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INFRA-RED HEATERS

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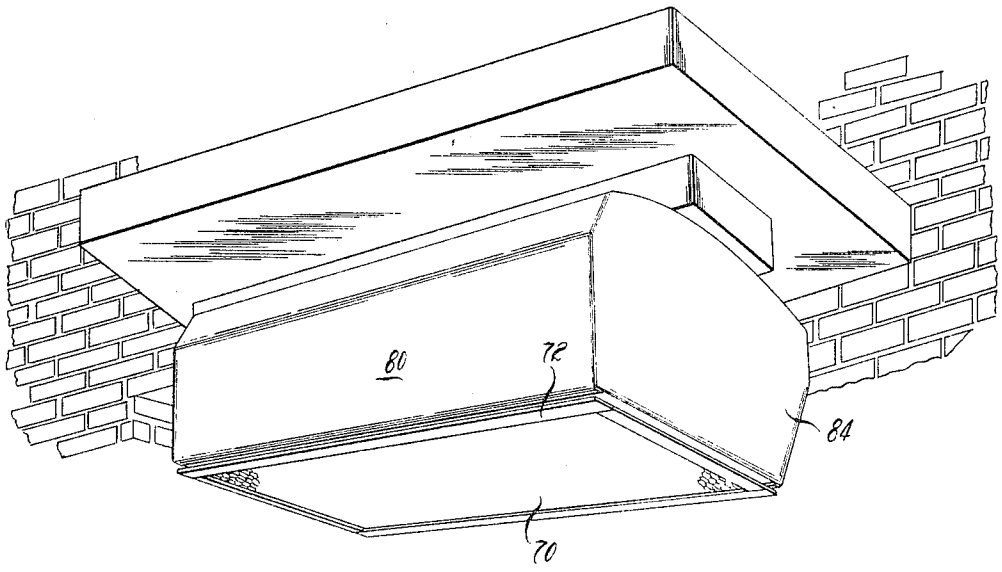

Fig. 1

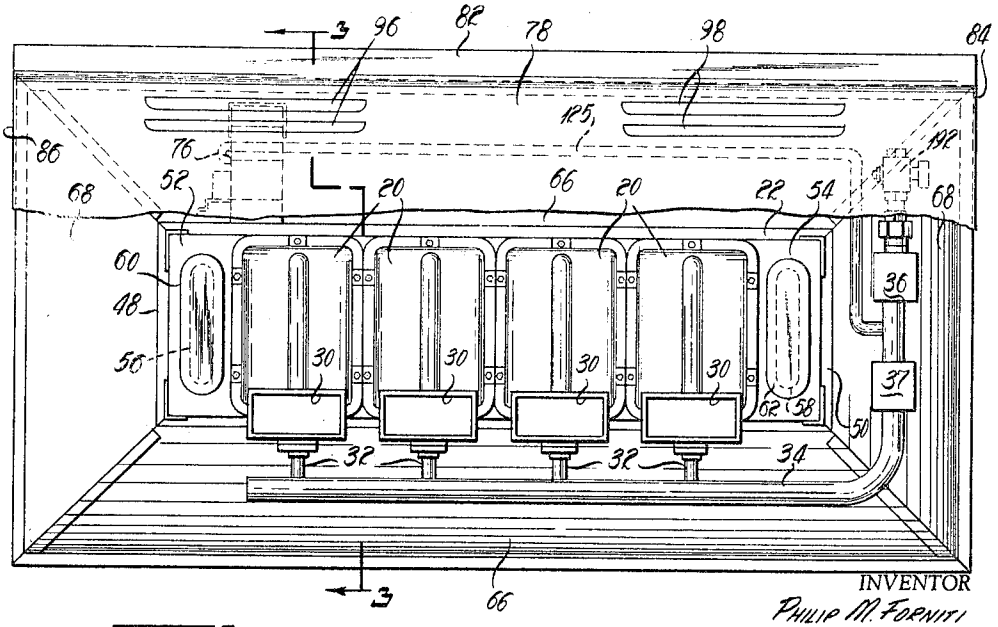

Fig. 2

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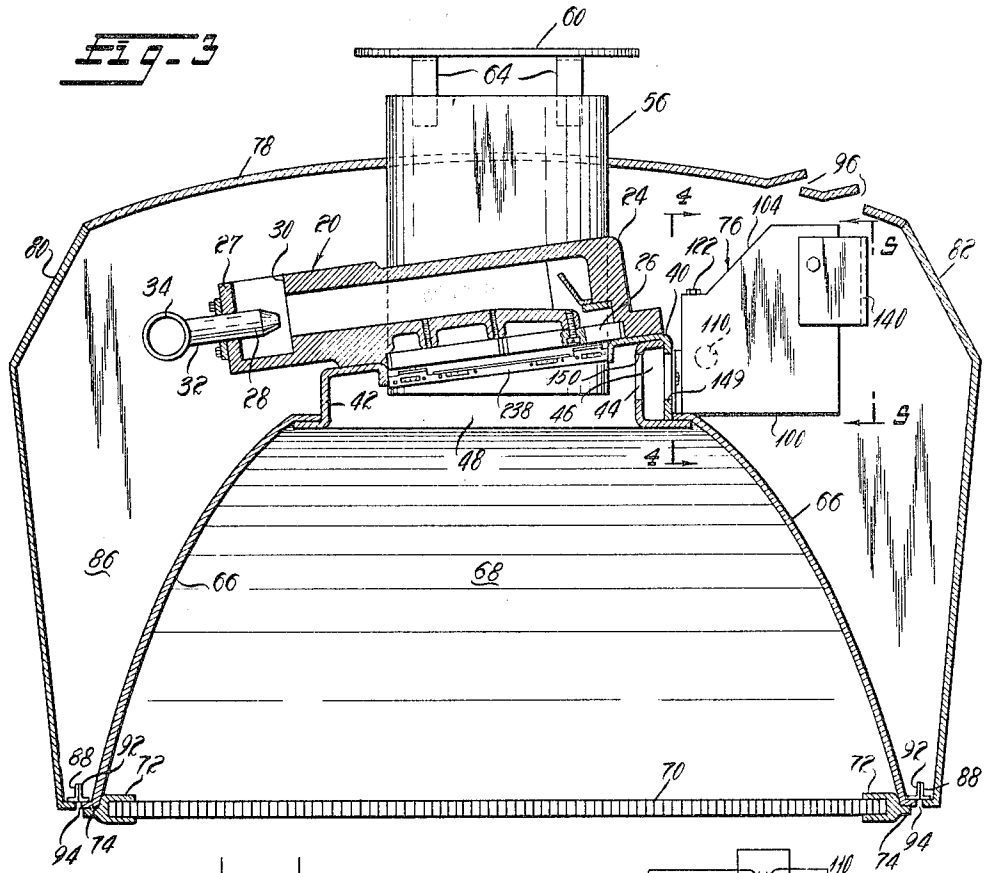
Fig. 3



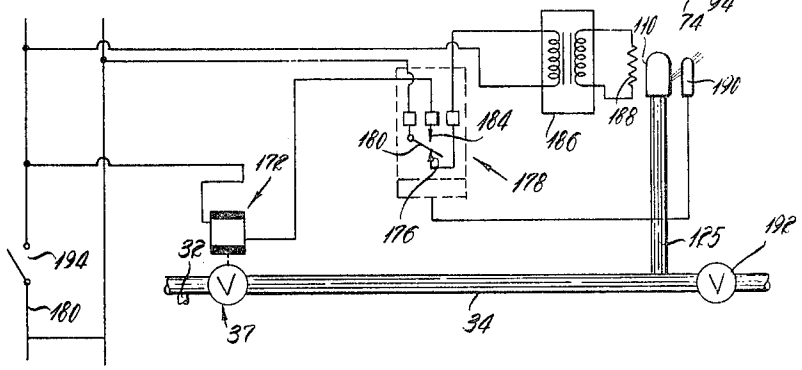


Fig. 2

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FIG. 4

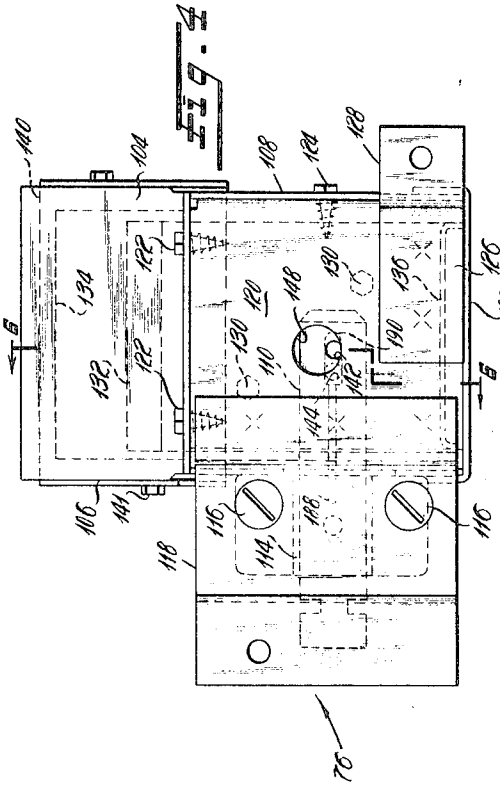


FIG. 5

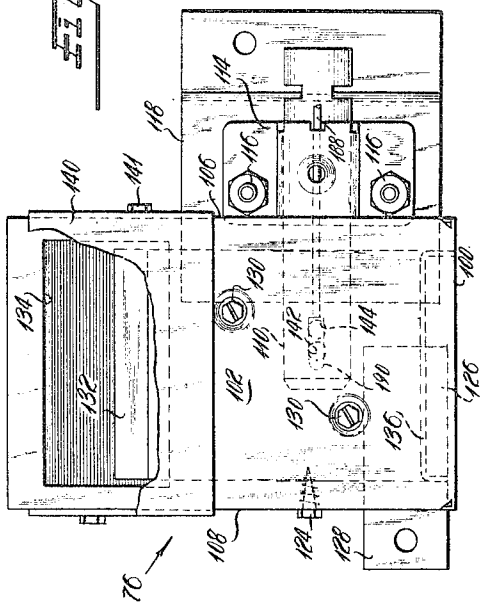


FIG. 6

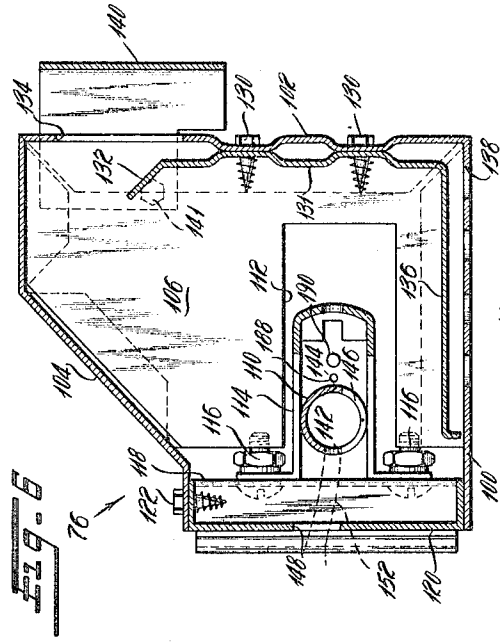
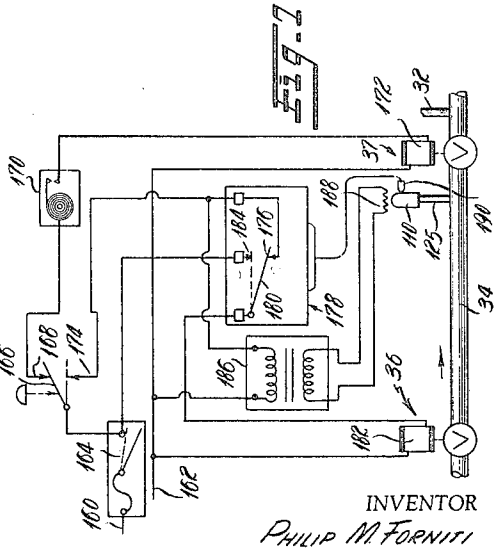


FIG. 7



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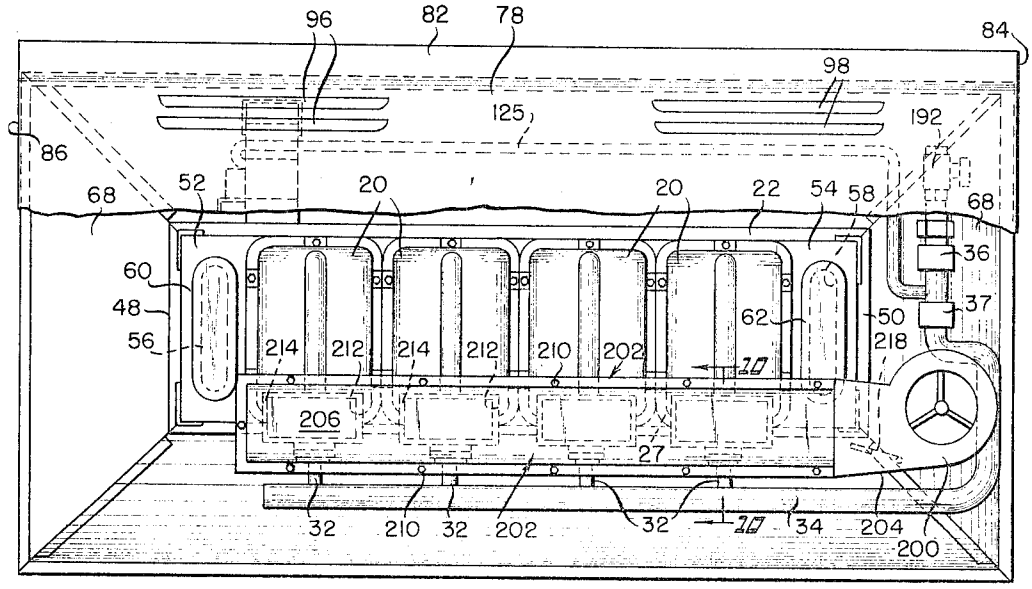

Fig. 9

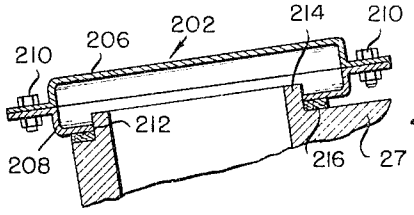

Fig. 10

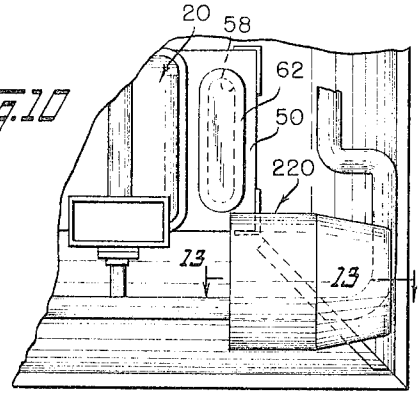

Fig. 12

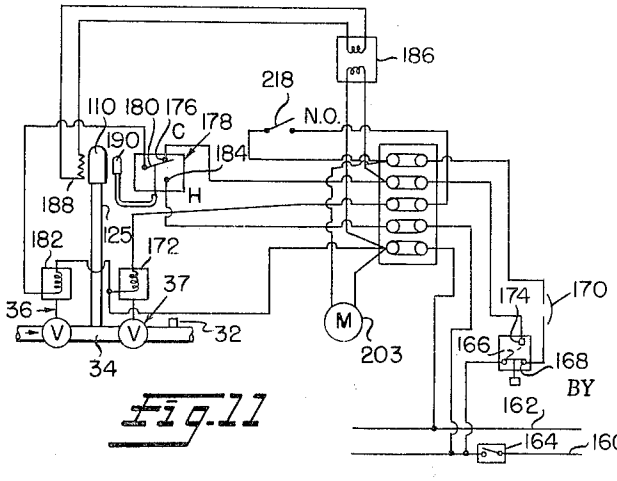

Fig. 11

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Fig. 17

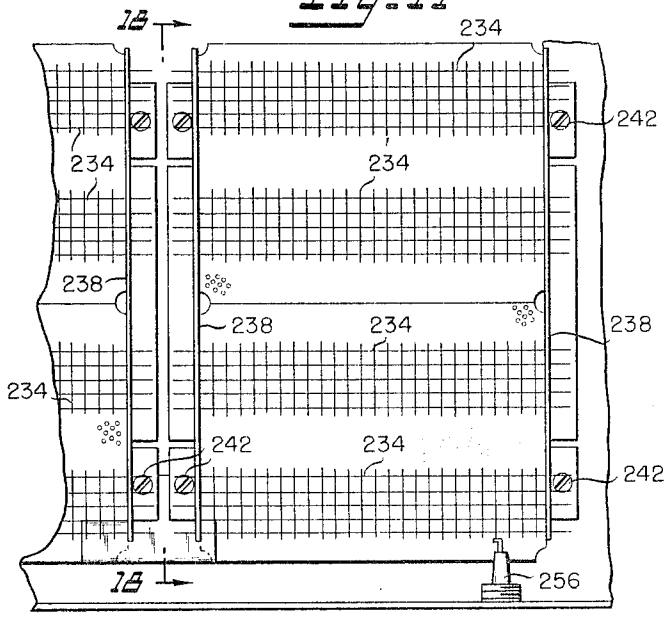
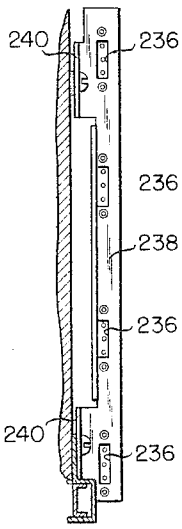


Fig. 18



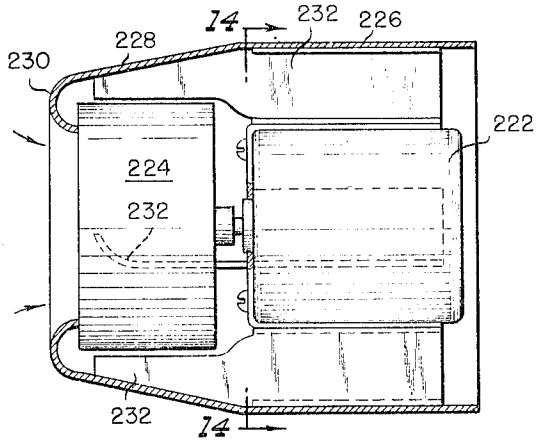


Fig. 13

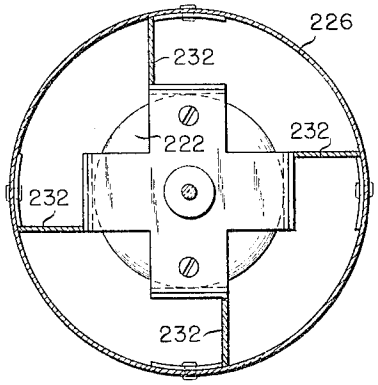


Fig. 14

Fig. 19

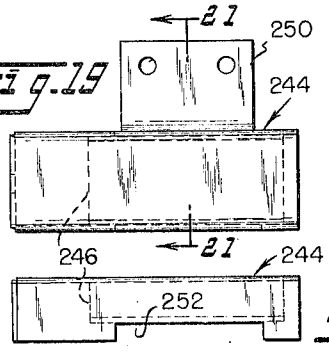


Fig. 20

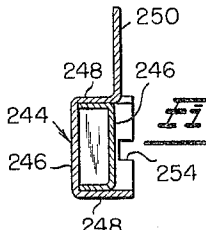


Fig. 21

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Fig. 15

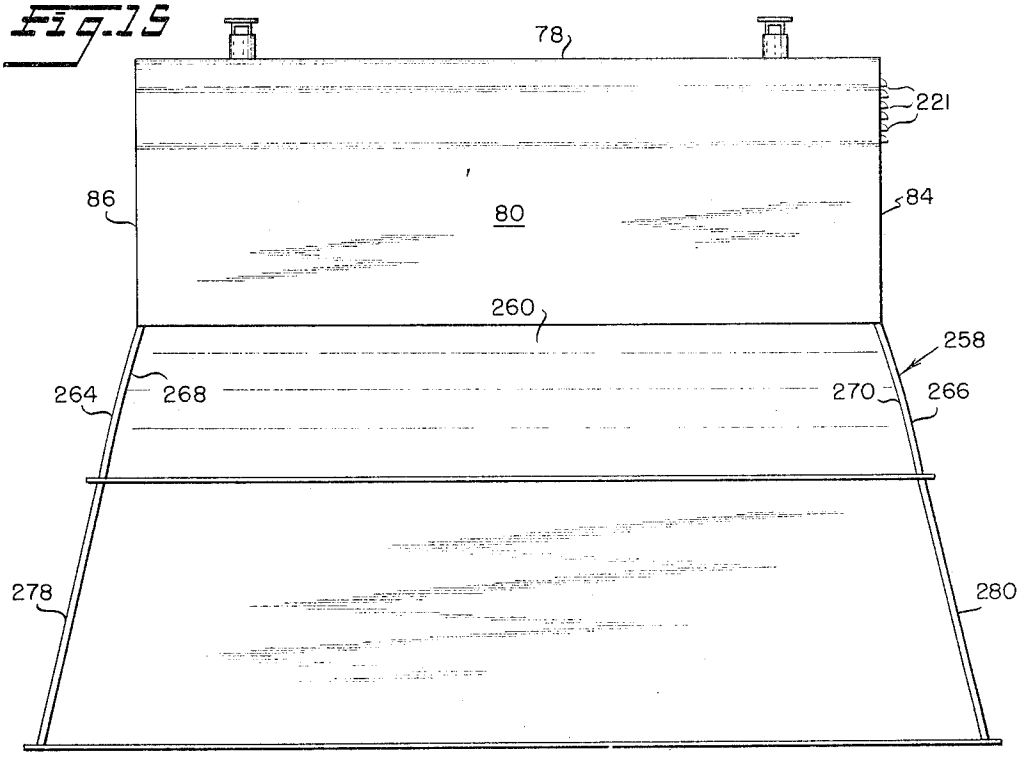
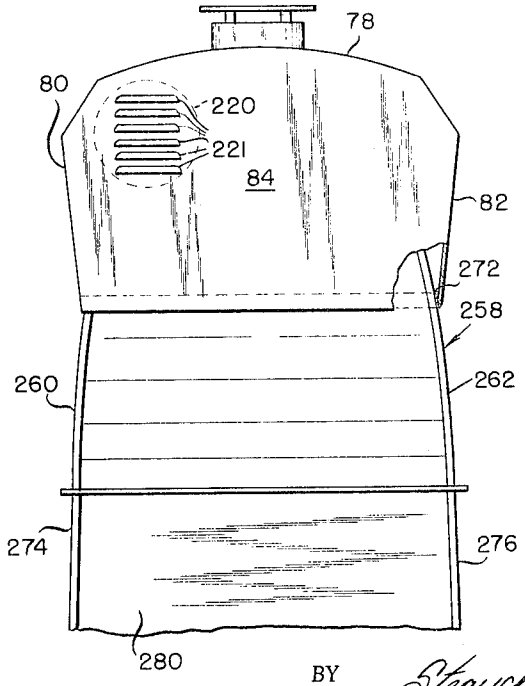


Fig. 16



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United States Patent Office 3,291,115 Patented Dec. 13, 1966

3,291,115

INFRA-RED HEATERS

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Filed Feb. 27, 1962, Ser. No. 176,021
10 Claims. (Cl. 126—92)

This is a continuation-in-part of application Serial No. 848,159 filed October 22, 1959, now abandoned.

This invention relates to gas burning infra-red heaters and more particularly to such heaters especially adapted for use out-of-doors or in other unprotected locations.

Infra-red heaters of the type with which the present invention is primarily concerned include one or more burners each of which comprises a dish-shaped housing, one wall of which is formed by perforated burner means. A mixture of gas and air is fed into the housing and exits from the device through the perforated burner means and burns at or adjacent the outer surface of the burner means which are thus heated sufficiently (1500° F.–1700° F.) to emit energy in the infra-red spectrum. One example of a burner of this type is shown in United States Patent 2,775,294.

Since infra-red heaters do not depend for their heating effect upon the heating of air, they are basically ideally suited for the outdoor use, for example in the heating of patios, outdoor cafes, theatre marquees, sidewalks, building entrances and similar locations. However such burners are designed to operate only in well protected locations since any appreciable wind blowing across the radiant face of the burner may make initial ignition of the burner difficult or impossible or may cause the burner to blow out if it is once ignited. Also, such winds may seriously affect the critical ratio of the fuel and air mixture supplied to the burner thus seriously reducing the efficiency of the burner or preventing successful combustion altogether. The many prior attempts to provide a fully protected efficient outdoor infra-red burner have at best been only partially successful, primarily because of the difficulty in solving the problem of providing adequate wind protection for the burner and yet providing for an adequate unrestricted supply of combustion air and the free venting of combustion products. Difficulties have also been experienced in prior attempts to provide a pilot effective to ignite the burner even under the most adverse conditions or to re-ignite the burner after it has been extinguished by high velocity wind gusts against which the main burner cannot be adequately protected.

With the foregoing considerations in mind, it is the principal purpose and object of the present invention to provide improved infra-red heaters which are substantially wind and weatherproof and which function efficiently out-of-doors or in other exposed locations where prior burners have failed.

It is a further object of the present invention to provide improved infra-red heaters which are effectively shielded against wind and which yet provide for adequate supply of combustion air and venting of the products of combustion.

It is also an object of the present invention to provide novel pilot units for infra-red heaters which are fully protected against violent wind gusts to assure ignition of the burner and re-ignition if it is blown out.

It is an additional object of the present invention to provide improved infra-red heaters having protective housings which effectively stabilize the air pressure in the region in which the combustion air is introduced into the burner.

It is also an object of the present invention to provide improved windproof infra-red heaters with novel means for simultaneously shielding the face of the burner element against wind currents and directing the radiated infra-red energy.

It is an additional object of the present invention to provide improved infra-red heaters having automatic or semiautomatic electric ignition systems.

It is a further object of the present invention to provide improved windproof pilots for gas burning heaters.

It is also an object of the present invention to provide novel means for establishing and maintaining in the region in which air is supplied to the burners a slight substantially constant superatmospheric pressure.

It is an additional object of the present invention to provide improved infra-red burner assemblies including a number of burner units arranged in side-by-side relation and novel means for propagating the flame from one burner unit to the next adjacent unit to facilitate ignition or re-ignition of the burner units.

It is a further object of the present invention to provide novel means for increasing the surface temperature of an infra-red gas burner.

In attaining these and other objects, the present invention provides a plurality of individual burner units mounted in a side-by-side relation within a unique housing which provides protected zones around the radiant face of the burners and around the fuel air inlet to the burner. The housing effectively stabilizes the pressures at all critical regions of the burners. Combustion air is supplied through an opening in the housing, the total area of which is sufficiently large to accommodate the necessary flow of air. However the configuration and location of the opening is such as to minimize pressure changes within the housing due to wind currents.

In one form of the invention, the air inlet to the burners is in open communication with the interior of the housing, combustion air being entrained with the gaseous fuel which is supplied to the burners under pressure. Because of the excellent protection afforded the burners, this form of the invention has proved to be satisfactory in all except the most unfavorable operating conditions.

In another embodiment of the invention a combustion air blower is mounted within the housing, and the outlet of the blower being open to the interior of the housing is being connected through a duct to the inlet to supply air under superatmospheric pressure directly to the burners. This unique arrangement makes the operation of the burner possible even under the most adverse conditions and effectively prevents the supply of excess air to the burners with consequent flare-out across the surface of the burners as well as starvation of the burners and consequent failure of combustion.

A novel sheltered pilot and electric control circuits are provided to effect either complete shutoff of all of the components in the event of failure of the main flame or operation of the ignition system in a starting cycle in event of flame failure.

The invention also provides in its preferred form a novel ignition system for a bank of burners including means for igniting one of the burners and means for propagating the flame from the burner to the next adjacent burner.

Preferably screen strips are mounted in a unique manner over portions of the radiant burner surface to increase the temperature of the burner surface and thereby increase the overall efficiency of the burner system.

Additional objects will become apparent as the description proceeds in connection with the accompanying drawings in which:

FIGURE 1 is a perspective view of one embodiment of an infra-red heater constructed in accordance with the present invention and installed for use in an out-of-doors location;

FIGURE 2 is a top plan view of the heater of FIGURE 1 with portions of the housing removed to show interior details;

FIGURE 3 is a transverse section of the heater taken substantially along line **3**—**3** of FIGURE 2;

FIGURE 4 is an elevation of the pilot unit looking in the direction of arrows **4**—**4** of FIGURE 3;

FIGURE 5 is an opposite side elevation of the pilot unit looking in the direction of arrows **5**—**5** in FIGURE 3;

FIGURE 6 is a central vertical section of the pilot unit taken along line **6**—**6** of FIGURE 4;

FIGURE 7 is a circuit diagram for electric ignition system providing complete shutoff in the event of pilot outage;

FIGURE 8 is a circuit diagram for an electric ignition system which effects automatic recycling in the event of pilot outage;

FIGURE 9 is a view similar to FIGURE 2 showing a modified form of the invention;

FIGURE 10 is an enlarged fragmentary section taken along line **10**—**10** of FIGURE 9;

FIGURE 11 is a modified circuit diagram controlling the operation of the embodiment of the invention shown in FIGURES 9 and 10.

FIGURE 12 is a fragmentary view similar to FIGURES 2 and 9 showing a further embodiment of the invention including a blower of novel construction;

FIGURE 13 is a transverse section of the blower incorporated in the embodiment of FIGURE 12 taken along line **13**—**13** of FIGURE 12;

FIGURE 14 is a vertical section of the blower taken along line **14**—**14** of FIGURE 13;

FIGURE 15 is a side elevation of a further embodiment of the invention including an extended radiation direction shield;

FIGURE 16 is an end elevation of the assembly of FIGURE 15;

FIGURE 17 is an enlarged fragmentary view of the radiant face of the burners;

FIGURE 18 is a transverse section taken along line **18**—**18** of FIGURE 17;

FIGURE 19 is an elevation of a carry-over channel which forms a part of the ignition system associated with the burners of the present invention;

FIGURE 20 is a side elevation of the unit of FIGURE 19; and

FIGURE 21 is a transverse section taken along line **21**—**21** of FIGURE 19 showing detailed construction.

The heater shown in FIGURES 1, 2 and 3 comprises four infra-red burners **20** which are of identical construction and arranged in side-by-side relationship transversely of an elongated rectangular frame **22**. The burner units **20** per se are preferably of the construction shown in the aforesaid United States Patent 2,775,294, to which further reference may be had for details of construction. Essentially the burners comprise a dish-shaped housing **24**, one wall of which is formed by a plurality of perforated ceramic tiles **26**. One end of the housing **24** is provided with a boss **27** in the end wall of which a fuel nozzle **28** is mounted. The boss **27** is open as at **30** to provide a passage through which the air entrained by the gas flowing out of nozzle **28** passes. It is a characteristic of burners of this type that the air passing through opening **30** constitutes the entire air supply necessary to effect combustion of the gas which occurs on or adjacent the outer surface of the ceramic tiles **26**. The gas nozzles **28** in each of the burner units **20** are connected through spuds **32** to a gas manifold **34** which is connected to a suitable source of supply not shown through conventional solenoid operated valves **36** and **37**.

As best shown in FIGURE 3, the burner supporting surface of the front channel member **40** of the frame **22** is elevated above the corresponding surface of the rear channel **42** so the end of the burner remote from the gas-

air inlet end is substantially elevated. Thus, the products of combustion issuing from the ceramic tiles **26** will move generally upwardly and toward the right as viewed in FIGURE 3. The front rail of the frame **22** includes an additional channel member **44** which, with the member **40**, forms a duct **46** extending substantially the full length of the frame **22** for a purpose to appear. The ends of the duct **46** are closed by symmetrically opposite end plates **48** and **50**. Extending across the space between the sides of the end burners and the end plates **48** and **50** are top cover plates **52** and **54** which are provided with openings to support identical flues **56** and **58** to the upper ends of which cover plates **60** and **62** are secured by straps **64**.

Suitably secured to the marginal flanges of the frame assembly **22** is a reflector assembly comprising identical side plates **66** and identical end plates **68**. Both the side and end members **66** and **68** are formed on a parabolic curve, the effect of which is to direct the radiant energy emitted by the burners in an essentially vertically downward direction as viewed in FIGURE 3.

The bottom of the space enclosed by the parabolic reflector assembly is traversed by a flat sheet **70** of honeycomb screen structure preferably made of bright aluminum. The marginal edges of the sheet **70** are received in the rectangular frame assembly **72** suitably secured to flanges **74** formed at the bottom of the reflector assembly. The honeycombed screen **70** performs several functions. It acts as a heat director in cooperation with the parabolic reflector assembly to concentrate the radiant heat in the area directly beneath the burner. Since the sheet **70** is formed of very thin metal strips, it does not materially reduce the amount of heat transmitted. The sheet **70** also functions as an effective wind barrier and effectively prevents direct impingement of wind currents on the surface of the radiant burner elements **26**. Also, despite its light construction, the honeycomb sheet **70** has sufficient strength to guard against accidental dislodgement of small pieces of the ceramic burner elements **26**. While a flat honeycomb screen **70** has been illustrated, other configurations may also be employed when it is desired to produce different patterns of heat radiation. For example, the sheet **70** may be curved concavely or convexly, may be of convex or concave V-shape, or may be of zig-zag or wavy configuration to provide practically any desired pattern of heat concentration or heat dispersion without changing the basic construction of the remainder of the heater assembly.

The ignition of the burners **20** is effected by a pilot assembly indicated generally at **76** suitably secured to the front frame channel assembly **40** and an electric control system both of which are described in detail below.

The upper portion of the assembly thus far described is enclosed in a windproof shroud assembly comprising a top cover plate **78**, side plates **80** and **82** and identical end plates **84** and **86**. The members comprising the shroud assembly are secured together by screws or clips to form a tight windproof unit and the entire shroud assembly is held in assembled relation to the remainder of the unit by any suitable number of clips **88** secured to the bottom flanges of the shroud members which are detachably secured to mating clips **92** secured to the flanges **74** of the reflector assembly. The clips are so arranged as to provide a restricted annular gap **94** extending around the entire burner assembly between the adjacent rims of the shroud and the reflector. In a typical burner in which the bottom of the reflector measures 18" x 42", the gap **94** will be approximately ⅛" across to provide a total space of approximately **15** square inches which is more than adequate to permit the supply of combustion air to the burners **20** and yet is sufficiently restricted to prevent the entry of wind gusts into the area adjacent the burner openings and to prevent violent changes in pressure in this region.

The combustion products exit from the interior of the

shroud through two sets of relatively small vent openings 96 and 98 formed in the upper shroud panel member 78 at the side of the unit adjacent the elevated ends of the burners 20. It will be noted that the openings 96 are positioned directly above the pilot assembly 76. Actual experience has shown that this construction effectively stabilizes the primary air supply pressure and, as can be noted from FIGURE 1, the shroud assembly also provides an attractive, neat external appearance for the unit.

The pilot assembly 76 which forms an important part of the present invention will now be described in detail with particular reference to FIGURES 4. 5 and 6. The bottom 100, rear side 102 and the top 104 of the pilot assembly housing are preferably formed from a single piece of sheet metal bent to the desired configuration. Welded or otherwise secured in place are end members 106 and 108. The pilot burner 110 extends through an opening 112 formed on the side wall 106 and is frictionally held in a U-shaped bracket 114 secured by screws 116 to the rear surface of a mounting member 118 welded to a front housing member 120 secured by screws 122 and 124 to top and side members 104 and 108, respectively. The pilot burner 110 is supplied with gas through a conduit 125 connected to the manifold 34 between the valves 36 and 37. A clip 126 welded to the front surface of the housing member 120 is provided with a flange 128 in alignment with the corresponding flange of the member 118 to provide surfaces for attachment of the pilot assembly to the front channel member 40. Secured by screws 130 to the rear wall 102 of the pilot housing is an L-shaped baffle 131 having an inturned upper edge 132 positioned opposite a rectangular opening 134 formed in the rear wall member 102. The baffle 131 also has a base portion 136 which extends over a plurality of openings 138 formed in the bottom housing wall 100. A U-shaped external baffle 140 is positioned opposite the opening 134 and is secured by screws 141 to the respective side walls 106 and 108. The pilot burner 110 is provided with front and rear openings 142 and 144, respectively, which are connected by a thin cut 146. The front opening faces toward a circular hole 148 formed in the front housing member 120, but as best shown in FIGURES 4 and 6, the axis of the opening 142 is spaced well below the center of the opening 148. As best shown in FIGURE 3, the pilot assembly 76 is mounted to dispose the opening 148 of the pilot element 110 opposite one of a series of slots 149 and 150 formed in the channel members 40 and 44, respectively, which are provided to permit the free venting of the products of combustion. Combustion air for the pilot burner enters the housing through the openings 138 and the combustion products are freely vented through the opening 134 and pass out the main vent openings 96 along with the combustion products of the main burners. The baffle portion 136 completely shields the burner against upwardly directed air currents and the baffles 140 and 132 completely shield the burner against reverse air currents entering through the vent openings 96. Also because of its placement below the centerline of the opening 148, the pilot is completely shielded against air currents passing to the right through this opening. Any such currents will tend to pass above the pilot per se. If they do not, and succeed in extinguishing the main pilot flame, the auxiliary pilot flame issuing from the port 144 will continue to burn because of its particularly well protected location and will immediately re-ignite the main pilot flame issuing from the port 142 through the cut 146. Thus this construction solves a particularly difficult problem in the art, that of providing a pilot burner which is completely shielded against wind currents and yet is in sufficiently intimate communication with a region adjacent the burner to provide immediate ignition either when the burner is initially operated or after it has been blown out.

The pilot is operated with a "hard flame," that is with an excessive amount of primary air which would cause the flame to lift off the port 142 if it were not installed in the protective housing. Such a flame is considerably more resistant to blow-out than the ordinary flame and may be projected further into a region where ignition of the main burner can be effected.

In accordance with the present invention, the ignition of the pilot burner is effected electrically by means of the circuits illustrated diagrammatically in FIGURES 7 and 8, the apparatus of FIGURE 7 being effective to discontinue the flow of gas to the main burners and to the pilot burner in the very unlikely event of pilot outage and the apparatus of FIGURE 8 being effective to re-ignite the pilot burner automatically under such circumstances.

Referring first to the circuit of FIGURE 7, the electrical system thereshown is connected to a source of power by means of conductors 160 and 162, the former being connected to a normally closed fused line switch 164 which serves as a junction of the two circuits arranged in parallel. The first circuit leading from the switch 164 comprises a single pole double throw manually operated switch 166, contact 168 of which is connected to a thermostat 170. Connected to the main power leads through the switch 166 and the thermostat 170 is the solenoid coil 172 of the valve 37, the valve element of which closes the conduit 34 except when the coil 172 is energized. The other contact 174 of the switch 166 is connected to the cold terminal 176 of the flame detector switch 178. When the contact arm 180 is in its normal full line position, the circuit will be completed through the switch 178 to the coil 182 of the upstream solenoid valve 36, the valve element of which is arranged to close the conduit 34 except when the coil 182 is energized. When the hot contact 184 of the switch 178 is closed, a circuit is completed through the solenoid 182 by-passing the switch 166 and the thermostat 170. Closing of the contact 174 also energizes a transformer 186, the secondary winding of which is connected to a hot wire igniter 188 which is positioned within the pilot housing adjacent the port 144.

The flame detector switch 178 is of conventional construction and includes a liquid filled bulb 190 positioned adjacent the path of the flame issuing from the pilot port 144 and which is sensitive to the heat of the flame to evert a force which causes contact arm 180 to snap from engagement with cold contact 176 into engagement with the hot contact 184.

Assuming that the pilot is not burning, the solenoid valves 36 and 37 will be closed and the flow of gas to the pilot as well as the main burner will be completely shutoff. Ignition of the pilot burner is effected by depressing the switch 166 to close contact 174 which will energize the igniter 188 and complete a circuit through the switch 178 to open the main valve 36 to permit the flow of gas to the pilot burner 110. However since the valve 37 remains closed, no gas will be supplied to the main burner 20. Switch 166 is held depressed until the ignition of the pilot flame is effected and the bulb 190 has been heated sufficiently to close contact 184 and open contact 176. When the manual switch 166 is released the igniter will be de-energized but coil 182 of the solenoid valve 36 will continue to be energized thus permitting the continued flow of gas to the pilot burner 110. Any time when the thermostat 170 is closed calling for heat, the coil 172 will be energized thus permitting flow of gas to the main burners 20. Because of the positioning of the pilot burner 110 with respect to the main burners 20, the flame indicated at 152 which issues from the port 142 of the burner 110 passes through the opening 148 and into the space 46 formed between the members 40 and 44. When gas begins to flow to the main burners 20, the unburned gas will move into the space 46 because of the inclination of the burners and ignition will immediately be effected by the pilot flame. Re-ignition of the burners will be effected in the same manner. In the extremely unlikely event that the pilot 110 is blown out, the bulb 190 will be cooled and the contact 184 of switch 178 will be opened thus de-energizing the coil 182 of the valve 36 discon-

tinuing the flow of gas both to the pilot and the main burner to provide complete shutoff of the entire unit.

The burner and pilot assembly of the present invention are essentially completely windproof and the pilot can be blown out only under the most extraordinary transient conditions which quickly subside. Thus in most cases it will be desirable to provide for automatic re-ignition of the pilot. A mechanical-electrical arrangement for effecting this result is shown in FIGURE 8. In this highly simplified system, the flame detector switch **178** and its associated components, the transformer **186**, the igniter **188**, and the solenoid valve **37** and its associated solenoid coil **172** are retained. The remaining elements are eliminated. The upstream solenoid valve **36** is replaced by a manual shutoff valve **192** which will be open at all times when the burner is in operation or its operation is contemplated. A manual master switch **194** is also provided which will be closed at all times when the burner is in operation. Assuming then that the valve **192** has just been opened and the switch **194** has just been closed, gas will flow to the pilot burner **110** and a circuit will be completed to the igniter **188** through the cold contact **176** of the flame detector switch **178**. As soon as ignition of the pilot **110** is effected and the bulb **190** is heated sufficiently, the circuit through the hot contact **184** of the switch **178** is completed which de-energizes the igniter **188** and energizes the coil **172** of the solenoid valve **37** thus permitting gas to flow to the main burners **20** which are immediately ignited in a manner previously described. If the main burners are blown out, they will immediately be re-ignited by the protected pilot **110**. If transient conditions result in the extinguishment of the pilot burner, gas will continue to flow through the pilot burner and the main burners. However the circuit through the cold contact **176** of the switch **178** will be immediately established thus re-energizing the igniter and shutting off the flow of gas to the main burner and the original ignition cycle will be repeated.

Alternately a substitute or additional igniter may be positioned adjacent the elevated ends of the burners to effect direct ignition of the burners. Such igniter may be included in the circuits of FIGURES 7 and 8 to provide shut-off or re-cycling as desired.

After combustion of the main burner is initiated, a limited amount of combustion products may pass through the slots **149** and **150** and through the opening **148**. Under these conditions the pilot flame retracts into the pilot housing. Any portion of the products of combustion from the main burners which enter the pilot housing **76** will pass over the top of the pilot without adverse effect.

Thus, by the unique combination of the pilot assembly, the reflector, the honeycomb screen and the shroud together with the provision and location of appropriate primary air openings and vent openings, a windproof infrared burner has been provided which operates effectively and efficiently under conditions formerly thought to be beyond the range of such heaters.

The form of the invention shown in FIGURES 9 and 10 is preferred for installations in which the unit is exposed to unusually unfavorable and severe operating conditions. Experience has shown that even with the degree of protection afforded by the embodiment of the invention just described, the unit may be subject to erratic or inefficient combustion when subjected to very high winds or gusts, particularly when the direction of the wind is changed rapidly. Under such conditions, pressure changes are produced in the housing which tend either to inhibit combustion or produce excessive combustion accompanied by billowing of the flame.

It has been discovered that these undesirable effects can be eliminated by means for establishing and maintaining a predetermined slight positive pressure in the region of the burner inlet. For this purpose a blower and duct arrangement is incorporated in the unit.

The embodiment shown in FIGURES 9 and 10 is identical to the unit previously described except for the inclusion of the blower **200** and the duct assembly indicated generally at **202** and a slightly modified control system shown in FIGURE 11 and described in detail below. The blower **200** and the electric drive motor **203** (shown schematically in FIGURE 11) are mounted on a suitable bracket at the end of the unit in the space between the outer shroud wall **84** and the reflector panel **68**. The outlet of the blower **200** is connected by a transition section **204** to the duct assembly **202** which extends the full length of the bank of burners **20**. As best shown in FIGURE 10, the duct assembly **202** is of relatively shallow rectangular section and comprises upper and lower sheet metal members **206** and **208** provided with marginal flanges secured together by a plurality of bolts **210**. If desired the joint between the upper and lower members may be sealed by suitable compound and gasket.

The lower duct member **208** is provided with openings **212** which fit snugly around upwardly projecting rims **214** formed on the bosses **27** surrounding the air inlet opening of each of the burners. A suitable heat resistant gasket **216** of fibrofax or similar material is clamped around each of the ridges **214** to provide an airtight connection at this point.

A sail switch **218** is mounted in the transition section **204**, the switch being of the type which is biased by gravity or a spring to open position and is moved in a closed position by the passage of air through the transition section **204**. Accordingly, the switch is closed only when the blower **200** is in operation. In a typical case, the blower may be of very small size having a rated capacity, for example, of 100 c.f.m. since the air flow to the burners is relatively small and only a slight superatmospheric pressure, i.e. about .02" water column static is desired.

The modified control circuit shown in FIGURE 11 to which detailed reference will be made is similar to that shown in FIGURE 7 except for the inclusion of the motor **203** for blower **200** and the normally open sail switch **218** connected in a series with the coil **172** of the main gas valve **37**.

The control circuit is shown in FIGURE 11 in its completely "off" condition. The burner may be placed in operation by closing the main line switch **164** and depressing the momentary contact switch **166** to close contact **174**. Closing this contact opens the pilot valve **36**, the circuit being completed through the cold contact **176** of the flame detector switch. The transformer **186** is also energized to energize the glow plug **188**. The ignition of the pilot burner **110** heats the bulb **190**, which causes the flame detector switch **180** to close the hot contact **184** which maintains the circuit through the coil of valve **38** bypassing the switch **166** which may be released to de-energize the transformer **186**. The system is now under command of the thermostat **170**. When this thermostat closes the blower motor **203** is energized closing the sail switch **218**, completing the circuit through the coil **172** of the main valve **37**, and the unit is placed in full operation. When the demand for heat has been satisfied, the thermostate **170** opens de-energizing the motor **203**, permitting the sail switch **218** to open to thereby close the main valve **37** while the pilot valve remains open. In the event of failure of the motor **203** the sail switch also opens closing the main valve while maintaining the pilot in operation. In the event of blow-out of the pilot **110**, the thermosensitive switch **180** returns to the position shown in FIGURE 11 closing the pilot valve **36**, which prevents the flow of gas to both the pilot burners and the main burner, while permitting the blower motor **203** to remain in operation to purge the system so long as the thermostat **170** remains closed.

The modified burner of FIGURE 12 is like the burners previously described in its main structure but differs in the use of modified blower arrangement. In this form of the invention the blower assembly indicated gen-

erally at 220 draws air into the housing through a louvered opening 221 in the end of the housing wall, for example, as shown in FIGURES 15 and 16, and delivers it directly into the interior of the shroud assembly maintaining a slight constant superatmospheric pressure within the shroud assembly. It has been found that this pressure can be maintained in the region of the air inlets of the individual burners without the use of the duct assembly 202 leading directly to the burners. The construction of the blower is such that it delivers air coaxially along one side of the burner assemblies.

As shown in FIGURES 13 and 14, the blower is provided with a motor 222, which drives a squirrel-cage rotor 224. The motor and rotor assembly are encased in a shroud comprising the cylindrical portion 226 and a frusto-conical portion 228, the latter terminating in a curved upper lip 230 formed as an air inlet opening. Suitably secured in position in the space between the motor-rotor assembly and the shroud are a plurality of vanes 232, the forward ends of which are curved to produce the desired straightening effect. The axial flow shrouded blower is particularly well suited for its purpose, not only because it is efficient and quiet, but also because it effectively cools the motor 222, and the associated wiring which might otherwise be exposed to excessive temperatures because of the location within the shroud assembly.

All of the burners thus far described are preferably equipped with screen strips as shown in detail in FIGURES 17 and 18, and ignition devices are shown in FIGURES 19, 20, and 21.

As shown in FIGURE 17 the screen strips 234, which are relatively coarse mesh heat resistant steel such as Nichrome, are disposed in parallel spaced relation and extend laterally of the individual burner units and longitudinally of the combined assembly. Preferably, four such strips are installed in each of the individual burner units, making a total of sixteen in all.

The projecting ends of the screen strips extend through openings 236 formed in sheet metal mounting strips 238 which are provided with lateral tabs 240 for attachment by screws 242 to the burner castings. As explained more fully in co-pending Application Serial No. 729,153 filed April 17, 1958, now Patent No. 3,151,659, for burners and owned by applicants' assignee, the partial screen assemblies substantially raise the temperature of the ceramic blocks and thus improve the overall efficiency of the burner while at the same time permitting combustion to continue with such efficiency that the percentage of carbon monoxide produced is well within permissible limits. It has been found that the surface temperature of the ceramic burner elements which is normally in the neighborhood of 1550° F. can be maintained with a substantially reduced supply of fuel.

The increase in surface temperature of the radiant blocks is produced by the fact that the screen strips absorb a substantial amount of heat energy from the hot products in combustion, as well as radiant energy transferred from the incandescent surface of the ceramic burner elements. In a short time the screen approaches the temperature of the ceramic surface. Since the screen strips function in the position of a receiver for at least a limited portion of the energy emitted by the radiant ceramic blocks, the net rate of energy transferred away from the blocks in this area is substantially decreased and the portion of the blocks accordingly become substantially hotter. Normally the screen strips are placed at a distance of about ⅝" of the surface of the radiant blocks.

Since the total radiant surface provided in the subject burner includes four separate burner units, separated by the margins of the burner castings, positive ignition cannot be obtained unless separate igniters are provided for each of the individual burner units or provision is made for transferring the flame generated by one burner unit to the next adjacent burner unit. In accordance with the present invention, the expense and complexity of separate igniters is avoided by the provision of simple yet effective flame transfer units, which are shown in detail in FIGURES 19, 20, and 21.

This unit comprises an elongated rectangular channel formed by an upper member 244, and a lower member 246 welded to the side walls 248 and a laterally projecting tab 250 to permit the attachment of the assembly to the burner casting by means of two of the screws 242, which hold the screen strip retainer members in place. As shown in FIGURE 20, the side walls 248 are cut away as at 252, to accommodate the slightly raised burner casting, the portions of the side walls beyond the cut 252 being in direct contact with the surface of the ceramic block. The right end of the assembly as viewed in FIGURES 19 and 20 is completely open. The left end is closed except for a small opening 254. The lower channel members 246 function to prevent side leakage and the escape of gas into the areas where no flame is desired. The unit is installed as shown in FIGURE 17 with the open end of the channel facing the burner which is at the end of the assembly provided with a pilot or alternatively a spark igniter, 256.

In operation after the flow of gas to the burners is established the gas flows to the interior of the channel formed by the members 244 and 246 and passes toward the open end of the channel which is exposed to the flame established on the previously ignited burner. Ignition of the combustible mixture then occurs within the channel and flashes back through the channel and out of the pilot opening 254 and immediately ignites the next adjacent burner. Similar units are provided on the two adjacent burners not shown in FIGURE 17 to permit the smooth and rapid transmission of the flame across the entire assembly.

The heater shown in FIGURES 15 and 16 is essentially the same as the heaters described above except for the reflector assembly, indicated generally at 258, which is substituted for the reflector assembly previously described.

The reflector assembly 258 as in the previous embodiments comprises identical side members 260 and 262, and a pair of opposite identical end members 264 and 266, the end members being provided with flanges 268 and 270 which may be spot or seam welded to the ends of the side members 260 and 262. At its upper end, the reflector assembly is secured to the burner frame assembly 50. The joint between the shroud sections 80, 82, 84, and 86, and the corresponding reflector elements is preferably sealed by a strip of insulating material 272, such as a felted ceramic material sold under the trade name of "Fiber Frax." The sealing of this joint at this area facilitates maintaining the slight superatmospheric pressure within the shroud developed by the blower 220. As in the previously described reflector, the reflector elements 260, 262, 264, and 266 are preferably of parabolic form. The reflector is extended by side panels 274 and 276 and end panels 278 and 280, the upper edges of which are flanged for attachment to the lower flanged edges of the panels 260–266. The panels 274–280 are preferably flat. However, they closely approach a true parabolic form and afford the same performance as a true parabolic.

This application is a continuation-in-part of application Serial No. 848,159 filed October 22, 1959 for infra-red heaters.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are 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 equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. An infra-red heater comprising a plurality of infra-

red burners mounted in side-by-side relation on a frame, said burners each having an infra-red generating surface, a reflector assembly mounted on said frame and extending away from said burner surfaces, a honeycomb screen extending across the open end of said reflector assembly, an essentially imperforate windproof shroud assembly enclosing said burners and said reflector assembly, the marginal edges of said shroud assembly and said reflector assembly being spaced to provide a restricted inlet passage for combustion air and said shroud having an outlet for combustion products, and a pilot assembly positioned within said shroud adjacent said burners.

2. An infra-red heater comprising a plurality of infra-red burners having a combustion air inlet at one end and a downwardly facing infra-red generating surface, a frame mounting said burners in side-by-side relation, said burners being inclined upwardly from said air inlet to promote the passage of combustion products in a direction away from said inlet, a pilot assembly carried by said frame adjacent the elevated end of at least one of said burners, a reflector assembly extending downwardly away from said burner surfaces, and an essentially imperforate windproof shroud assembly enclosing said burners and said reflector assembly and providing at its lower marginal edges a passage for combustion air and said shroud assembly having a restricted outlet for combustion products.

3. An infra-red heater assembly comprising a plurality of infra-red burners, each having a combustion air inlet at one end and a downwardly facing infrared generating surface, a frame mounting said burners in side-by-side relation and inclining the burners upwardly from said air inlet end to promote the passage of combustion products in a direction away from said air inlet, the portion of the frame at the elevated end of said burners having openings to permit the passage of combustion products therethrough, a pilot housing mounted on said frame adjacent said openings, a pilot burner within said pilot housing, said pilot housing having an opening in registry with and closely adjacent to certain of said openings to permit the flame from said pilot burner to project toward said certain openings, a reflector assembly mounted on said frame and extending away from said burner surfaces, and an essentially imperforate shroud assembly enclosing said burners, said pilot housing and said reflector and providing restricted inlet and outlet passages for combustion air and combustion products, respectively.

4. An infra-red heatre comprising a plurality of infra-red burners, each of said burners having an infra-red generating surface, a frame mounting said burners in side-by-side relation, a reflector assembly mounted on said frame and extending a substantial distance away from said burner surfaces and an essentially imperforate shroud assembly enclosing said burners and said reflector assembly, the marginal edges of said shroud assembly being spaced slightly from the adjacent edges of said reflector assembly to provide a restricted air inlet opening, said shroud also having a restricted outlet opening for the products of combustion generated by said burners.

5. An infra-red heater comprising a plurality of infra-red burners, each of said burners having an infra-red generating surface, a frame supporting said burners in side-by-side relation to dispose said infra-red generating surfaces in a generally downwardly facing direction, a reflector assembly carried by said frame and extending downwardly therefrom away from said burner surfaces, the end of said reflector assembly remote from said burner terminating in a substantially horizontal rim, and an essentially imperforate shroud assembly enclosing said burners and said reflector assembly and extending over the top of said burners and terminating at its lower end in a rim adjacent the rim of said reflector assembly, the respective rims of said reflector assembly and said shroud assembly being spaced slightly to provide a restricted air inlet opening for combustion air, said shroud assembly having outlet openings of limited area above said burners to permit the venting of combustion products.

6. The heater assembly according to claim 5 together with a honeycomb screen carried by the rim of said reflector assembly and extending across the open end of said reflector assembly.

7. The infra-red heater assembly according to claim 5 together with a pilot assembly carried by said frame within said shroud assembly adjacent said outlet openings in said shroud assembly.

8. An infra-red heater comprising a plurality of infra-red burners each having a combustion air inlet at one end and a downwardly facing infra-red generating surface, a frame assembly mounting said burners in side-by-side relation, said burners being inclined upwardly from said air inlet to promote the passage of combustion products in a direction away from said inlet, the portion of the frame adjacent the relatively elevated end of said burners forming an elongated duct having slotted sides, a pilot housing carried by said portion of said frame, said pilot housing having an opening in registry with and closely adjacent to certain of said slots, a pilot burner in said housing facing and closely adjacent said opening in said housing through which the flame from said pilot burner projects toward said burners through said certain slots, said pilot housing having inlet and outlet openings for combustion and and combustion products, respectively, and a main housing completely enclosing said burners and said pilot housing except for the area opposite said infra-red generating surfaces, said main housing having an outlet for combustion products adjacent the combustion products outlet formed in said pilot housing.

9. An infra-red heater comprising infra-red burner apparatus, said apparatus incorporating an infra-red generating surface on its under side and an opening to admit combustion air on its upper side, a reflector assembly surrounding and depending below said surface, a shroud assembly enclosing said burner apparatus and said reflector assembly except the side below said generating surface, and at least one imperforate exhaust conduit directly connected at one end to the the upper part of the space within said reflector assembly and extending through the space between said reflector assembly and said shroud assembly, said conduit being in communication at its other end with the atmosphere outside of said shroud, said shroud being completely closed except for restricted inlet and outlet openings.

10. The combination according to claim 9, together with a blower carried by said heater and having an outlet within said shroud for delivering air under super atmospheric pressure to the opening for combustion air incorporated in said burner apparatus.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,291,115 December 13, 1966

Philip M. Forniti

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 42, for "evert" read -- exert --; column 12, line 27, for "and", first occurrence, read -- air --.

Signed and sealed this 19th day of September 1967.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents