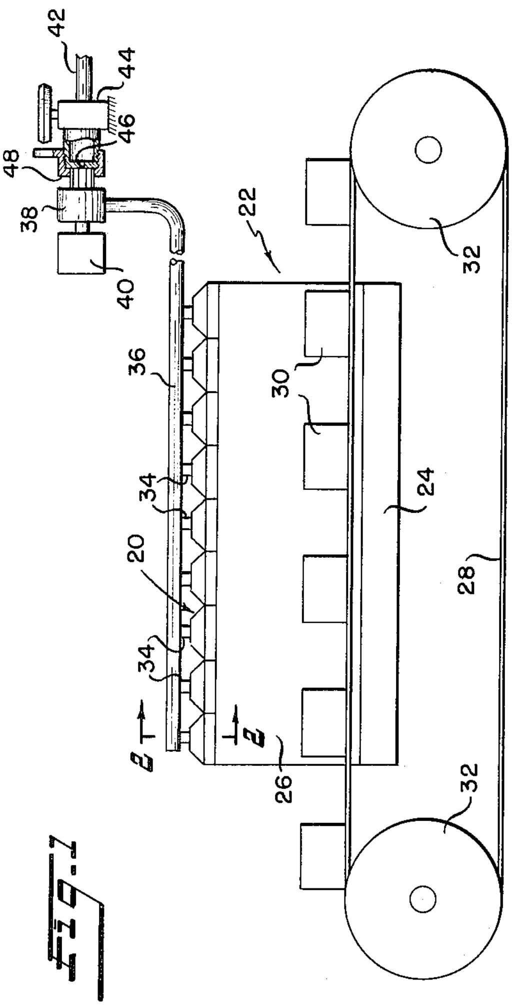
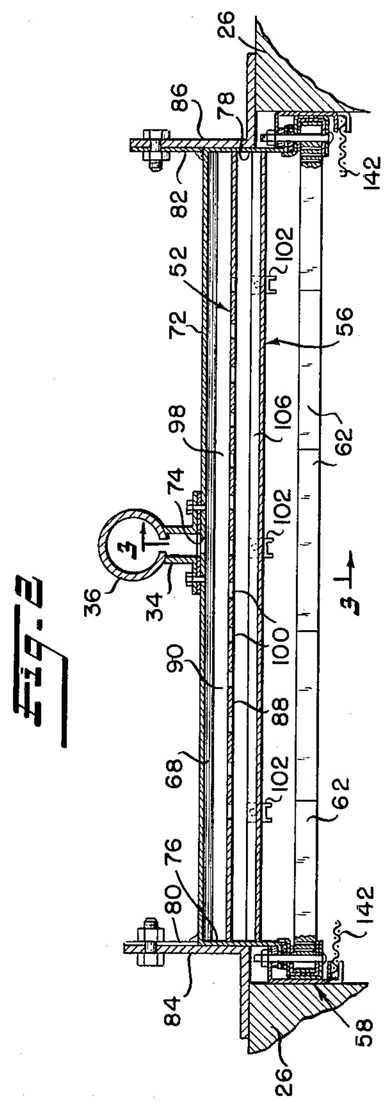
Jan. 11, 1966 K. E. BAUER 3,228,614

GAS FIRED INFRA-RED HEATERS

Filed June 15, 1962 5 Sheets-Sheet 1





INVENTOR
Konrad E. Bauer

BY Strauch, Nolan & Neale
ATTORNEYS

Jan. 11, 1966 **K. E. BAUER** **3,228,614**

GAS FIRED INFRA-RED HEATERS

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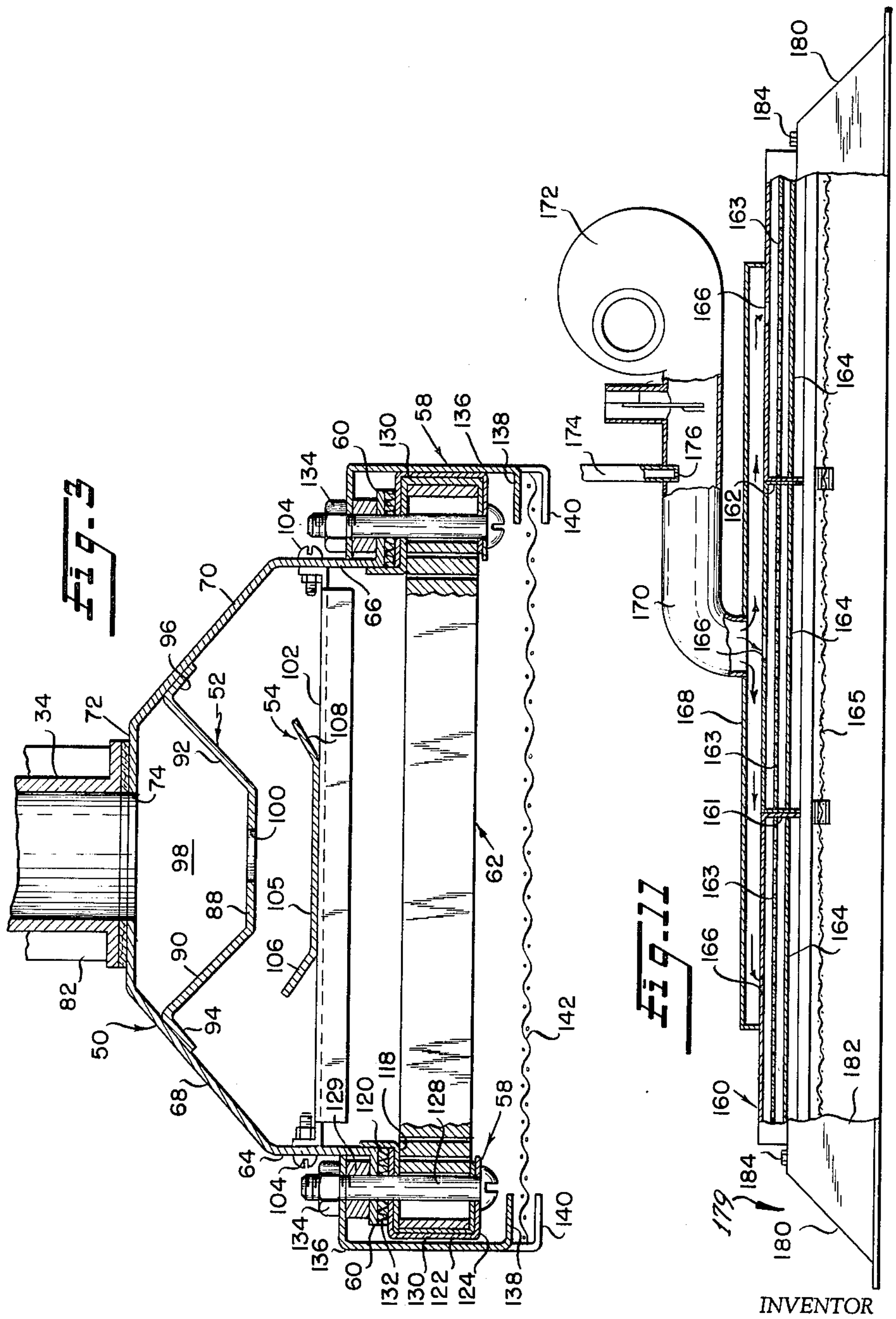

INVENTOR

Konrad E. Bauer

BY Strauch, Nolan & Neale

ATTORNEYS

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GAS FIRED INFRA-RED HEATERS

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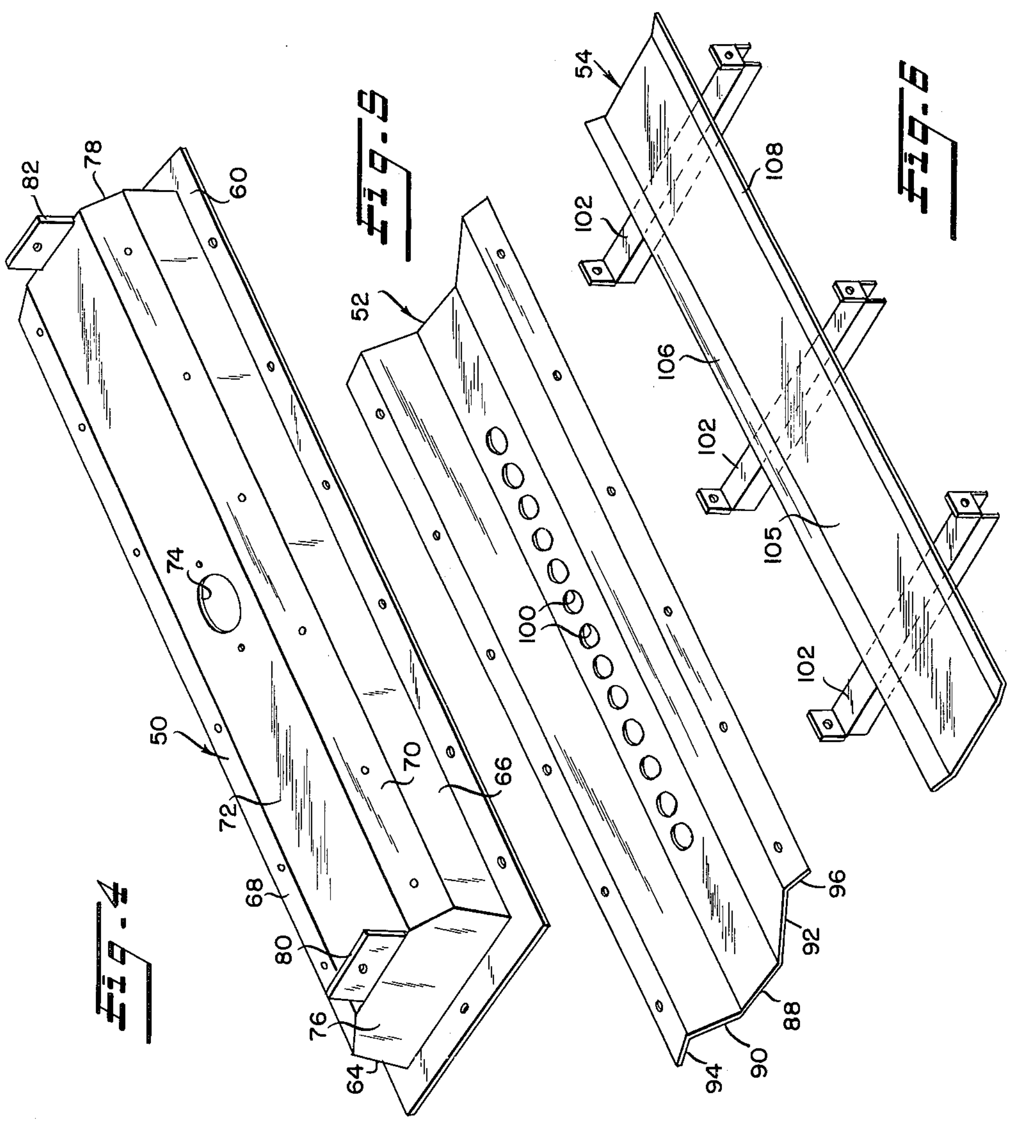

INVENTOR
Konrad E. Bauer

BY Strauch, Nolan + Neale
ATTORNEYS

GAS FIRED INFRA-RED HEATERS

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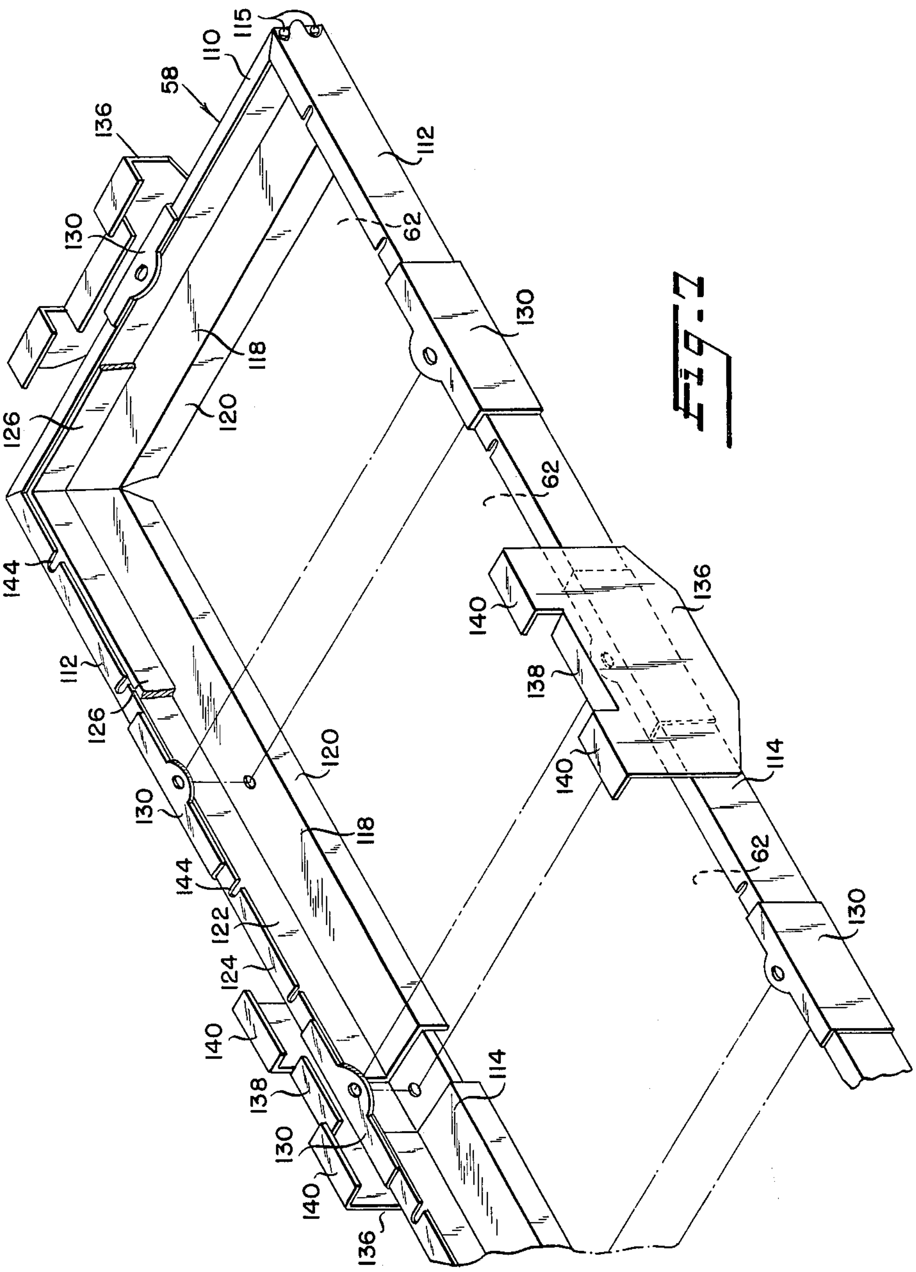

Fig-7

INVENTOR
Konrad E. Bauer

BY Strauch, Nolan & Neale
ATTORNEYS

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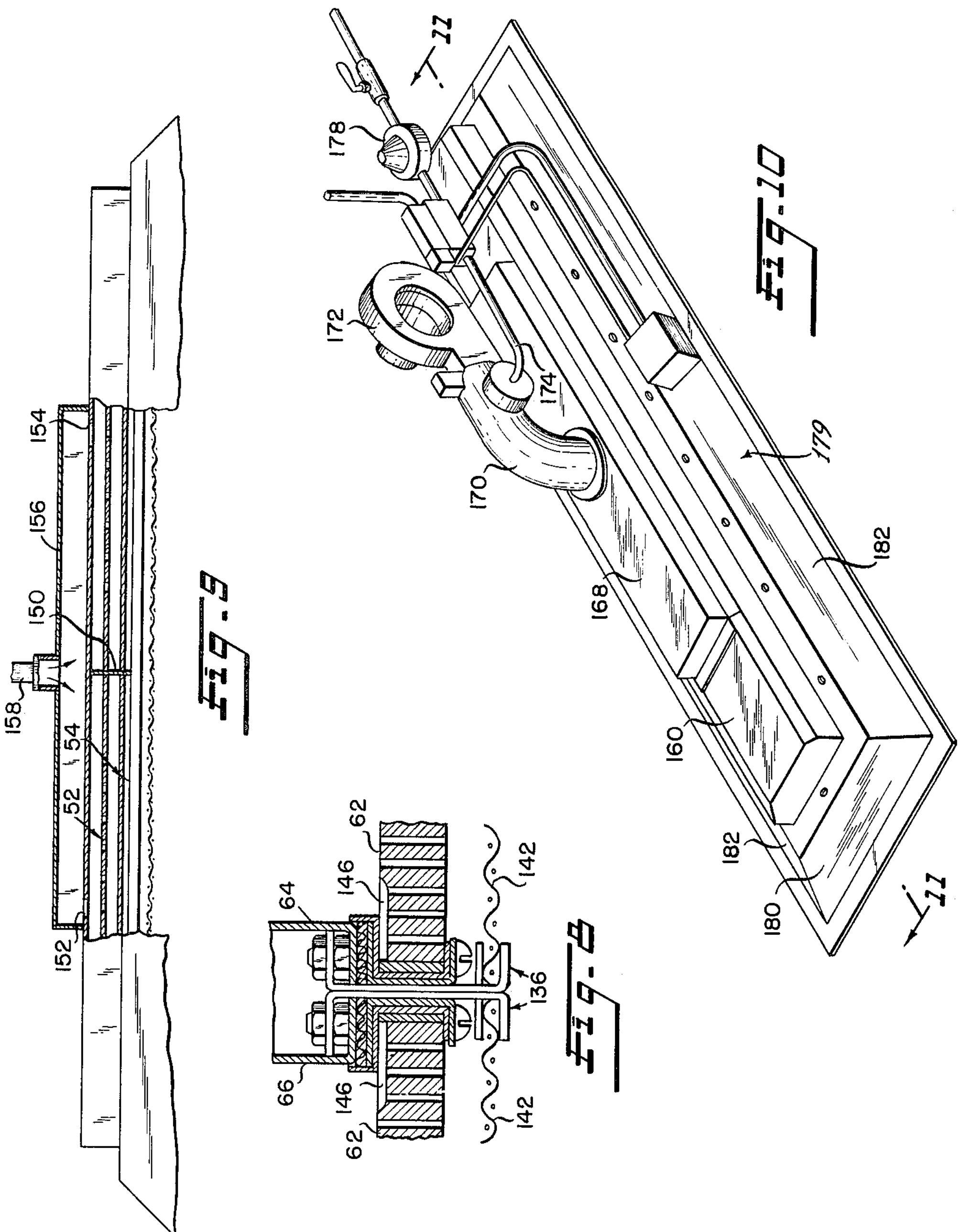
GAS FIRED INFRA-RED HEATERS

Filed June 15, 1962 5 Sheets-Sheet 5



INVENTOR
Konrad E. Bauer

BY Strauch, Nolan & Neale

ATTORNEYS

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3,228,614
GAS FIRED INFRA-RED HEATERS
Konrad E. Bauer, Mentor, Ohio, assignor to Hupp Corporation, Cleveland, Ohio, a corporation of Virginia
Filed June 15, 1962, Ser. No. 202,728
4 Claims. (Cl. 239—432)

This invention relates to gas fired infra-red heaters and more particularly to such heaters of large capacity which are supplied with a combustible fuel-air mixture at super-atmospheric pressure.

One of the most successful prior gas fired infra-red heaters is disclosed and claimed in United States Patent No. 2,775,294. This prior burner comprises a housing, one wall of which is formed by one or more ceramic blocks having a large number, for example about 200 per square inch, of small through perforations. Gas is supplied to the burner through a nozzle positioned adjacent the inlet of a venturi tube which extends into the housing. The gas entrains a flow of air which is mixed in the venturi and in the housing and which passes through the perforations of the blocks for combustion on the outer surfaces of the blocks. The surface temperature of the blocks is raised to about 1600° F., thus generating energy in the infra-red portion of the spectrum.

While such burners are efficient and reliable and have come into widespread use in the United States and foreign countries, nevertheless their capacity is limited by several factors. For example, in order to entrain enough air for complete combustion of the gas, the back pressure in the housing must be kept low which limits the amount of mixture which can be passed through a perforation of a given size in the ceramic block, consequently limiting the amount of gas which can be burned on a surface of a given area. Also, the total area of the surface which can be supplied with the mixture from a single venturi is limited due to back pressure developed in delivering the mixture from the venturi to the more remote parts of the burner. Finally, uniform distribution to all parts of the ceramic block can be achieved in the prior burner only if the area of the burner is relatively small since there is a rapid pressure drop as the gas mixture moves to the more remote portions of the ceramic block with reduced pressure reducing the flow of gas to these more distant perforations and rendering uniformity of performance difficult to achieve. Thus, these prior heaters, while efficient and effective, are inherently of relatively small size, for example 12,000 B.t.u./hr. per unit. Where such heaters were employed for processing or for heating large areas, it has been necessary to use a large number of these relatively small individual units. Since each requires valves, both manual and electrical, pressure regulators, pilots, safety controls and associated pipes and wiring, such an installation is not only expensive but is subject to component failure and maladjustment.

It is the primary purpose and object of the present invention to provide improved gas fired infra-red heaters which are not subject to these limitations and which are capable of producing from 100,000 B.t.u. to 200,000 B.t.u. per hour or greater without loss of efficiency.

In accordance with the present invention, the combustible gas-air mixture is formed externally of the burner units and supplied under superatmospheric pressure to the burner units.

For industrial processes such as the heat treatment of metals for baking molds, parts or finishes or for drying materials, a number of burners are used which are supplied with premixed gas and air from a common source. For space heating the burners of the present invention are spaced apart and rather widely distributed over the area to be heated and in this case relatively small gas pipes are run to the individual heaters and individual blowers are employed with the heaters to mix the air and gas and supply it under super-atmospheric pressure to the interior of the burner housings.

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The burners of the present invention together with the means for supplying premixed gas and air have several advantages over prior burners in which air is induced into a venturi by the flow of the gas stream. For example, more heat can be obtained efficiently from a given size burner because the gas-air ratio can be maintained close to the theoretically correct value at all times and in all parts of the burner. The increase in efficiency is obtained primarily by eliminating the necessity of providing excess air to assure perfect combustion which reduces burner efficiency in prior units. Also, the diameter of the perforations in the ceramic burner elements can be reduced, lessening the danger of flash-back and making possible the operation of the burner at a higher temperature. The uniformity of mixture, achieved with the apparatus of the present invention, also provides more uniform distribution of the emitted heat and results in increased capacity and prevents hot spots which might cause flash-back.

Further, the apparatus of the present invention permits a much more compact arrangement of the burner units because of elimination of the separate venturis and other components previously utilized in each burner.

The burners of the present invention, when used for processing applications, are frequently inverted over the work to emit radiation downward, or in other locations which expose the burner to heat carried back from the work either by conduction or re-radiation increasing the susceptibility of the unit to flash-back and to mechanical deterioration. It is, accordingly, a further important object of the present invention to provide improved gas fired infra-red heaters in which these difficulties are avoided and which can be operated at higher surface temperatures at increased output with several of the burners placed adjacent to each other to provide a substantially continuous radiant heating surface of almost any desired area.

It is an additional object of the present invention to provide improved gas fired infra-red heaters in which provision is made for uniform distribution of the gas-air mixture to all portions of the radiant surface, even a relatively long, slender burner which has a configuration which has been found particularly useful for processing applications.

It is also an object of the present invention to provide improved gas fired infra-red heaters which are fabricated of sheet metal which can be produced at low cost and which incorporate a unique relationship between the ceramic burner elements and the housing which protects the sheet metal housing from overheating or deterioration due to re-radiated or convected heat.

It is a further object of the present invention to provide improved gas fired infra-red heaters incorporating a metallic housing and ceramic burner elements, the latter being so arranged that they are not damaged even by continued misuse at high temperature and are free to expand and contract with temperature changes, are thermally isolated from the burner housing and are mounted in such manner as to facilitate replacement when necessary.

It is also an object of the present invention to provide improved gas fired infra-red heaters incorporating a self-contained air-blower which moves air into the burner under super-atmospheric pressure, provision being made for feeding gas into the airstream under still higher pressure under conditions which promote thorough mixing, the burners incorporating means for distributing the gas-air mixture uniformly to all areas of the radiant face of the burner at the same rate.

It is an additional object of the present invention to provide improved gas fired infra-red burners which have markedly improved performance in exposed locations since their operation is substantially unaffected by drafts, winds or other air currents.

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

FIGURE 1 is a semi-diagrammatic view of a conveyor type furnace incorporating a plurality of the gas burning infra-red heaters of the present invention;

FIGURE 2 is a longitudinal vertical section of one of the heaters taken along line 2—2 of FIGURE 1;

FIGURE 3 is a transverse vertical section of one of the individual heaters taken along line 3—3 of FIGURE 2;

FIGURE 4 is an isometric view of one of the individual heater housings;

FIGURE 5 is an isometric view of a distributor baffle incorporated in the housing of FIGURE 4;

FIGURE 6 is an isometric view of a further baffle located in the housing of FIGURE 4;

FIGURE 7 is an inverted isometric view of a portion of the frame by which the ceramic burner elements are supported on the housing of FIGURE 4;

FIGURE 8 is an enlarged fragmentary section through the joint between two adjacent burners illustrating means for igniting one of the burners from the other;

FIGURE 9 is a longitudinal elevation with parts broken away to show interior details illustrating a modified form of the burner which is twice the length of the burner of FIGURES 1 and 2;

FIGURE 10 is an isometric view of a modified form of the heater of the present invention; and

FIGURE 11 is a central vertical section of the burner of FIGURE 10 taken along line 11—11 of FIGURE 10.

Referring now more particularly to the drawings, FIGURE 1 shows a typical application of the heaters of the present invention in industrial processes. The heaters, which are indicated generally at 20 and which will be described in detail below, are arranged in side-by-side relation and extend across the top of a furnace indicated generally at 22.

The furnace or oven 22 has an insulated bottom wall 24, and insulated side walls 26, which together with the heaters 20 form an open ended passage for the upper reach of the conveyor belt 28 which carries the articles 30 which are to be treated. The conveyor belt 28 is supported on the usual sprockets 32 which may be driven by suitable means not shown. The heaters 20 are so disposed that they direct radiant energy downwardly onto the articles to be treated. The heaters are connected by individual stub pipes 34 to a manifold 36 which leads from the output side of a blower 38 driven by a motor 40. The main gas supply line 42 is connected through a conventional pressure regulator 44 which delivers gas to an orifice 46 at a slightly super-atmospheric pressure. When the blower 38 is in operation, gas is forced through the orifice 46 and air is drawn into the space between the housing of blower 38 and a control cap 48 which is rotatable to adjust the effective area of the air space and the effective opening of the orifice 46, thus regulating the flow of air and gas together to vary the input to the burners without changing the fuel-air ratio.

The air and gas are thoroughly mixed in the blower 38 and the mixture is forced under pressure through the manifold 36 into the individual burners.

The particular mixer shown is one of a number of commercially available gas-air mixers suitable for the purpose. The unit shown is merely illustrative of a device for pre-mixing the air and gas in stoichiometric proportions and delivering the mixture to the burners under super-atmospheric pressure.

The principal components of the individual burners are a housing 50 (FIGURE 4), a distributor 52 (FIGURE 5), a baffle 54 (FIGURE 6), a frame assembly 58 (FIGURE 7), secured to a marginal flange 60 of the burner housing 50 and the ceramic burner elements 62, carried by the frame assembly 58, as explained in detail below.

The housing 50 which is of stamped sheet metal construction is of elongated rectangular configuration and has flat side walls 64 and 66 which are connected by inclined upper wall portions 68 and 70 to a flat top wall 72, which has a central opening 74 to which the fuel-air mixture supply pipe 34 is connected. The flat end walls 76 and 78 of the housing are provided at their upper ends with attaching tabs 80 and 82 to permit the heaters to be mounted as shown in FIGURE 2 to suitable brackets 84 and 86 carried by the furnace walls 26.

As shown in FIGURES 3 and 5, the distributor 52 is a stamped sheet metal part of trough-shaped configuration having a flat bottom wall 88 and upwardly inclined walls 90 and 92 terminating at their upper edges in flanges 94 and 96 welded to the respective inclined walls 68 and 70 of the housing 50. The distributor 52 forms a chamber 98 to which the fuel-air mixture is supplied by the conduit 34, the mixture thereafter passing through a series of openings 100 in the distributor 52. The openings 100 are so sized and arranged as to proportion the flow evenly along the length of the burner. In a typical case, when the width of the housing is approximately five inches and its length is about 22 inches, thirteen openings 100 are provided which have a $\frac{7}{16}$ inch diameter and are located on $\frac{7}{8}$ inch centers, the openings 100 being grouped at the central portion of the distributor 52.

The baffle assembly 54 is supported on cross bars 102, the opposite ends of which are secured by screws 104 to the housing side walls. The baffle 54 is positioned symmetrically of the burner beneath the openings 100 and is in the form of a trough, having a flat bottom wall 105 and upwardly inclined edge portions 106 and 108. The baffle acts as a spreader distributing the mixture issuing from the openings 100 evenly across the width of the burner. Without the distributor 52 and the baffle 54 the gas flow would be concentrated at the center burner, which would lead to overheating of the central portion of the burner and starving of the ceramic burner elements at the ends of the burner.

The unique frame assembly 58 shown separately in FIGURE 7 which supports the ceramic burner elements 62 is formed of thin sheet metal strips, preferably of stainless steel or similar heat resistant metal. In the typical burner referred to above, which is approximately five inches by twenty-two inches, the frame assembly comprises eight separate strips comprising two identical end strips 110, four corner strips 112, and two center strips 114. The strips 110 are secured to the strips 114 by tabs 115. Each of the strips is of channel configuration and each has a flat bottom wall 118 with an inturned lip 120, a vertical wall 122, with an inturned lip 124. The frame assembly thus forms a peripheral channel which is of slightly greater width and length than the aggregate width and length of the ceramic blocks 62 and of slightly greater depth than the ceramic blocks. The vertical walls 122 are lined with strips 126 of felted ceramic fibers, against which the marginal edges of the burner blocks 62 rest.

The frame assembly is secured to the marginal flange 60 of the housing 50 by bolts 128 and nuts 129, the bolts passing through aligned openings in U-shaped clips 130 which closely surround the frame and are positioned at suitably spaced points around its periphery. To insulate the ceramic blocks 62 and the frame assembly from the housing, insulating strips such as strips 132 of felted ceramic fibers are interposed between the frame assembly and the housing flange 60. The insulating strips 126 and 132 not only provide thermal insulation but also accommodate irregularities in the frame assembly and the ceramic blocks to prevent leakage of the gas and accommodate the effects of unequal expansion of the parts.

Certain of the bolts 128 are elongated and are provided with second nuts 134 to support stainless steel clips 136, which extend to the front of the frame assembly. The clips **136** are provided with integral tabs **138** and **140** which support a screen **142** covering the entire radiant face of the burner. The screen **142** is preferably made of heat resistant wire such as Nichrome, the wire being about 3/64 of an inch thick and the screen having a mesh of about 1/4 of an inch. The screen is positioned about 1/4 of an inch from the radiant face of the ceramic blocks **62** and is heated by the blocks and re-radiates a part of the energy back to the face of the blocks raising their temperature and increasing the total radiation emitted by the burner.

The ceramic blocks **62** are preferably of the type disclosed and claimed in United States Letters Patent 2,775,294. They are made of a ceramic material having a high heat resistance and low thermal conductivity and are provided with a large number of through perforations distributed uniformly over the entire area of the blocks except for a narrow border which is left unperforated. In a typical case, the burner blocks have approximately two hundred perforations per square inch, each of the perforations being about one millimeter in diameter. Burner elements other than those described in United States Letters Patent 2,775,294 may be employed in this burner if they possess the desired heat resistance and low thermal conductivity.

In operation, a stoichiometric mixture of gas and air is supplied through the conduits **34** to the individual burners and is uniformly distributed by the distributor **52** and the baffle **54** to the inner surface of the ceramic burner blocks **62**. The mixture passes through the perforations in each of the burner blocks for combustion closely adjacent to their outer surface. The combustion may be initiated in any convenient way but is preferably initiated by the automatic ignition and control apparatus described below.

Combustion of the gas-air mixture occurs closely adjacent the outer surface of the blocks and rapidly raises the temperature of this surface from 1600° F. to 1800° F. causing the surface to emit large amounts of infra-red radiation. The dimensions and thermal conductivity of the ceramic blocks **62** are such that there is no tendency for combustion to flash-back through the perforations into the interior of the housing **50**. The tendency toward flash-back is minimized by the disposition of the blocks covering the entire front face of the burners to prevent exposure of the metal portions of the burners to re-radiation of heat from the objects **30** or other material to be heated. Conduction from the frame assembly to the housing assembly is reduced by the insulating strips **132**. This insulating plus the constant inflow of relatively cool gas and air maintains the housings at a temperature well below the ignition temperature of the gas-air mixture. The insulating strips also seal the mechanism to prevent the escape of gas and accommodate the effects of differential thermal expansion. Also, as shown in FIGURE 7, the adjacent ends of the frame strips **112** and **114** are spaced apart to accommodate the effects of thermal expansion and the strips are notched as at **144** for a similar purpose.

The frame assembly in addition to supporting the ceramic burner elements and protecting them against accidental dislodgement and deterioration due to thermal expansion and contraction also facilitates their replacement. If it becomes necessary to replace one of the ceramic elements, it is necessary merely to remove one or more of the bolts **128** and separate the frame strips slightly. This frees the ceramic plate involved, which may then be removed and replaced.

Ordinarily, when the burners are employed in banks as shown in FIGURE 1, the burner at one end of the bank is ignited by a pilot or other suitable means and the flame is transferred from one burner to each succeeding burner along the length of the bank preferably by the structure shown in FIGURE 8. As shown in FIGURE

8, a shallow groove **146** about a quarter of an inch wide is cut in the inner surface of one of the ceramic burner elements **62** at each side of the burner to permit the passage of gas to the outermost of the perforations which are otherwise blocked by the strips of the frame assembly **58**. The grooves **146** permit gas to reach the holes at the side of the burner which are close enough to the holes in the next adjacent burner so that one burner ignites quickly from the other. It is to be understood that the screen retaining clips **136** are positioned out of registry with the grooves **146**.

FIGURE 9 to which detailed reference will now be made, illustrates a slightly modified burner which is twice the length of the burner shown in FIGURE 2. Essentially the burner of FIGURE 9 comprises two of the burners of FIGURE 2 placed in end-to-end relation. For this purpose, two of the housings **50** may be placed end-to-end or one of the housings having twice the length of the housing **50** may be employed. If two of the housings **50** are employed for this purpose, the adjacent end walls **76** or **78** form a partition centrally of the unit. If one elongated housing is used, a separate partition member **150** will be installed at the midpoint of the housing. The structure at each side of the partition is exactly the same as the structure of the individual burner units described above and each section includes a distributor assembly **52**, a baffle **54** and a screen frame. The top housing wall is provided with two openings **152** and **154** which are in communication with the interior of a header **156** which is supplied with a combustible mixture of fuel and air through a conduit **158** which may be connected to a common manifold such as that shown in FIGURE 1.

The operation of the burner in FIGURE 9 is in all respects the same as the operation of the burner of FIGURES 1–8 described above.

The burner installations thus far described are particularly suitable for industrial applications of the type shown in FIGURE 1. However for space heating for example in hangars or large buildings, the individual heaters are spaced apart and are rather widely distributed over the area to be heated. In this case it is more economical to run small gas pipes to the heaters than to use the large size piping required to carry the mixture of gas and air. Also it is usually desirable to control the heaters individually. Accordingly, each heater should be a complete unit capable of independent operation.

A heater installation suitable for this purpose is shown in FIGURES 10 and 11 to which detailed reference will now be made. The burner of FIGURES 10 and 11 comprises a main burner housing **160** which is divided by internal vertical partitions **161** and **162** into three compartments which are identical to the individual burner assemblies shown in FIGURE 2. Thus, each compartment includes a perforated distributor **163** of the same configuration as the distributor **52** and each compartment contains a baffle **164** identical to the baffle **54** of FIGURE 6. The ceramic blocks **62** and the screen **165** are supported by a frame assembly identical to the assembly of FIGURE 7 except that it is elongated and includes additional intermediate side strips **114**. The top wall of each of the compartments is provided with a central opening **166** in communication with a header **168** to which a combustible mixture of fuel and air is supplied through a conduit **170**. Air is forced through the conduit **170** by a blower **172** and the gaseous fuel is supplied to the conduit **170** through a pipe **174** which extends transversely of the conduit **170** and is provided at its inner end with an orifice **176**. The pressure at which the gas is supplied to the pipe **174** may be controlled by a conventional pressure regulator **178**.

The blower **172** is sized to deliver slightly more air than is required for the complete combustion of sufficient gas to provide the required heating capacity to assure operation of the burner with 100% primary air. Since the gaseous fuel is introduced in a direction transverse to the flow of air delivered by the blower **172**, the gas and air are thoroughly mixed before being introduced into the header **168**. To deliver equal amounts of the combustible mixture to the three burner compartments, the central opening **166** is considerably smaller than the end openings. In a typical case, the openings leading to the end compartments are each two inches square, whereas the opening to the center compartment is a round hole having a diameter of three-quarters of an inch. After the mixture of fuel and air is delivered to the individual burner compartments, it is distributed uniformly to the inner surface of the ceramic blocks **62** by the distributor **163** and the baffle **164** as described above. When the burner is ignited, combustion occurs and radiant energy is produced in the same manner as described above in connection with the previous embodiments.

Since the unit of FIGURES 10 and 11 is used for space heating, a reflecting shade assembly **179** is included to prevent dissipation of the radiation outside of the space to be heated. The reflector assembly is preferably of frusto-pyramidal form and includes a pair of identical end members **180** and identical side members **182**, which are secured together by any suitable means such as seam or spot welding. The reflector assembly is detachably secured to the burner by additional nuts **184** provided on the ends of the retainer bolts **128**.

Also the apparatus for introducing the gas into the airstream as disclosed herein is preferred because it is simple and effective. However, other conventional commercially available units may be employed for this purpose. While the preferred embodiments incorporate ceramic burner elements of the type disclosed in United States Letters Patent 2,775,294, other burner elements may be employed. For example, the openings may be of other shapes such as narrow slots or diamond shapes, and the wall through which they pass may be of other material or structure such as a fine screen or several layers of screen.

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. Gas fired infra-red generating apparatus comprising an elongated housing member having a top wall provide with an opening and having side walls terminating at their lower edges in an outwardly extending flange, a frame assembly detachably secured to said flange, a plurality of ported burner members carried by said frame assembly, each of said burner members extending over a portion of said flange, means for supplying a combustible fuel-air mixture to the opening in said housing member at superatmospheric pressure, a distributor carried by said housing member internally thereof and extending from end to end and from side to side thereof, said distributor having a central ported area, and an imperforate elongated baffle

interposed between said distributor and said burner members, the lateral edges of said baffle being spaced a substantial distance from said housing member side walls, and said baffle extending longitudinally beyond the ends of said ported area, said distributor and said baffle co-operating to supply said combustible fuel-air mixture uniformly to all portions of said ported burner members.

2. Gas fired infrared generating apparatus comprising an elongated housing member having a top wall provided with an essentially central opening and having side walls terminating at the lower edges in an outwardly extending flange, ported burner means carried by said flange, said burner means extending over a portion of said flange, means for delivering a combustible fuel-air mixture through the opening in said housing member in a direction essentially normal to the axis of said elongated housing, a sheet metal distributor carried by said housing member internally thereof and extending from end to end and from side to side of said housing member to thereby block flow of said fuel-air mixture around the ends and over the edges of said distributor, said distributor having a central ported area to permit the flow of said fuel-air mixture therethrough, and an elongated imperforate baffle interposed between said distributor and said ported burner means, said baffle extending longitudinally of said housing beyond the ported area of said distributor and the lateral edges of said baffle being spaced a substantial distance from the side walls of said housing member whereby said fuel-air mixture flows over the lateral edges of said baffle, said distributor and said baffle co-operating to supply said combustible fuel-air mixture uniformly to all regions of said ported burner means.

3. The apparatus according to claim **2** together with a plurality of clips secured to the upper surface of said flange and extending around said flange and having portions projecting inwardly over, and in spaced relation to, the outer surface of said ported burner means, and a screen assembly carried by said clip portions and extending over said outer surface of said ported burner means.

4. The apparatus according to claim **2** wherein said ported burner means is essentially flat and said baffle has a central flat section parallel to said burner means and edge portions inclined away from said burner means.

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FREDERICK L MATTESON, Jr., *Primary Examiner.*

JAMES W. WESTHAVER, *Examiner.*