April 9, 1940. M. J. MAYNARD 2,196,443

BURNER CONTROL SYSTEM

Filed May 7, 1938 2 Sheets-Sheet 1

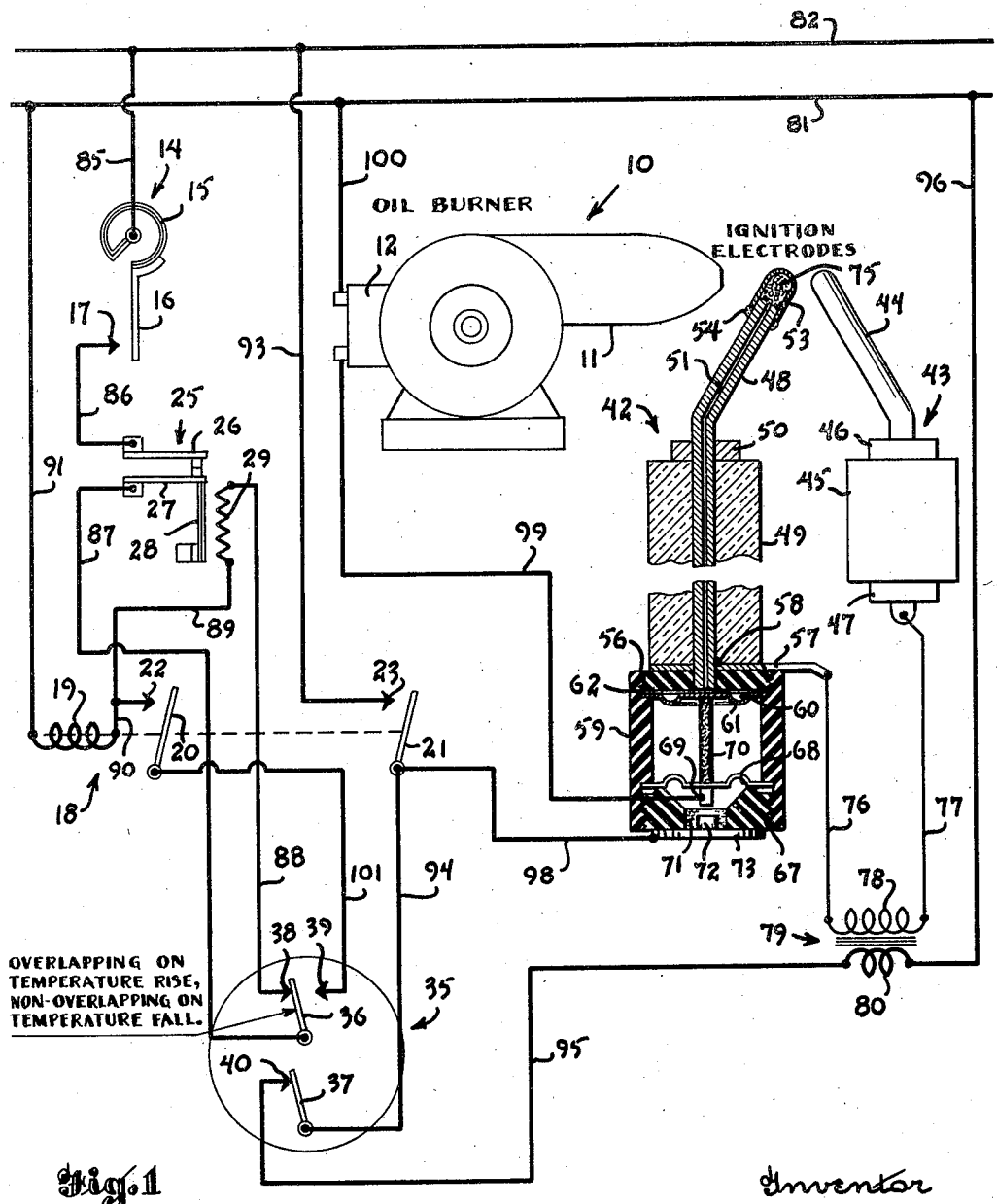


Fig. 1

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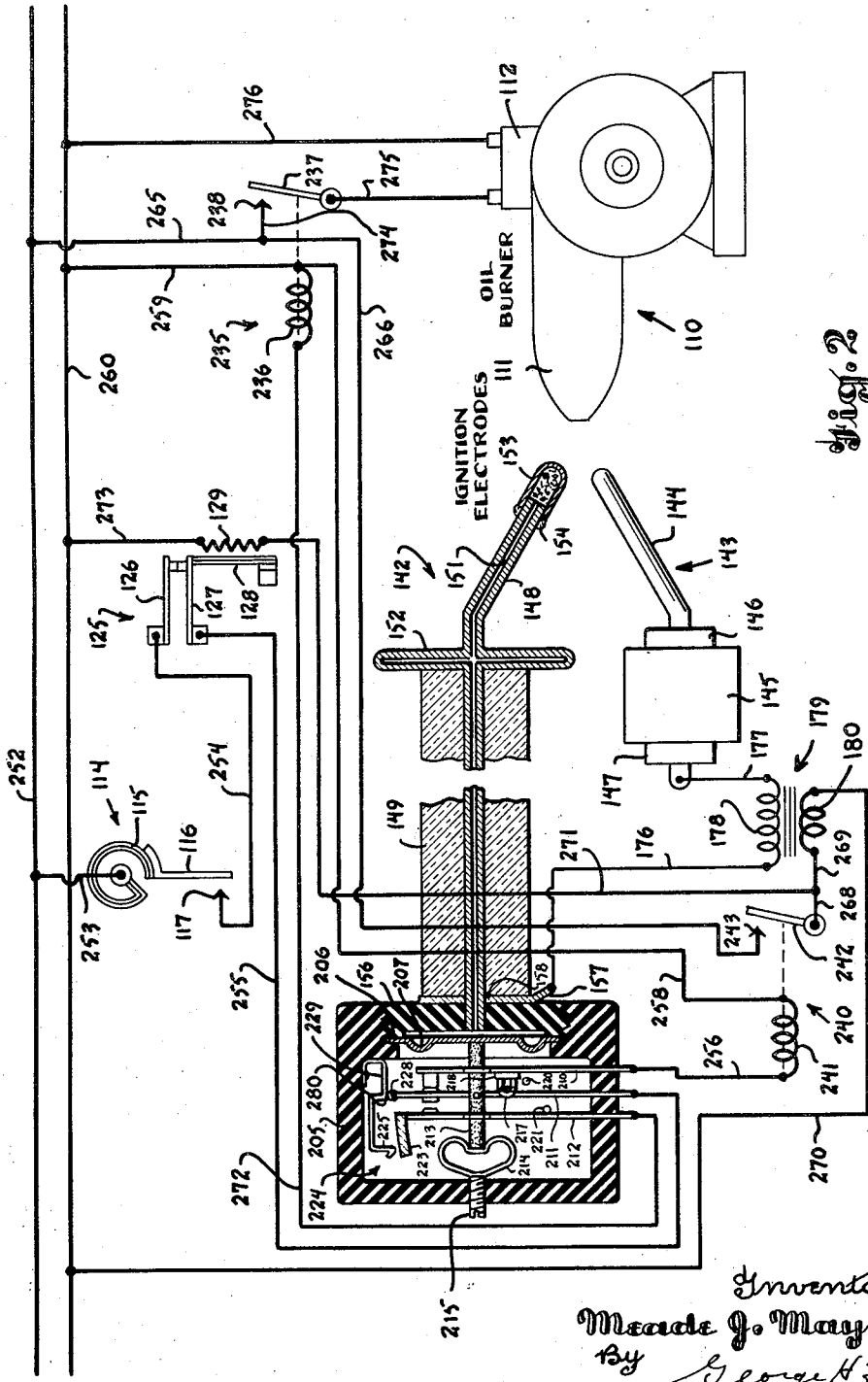


Fig. 2

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BURNER CONTROL SYSTEM

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Application May 7, 1938, Serial No. 206,592

11 Claims. (Cl. 158—28)

My invention relates to a burner control system and more particularly to one provided with means for checking the electrical ignition.

It is common in the burner control art to employ electrical ignition means for igniting the fuel as it is fed to either a main or pilot burner. This ignition means usually takes the form of a pair of spaced electrodes between which a high voltage spark is produced. In view of the fact that it is always possible that this ignition means may not function properly and that it is undesirable to have fuel supplied to the burner if the ignition means is not properly functioning, it has been proposed to provide means for checking the ignition to be sure that it in operating properly. Some of the prior art arrangements relied for the checking upon conditions that existed only when the ignition means was in operation. In the case of intermittent ignition in which the ignition is turned off as soon as the burner becomes lighted, this has the disadvantage that some other means must be provided for continuing the burner in operation after the ignition is deenergized. For this reason, it has been proposed to employ a temperature responsive means positioned adjacent the gap between the two electrodes for controlling the burner motor according to the heat of the spark gap. This furnishes a very reliable check inasmuch as the device responds only to a spark of approximately the proper intensity to light the burner. If the electrodes are spaced too far apart, no spark at all will result. If, on the other hand, the electrodes are in engagement so as to provide a short circuit, practically no heat will be produced at the spark gap. This arrangement has a further advantage that the control device for the burner controlled thereby will continue to maintain a position such as to keep the burner in operation since even though the ignition is turned off the temperature to which the temperature responsive element is subjected will continue to be very high by reason of the operation of the burner. The objection to such prior art arrangements however has been that difficulty has been encountered by reason of the very much higher temperature during burner operation than is encountered when the ignition means alone is energized. It will be obvious that if a switch, valve, or other control device is so adjusted as to be operated at one temperature the subjecting of the temperature responsive element to the much higher temperature of burner operation may severely injure the switch or other control device. Another disadvantage has been that such arrangements have not only not been compact but have usually decreased the efficiency of the ignition means.

An object of the present invention is to provide an ignition checking arrangement wherein one of the electrodes is hollow and in which a temperature responsive device is located in the hollow portion in conductive relationship with the tip of the electrode, the temperature responsive means controlling the flow of fuel to the burner.

A further object of the invention is to provide such an ignition checking arrangement in which the temperature responsive means is a volatile fluid.

A further object of the invention is to provide such an ignition checking arrangement in which the temperature responsive means is a vaporizable fluid, the quantity of the fluid being such that it is completely vaporized when subjected to a temperature slighly higher than the normal temperature of a spark.

A further object of the invention is to provide a burner control system employing temperature responsive means for checking the spark in which the further rise in temperature resulting from ignition of the burner is used to actuate a switch to place the apparatus in the position which it assumes during normal operation of the burner.

A further object of the invention is to provide a burner control system employing a novel form of temperature responsive switch for deenergizing the ignition and the heating element of a thermal safety switch upon the burner being ignited.

A further object of the invention is to provide a novel form of condition responsive switching mechanism providing overlapping in one direction but not in the other.

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

Figure 1 is a schematic showing of one form of the improved oil burner control system, and of which

Figure 2 is a schematic form of a modified form of the burner control system.

For a more detailed understanding of the system, reference is made to the drawings. The species of Figure 1 will first be described inasmuch as the species of Figure 2 is a further development of that of Figure 1.

The oil burner is generally designated in this figure by the reference numeral 10. This burner comprises a nozzle 11 and a burner motor 12. It

is understood that the burner is of the conventional type wherein a motor operates to force a mixture of fuel and air through the nozzle.

A thermostat 14 is used as a primary control of the oil burner, this thermostat being preferably located in a room of the building being heated. As shown in the drawings the thermostat comprises a bimetal element 15 to which is secured a contact arm 16 adapted to engage the fixed contact 17 upon the temperature falling below a predetermined value.

The thermostat 14 directly controls the energization of a relay 18. This relay comprises a relay coil 19 and a pair of switch arms 20 and 21. The switch arms 20 and 21 are adapted to cooperate with fixed contacts 22 and 23, being biased out of engagement therewith by any suitable means (not shown). Upon energization of the relay coil 19 switch blades 20 and 21 are moved into engagement with contacts 22 and 23 against the action of the biasing means.

A thermal safety switch is generally designated by the reference numeral 25. This safety switch may take any suitable form, one preferable form being that shown in the patent to F. S. Denison No. 1,958,081 issued May 8, 1934. As shown in the drawings, the switch comprises a pair of switch arms 26 and 27, the lower one of which is pivotally mounted and adapted to drop away from switch arm 26. The switch blades 26 and 27 are normally held in engagement by bimetal element 28, the upper end of which projects under the right-hand end of the lower switch blade 27. Associated with bimetal element 28 is a heating element 29. The heating element 29 upon energization thereof is adapted to heat the bimetal element 28 to cause the same to deflect to the right. Upon such deflection continuing sufficiently far, the end of the bimetal element is moved out from under the switch blade 27 permitting this blade to drop away from switch blade 26. After this has happened it is necessary to manually reclose switch blades 26 and 27 to reestablish the system controlled thereby.

A stack switch is generally indicated by the reference numeral 35, this stack switch comprising two switch blades 36 and 37. The switch blade 36 is adapted to move between two contacts 38 and 39. The switch blade 37 is adapted to move in and out of engagement with a fixed contact 40. The two switch blades 36 and 37 are actuated by a temperature responsive element secured in the stack, the switch blades being connected to the temperature responsive element through a slip friction connection. By reason of this slip friction connection, the switch blades are moved almost immediately when the temperature changes in a direction opposite to that in which it was previously changing. Thus, if the temperature should be rising to cause movement of switch blades 36 and 37 to the right, the initial change in temperature is effective to move the switch blades 36 and 37. As soon, however, as the necessary movement of switch blades 36 and 37 has taken place, the blades will thereafter slip with respect to bimetal element. The result is that as soon as the temperature starts falling, the blades will be almost immediately moved in the reverse direction. The assembly consisting of switch blades 36, 37, 38, and 39 is so constructed that upon a temperature rise switch blade 36 engages contact 39 before it disengages contact 38. Upon a temperature fall however the switch blade 36 disengages contact 39 before it engages contact 38. The assembly consisting of the temperature responsive element, the switch blade 36, and the contacts 38 and 39 may take the form shown in the patent to A. F. Erickson, No. 1,969,974, issued January 2, 1934.

The system as described so far is a conventional one and the improved features of the system of Figure 1 will now be described. Located adjacent to one end of the nozzle 11 are two electrodes generally indicated by the reference numerals 42 and 43. Electrode 43 is of more or less conventional structure consisting of a conducting rod 44 the upper portion of which is bent angularly and the lower portion of which extends through an insulating member 45 secured in position by two collars 46 and 47. Electrode member 42 likewise consists of a conductive rod 48, the upper end of which is bent at an angle so as to be inclined towards the upper portion of rod 44. Similarly, the lower portion of rod 48 extends through a cylindrical member 49 of insulating material. A collar 50 adjacent one end of the insulating material serves partially to hold the insulating member in position. It is understood that members 45 and 49 are of an insulating material which will resist the high temperatures to which they will be subjected by reason of their proximity to the burner. Unlike the rod 44, the rod 48 is provided with a passage 51 extending therethrough so as to form a hollow portion throughout the entire length of the rod. Welded to the end of rod 48 is a tip member 53 in the form of a cap, the welded connection being indicated in the drawings by the reference numeral 54. The space enclosed by cap 53 forms an enlarged continuation of the hollow portion provided by passage 51. The cap 53 is of good heat conductive material so that the temperature at the tip will be readily transmitted to the interior of the cap 53. It is also to be understood that the cap 53 is of good electrically conductive material since it is necessary that this carry the current or spark. The lower end of rod 48 is provided with a collar 56 of a phenolic condensation product or other suitable insulating material. It is to be understood that the rod 48 is preferably sufficiently long that the collar 56 is not in a region of excessive heat. Located between the collar 56 and the insulating member 49 is a terminal member 57, which terminal member is electrically connected at 58 to the rod 48. Threadedly engaged with the collar 56 is a tubular member 59 of material the same or similar to that of which collar 56 is formed. Clamped between a shoulder of tubular portion 59 and collar 56 is a diaphragm 60 which may be corrugated as at 61. A gasket 62 may be interposed between the diaphragm 60 and the collar 56 to insure a fluid tight connection therebetween. A closure plug 67 of insulating material similar to that of which collar 56 is formed is screw threaded into the lower end of member 59. A corrugated spider 68 is clamped between plug 67 and member 59, and a contact 69 is secured to the spider 68. Extending between spider 68 and diaphragm 60 is an insulating rod 70. The plug 67 is apertured as at 71 and extending into this aperture is a contact member 72 carried by conductive plate 73 secured by any suitable means to the plug 67.

It will be noted that the electrode 42 is hollow throughout almost its entire length. In the upper portion of the electrode the cap 53, the rod 48, and the diaphragm 60 enclose a fluid tight chamber. Located within the cap 53 is a volatile

fluid. Whenever the cap 53 is subjected to a temperature such as exists when a spark occurs between the two electrodes, this voltaile fluid is volatilized increasing the pressure within the chamber above referred to and causing diaphragm 60 to be forced downwardly. This downward movement of diaphragm 60 is effective through the insulating push rod 70 to move the central portion of spider 68 and consequently contact 69 into engagement with contact 72. When the fluid is cooled, the spider 68 is effective to return the contact 69 to the position shown in the drawing by reason of the inherent flexibility of the spider. In order to avoid any distortion of the parts when the electrodes are subjected to the burner flame itself, the volatile fluid, which is designated by the reference numeral 75, is so chosen that at or slightly above the temperature of a normal spark, the liquid is completely volatilized. After the liquid has so volatilized there will be no increase in vapor pressure and the only increase in pressure exerted on the diaphragm will be that due to an expansion of the vaporized liquid which increase is relatively slight. While the liquid will tend to condense in the space between collar 56 and diaphragm 60, this liquid will be volatilized by reason of the heat conducted by rod 48 to the interior of this space adjacent diaphragm 60. In lieu of a vaporizable fluid, the space within cap 53 may be filled with charcoal which has been subjected to a gas so as to be absorbed thereby. As the temperature to which the charcoal mixture is subjected rises, the gas is forced out of the charcoal to expand the diaphragm in the same manner as is done with the vaporizable fluid. The pressure that the mixture is capable of exerting however is limited by the total amount of gas in the mixture so that there is no danger of distorting any of the parts.

The two electrodes 42 and 43 are connected through conductors 76 and 77 to the secondary 78 of the step-up transformer 79. The secondary winding 78 is a high voltage winding whereas the primary transformer which is designated by the reference numeral 80 is a line voltage winding.

Power is supplied to this system through line wires 81 and 82 leading to any suitable source of power (not shown).

Operation of Figure 1 species

The various elements of the system of Figure 1 are shown in the position in which they occupy when the temperature to which thermostat 16 is subjected is at or above the desired value. Let it be assumed now that the temperature drops until contact arm 16 is moved into engagement with contact 17. Under these circumstances, the following circuit will be established to relay coil 19: from line wire 82 through conductor 85, bimetal element 15, contact arm 16, contact 17, conductor 86, switch blades 26 and 27, conductor 87, switch blade 36, contact 38, conductor 88, heating element 29, conductors 89 and 90, relay coil 19, and conductor 91 to the other line wire 81. The establishment of this circuit causes the energization of relay 18 with the result that switch arms 20 and 21 are moved into engagement with contacts 22 and 23.

The movement of switch arm 21 into engagement with contact 23 establishes the following circuit to the primary winding 80 of the ignition transformer 79: from line wire 82 through conductor 93, contact 23, switch blade 21, conductor 94, switch blade 37, contact 40, conductor 95, primary 80, and conductor 96 to the other line wire 81. Under normal conditions, the establishment of this circuit to the primary 80 of step-up transformer 79 results in a spark being produced between electrode members 42 and 43. If the electrodes are properly spaced apart to provide a proper spark, the spark will be accompanied by considerable heat. The effect of this heat will be to cause the vaporization of the fluid 75 causing the latter to exert pressure on the diaphragm 60. This in turn will yield and will move contact 69 into engagement with contact 72. When this takes place, the following circuit will be established to the oil burner motor 12: from line wire 82 through conductor 93, contact 23, switch blade 21, conductor 98, plate 73, contact 72, contact 69, conductor 99, burner motor 12, and conductor 100 to the other line wire 81.

The establishment of the above traced circuit to the oil burner will result in fuel being issued through nozzle 11. By reason of the fact that the burner has not been energized until it has been assured that the ignition means is working properly, the probability is that the oil will be immediately ignited. When this takes place, the temperature within the stack of the furnace will rise very rapidly causing the temperature responsive element of stack switch 35 to move switch blades 36 and 37 to the right, switch blade 36 being moved into engagement with contact 39. Movement of switch blade 36 into engagement with contact 39 results in the establishment of the following holding circuit to relay coil 19: from line wire 82 through conductor 85, bimetallic element 15, contact arm 16, contact 17, conductor 86, switch blades 26 and 27, conductor 87, switch blade 36, contact 39, conductor 101, switch blade 20, contact 22, conductor 90, relay coil 19, and conductor 91 to the other line wire 81. It will be noted that this new circuit is independent of the heating element 29 and effectively shunts the same out of the circuit. Almost immediately after switch blade 36 makes contact 39 to establish this new relay circuit, the switch blade 36 is separated from contact 38 thus interrupting the circuit through heating element 29 and entirely deenergizing the same.

The separation of switch blade 37 from contact 40 results in deenergization of the primary 80 of the ignition transformer and consequently of the deenergization of the ignition means. In view of the fact that the burner is now ignited, the ignition means is no longer needed and it is desirable to have the same deenergized to prolong the life of the electrodes and to save the current which would otherwise be consumed thereby. The deenergization of the ignition means does not result in the separation of contacts 69 and 72 by reason of the fact that the tip 53 of electrode 52 is now subjected to the burner flame. The temperature of the burner flame is now effective to maintain the volatile liquid 75 sufficiently vaporized to maintain contacts 69 and 72 in engagement. By reason of the fact moreover that the quantity of the volatile liquid 75 is limited as described above, the pressure within the chamber formed by diaphragm 60, passage 51, and cap 53 will not reach an excessively high value in spite of the fact that the oil burner flame is much higher than that produced by the spark. It will thus be seen that in spite of the deenergization of the ignition means, the oil burner remains in operation without the establishment of a parallel circuit thereto.

The operation which has just been described

is that which takes place when everything occurs as it should and as it normally does. Under normal circumstances the burner will continue in operation until thermostat 16 is satisfied at which time the entire system is deenergized. The stack will then cool off and the switch blades 36 and 37 will return to the position shown in the drawings. It is to be understood that if a proper spark does not occur, contacts 69 and 72 will never be closed with the result that the burner is not placed in operation. If combustion does not take place by reason of this fact or by reason of the fact that for some reason or other even after the burner motor is in operation the fuel is not ignited, the stack switch 35 will remain in the position shown in the drawings. When this occurs the current to relay 19 will continue to pass through the heating element 29. If this action continues sufficiently long the upper end of bimetallic element 28 will be deflected to the right sufficiently to allow switch blade 27 to drop away from switch blade 26 entirely deenergizing the system. The system cannot again be placed in operation until switch blades 26 and 27 are again manually reclosed. This insures that the attendant will have an opportunity to inspect the cause of the difficulty.

If the system is placed in operation in the normal manner as outlined above and the burner is for some reason or other temporarily extinguished, provision is made for reigniting the burner, if possible. As soon as the burner is extinguished, the temperature within the stack begins to fall causing switch blades 36 and 37 to almost immediately move to the left. The switch blade 36 first disengages contact 39 and deenergizes the relay 19 thus deenergizing the burner motor 12. Shortly thereafter switch blade 37 reengages contact 40 reestablishing the circuit to the ignition transformer and consequently reenergizing the ignition means. The apparatus is so adjusted however that a certain amount of time is allowed to elapse between the disengagement of switch blade 36 from contact 39 and the engagement of switch blade 37 with contact 40. During this time no fuel is being introduced into the furnace and an opportunity is given the fuel already accumulated therein to pass out through the stack. Shortly after switch blade 37 engages contact 40 to reenergize the ignition, switch blade 36 reengages contact 38 to reestablish the first traced energized circuit to relay coil 19 through the heating element 29. After the relay has thus been reenergized and as soon as the ignition is established, causing contacts 69 and 72 to reclose, the burner is placed into operation and conditions are again established to produce combustion. If the condition which caused the extinguishment of the burner has been overcome, the burner will again be placed in operation, the stack switch will be heated and the operation just described will be repeated. If, however, the burner is not ignited due to the condition having produced the extinguishment being of a more permanent nature, the heating element 29 will cause the separation of switch blades 26 and 27 shutting down the system in a manner similar to that previously described.

Species of Figure 2

In the species of Figure 2, the bulb associated with the electrode tip is employed to perform the functions which the stack switch 35 performs in the previously described species. Thus with the arrangement of Figure 2, it is unnecessary to employ a stack switch.

In order to enable a more ready comparison of the two figures, those elements in the species of Figure 2 which correspond identically to elements of Figure 1 have been assigned reference numerals 100 higher than the same elements of Figure 1. Moreover, because of the fact that they are identical to such elements of Figure 1, a detailed description thereof has been omitted.

The oil burner in this figure is designated by the reference numeral 110, being provided with a nozzle 111 and a motor 112.

The room thermostat is designated by the reference numeral 114, being provided with a bimetallic element 115 to which is secured a contact arm 116 movable into engagement with a fixed contact 117. A thermal switch which corresponds to thermal switch 25 of Figure 1 is designated by the reference numeral 125. The switch comprises blades 126, 127, bimetallic element 128 and a heater 129.

A pair of ignition electrodes which are employed for igniting the fuel issuing from the burner is designated generally by reference characters 142 and 143. These two electrodes are shown as though they extend from the opposite side of the furnace towards the oil burner. They are shown in this position, however, merely to more clearly illustrate the same. It is to be understood that the electrodes of the associated apparatus will extend into the furnace from the same side as the oil burner, the electrode tips being adjacent the oil burner nozzle.

The electrode 143 is more or less conventional in form, consisting of a conductive rod 144, the outer end of which is bent angularly and the inner portion of which extends through an insulating member 145 secured in position by two collars 146 and 147.

Electrode member 142 likewise consists of a conductive rod 148, the inner portion of which is bent at an angle so as to be inclined towards the inner portion of rod 144. Similarly, the outer portion of rod 148 extends through a cylindrical member 149 of insulating material. It is to be understood that this insulating member is relatively long so that it projects through the wall of the furnace. As shown in the drawing, a portion of the insulating member 149 and the rod 148 has been broken away. The rod 148 is enlarged at 152 in the form of a hollow disc. The insulating member 149 abuts at one end against the shoulder formed by disc 152. At the inner end of the rod, a collar 156 of a phenolic condensation product, or some similar material, is secured to the rod. The collar 156 serves to clamp the insulating member 149 in position. Interposed between the insulating member 149 and the collar 156 is a terminal member 157, which terminal member is electrically connected at 158 to the rod 148.

It is to be understood that members 145 and 149 are both of insulating material which will resist the high temperatures to which they are subjected by reason of their proximity to the burner. The rod 148 unlike the rod 144 is provided with a passage 151 extending therethrough so as to form a hollow portion throughout the entire length of the rod. This hollow portion 151 includes the hollow portion within the disc 152. Welded to the end of the rod 148 is a tip member 153 in the form of a cap, the welded connection being indicated in the drawings by the reference numeral 154. The space enclosed by cap 153

forms an enlarged continuation of the hollow portion provided by passage 51. The cap 153 is of good heat conducting material so that the temperature at the tip will be readily transmitted to the interior of the cap 153. It is also to be understood that the cap 153 like cap 53 is of good electrically conducting material.

The two electrodes form the high tension electrodes of a spark ignition system. A step-up high tension transformer 179 is employed to supply high voltage power to these electrodes. The transformer 179 comprises a primary 180 and a high voltage secondary 178. The high voltage secondary is connected by conductors 176 and 177 to electrodes 142 and 143, respectively. When the circuit to primary 180 is closed, a high voltage is applied between the electrodes 142 and 143 which results in a spark therebetween if the electrodes are properly spaced from each other.

The rod 148 of electrode 142 is filled with an expansible fluid, as will be discussed later, and is employed as both a spark temperature and a flame temperature responsive device to actuate switching mechanism. This switching mechanism is located within a casing 205 of insulating material, which casing is threadedly engaged with and supported by the collar 156. The casing 205 is preferably of the same type of insulating material as the collar 156. Secured between the casing 205 and the collar 156 is a diaphragm 206 which is corrugated at 207. The diaphragm 206 is so clamped between the casing 205 and collar 156 as to have fluid tight engagement with collar 156. If desired, a gasket may be interposed between the diaphragm 206 and the collar 156.

Mounted within casing 205 are resilient switch blades 210, 211, and 212. The middle switch blade 211 has secured thereto a rod 213 of insulating material, which rod abuts at one end against the diaphragm 206 and at the other end against a spring retainer 214, and which extends freely through openings in blades 210 and 212. A set screw 215 engages the spring retainer 214 and serves to vary the force with which spring retainer 214 urges rod 213 against the diaphragm 206. The blade 211 carries a magnet 217 which cooperates with an armature 218 carried by switch blade 210. The switch blade 210 is biased to the right but by reason of the attraction of magnet 217 and armature 218, upon movement of switch blade 211 to the left, the switch blade 210 is likewise moved to the left against its bias until it engages a stop 220. The switch blade 212 is biased to the right, the movement thereof to the right being limited by a stop 221. The stop 220 is so positioned with respect to the stop 221 that the switch blade 211 engages switch blade 212 before switch blade 210 engages the stop 220 to be separated from switch blade 211.

At its upper end, the switch blade 212 carries an arcuate friction plate 223. Cooperating with this friction plate is a resilient spring member 224, which is secured at its innermost end to the casing 205. At its outmost end, spring member 224 is provided with a downwardly extending portion 225 which is adapted to engage the friction surface 223 when the spring member 224 is not otherwise restrained. It is to be understood that the spring member 224 is biased in the direction of the friction member 223. The spring member 224 is held away from its biased position, as shown in the drawings, by the engagement of a roller 228 carried by the end of switch blade 211 against a depressed portion 229 of spring member 224. As long as the roller 228 is under this depressed portion 229, the spring member 224 is held against its bias in a position wherein the downwardly extending portion 225 thereof is out of engagement with the friction member 223. Upon movement of switch blade 211 to the left, the roller 228 is carried beyond the depressed portion 229 allowing the downwardly extending portion 225 of spring member 224 to engage the friction surface 223. The friction between spring member 224 and friction member 223 is sufficient to retain switch blade 212 in any position to which it is moved. The parts are so designed that switch member 211 will ride off of the depressed portion 229 before it engages switch blade 212 so that during all the time that it is in engagement with switch blade 212, the friction between member 224 and friction surface 223 is effective.

The chamber formed by the diaphragm 206, the rod 151, the disc 152, and the cap 153 has an expansible fluid therein which upon temperature rise expands and exerts a pressure against diaphragm 206. This fluid is preferably a fluid which volatilizes within the temperature range to which it is subjected although it may be a fluid whose expansion is solely the normal expansion with change in temperature. The pressure exerted on diaphragm 206 causes this to move the rod 213 to the left and consequently to move switch blade 211 to the left. This volatilization of the fluid may occur both by reason of the heating of the cap 153 by a spark between rods 142 and 143 and by reason of the radiant heat to which disc 152 is subjected during burner operation.

A relay 235 controls the operation of the oil burner. This relay comprises a relay coil 236, a switch blade 237, and a fixed contact 238 with which the switch blade 237 is adapted to engage on energization of coil 236. The energization of the ignition is controlled by a second relay 240. This relay comprises a relay coil 241, a switch blade 242, and a contact 243 with which the switch blade is engaged upon energization of coil 241.

Operation of Figure 2 species

The various elements are shown in the drawings in the position which they occupy when the system is shut down. This is the condition assumed when the temperature to which thermostat 114 is responsive is at or above the desired value. Let it be assumed that the temperature begins to fall. The bimetallic element 114 is so arranged that upon a sufficient drop in temperature, contact arm 116 is moved into engagement with contact 117. When this happens, the energizing circuit is established to relay coil 241 as follows: from a line wire 252 (one of two line wires leading to a suitable source of power, not shown), through conductor 253, bimetallic element 115, contact arm 116, contact 117, conductor 254, switch blades 126 and 127, conductor 255, switch blade 211, switch blade 210, conductor 256, relay coil 241, and conductors 258 and 259 to the other line wire 260. Upon the establishment of this energizing circuit to relay coil 241, the relay is energized causing switch blade 242 to move against its bias into engagement with contact 243. When this happens, the following circuit is established to the primary of transformer 179: from line wire 252 through conductors 265 and 266, contact 243, switch blade 242, conductors 268 and 269, primary winding 180 and conductor 270 to the other line wire 260. The moving of switch blade 242 into engagement

with contact 243 also establishes the following circuit to the heating element 129: from line wire 252 through conductors 265 and 266, contact 243, switch blade 242, conductors 268 and 271, heating element 129, and conductor 273 to the other line wire 260. The establishment of this last circuit causes the heating of bimetallic element 129.

The establishment of the circuit traced to primary winding 180 causes the transformer 179 to be energized so that a relatively high voltage is impressed between electrodes 142 and 143. If the electrodes are properly spaced, a spark will appear between electrodes 142 and 143 upon the voltage of secondary 178 being impressed upon them. This spark by reason of the relatively great heat conductivity of cap 153 will heat up the volatile fluid contained within the cap 153 so that the vapor pressure thereof is exerted upon the diaphragm 206. The diaphragm 206 is moved to the left by reason of this increased pressure, moving switch blade 211 also to the left. As the switch blade 211 moves to the left, switch blade 210 is carried along with it due to the magnetic attraction between the electromagnet 217 and the armature 218. After this movement has proceeded for a while, the roller 228 will ride off of the depressed portion 229 of spring member 224 allowing the lower portion 225 of spring member 224 to bear upon the friction surface 223. Continued movement of switch blade 211 will result in the same moving into contact making engagement with switch blade 212.

As soon as switch blade 211 is moved into such contact making engagement with said switch blade 212, the following circuit will be established: from line wire 252 through conductor 253, bimetallic element 115, contact arm 116, contact 117, conductor 254, switch blades 126 and 127, conductor 255, switch blade 211, switch blade 212, conductor 272, relay coil 236, and conductor 259 to the other line wire 260. The establishment of this energizing circuit to relay coil 236 results in switch blade 237 being moved into engagement with contact 238, establishing the following circuit to the oil burner motor 112: from line wire 252, through conductor 265, conductor 274, contact 238, switch blade 237, conductor 275, burner motor 112, and conductor 276 to the other line wire 260. With the establishment of the circuit last traced, both the oil burner motor and the ignition means are operating if the equipment is functioning properly. In view of the fact that the oil burner motor was not energized until an assurance was had that a spark existed between electrodes 142 and 143, the probability is that the oil will be immediately ignited. As soon as the oil is ignited, the radiant heat from the burner flame will act upon disc 152 to further raise the temperature of the fluid within rod 151 to further volatilize the same. The result would be that diaphragm 206 will be subjected to an even greater pressure to move the switch blade 211 even farther to the left. The continued movement of switch blade 211 to the left will cause switch blade 210 to engage the stop 220 so that armature 218 is pulled out of engagement with magnet 217. As soon as this happens, the switch blade 210 will spring back to the right to the position to which it is biased and in which it is shown in the drawing. The switch blade 211 will continue to move switch blade 212 to the left until a point is reached at which the temperature to which disc 152 is subjected no longer rises.

The separation of switch blade 211 from blade 210 interrupts the previously traced energizing circuit to relay coil 241 with the result that switch blade 242 is separated from contact 243. This results in both the deenergization of the ignition transformer and in the deenergization of the heating element 129. By reason of the deenergization of the heating element, bimetallic element 28 is no longer warped to the right so that switch blades 126 and 127 remain in engagement. If for some reason or other, combustion did not take place either by reason of the ignition means failing to operate or by reason of combustion not taking place even though the ignition means was operating properly, the heating element 129 would continue to remain energized with the result that bimetallic element 128 would warp to the right sufficiently to permit separation of switch blades 126 and 127. The separation of these switch blades as in the preceding case results in deenergization of the entire system and prevents the system being again placed into operation until the switch is manually reclosed.

If for some reason, combustion is interrupted after it has once been established, the volatile fluid will be cooled down quite rapidly causing the diaphragm 206 to move back towards the right. Due to the frictional engagement of portion 225 of spring member 224 with the frictional surface 223, the switch blade 212 does not travel back as switch blade 211 is moved back to the right. The result is that the burner motor is almost immediately stopped so that oil is no longer pumped into the combustion chamber. As the furnace cools down, a point will be reached when switch blade 211 has moved back to the right sufficiently that roller 228 engages the shoulder adjacent the depressed portion 229, this shoulder being designated in the drawing by the reference numeral 280. By the time that the roller 228 does engage the shoulder 280, the switch blade 211 will have moved to a point where engagement of switch blades 211 and 212 could not be effected even if switch blade 212 were released. The switch blade 212 is not, however, immediately released at this stage of the operation. Due to the abruptness of the shoulder 280, there is little tendency of the roller 228 to raise the spring member 224. As the rod 213 continues to pull the switch blade 211 to the right, the switch blade 211 is merely bowed. This bowing effect tends to move the contact carried thereby still further away from the contact carried by switch blade 212 so that it would be impossible upon release of switch blade 212 for the contacts of switch blades 211 and 212 to be moved into engagement. After this bowing has continued sufficiently far, the roller 228 will ride down the shoulder 280 onto the depressed portion 229 raising the spring member 224 and releasing the switch blade 212. This has no effect, however, due to the fact that the contact of switch blade 211 which would normally engage the contact of switch blade 212 is in a position where such contacts cannot be engaged, the movement of switch blade 212 to the right being limited by the stop 221. After the temperature has cooled down somewhat further, the switch blade 211 will be moved to a point where the engagement of switch blades 211 and 210 is effected. This engagement is an abrupt one by reason of the magnet 217 and armature 218. As soon as switch blades 211 and 210 are reengaged, the energizing circuit to re-

lay coil 241 is reestablished, again energizing the ignition transformer 179 and the heating element 129. It will be noted that the heating element 129 is not reenergized until the ignition means is also reenergized. This is advantageous in that considerable time may elapse between the extinguishment of the oil burner and the reenergization of the ignition and if it were not for the feature just mentioned, the heating element 129 might well open the switch 125 before the ignition was reenergized. If conditions are again proper to establish combustion, the cycle previously outlined will be repeated.

If, as is usually the case, the burner continues to operate until the room temperature is satisfied, the thermostat 114 will open its contacts to deenergize the entire system. The various elements will then cool off and eventually assume the position shown in the drawings.

It will be seen that with the species just described, the use of a stack switch is entirely avoided. With this arrangement, the spark is checked and also the establishment of combustion is checked by a single relatively compact device.

It will further be seen that with both forms of the invention, the presence of a proper spark is checked by a device which is extremely simple and compact.

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

I claim as my invention:

1. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes having a hollow portion, temperature responsive means in said hollow portion and located in heat conducting relationship with the electrode tip, a control device, means operatively connecting said temperature responsive means to said control device to actuate the latter, and means including said control device operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative.

2. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes having a hollow portion, an expansible fluid partially filling said hollow portion and in heat conducting relationship with the electrode tip, a control device, pressure responsive means operatively connected to said control device and exposed to the pressure of said expansible fluid, and means including said control device operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative.

3. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes having a hollow portion, temperature responsive means in said hollow portion and located in heat conducting relationship with the electrode tip, a switch, means operatively connecting said temperature responsive means to said switch to actuate the latter, and means including said switch operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative.

4. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes having a hollow portion, temperature responsive means in said hollow portion and located in heat conducting relationship with the electrode tip, a control device also located in said hollow portion, means operatively connecting said temperature responsive means to said control device to actuate the latter, and means including said control device operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative.

5. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said controlling means, one of said electrodes having a hollow portion, temperature responsive means in said hollow portion and located in heat conducting relationship with the electrode tip, a switch also located in said hollow portion, means operatively connecting said temperature responsive means to said switch to actuate the latter, and means including said switch operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative.

6. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes comprising an elongated hollow conductive member and a relatively large hollow member secured thereto with the hollow portions in communication, an expansible fluid in the hollow portion of said elongated member, pressure responsive means in the hollow portion of said relatively large member, a control device operatively connected to said pressure responsive means, and means including said control device operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative.

7. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes comprising an elongated hollow conductive member and a relatively large hollow member secured thereto with the hollow portions in communication, an expansible fluid in the hollow portion of said elongated member, pressure responsive means in the hollow portion of said relatively large member, a control device also located in the hollow portion of said relatively large member operatively connected to said pressure responsive means, and means including said control device operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative.

8. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes comprising an elongated hollow conductive member and a relatively large hollow member secured thereto with the hollow

portions in communication, an expansible fluid in the hollow portion of said elongated member, pressure responsive means in the hollow portion of said relatively large member, a switch also located in the hollow portion of said relatively large member and operatively connected to said pressure responsive means, and means including said switch operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative.

9. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes having a hollow portion, a volatile fluid partially filling said hollow portion and in heat conducting relationship with said electrode tip, a control device, pressure responsive means operatively connected to said control device and exposed to the pressure of said volatile fluid, and means including said control device operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative, the amount of said volatile fluid being such that the fluid is completely vaporizable at a temperature corresponding to or slightly higher than the normal temperature of a proper spark.

10. In combination, a burner, means controlling the flow of fuel to said burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes comprising an elongated hollow conductive member and a relatively large hollow member secured thereto with the hollow portions in communication, a volatile fluid in the hollow portion of said elongated member, pressure responsive means in the hollow portion of said relatively large member, a control device operatively connected to said pressure responsive means, and means including said control device operative to so control the fuel flow controlling means as to cause a flow of fuel to said burner only when the ignition means is properly operative, the amount of said volatile fluid being such that the fluid is completely vaporizable at a temperature corresponding to or slightly higher than the normal temperature of a proper spark.

11. In combination, a burner, means controlling the flow of fuel to the burner, an ignition circuit including a pair of electrodes for igniting the fuel supplied by said fuel controlling means, one of said electrodes having a hollow portion extending adjacent the electrode tip and also into an extension of the electrode exposed to the radiant heat from the burner, a temperature responsive fluid partially filling said hollow portion, a control device, pressure responsive means operatively connected to said control device and exposed to the pressure of said fluid, and means including said control device operative upon the existence of a temperature adjacent said electrode of a value accompanying proper operation of said ignition means to cause said fuel flow controlling means to effect a delivery of fuel to said burner and upon a rise in the radiant temperature as a result of the burner being ignited to deenergize said ignition circuit.

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