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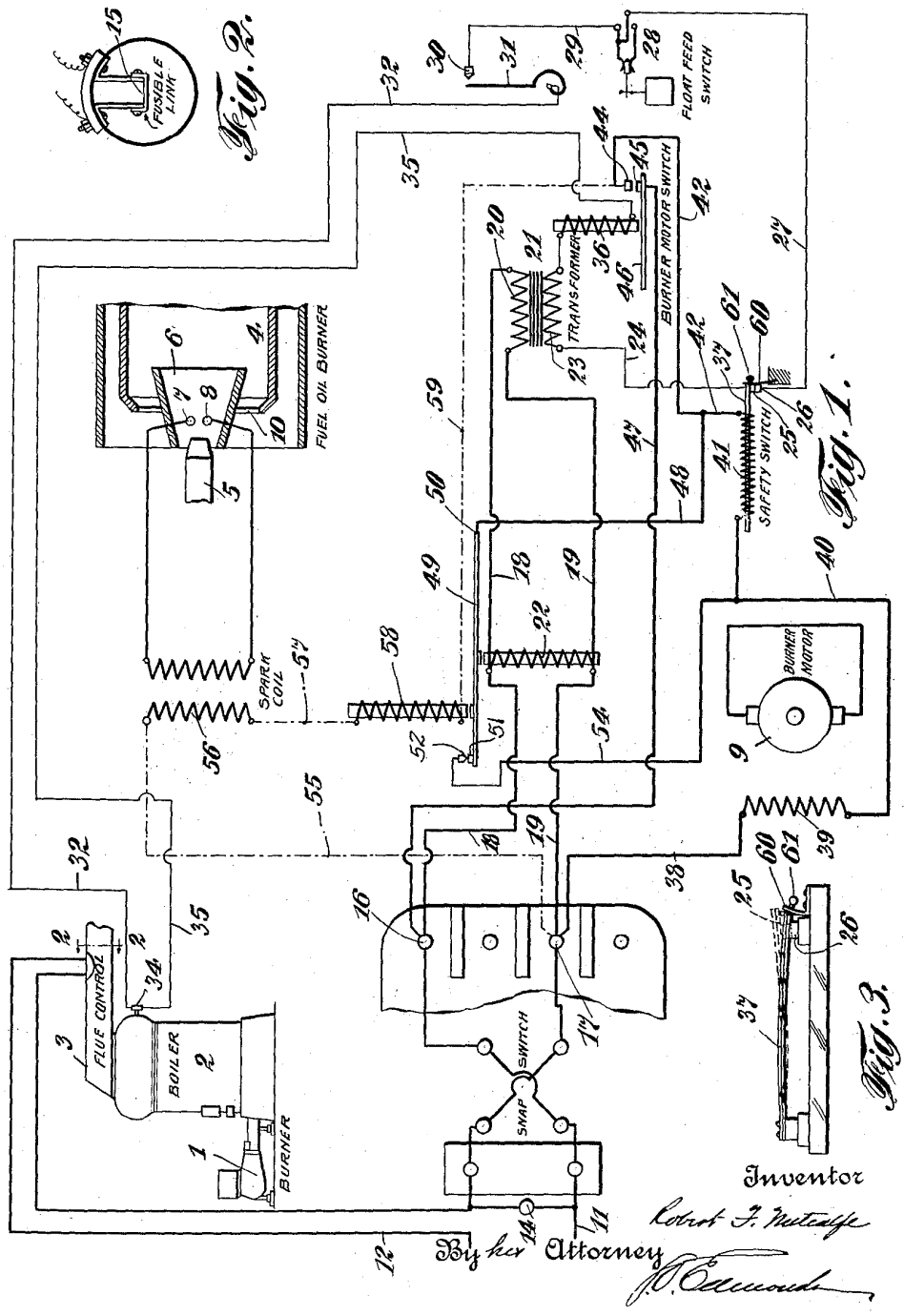

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METHOD OF AND APPARATUS FOR CONTROL OF LIQUID-FUEL BURNERS.

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This invention pertains to a new and novel method, and the means therefor, for electrically controlling the operations of an apparatus.

In particular the invention has to do with the utilization of the variations in the conditions of gases at a definite location in an apparatus for the purpose of varying the electrical control of the apparatus.

My invention, in one of its particular uses, will be described as being applied to and incorporated in a liquid fuel burner especially adapted for use in homes, and apartments and, in industrial work, to the heating of heat treatment furnaces, chemical vats and the like. It is to be understood that my invention may also be employed in other apparatus and for other like uses.

I have discovered that there is a variation in the response to the passage of electrical current through a mixture of gases within a combustion chamber of a liquid fuel burner, before combustion takes place and after combustion takes place.

In my discovery and in providing suitable electrical and mechanical apparatus responsive to these variations, I found that the automatic operation of a fuel burner may be controlled in a novel and improved manner to accomplish an efficient operation and to thereby assist in eliminating fire hazards and dangers to persons, apparatus and buildings.

It is well known that automatically operating fuel burners have been in use for a considerable period of time. It is also well known that the use of liquid fuel, such as lighter weight oils, have been employed in such burners. It has long been recognized that some part of the automatic control of such burners is responsive to a heat condition at some definite point. It is desired to combine with such control an improved means to increase the efficiency of operation of such burners in that they will automatically be fully stopped if ignition of the fuel does not take place when the burner starts up, or when there is a cessation of combustion of the fuel after the original ignition has been accomplished.

This invention, therefore, has as its main object the provision of a novel method of operation and desirable means for controlling an apparatus by utilizing the variations in the composition of gases at some predetermined point in the apparatus.

It is also an object of this invention to provide a novel and improved control means which cooperates with other control features of an automatic fuel burner and which is responsive to the conditions of the gases within the burner or in a furnace in which the burner is placed or in the stack leading from the furnace.

It is a further object of my invention to provide a cooperating control means which is subject to being varied by reason of the electrical conductivity of gases within the burner.

A particular object of my invention is to provide an improved control for a liquid fuel burner whereby the variations in the gases which pass between the points of a spark ignition plug are utilized to maintain the burner in operation or to stop the burner.

Other objects and advantages of my invention will be appreciated as the detailed description set forth below is read.

While the invention hereinafter disclosed in detail has been shown as applied to a fuel burner constructed to operate on liquid fuel such as heavy oil, it is understood that a part of the control may be responsive to gases which develop in the burning of coal. Also the position of the responsive means may be within the burner itself, within the furnace with which the burner is associated or in the stack leading from the furnace, or in any other desirable position where its function will be carried on.

The preferred manner in which I desire to disclose my invention is herein shown in the accompanying drawing representing a liquid fuel heating system, and in this drawing:

Fig. 1 is a diagrammatic view of the preferred form of electrical control showing a furnace and a burner associated therewith and an enlarged portion of the burner, all combined with certain safety means;

Fig. 2 is an enlarged view of one of the safety devices taken on the line 2—2 of Fig. 1, and

Fig. 3 is an enlarged view of a desirable form of safety switch shown in diagrammatic form in Fig. 1.

Referring now to the drawing, a suitable liquid fuel burner 1 is shown in association with a heat absorbing device such as a boiler or furnace 2 which in turn is provided with a suitable flue or stack 3. A combustion chamber 4 of the burner is shown in section in Fig. 1 and the burning of the fuel may

be totally or partially accomplished within this combustion chamber. A suitable pipe 5 provides for the introduction of the fuel with air to support combustion into the usual cone 6. The combustible mixture preferably consists of oil and air in the form of gases and is preferably ignited by the passing of sparks between the electric contacts 7 and 8 which usually form parts of a spark-plug. It has been found desirable to mount the spark-plug in the cone 6.

The fuel burner 1 is usually provided with some means of operation and in this instance I have provided a suitable motor 9 which performs the functions of supplying oil and air to the pipe 5 and supplying a supplementary amount of air through an opening 10 so that the complete combustion of the oil may be obtained for the purpose of heating the water or air within the furnace 2.

Any suitable means may be provided for controlling the operation of the liquid fuel burner, but I have found it desirable to provide an electrical control system. I, therefore, provide electrical supply lines 11 and 12 having a suitable indicating lamp 14 placed across the lines at a point between a fusible link 15 and a suitable snap switch in order to note that there is a proper supply of electricity. Usually this supply is of 110 volts as taken from the house supply lines. The line 12 passes through a safety device preferably in the form of a fusible link 15 (Fig. 2) mounted in the flue of the boiler 2. The electrical supply lines pass through a suitable snap switch to terminal posts 16 and 17.

One circuit of the control system, which may be designated as a subelectrical circuit, comprises leads 18 and 19 which are connected to a primary winding 20 of a suitable transformer 21. Connected in the lines 18 and 19 is an electro-magnet or relay 22, the operation of which will hereinafter be described. From the secondary winding 23 of the transformer 21 an electrical conductor 24 leads to a contact 25, which is normally closed on contact 26.

A conductor 27 leads to a float switch 28 and from there by means of conductor 29 to contact 30 which cooperates with a moving part 31 of a suitable thermostat that may be located near the boiler 2 or at any desirable place in the home. A conductor 32 leads to the usual aquastat 34 mounted in the boiler. A conductor 35 leads from the other side of the aquastat to an electro-magnet 36 which in turn is connected to the other side of the secondary winding 23 of the transformer 21.

The float feed switch 28 is adapted to open the control when the supply of liquid fuel, such as oil, is either too high or too low. If the supply of oil is not proper it is usually found that an explosive mixture is fed to the combustion chamber 4 of the burner and this float switch 28 prevents the starting of the burner unless the proper supply of liquid fuel is available. The aquastat 34 operates to open the circuit in the event there is a dangerous low water condition in the boiler 2. It is well understood that the aquastat may be supplemented by a pressure device which will open the circuit when the pressure of steam within the boiler 2 becomes excessive. When any of these switches are opened, which would be due to abnormal existing conditions, it will be noted that the normal closing of the thermostat 31 would have no effect in starting the burner. Under normal conditions the closing of the thermostat would start the burner and the burner would continue in operation until the thermostat opened due to the desired amount of heat having been supplied.

The contacts 25 and 26 are normally in engagement and I have preferred to mount contact 25 on the free end of a metallic member 37 which member will automatically move to separate contact 25 from contact 26 when the metallic member 37 has become heated to a predetermined extent as will be hereinafter described. The separation of contacts 25 and 26 will likewise prevent the starting of the burner when the thermostat 31 normally closes, or if during the running of the burner these contacts should be opened the burner will be automatically stopped.

A second subcircuit leading from the terminal posts 16 and 17 consists of a lead 38 which passes through a field winding 39 of the burner motor 9 and through the conductor 40 to a winding 41 which is associated with the metallic member 37. It is preferred to place this winding 41 around the metallic member as illustrated in Fig. 1, although it may be associated in any other desirable form. An electrical conductor 42 leads from the other end of the winding 41 to a contact 44 which is adapted to be engaged by a contact 45 carried on an arm 46 which in turn is influenced by the magnet or relay 36. A conductor 47 leads from the contact 45 to terminal post 16.

A part of this invention consists in providing some means for holding winding 41 out of circuit during normal operation. In accomplishing this end I have provided a shunt circuit around the winding 41 associated with the metallic member 37, and in providing this shunt circuit a conductor 48 leads from conductor 42 to a flexible contact carrying member 49 preferably pivoted at 50 and having its free end provided with a contact 51 which engages a suitably mounted contact 52 which in turn is connected by a conductor 54 that leads to the conductor 40.

Another electrical subcircuit of the control system is that illustrated by conductor 55 which leads from terminal post 17 to the primary winding 56 of a spark coil transformer. A suitable conductor 57 leads from the other end of winding 56 to a magnet or relay 58 and

from there conductor 59 leads to contact 44. When the contacts 44 and 45 are closed the spark coil winding 56 and the magnet 58 are connected to the other side of the supply line at terminal post 16 by means of conductor 47.

The safety device in the flue or stack as illustrated by the fusible link 15 is provided to open the electrical supply circuit in case of failure of aquastat 34, or when the water has been boiled out of the boiler or furnace 2, for under those conditions it will be seen that there will be no water in the boiler to absorb the heat and thus there will be an excessive amount of heat passing through the flue. This excessive heat acts to fuse the link 15 and open the electrical supply circuit thereby stopping the operation of the burner. If desired, another type of safety means for accomplishing the same end may be employed.

The metallic member 37 illustrated in detail in Fig. 3 may be any desired type of heat responsive means. For matter of convenience I have called it a metallic member. Preferably it consists of two strips of metal which have different coefficients of expansion and they are fastened together so that upon being heated the metallic member will automatically bend and its free end will rise. Since the free end carries contact 25 it will be seen that this contact will be carried away from contact 26. Other types of circuit opening heat responsive means may be employed if desired.

In order to prevent the movement of the metallic member 37 unless the actual desired conditions for its movement exist, I have herein provided a suitable means for maintaining the member 37 in its normal position. This preferred means consists of a catch 60 having a suitable handle 61. When the metallic member 37 is in its normal position this catch engages, preferably by friction, the end of that member and is forced somewhat out of its normal position. When the metallic member 37 is heated and bends it overcomes the frictional engagement between it and the catch 60 and passes out of engagement with the catch 60. It will be noted from Fig. 3 that the catch will then move to the left and upon the cooling of the member 37 the catch prevents this member from returning to its normal position that permits contact 25 to engage contact 26. It is desired that a manual operation be performed to reset this switch. This operation is accomplished by moving the catch 60 by grasping its handle 61 and pulling it somewhat to the right and thus permitting the contact 25 to return to engagement with contact 26. Thus the preferred safety switch consists of the metallic member 37 with its various elements and it may be returned to its normal operating position by a suitable manual movement. The manual movement may be substituted by a remote control device if desired. In the specification and claims it is desired to refer to this switch as the heat responsive safety switch.

One of the main features of my invention is to utilize the phenomenon of the variation in resistance to the passage of sparks between any two contacts. The resistance in this instance is offered by the gases within the combustion chamber 4. I have found that I may take advantage of this phenomenon by utilizing the resistance to the passage of sparks between the points of the spark-plug employed for igniting the combustible mixture. It is to be understood, however, that I may, in addition to the presence of a spark-plug, introduce two other contacts within the combustion chamber 4 and connect them suitably in the electrical control system so that the system may be varied due to the resistance to passage of sparks between the contacts and to cause the control system to close down or stop the burner when the resistance to the passage of the sparks continues for a length of time sufficient to cause the heat responsive safety switch to operate. In this instance I find that I may obtain the utilization of this variation of resistance of the gases by connecting suitable means or apparatus in the circuit which includes the spark-plug. I have, therefore, in the drawings only shown contacts 7 and 8 as being employed. The spark-plug operates for both that is, for igniting the mixture and for taking advantage of the variations of resistance to the passage of sparks between the two contacts.

It will be noted that upon the start of the burner that there will be a supply of gas passing between the spark-plug contacts which supply is more or less pure air, and this will then be changed by the introduction of fuel in its vaporized state as it also issues from the pipe 5. The two intermixed gases passing from the pipe 5 change the resistance to the passage of the sparks between points 7 and 8 from the resistance offered by the substantially pure air. In this case the resistance is reduced. When combustion takes place within the combustion chamber 4 it has been found that some of the burning gases will find their way back into the cone 6 and these gases become mixed with the gases issuing from pipe 5 and will thereby cause a different mixture of gases between the contacts 7 and 8. It has been found as a result of experiment that under normal burning conditions that the gases between the points 7 and 8 offer less resistance to the passage of sparks between these points than the resistance offered by substantially pure air passing from the pipe 5. It will be noted that when the resistance between points 7 and 8 to the passage of sparks is material there will be a relatively small flow of electrical current through the primary winding

56 of the spark coil in accordance with Ohm's law, and since electro-magnet 58 is connected in series with winding 56 there will be a relatively small ampere-turn result in magnet 58. When the resistance to passage of sparks between points 7 and 8 is less there will consequently be an increase of electrical current passing through the winding 56 and through the winding of the electro-magnet 58. Under that condition the strength of magnet 58 will be increased. I, therefore, take advantage of the resistance to the passage of sparks between the points 7 and 8 for varying the electrical control system which in turn controls the operation of the burner.

In the operation of the device, assume that contacts 25 and 26 are closed and that the float feed switch 28 and the aquastat 34 are closed, the burner 1 will then be placed in operation or started upon the closing of the thermostat arm 31 on to contact 30. The closing of these contacts completes the secondary winding circuit through the transformer 21 and the electro-magnet 36 operates to close the contacts 44 and 45 thereby permitting the burner motor 9 to start. Upon the closing of contacts 44 and 45 the spark coil becomes energized and likewise the electromagnet 58. When the secondary winding 23 of the transformer 21 is closed there will be a larger flow of current through the primary circuit of the transformer and electro-magnet 22 will be come active to pull the flexible switch arm or member 49 downward to maintain the contacts 51 and 52 open.

As noted above, in the starting of the burner there will be a supply of air and of atomized fuel between the contacts 7 and 8 and there will be a relatively high resistance and consequently electro-magnet 58 will exert a comparatively small force and will not pull the flexible lever 49 away from the influence of electro-magnet 22 thereby closing the shunt circuit around the heat responsive safety switch.

In case the fuel does not ignite at once the influence of electro-magnet 58 will still continue less than the influence of magnet 22 as there will be less current passing through the spark-plug circuit as the resistance to the passage of sparks between points 7 and 8 still maintains the same, and current will then pass through coil 41 of the heat responsive safety switch and will heat the metallic member 37 and cause it to rise to the dotted line position noted in Fig. 3 and will thereby cause contacts 25 and 26 to separate, thus opening the circuit and stopping the operation of the fuel burner. The burner may be again started only after the manual operation of pulling catch 60 to the right to permit contacts 25 and 26 to return to engaging position.

Assume now, that upon the start of the burner ignition takes place, the resistance of the gases between the contact points 7 and 8 will be decreased as above noted and consequently the amount of current required to pass through winding 56 and through electro-magnet 58 will increase, and since electro-magnets 58 and 22 are designed in the proper manner to balance against each other the magnet 58 now becomes predominating over magnet 22 and draws the flexible arm 49 upward to close contacts 51 and 52 thereby closing the shunt circuit around the heat responsive safety switch. In that condition the current required for the operation of the burner motor then passes through conductor 38, winding 39, conductor 40, conductor 54, contacts 51 and 52, flexible arm 49, conductor 48 to contact 44 and from there back to terminal post 16 by means of conductor 47. The operation of the burner will now continue normally until the thermostat opens and the burner automatically ceases operation.

Should the fire or burning of the gases in the combustion chamber 4 go out or cease for any reason there will then be a higher resistance to the passage of sparks between the contact points 7 and 8 as noted above and consequently there will be a decrease of current in coil 56 and through magnet 58 causing magnet 22 to predominate over magnet 58 thereby pulling flexible arm 49 down and opening the shunt circuit around the heat responsive safety switch. As soon as this heat responsive safety switch has heated up as it will normally do when current passes through winding 41, it will separate contacts 25 and 26 thereby so varying the electrical control system that it is opened by means of the de-energization of the electro-magnet 36 causing contact 45 to separate from contact 44.

It will thus be seen from the foregoing description that my new and novel control of an oil or liquid fuel burner is accomplished by the utilization of the variation of conditions of mixture of the gas between electrical contact points suitably mounted in the combustion chamber of a fuel burner. If desired the same thought may be expressed in detail in respect to the present disclosure by saying that the control of the fuel burner is responsive to the conditions of gases at the points of the spark-plug. It will be further noted that this method of control gives a means for regulating the burner independent of the pressure or temperature existing in the combustion chamber and is dependent upon the resistance to the passage of electric sparks between two given contact points. In the particular disclosure I have utilized the electrical energy change in the primary winding of spark coil transformer to vary or change the control system of the oil burner, and in so doing I have, in the preferred disclosure, balanced one electro-magnet against another and arranged to have one of these electro-magnets

predominate under certain conditions and to have the other electro-magnet predominate under other conditions. It will also be noted that any variations in the voltage in the supply line will apply throughout the whole apparatus and therefore be compensated.

It will be understood that while I have herein described in detail a particular embodiment of my invention for purposes of full disclosures and some detailed features which I am specifically claiming for a special advantage, many changes and modifications may be made in the particular construction and arrangement of parts without departing from the broad scope of my invention.

I claim:—

1. In combination, a liquid fuel burner, a combustion chamber therein for receiving a mixture of gases capable of combustion, electrical contacts positioned in said chamber and adapted to have the gases pass around and between them, an electrical control system for said burner, said system having included therein means for passing sparks across said contacts for igniting the mixture of gases, and another means in said electrical system controlled by the resistance offered by the gases to the passing of sparks between said contacts while the sparking continues for varying said electrical control system to stop the operation of said burner.

2. In a fuel burner, means for operating the same, an electrical control system for governing the operation of said burner, contacts mounted within said burner and spaced apart so that electric sparks may pass from one contact to another, said contacts being mounted so that the gases within the burner may move into contact therewith and fill the space therebetween, and means in said electrical control system responsive to continuous high resistance of the gases through which sparking occurs for opening the electrical control system to stop said burner.

3. In a liquid fuel burner, means for operating the burner, means for controlling the operation of said burner, a spark-plug in said controlling means for igniting the fuel, said controlling means being responsive to the resistance offered by the gases in the burner to the passing of sparks across the points of said plug while the sparking continues to vary the controlling means under conditions of a continued high resistance to stop said burner.

4. In combination, a liquid fuel burner, a combustion chamber therein for receiving a mixture of gases capable of supporting combustion, an electrical system for controlling the operation of said burner, spark-plug terminals mounted in said combustion chamber and adapted to have the gases pass therebetween, said terminals being included in the electrical system, a transformer means in said electrical system for causing sparks to pass between said terminals, a magnet in circuit with said transformer means and adapted to have its strength varied as the gases in said chamber resist the passage of sparks between said terminals, and a cut-out means also included in said electrical system and being controlled by the variation in the strength of said magnet and operating to vary said electrical system by opening the same when said magnet continues to exert relatively small strength.

5. In combination a liquid fuel burner, a combustion chamber therein adapted to receive a mixture of gases capable of supporting combustion, an electrical control circuit for governing the operation of said burner, a spark-plug connected in said electrical circuit and adapted to ignite said combustible mixture, a heat responsive safety switch included within said electrical circuit and adapted to open said circuit after being heated to a predetermined temperature, means in said system for shunting said safety switch during normal operations of said burner, and means also in said electrical system influenced by the resistance of the gases to the passage of sparks between the points of said spark-plug to open the shunt around said heat responsive safety switch to permit said switch to become operative.

6. In combination a liquid fuel burner, a combustion chamber therein adapted to receive a mixture of gases capable of supporting combustion, an electrical control circuit for governing the operation of said burner, a spark-plug connected in said electrical circuit and adapted to ignite said combustible mixture, a heat responsive safety switch included in said electrical circuit and adapted to open said circuit after being heated to a predetermined temperature, a magnet included in the immediate spark-plug circuit, a switch in the control circuit for shunting electric current around said heat responsive safety switch, said magnet normally holding the shunting switch in closed position, and means operating in opposition to the strength of said magnet for holding open said shunting switch when the energy required to pass sparks between the contacts of said spark-plug against high resistance is substantially contant thereby permitting the heat responsive safety switch to operate to stop the operations of said burner.

7. In combination a liquid fuel burner, a combustion chamber therein adapted to receive a mixture of combustible gases, means for operating said burner, an electrical system for controlling the operation of said burner, a spark-plug mounted in association with said combustion chamber for igniting the combustible mixture, a subelectrical circuit in said control system in which said spark-plug is connected, a magnet also connected in said subelectrical circuit and adapt-

ed to vary in strength in accordance with the resistance offered by the gases to the passage of sparks between the points of said spark-plug, a second sub-electric circuit in said control system, a magnet connected in said second subcircuit, a heat responsive safety switch connected in said control system, a shunt connection around said heat responsive safety switch, a flexible member carrying a contact to open and close the shunt circuit around said heat responsive safety switch, said flexible member being mounted to be influenced by said magnets in opposite directions, said second magnet acting to maintain open the shunt around said heat responsive safety switch to permit said heat responsive safety switch to be actuated when the resistance of the gases to the passage of the sparks is constant and great to thereby open the control system to stop the burner.

8. In combination a liquid fuel burner, a combustion chamber therein for receiving a mixture of gases capable of combustion, means for operating said burner, an electrical control system for said burner, a spark-plug associated with said combustion chamber for igniting the mixture of gases, a transformer mounted in the control system and having a magnet connected in the high voltage side thereof, burner control devices connected in the low side of said transformer, means in the high voltage circuit for impressing a potential across the terminals of said spark-plug, a second magnet in the high voltage circuit of said control system, a heat responsive safety switch also mounted in the high voltage circuit of said control system, a circuit for shunting the passage of current around said heat responsive safety switch, a switch mounted in said shunt circuit, said shunt circuit switch adapted to be influenced by said magnets which are positioned to oppose the action of each other, said first magnet becoming effective to open said shunt circuit when the resistance to the passage of sparks between the terminals of said spark-plug is abnormally high.

9. In combination, a liquid fuel burner, a combustion chamber therein for receiving a mixture of gases capable of combustion, electrical contacts positioned in said chamber and adapted to have the gases pass around and between them, an electrical control system for said burner, said system having said electrical contacts included therein, means in said control system for passing sparks across said contacts for igniting the mixture of gases, another means in said electrical system affected by the gases, when unignited by the sparks, and offering relatively high resistance to the passing of sparks between said contacts while the sparking continues for varying said electrical control system to stop the operation of said burner, and a thermostat responsive to heat conditions at a predetermined place, for operating said burner intermittently.

10. In combination, a liquid fuel burner, a combustion chamber therein for receiving a mixture of gases capable of combustion, electrical contacts positioned in said chamber and adapted to have the gases pass around and between them, an electrical control system for said burner, said system having said electrical contacts included therein, means in said control system for passing sparks across said contacts for igniting the mixture of gases, another means in said electrical system affected by the gases, when unignited by the sparks, and offering relatively high resistance to the passing of sparks between said contacts while the sparking continues, said other means adapted to vary said electrical control system to stop the operation of said burner, a thermostat responsive to heat conditions at a predetermined place for operating said burner intermittently, and safety devices in the electric control system for preventing the operation of said burner when said thermostat closes if the burner is in abnormal condition.

11. In combination, a liquid fuel burner, a combustion chamber therein for receiving a mixture of gases capable of combustion, electrical contacts mounted in said chamber and adapted to have the gases pass around and between them, an electrical control system for said burner, said system having said electrical contacts included therein, means in said control system for passing sparks across said contacts for igniting the mixture of gases, a magnet connected in circuit with the spark passing means and capable of being excited to a greater or less degree due to the variations in electrical current in said spark passing means caused by the variations in resistance offered by the gases to the passage of sparks between said contacts, a heat responsive safety switch connected in said electrical control system which when actuated opens said control system and stops the burner, a circuit in said system for shunting said heat responsive safety switch, a switch in said shunt circuit adapted to be influenced by said magnet to maintain closed said shunt circuit when the resistance of the gases to the passage of sparks is relatively small, and a thermostat positioned to be responsive to heat conditions at a predetermined place and arranged to cause said burner to normally operate intermittently.

12. In combination, a liquid fuel burner, a combustion chamber therein for receiving a mixture of gases capable of combustion, electrical contacts mounted in said chamber and adapted to have the gases pass around and between them, an electrical control system for said burner, said system having said electrical contacts included therein, means in said control system for passing sparks across

said contacts for igniting the mixture of gases, a magnet connected in circuit with the spark passing means and capable of being excited to a greater or less degree due to the variations in electrical current in said spark passing means caused by the variations in resistance offered by the gases to the passage of sparks between said contacts, a heat responsive safety switch connected in said electrical control system which when actuated opens said control system and stops the burner, a circuit in said system for shunting said heat responsive safety switch, a switch in said shunt circuit adapted to be influenced by said magnet to maintain closed said shunt circuit when the resistance of the gases to the passage of sparks is relatively small, a thermostat positioned to be responsive to heat conditions at a predetermined place and arranged to cause said burner to normally operate intermittently, and safety devices connected in series with said thermostat to prevent operation of said burner when abnormal conditions exist.

13. In a liquid fuel burner the combination of a combustion chamber, a spark-plug mounted in said chamber in the path of liquid fuel and air fed to said burner, an electrical control system for governing the operation of said burner, a sub-electric circuit in said system for supplying current to said spark-plug, an electro-magnet in said subcircuit, the strength of said magnet being varied due to the variation in current flowing in said magnet in response to the resistance offered to the passing of sparks between the points of said spark-plug due to the variation in conductivity of the gases between the points of said spark-plug, a second subcircuit in said control system, a magnet connected in said second subcircuit, a third subcircuit in said system, a heat responsive safety switch mounted in said third subcircuit and adapted to open the control system under abnormal conditions of operation, a shunt circuit connected around said heat responsive safety switch, a flexible switch member mounted in said shunt circuit, said flexible switch member being responsive to the differences of the pulls of said magnets, said flexible switch member adapted to be opened by said second magnet when the resistance to the passage of sparks between the points of said spark-plug is continuous and material thereby permitting current to flow through said heat responsive safety switch causing the same to open said electric control system and stop the operation of said burner.

14. In combination, an operating apparatus having a varying mixture of gases therein during operation, and electrical means for controlling the operation of said apparatus, said electrical means having included therein electrical contacts mounted in spaced relation to form a spark gap and being positioned in the path of said gases, said electrical means adapted to be varied by the changes in the resistance to the passage of sparks between said contacts due to the variations in the electrical conductivity of said gases to maintain continuation of operation of said apparatus under predetermined conditions and to stop said operations under other conditions.

15. In combination, an operating apparatus having a varying mixture of gases therein during operation, and electrical means for controlling the operation of said apparatus, said electrical means having included therein electrical contacts mounted in spaced relation to form a spark gap and being positioned in the path of said gases, said electrical means adapted to be varied by the changes in the resistance to the passage of sparks between said contacts due to the variations in the electrical conductivity of said gases to maintain continuation of operation of said apparatus under predetermined conditions and to stop said operations under other conditions, and means in said electrical control system being brought into operation when the resistance to the passage of sparks between said contacts is high and continuous thereby varying the electrical control to stop the operation of said apparatus.

16. The method of controlling the operation of a liquid fuel burner which includes maintaining the passage of sparks across a gap located in the combustion area of the burner, and controlling the operation of the burner in response to the lesser resistance offered by the gases at the gap to the passing of said sparks across said gap when there is combustion of said gases than when there is no combustion thereof.

This specification signed this 5th day of May, 1926.

ROBERT F. METCALFE.