

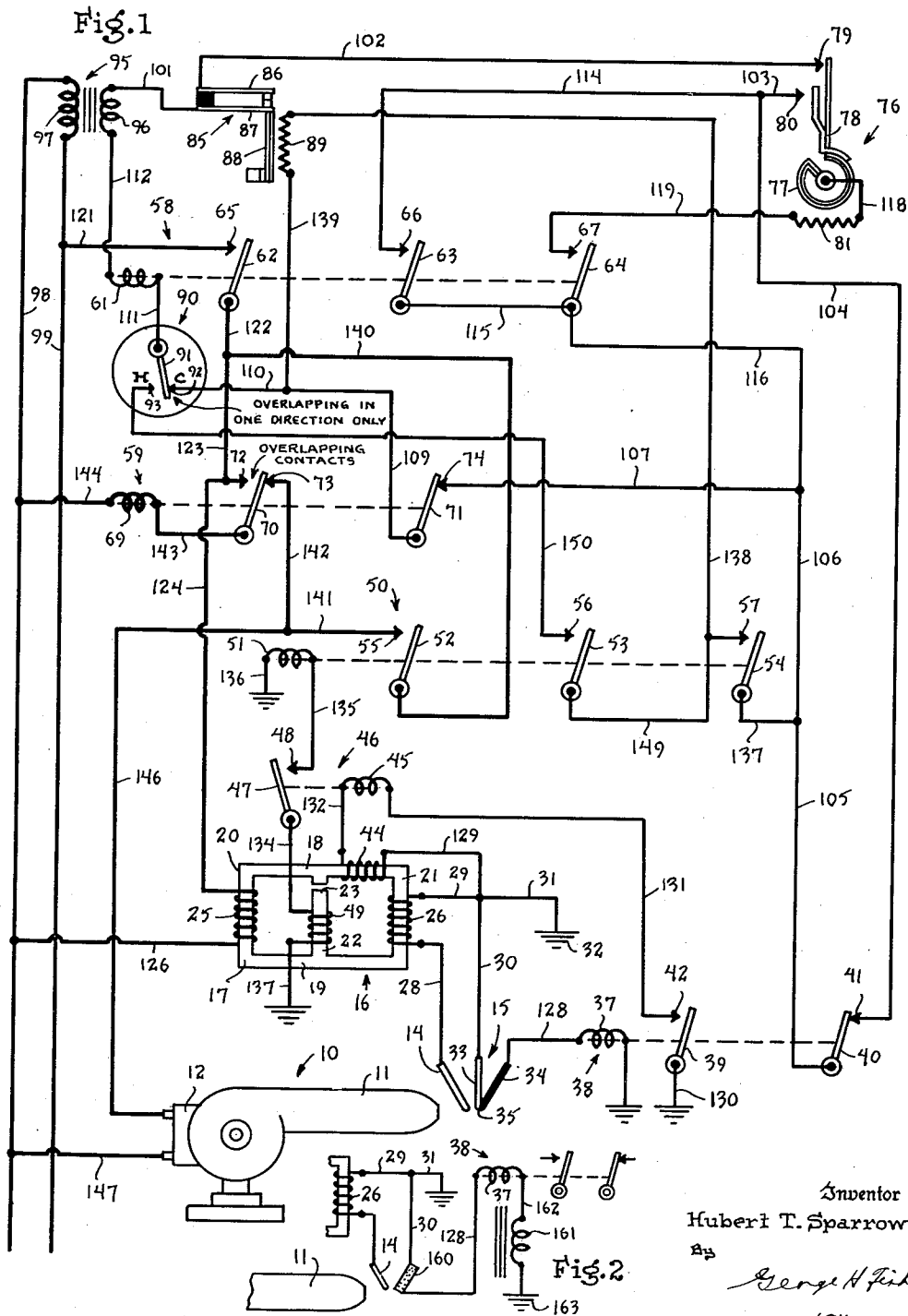
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FLUID FUEL BURNER CONTROL SYSTEM

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FLUID FUEL BURNER CONTROL SYSTEM

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The present invention is concerned with a fluid fuel burner control system and more particularly with such a system in which means is provided for checking the ignition spark.

In Patent No. 2,143,076 issued to Allan M. Koerner, on January 10, 1939, a fluid fuel burner control system is disclosed in which means is provided for checking the ignition spark. This means takes the form of a pair of auxiliary windings on the ignition transformer, each of which controls a separate relay. When the spark is proper, both of the relays will be energized but when there is either a short circuit condition or an open circuit condition in the ignition circuit, one or the other of the two relays is not energized so that the fuel feeding means is not placed in operation. Such a system has an advantage over many types of previous systems in that it checks for both a short circuit and an open circuit condition. The system has the disadvantage that it is responsive only to the current flow in the ignition circuit and that if this current flow is caused by a condition simulating a spark in the leads between the secondary winding and the spark electrodes, a false indication of a proper spark may be given.

In the copending application of Willis H. Gille, Serial No. 94,502, filed August 6, 1936, a spark checking system is disclosed in which a thermo-couple is closely associated with the spark gap. This thermo-couple is heated only when there is a proper spark directly at the spark gap since in the event of either a short circuit or an open circuit condition, very little heat is generated at the spark gap. This system has the disadvantage that the thermo-couple inherently is slightly slow in response. While a thermo-couple is much quicker in response than other temperature responsive means in that it depends merely upon the difference in temperature between two points rather than upon the absolute temperature, there is nevertheless an appreciable delay in the response of the thermo-couple to the termination of ignition.

The present invention is concerned with a system wherein the advantageous features of both of the aforementioned systems are combined in a novel manner to provide a spark checking system having new and unexpected advantages.

An object of the present invention is to provide a fluid fuel burner control system having a means directly but slowly responsive to the temperature of the ignition spark gap, a second means quickly responsive to the current flow in the ignition circuit, and means for causing a flow

of fuel to the burner only in the event of both means indicating the presence of a proper spark.

A further object of the invention is to provide such a system wherein the slow acting means is a thermo-couple.

A further object of the invention is to provide such a system in which the slow acting means is an element having a negative temperature coefficient of resistance.

A further object of the present invention is to provide such a system wherein the ignition cannot initially be energized until the slow acting temperature responsive checking means is in its cold position.

A still further object of the present invention is to provide such a system in which the initial energization of the ignition means is dependent upon both spark checking means being in their deenergized positions.

A further object of the present invention is to provide a novel spark checking system employing an element having a negative temperature coefficient of resistance responsive to the temperature at the spark gap.

A still further object of the present invention is to provide a new and novel circuit of the type employing auxiliary windings on the ignition transformer for checking the presence of a proper spark.

A further object of the invention is to provide a fluid fuel burner control system having a timing switch for shutting down the system unless burner operation occurs within a predetermined period of time and in which there is a spark checking system with means to insure that the timing period of the timing switch does not begin until after the spark checking system has indicated the establishment of a proper spark.

Other objects of the invention will be apparent from a consideration of the accompanying specification, claims and drawing of which:

Figure 1 is a schematic view of one form of the invention, and

Figure 2 is a view of a portion of the system shown in modified form.

Referring to the drawing, a fluid fuel burner is generally designated by the reference numeral 10. This burner comprises a nozzle 11 with which is associated a motor 12 through which fuel is forced by a blower driven by a motor 12.

Located adjacent to the open end of the burner nozzle 11 is a pair of spark electrodes 14 and 15. These two electrodes 14 and 15 are subjected to a high voltage produced by an ignition transformer 16. This transformer is shown as being of the

leakage type comprising a magnetic core 17 having two side legs 18 and 19, two end cross legs 20 and 21, and an intermediate cross leg 22 which has a gap 23 therein and which functions as a leakage path. The primary winding 25 is located upon the cross leg 20 and a secondary winding 26 on the cross leg 21. One terminal of the secondary winding 26 is connected by means of a conductor 28 to the electrode 14. The other terminal is connected by means of conductors 29 and 30 to the electrode 15. This latter terminal of the secondary 26 is connected by means of conductors 29 and 31 to ground at 32.

Electrode 15 takes the form of a thermo-couple in the species of Figure 1. This thermo-couple comprises the usual two elements 33 and 34 of dissimilar thermo-electric characteristics. The two elements are joined at 35 to provide a hot junction. It will be noted that this hot junction is immediately adjacent the gap between the two electrodes. The thermo-couple 15 controls the energization of a relay 38 which includes a relay coil 37 and two switch blades 39 and 40 which are biased to the right. Switch blade 40 engages a fixed contact 41 when relay coil 37 is deenergized and switch blade 39 is adapted to be moved into engagement with a fixed contact 42 when relay coil 37 is energized. It is to be understood that the thermo-couple is of relatively high efficiency and that the various conductors between the thermo-couple and its associated relay coil are of relatively large size so that the small electromotive force generated by the thermo-couple produces sufficient current flow through the relay coil 38 to cause the same to pull in its associated switch blades. Such thermo-couple actuated relays are now well known in the art.

Located on the side leg 18 is an auxiliary secondary winding 44 which is connected to a relay coil 45 of a relay 46. The relay 46 comprises a switch blade 47 which is adapted to be moved into engagement with a fixed contact 48. The switch blade 47 is normally biased out of engagement with the contact 48.

Located upon the leakage leg 22 is a second auxiliary secondary winding 49. This winding 49 is adapted to control the energization of a relay 50 comprising a relay coil 51, switch blades 52, 53, and 54 and associated contacts 55, 56, and 57. The switch blades 52, 53, and 54 are biased out of engagement with contacts 55, 56, and 57 and are adapted to be moved into engagement therewith upon the energization of relay coil 51.

In addition to relays 38, 46, and 50 there are two other relays in the system, these being designated by the reference numerals 58 and 59. The relay 58 comprises a relay coil 61 with which are associated switch blades 62, 63, and 64. The three switch blades 62, 63, and 64 are adapted to engage contacts 65, 66, and 67, respectively. The switch blades are normally biased out of engagement with the contacts and are adapted to be moved into engagement therewith upon energization of relay coil 61.

The relay 59 comprises a relay coil 69, switch blades 70 and 71 and fixed contacts 72, 73, and 74. Switch blades 70 and 71 are biased into engagement with contacts 73 and 74 and are adapted to be moved out of engagement therewith upon energization of relay coil 69. Upon such energization of relay coil 69, the switch blade 70 is moved into engagement with contact 72 before it is moved out of engagement with contact 73. In

other words, the switch blade 70 "overlaps" the contacts 72 and 73.

The energization of relay coil 58, which constitutes the main controlling relay of the system, is controlled by a room thermostat 76. This thermostat comprises a bimetallic element 77 to which is secured a composite contact arm 78 which is adapted to sequentially engage fixed contacts 79 and 80. The bimetallic element 77 is so arranged that upon a temperature fall the contact arm 78 is adapted to engage first contact 79 and then contact 80. The portion of the contact arm which engages contact 79 is flexible to permit such further movement of the contact arm. Associated with the bimetallic element is a heater 81 which is adapted to locally heat the bimetallic element to cause the thermostat to cease calling for heat slightly before it would solely by reason of the rise in ambient temperature.

A thermal safety switch is generally designated by the reference numeral 85. This switch is preferably of the type shown in the patent to Frederick S. Denison No. 1,958,081 of May 8, 1934. This switch, as shown for purposes of illustration, comprises a pair of switch blades 86 and 87, the switch blade 87 being biased downwardly away from switch blade 86 but being normally held in engagement therewith by a bimetallic element 88 with which is associated an electrical heater 89. Upon heating of the bimetallic element 88, the element is adapted to slowly move toward the right. If such movement continues sufficiently far, switch blade 87 will be allowed to separate from switch blade 86. After the switch blades 86 and 87 have once been separated, it is necessary to manually reclose the switch.

A stack switch is generally designated by the reference numeral 90. This stack switch comprises a bimetallic element (not shown) which is connected to a switch blade 91 through a slip friction connection. The switch blade 91 is adapted to be moved between contacts 92 and 93. Contact 92 is engaged when the temperature is falling or is cold while the contact 93 is engaged upon a rise in temperature. The contact structure is so arranged that engagement of switch blade 91 with contact 93 is effected before switch blade 91 has disengaged contact 92. Upon a temperature fall, however, switch blade 91 disengages contact 93 before it engages contact 92. Such a switch structure is shown in Patent No. 1,941,540 issued to F. S. Denison et al on January 2, 1934.

Power for operation of the system is supplied by a step-down transformer 95. This transformer comprises a low voltage secondary 96 and a line voltage primary 97 which is connected to line wires 98 and 99 leading to any suitable source of power (not shown).

Operation

The various elements are shown in the position they occupy when the thermostat 76 is satisfied, that is, when the temperature to which it is subjected is at or above the desired temperature. Let it be assumed now that the temperature drops until both contacts 79 and 80 are engaged by contact arm 78. Until both contacts are engaged, no circuit is established. Upon such engagement, however, the following circuit is established to relay coil 61 of relay 58: from the upper terminal of secondary 96, through conductor 101, switch blades 87 and 86, conductor 102, contact 79, contact arm 78, contact 80, conductors 103 and 104, contact 41, switch blade 40, conductors 105, 106, 75

and 107, contact 74, switch blade 71, conductors 109 and 110, contact 92, switch blade 91, conductor 111, relay coil 61, and conductor 112 to the other terminal of secondary winding 96.

5 The energization of relay coil 61 as a result of the establishment of the above traced circuit results in switch blades 62, 63, and 64 being moved into engagement with contacts 65, 66, and 67. The engagement of switch blade 63 with contact 10 66 establishes a circuit to relay coil 61 which is independent of the engagement of thermo-couple switch blade 40 with contact 41, this circuit being as follows: from the upper terminal of secondary 96 through conductor 101, switch 15 blades 87 and 86, conductor 102, contact 79, contact arm 78, contact 80, conductors 103 and 114, contact 66, switch blade 63, conductors 115, 116, and 107, contact 74, switch blade 71, conductors 109 and 110, contact 92, switch blade 91, conductor 111, relay coil 61, and conductor 112 to the other terminal of secondary 96. It will be noted that the original energizing circuit to the relay coil depended upon the thermo-couple relay 20 38 being deenergized so that the switch blade was in engagement with contact 41. This was to insure that the system would not be started when the thermo-couple was still hot from a previous operation so as to give a false check.

At the same time as the circuit just traced to 30 relay coil 61 is established, a further maintaining circuit is also established to relay coil 61 as follows: from the upper terminal of secondary 96 through conductor 101, switch blades 87 and 86, conductor 102, contact 79, contact arm 78, 35 bimetallic element 77, conductor 118, heating element 81, conductor 119, contact 67, switch blade 64, conductors 116 and 107, contact 74, switch blade 71, conductors 109 and 110, contact 92, switch blade 91, conductor 111, relay coil 61, 40 and conductor 112 to the other terminal of secondary 96. It will be noted that this new circuit is independent of the engagement of contact 78 with contact 80 so that the circuit to relay coil 61 is not interrupted until contact arm 78 has 45 separated from contact 80. This is for the purpose of providing a differential between starting and stopping of the apparatus so as to prevent an excessive number of operations and also to prevent chattering of the relay when the thermostat first makes or breaks its contacts. It will also be noted that in the circuit last traced, the heater 81 was connected. The heater 81 is, however, relatively deenergized as long as contact 50 arm 78 engages contact 80 inasmuch as the same is effectively shorted out by a circuit from heater 81 through conductor 118, bimetal 77, through contact arm 78, contact 80, conductors 103 and 114, contact 66, switch blade 63, conductor 115, 55 switch blade 64, contact 67 and conductor 119 to heater 81.

The engagement of switch blade 62 with contact 65 results in an energizing circuit being established to the primary winding 25 of the ignition transformer 16 as follows: from line wire 99 through conductor 121, contact 65, switch 65 blade 62, conductors 122, 123, and 124, primary winding 25 and conductor 126 to the other line wire 98. Upon the energization of the primary winding 25, a spark will normally be produced 70 between the electrode 14 and the thermo-couple electrode 15. The spark between electrodes 14 and 15 will cause a gradual heating of the hot junction 35 of thermo-couple 15. The thermo-couple 15 is connected to relay coil 38 by an ener-

gizing circuit as follows: from thermo-couple 15 through conductors 30 and 31, through the ground, relay coil 37, and conductor 128 to the other terminal of the thermo-couple. When the hot junction becomes sufficiently heated, the energizing current flowing to relay coil 37 through 5 this circuit will be sufficient to cause switch blade 40 to be moved out of engagement with contact 41 and switch blade 39 into engagement with contact 42. 10

As soon as switch blade 39 moves into engagement with contact 42, an energizing circuit is established to relay coil 45 as follows: from the auxiliary winding 44 through conductors 129 and 31 to ground, through the ground, conductor 130, 15 switch blade 39, contact 42, conductor 131, relay coil 45, and conductor 132 to the other terminal of auxiliary winding 44. The auxiliary winding 44 will be energized so long as the resistance of the spark gap circuit is not excessively low. In 20 other words, the winding 44 is energized by the same flux as the winding 26. If the resistance of the secondary circuit is excessively low, very little flux will flow through the portion including secondary 26, the larger portion of the flux flowing through the leakage leg 22. The result will be that the flux to which winding 44 is subjected 25 will be insufficient to energize relay coil 45. If the resistance of the circuit is not excessively low, however, relay coil 45 will be energized to cause 30 engagement of switch blade 47 with contact 48.

Upon switch blade 47 engaging with contact 48, a circuit is established to the relay coil 51 of relay 50 as follows: from the upper terminal of winding 49 through conductor 134, switch 35 blade 47, contact 48, conductor 135, relay coil 51, conductor 136 through the ground, and conductor 137 to the other terminal of winding 49. The auxiliary winding 49 is energized sufficiently to cause relay coil 51 to actuate its associated 40 switch blades only if the resistance in the secondary circuit is not excessively high. If an open circuit condition exists in the secondary circuit or if the resistance is extremely high so that a spark would not occur, the flux will 45 all pass through the leg of the transformer upon which the secondary winding 26 is located so that practically no flux will pass through the leakage leg. Under these circumstances, of course, winding 49 will be incapable of energizing relay coil 51 sufficiently to actuate the relay. 50 If, however, the current flow in the secondary winding is of a value accompanying a proper spark, the relay coil 51 would be energized to cause switch blades 52, 53, and 54 to move into 55 engagement with contacts 55, 56, and 57.

The thoroughness of the spark checking operation is increased by reason of the fact that the circuit between auxiliary winding 49 and its relay coil is the last of the spark checking circuits to be closed. As soon as this circuit is 60 closed, current flows in winding 49 so as to cause counter flux in the leakage leg and thus force more of the flux through the portion of the core on which windings 26 and 44 are located. Since 65 winding 49 and relay 46 are provided for checking against a condition in which insufficient flux flows through the leakage leg, this diversion of some of the flux from the leakage leg makes this test more rigid. Moreover, since tests have 70 already been made to insure that the spark is adequate and since the forcing of more flux through the secondary portion of the core increases the intensity of the spark, it will be assured that the spark is even more intense 75

than absolutely necessary. This precludes any possibility of the spark being blown out when the burner is started due to the spark being just sufficient to cause the spark checking arrangement to function but insufficient to withstand the draft created by the burner blower.

Upon switch blade 54 engaging contact 57, a new relay energizing circuit is established through the heater element 89. Inasmuch as any circuit through contact 80 parallels between contact 80 and switch blade 54, an equivalent circuit through the heater 81, the only circuit which will be traced is that through heater 81, this circuit being as follows: from the upper terminal of secondary 96 through conductor 101, switch blades 87 and 86, conductor 102, contact 79, contact arm 78, bimetallic element 77, conductor 118, heater 81, conductor 119, contact 67, switch blade 64, conductors 116, 106, and 137, switch blade 54, contact 57, conductor 138, heating element 89, conductors 139 and 110, contact 92, switch blade 91, conductor 111, relay coil 61, and conductor 112 to the other terminal of secondary 96. It will be noted that the circuit just traced is through heating element 89. The heating element 89 is not immediately energized, however, since there still exists the previously traced circuit through switch blade 71 and contact 74 which parallels the heating element 89.

Engagement of switch blade 52 with contact 55 results in an energizing circuit to relay coil 69 as follows: from the line wire 99 through conductor 121, contact 65, switch blade 62, conductors 122 and 140, switch blade 52, contact 55, conductors 141 and 142, contact 73, switch blade 70, conductor 143, relay coil 69, and conductor 144 to the other line wire 98. The energization of relay coil 69 causes switch blade 70 to move from engagement with contact 73 into engagement with contact 72. As previously noted, the engagement of switch blade 70 with contact 72 is effected before the disengagement of the switch blade from contact 73. Upon switch blade 70 engaging contact 72, a holding circuit is established to relay coil 69 as follows: from line wire 99 through conductor 121, contact 65, switch blade 62, conductors 122 and 123, contact 72, switch blade 70, conductor 143, relay coil 69, and conductor 144 to the other line wire 98. The new energizing circuit for relay coil 69 is dependent only upon the energization of relay 58 and is independent of relay 50.

The energization of relay-coil 69 also causes switch blade 70 to disengage from contact 74. This interrupts the first traced circuits to relay coil 61 so that the only circuits remaining to this coil are through heating element 89.

The closure of switch blade 52 with contact 55 also results in a circuit being established to the oil burner motor 12 as follows: from line wire 99 through conductor 121, contact 65, switch blade 62, conductors 122 and 140, switch blade 52, contact 55, conductors 141 and 146, oil burner motor 12, and conductor 147 to line wire 98.

It will be noted from the preceding description that upon relay 50 becoming energized the oil burner is started and that relay 59 is energized to break the shunt circuits around the heating element 89 and to cause this element to be energized. The energization of heating element 89 results in the timing operation of the thermal switch 85 being initiated. Thus with the present system, this timing operation is not

initiated until a check has been established on the ignition spark. This is a particularly valuable feature in a system employing a thermocouple as a spark checking means since a thermocouple inherently requires a certain amount of time to respond to the presence of a spark. This time may be somewhat variable and thus results in a variation in the timing period for ignition of the burner after the oil has once been supplied, if the timing period is allowed to begin with a call for heat as has been previously the case. Even in a system in which there is a quick acting spark check, it may so happen that the ignition apparatus does not immediately respond and first produces a proper spark only at the end of the normal timing period. This will result in the apparatus shutting down by reason of the release of the thermal safety switch even though conditions are at that moment proper to establish combustion. With the present system, the time for establishing ignition and the checking thereof may be as long as possible without affecting the timing period for the ignition of the fuel.

Inasmuch as the ignition has been checked before the oil burner is turned on, combustion will presumably take place immediately. This will eventually cause a rise in stack temperature causing the stack switch blade 91 to first engage contact 93 and then disengage contact 92. The engagement of switch blade 91 with contact 93 will result in the following energizing circuit being established to relay coil 61 through the hot contact 93: from the upper terminal of secondary 96 through conductor 101, switch blades 87 and 86, conductor 102, contact 79, contact arm 78, bimetal 77, conductor 118, heating element 81, conductor 119, contact 67, switch blade 64, conductors 116, 106, and 137, switch blade 54, contact 57, conductor 149, switch blade 53, contact 56, conductor 150, contact 93, switch blade 91, conductor 111, relay coil 61, and conductor 112 to the other terminal of secondary 96. It will be noted that the new circuit is independent of heating element 89 and constitutes a shunt therearound. Thus immediately upon switch blade 91 engaging contact 93, the heating element 89 is effectively deenergized. As soon as switch blade 91 disengages contact 92, the circuit through heating element 89 is completely interrupted. Under normal circumstances this movement in the position of stack switch blade 91 will occur before heating element 89 has heated bimetal 88 to a point to effect opening of switch blades 87 and 86. If, however, the establishment of combustion requires an excessive period of time, the switch blades 87 and 86 are separated so as to interrupt all circuits to relay coil 61 and thus deenergize the entire system.

Under normal circumstances, the operation of the burner will be established within the proper time and will cause the temperature of the space in which thermostat 76 is located to gradually raise contact arm 78 and separate it from contact 80. When this takes place the only circuit remaining to relay coil 61 is the one including the heating element 81. Up until this time, the heating element 81 has been shunted by a circuit previously traced. When all of the current to relay coil 61 begins to flow through heating element 81, this heating element rises in temperature and subjects the bimetal 77 to a temperature higher than ambient. The effect of this is to cause the movement of contact arm 78 to the right to be accelerated so as to cause contact arm 78 to sep-

arate from contact arm 79 in a much shorter period of time than if separation were caused solely by a rise in ambient temperature. It will be noted that the heat is not applied to the thermostat, however, until the ambient temperature had risen sufficiently to cause contact arm 78 to separate from contact 80. The application of heat from heater 81 is thus used to accelerate an already existing movement of contact arm 78. The purpose of this, as is well known in the art, is to anticipate the delivery of heat to the space and thus prevent overshooting of the temperature due to the lag in delivery of the heat.

The system shown is of the constant ignition type. With this system, it is highly desirable to insure even after the oil burner is running that the ignition remains established at all times. The present system insures that upon failure of ignition, the oil burner is stopped and ignition is not reestablished until time has been provided for elimination of accumulated unburned oil vapor from the furnace. Let it be assumed that either a short circuit or an open circuit condition occurs in the ignition circuit. Either of these conditions will result in the deenergization of relay coil 51 with the resultant separation of switch blades 52, 53, and 54 from their associated contacts 55, 56, and 57. The separation of switch blade 54 from contact 57 will interrupt the energizing circuit of relay coil 61 since the only energizing circuits to relay coil 61 traced in the foregoing portion of the specification which are not through switch blade 54 and contact 57, are through contact 74 and switch blade 71. Switch blade 71 is engaged with contact 74, however, only when relay coil 69 is deenergized. Since relay coil 69 has a holding circuit through switch blade 62 and contact 65, it is not deenergized until after relay 58 is deenergized. Thus upon relay 50 being deenergized, with the resultant separation of switch blade 54 from contact 57, relay 58 is deenergized. Upon this relay being deenergized, the operation of the entire system is terminated. The system cannot again be restarted until stack switch 90 has cooled down to a value such that switch blade 91 has reengaged contact 92 and until the thermo-couple 15 has cooled down sufficiently to permit relay 38 to move to its deenergized position. This is true because the initial energizing circuit for relay coil 61 is through both contact 92 of the stack switch and the out contact 41 of the relay 38. Thus even though there be no stack switch present, a delay is interposed between the interruption of ignition and the reestablishment thereof, this delay arising because of the time required for the cooling of the thermo-couple. Thus the system can be successfully operated without a stack switch by merely connecting conductors 110 and 150 directly to conductor 111 and by eliminating the thermal safety switch.

Such a delay will also result whenever the system is energized, even momentarily, for any reason whatsoever. Thus if there is a momentary power failure or if the thermostat is manually opened and then closed, it is impossible to reenergize the ignition until sufficient time has elapsed for any unburned gases to pass up the stack.

It will be seen that I have provided an extremely safe fluid fuel burner control system in which a spark is checked in a manner as to absolutely preclude the possibility of a faulty check and in which assurance is had that the oil burner will be given its normal timing period in which to be

placed in operation despite any delay that may occur in connection with the establishment of or the checking of ignition.

While the electrode 15 has been shown in Figure 1 as being formed of a thermo-couple, it is possible to employ in lieu thereof an arrangement utilizing a ceramic element 160 having a negative temperature coefficient of resistance. This element is connected into the circuit in a very similar manner to the way in which thermo-couple 15 was connected in Figure 1. In other words, one terminal of the element is connected to the conductor 30 which is connected through conductor 29 to one winding of the secondary 26. The conductor 30 is also connected to ground through conductor 31. The other terminal of the element 160 is connected through the conductor 128 to the relay coil 37 of relay 38. With the use of a resistance element instead of a thermo-couple, it is of course necessary to provide some source of power since the resistance element does not itself generate an electromotive force. This is accomplished by the provision of an extra secondary winding 161 which may be provided on the transformer 95. The right hand terminal of relay coil 37 is connected through conductor 162 to the secondary winding 161 and the other terminal of the secondary winding is connected to ground at 163. Upon the existence of a proper spark, the ceramic element 160 will be heated to cause a flow of current through relay coil 37 sufficient to move the associated switches to their energized position. The ceramic element thus works in essentially the same manner as the thermo-couple, one principal difference being that the operation of the ceramic element depends solely upon the temperature to which it is subjected and not the difference in the temperature between two points thereof as in the case of the thermo-couple. The ceramic element on the other hand, causes a much more abrupt change in current delivered to the relay and hence minimizes relay chattering.

While I have shown certain specific embodiments of the invention for purposes of illustration, it is to be understood that the invention is limited only by the scope of the appended claims.

I claim as my invention:

1. In combination, a fluid fuel burner, ignition means comprising a high tension ignition circuit including a spark gap, means directly but slowly responsive to the temperature at the spark gap, means quickly responsive to the current flow in said ignition circuit, and means for causing fuel to be fed to said burner only when said temperature responsive means and said current responsive means both indicate the presence of a proper spark.

2. In combination, a fluid fuel burner, ignition means comprising a high tension ignition circuit including a spark gap, first spark checking means including a device directly but slowly responsive to the temperature at the spark gap and movable between cold and hot positions, second spark checking means quickly responsive to the current flow in said ignition circuit, means for initiating energization of said ignition means only when said first checking means is in its cold position, and means for causing fuel to be fed to said burner only when said first checking means is in its hot position and said second checking means indicates the presence of a current in said ignition circuit of a magnitude accompanying a proper spark.

3. In combination, a fluid fuel burner, ignition

means comprising a high tension ignition circuit including a spark gap, a thermo-couple having its hot junction adjacent said spark gap, a controller associated with said thermo-couple and movable between cold and hot positions depending upon the output of said thermo-couple, means quickly responsive to the current flow in said ignition circuit, and means for causing fuel to be supplied to said burner only when said controller is in its hot position and said current responsive means indicates the presence of a proper spark.

4. In combination, a fluid fuel burner, ignition means comprising a high tension ignition circuit including a spark gap, a thermo-couple having its hot junction adjacent said spark gap, a controller associated with said thermo-couple and movable between cold and hot positions depending upon the output of said thermo-couple, means quickly responsive to the current flow in said ignition circuit, means for initiating energization of said ignition means only when said controller is in its cold position, and means for causing fuel to be fed to said burner only when said controller is in its hot position and said current responsive means indicates the presence of a proper spark.

5. In a fluid fuel combustion control system; electrically operated fuel feeding means; a high voltage circuit including a spark gap for igniting the fuel; a transformer including a core, a primary winding, and a secondary winding connected in said high voltage circuit; an energizing circuit for said fuel feeding means including switch means controlling said circuit; and electromagnetic actuating means for said switch means; a temperature responsive device adjacent said spark gap; means secured on said transformer core and directly responsive to the flux flow therein; and means including both said temperature responsive device and said flux responsive means operative to cause said electromagnetic actuating means to close said switch means only when said temperature responsive device is subjected to the heat of a proper spark and when the flux assumes a value within the range accompanying a proper spark.

6. In a fluid fuel combustion control system; electrically operated fuel feeding means; a high voltage circuit including a spark gap for igniting the fuel; a transformer including a core, a primary winding, and a secondary winding connected in said high voltage circuit; an energizing circuit for said fuel feeding means including switch means controlling said circuit; an electromagnetic actuating means for said switch means; a thermo-couple having its hot junction adjacent said spark gap; means secured on said transformer core and directly responsive to the flux flow therein; and means including both said thermo-couple and said flux responsive means operative to cause said electromagnetic actuating means to close said switch means only when the hot junction of said thermo-couple is subjected to the heat of a proper spark and when the flux assumes a value within the range accompanying a proper spark.

7. In a fluid fuel combustion control system; electrically operated fuel feeding means; a high voltage circuit including a spark gap for igniting the fuel; a transformer including a core, a primary winding, and a secondary winding connected in said high voltage circuit; an energizing circuit for said fuel feeding means including switch means controlling said circuit; an electromagnetic actuating means for said switch means; a resistance element having a negative temperature

coefficient of resistance located adjacent said spark gap; means secured on said transformer core and directly responsive to the flux flow therein; and means including both said resistance element and said flux responsive means operative to cause said electromagnetic actuating means to close said switch means only when said resistance element is subjected to the heat of a proper spark and when the flux assumes a value within the range accompanying a proper spark.

8. In combination; a fluid fuel burner; means for controlling the flow of fuel to said burner; means for igniting the fuel, said igniting means comprising a high voltage source of power and a pair of spaced terminals each connected to said source of power, one of said terminals including a resistance element having a negative temperature coefficient of resistance; an electrical circuit including said resistance element, a source of power, and current responsive means; and means controlled by said current responsive means and operable to cause a flow of fuel to said burner only when said resistance element is subjected to the heat of a normal spark.

9. In a fluid fuel burner control system, a fluid fuel burner, electrically operated means for controlling the flow of fuel to said burner and operable upon energization thereof to admit fuel to the burner, means for igniting the fuel, said igniting means comprising a high voltage source of power and a pair of spaced terminals each connected to said source of power, one of said terminals including a resistance element having a negative temperature coefficient of resistance and extending adjacent to the gap between said terminals, a switch in the circuit of said fuel controlling means, and electromagnetic actuating means connected to a source of power in series with said resistance element.

10. In a fluid fuel burner control system, a fluid fuel burner, electrically operated means for controlling the flow of fuel to said burner and operable upon energization thereof to admit fuel to the burner, means for igniting the fuel, said igniting means comprising a high voltage circuit including a spark gap, a resistance element having a negative temperature coefficient of resistance extending closely adjacent the spark gap and subjected to the heat of the spark in the gap, a switch in the circuit of said fuel controlling means, and electromagnetic actuating means connected to a source of power in series with said resistance element.

11. In a fluid fuel combustion control system; fuel feeding means; ignition means comprising a high voltage circuit having a spark gap for igniting the fuel; a leakage transformer comprising a core, a primary winding, and a secondary winding connected in said high voltage circuit, said core having a portion constituting a leakage path around that portion of the core on which the secondary winding is located; and means responsive to a condition of said ignition means and operative upon said condition assuming a value accompanying a proper spark to force part of the flux in the leakage path portion of the transformer into the secondary portion to increase the voltage in said high voltage circuit and thereafter to cause said fuel feeding means to deliver fuel to said burner.

12. In a fluid fuel combustion control system; fuel feeding means; ignition means comprising a high voltage circuit having a spark gap for igniting the fuel; a leakage transformer comprising a core having a leakage leg, a primary winding on

one side of said leakage leg, a secondary winding on the other side of said leakage leg, and an auxiliary winding on the leakage leg itself; a normally open low impedance circuit including said auxiliary winding; and means responsive to a condition of said ignition means and operative upon said condition assuming a value accompanying a proper spark to close said low impedance circuit and thereby force part of the flux normally in the leakage leg of the transformer core into the secondary portion to increase the voltage in said high voltage circuit and thereafter to cause said fuel feeding means to deliver fuel to said burner.

13. In a fluid fuel combustion control system; electrically operated fuel feeding means; ignition means comprising a high voltage circuit having a spark gap for igniting the fuel; a leakage transformer comprising a core having a leakage leg, a primary winding on one side of said leakage leg, a secondary winding on the other side of said leakage leg, and an auxiliary winding on the leakage leg itself; a relay comprising a normally open switch and a low impedance relay coil for closing said switch, said switch controlling the energization of said fuel feeding means and said relay coil being connected to said auxiliary winding; a normally open second switch in the connections between said auxiliary winding and said relay coil; and means responsive to one condition of said ignition means and operative upon said condition assuming a value accompanying a proper spark to close said second switch and thereby force part of the flux normally in the

leakage leg of the transformer core into the secondary portion to increase the voltage in said high voltage circuit, said auxiliary winding being effective if the flux in the leakage leg is still of a value accompanying a proper spark to energize said relay and thereby cause the energization of said fuel feeding means.

14. In a fluid fuel combustion control system; electrically operated fuel feeding means; ignition means comprising a high voltage circuit having a spark gap for igniting the fuel; a leakage transformer comprising a core having a leakage leg, a primary winding on one side of said leakage leg, a secondary winding and a first auxiliary winding on the other side of said leakage leg, and a second auxiliary winding on the leakage leg itself; a relay comprising a normally open switch and a low impedance relay coil for closing said switch, said switch controlling the energization of said fuel feeding means and said relay coil being adapted to be connected in a closed circuit with said second auxiliary winding, the impedance of said relay coil being sufficiently low that when said second auxiliary winding is connected in a closed circuit therewith, part of the flux normally in the leakage leg of the transformer is forced into the secondary portion to increase the voltage in said high voltage circuit; and a second relay comprising a relay coil connected to said first auxiliary winding and a switch controlling the connections of said second auxiliary winding to the relay coil of said first mentioned relay.

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