FIG. 9
COMBUSTION TYPE RADIANT HEATER

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ABSTRACT OF THE DISCLOSURE

An infrared heater having a compartmentalized housing with a pair of infrared generators mounted side by side in one compartment and a fuel and combustion air mixing chamber including control means mounted in another compartment with separate fuel supply conduits extending from the mixing chamber in the other compartment to each infrared generator in the one compartment. Means in the mixing chamber to supply equal amounts of fuel to each generator including adjustable stops to vary the proportion of the fuel and air. A flame propagation means disposed between the generators insures ignition of each generator and a flame sensor assoicated with at least one of the generators shuts off the fuel if a generator flames out or fails to ignite. Reflectors surround both of the infrared generators to give direction to the infrared rays.

Background of the invention

The radiant heaters disclosed herein are particularly well suited for use out-of-doors in adverse weather conditions both to make areas comfortable for their occupants and to prevent ice and snow from accumulating. However, they may of course be utilized in any application in which radiant heat can be beneficially employed.

In radiant heaters of the type to which the present invention relates, multiple combustion type infrared generators are utilized to produce radiant energy for area or object heating. The infrared generators operate on a combustible mixture of fuel and air supplied from a fuel-air mixing chamber connected to each of the generators by a combustible mixture supply conduit.

Summary of the invention

One of the important features of the present invention is the provision of novel structure for insuring that the combustible mixture supplied by the mixing chamber is proportioned equally among the infrared generators. In general, this structure consists of a novel arrangement of baffles in the mixing chamber between the combustible mixture supply tubes and inlets to the mixing chamber for fuel and combustion air. These novel baffles also insure thorough mixing of the fuel and air and, in addition, provide legs to which a detachable mixing chamber cover can be attached.

In the infrared generators employed in the heaters of the present invention, a fuel-air mixture distribution tube and a ribbon type orifice grid are employed to distribute the combustible mixture to a combustion zone adjacent the outlet ends of ports formed by the ribbons in the grid. A radiant grid surrounding the combustion zone is heated by the burning gases and converts the energy of the latter to radiant energy of wave lengths suitable for area and object heating. Operation of the infrared generators may be controlled by any desired type of control system, but the latter is preferably provided with a flame sensor responsive to the presence and absence of flame in the combustion zone so that the supply of fuel to the infrared generators will be terminated if the generators fail to ignite or the flame goes out. The flame sensor, which may be of conventional construction, extends through the combustion zone of one of the infrared generators adjacent its distribution tube and is surrounded by the radiant grid of the infrared generator. It is also preferred that the flame sensor be located to one side of the combustion zone in the radiant heaters of the present invention rather than in the center of the combustion zone. This prevents overheating of the flame sensor, extending its useful service life.

Another important feature of the present invention is a novel improved construction of the radiant grid for protecting the flame sensor against the effects of low temperatures and high winds, which will cool the flame sensor so that the latter will falsely indicate a flameout. The flame sensor will therefore operate properly under adverse conditions, and the radiant heaters disclosed herein may consequently be used out-of-doors in the most severe weather without the necessity of protecting the radiant heater from the elements.

In conjunction with the foregoing, when the type of infrared generator discussed above is first lit and its radiant grid is cold, the flame will tend to blow through the radiant grid to its exterior; and the flame sensor will not respond properly. However, the novel grid construction provided by the present invention confines the flame within the grid even when the grid is cold so that proper operation of the flame sensor is obtained during the starting up of the infrared generator.

To further adapt the radiant heaters of the present invention for use in cold and/or windy environments, the infrared generators are preferably provided with side reflectors of novel configuration to prevent the disturbance of combustion in the infrared generators. The resulting steady and even combustion eliminates the alternate heating and cooling of the grids and resulting grid deteriorating warpage which occurs in operating other combustion type infrared generators in such environments. This solves one of the major problems which has heretofore made it impractical to use combustion type radiant heaters in environments of the type mentioned above as well as increasing the efficiency of the heater, which is reduced by cooling of the radiant grids.

The side reflectors also concentrate and direct the radiant energy onto the object or into the area to be heated. To further concentrate the radiant energy emanating from the infrared generators into the desired pattern, the radiant heaters disclosed herein may also be provided with casing supported reflectors similar to those disclosed in our copending application No. 405,944 filed Oct. 23, 1964, now Patent No. 3,307,529.

In radiant heaters of the type disclosed herein, it is important that all of the infrared generators ignite quickly when the radiant heater is lighted. To insure rapid ignition, the radiant heaters disclosed herein are preferably provided with a novel transfer burner for propagating the flame after initial ignition.

The infrared generators employed in the radiant heaters of the present invention are also preferably provided with a combustion air damper in the mixing chamber which is movable between a closed position and an open position in which it is positioned away from the inlet and does not impede air flow into the mixing chamber. This damper is operatively connected to the end of a bimetallic actuator which is warped between first and second limit positions as the heater alternately heats up to operating temperature and cools off. When the heater is cold, the actuator moves the damper to its minimum flow position, restricting the flow of air to provide a fuel-rich mixture which ignites easily
when the heater is started up. As the heater warms up, the bimetallic actuator is heated and moves the damper to the maximum flow position; and the air flow increases to provide a lean mixture which burns with a short sharp flame. Such a flame ensures complete combustion and heats the radiant grid of the infrared generator most efficiently.

From the foregoing, it will be apparent that one important and primary object of the present invention resides in novel improved radiant heaters of the combustion type.

Other related and important, but more specific objects of the present invention include the provision of combustion type infrared generators:

1. which are suited for use out-of-doors in adverse weather conditions, for example, by low temperatures, high or gusty winds, or precipitation in the form of rain, sleet, or snow;

2. which do not require protection from the elements when used out-of-doors in adverse weather conditions.

3. in which the radiant grid is protected from the elements to prevent cooling of the radiant grid and disturbances in combustion which would cause a reduction in output and/or warpage of the grid.

4. in which a control system including a flame sensor controls operation of the heater and in which the flame sensor is protected from the elements to insure that it operates properly in adverse weather conditions.

5. which include multiple infrared generators and a novel arrangement for propagating the flame when the heater is lit so that all of the infrared generators are rapidly ignited.

6. which include multiple infrared generators and a novel arrangement for ensuring equal flows of a homogeneous combustible mixture to the infrared generators.

7. which include a novel simplified control for automatically adjusting the flow of combustion air to provide a rich starting mixture and a lean running mixture.

8. which include novel reflectors capable of effectively protecting the radiant grids of the infrared generators against cooling by wind or air currents as well as concentrating and redirecting the radiant energy emanating from the infrared generators.

9. which are highly accessible for servicing.

10. which are more efficient and less expensive to manufacture than comparable radiant heaters hitherto available.

Brief description of the drawings

Other objects, additional novel features, and other important advantages of the present invention will become more fully apparent from the appended claims and as the ensuing detailed description and discussion proceeds in conjunction with the accompanying drawings, in which:

FIGURE 1 is a perspective view of a combustion type infrared generator constructed in accord with the principles of the present invention;

FIGURE 2 is a section through the infrared generator of FIGURE 1;

FIGURE 3 is a schematic diagram for a control system incorporated in the radiant heater of FIGURE 1;

FIGURE 4 is a fragmentary section through an infrared generator incorporated in the radiant heater of FIGURE 1 and a flame sensor incorporated in the control system of FIGURE 3, showing the physical relationship of the flame sensor to a radiant grid incorporated in the infrared generator;

FIGURE 5 is a view similar to FIGURE 4 showing the relationship between the radiant grid and a spark plug type igniter incorporated in the radiant heater;

FIGURE 6 is a plan view, partly sectioned, of the arrangement provided for supplying a combustible fuel-air mixture to the generators incorporated in the radiant heater of FIGURE 1;

FIGURE 7 is a section through a fuel-air mixing chamber and other components incorporated in the combustible mixture supply chamber of FIGURE 6;

FIGURE 8 is a perspective view of a combustion air controlling damper incorporated in the combustible mixture supply system; and

FIGURE 9 is a section through the infrared generators incorporated in the radiant heater of FIGURE 1, showing a transfer burner employed to propagate the flame from one infrared generator to the other when the radiant heater is lit.

Detailed description of the preferred embodiment

Referring now to the drawings, radiant heater 20 includes two combustion type infrared generators 22 and 24 mounted in side-by-side relationship in a heater casing 26 together with combustible mixture supply and heater control systems 28 and 30.

Turning first to FIGURES 1 and 2, heater casing 26 is composed of a U-shaped main cover member 32, end covers 34 and 36, and a transverse partition 38, which divides the interior of casing 26 into an infrared generator compartment 40 and a blower-control compartment 42. End covers 34 and 36 are removably fixed to cover member 32 by screws 44 which extend through the side walls 46 of cover member 32 into nuts 48 attached to vertically extending end cover flanges 50. The foregoing arrangement enables access to compartments 40 or 42 to remove, replace, or service infrared generators 22 and 24 and/or systems 28 and 30 to be readily gained simply by removing screws 44.

Partition 38 is fixed to casing member 32 by spot welding or riveting casing member side wall 46 and top wall 52 to a flange 54 bent from the top edge of the partition and similar flanges (not shown) bent from its side edges. As best shown in FIGURE 9, each of the infrared generators 22 and 24 includes a fuel-air mixture distribution tube 56, an orifice grid 58, through which the fuel-air mixture flows from the interior of the distribution tube 56 to a combustion zone 60 adjacent its outer end or face; and radiant grids 62a and 62b, which are assembled end-to-end with a space theretebetween to accommodate expansion and contraction and are heated to incandescence by the combustion of the fuel-air mixture. Each infrared generator also includes reflectors 64 for concentrating the radiant energy and projecting it in the desired direction or directions and for protecting radiant grids 62a and 62b from wind and air currents together with end brackets 66 and 68, which form closures for the open ends of distribution tube 56 and support the infrared generators from casing 26.

Referring now to FIGURE 9, distribution tube 56 has four side walls 70 providing a generally diamondlike configuration. The opposed lateral edge portions of the sheet from which distribution tube 56 is formed are bent at angles to the two distribution tube walls 70 with which they are integral to form two parallel, spaced apart flanges 72. These flanges provide an outlet passage 74 from the interior to the exterior of the distribution tube.

Orifice grid 58, through which the combustible fuel-air mixture exits from distribution tube 56, is mounted in outlet passage 74 to distribute the combustible mixture uniformly over combustion zone 60 and to prevent the flame from flashing back from the combustion zone through the passage to the interior of the distribution tube. The illustrated orifice grid is of the ribbon type (it is not critical that a ribbon type orifice be employed), consisting of embossed metallic ribbons which provide a number of small passages extending between and opening onto the opposed lateral edges of the assemblage of ribbons. Ribbon type grids are described in more detail in copending application No. 395,839 filed Sept. 11, 1964, now Patent No. 3,531,048, to which reference may be had if deemed necessary for a more complete understanding of the present invention.

In the present invention, strips 76 of heat resistant metal are preferably interposed between the orifice grid and distribution tube flanges 72 to stiffen the latter and
to protect them from the heat generated in combustion zone 60. This arrangement helps to prevent warpage of the flanges and, therefore, materially increases the service life of the type of infrared generator disclosed herein.

As shown in FIGURE 9, bolts 78, which extend laterally through distribution tube flanges 72 at spaced intervals therealong, locate orifice grid 58 relative to the inner end of passage 74. Retainers 80, threaded on the ends of bolts 78, clamp flanges 72 against orifice structure 58 to retain it in passage 74. Bolts 78 pass through holes (not shown) in heat resistant strips 76 and retain the strips in place when the orifice grid is removed for cleaning or other maintenance.

Radiant grids 62a and 62b are preferably of the perforated construction disclosed in copending application No. 395,839. Each grid is made of a sheet of heat resistant metal bent into a horseshoe configuration providing a radiation emitting body 82 and intumescing mounting flanges 84. The length of the radiant grids is preferably limited to about 18 inches to keep expansion and contraction of the grids within acceptable limits.

The body 82 of each radiant grid is formed into a configuration in which rows of loops 86 are displaced from the sheet from which the grid is formed at regular intervals to form openings extending normal to the sheet through which the combustion products may pass from the combustion zone. In flanges 84, loops 86 are flattened back into the plane of the flanges or are omitted to facilitate the attachment of the grid to distribution tube 56.

End plates 88 are disposed between two rows of loops 86 at the outer ends of grids 62a and 62b and secured in place by ears (not shown) bent from the grid and fixed as by welding to the end plates. End plates 88 support the ends of the grids to which they are attached and maintain the grids in the desired shape. They also prevent air currents from disturbing the flame. The method of attaching the end plates just mentioned is described in more detail in copending application No. 548,941 filed May 10, 1966. Reference may be had to the latter application if deemed necessary for a complete understanding of the present invention.

The ends of radiant grids 62a and 62b to which the end plates are assembled are supported from brackets 66 and 68, respectively, as by screws 90. With the end plates thus assembled to the end brackets, orifice grids 58 and the ends of heat resistant strips 76 extend through square notches 92 in the end plates.

Referring now to FIGURES 2 and 9, U-shaped clips 94 support the ends of radiant grids 62a and 62b opposite end plates 88. Each of the clips 94 has a base 96 and two notched legs 98 extending normally from the base at opposite ends thereof. The base of each clip is fixed as by welding, to the mounting flanges 84 of the associated radiant grid. The clips therefore perform the function of maintaining the radiant grids in the desired shape or configuration.

The legs of mounting clips 94 extend through elongated slots 100 in reflectors 64. The projecting portions of legs 98 engage the reflectors adjacent the ends of slots 100, laterally positioning the ends of the radiant grids to which they are attached. At the same time, the elongated slots accommodate longitudinal movement of clips 94. Therefore, the radiant grids are free to expand and contract longitudinally during the cycling of heater 20. Clips 94, their advantages, and the manner in which they are used for infrared generators equipped with other than two radiant grids are described in detail in copending application No. 548,941.

Referring now to FIGURES 1 and 9, the reflectors 64 with which the infrared generators are provided each have a first reflecting leg 102, a second reflecting leg 104, and a mounting leg 106 by which the reflectors are fixed to the distribution tube and radiant generator with which it is associated. The reflecting legs 102 of the reflectors extend normally from mounting legs 106 generally parallel to and spaced from the mounting flanges 84 of radiant grids 62a and 62b.

Reflecting legs 104 extend normally from reflecting legs 102 closely adjacent the sides of the radiant grids. At approximately or beyond the level of maximum grid width, legs 104 diverge away from the radiant grids and from each other at a diminishing angle (typically on the order of about ten degrees). As shown in FIGURE 9, the free edges of legs 104 extend well beyond the radiant grids.

The form of reflector just described is particularly advantageous for radiant heaters employed out-of-doors or in environments where strong drafts or other air currents are present. Even under extremely adverse conditions, such reflectors effectively protect the infrared generators against the radiant grid cooling and combustion disturbing effects of low temperatures and winds or air currents. This eliminates the reduction in efficiency resulting from the cooling of the radiant grids. It also eliminates the reduction in output and warpage of the grids which accompany the irregular heating of the grid that occurs when there is disturbance of the combustion in zone 60.

Reflectors 64 are approximately the same length as radiant grids 62a and 62b and are assembled to the distribution tube 56 of the associated infrared generator in end-to-end relationship with gaps between adjacent reflectors. These accommodate expansion of the reflectors during operation of radiant heater 20. Reflectors 64 are held in place by the bolts 78, mentioned above, which extend through mounting legs 106, and by retainers 80, which clamp mounting legs 106 against distribution tube flanges 72. This protects the distribution tube flanges against the heat generated in combustion zone 60 and materially stiffens them, further increasing their resistance to warpage.

Further, as shown in FIGURE 9, mounting legs 106 and heat resistant strips 76 are dimensioned so that they extend well beyond the free edges of flanges 72 toward combustion zone 60. Therefore, the edges of the flanges are recessed between the associated flange and heat resistant strip. This also protects the edges of flanges 72 from the heat generated in combustion zone 60, further minimizing warpage of the distribution tube flanges.

Referring now to FIGURES 1 and 2, the brackets 66 by which the ends of infrared generators 22 and 24 nearest casing end cover 34 are supported from casing 26 have two integral legs 106 and 108 bent at right angles into an L-shaped configuration. Bracket legs 108 form closures for the open ends of the distribution tubes while legs 106 extend in parallel, spaced relationship along the tops of the distribution tubes. Brackets 66 are similar to end brackets 65, but have only a single, closure forming leg 110.

The closure forming legs 108 and 110 of brackets 66 and 68 extend well below the outer end of orifice grid 58. A rectangular aperture or slot (not shown) is formed in each of the closure legs adjacent its lower end. As shown in FIGURE 2, the ends of orifice grids 58 extend through these apertures so that the elongated closure forming legs assist in retaining orifice grids 58 in their proper position relative to distribution tubes 56.

End brackets 66 and 68 are attached to fuel-air mixture distribution tubes 56 by angle clamps 112 which are best illustrated in FIGURE 9 and which are fixed, as by spot welding, to the ends of fuel-air mixture distribution tubes 56. Angle clamps 112 are described in detail in our copending application No. 397,775 filed Sept. 21, 1964, now Patent No. 3,339,539, to which reference may be had, if desired, for a more detailed description of these components. The closure forming legs 108 and 110 of end brackets 66 and 68 are fixed to angle clamps 112 by bolts 114 and nuts 116.

Referring now to FIGURE 2, to prevent the combustible mixture from leaking through the ends of fuel-air mixture distribution tubes 56, gaskets 118 are assembled between the closure forming legs 108 and 110 of end
brackets 66 and 68 and the associated ends of distribution tubes 56 (see FIGURE 6). When nuts 116 are tightened, gaskets 118 are compressed and form gastight seals between the distribution tubes and end brackets.

Infrared generators 22 and 24 are removable supported in heater casing 26 by combustible mixture supply conduits 120 and 122 incorporated in the combustible mixture supply system 28, and by hangers 124 fixed to the top wall 52 of casing member 32. Combustible mixture supply conduits 120 and 122 extend from blowers-control compartment 42 through partition 38, brackets 68, and gaskets 118 into the two fuel-air mixture distribution boxes and support the ends of infrared generators 22 and 24 nearest the partition.

Hangers 124, which support the ends of the infrared generators nearest casing end cover 34, extend across casing member 32 and have an inverted hat-shaped cross section providing a laterally extending flange 126 to the bottom of which the end portions of a generator supporting strap 128 are fixed as by welding. The central portion of each strap is offset from its end portions (see FIGURE 2) and, therefore, spaced from the associated flange 126. This forms a slot 130 into which the mounting leg 106 of the end bracket 66 of the associated infrared generator 22 or 24 slipably extends.

The infrared generators can be readily removed from infrared generator compartment 40 for servicing or replacement by simply removing end cover 34 and sliding the desired generator (or both generators) out of the burner compartment.

When end cover 34 is closed, infrared generators 22 and 24 are prevented from moving longitudinally in casing 26 toward blowers-control compartment 42 by the engagement of infrared generator supporting straps 128 with the closure forming legs 108 of brackets 66. Movement in the opposite direction is prevented by stops 132 (only one of which is shown) having flanges 134 fixed to end cover 34.

Referring now to FIGURE 1, casing mounting side reflectors 136 are provided in addition to the reflectors 64 described above to concentrate the radiant energy emitted from the infrared generators 22 and 24 and project it in the desired direction. The upper edges of side reflectors 136 (which extend the length of infrared generator compartment 40) are fixed to the top wall 52 of U-shaped casing member 32 by strap-like brackets 138. The lower edges of the reflectors rest in grooves provided by inwardly and then upwardly extending flanges 140 (only one of which is shown) at the lower edges of U-shaped casing member side walls 46. As illustrated, side reflectors 136 have a generally parabolic section. They may, however, have any degree of curvature necessary to provide the desired pattern of radiation emission.

In addition to those discussed briefly and in detail above, additional components are incorporated in radiant heater 20 to insure proper operation. These include a flue collar 142 through which combustion products are vented from infrared generator compartment 40. To prevent rain from entering heater compartment 40 through flue collar 142, a U-shaped rain cover 144 is fixed to casing top wall 52. Rain cover 144 is of generally the same width as flue collar 142, but has a length substantially longer than the flue collar diameter, which effectively prevents even a driving rain from entering the open upper end of the flue collar. Screens 146 at each end of the rain cover exclude foreign objects such as bird nests.

Also, to prevent control system 30 from being overheated during the operation of radiant heater 20, heat shields 148 are disposed adjacent partition 38 to thermally isolate control compartment 42 from infrared generator compartment 40. The heat shields may be configured and fixed to partition 38 in the manner described in detail in copending application No. 405,944.

A further important component of radiant heater 20 is a grill or grate 150 across the open side of heater casing member 32, which prevents air circulating across the opening from cooling the radiant grid of infrared generators 22 and 24 and thereby decreasing heater efficiency. The use of grate 150 also assures instant ignition of the combustible mixture, even though a strong wind is blowing on the heater. Grill 150 is of honeycomb or egg-crate configuration and is fabricated of intersecting strips arranged on edge in normally disposed rows.

Grill 150 passes all but an insignificant portion of the radiation impinging on it and yet effectively shields infrared generators 22 and 24 from the effect of air currents. Grill 150 is supported on the lips of the flanges 140 bent from the lower edges of casing side walls 46.

Referring now to FIGURES 2, 6, and 7, the combustible mixture supply system 28 of radiant heater 20, mentioned briefly above, includes a combustion air blower 154, a fuel supply conduit 156, a mixing chamber 158 in which the fuel and combustion air are mixed, and the combustible supply conduits 120 and 122 for delivering the combustible mixture to infrared generators 22 and 24.

As shown in FIGURE 6, mixing chamber 158 is a generally rectangular, open sided box supported from angles 159, which are bolted to partition 38. Fixed across the open side of 22 or 24 chamber 158 is a sheet metal cover 160. Flanges 162 on cover 160 engage the mixing chamber walls; and a gasket 164 extending around the periphery of the mixing chamber between its walls and cover 160 seals the joint between the mixing chamber and cover.

Combustion air blower 154, which is of conventional construction, has an outlet 166 bolted to mixing chamber cover 160 and communicates with the interior of the mixing chamber through apertures 168 and 170 in cover 160 and gasket 164, respectively. Combustion air enters compartment 42 through its open lower end and flows upwardly through the compartment into the blower intake around a control supporting pan 172 mounted in the bottom of the compartment with its edges spaced inwardly from the compartment walls. Baffles 173 above pan 172 protect the control system components from the elements, but permit air to flow around pan 172 to the inlet of the blower.

Fuel supply conduit 156 extends into the interior of compartment 42 through an opening in casing member 32 and a seal 173a providing a watertight joint between the conduit and casing member and then upwardly toward mixing chamber wall 158 where it is threaded into a T-shaped manifold 176 extending into the mixing chamber. Orifice members 178 are threaded on the oppositely directed outlets of manifold 176. These increase the velocity of the fuel as it flows from conduit 156 into the mixing chamber and direct the fuel into the stream of air flowing into the mixing chamber from the combustion air blower.

Combustible mixture supply conduits 120 and 122 are braised to mixing chamber 158 adjacent partition 38 and extend through the partition, heat shields 148, and end brackets 68 into the interiors of the distribution tubes. As shown in FIGURE 6, lips 180 on the ends of tubes 120 and 122 facilitate the sliding of the infrared generators onto the tubes, simplifying assembly and servicing of radiant heater 20.

FIGURE 3 shows in schematic form the electrical portion of an exemplary control system 30 for radiant heater 20, which includes:

(1) A solenoid valve V which is normally closed but which opens when its solenoid is energized. Solenoid valve V is disposed in fuel supply conduit 156 and controls the flow of fuel into mixing chamber 158 (a manual valve (not shown) may also be incorporated in conduit 156, if desired).

(2) A normally open centrifugal switch CS incorpo-
rated in the motor M of combustion air blower 154. Switch CS closes its contacts when the motor reaches a predetermined operating speed. (3) A manual or thermostatic switch S which prevents operation of heater 20 when the switch is open. (4) A spark transformer T. (5) A spark plug SF which, as shown in FIGURE 5, is mounted on partition 38 and extends through heat shields 148 and an aperture 181 in the end plate 88 of radiant grid 62a and has its spark gap in combustion zone 60 of infrared generator 24. (6) A resistor R2 which is adapted to be connected in series between the solenoid of fuel valve V and power source 182. The resistance of resistor R2 is such that, when it is connected between valve V and power source 182, the current flowing through the solenoid will maintain the valve open if it is already open, but will not open the valve if it is closed. (7) A resistor R3 adapted to be connected in series with spark transformer T to reduce the voltage across secondary TS to a sufficiently low value that there will be no spark across the gap of spark plug SP. (8) A normally closed flame switch FS. With its flame detector unheated, switch FS is closed. When infrared generator 22 is in operation and heated, it is open. (9) A safety cutout coil H connected in series with a normally closed bimetallic switch BS. Switch BS opens after a predetermined period of current flow through heater H. (10) A resistor R1 connected into a bridge-circuit with resistors R2 and R3 and transformer primary TP. With the exceptions noted previously such as combustion air blower motor M, the control system components discussed above are mounted on pan 172.

Operation of heater 20 is initiated by the closing of switch S, which completes a circuit through motor M of combustion air blower 154, causing the blower to supply combustion air to mixing chamber 158. When the motor is up to normal operating speed, centrifugal switch CS closes, completing a circuit from power source 182 through valve V, heater H, and switch BS, normally closed flame switch FS, and transformer T, which is connected in parallel with the foregoing components.

Energization of transformer primary TP generates a voltage in secondary TS which causes a spark across the spark gap of spark plug SP. At the same time, solenoid valve V opens, permitting gas to flow through fuel supply conduit 156 to mixing chamber 158 to form a combustible mixture which is supplied to infrared generators 22 and 24 in the manner described above.

If the gas fails to ignite within a predetermined period the current flow through heater H will generate sufficient heat to warp bimetallic switch BS open and interrupt the circuit to spark transformer T and solenoid fuel valve V, cutting off the fuel flow and ignition spark.

If the burner ignites, it heats flame switch FS. This opens the flame switch and breaks the circuit through heater H so the safety cutout bimetallic switch BS remains closed, preventing the cutting off of the fuel flow and ignition spark. Opening of flame switch FS also puts resistor R3 in series with transformer T which cuts off the spark and puts resistor R2 in series with solenoid valve V. As mentioned above, resistor R2 limits the current through the solenoid of valve V to an amperage which will hold valve V open but is too low to open it.

Therefore, if valve V later closes because of a stoppage of electric power or failure of the gas supply, for example, valve V will not reopen until radiant heater 20 has gone through another starting cycle.

If the ignited infrared generator flames out, flame switch FS closes, taking resistor R3 out of series with heater H. The latter will then heat the warp open switch BS, closing with the same manner as when the infrared generator fails to ignite. To restart the heater if the heater fails to ignite or goes out, switch S is opened, interrupting the circuit to heater H. Switch BS will then close as it cools. Switch S is then closed to restart the heater. If the power fails after the heater is started or switch S is opened, valve V will close, shutting off the heater. As soon as flame sensor FS cools and closes, the heater can be restarted by the restoration of power.

One of the important features of the present invention is the protection of flame sensor FS from cooling by low temperatures and/or wind or other air currents such as drafts. This plays a major role in the successful operation of radiant heaters of the type disclosed herein under adverse weather conditions. In contrast, in heretofore known radiant heaters in which such protection is not provided cooling of the flame sensor causes the latter to falsely signal a flameout, shutting down the heater even though it is operating properly.

Referring now to FIGURES 4 and 9, flame sensor FS is mounted on one of the heat shields 148 adjacent partition 38 and extends from the heat shield through an opening 193 in radiant grid end plate 88 of infrared generator 22 (see FIGURE 9) through the space between radiant grid 62a and the outlet end of orifice grid 58. As shown in FIGURE 4, the loops 86 in grid 62a are omitted or flattened for a distance equal to that spanned by the flame sensor so that there are no openings through this region of the grid.

This arrangement effectively prevents air currents from penetrating through the grid and cooling the flame sensor, satisfactory operation being obtained in winds as high as 40 miles per hour and higher. It also prevents flame from blowing through the grid when radiant heater 20 is started up and infrared generator 22 is cold, confining the flame within the grid so that flame sensor FS responds properly to the presence and absence of combustion even during the starting up of the radiant heater.

In addition to being protected from exposure to the elements as discussed above, flame sensor FS is preferably located to one side of combustion zone 60 as shown in FIGURE 9. This protects overheating the flame sensor and therefore insures that it operates properly.

Referring now to FIGURES 6 and 7, control system 20 includes, in addition to the components discussed above, a damper 184 controlled by a bimetallic operator 186 to automatically proportion the ratio of air to fuel for ease in starting and for optimum efficiency and complete combustion as the temperature of the infrared generator increases to normal operating temperature. Damper 184 is pivotally mounted in mixing chamber 158 and in the combustion air supply blower outlet 166 on a pivot rod 188 which extends through ears 190 fixed to the damper and hinges 192 bolted to mixing chamber cover 160.

Dampers 184 has a maximum position (shown in dotted lines in FIGURE 7) in which a stop 194 fixed to damper leg 196 engages a screw 198 adjustable threaded through mixing chamber cover 160. The damper also has a minimum flow position (shown in full lines) in which damper leg 200 engages a second screw 202 adjustable threaded through the mixing chamber cover. The damper is automatically pivoted from its full line, minimum flow position, which provides a rich start-up mixture, to its dotted line, maximum flow position to provide a relatively lean running mixture as the temperature of the infrared generators increases through the combined effects of bimetallic actuator 186 and the air flowing into mixing chamber 158 from blower 154.

Specifically as shown in FIGURE 7, bimetallic actuator 186 has an L-shaped configuration with its shorter leg 204 fixed to a heat shield 148. Bimetallic operator leg 204 responds to increasing and decreasing temperatures within infrared generator compartment 40; and the compartment temperature, in turn, increases and decreases as the temperatures of infrared generator 22 and 24 change. Heat transferred to bimetallic operator leg 204 is transferred by conduction to the longer operator leg.
206, which extends through heat shields 148 and partition 38 into compartment 42.

At its free end, operator leg 206 engages a pin 208 loosely fitted in a guide 210 extending through mixing chamber wall 212 so that the end of pin 208 opposite that engaged by the bimetallic actuator is positioned to engage damper leg 196. The enlarged head 214 of pin 208 prevents the pin from falling through guide 210 into mixing chamber 158 when damper 184 is removed. The downturned portion of leg 196 facilitates replacement of damper 184 as pin 208 will readily slide up the latter when it is replaced in the mixing chamber.

With radiant heater 20 off, bimetallic operator 186 presses against pin 208 which, in turn, presses on damper leg 196, holding the damper in the minimum flow position. As the temperature of infrared generator 22 increases, bimetallic operator leg 206 is heated and moves upwardly toward the position shown in dotted lines. The force of the air supplied by blower 154 then pivots the damper to the dotted line position, increasing the air-to-fuel ratio to provide a lean running mixture. The manipulation of damper 184 from the minimum flow position to the lean running mixture position is therefore automatically accomplished with an extremely simple mechanism, a further advantage of radiant heaters constructed in accord with the principles of the present invention.

The fuel-air ratio in both the minimum flow or choked and maximum flow or running positions of the damper can be adjusted for optimum performance by manipulation of stop screws 199 and 202.

Referring still to FIGURES 6 and 7, another important feature of the present invention is a novel arrangement for insuring that the combustible mixture supplied to the two infrared generators 22 and 24 is equally proportioned between them. This arrangement includes a pair of generally-"U" shaped brackets 216 and 218 with their webs 220 fixed to mixing chamber walls 222 and 224, respectively. As shown in FIGURE 7, the brackets are the same height as the mixing chamber.

From webs 220, legs 228 extend toward each other and the center of mixing chamber 158 parallel to and spaced approximately one-half inch from mixing chamber walls 230 and between wall 230 and fuel supplying orifice members 178. The two legs 228 are of equal length; and their free edges are spaced on the order of one inch apart, providing a passage from the interior of the mixing chamber to combustible mixture supply tubes 120 and 122.

Shorter legs 232 at the opposite ends of webs 220 provide a convenient way of securing mixing chamber 160 in place. As shown in FIGURE 6, the cover can be removably retained in place by screws 234 threaded into bracket legs 232.

The structure just described has been found to be very effective in ensuring equal proportioning of the combustible mixture supply tubes 120 and 122. It has also been found to be highly effective in ensuring that a thoroughly mixed, homogeneous mixture of fuel and air is supplied to tubes 120 and 122. At the same time, this structure is extremely simple and therefore adds little to the cost of the radiant heater.

For a multiple generator type radiant heater to operate properly, there must be virtually simultaneous ignition of the infrared generators. This is accomplished in the present invention by a novel transfer burner 236 (see FIGURE 9) consisting of a flame spreader 238 and a combustible mixture supply tube 240. Flame spreader 238 is a U-shaped member of heat resistant metal disposed between and at right angles to infrared generators 22 and 24 at a location corresponding to the gaps between the radiant grids 62a and 62b of the infrared generators. Openings 242 in reflectors 64 of infrared generators 22 and 24 opposite the open ends of flame spreader 238 provide communication between the combustion zones 60 of the two infrared generators and the flame spreader since the ends of the radiant grids opposite openings 242 are open, as described above.

The supply tube 240 of the transfer burner is connected between flame spreader 238 and the distribution tube 56 of infrared generator 24, as shown in FIGURE 9. Therefore, a small portion of the combustible mixture supplied to infrared generator 24 flows into tube 240, filling flame spreader 238.

When infrared generator 24 is ignited, the flame is immediately propagated from it through apertures 242 and flame spreader 238 to the combustion zone 60 of infrared generator 22. The two infrared generators are therefore ignited at virtually the same instant.

The novel radiant heater 20 just described is attached to suitable supporting structure (not shown) by Z-shaped hanger brackets 244 (see FIGURES 1 and 2). Hanger brackets 244 are attached at opposite ends of the heater to the top wall 52 of casing member 32. The upper, vertically extending, mounting legs 246 of the brackets are provided with apertures 248 through which bolts or other fasteners are inserted to attach the mounting legs to the heater supporting structure.

The lower leg 250 of the left-hand bracket 244 extends downwardly at an angle over and spans end cover 34 at the left-hand end of infrared generator compartment 40, preventing rain from entering the outlet passage 252 between the upper edge of end cover 34 and the casing member. The lower leg 250 of the right-hand mounting bracket 244 is similarly configured to cover the outlet opening 254 between the upper edge of casing end cover 36 and casing member 32 to prevent rain and other precipitation from entering blower-control compartment 42.

Numerous modifications may be made in the novel radiant heater 20 just described without exceeding the scope of the present invention. Such modifications are fully intended to be embraced within the scope of this invention except as specifically excluded from the appended claims.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalence of the claims are therefore intended to be embraced therein.

What is claimed is:

1. An infrared heater of the combustion type, comprising:
   (a) an elongated casing;
   (b) a partition extending across said casing and dividing it into first and second compartments;
   (c) first and second infrared generators mounted side-by-side in said first compartment, said infrared generators each having a fuel-air mixture distribution tube extending lengthwise of said compartment and having one end adjacent said partition;
   (d) a fuel and combustion air mixing chamber in said second compartment;
   (e) independent combustible mixture supply conduits having inlets in said mixing chamber and extending from said mixing chamber through said partition and communicating with the interiors of said distribution tubes;
   (f) separate means for supplying fuel and combustion air to said mixing chamber; and
   (g) means in said mixing chamber between said inlets and said fuel and combustion air supply means for promoting the mixing of the fuel and air and for equalizing the flow of the combustible mixture into said combustible mixture supply conduits.

2. An infrared heater of the combustion type, comprising:
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(a) an elongated casing;
(b) a partition extending across said casing and dividing it into first and second compartments;
(c) first and second infrared generators mounted side-by-side in said first compartment, said infrared generators each having a fuel-air mixture distribution tube extending lengthwise of said compartment and having one end adjacent said partition;
(d) a fuel and combustion air mixing chamber in said second compartment;
(e) independent combustible mixture supply conduits extending from said mixing chamber through said partition and communicating with the interiors of said distribution tubes;
(f) means for supplying fuel and combustion air to said mixing chamber;
(g) means in said mixing chamber for promoting the mixing of the fuel and air and for equalizing the flow of the combustible mixture into said combustible mixture supply conduits;
(h) said mixing chamber having first and second spaced apart inlets in a wall thereof providing communication between the interior of the mixing chamber and the combustible mixture distribution tubes; and
(i) said mixture promoting and flow equalizing means comprises first and second members on opposite side of said mixing chamber and having first legs extending from the sides of said mixing chamber across said inlets in spaced relation to the mixing chamber wall in which said inlets are formed, the nearest edges of said legs being spaced apart to provide passage means therebetween.

3. The combustion type infrared heater of claim 2, wherein:
(a) said members have second legs extending from the sides of said mixing chamber toward the center thereof at the end of said mixing chamber opposite that defined by the wall in which the inlets are formed; and
(b) said opposite end of said mixing chamber is open;
and
(c) said mixing chamber includes a cover extending across the open end thereof and means removably fixing said cover to the second legs of said member.

4. The infrared heater of claim 2, together with:
(a) a combustion air blower in said second compartment with its outlet communicating with the interior of said mixing chamber on the side of said first legs opposite and wall in which the inlets to the combustible mixture distribution tubes are formed;
(b) a fuel supply conduit extending into said mixing chamber; and
(c) a pair of orifice incorporating members in said mixing chamber communicating with the fuel supply conduit and oriented to discharge fuel entering the mixing chamber through the fuel supply conduit into said mixing chamber in opposite directions toward the side walls of the mixing chamber and into the stream of combustion air flowing into said mixing chamber from said combustion air blower, said orifice incorporating members being located on the opposite sides of said first legs from the wall in which the inlets to the combustible mixture distribution tubes are formed.

5. A fluid fuel-fired infrared heater, comprising:
(a) an elongated casing;
(b) a partition extending across said casing and dividing it into first and second compartments;
(c) an elongated infrared generator in said first compartment extending from adjacent said partition toward the other end of said compartment, said infrared generator comprising a fuel-air mixture distribution tube extending lengthwise thereof, and a radiant grid substantially coextensive in length with and fixed to said distribution tube, said radiant grid being configured to provide a combustion space between said grid and the distribution tube and having multiple openings therethrough through which combustion products can escape from the combustion zone;
(d) a flame detector having an elongated flame sensor portion and a switch portion, said switch portion being located within said second compartment and said flame sensor portion extending from said second compartment through said partition and into the space surrounded by the radiant grid in parallel spaced relationship to the distribution tube of said infrared generator;
(e) the portion of said radiant grid opposite said flame sensor being substantially impervious to confine the flame in the area of the combustion zone spanned by the flame sensor within the radiant grid; and
(f) said flame sensor being displaced to one side of said combustion zone to prevent overheating of said flame sensor during operation of said heater.

6. An infrared heater of the combustion type, comprising:
(a) a heater casing having an infrared generator compartment formed therein, one side of said compartment being open;
(b) at least one infrared generator in said compartment, said generator having a fuel-air mixture distribution tube extending from adjacent one end of said compartment to adjacent the opposite end thereof and radiant grid means substantially coextensive in length with said distribution tube facing the open side of said compartment; and
(c) reflectors substantially coextensive in length with said compartment and of like configuration fixed in mirror image relationship to said distribution tube on opposite sides of said radiant grid;
(d) said reflectors having reflecting legs with first portions which are substantially parallel and extend from the level of said distribution tube toward said radiant grid means adjacent the sides thereof and second portions which are integral with said first portions and extend from a level near that at which said grid is wider than said grid means, the second portions of said legs being disposed in diverging relationship to each other and diverging away from the sides of said radiant grid means.

7. The infrared heater of claim 6, together with reflectors fixed to said casing in said infrared generator compartment and extending substantially the length thereof, said reflectors each having a concave configuration with one edge thereof adjacent the open side of said compartment and the second edge thereof adjacent the reflecting leg of a distribution tube supported reflector.

8. An infrared heater of the combustion type, comprising:
(a) a casing having an elongated heater compartment therein;
(b) at least two infrared generators in said compartment and extending substantially the length thereof;
(c) said infrared generators being mounted in closely spaced side-by-side relationship and each including:
(d) a fuel-air mixture distribution tube extending the length of the generator;
(e) radiant grid means fixed to the distribution tube and extending the length thereof, said radiant grid means comprising at least one radiant grid configured to define a space between it and said distribution tube;
(f) means for conducting said combustible mixture to a combustion zone extending substantially the length of said generator in the space defined by said distribution tube and said grid means; and
(g) means for propagating flame from the combustion
zone of one infrared generator to the combustion zone of the other of said infrared generators.

9. The infrared heater of claim 8, wherein said flame propagating means comprises:
   (a) a flame spreader disposed between said infrared generators and communicating with the grid means of the two infrared generators; and
   (b) a combustible mixture supply tube for conducting combustible mixture from the distribution tube of one of said infrared generators to said flame spreader.

10. The infrared heater of claim 9, wherein said flame spreader is a U-shaped member with the ends thereof facing the grid means of said infrared generators.

11. In an infrared heater of the combustion type:
   (a) infrared generator means;
   (b) means including a combustion air blower for supplying a combustible fuel-air mixture to the infrared generator means;
   (c) means for varying the ratio of fuel to air in said mixture including:
      (d) a damper mounted in the outlet of said blower for movement between minimum and maximum flow positions adapted to be moved toward said maximum flow position by the air flowing through the outlet of said damper;
      (e) a bi-metallic element mounted in heat transfer relationship to said infrared generator means for movement between first and second positions as the temperature of the infrared generator means increases;
      (f) a movable motion transmitting member operatively interposed between and adapted to engage said damper and said bi-metallic element, said bi-metallic element in its first position so positioning said member that said member maintains said damper in its minimum flow position, said bi-metallic element moving away from said member as the temperature of the infrared generator increases to permit said flowing air to move said damper toward said maximum flow position, whereby the fuel to air ratio of the combustible mixture is high and the mixture easily ignitable when the heater is cold and the ratio of fuel to air-lower to provide maximum combustion efficiency and complete combustion of said mixture when the infrared generator means attains operating temperature; and
   (g) first and second selectively adjustable stop means for respectively limiting the movement of the damper toward and away from the outlet of the blower, whereby the minimum and maximum rates of flow through said outlet may be selectively varied.

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