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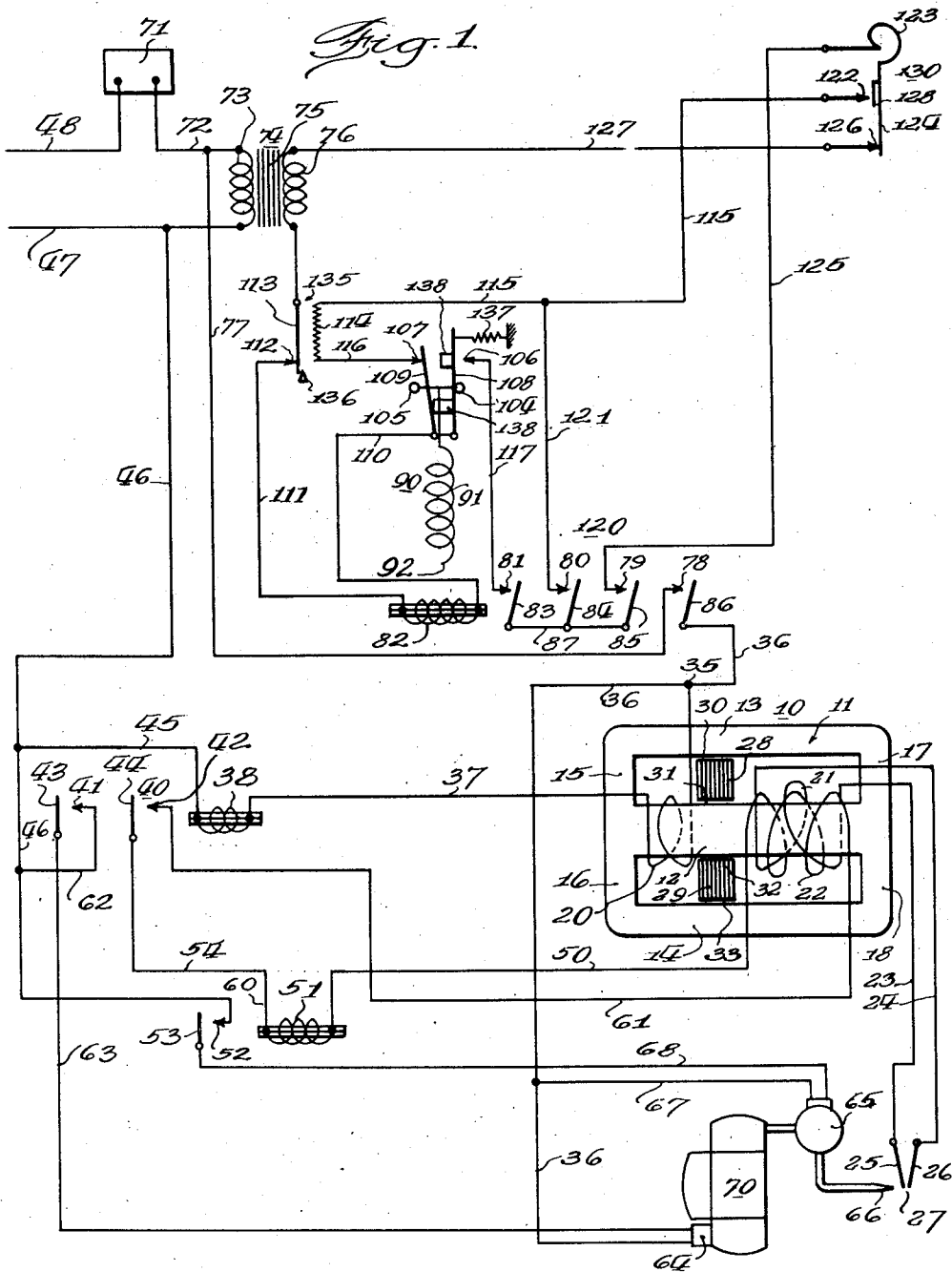
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SAFETY FUEL IGNITION DEVICES

Filed May 27, 1940

3 Sheets-Sheet 1



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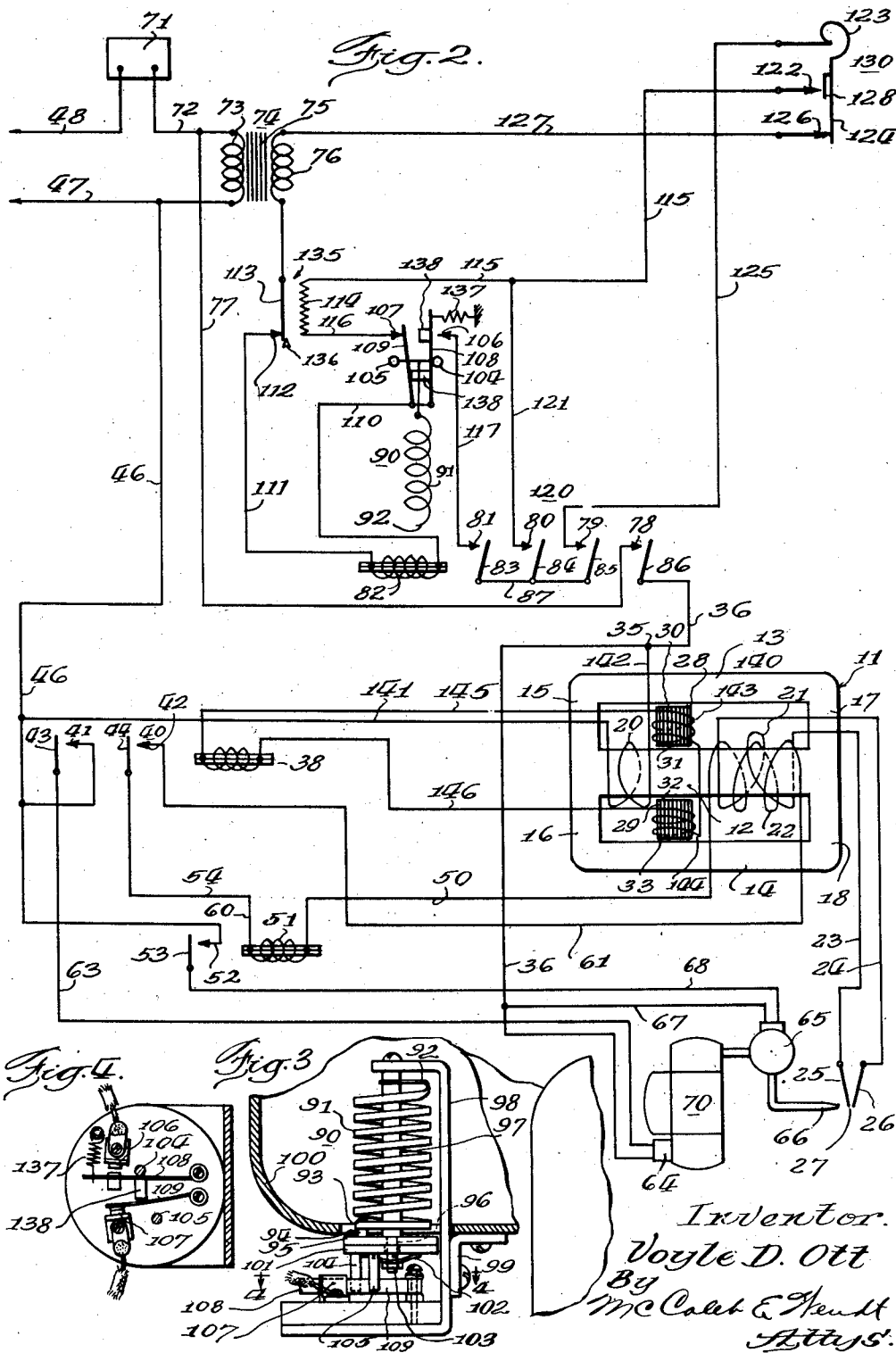
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SAFETY FUEL IGNITION DEVICES

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3 Sheets-Sheet 2



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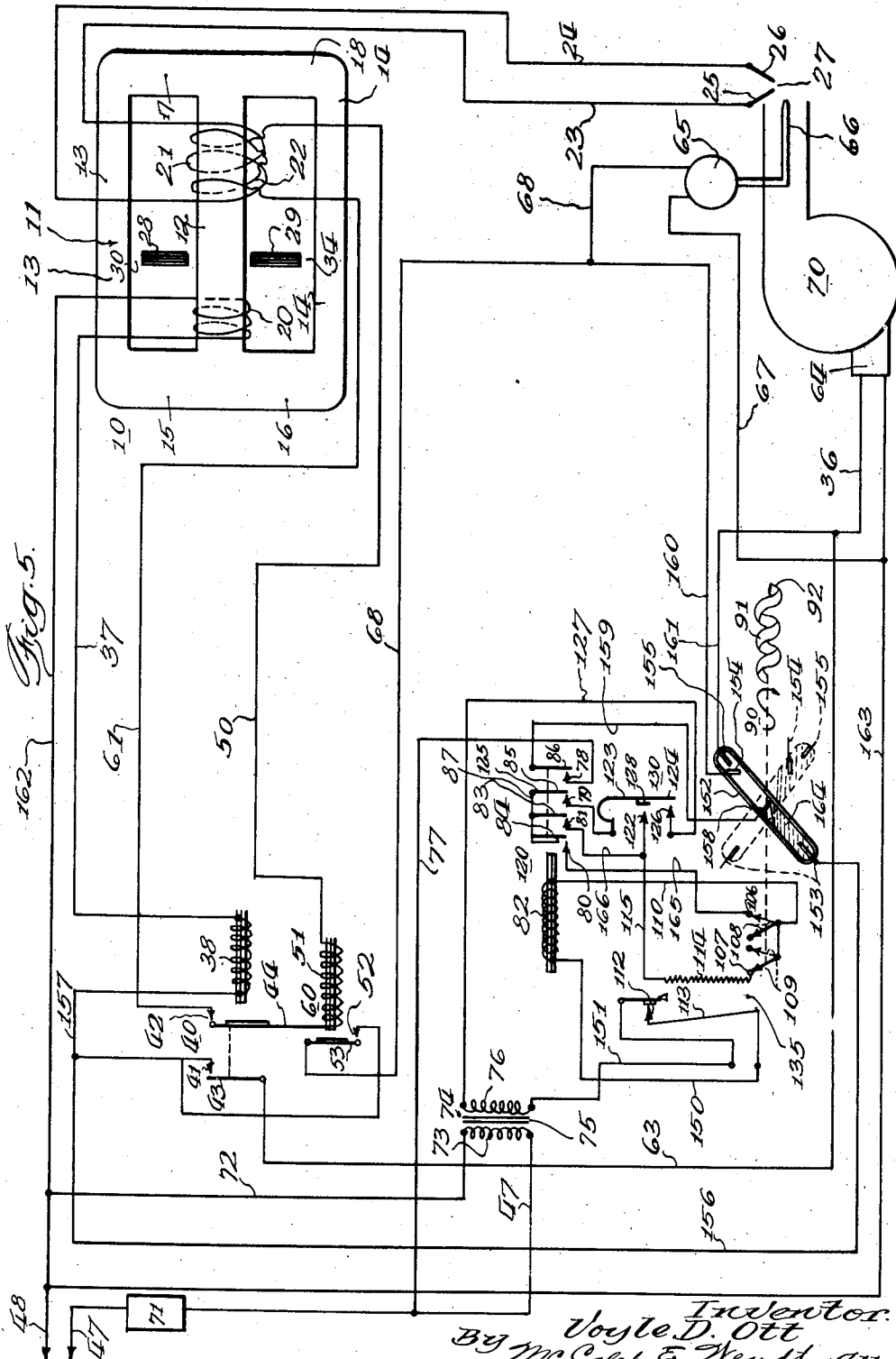
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SAFETY FUEL IGNITION DEVICES

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UNITED STATES PATENT OFFICE

2,301,446

SAFETY FUEL IGNITION DEVICE

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16 Claims. (Cl. 158—28)

The present invention relates to safety fuel ignition devices, and is particularly concerned with control transformers and circuits for the control of the fuel supply and ignition of the various types of fuel combustion systems. It is applicable to all types of fuel combustion systems, such as oil burning or gas burning, or otherwise, in which the fuel is adapted to be ignited by means of an electrical spark.

One of the objects of the invention is the provision of such a safety fuel ignition transformer that it will only operate the fuel control when the spark is of proper value, and will not operate the auxiliary apparatus on open circuit or short circuit.

Another object of the invention is the provision of an improved safety fuel ignition system in which the blower for combustion air is adapted to be started before fuel is supplied so that an ignition spark may be established across a gap and the spark may be lengthened due to the action of the air blowing on it at any of a plurality of different high rates of air feed, by means of which fuel will not be supplied to the burner if there is a short circuit in the secondary circuit or an open circuit in the secondary circuit of the ignition transformer or if satisfactory spark conditions are not established with the blower operating at high speed and extending the arc.

One of the objects of the present invention is the provision of an improved safety fuel ignition transformer which will operate satisfactorily over a range of voltage such as is now supplied by commercial power companies. In order to meet the approval of certain testing authorities, such a device must work on seventy percent of the rated line voltage.

Another object of the invention is the provision of an improved safety fuel ignition transformer which eliminates the foregoing disadvantages of the devices of the prior art, and which is adapted to positively prevent the delivery of fuel to the combustion chamber whenever there is no spark across the electrodes.

Another object of the invention is the provision of an improved safety fuel ignition system of the class described which is adapted to be embodied in a continuous ignition system or an intermittent ignition system.

The present safety fuel ignition system includes a transformer which is adapted to supply the ignition current at suitable voltage and which is also adapted to operate a pair of magnetic switches.

One of these switches is adapted to control a

motor and blower, and it also has auxiliary contacts for controlling another magnetic switch. These auxiliary contacts, according to one embodiment of the invention, are connected in series with the energizing coil and auxiliary coil located on the same leg of the ignition transformer.

The same magnetic switch is adapted to operate a fuel control means, but only in the presence of an elongated spark flowing across the spark gap which is produced by the blast of air from the blower under proper ignition conditions.

In the absence of such a spark, or if there is a short circuit, no fuel whatever will be delivered to the combustion chamber of any fuel system embodying my invention.

I desire it to be understood that the present transformer may be used with other combustion control systems than those which are exemplified in the accompanying drawings and description, which are merely exemplary of several forms of control systems that may be used.

Referring to the three sheets of drawings accompanying the specification,

Fig. 1 is a wiring diagram including diagrammatic representations of the circuits and various elements of a safety fuel combustion system embodying my invention;

Fig. 2 is a similar wiring diagram and diagrammatic representation of the elements of a modified form of system;

Fig. 3 is a fragmentary elevational view of one form of thermostatic stack switch which may be employed in the system;

Fig. 4 is a sectional view, taken on the plane of the line 4—4 of Fig. 3, looking in the direction of the arrows, showing the arrangement of the movable switch arms and contacts of the switch of Fig. 3;

Fig. 5 is a wiring diagram of another modification of the system showing the adaptation of my safety ignition transformer and system to an intermittent ignition system.

Referring to Fig. 1, 10 indicates in its entirety a safety ignition transformer embodying the features of the present invention. It preferably consists of a closed circuit core 11 of magnetic metal of the shell type, having a central leg 12 joined to the two side legs 13 and 14 by the end portions 15 to 18, the cross sectional area of the portions 15 to 18, and the outer legs 13 and 14 being substantially half of the cross sectional area of the middle leg 12.

The middle leg 12 preferably supports the primary coil 20 at one end, and at the opposite end it carries the secondary coil 21 and the auxiliary

coil 22. The terminals of the secondary coils are connected by the conductors 23 and 24 to the electrodes 25 and 26, respectively, which are spaced from each other to provide the spark gap, which is indicated by the numeral 27.

The primary coil 20 includes a suitable number of turns of wire of relatively larger size than the wire used in the secondary coils 21, which are smaller, and which include a greater number of turns, depending on the voltage ratio or increase in the voltage desired between the primary and secondary.

The transformer is provided with a pair of magnetic shunts 28, 29, which are located between the central leg 12 of the core and each of the outer legs 13 and 14, and which separates the primary coil from the other two coils.

The shunts 28 and 29 afford a magnetic leakage path of high reluctance, and are adapted to control the current in both the secondary and auxiliary windings 21 and 22, respectively. These shunts are so designed that a higher voltage is generated in the auxiliary coil 22 when the secondary is operating on extended spark, by virtue of the air passing over the spark gap.

The reluctance of the shunts 28, 29 is such that they maintain a constant voltage in the auxiliary coil 22, with a fluctuating line voltage under the operating conditions of a spark gap.

The air which is passing over the stationary or fixed gap produces an elongated spark and generates a lesser counter-magnetic motive force in the leg 12. Due to the reduced flux density in the leg 12, less flux will be by-passed through the magnetic shunts 28 and 29, due to their high reluctance.

This permits more flux to cut the auxiliary coil 22, and generates a higher voltage in the auxiliary coil 22 than when the transformer secondary 21 is short-circuited, or when it is operating on a fixed gap in still air.

The reactance of the transformer increases with leakage of magnetic flux. Therefore, when a lower primary voltage is applied to the primary of a high reactance transformer, there will be a lower flux density generated in the core leg 12, and there will be less magnetic flux by-passed by the magnetic shunts 28, 29. The transformer will, therefore, generate a fairly constant voltage.

On the other hand, should a higher voltage than normal be applied to the primary 20 of the transformer 10, a higher flux density will be generated in the core leg 12 and a greater counter-electromotive force generated by the coils 21 and 22, during the operation.

Then a greater amount of flux will be by-passed by the shunts 28, 29, and the voltage at the secondary will be maintained substantially constant.

In other words, the reluctance of the shunts 28, 29 is such that they maintain a substantially constant voltage in the auxiliary coil 22, with a fluctuating line voltage under the operating conditions of a spark gap.

A lower voltage in the primary will produce a lower flux density in the core 11, and therefore less flux will be by-passed by the shunts 28 and 29 due to their high reluctance.

A higher voltage in the primary will produce a high flux density in the core 11, and therefore a greater flux will be by-passed by the shunts 28, 29. Therefore, these shunts produce a relatively steady current in the auxiliary coil 22, which permits the relay 30 to function satisfactorily over a

considerable range of operation in primary voltage.

These shunts and the core 11 include a plurality of laminations of magnetic metal, such as soft iron, suitably secured together, and the shunts 28 and 29 are spaced from all of the legs 12 to 14 by air gaps, indicated at 30, 31, 32, and 33.

One of the terminals of the primary coil 20 is connected at 35 to a conductor 36 which leads to the source of supply of alternating current to other suitable controlling devices, further to be described.

The other terminal of the primary coil 20 is connected by conductor 37 to the controlling coil 38 of a relay, which may be indicated in its entirety by the numeral 40. This relay has two fixed contacts, 41 and 42, and a pair of movable contacts 43 and 44, the movable contacts being controlled by the energization of the relay coil 38. The other terminal of the relay coil 38 is connected by conductor 45 to a conductor 46, which leads to one of the alternating current line conductors 47.

The line conductors 47 and 48 may consist of any standard 110 volt lighting circuit alternating current supply. The auxiliary coil 22 preferably has its windings located under the secondary coil 21 to get the best results or located at the end of the leg 12 opposite from the magnetic shunts 28 and 29.

One of the terminals of the auxiliary coil 22 is connected by conductor 50 to the controlling coil 51 of a magnetic relay having a fixed contact 52 and a movable contact 53. The other terminal of the relay coil 51 is connected by conductor 54 to the movable contact 44 of the relay 40.

It will thus be observed that the relay 38 controls the energization of the relay coil 51. The relay, including this coil and contacts 52, 53, may be indicated in its entirety by the numeral 60.

The other terminal of the auxiliary coil 22 of the transformer 10 is connected by conductor 61 to the fixed contact 42 of the relay 40. The fixed contact 41 of the relay 40 is connected by conductor 62 to the conductor 46, previously mentioned as being connected to the line 47.

Movable contact 43 of the relay 40 is connected by conductor 63 to the energizing circuit of the motor 70 of a motor driven blower, which has a terminal box 64. The other lead from the terminal box 64 of the motor 70 is connected to conductor 36. 65 indicates a motor driven fuel feeding means, such as a liquid fuel pump, or it may consist of a magnetically controlled valve for controlling the supply of gaseous fuel to a nozzle 66.

For example, the pump may be driven by a separate motor, energized through conductors 67, 68, or the pump may be driven by the blower motor and controlled by a solenoid at 69.

Conductor 69, leading from the fuel control means 65, is connected to the movable contact 53 of the relay 60.

Referring now to the upper part of the diagram of Fig. 1, 71 indicates the limit control switch, which is interposed in the line conductor 48, 72 leading to the primary 20 of a transformer. Thus the limit control switch is adapted to disconnect the entire energizing system when it is actuated.

The transformer, indicated at 74, also includes the core 75 and secondary 76 for energizing the various controlling devices at the upper part of the circuit. A conductor 77 leads from the

conductor 72 to the fixed contact 78 of an alternating current relay, which has a plurality of fixed contacts 78 to 81.

The coil of this A. C. relay is indicated by 82, and the movable contact arms by 83 to 86. Conductor 36 is connected to the movable contact arm 86, so that the energization of the motor driven blower 70 is controlled by the relay 82.

The movable contact arms 83 to 85 are connected together by a conductor 87 for the purpose of controlling the common connection of the contacts 79, 80 and 81 together. 90 indicates a stack switch which is adapted to be controlled and actuated by a helically coiled bi-metallic element 91, which is located in the stack leading from the combustion chamber.

One end of the coiled bi-metallic element 91, such as, for example, the end 92, may be fixed. One end, such as the end 92, is fixedly secured to a suitable support. This thermostatic switch 90 is further illustrated in Fig. 3, and arranged as follows:

The other end 93 of the thermostatic element is secured to a pin 94, carried by a disc 95, which is rotatably mounted on a trunnion 96 carried by the shaft 97. The support for the fixed end of the bi-metallic element 91 may consist of a bracket 98 fixedly secured by an angle 99 to the wall 100 of the stack.

The rotatable disc 95, which is actuated by the bi-metallic element 91, is frictionally engaged by another disc 101, which is also mounted for rotation on the trunnion 96.

The discs are held in resilient engagement with each other by a spring 102, the pressure of which may be arranged by the nut 103 on the voltage end of the trunnion 96. Disc 101 carries a pair of axially projecting pins 104, 105, which are seen in section in Fig. 4.

The thermostatic switch 90 includes the fixed contacts 106, 107 and the movable contact arms 108, 109. These contacts are also similarly indicated in the diagram Fig. 1. The two contacts 108, 109 are connected together with a conductor 110, which also extends to one of the terminals of the relay coil 82. The other terminal of the relay coil 82 is connected by conductor 111 to a fixed contact 112 of a bi-metallic stack switch, the bi-metallic element being indicated at 113.

There is an electrical resistor 114 in close proximity to this bi-metallic element 113; for example, the resistor may be wrapped about the bi-metallic element with suitable insulation interposed. The resistor 114 has one of its terminals connected to the conductor 115, and the other connected to a conductor 116, which leads to the fixed contact 107.

The fixed contact 106 of the thermostatic stack switch 90 is connected by conductor 117 to the fixed contact 81 of the relay, which is indicated in its entirety by the numeral 120. The fixed contact 80 of this relay is connected by conductor 121 to conductor 115, and conductor 115 is extended to a fixed contact 122 of the room thermostat 130.

The room thermostat may comprise any suitable form of thermostatic switch, such as a bi-metallic thermostatic element 123 and an elongated switch arm 124.

The switch arm 124 and thermostat 123 serve as conductors, being connected to the conductor 125, which is connected to fixed contact 79 of the relay 120. The fixed contact 126 of the room thermostat 130 is connected by one conductor 127

to one terminal of the secondary 76 of transformer 74.

The room thermostat arm 124 also preferably carries a resilient movable contact member 128, which engages its fixed contact 122 only after there is firm engagement between the end of the switch arm 124 and the fixed contact 126, to prevent any chattering.

I desire it to be understood that my present safety ignition transformer and system may be utilized with other controlling circuits than those which are exemplified at the top of Fig. 1 and connected to the lower relay circuits and transformer by the conductors 36 and 46. The complete system is illustrated in this preferred form for the purpose of illustrating the safety operation of the fuel supply system.

The operation of the system is as follows: The control transformer 74 is at all times connected to the line on the primary side through the limit control switches. As the room temperature declines, the room thermostat 130 first makes contact with the fixed contact 126, but the circuit of the secondary coil 76 is still open on the main control relay at 79, 85, and thus no operations of the burner are instituted.

A further decrease in the room temperature causes the thermostatic arm contact to make contact with the fixed contact 122, and the circuit through the secondary coil 76 is then completed through the contacts 122, 128, arm 124, contact 126, conductor 127, coil 76, thermostat 113, contact 112, conductor 111, relay coil 82, conductor 110, switch arm 109, contact 107, conductor 116, heater 114, conductor 115, to contact 22.

The thermostat 113 and heater 114, and fixed contact 112 make up a warp switch, which is indicated in its entirety by the numeral 135. The energization of the relay winding 82 closes all of the four contacts 78 to 81 and 83 to 86 of this main relay switch.

The right hand contacts 78 and 86 are in connection with the motor 70 of the motor blower and the line through conductors 36, 63, contacts 41, 43, conductor 62, conductor 46 and conductor 47. These two contacts 78 and 86 are also connected to the primary of the ignition transformer through conductors 36, 35, 37, relay coil 38, conductor 45, conductor 46, and 47. Thus the right hand switch of the main relay, by contacts 78 and 86, is adapted to start both the motor and the ignition transformer.

The next two switches to the left in the main relay 120 are adapted to complete the transformer circuit for eliminating the control by means of the contacts 122, 128 of the room thermostat from the circuit, but maintaining the flow of secondary current through the heater coil 114, through the solenoid winding 82 and the warp switch 135 back to the secondary.

It will thus be observed that the movable contacts 84 and 85 will connect the fixed contacts 79 and 80 together so that both of the circuits 115 and 125 from the thermostat 123 and the contact 122 are connected to the conductor 115.

If no ignition or flame occurs at the burner, the continued flow of secondary current through the heater 114 will cause the warp switch or thermostat 113 to become warped, and it will open into a locked position, indicated by the latch 136, which holds the thermostat 113 out of contact with the contact 112, when the thermostat moves over into engagement with the latch 136.

This results in a de-energization of the relay 82 by reason of the failure of flame at the burner,

and this renders the burner inoperative by opening the contacts of the main relay 120 until it is reset manually by means of a button or other manual device, actuating the latch 135, to release the warp switch 113.

If, however, a flame occurs, the bi-metallic element 91 in the stack will twist, causing the hot contacts in the stack switch to close, thereby shorting out the heater coil 114.

It should be noted that the thermostatic stack switch 90 is arranged so that the hot-cold contacts overlap on temperature rise and so that the ignition breaks after the break of the cold contact on heating and makes before the cold contact on cooling.

In Fig. 1 the contact 107 has been designated as the cold contact, and the contact 106 as the hot contact. The temperature rise by heating of the thermostat 91 in the stack 100 causes the discs 95 and 101 to move together in such manner that the pins 104, 105 move toward the right in Fig. 1 on a rise of temperature. The arm 108, engaging the hot contact 106, is actuated by a spring 137, and the spacing of the pins 104, 105 is such that contact is made between the arm 108 and contact 106 before it is broken at contacts 107, 109 by the pin 105.

After the contacts 106, 108 are in engagement and the contacts 107, 109 are broken on an increase of temperature, a further movement of the thermostat 91 is permitted by the frictional engagement between the discs 95 and 101, which slip on each other, permitting the disc 101 to stand still.

However, immediately upon any cooling of the stack and the stack thermostat 91, the two discs 95 and 101 (Fig. 3) move together again, due to their frictional engagement. This causes the pins 104, 105 to move toward the left immediately. This brings about an opening of the hot contacts 106, 108 first, and thereafter the engagement of the insulating block 138 with the arm 109 causes a closing of the cold contacts 107, 109.

The circuit is then in condition to be re-started upon room demand for heat, as indicated by the room thermostat 130.

Referring to the lower part of the wiring diagram of Fig. 1, that is, that portion which is connected to the upper part by the conductors 36 and 46, the operation of this portion of the circuit is as follows.

It has already been shown that the entire system is under the control of the limit switches 71, which control all energization, and the system is such that there is an adjustable period of operation during which the system will be energized for the purpose of igniting the fuel.

This period will run its course, whether or not flame takes place. At the expiration of this period, if the flame does not take place, the entire fuel combustion system is shut down, and can only be placed in condition for another operation by means of the manual control of the re-setting latch 135.

The purpose of the present safety ignition transformer and system is to positively prevent the supply of any fuel to the combustion chamber unless the spark is in condition to effect ignition and flame. During the period of the energization of the transformer 10, the motor blower also has its motor energized, and a blast of air is blowing across the electrodes 25, 26, effectively lengthening the gap 27.

In the event of the flow of current in the sec-

ondary coil 21, a counter electromotive force will be built up in the central leg 12 of the transformer 10, thereby permitting a greater current to flow through the primary 20 of the transformer 10.

This increased current in the primary 20 of the transformer 10 energizes the relay coil 38 and causes the contacts 44, 42 and 41, 43 to close. It is the contacts 41, 43 that control the blower circuit and operate the blower when current is flowing in the secondary 21, as just described.

In the event that current in the secondary is actually flowing across the gap 27, the arc will be elongated by the air passing over the gap 27, permitting sufficient current to be generated by the auxiliary coil 22 to energize the energizing coil 51 of the relay 60, which is connected in series with the auxiliary coil 22.

The relay 60 then closes the contacts 52, 53, which are in series with the fuel actuating or controlling means 65 in the form of a motor driven liquid fuel pump or a solenoid actuated valve for gaseous fuel.

The foregoing is the operation of the safety transformer when there is a proper ignition spark across the gap 27 adapted to ignite the fuel when supplied to the combustion chamber through the nozzle 66.

It should be noted that the electrodes 25, 26 are preferably located just outside of the field of spray of the nozzle, and the spark or arc is blown into the range of the spray by the action of the air blast.

Thus the electrodes are not subject to accumulations of carbon which would otherwise burn on the electrodes and build up between them if the electrodes were located in the oil spray.

In the event there is a short circuit in the secondary coil 21 or across the gap 27 of the ignition electrodes 25 and 26, a larger counter-electromotive force will be built up in the middle leg 12 of the transformer. This larger counter-electromotive force will permit the major portion of the flux that is caused by the energization of the primary to be by-passed around the primary through the magnetic shunts 28 and 29. This reduced flux will not produce sufficient voltage in the auxiliary coil 22 to move the switch arm 53 into engagement with the contact 52. Thus the circuit 52, 53, 67, 65, 66 to the fuel controlling means 65 will not be energized, allowing no fuel to enter the combustion chamber when there is a short circuit either in the secondary or across the gap 27.

In the event there is no current flowing in the secondary circuit, designated by the numerals 21, 24, 26, 27, 25, 23, there will not be sufficient current flowing through the primary 20 to energize the coil 38 to move the switch arms 43 and 44 into engagement with the fixed contacts 41 and 42, respectively.

Of course, the energization of the fuel feeding means 65 is controlled through relay 51 by contacts 42, 44 of relay 38, and there will be no actuation of the fuel feeding means if the relay 38 is not sufficiently energized to move the switch arms 43, 44. Furthermore, the blower motor is controlled by the contacts 41, 43.

Under these conditions, with no current flowing in the secondary circuit, the blower motor will not be energized either.

In the event of a short circuit in the high tension circuit, which includes the secondary 21, conductors 23, 24, electrodes 25, 26, and gap 27, which would cause the coil 38 to be energized,

and would permit the blower circuit to be energized at 41, 43 and to operate continuously, the fuel combustion system would be shut down by the control circuits at the top of the diagram of Fig. 1, after the predetermined period of energization had run its course. It should be noted under these conditions that the fuel feeding means 65 would not have been energized at all.

In the event of no current flowing in the high tension circuit, including the electrodes 25, 26 and gap 27, the relays 40 and 60 would not be energized, and after the passage of the predetermined energization period, the fuel combustion control, exemplified at the top portion of the diagram of Fig. 1, would shut down the fuel combustion system.

In order to give one example of the best mode of applying my invention, I shall now describe in detail the specifications for a transformer and relay of the type utilized in Fig. 1.

The core of the transformer 10 may consist of laminations of 26 gauge Allegheny Trans. steel, grade "C." The size of the core may be as follows: The width of the central leg may be $1\frac{1}{4}$ ". The width of each of the side legs 13 and 14 may be $1\frac{1}{32}$ ". The corners of the core may be rounded off so that they are described on a $1\frac{1}{32}$ " radius.

The overall width of the core from the outside of leg 13 to the outside of leg 14 may be $4\frac{1}{4}$ ".

The primary coil may consist of 314 turns of No. 18 wire, insulated with paper and enamel with a 10% lap. The size of the inside of the primary coil at the core may be $1\frac{1}{32}$ " x $1\frac{1}{32}$ " and the length of the coil may be $\frac{3}{4}$ ".

The secondary coil 21 may consist of 15,000 turns of No. 39 wire, insulated with plain enamel, and with two wraps of .00075 Glassine paper between each layer.

The size of the secondary coil at the aperture for the core may be $1\frac{1}{4}$ " x $1\frac{1}{4}$ ", and its length may be $1\frac{1}{4}$ ". Two such secondary coils may be used to make up the secondary winding.

The auxiliary coil 22 may comprise 68 turns of No. 22 insulated wire, the size of the coil aperture being $1\frac{1}{32}$ " x $1\frac{1}{32}$ ", and the length being $2\frac{1}{4}$ ".

The relay coil No. 38 of the relay 40 may consist of 193 turns of No. 19 paper enameled wire having 10% paper lap, mounted on a round core, having a diameter of .510" and a length of $\frac{3}{4}$ ".

The relay coil 51 of relay 60 may consist of 500 turns of No. 24 insulated wire. The core size may be $1\frac{1}{32}$ " round and $\frac{3}{4}$ " long.

The cores of the relays and the armatures may consist of Armco iron, $1\frac{1}{4}$ ", $1\frac{1}{4}$ " wide x .093" thick. The pole piece may be $\frac{1}{4}$ " diameter by .9667" long. The shunts may be 26 gauge thick, $1\frac{1}{4}$ " long, and .944" wide.

These magnetic shunts 28, 29 may have $11\frac{1}{2}$ wraps of .005" Gummed Fish paper around the outside of the shunt, to hold the shunt securely between the laminations.

Forty-nine laminations may be used, having a weight of 5.32 ounces and a thickness of .015".

I desire it to be understood that the foregoing specifications for the transformer and relay are merely exemplary, and are not to be considered limitative in any respect. The operation of the present transformer and relays involves quantitative relationships between the current established at various conditions of operation, and therefore the foregoing specifications are merely given in order to provide complete information for the making of one preferred embodiment of the invention.

One of the problems involved is to have enough current left in the ignition circuit above the relay requirements for the ignition spark. My invention should be carefully distinguished from any devices which involve the starting of the transformer with no air blast on the air gap. Under those conditions the characteristics of the transformer circuit cannot differentiate between a short or open circuit at the spark gap.

According to my invention, the fan and ignition transformer are started first; but there is no oil flow. When the blower is operating, the air blast draws out the spark. Then the present transformer and safety circuit have the capability of differentiating between a short and open circuit, the air gap at the electrodes under those conditions acting like a wider gap. In the event the motor sticks or stops and the air blast ceases, the relay 60 cuts the circuit out.

Referring to Fig. 2, this is a modification of the invention utilizing a modified form of safety fuel ignition transformer, which is indicated in its entirety in this case by the numeral 140. This transformer has its core 11 and magnetic shunts 28 and 29 identical in construction to those of the transformer 10, previously described.

The primary 20 in this case has its terminals connected by conductors 141 and 142 to the conductors 46 and 36, previously mentioned. The relay 38 in this case is controlled by auxiliary coils 143, 144, which are wound on the magnetic shunts 28 and 29.

These auxiliary coils 143, 144 are connected in series with each other, and have their terminals connected by conductors 145, 146 to the terminals of the relay coil 38.

The operation of this embodiment is substantially the same as that of Fig. 1, with the following exception. A current flowing in the secondary 21 will cause counter-magnetomotive force to be built up in the leg 12, causing a portion of the flux to flow through the shunts 28 and 29, energizing the coils 143, 144. By virtue of these coils being directly connected to the coil 38 of the relay 40, this will cause the contact arms 43 and 44 to move into engagement with the contacts 41 and 42. With the exception that the relay coil 38 is controlled by the coils 143, 144 located on the shunts 28 and 29, this embodiment of the invention operates substantially the same as that of Fig. 1, and will produce the same results.

Referring now to Fig. 5, this is a schematic diagram and circuit for a safety fuel system embodying my invention, and arranged for intermittent ignition.

Many of the elements of this circuit are substantially the same as the one previously described. As to these the same numerals have been applied. There are, however, certain differences in the connection of some of the elements of the circuit, and additional elements included, in order that the ignition may be cut off after a predetermined period of operation, while the burner continues to operate if the room thermostat is not satisfied.

In this embodiment of the invention the warp switch 113 has its movable blade connected to the coil 52 of main relay 120 by a conductor 150. The contact 112 of the warp switch is connected by conductor 151 to the coil 76 of relay 74. This is merely a reversal of the previous arrangement. The stack switch 80 has its thermostatic element 91 arranged to actuate a mercury switch 152, which is provided with the contacts 153, 154, 155.

Contact 153 is connected by a conductor 156

to the contact 41 of relay 40. Another conductor 157 extends from conductor 56 to the coil 38 of relay 40.

The mercury switch 152 also has a centrally located contact 158, which is connected by a conductor 159 to the movable contact switch arm 86 of the main relay 120. The contact 154 of mercury switch 152 is connected by means of conductor 160 to the conductor 88, which leads back to the contact 53 of the relay 60. Contact 155 of the mercury switch 152 is connected by conductor 161 to the conductor 36, leading to the blower motor 70.

The primary 20 of the ignition transformer has one of its terminals connected by a conductor 162 directly to the line 48. The electric motor of the fan 70 has one of its terminals connected by the conductor 163 to the conductor 67 from the electric oil valve 65 and to the electric supply line at 48.

The supply of mercury 164 in the envelope of mercury switch 152 is sufficient to cover contacts 153 and 158, simultaneously, and it is also so arranged that contacts 154 and 155 are connected with center contact 158 before the circuit is broken between contacts 158 and 153.

In this embodiment the contact 106 is connected by a conductor 165 to the contact 80 of the main relay 120. Conductor 115 from the heater coil 114 is connected by conductor 166 to the contact 81.

The operation of this embodiment of the invention is as follows: When the temperature of the room cools down, the thermostat 123 of the room thermostat 130 first causes contact between the arm 124 and the contact 126, and thereafter between contacts 122 and 128. This permits low voltage current from the secondary of the step-down transformer 74 to flow through conductor 127, contacts 126, 124 to contacts 128, 122, conductor 115, heater coil 114, contact 107, arm 109, conductor 110, relay coil 82, conductor 150, warp switch 113, contact 112, conductor 151, back to the other side of the secondary winding 76.

This energizes the main relay winding 82, and it attracts the armature attached to the switch arms 83-86, closing all four contacts of the main relay 120.

As in the previous embodiment, the closure of contacts 78, 85, and 81, 83 merely by-passes the contacts on the room thermostat so that the low voltage current flows directly from contact 126 through the blade 124 and the two contacts mentioned to the resistance heater 114.

The closure of the contacts 80, 84 does nothing at this time, since that circuit is open at contacts 106, 108.

The closure of contacts 78, 86 provides a path for power current to flow from the line 47 through conductor 77, contacts 78, 86, conductor 159, to the center contact 158 of mercury switch 152. This center contact is in connection through mercury 164 with contact 153, conductor 156, 157, coil 38, conductor 37, primary 20 of the ignition transformer, conductor 162, to line 48. Thus the closure of the main relay 120 energizes the primary of the ignition transformer.

If the secondary of the ignition transformer is open, there will be insufficient current flowing through the primary winding and through the relay winding 38 to operate the relay 40. Under these conditions nothing further will happen except that the continued flow of low voltage current through the heater coil 114 will cause the warp switch 12 to become heated and move

to open position, where it will be held by a latch 136, similar to that described in connection with Fig. 1, and manual resetting and restarting of the circuit will be required. This manual resetting is an indication of the fact that something has gone wrong with the system.

If, however, the secondary of the ignition transformer is not open circuit, then there will be sufficient current flowing in the primary and in the coil 38 of the relay 40 to actuate the armature and close the contacts 42, 44 and 41, 43. The closure of the contacts 41, 43 closes a circuit to the blower motor 70 from the line, as follows: Line 48, conductor 163, motor 70, conductor 36, conductor 63, contacts 43, 41, conductor 157, conductor 156, contact 153, mercury 164, contact 158, conductor 159, contacts 86, 78, conductor 77, to line at 47. Thus the closure of contacts 41, 43 starts the blower motor 70.

The closure of the contacts 42, 44 closes a circuit through the winding 51 of relay 80 and through the auxiliary winding 22 of the ignition transformer 10.

If the secondary is short-circuited, then there will be insufficient current flowing in this circuit, which includes the relay 60, and this relay will not operate, with the result that no oil will be fed to the burner. Under this condition the flow of current through the heater 114 will again heat the thermostatic warp switch 113 and open the circuit at contacts 112, 113.

If, however, there is a normal spark at the electrodes, then sufficient current will flow through the relay 60 to close the contacts 52 and 53 leading to the electric oil valve 65, and the oil valve will be opened so that fuel will be fed to the burner. Since the spark is now in proper condition, the burner should be ignited.

Of course, if there is no oil supplied under these conditions, then no ignition could take place, even though there were a normal spark, and under these conditions the warp switch would again open.

If the ignition of the burner actually takes place, the combustion will raise the temperature in the stack, and the thermostat 91 of the stack switch will become heated and actuate the stack switch.

Contacts 106, 108 will first be closed by passing the heater coil 114, and thereafter the contacts 107, 109 will be opened. Since proper ignition has taken place, and as evidenced by combustion and heating of the stack switch, the warp switch heater 114 is now out of circuit.

The stack switch 90 also causes the mercury switch 152 to tilt, and, as previously stated, this switch is so arranged that the mercury 164 connects with contacts 158, 154, 155 before a break is made between contacts 158 and 153.

When contacts 158, 154 and 155 are connected, the circuit is adapted to be maintained closed through the motor 70, and the electric fuel valve 65 or electric fuel motor 65, as the case may be, before the circuit is broken at 153. Breaking of the circuit at 153 cuts off the ignition because this contact is in the primary circuit of the ignition transformer 10.

When the room temperature is satisfied, the room thermostat opens, and the main relay 120 drops out, opening all circuits. The stack switch 90 then cools off first, and opens contacts 106, 108, and then at some lower temperature closes the contacts 107, 109.

The mercury switch is also tilted back from the dotted line position of Fig. 5 to the full line

position, and the burner is then ready for the next ignition cycle.

If the flame should fail during operation, the stack switch would cool off and re-establish connection between the contacts 153 and 158, and open contacts 106, 108. At a lower temperature contacts 107, 109 would be closed, and this would place the burner in condition for a new cycle of ignition. As the room thermostat would not yet be satisfied, the burner would then attempt to start, and the controls would then again go through their test cycle, as before.

If the condition which caused the flame failure still exists, the burner will lock out on safety, no matter whether the cause is due to transformer trouble or lack of oil.

Of course, since the flame failed in operation under these conditions, the failure would surely be due to lack of oil.

While the description of the sequence of events in starting the burner takes a substantial time, it is a fact that when the main relay 120 closes, the events described take place immediately thereafter, so that the oil valve will either be opened at once, or definitely will not open at all. From there on, the heater causes the warp switch to lock out of position.

It will thus be observed that my safety fuel system is adapted to be used with systems or circuits designed for continuous or intermittent ignition. All of my systems are so arranged that no oil can be supplied to the burner unless the spark is in proper condition for ignition. The existence of a short circuit or an open circuit will positively prevent the supply of any oil to the burner, and if anything should go wrong with the circuits, the main relay will be de-energized and shut the whole system down.

Therefore, the present ignition and fuel supply system is safe under all conditions.

While I have illustrated a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details of construction set forth, but desire to avail myself of all changes within the scope of the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In a safety fuel supply system for combustion devices, the combination of a source of alternating current with a step-down transformer, a room thermostat for controlling electric contacts responsive to the demand for heat, a main relay controlled by said room thermostat and having contacts for controlling the energization of an ignition transformer, a thermostatic stack switch having contacts controlling the energization of said main relay, a warp switch having a thermostatic switch arm and an electric heater, contact means and latching means whereby the warp switch will hold the main relay winding on open circuit upon failure of ignition, said stack switch superseding said warp switch upon heating of the stack, an ignition transformer having a primary, secondary, and auxiliary windings, said primary being controlled by said main relay, and having a magnetic core with a plurality of legs, said primary being located on said core, and said core also supporting said secondary, and said auxiliary winding, an electrically actuated source of air supply for the burner, an electrically controlled source of fluid fuel supply for the burner, a fuel supply relay having contacts controlling said fuel

supply, said fuel supply relay being in circuit with said auxiliary winding, a second relay having two sets of contacts, one set of said contacts controlling the energization of said fuel supply relay, and the other of said contacts controlling the energization of said electrically controlled air supply, the winding of said second relay being in said primary circuit, said transformer having magnetic means for short circuiting flux under predetermined conditions whereby the safety system is adapted to be shut down without supply of fuel unless the spark adapted to be supplied by said secondary winding is of suitable characteristics for ignition under air blast conditions.

2. In a safety fuel supply system for combustion devices, the combination of a source of alternating current with a step-down transformer, a room thermostat for controlling electric contacts responsive to the demand for heat, a main relay controlled by said room thermostat and having contacts for controlling the energization of an ignition transformer, a thermostatic stack switch having contacts controlling the energization of said main relay, a warp switch having a thermostatic switch arm and an electric heater, contact means and latching means whereby the warp switch will hold the main relay winding on open circuit upon failure of ignition, said stack switch superseding said warp switch upon heating of the stack, an ignition transformer having a primary, secondary, and auxiliary windings, said primary being controlled by said main relay, and having a magnetic core with a plurality of legs, said primary being located on said core, and said core also supporting said secondary, and said auxiliary winding, an electrically actuated source of air supply for the burner, an electrically controlled source of fluid fuel supply for the burner, a fuel supply relay having contacts controlling said fuel supply, said fuel supply relay being in circuit with said auxiliary winding, a second relay having two sets of contacts, one set of said contacts controlling the energization of said fuel supply relay, and the other of said contacts controlling the energization of said electrically controlled air supply, the winding of said second relay being in said primary circuit, said transformer having magnetic means for short circuiting flux under predetermined conditions whereby the safety system is adapted to be shut down without supply of fuel unless the spark adapted to be supplied by said secondary winding is of suitable characteristics for ignition under air blast conditions, said circuit being arranged for continuous ignition at a spark gap controlled by said secondary while the burner is operating.

3. In a safety fuel supply system for combustion devices, the combination of a source of alternating current with a step-down transformer, a room thermostat for controlling electric contacts responsive to the demand for heat, a main relay controlled by said room thermostat and having contacts for controlling the energization of an ignition transformer, a thermostatic stack switch having contacts controlling the energization of said main relay, a warp switch having a thermostatic switch arm and an electric heater, contact means and latching means whereby the warp switch will hold the main relay winding on open circuit upon failure of ignition, said stack switch superseding said warp switch upon heating of the stack, an ignition transformer having a primary, secondary, and auxiliary windings, said primary being controlled by said main relay, and having a magnetic core with a plurality of legs, said pri-

mary being located on said core, and said core also supporting said secondary, and said auxiliary winding, an electrically actuated source of air supply for the burner, an electrically controlled source of fluid fuel supply for the burner, a fuel supply relay having contacts controlling said fuel supply, said fuel supply relay being in circuit with said auxiliary winding, a second relay having two sets of contacts, one set of said contacts controlling the energization of said fuel supply relay, and the other of said contacts controlling the energization of said electrically controlled air supply, the winding of said second relay being in said primary circuit, said transformer having magnetic means for short circuiting flux under predetermined conditions whereby the safety system is adapted to be shut down without supply of fuel unless the spark adapted to be supplied by said secondary winding is of suitable characteristics for ignition under air blast conditions, said system being arranged for intermittent ignition of the spark gap in the circuit of said secondary winding, said stack switch also including contact means for controlling the energization of said transformer and for deenergizing said transformer after a predetermined period of time.

4. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or de-energizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions.

5. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or deenergizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said ignition transformer having a closed core provided with means for short circuiting flux under predetermined conditions and proportioned to maintain substantially uniform spark conditions at the gap over a wide

range of voltages applied at the primary of said transformer.

6. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or deenergizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said fuel feed means comprising an electrically driven pump for supplying liquid fuel under pressure.

7. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or deenergizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said fuel feed means comprising an electrically actuated valve for controlling the flow of fuel to a burner.

8. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or deenergizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said ignition transformer having a closed core provided with means for short circuiting flux under predetermined condi-

tions and proportioned to maintain substantially uniform spark conditions at the gap over a wide range of voltages applied at the primary of said transformer, said means for short circuiting flux being disposed between the primary winding and the other two windings, and said windings being located upon the same portion of said core.

9. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or deenergizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said ignition transformer having a closed core provided with means for short circuiting flux under predetermined conditions and proportioned to maintain substantially uniform spark conditions at the gap over a wide range of voltages applied at the primary of said transformer, said transformer having windings disposed about said flux short circuiting means, and said latter windings being connected to a relay controlling both the fuel and the air feed.

10. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or deenergizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said ignition transformer having a closed core provided with means for short circuiting flux under predetermined conditions and proportioned to maintain substantially uniform spark conditions at the gap over a wide range of voltages applied at the primary of said transformer, and relay means connected to the primary winding of said transformer for controlling the energization of said air feed means and said fuel feed means.

11. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair

of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or deenergizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said ignition transformer having a closed core provided with means for short circuiting flux under predetermined conditions and proportioned to maintain substantially uniform spark conditions at the gap over a wide range of voltages applied at the primary of said transformer, relay means connected to the primary winding of said transformer for controlling the energization of said air feed means and said fuel feed means, and a second relay means controlled by the first-mentioned relay means and connected to said auxiliary winding for effecting the control of said fuel feed means.

12. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energization of said fuel feed means, and means controlled by said transformer for energizing or deenergizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said ignition transformer having a closed core provided with means for short circuiting flux under predetermined conditions and proportioned to maintain substantially uniform spark conditions at the gap over a wide range of voltages applied at the primary of said transformer, said system being arranged for continuous ignition at the spark gap controlled by said secondary while the burner is operating.

13. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, electric ignition means including a pair of spaced electrodes arranged for a spark gap in the path of travel of the combustion air, an ignition transformer for selectively controlling the air feed means and the fuel feed means, said transformer having a primary winding, a secondary winding, and an auxiliary coil, said secondary winding being connected in circuit with said spaced electrodes of the spark gap, and said auxiliary winding controlling the energiza-

tion of said fuel feed means, and means controlled by said transformer for energizing or de-energizing said air feed means prior to the energization of said fuel feed means, said ignition transformer being constructed and arranged to prevent the energization of said fuel feed means unless the spark supplied at said air gap is of suitable characteristics for ignition under air blast conditions, said ignition transformer having a closed core provided with means for short circuiting flux under predetermined conditions and proportioned to maintain substantially uniform spark conditions at the gap over a wide range of voltages applied at the primary of said transformer, said system being arranged for intermittent ignition of the spark gap in the circuit of said secondary winding while the burner is operating.

14. In a safety fuel supply system for combustion devices, the combination of an ignition transformer having a primary, secondary, and auxiliary windings, said primary being controlled by said main relay, and having a magnetic core with a plurality of legs, said primary being located on said core, and said core also supporting said secondary, and said auxiliary winding, an electrically actuated source of air supply for the burner, an electrically controlled source of fluid fuel supply for the burner, a fuel supply relay having contacts controlling said fuel supply, said fuel supply relay being in circuit with said auxiliary winding, a second relay having two sets of contacts, one set of said contacts controlling the energization of said fuel supply relay, and the other of said contacts controlling the energization of said electrically controlled air supply, the winding of said second relay being in said primary circuit, said transformer having magnetic means for short circuiting flux under predetermined conditions whereby the safety system is adapted to be shut down without supply of fuel unless the spark adapted to be supplied by said secondary winding is of suitable characteristics for ignition under air blast conditions.

15. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel

feed means, a relay for controlling the energization of said fuel feed means, and an ignition transformer, said transformer having a primary winding, a secondary winding connected to ignition electrodes to effect ignition under air blast conditions, and an auxiliary winding, said relay having its contacts connected in series with said auxiliary winding for controlling the energization of the fuel feed means, said transformer having a core, and said windings and core and relay being so proportioned and arranged in respect to each other that a short circuit in said secondary winding will limit the amount of current flowing in said auxiliary winding in such manner that said relay will not be actuated, thus preventing the actuation of said fuel feed means.

16. In a fuel control system for combustion devices, the combination of electrically controlled air feed means for supplying a blast of combustion air with electrically controlled fuel feed means, a relay for controlling the energization of said fuel feed means, and an ignition transformer, said transformer having a primary winding, a secondary winding connected to ignition electrodes to effect ignition under air blast conditions, and an auxiliary winding, said relay having its contacts connected in series with said auxiliary winding for controlling the energization of the fuel feed means, said transformer having a core, and said windings and core and relay being so proportioned and arranged in respect to each other that a short circuit in said secondary winding will limit the amount of current flowing in said auxiliary winding in such manner that said relay will not be actuated, thus preventing the actuation of said fuel feed means, said system also including another relay having its winding in series with the primary of said transformer, said second mentioned relay having its contacts controlling the circuit of the first mentioned relay, whereby an open circuit in the secondary of the transformer will so limit the current in the primary winding that the second mentioned relay will not be actuated to close the circuit of the first-mentioned relay, thereby preventing the supply of fuel under either condition of open circuit or short circuit.

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