises according to the voltage at the plate C5*a* of the capacitor C5.

The junction 92 is connected to the gate, or control, electrode 93 of SCR4 through the break down diode BD1, and when the voltage at the junction 92 has increased to a level which is sufficiently high to render the break down diode conductive the capacitor C5 discharges through junction 92, diode BD1, gate 93 of SCR4, junctions 83, 82 and to the plate C5*b* of the capacitor. It is apparent that when the capacitor discharges, the SCR4 is rendered conductive to provide the aforementioned discharge path for the capacitor C4 through the primary of the transformer TR1. It will be understood, in reference to the spark gap SG that the accompanying drawing is a schematic illustration and that in practice the spark gap is adjacent the burner 13. The illustrated circuitry shows the spark gap and the burner separated only for convenience of illustration.

During the relatively short time that the pulsing circuit maintains the SCR3 conductive, about four seconds, numerous sparks are produced across the spark gap SG to insure ignition of the fuel at the burner 13. When the capacitor C1 has been charged sufficiently to render the diode D3 non-conductive, the emitter-base circuit of Q1 is interrupted to cause the pulsing circuit B to become ineffective to produce 60 cycle pulses, SCR3 is no longer rendered conductive during positive half cycles of the power supply and the capacitors C4, C5 are no longer charged during such positive half cycles since their charging circuits are interrupted.

During normal operation of the range, it is to be understood that the flame at the burner 13 is established by the sparks produced across the spark gap SG and which flame extends between the burner 13 and a probe 95 which forms part of a flame detector circuit D of the control circuit A. The flame detector circuit D includes elements for maintaining the solenoid coil 27 energized and the valve V open in response to the presence of a flame at the burner 13 and after the pulsing circuit B has been rendered ineffective to maintain the valve V open as described above.

The flame detector circuit D additionally includes means for regulating an controlling the voltage applied across the elements of the circuit D as well as the circuit elements of the pulsing circuit B and the igniter circuit C. The regulator means includes a capacitor C6 connected between the junctions 45, 42, which functions to suppress circuit transients, and a break down diode BD2 which has a breakdown voltage at a predetermined voltage level and is effective to clip the voltages thereacross which have a peak value greater than the predetermined voltage level to thereby maintain voltages across elements of the circuitry A at the predetermined voltage or lower. The regulating circuit established by conduction of the diode BD2 is established between the junctions 46, 41 through the resistor R1, junction 47, the diode BD2, a junction 96, and a resistor R16. The junction 96 and the junction 75 are connected through the primary winding TR2P of a transformer TR2, the anode and cathode electrodes of a diode D8, a break down diode BD3, a junction 100, and a capacitor C7.

During a negative half cycle of the power supply and when a flame is present between the probe 95 and burner 13, a charging circuit for the capacitor C7 is provided between the positive terminal T2 of the power supply through the junctions 42, 41, the resistor R16, junction

96, capacitor C7, junction 100, probe 95, the flame F and to the grounded burner 13. It is to be understood that the circuit is completed through the flame as a result of the well known rectifying effect of flames on electric current.

Due to the presence of the flame F, a charge is developed on the plate C7*a* of the capacitor C7 adjacent the junction 96 while the charge produced at the other plate C7*b* of the capacitor C7 is dissipated to ground through the flame such that during charging of the capacitor C7, the plate C7*a* thereof is positive with respect to the plate C7*b*. During positive half cycles of the power supply, the voltage at the plate C7*a* of the capacitor C7 is substantially equal to the voltage at the relatively negative terminal T2 of the power supply, and since the voltage across the capacitor C7 tends to remain constant, the voltage at the plate C7*b* maintains its negative relationship with respect to the voltage at the plate C7*a* so as to become more negative than the negative terminal T2 of the power supply. It should be appreciated that the negative voltage is maintained at the plate C7*b* of the capacitor C7 due to the inability of the flame F to conduct efficiently from the grounded burner 13 to the probe 95. During positive half cycles of the power supply, the voltage at the cathode electrode of the diode D8 is maintained susbtantially the same as the positive voltage at the terminal T1 so that the voltage across the break down diode BD3 is, in effect, equal to the difference between the voltage at the terminal T1 and the voltage level at the plate C7*b* of the capacitor C7. The break down diode BD3 is selected to have a breakdown voltage of approximately 34 volts so that during a positive alternation of the power supply, when the plate C7*b* of the capacitor C7 is sufficiently negative relative to the terminal T1 of the power supply, the voltage across the break down diode BD3 exceeds 34 volts and that diode breaks down to establish a circuit, for discharging C7, from the terminal T1 of the power supply through the switch means 11, junctions 30, 45, 46, 75, the primary TR2P of the transformer TR2, the diode D8, break down diode BD3, junction 100, and to the plate C7*b* of the capacitor C7.

The circuit established through the break down diode BD3 is effective to induce a voltage in the secondary winding TR2S of the transformer TR2 which provides a pulse, or signal, to the control electrode 110 of an SCR5 so as to render that SCR conductive during positive half cycles of the power supply. The signal circuit can be traced from the secondary winding TR2S through the gate 110 and cathode electrodes of SCR5, a junction 64, resistor R10, junctions 111, 39, 40, a resistor R17 and to the secondary winding TR2S. The SCR5 is rendered conductive to establish a circuit from the terminal T1 through junction 77, a resistor R18, a junction 112, SCR5, junction 64, resistor R10, junctions 111, 39 and to the terminal T2. Additionally a parallel circuit is established from the junction 64 through the resistor R9, junction 63, resistor R8, junction 37 and to the terminal T2. The parallel circuit just described provides a voltage level at the junction 63 (connected to the gate 71 of SCR1) which is effective to render SCR1 conductive and energize the solenoid coil 27 to maintain the valve V open as described previously in reference to the switch means 28. A capacitor C8 is connected to the junctions 112, 111 and around the SCR5 and resistor R10 to suppress circuit transients which might otherwise adversely affect operation of the SCR.

The capacitor C7, which controls the pulse rate of TR2, is chosen so that when a flame is present between the burner 13 and probe 95, the primary TR2P of the transformer TR2 is pulsed during every positive half cycle of the power supply and thereby maintains the switch means 28 conductive and the solenoid 27 of the valve V energized in response to such flame thus maintaining the valve V open at all times when a flame is present at the burner 13. If the flame between the probe 95 and burner 13 is extinguished for some reason, or is not initially ignited, the capacitor C7 is not charged during negative half cycles of the power supply since the voltage at the plate C7*b* thereof cannot be dissipated to ground through the flame F. It should be apparent that when the capacitor C7 is not charged the voltage across the break down diode BD3 never becomes sufficiently high to render that diode conductive and consequently the primary TR2P of the transformer TR2 receives no pulses during positive half cycles of the power supply.

When the oven is to be initially heated, the control knob 20 is rotated from its "off" position to a position wherein a desired temperature is to be maintained in the oven, thereby closing contacts of the switch means 11 and energizing the circuit A. The energization of circuit A opens the valve V, ignites the fuel at the burner 13 and maintains the valve V open, as described above. When the oven temperature reaches the preselected temperature, contacts of the switch means 11 open in response thereto, to de-energize the circuitry. When the contacts of the switch means 11 open, the capacitor C1 discharges through the resistor R6, junctions 60, 48, resistor R2, junction 50, resistor R4, and junctions 57, 56, 55, resetting the pulsing circuit B. Because of the relatively large resistance of the discharge path of the capacitor C1, resetting may take as long as 10 seconds however, this period is much shorter than the time required for the switch means 11 to reclose under normal circumstances. When the temperature in the oven is reduced below the preselected temperature, the switch means 11 recloses and the circuitry A is recycled in the manner described.

It can now be seen that an improved burner control has been provided which is effective when energized to provide a flow of fuel to a burner, to ignite the fuel flowing from the burner and to maintain the flow of fuel to the burner in response to combustion thereof and which is also effective to cut off the flow of fuel from the burner when combustion of the fuel is discontinued or when the ignition thereof is not originally effected and that such a burner control, utilized in conjunction with a thermostatic switch is operative to provide accurate, reliable and safe control of temperatures of mediums to be heated.

The following circuit elements and their values have been found suitable for use in the circuitry illustrated in the drawing.

Resistors:

R1	ohms	180
R2	do	1.5K
R3	do	1K
R4	do	470
R5	megohms	4.7
R6	ohms	680K
R7	do	2.2K
R8	do	4.7K
R9	do	180
R10	do	330
R11	do	2.2K
R12	do	1.2K
R13	do	180
R15	megohms	1
R16	ohms	330
R17	do	1K
R18	do	330

Diodes:		Type
D1	50 volts	B–50
D2	50 volts	B–50
D3	50 volts	B–60
D4	50 volts	B–50
D5	100 volts	B-100
D8	50 volts	B–50

Transistor:	
Q1	MPS 3638

Silicon-controlled rectifiers:

SCR1	50 volts	C106A
SCR2	50 volts	C106A
SCR3	100 volts	C106F
SCR4	100 volts	2N2888
SCR5	50 volts	C106A

Transformers:

TR1	Aladdin 29–2095
TR2	Aladdin 317–153

Inductor:

L1	Aladdin 17–475

Break down diodes:

BD1	34 volts	STD–34
BD2	34 volts	STD–34
BD3	34 volts	STD–34

Capacitors:	Mf.
C1	10
C2	0.047
C3	20
C4	20
C5	0.047
C6	0.047
C7	0.0047
C8	0.047

While a single embodiment of the present invention has been illustrated and described herein in considerable detail, it should be understood that the present invention is not to be considered to be limited to the precise construction shown, for example, such a control is well suited for use in top burners of domestic gas ranges as well as for gas fired furnaces, water heaters and the like, whether domestic or industrial. It is, therefore, our intention to cover hereby all adaptations, modifications and uses of the present invention which come within the scope of the appended claims.

Having described our invention, we claim:

1. Burner control apparatus including a burner, and circuitry connectable to an AC power supply for controlling the temperature of a medium heated by a flame at the burner and comprising, thermostatic control switch means closed to render said circuitry operative, valve means including a valve member positioned in a fuel supply conduit for said burner and electrically energized actuating means for moving said valve member to a position wherein fuel flows to said burner, said actuating means having an energizing circuit connected across said power supply through said control switch means and a second switch means, said second switch means comprising a semiconductor element having a control electrode which renders the semiconductor conductive in response to a current pulse to the control electrode, pulsing circuit means operative to produce pulses for rendering said second switch means conductive to open said valve means, said pulsing circuit comprising, a rectifier, a charging circuit connected to said rectifier and operable to provide a gradually changing voltage level at a point therein, a transistor having its control electrode connected to said point in said charging circuit and with its input circuit connected across said power supply through said rectifier, said transistor having an output circuit connected to said second switch means and operable to transmit pulses thereto during alternate half cycles of said power supply, said charging circuit means effective to render said transistor non-conducting a predetermined time after closing of said switch means and flame detector circuit means for sensing flame at said burner and for maintaining said semiconductor conductive after said predetermined time as long as flame is sensed at said burner.

2. Apparatus as defined in claim 1 wherein said charging circuit means includes a resistance element connected to said rectifier and a capacitor serially connected to said resistance element and with said point located between said resistance element and said capacitor so that a gradually increasing voltage level is provided at said point, said inpuut and output circuits of said transistor rendered non-conductive when said voltage at said point increases to a predetermined level.

3. Apparatus as defined in claim 2 wherein said capacitor in said charging circuit is discharged after said control switch is open to reduce the voltage at said point below said predetermined level and thereby reset said pulsing circuit means.

4. Apparatus as defined in claim 1 wherein said flame detector circuit means includes elements for producing pulses in response to the presence of a flame at said burner including a pulse transformer and further including a control semiconductor rendered conductive by pulses in a secondary winding of the transformer for rendering said semiconductor switch conductive subsequent to said transistor of said pulsing circuit means being rendered non-conductive.

5. Apparatus as defined in claim 1 wherein said thermostatic control switch means operates in response to temperature of the heated medium and opens to deenergize said valve means and disconnect at least said charging circuit from said power supply when medium temperatures are above a preselected temperature, and said control switch means reclosing at medium temperatures below said preselected temperature to permit reenergization of said valve and pulsing circuitry.

6. Burner control appartus as defined in claim 1 and wherein said charging circuit means continues charging through said rectifier after said predetermined time has elapsed and until said rectifier is nonconductive, and further including elements defining a discharge path for said capacitor, said discharge path connected in parallel with said capacitor and in series with said rectifier, and wherein said capacitor discharges through said path when said control switch is open.

7. Burner control apparatus as defined in claim 1 wherein said electrically energized actuating means of said valve means includes a solenoid and said semiconductor element of said second switch means comprises a silicon controlled rectifier connected in series with said solenoid and said thermostatic control switch means.

8. Burner control apparatus as defined in claim 1 wherein said flame detecting circuit means comprises at least an electrode spaced from the burner for establishing conduction through flame at the burner during alternate half cycles of the power supply, a capacitor connected in a circuit with the electrode and charged in response to conduction through a flame, a voltage responsive conductor rendered conductive when said capacitor is charged to a predetermined level, and a pulse transformer having a primary winding in series with said voltage responsive conductor and a secondary winding for producing a pulse in response to conduction through said primary winding and said voltage responsive conductor.

9. Burner control apparatus as defined in claim 8 and further including a controlled rectifier having a control electrode connected in a circuit with said secondary winding and anode and cathode electrodes connected in a circuit with the control electrode at said second switch means, a current pulse in said secondary winding effective to render said controlled rectifier conductive to provide a current pulse through said control electrode of said second switch means.

10. Apparatus for controlling flame at a burner comprising:

(a) an electric power supply;

(b) an electrically energized fuel control valve having a deenergized condition in which the valve is closed and an energized condition in which the valve is open to supply fuel to the burner;

(c) a semiconductor switch connected in a circuit with said valve and including a control electrode which is effective to render said semiconductor conductive to energize said valve in response to a current to said control electrode;

(d) a timing circuit operable to transmit current to said control electrode for energizing said fuel valve, said timing circuit including elements for rendering said timing circuit operable for a brief period and preventing transmission of current to said control electrode thereafter;

(e) flame detecting circuitry operable to produce current in response to the presence of flame at the burner;

(f) and coupling circuitry between said flame detecting circuitry and said control electrode for transmitting current to said control electrode so that said fuel valve is maintained energized after said period while flame is sensed at the burner.

11. Apparatus for controlling flame at the burner as recited in claim **10** wherein said timing circuit elements comprise a charging circuit including a resistor and capactor connected in series, said timing circuit further including a transistor having a control electrode connected to a point in said charging circuit and an output circuit connected to said electrode of said semiconductor switch, said charging circuit having a charge condition permitting conduction of said transistor when said timing circuit is initally energized and a second charge condition preventing conduction of said transistor after said period so that the said fuel control valve cannot be maintained open by operation of said timing circuit after said period.

12. Apparatus as defined in claim **11** and further including a thermostatic control switch connected in circuit between said power supply and at least said charging circuit of said timing circuit, said control switch having an open position in which said charging circuit is disconnected from said power supply, and wherein said timing circuit further includes circuit elements establishing a discharge path for said capacitor, said capacitor discharging through said path only when said thermostatic control switch is open.

13. Apparatus as defined in claim **12** wherein the impedance of said discharge path is greater than the impedance of the path through which said capacitor is charged so that the interval during which said capacitor is discharged is longer than said period.

14. Apparatus as recited in claim **10** and further including electrically operated fuel ignitor circuitry, said ignitor circuitry including elements for producing sparks at a burner and an ignitor control switch having a conductive condition for rendering said ignitor circuit effective to produce sparks, said ignitor control switch having a control electrode connected to said timing circuit and rendered conductive by said timing circuit during said period.

15. Apparatus for controlling flame at a burner as recited in claim **10** wherein said flame detecting circuitry produces current pulses in response to the presence of flame at the burner, said coupling circuitry comprising a pulse transformer having the primary winding in said flame detecting circuitry and a secondary winding, said coupling circuitry further including circuit elements connected to said secondary winding for transmitting current to said control electrode of said semiconductor switch so that said semiconductor switch energizes said control valve when flame is present at said burner.

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