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 Continuation of application Ser. No. **823,826, May 12, 1969, now abandoned,**
 Division of Ser. No. **680,614, Oct. 30, 1967,**
 now Patent No. **3,497,849, dated Feb. 24,**
1970, which is a continuation-in-part of
 application Ser. No. **657,950, Aug. 2, 1967,**
 now abandoned.

[56]

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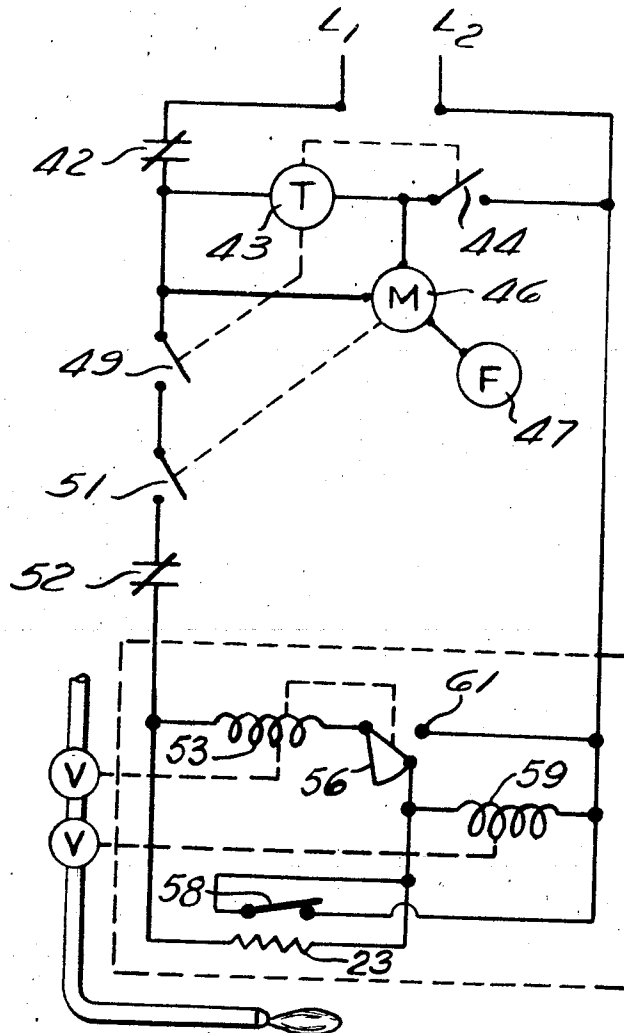
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[54] BURNER CONTROL SYSTEM 27 Claims, 7 Drawing Figs.

[52] U.S. Cl. 431/29,
 431/31, 431/66.
 [51] Int. Cl. F23n 5/00
 [50] Field of Search 431/29-
 -31, 66

ABSTRACT: A burner ignition and control system including two solenoid valves connected in series between the fuel supply and burner. An electrical resistance-type ignitor is provided to cause ignition and a sensor determines when the ignitor is in ignition condition and when combustion occurs properly. The circuit is arranged to provide automatic recycling when combustion does not occur or is prematurely terminated. A delay is provided when recycling occurs during which the burner and related system is purged of unburned fuel or products of combustion. The sensor is an ambient temperature compensated device operated by a bimetallic element to sense the rate of radiant heat emission from the ignitor and burner. The sensor is not directly exposed to the high temperature conditions at the ignitor and in the combustion zone so a simple bimetallic element is directly connected to operate the sensor switch.



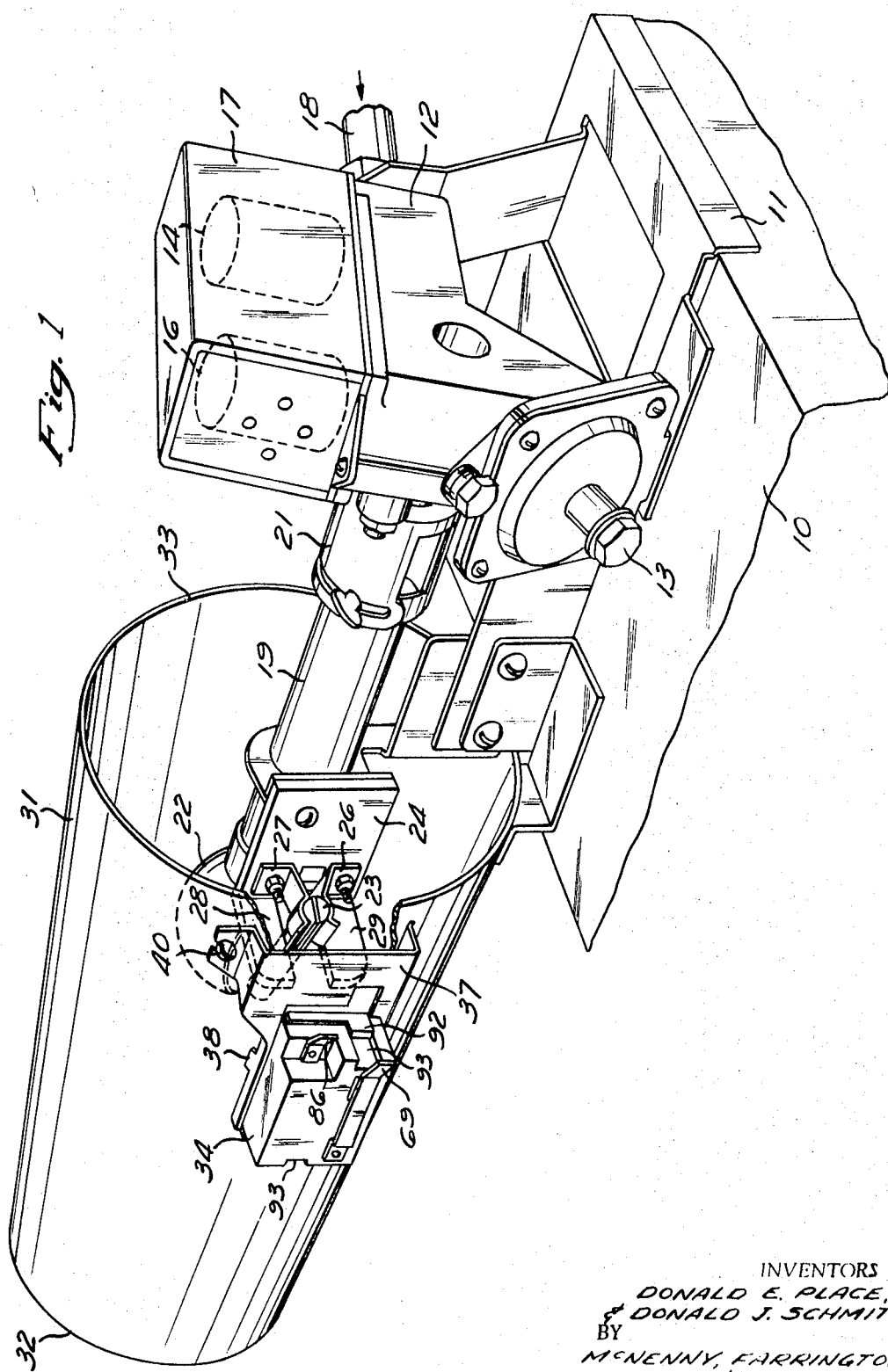


Fig. 1

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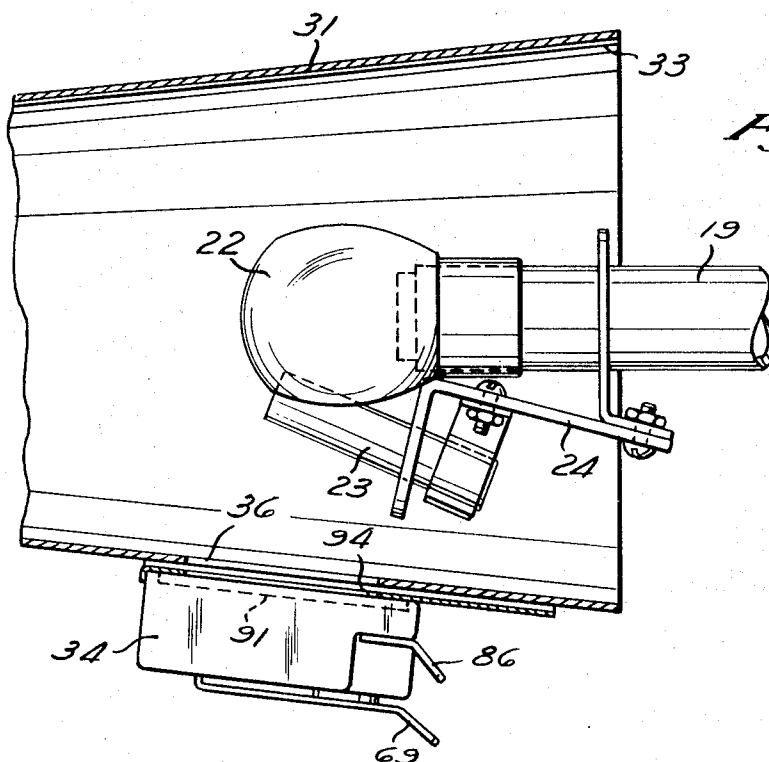


Fig. 2

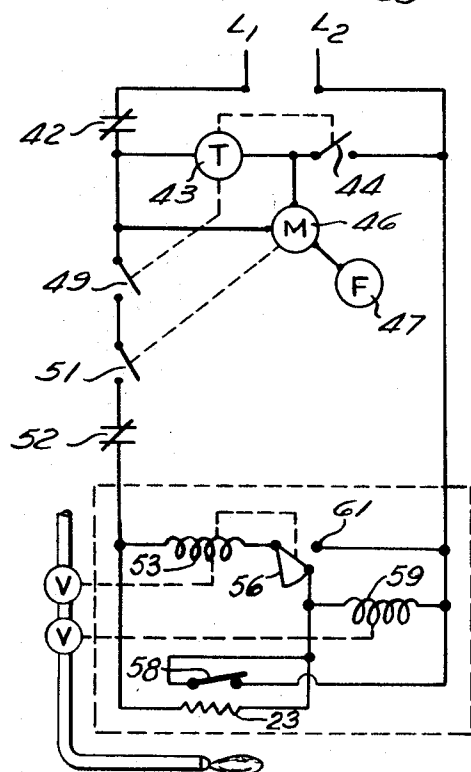


Fig. 3

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BURNER CONTROL SYSTEM

BACKGROUND OF THE INVENTION

This is a continuation of our copending application, Ser. No. 823,826, filed May 12, 1969 now abandoned which, in turn, is a division of our application, Ser. No. 680,614, filed Oct. 30, 1967, now U.S. Pat. No. 3,497,849, patented Feb. 24, 1970, which, in turn, is a continuation-in-part of our application, Ser. No. 657,950, filed Aug. 2, 1967, now abandoned.

This invention in one of its broader aspects relates generally to burner control systems and more particularly to a novel, improved and simplified ignition and fuel control system suitable for controlling the ignition and operation of burners of the type used in clothes dryers, furnaces and the like. In another of its broader aspects this invention relates to a novel and improved heat-sensing device which operates in response to rates of flow of radiant heat.

PRIOR ART

A variety of control systems have been provided to control the ignition and operation of burners. Generally such systems provide an ignition device and means to control the flow of fuel to the burner. When the fuel is gas it has been common to provide a pilot light, spark generators or resistance heaters for ignition.

When such systems are used to control the ignition and/or operation of a burner it has been common to provide a temperature sensing device to establish that the ignition device is in condition to cause ignition of the fuel before fuel flow is initiated. Some systems have also provided automatic recycling in the event that the ignition does not occur. Such systems have also been provided with various safety devices intended to insure safe and reliable operation. However, such systems are usually relatively complicated, costly, and in some instances, have imposed maintenance problems because of their complexity.

SUMMARY OF THE INVENTION

In one of its broader aspects, this invention provides a simplified system for controlling the operation of a burner in which a minimum number of subassemblies or elements are interconnected to provide ignition and control of a burner. The system insures safe operation by terminating or preventing the initial fuel flow when a malfunction occurs. The system also provides a minimum period of delay before ignition so that any unburned fuel can be purged to prevent any possibility of explosion or the like. Further, the system employs two valves in series to prevent any possibility of leakage. The various subassemblies or elements are arranged, in most instances, so that they perform dual functions. Therefore, the various functions of a safe system are provided with a minimum number of components.

The ignition and fuel control employs only four basic elements; namely, two solenoid valves, an electrical igniter, and a radiant heat sensor. These elements are interconnected so that the fuel flow cannot commence until the igniter is well above ignition temperature and cannot continue unless proper combustion is achieved. In the event that ignition does not occur, or combustion is terminated for any reason, the system automatically recycles after a sufficient delay to permit complete purging of the products of combustion or unburned fuel. Therefore, safe, reliable operation is achieved with a simple low cost system.

In the illustrated embodiment heat sensing is provided by a novel and improved switching device which senses radiant heat. Since the heat sensor does not require convection or conduction heat for its operation, it can be located at a cool location. Consequently, the heat sensor is not subjected to damaging temperatures and it operates in a reliable manner for substantially the entire life of the system without maintenance or repair.

The radiant heat sensor incorporates a simple ambient temperature compensated bimetallic element to operate a switch in response to predetermined conditions of radiant heat flow. Since the radiant heat emitted by the igniter and the flame is the function of temperature, this radiant heat sensor determines the presence or absence of the proper temperature conditions without being exposed to the actual temperatures being measured. Consequently, the sensing device is not exposed to excessive temperatures and can be directly connected to operate the sensing switch. Although the radiant heat sensor is illustrated in a burner control system, it also has utility in many other installations since it operates effectively to sense a condition without being directly exposed to the temperatures in the zones at the origin of the heat. Consequently, this sensor finds utility in many control systems for many kinds of equipment. It finds particular utility in installations where relatively high temperatures must exist in certain zones and where it is desirable to sense a heat condition at such zone. Therefore, a heat sensor incorporating this invention is not limited to the particular application illustrated but rather is a device of broad utility.

OBJECTS OF INVENTION

It is an important object of this invention to provide a novel and improved ignition and fuel control system for burners or the like which employs a minimum number of parts and which provides safe and reliable operation.

It is another important object of this invention to provide a novel and improved ignition control system including a radiant-heat sensing device to determine the operating conditions of the system.

It is another important object of this invention to provide a novel and improved ignition and fuel control system according to either of the preceding objects in which two fuel control valves are provided in series to eliminate any possibility of leakage and wherein the two valves are connected as an integral part of the system employed for automatic recycling in the event combustion is not properly initiated or is terminated for any reason.

It is another important object of this invention to provide a novel and improved radiant-heat sensing device for determining the rate of radiant heat emission from a zone or device which emits radiant heat.

It is another important object of this invention to provide a novel and improved radiant heat sensor which is ambient temperature compensated.

It is still another object of this invention to provide a novel and improved radiant heat sensor employing a simple bimetallic element to directly operate a sensing switch.

Further objects and advantages will appear from the following description and drawings, wherein:

FIG. 1 is a perspective view of a typical burner control system incorporating this invention which is adapted for use in a clothes dryer or the like;

FIG. 2 is a fragmentary plan view, partially in section, and with parts broken away for purposes of illustration, illustrating the burner, igniter, and radiant sensing switch;

FIG. 3 is a circuit diagram of the ignition and fuel control system;

FIG. 4 is an exploded perspective view of the radiant sensing device;

FIG. 5 is a side elevation, partially in section, of the radiant sensor illustrating the elements in the closed contact position;

FIG. 6 is a side elevation similar to FIG. 5 illustrating the sensing device in the contact open position; and,

FIG. 7 is an enlarged end view, partially in cross section, illustrating the sensing device mounted on the burner assembly.

FIG. 1 illustrates a burner system for a gas clothes dryer incorporating this invention. The assembly is mounted on the base 10 of the dryer by means of a support bracket 11. Mounted on the bracket 11 is a gas control manifold 12 which supports and connects a pressure regulator 13 and a pair of

solenoid valves 14 and 16 enclosed by a cover 17. Gas is supplied to the manifold 12 through an inlet pipe 18 and after passing through the series connected regulator 13 and solenoid valves 14 and 16 passes out of the manifold to the burner tube 19 through an air mixture control 21. A baffle 22 is mounted on the end of the burner tube 19 in a location arranged to insure proper mixing of the gas and air to insure complete combustion.

Ignition of the gaseous fuel is provided by an igniter 23 which in the illustrated embodiment is a resistance heating element of the type known as a "Globar." A "Globar" is a resistance-type electrical igniter having a substantial thermal mass which is operable when supplied with rated voltage to reach a temperature above the minimum temperature required to cause ignition of the gaseous fuel. The igniter 23 is mounted by a suitable bracket 24 and mounting terminals 26 and 27 on the forward end of the burner tube 19. The bracket 24 is preferably formed of a ceramic material and is provided with shielding projections 28 and 29 which extend laterally from the burner tube 19 to shield the terminal pieces 26 and 27. A burner funnel or duct 31 surrounds the burner and forms a combustion chamber for the burner. The forward end 32 of the funnel 31 connects to the dryer so that the heated air and the combustion products are drawn through the dryer in the usual manner by the dryer fan. Consequently, air enters the rearward end 33 and mixes with the products of the combustion before entering the drying area of the dryer.

Mounted on the outside of the funnel 31 adjacent to the igniter 23 is a sensor 34 which is sensitive to radiant heat emitted by the igniter 23 and the flame at the burner after combustion occurs. A window 36 (illustrated in FIGS. 2 and 7) is provided in the wall of the funnel 33 so that radiant heat may reach the sensor 34. The sensor 34, being located on the outside of the funnel 31, is not subject to high temperatures since it is substantially isolated from conductive and convective heat originating at the burner. A bracket 37 is used to mount the sensor 34 on the funnel. This bracket includes a pair of projections 38 and 39 (illustrated in FIG. 4) which extend through mating openings in the wall of the tunnel and cooperate with a screw 40 so that the bracket and sensor are removably mounted on the funnel.

The structural arrangement and the mode of operation of the sensor 34 are discussed in detail below. However, for purposes of understanding the operation of the circuit for controlling the ignition and fuel flow, it suffices to recognize that the sensor 34 provides a normally closed switch which is opened only when the igniter 23 and/or the flame of combustion radiates heat at a predetermined level.

FIG. 3 illustrates a one circuit arrangement for a dryer incorporating this invention. Line power is supplied to the dryer through the lines L_1 and L_2 . Power is supplied to the circuit from L_1 through a door switch 42 which is closed only when the dryer door is closed. Therefore, the dryer cannot operate if the dryer door is open. A timer 43 is connected across the line after the door switch 42 through a timer switch 44. This switch 44 closes when timer operation is initiated and causes the timer to continue to run, whenever the door is closed, until the desired cycle is completed. At the completion of the cycle of drying, the switch 44 opens to stop the timer 43 until it is reset for a subsequent cycle of drying.

The main drive motor 46 of the dryer is connected in parallel with the timer 43 so that it operates whenever the timer is operating and is turned off when the timer switch 44 opens at the end of the cycle. The motor 46 powers the tumbler if the dryer is a tumbler type and is also directly connected to operate a fan 47 which draws air into the rearward end 33 of the funnel 31, and carries the heated air through the dryer to the dryer vent along with the products of combustion.

Enclosed within the dotted box 48 is the circuit of the ignition and fuel control system. This system is connected across the line in series with the door switch 42, a normally open timer switch 49, a normally open motor-operated switch 51, and a limit switch 52. The timer switch 49 is closed by the

timer 43 when combustion is desired and the motor switch 51 is closed only when the motor 46 is properly operating at rated speed. The limit switch is normally closed and is operated by a thermostatic device to open and terminate combustion in the event temperature in the dryer exceeds a predetermined maximum temperature. Ignition and combustion cannot occur unless the dryer door is closed to close the switch 42, the timer is operating to close the switch 49, and the motor switch 51 is closed indicating proper operation of the motor 46. Even when these conditions are present, opening of the limit switch will terminate combustion if excessive temperatures occur in the dryer.

The ignition and fuel control system 48 includes the solenoid coil 53 of the first solenoid valve 14 which is connected on one side at 54 to the line L_1 after the limit switch 52. The other side of the coil 53 is connected through a switch 56, when the switch 56 is in the position illustrated, to a point 57. The point 57 is connected to the line L_2 through a normally closed sensing switch 58 of the sensor 34, and the solenoid coil 59 of the solenoid valve 16. The igniter 23 is connected between the point 54 and the point 57. The switch 56 is part of the solenoid 14 and is operated by the solenoid coil 53 to make a connection with a point 61 (connected with the line L_2) when the solenoid valve 14 picks up. The switch 56 is arranged so that an overlap is provided so that it is closed with the point 61 before it opens and disconnects from the point 57.

Fuel flow to the burner through the two solenoid valves 14 and 16 can only occur when both valves are open since these two valves are connected in series between the fuel inlet 18 and the burner 19. By providing two valves in series substantially all danger of leakage of fuel is eliminated since the probability of leakage in both valves due to improper seating of the valves is virtually nonexistent.

NORMAL OPERATION FOR IGNITION

In normal operation ignition occurs in the following manner. The operator closes the dryer door after inserting the wet clothes. This closes the switch 42. The timer 43 is then set causing the timer switches 44 and 49 to close. This initiates timer operation and starts the motor 46. As soon as the motor 46 reaches operating speed, the centrifugal switch 51 closes and power is supplied to the ignition and fuel control system 48. Ignition does not occur immediately as will be described in detail below, but the fan operates to purge the burner and the dryer of any combustion products or unburned fuel which might be present for any reason in the dryer.

As soon as the centrifugal switch 51 closes, line voltage is supplied to the igniter 23 and the coil 53 of the solenoid valve 14 through the closed sensor switch 58. This causes the solenoid valve 14 to pick up and opens the valve 14. Simultaneously the switch 56 closes with the point 61 connecting the coil 53 of the solenoid valve 14 across the line and removing the connection of the coil 53 through the switch 58. The coil 59 of the solenoid valve 16 is shunted by the switch 58 so the solenoid valve 16 remains closed and fuel is not supplied to the burner. However, the igniter 23 is connected across the line so it heats up.

When the igniter reaches a predetermined temperature above ignition temperature, it emits radiant heat at a sufficiently high level to cause the switch 58 of the radiant heat sensor 34 to open. In the illustrated embodiment, this occurs when the igniter 23 is at a temperature of about 2,300° F. The igniter can cause ignition when its temperature is above 1,400° F. to 1,600° F. Therefore, the igniter is substantially above the temperature required for ignition when the switch 58 opens. As soon as the radiant heat operated switch 58 opens, the coil 59 of the solenoid 16 is connected in series with the igniter 23 across the line. The resistance of the igniter 23 and of the coil 59 are related so that a sufficient current flows through the coil 59 to open the valve 16. When the valve 16 opens the fuel is supplied to the burner. As soon as the switch 58 opens the

voltage across the igniter drops to a low value and the igniter starts to cool. However, the igniter 23 has sufficient thermal mass so that it remains at a temperature substantially above ignition temperature for a sufficient period of time for the gas to reach the burner to cause ignition.

If for any reason ignition does not occur properly, the voltage across the igniter, because it is in series with the coil 59, is insufficient to cause the igniter to remain at a high temperature and the temperature of the igniter rapidly drops to a relatively low value. When the temperature drops back to a relatively low temperature, the rate of radiant energy flow from the igniter is insufficient to hold the switch 58 open. This allows the switch 58 to close and shunt the coil 59 of the solenoid valve 16. This causes the valve to drop out and close to terminate fuel flow. Under this condition the solenoid 14 remains open. The closing of the switch 58 causes full line voltage to be applied to the igniter 23 which then again commences to heat up to the temperature required to open the switch 58 so automatic recycling is provided until proper ignition occurs.

Since there is a time lag between the closing and opening of the switch 58, during which the fan 47 continues to operate, any unburned fuel which might be admitted to the burner during the period when ignition did not occur is purged from the burner and from the dryer and is pumped out of the vent so that the danger of explosion or the like is eliminated.

If ignition occurs properly, sufficient heat is radiated by the flame and the igniter 23 to hold the switch 58 open. In the illustrated embodiment, the igniter drops to about 1,000° F. when equilibrium is reached after ignition occurs. This temperature is maintained in the igniter by the presence of the flame and the low voltage applied to the igniter.

RECYCLING OPERATION AFTER COMBUSTION IS TERMINATED

After combustion occurs, the flow of fuel is stopped if any of the switches 42, 49, 51 or 52 are opened. If the switch 42 opens, the entire system is deenergized and the timer 43 and motor 46 stop. However, if either of the switches 49, or 52 open, the timer 43 and the motor 46 continue to operate until the switch 44 opens even though combustion is terminated. In a normal cycle of operation, the timer switch 49 opens a predetermined period of time before the completion of the cycle and the opening of the switch 44. This provides continued operation of the motor 46 and fan 47, after termination of combustion, to cool the dryer and purge the dryer of combustion products. This is also important in the drying of certain types of articles, such as wash and wear articles, since the continued tumbling of the article until the temperature in the dryer is reduced minimizes the wrinkling of the article.

If premature termination of the combustion occurs for any reason, an automatic recycling is provided. Such premature termination occurs most often when the operator opens the dryer door to insert or remove articles. Opening the door causes opening of the switch 42 and deenergizes the entire system until the door is reclosed. Reclosing of the door causes the timer 43 and motor 46 to be immediately reenergized. If the door switch has been opened a sufficient time for the entire system to return to a sufficiently low temperature to close the radiant-heat operated switch 58, initiation of combustion is in the normal manner described above.

On the other hand, if the door switch 42 is opened only momentarily, reclosing of the door switch 42 can occur before the switch 58 closes. If this occurs, the voltage across the coil 59 of the solenoid valve 16 is sufficient to cause that valve to open. However, the solenoid valve 14 remains closed since its coil 53 is connected in parallel with the igniter 23 and both the coil 53 and igniter 23 are in series with the coil 59. Under this condition the voltage across the coil 53 is insufficient to cause the valve 14 to open and ignition cannot occur. When the burner and igniter cool to a sufficiently low temperature to reduce the emission of radiant heat to a level sufficiently low

to permit the switch 58 to close, the valve 16 closes and the valve 14 opens. Therefore, one valve or the other is closed and fuel cannot reach the burner. The switch 58 does not close until the temperature of the burner and the temperature of the igniter 23 are well below ignition temperature so an interval of time is provided to purge the burner and the entire dryer of any combustion products or unburned fuel. It should be noted that unburned fuel should not be present under this condition of operation since fuel flow terminated at the same moment combustion terminated. As soon as the switch 58 closes, the ignition system is in the initial condition for normal ignition operation with the solenoid valve 16 closed and the solenoid valve 14 opened. This connects the solenoid coil 53 across the line and applies full line voltage to the igniter. When the igniter reaches a temperature of about 2,3000° F., the switch 58 again opens and ignition occurs.

For normal ignition when the dryer is first started from a cool condition, ignition occurs about 30 seconds after line voltage is supplied to the igniter and fuel control system 48. However, recycling when ignition fails to occur or after combustion is terminated is usually about 60 seconds since cooling must occur before the switch 58 can reclose and the igniter must then again heat to the necessary temperature to cause opening of the switch 58. It should be recognized that other forms of temperature sensing devices can be used in a circuit incorporating this invention. However, if such other sensing devices require convection or conductive heat for their proper operation, the advantages realized by a radiant-heat sensing device are not present and the sensing device will be subjected to much higher temperatures. It should also be understood that, if desired, a thermostat may be provided in the control circuit to regulate the temperature in the dryer. Such a thermostat may be of any suitable type appropriately located in the dryer structure to sense the temperature of the air and combustion-products mixture passing through the dryer. Such a thermostat would normally be provided with a normally closed switch inserted in the circuit in the zone of the switches 49, 51, or 52. This switch would open when the temperature in the dryer reached a predetermined temperature to terminate the combustion and would thereafter close when the temperature in the dryer dropped below a second lower predetermined temperature to again initiate combustion. Such a system provides automatic temperature regulation by intermittently operating the burner.

THE SENSING SWITCH OPERATED BY RADIANT HEAT

Reference should now be made to FIGS. 4 through 7 for a clear understanding of the structure and operation of the sensing device 34. The sensing device 34 includes a body 66 preferably moulded of a nonconductive material, for example a phenolic material. Mounted in the body 66 is an elongated fixed contact support element 67 secured at one end to the body 66 by a rivet 68. The rivet also secures a terminal 69 and provides an electrical connection between the support 67 and the terminal 69. An adjusting screw 71 is threaded into the body and engages the backside of the support 67 at a location spaced from the rivet 68. Mounted on the free end of a fixed contact support 67 is a fixed contact 72 which is surrounded by a permanent magnet 73.

The body 66 is formed with a central wall 74 which divides the body into two chambers 76 and 77. The wall 74 terminates short of the end of the body at one end to provide communication between these two chambers. The fixed contact support 67 is mounted in the chamber 76.

A U-shaped bimetallic element 78 provides two substantially parallel legs 79 and 81 joined at one end by a cross portion 82. A stiffening rib 83 is provided at the cross portion or section 82. The leg 79 of the bimetallic element 78 is mounted in the body 66 by a rivet 84 which also mounts and connects to a second terminal 86. The leg 79 is positioned to extend along the chamber 77 with the cross portion 82 extending around the end of the wall 74 so that the leg 81 is in the chamber 76.

The free end of the leg 81 overlies the fixed contact 72. Mounted on the free end of the leg 81 is a mobile contact 87 and an armature 88. The armature 88 cooperates with a magnet 73 to provide snap action of the switch and the electrical connection is provided by the two contacts 72 and 87.

The various elements are proportioned so that when the two legs 79 and 81 are at the same temperature the mobile contact 87 is in engagement with the stationary contact 72. The magnet 73 and the armature 88 cooperate to provide sufficient pressure to insure a good electrical connection therebetween. When the elements are in this condition, electrical connection is provided between the terminals 69 and 86. It should be noted that if the temperature of the two legs 79 and 81 remains the same, similar increases or decreases in their temperature does not result in opening of the contacts since the two legs deflect from the normal position in a similar manner. Consequently changes in ambient temperature which result in similar changes in the temperature in the two legs 79 and 81 do not effect the operation of the switch so the device is ambient temperature compensated. When, however, the temperature of the leg 79 exceeds the temperature of the leg 81, differential bending occurs in the two legs. The various parts are arranged so that when the leg 79 reaches a temperature of about 25° F. above the temperature of the leg 81, sufficient force is developed to overcome the action of the magnet 73 and the mobile contact 87 snaps to a position as illustrated in FIG. 6. The separation of the two contacts 72 and 87 results in an opening of the electrical connection and the terminals 69 and 86 are then electrically disconnected. The leg 79, at least on its face adjacent to the source of radiant heat, is provided with a black coating to increase the efficiency of absorption of radiant heat.

The mobile contact 87 remains spaced from the fixed contact 72 so long as the temperature of the leg 79 is higher than the leg 81 by a predetermined amount. However, when the temperatures of the two legs 79 and 81 again approach the same temperature, the two legs move toward alignment and the mobile contact 87 approaches the fixed contact 72. When it reaches a point of close proximity, the action of the magnet 73 causes the contacts to snap close to reestablish an electrical connection between the two terminals 69 and 86.

A piece of glass 91 or similar piece of other material which is transparent to radiant heat is mounted on the body 66 by the bracket 37 so that it closes the body and the switch cavity. The bracket 37 is provided with a pair of ears 92 which are bent into mating recesses 93 to permanently connect the body and bracket. The bracket 37 is formed with a window 94 aligned with the leg 79 in the cavity 77 so that radiant heat can enter the cavity 77 and strike the leg 79. However, the portion of the bracket 37 aligned with the cavity 76 is imperforate so that radiant heat cannot impinge upon the leg 81. The bracket is also arranged to position its window 94 in alignment with the window 36 formed in the funnel 31 as best illustrated in FIG. 7. Consequently, radiant heat emitted from the igniter 23 can strike the leg 79 and cause its temperature to increase, but radiant heat cannot reach the leg 81. Consequently, radiant heat produces a temperature differential in the two legs to produce the switching operation. The bracket 37 is preferably formed so that the principal portion of the bracket closing the body 66 is spaced from the wall of the funnel 31 to minimize conductive heat flow to the sensing device. This also provides a space between the funnel wall and the sensing device through which the fan tends to draw air to minimize convective heat flow. However, convective and conductive heat does not tend to produce a differential temperature between the legs 79 and 81 and merely acts like an ambient temperature change as discussed above.

FIG. 6 illustrates schematically the condition of operation of the sensing device wherein a source of radiant heat is provided by a resistance element 96 so that the radiant heat can elevate the temperature of the leg 79 above the temperature of the leg 81 to cause opening of the switch. In the installation illustrated in FIG. 1 the source of the heat corresponding to

the resistance element 96 is the igniter 23 and the flame after combustion occurs. It is recognized that since the bimetallic element is conductive, there is a heat transfer from the leg 79 through the cross portion 82 to the leg 81 whenever the temperature of the leg 79 exceeds the temperature of the leg 81. However, heat is also lost through the body and the other structure parts of the device. The various elements are proportioned so that an equilibrium is reached with the temperature of the leg 79 sufficiently above the temperature of the leg 81 when the rate of radiant heat flow to the device being sensed is at the predetermined level desired to maintain the switch open. For example, the switch is arranged and mounted in the installation illustrated in FIG. 1 so that the switch opens when the temperature of the igniter 23 reaches about 2,300° F. and closes when the temperature of the igniter 23 drops well below the minimum ignition temperature unless flame is present to maintain a sufficiently high level of radiant heat flow to maintain the required temperature differential between the legs. When combustion occurs, the rate of radiant heat flow to the sensor is such that the switch remains open when the igniter stabilizes at a temperature of about 1,000° F.

In the embodiment of FIG. 1, the two contacts 72 and 87 cooperate to form the switch 58 described above in connection with the circuit of FIG. 3. When the sensing device incorporating this invention is used in a control system or sensing system where the signal or the operation of the sensing switch is intended to bear a direct relationship to the temperature of a particular element or zone, the sensing device is arranged and located relative to the source of radiant heat so that operating conditions will occur when the source of the heat is at a particular temperature. If the sensitivity of the device is to be reduced, the material of the bimetallic element 78 can be changed or its size can be changed. Further the transparency of the glass 91 or the size of the window 94 can be modified. Further adjustment can be provided by positioning the sensing device at a location where it receives more radiant heat when increased sensitivity is desired or positioning the sensor in a location where it receives less radiant heat at a given temperature of the zone being sensed when lower sensitivity is desired. These various changes can be made to change the operating characteristic in a particular installation since the sensing device responds to radiant heat rather than actual temperature.

There are many installations where a switch of this type is particularly desirable since difficulty is often encountered in determining or sensing the temperature of an article or element which reaches relatively high temperature levels. Since the radiant switch itself is not exposed to these high temperatures, even though it senses the rate of radiant heat emission, a device incorporating this invention is particularly advantageous in such installations.

Although a preferred embodiment of this invention is illustrated, it is to be understood that various modifications and rearrangements of parts may be resorted to without departing from the scope of the invention disclosed and claimed.

We claim:

1. A burner control system comprising a burner, a pair of solenoid valves connected in series with said burner operable to supply fuel to said burner only when both valves are open, intermittently operable igniter means, sensing means provided with switching means, and circuit means connecting said switch means with said solenoid valves and said igniter means, said sensing means and said circuit means being arranged to produce a cycle of operation each time ignition is required in which one of said valves is opened only when said sensing means determine that flame is not present and said igniter means are not in an ignition condition and thereafter opening said second of said valves only when said sensing means determine that said igniter is in an ignition condition, said sensing means and circuit means operating to cause said valves to terminate fuel flow when ignition does not occur within a predetermined interval after the flow of fuel is initiated.

2. A burner control system as set forth in claim 1 wherein a fan is provided which operates continuously when said circuit means are energized to evacuate unburned fuel or products of combustion from the area of said burner.

3. A burner control system as set forth in claim 2 wherein power is supplied to said control systems through switch means associated with said fan to power said circuit means only when said fan is operating.

4. A burner control system as set forth in claim 2 wherein said control system provides a purging delay during which said fan operates before fuel can be supplied to said burner.

5. A burner control system as set forth in claim 4 wherein said igniter means is an electrical resistance heating device with sufficient thermal mass to provide a heating delay before it reaches a temperature sufficiently high to operate said sensing means, and said heating delay provides said purging delay.

6. A burner control system as set forth in claim 1 wherein said igniter means is an electrical heating device operable when supplied with rated voltage to reach a temperature above ignition temperature, and said circuit continues to supply a low voltage below said rated voltage to said igniter means while combustion continues, said low voltage being sufficient to maintain said igniter means at a low temperature above ambient temperature and below ignition temperature, said sensing means initiating opening of said second valve only when said igniter means is above ignition temperature.

7. A burner control system as set forth in claim 6 wherein rated voltage is supplied to said igniter only when at least one of said valves is closed.

8. A burner control system as set forth in claim 1 wherein said igniter emits radiant heat at a rate which is a direct function of its temperature, and said sensing means are sensitive to and operate in response to the rate of emission of radiant heat.

9. A burner control system as set forth in claim 8 wherein said sensing means are located so that conductive and convective flow of heat from said burner and igniter means to said sensing means is relatively insignificant.

10. A burner control system as set forth in claim 8 wherein said sensing means are substantially insensitive to convective and conductive heat.

11. A burner control system as set forth in claim 8 wherein said sensing means are substantially unaffected by changes in ambient temperature.

12. A burner control system as set forth in claim 1 wherein said sensing means include support means, a bimetallic element providing at least two substantially parallel legs joined at one end, the other end of a first of said legs being supported by said support means, a switching contact carried by the other end of the second of said legs, said support means providing radiant energy communication between said igniter means and only one of said legs.

13. A burner control system as set forth in claim 12 wherein said support means provide radiant energy communication between said igniter means and said first leg.

14. A burner control system comprising a burner, a source of fluid fuel, first and second normally closed solenoid valves connected in series between said source and burner, an electrically operable resistance-type igniter, sensor means including a normally closed sensor switch operable to determine when said igniter is in condition to cause ignition and open said sensor switch, a holding switch connected so that it is in a first position when said first valve is closed and in a second position when said first valve is open, and a pair of power lines adapted to be supplied with line voltage, said second valve being connected in parallel with said sensor switch and being connected across said line in series with said igniter, and said first valve being connected across said lines in series with said sensor switch when said holding switch is in said first position and being connected across said lines directly when said holding switch is in said second position.

15. A burner control system as set forth in claim 14 wherein said holding switch is operated by the solenoid of said first valve and provides overlap.

16. A burner control system as set forth in claim 14 wherein said igniter provides sufficient thermal mass to remain above ignition temperature for the period of time necessary for fuel to reach said burner after said valves are both open.

17. A burner control system as set forth in claim 14 wherein the resistance of said second solenoid valve and the resistance of said igniter are arranged so that sufficient current is present to open said second valve when it is connected across said lines in series with said igniter.

18. A burner control system as set forth in claim 14 wherein the resistance of said two solenoid valves is arranged so that insufficient current is present to open said first valve when said valves are connected in series across said lines.

19. A burner control system comprising a burner, a source of fluid fuel, first and second normally closed solenoid valves connected in series between said source and burner, an electrically operable igniter, sensor means including a normally closed sensor switch operable to determine when said ignitor is in condition to cause ignition and open said sensor switch, a pair of power lines adapted to be supplied with electrical power, said first valve including first coil means connected in parallel with said ignitor, said valve including second coil means connected in parallel with said sensor switch, said ignitor and said first coil means being connected in series with said second coil means and said switch across said power lines when said valves are closed, and holding means operable to hold said first valve open when said sensor switch is open, said second coil means opening said second valve only when power is applied to said power lines and said sensor switch is open, said first coil means causing said first valve to open only when power is applied to said power lines and said sensor switch is closed.

20. A burner control system as set forth in claim 19 wherein said second coil means is operable to open said second valve when a voltage is applied to said second coil means which is less than the voltage applied to said power lines.

21. A burner control system as set forth in claim 20 wherein opening of said sensor switch causes substantial drop in the voltage applied to said ignitor and causes sufficient voltage to be applied to said second coil means to cause opening to said second valve.

22. A burner control system as set forth in claim 19 wherein said ignitor is a resistance-type ignitor and provides sufficient thermal mass to remain above ignition temperatures for the period of time necessary for fuel to reach said burner after said valves are open.

23. A burner control system as set forth in claim 19 wherein said first and second coil means are arranged so that insufficient current is applied to said first coil means to cause said first valve to open when said sensor switch is open.

24. A burner control system comprising a burner, a source of fluid fuel, first and second normally closed solenoid valves connected in series between said source and burner, an electrically operated ignitor, sensor means including a normally closed sensor switch operable to determine when said ignitor is in condition to cause ignition and open said sensor switch, a pair of power lines adapted to be supplied with electrical power, said first valve including first coil means connected in series with said sensor switch, said first coil means operating to open said first valve only when power is applied to said power lines and said sensor switch is closed, said second valve including second coil means connected in parallel with said sensor switch and being shunted thereby when said sensor switch is closed, said second coil means operating to open said second valve only when power is applied to said power lines and said sensor switch is opened, and holding means operable to hold said first valve open when said sensor switch is open and power continues to be supplied to said power lines.

25. A burner control system as set forth in claim 24 wherein said ignitor is connected in series with said sensing switch and said second coil means and said ignitor is a resistance-type ignitor, the voltage applied to said ignitor when said sensing switch is open being insufficient to maintain said ignitor at a sufficiently high temperature to maintain said sensing switch open.

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26. A burner control system as set forth in claim 25 wherein said second coil means is operable to open said second valve when a voltage is applied to said second coil means which is less than the voltage applied to said power lines.

27. A burner control system as set forth in claim 26 wherein

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said ignitor is a resistance-type ignitor and provides sufficient thermal mass to remain above ignition temperatures for the period of time necessary for fuel to reach said burner after said valves are open.

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