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SOLID STATE CONTROL SYSTEM FOR PILOT LIGHT FUEL BURNER

Filed Oct. 24, 1966

FIG. 1

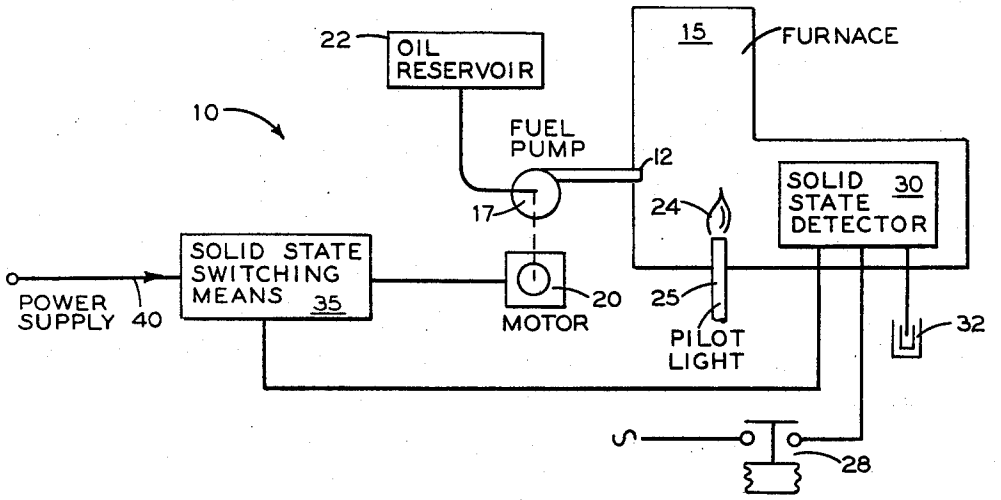


FIG. 2

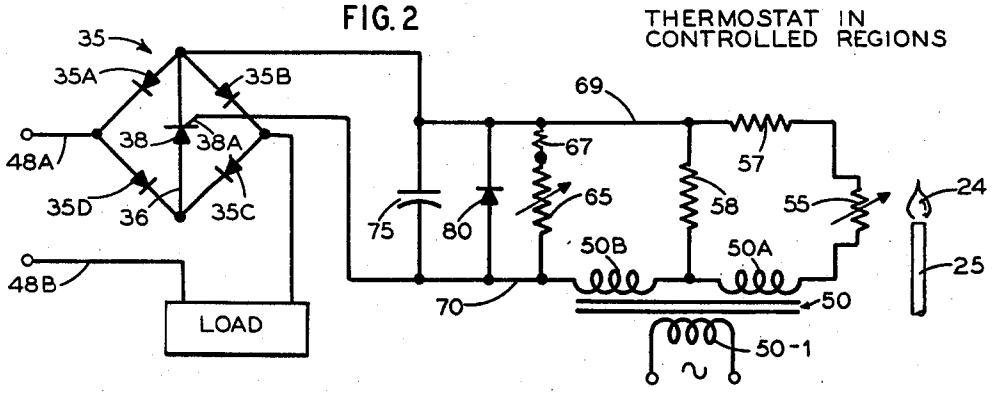
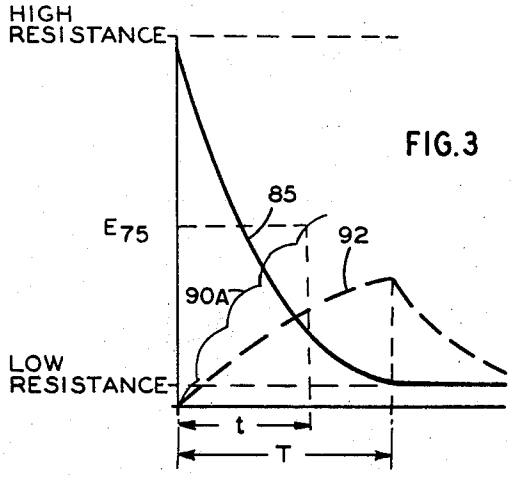


FIG. 3



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ABSTRACT OF THE DISCLOSURE

A pilot light detection system which includes a bi-directionally conducting diode bridge connected between an energy source and a fuel pump motor. Conduction of the bridge is initiated by a silicon controlled rectifier connected across the diagonal of the bridge. Conduction of the silicon controlled rectifier is controlled by a pilot light responsive device which is adapted to be disabled in a predetermined interval of time if no pilot light is present to shut off the supply of fuel to the burner.

This invention relates to a control system utilizing solid state and static components for controlling a fuel burner system for a fuel burner equipped with a pilot light, in order to permit the supply of fuel to the burner when the pilot light is operative to ignite the fuel supplied to the burner, and to prevent the supply of fuel to the burner when the pilot light is accidentally extinguished and would therefore be unable to ignite any fuel supply to the burner.

A control system which employs relays and other movable parts for controlling the operation of the fuel burner requires considerable space and correspondingly large boxes or covers for protection against dust and other undesirable external materials. Among the functions of such control system is the detection of the condition of a pilot light used with the fuel burner in order to determine whether the pilot light is burning as it should be, or whether the pilot light has become accidentally extinguished.

The present invention is directed to a control system in which solid state components are utilized with appropriate circuitry to accomplish the switching operations required between an alternating current supply circuit and an alternating current motor for driving the fuel pump, with solid state elements arranged in special circuitry to detect the condition of the pilot light, that is, whether the light is burning or extinguished, in order to permit the operation of the switching means to energize the motor when the pilot is operating and available to ignite fuel if fed to the burner, and to prevent the operation of such solid state switching means to the motor if the pilot light is accidentally extinguished.

The switching means between the supply circuit in the motor for the pump includes a four armed bridge with a diode on each arm of the bridge, and a control diode in the cross diagonal of the bridge to render the bridge conductive bilaterally for alternating current when the control diode is conductive, and to hold the bridge in non-conducting condition so long as the control diode in the diagonal circuit is not biased to conduction.

The conductivity of the bridge is thus controlled by an arrangement of solid state circuitry which serves as the detector that determines the lighted or unlighted condition of the pilot light for the burner.

The burner may be for a heating system for a room or building, or for a furnace in which a predetermined temperature is of achieved or maintained. Thus the existence or nonexistence of such predetermined temperature may be utilized to operate a thermostat or equivalent control

equipment to initiate the demand on the control system contemplated herein for supplying fuel to the burner.

The operation of the detection system for the pilot light also uses the solid state components as previously mentioned and contemplates circuitry for charging or for discharging or preventing the charging of a condenser which is charged to accumulate voltage needed to bias the controlled diode of the switching means into conduction, or the condenser is short-circuited to prevent it from accumulating a voltage sufficient to bias such diode into conduction.

A main object of the invention is to provide a control system for a fuel burner which system will employ and utilize only solid state or static components in the detection elements for the pilot light and in the switching circuitry between the power supply and the motor that drives the fuel pump.

Another object of the invention is to provide a novel switching system utilizing a Wheatstone type bridge in which the diagonal circuit is controlled to be conductive or non-conductive of the bridge as a switching means for transmitting energy from a supply circuit to the fuel pump motor.

Another object of the invention is to provide a control circuit utilizing solid state and static components for ascertaining the lighted or unlighted condition of a pilot light of the furnace or of the burner, and for then appropriately controlling the switching means bridge between the supply circuit and the motor.

The nature of the components employed and their arrangement in the control system are described in the following specification, taken together with the description of the accompanying drawings, in which

FIG. 1 is a schematic, functional block diagram of the burner and the control system embodying the present invention;

FIG. 2 is a specific circuit diagram showing the particular components utilized in the control circuitry of the system in accordance with the present invention; and

FIG. 3 is a graph showing the time relationship between the charging curve of the bias condenser associated with the pilot light detector system and shows further a second graph of the change in resistive condition of the thermistor element which operates to control the effectiveness of the bias condenser.

As shown in FIG. 1, the control system **10** embodying the principles of the present invention, is supplied to control the operation of a burner **12** which is supplied with fuel, for example, oil in this case, through a blower **17**, driven by an electric motor **20** to supply the fuel oil from a reservoir **22** to the burner **12**, when a demand is made for fuel to be supplied to the burner, and the condition of the burner is correct for normal operation to ignite such fuel, as indicated by the existence of a flame burning at the pilot light.

Assuming that the burner is employed to heat some region which may be a room or a furnace space, some suitable temperature detector **28** will be utilized to respond to the temperature of that space or room and provide a demand signal for energy to the furnace, when needed, to establish or to maintain the desired temperature in that region.

Thus, as may be seen in FIG. **1** when a demand for heat is made by the operation of the thermostat or temperature detector **28**, the pilot light detector **30** determines whether fuel may be safely supplied to the burner and if the pilot light is burning the detector **30** operates the switching means **35** to connect the motor to the supply circuit and drive the pump **17** to supply fuel to the burner.

However, if the pilot light flame **24** is extinguished so

that there is no flame available to ignite fuel that would be supplied to the burner, the pilot light detector **30** operates to hold the solid state switching means **35** in nonconductive condition so that no energy can be supplied from the electric supply line **40** to the motor, and the equipment is left stationary.

One of the functional features of the pilot light detector **30** involves the provision of a time element which provides a time interval that is sufficient to enable the control system to function, if the pilot light flame is burning and operatively available. If the flame is not available, the pilot light detector will not function to operate the switching means **35** into conductive condition. Consequently, after the time interval provided for in the detector **30** the system will be locked into nonconducting condition and the switching means **35** prevented from operation, in order to direct attention to the fact that there is something wrong in the system so that suitable supervision will be attracted to correct the existing trouble.

To indicate the existence of such a time element function in the operation of the pilot light detector **30**, the dashpot **32** is shown.

As shown in more detail in FIGURE 2, the solid state switching means **35** of FIG. 1 is now shown in its complete form as a Wheatstone type bridge having four arms with a diode means in each arm disposed as shown, and identified as **35A** to **35D** respectively. These arms of the bridge are connected in series with the one conductor **48A** of the supply circuit but are so oriented that the bridge is nonconductive to either positive or negative pulse of the alternating current unless the diagonal circuit **36** is made conductive.

The diagonal circuit **36** of the bridge **35** is shown as including a controlled diode **38**, such as a silicon control rectifier, which is a diode with an auxiliary electrode **38A** to inject a suitable bias voltage and current to move the diode **38** into conduction. When the diode **38** becomes conductive, even though it is conductive in one direction only, the bridge **35** becomes bidirectionally conductive to transmit both positive and negative pulses of the alternating current which will go through the diodes of the four arms in the directions indicated, while traversing the diagonal diode **38**, always in the same direction.

The use of this diode bridge with the diagonal diode to render the bridge bidirectionally conductive, is one of the features of this invention.

The bias voltage for the diagonal diode **38** is either provided through the electrode **38A**, or is withheld, thereby to prevent bias operation of the diode **38A**, depending upon the existence or absence of the pilot light **25**.

The detector **30** for the condition of the pilot light consists of a circuitry **30** which includes a transformer **50** having a primary **50–1** and a split secondary having two parts **50A** and **50B**. The circuit energized from the transformer secondary **50A** includes the thermistor **55** and a protective limiting resistor **57**. The resistance of the thermistor **55** drops to a low value due to the presence of the pilot flame **25**.

The transformer secondary **50B** also includes a circuit containing a thermistor **65** and a limiting resistor **67**, proceeding to a common conductor **69**. The outer terminal of the secondary winding **50B** goes to a conductor **70**. Between the two conductors **69** and **70** is connected a capacitor **75** which serves to receive and accumulate pulses from the secondary winding **50A** and **50B** of the transformer, under certain conditions as will be presently explained. Paralleling the capacitor **75** is a diode **80** which cooperates with the capacitor **75** and the thermistor **65** to provide for the establishment of a time element in the form of a time delay in the accumulation of the critical voltage in the capacitor **75** that will be sufficient to supply the operating bias to fire the control diode **38**.

A resistor **58** is disposed in the mutual circuit between the two sections **50A** and **50B** of the transformer secondary to provide current limiting action with respect to the

two thermistors **55** and **65** in their own circuits while at the same time permitting the thermistor **65** to serve as a low resistance device or short circuiting device essentially across the terminals of the capacitor **75** to prevent the capacitor **75** from accumulating charge and increasing its voltage, if it does not do so within the short time interval required for the thermistor **65** to drop its resistance value from its normally high resistance while cold, to a very low resistance when heated by its self heat due to the current through the thermistor **65**.

The manner in which the two thermistors **55** and **65** function may now be briefly considered.

When the main switch or thermostat **28** indicates a need for more heat in the burner and closes to energize the primary of the transformer **50**, the two secondaries **50A** and **50B** energize their two related circuits through the two thermistors **55** and **65**. At the same time, the alternating current voltage across the thermistor **65** as represented by the voltage difference between conductors **69** and **70**, is impressed across the two terminals of capacitor **75** and across the two terminals of the diode **80**. The positive pulses will go through the diode **80** as a substantially zero resistance, thereby practically preventing any charge from entering the capacitor **75** during the positive pulse. During the negative pulse from the transformer secondary circuit, the diode **80** is nonconductive and therefore substantially of high resistance. Similarly, the thermistor **65** is initially of relatively high resistance as are the other two circuits including the resistor **58** and the thermistor **55** and its limiting resistor **57**. Consequently, the current charge into the capacitor **75** is relatively small. Thus each negative wave of the alternating current puts a very small current charge into the capacitor **75**. In the meantime however, the thermistor **65** is self heating and its resistance diminishes with the increase in its self temperature. At the same time, if the flame **25** of the pilot light is present and burning, the thermistor **55** is heating more quickly and therefore reducing its temperature more quickly than the self heating condition in the thermistor **65**.

Thus if the pilot flame **25** is burning, the resistance in thermistor **55** will diminish to a low value so that the current through the resistor **57** and into condensor **75** will increase. Under such conditions, the condenser **75** will charge fast enough to reach the critical bias value for the control diode in the bridge **35** rather quickly. Such bias voltage will be reached before the resistance of thermistor **65** can drop low enough to a value sufficient to constitute a short circuit across the condenser **75**.

However, if the flame at the pilot light **25** is not burning, the thermistor **55** will remain at a high resistance value, and very little current will be transferred into the capacitor **75**, while at the same time the thermistor **65** is reducing its resistance with increase in temperature. After a short time interval, according to the characteristics of the thermistor **65**, the resistance of that thermistor **65** will be sufficiently small to short-circiut the capacitor **75** and lock it out so that it cannot accumulate any voltage that would rise to the bias value necessary to operate the diode in the bridge.

The manner in which these operations in thermistor **65** and in condenser **75** occur may be now seen upon reference to FIG. 3. As there shown, curve **85** shows how the value of the resistance of thermistor **65** drops from its high value to a low value after a time interval indicated by T. With the circuit as arranged, the thermistor **65** may thus be utilized to provide a time interval measured by the time element indicated by the letter T.

FIG. 3 indicates, by the stepped curved **90A** the manner in which the capacitor **75** becomes charged by a series of negative waves under normal conditions that would not be affected by the resistance of the thermistor **65**. Thus without any action on the part of the thermistor **65** the voltage across the capacitor **75** as indicated by the symbol E75 would reach the bias voltage value during the small

interval indicated by *t*. In this case, the voltage across the capacitor **75** has reached its critical bias value for the diode **38** before the resistance of the thermistor **65** has dropped to a value sufficient to prevent the capacitor **75** from increasing voltage. Consequently, upon attaining the bias voltage across the condenser **75** the diode **38** will be caused to operate and the continued reduction in resistance of the thermistor **65** to short-circuit the condenser **75** will then be ineffective to change the state of conductivity of the diode in the conducting bridge **35**.

On the other hand if the flame **24** is not present at the pilot light, the thermistor **55** will remain cold, at high resistance, and the charge on the condenser **75** will follow a slower curve such as indicated by the broken line graph **92**, which will not enable the capacitor **75** to reach the bias voltage value until long after the thermistor **65** has dropped to its short-circuiting, low resistance value after the interval indicated by T in FIG. 3. Thereupon, the short-circuit across the capacitor **75** will prevent a voltage across **75** from rising and will in fact provide a short circuit that will discharge the condenser **75** so that its voltage will be far below the critical bias voltage.

When the temperature in the region heated by the burner rises to a value above the desired temperature to be established or maintained, the thermostat device **28** will open its circuit to deenergize the primary winding of the transformer **50**, whereupon the bias voltage will be removed from the controlled rectifier **38** and that controlled rectifier **38** will drop back into its non-conducting state, which will thereupon open the circuit between the two arms of the bridge **35** and thus render the bridge nonconductive to the alternating current of the circuit.

Thus by means of the arrangement as is here illustrated and by the use of solid state devices connected in the circuitry as here disclosed, a simple and effective solid state control system is provided which will control the supply of energy or fuel to a burner, only under safe conditions when the pilot light is functioning and availible to ignite the fuel that would be fed to the burner.

While modifications of the circuitry and of the devices as employed and illustrated herein may be made within the spirit of the invention and without departing from the scope of the claims herein, what is claimed is:

1. A solid state control system for controlling the transfer of energy from an alternating current supply circuit to a load circuit, such a control system comprising a four-arm bridge having two circuits with two connected arms in series in each of said circuits, with a common junction point between the two arms of each circuit and in which each arm contains a unidirectional solid state device; means connected to constitute a diagonal circuit for said bridge between said junction points, with said diagonal circuit containing a solid state unidirectional conducting device with a control electrode to stimulate said conducting device into conduction of current between said two junctions to thereby conduct both polarities of an alternating current through said bridge from the supply circuit to the load circuit; means connected to said control electrode for exciting said control electrode to render said bridge bidirectionally conductive between said supply and said load; said load circuit including a motor for driving a pump to feed oil to an oil burner having a pilot light to ignite the oil at the burner; said means for exciting said control electrode for said unidirectional conductive device in a diagonal circuit of said bridge including means responsive to a condition of said pilot light; said system further including

means for establishing a demand for energy to the pump motor from the supply circuit;

and means for shunting said exciting means to prevent operation of the bridge if said exciting means for the unidirectional conductive device is not made effective within a predetermined time interval after said demand is established.

2. A control system utilizing solid state current conducting components for controlling the transmission of current from an alternating current supply circuit to an alternating current motor in a load circuit, according to the existence of a condition related to said load circuit, said system comprising a network of unidirectional conducting elements including a control element effective to render the network bidirectionally conductive or to render said network unconductive to current between said supply circuit and said load, said control element consisting of a diode device having an exciting electrode; means responsive to the existence of a predetermined condition related to the load for energizing the exciting electrode to render the network conductive to transfer current from the supply circuit to load;

means for demanding energy supply to said load;

means for energizing said condition-responsive means to sense said predetermined condition when demand is made for energy to said load;

and means including time-measuring means for permitting said condition-responsive means to be effective to energize said exciting electrode within a pre-measured interval and for preventing said condition-responsive means for energizing said exciting electrode after the expiration of said pre-measured interval.

3. A control system, as in claim **2**, in which said network consists of a bridge of unidirectional devices and said control element consists of a controlled rectifier having a control electrode and a cathode to excite said controlled rectifier to conduction;

and said means responsive to the existence of a predetermined condition consists of a thermistor device connected between said control electrode and said cathode having a high resistance value at low temperature and a low resistive value at elevated temperature.

4. A control system for a fuel burner having a pilot light and a motor-operated pump to supply fuel to said burner; said control system comprising

a voltage supply circuit to supply energy for the pump motor;

solid state switching means for transmitting energy from the supply circuit to said pump motor;

means normally holding said solid state switching means in non-conducting condition;

and means responsive to a condition of the pilot light for controlling the effectiveness of said normally holding means to selectively permit or prevent biasing of said solid state switching means into conduction.

5. A control system for a fuel burner having a pilot light and a motor operated pump to supply fuel to said burner, said control system comprising an electric supply line; an electric motor to operate said fuel pump; an electronic switch to connect said supply line to said motor; means responsive to said pilot light according to whether said pilot light is burning or accidentally extinguished, for controlling the operation of said electronic switch either for transmitting current to the motor if the pilot light is burning, or for holding said electronic switch open if said pilot light is accidentally extinquished;

said electronic switch comprises a four-arm Wheatstone bridge with diode means in each arm, and a diagonal circuit containing a diode with a bias-control electrode to bias the diode into conductivity;

and said pilot-light-responsive means includes a capacitive means to accept a charge for accumulation to reach the voltage to energize said control electrode to proper bias to operate its diode, with means for discharging said condenser thereby to prevent accumulation of bias voltage to the operating value necessary to operate said diode to conductivity.

6. A control system, as in claim **5**, in which said capacitor is connected to said diagonal circuit diode and the

bias-control electrode thereof to impress bias voltage on said bias-control electrode;

and said pilot-light-responsive means further includes a first resistive element for impressing a gradually increasing voltage on said capacitor toward a critical value sufficient to bias the diode into conduction, and includes a second resistive element for short-circuiting the capacitor if the critical bias value of voltage is not attained within a predetermined interval starting when the accumulating voltage is first impressed on the capacitor.

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