Feb. 9, 1971

W. H. BEST

3,561,902

RADIANT BURNER

Filed Sept. 19, 1968

2 Sheets-Sheet 1

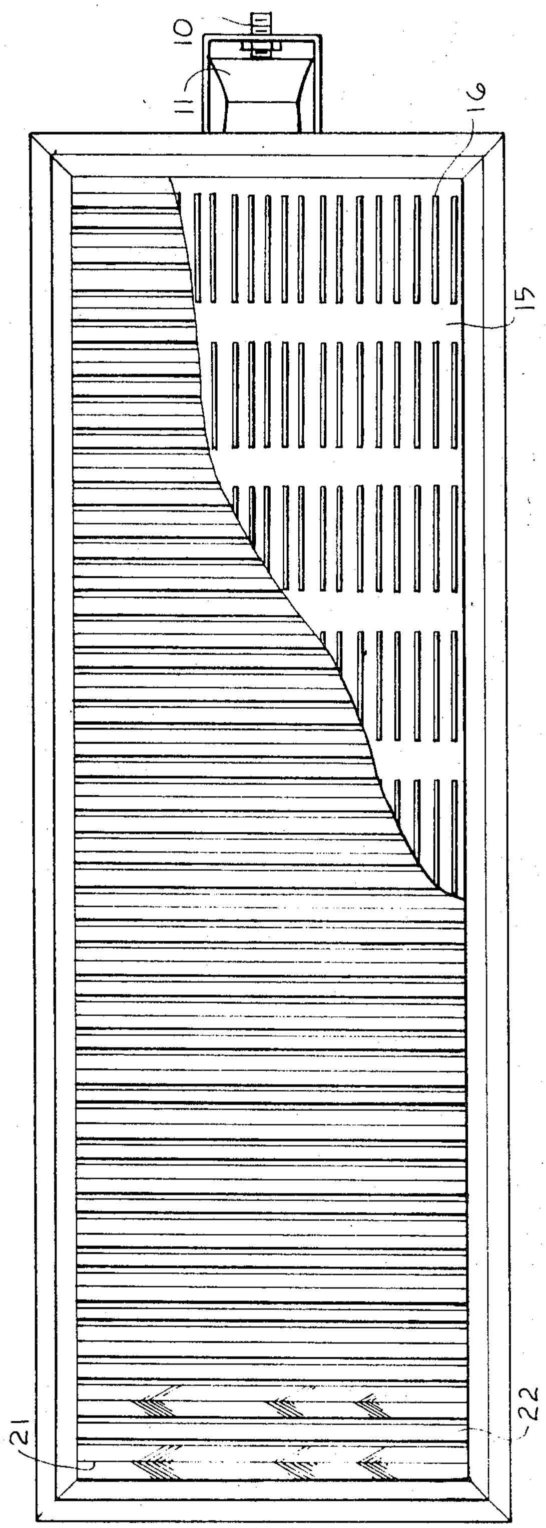

Fig. 1

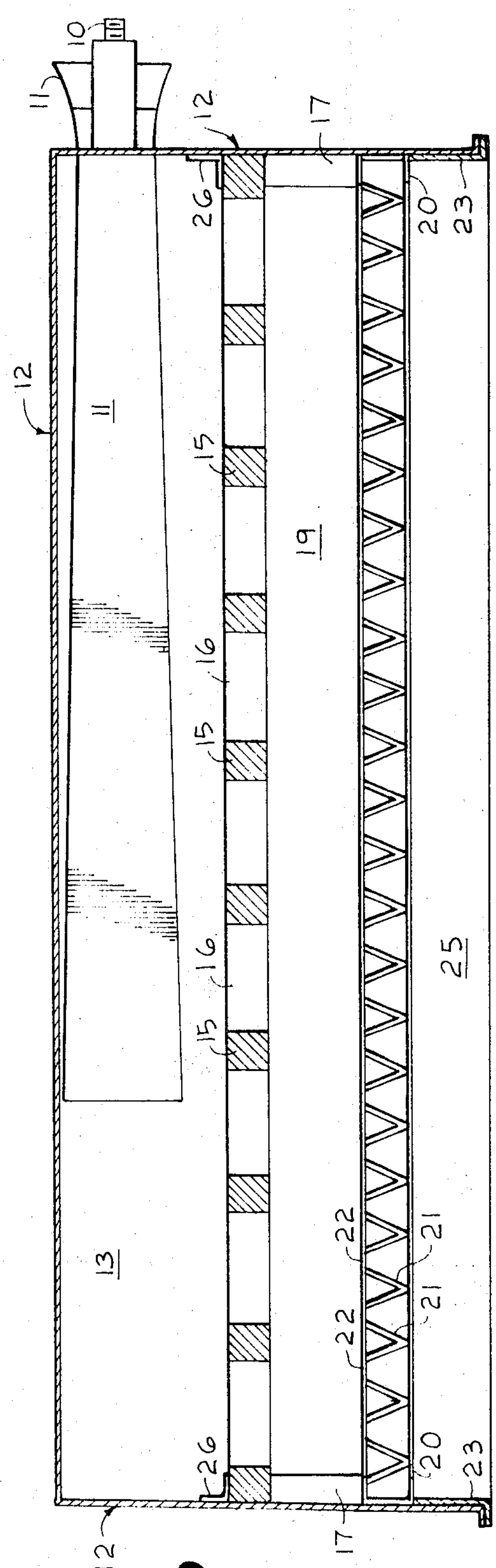

Fig. 2

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RADIANT BURNER

Filed Sept. 19, 1968 2 Sheets-Sheet 2

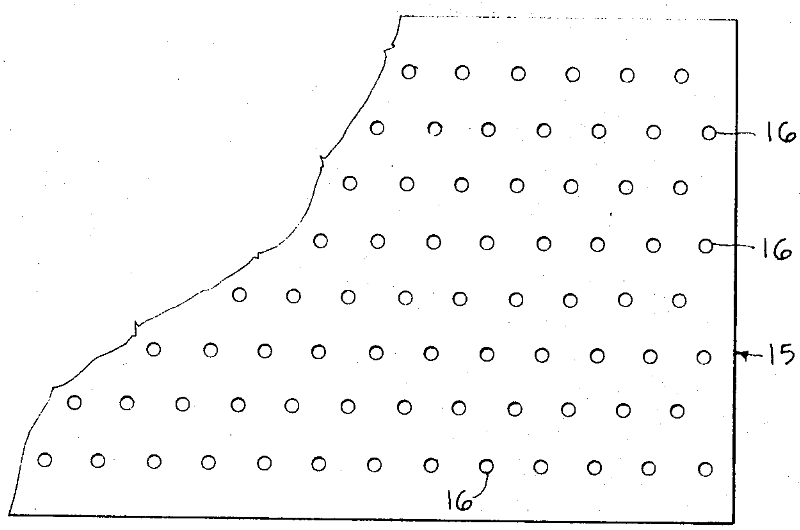

Fig. 6

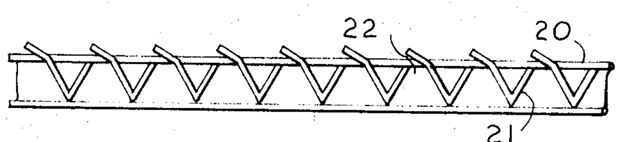

Fig. 5

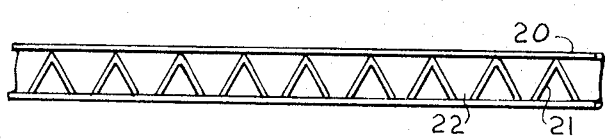

Fig. 4

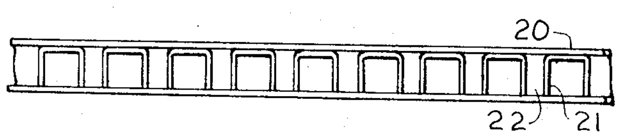

Fig. 3

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3,561,902
RADIANT BURNER

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Int. Cl. F23d *13/14*
U.S. Cl. 431—328 5 Claims

ABSTRACT OF THE DISCLOSURE

A radiant burner composed of a housing, a gas orifice, a venturi, a plenum, a separating plate with ports therein, a combustion chamber, radiant elements and exhaust openings.

This invention is concerned with improving the efficiency of radiant burners. More particularly, this invention is concerned with increasing the efficiency of radiant burners by utilizing the heat energy created by combustions away from the emitting surface of the burner.

In the prior art there are a number of gas fired, radiant type burners. Although their burners generally employ the same basic principles, their specific designs vary considerably. Generally, all the prior art radiant burners depend upon surface combustion on the area of the emitting surface. This surface when heated to a predetermined high temperature becomes incandescent and radiant heat rays are emitted. In order to prevent random convection air currents from cooling the radiating surface, generally in the prior art a nichrome wire screen is positioned in front of the emitting surface. It acts as a thermal barrier to these convection currents.

There are a number of disadvantages in these prior art burners. At it is necessary to have combustion of the gas air mixture occur uniformly over the entire surface area, it is necessary that a relatively high percentage, 29 percent to 65 percent of the total area be in open apertures. This high percentage of openings results in the velocity of the gas air mixture being substantially less than the rate of flame propagation. These apertures or openings are sufficiently small to prevent retrogression of the flame, oxidation of the gas air mixture, into the plenum even though the rate of flame propagation is considerably greater than the velocity of the gas air mixture through the apertures. This principle of flame quencing is fully disclosed in U.S. Pat. 3,277,948 to Best. As a result of the relatively low velocity of the gas air mixture and the high percentage of apertures, the radiant burners of this type are highly susceptible to clogging from airborne dust particles. These particles are brought into the plenum along with the entrained air, and the velocity of the gas air mixture through the apertures is not sufficient to force these particles through the apertures where they would be consumed on the surface during combustion.

Anoter disadvantage of these prior art radiant burners employing only surface combustion is the operation and efficiency of these burners are seriously affected by low velocity air movements. The nichrome wire used in these burners is effective as to random convection currents, but it is not effective as a shield for the surface against small air velocities.

A further disadvantage of these prior art radiant burners is their limited pressure operating range. They are highly susceptible to being overfired with an increase in gas pressure for a fixed orifice size. Even at increased operating pressures, the gas air mixture velocity is still substantially less than the rate of flame propagation; therefore, the flame remains in close contact with the emitting surface and the temperature of the emitting surface will continue to increase. Obviously, this is desirable on the present type of burners; otherwise, any burning that occurred away from the emitting surface would only generate convection heat which would not contribute to additional radiation from the heater. Since the present type radiant burners are dependent upon the radiation from the combustion surface, and there is no way to recover the energy of combustion which occurs away from the surface, these prior art burners are limited to a fairly narrow operating range. If a typical burner was orificed to operate at four inches water column, the burner would be overfired at ten or twelve inches water column and backfiring would occur in the plenum.

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It is therefore the primary object of this invention to provide a radiant burner which uses the energy of the exhaust gases for the purpose of generating radiation.

Another object of this invention is to provide a radiant burner with radiation enregy being emitted from two surfaces.

A further object of this invention is to provide a radiant burner which can accommodate high velocities of the gas air mixture.

Still another object of this invention is to provide a radiant burner which uses a small number of apertures which are of increased size.

Still a further object of this invention is to provide a radiant burner which is resistant to wind interference.

Another object of this invention is to provide a radiant burner which is not sensitive to overfiring at high pressures.

These and other objects, features and advantages of the present invention will be apparent from consideration of the following detailed specification taken in conjunction with the accompanying drawings.

FIG. 1 is a partial sectional bottom plan view of the radiant burner of this invention;

FIG. 2 is a cross-sectional elevational view of the radiant burner;

FIGS. 3, 4, and 5 are partial cross sections of heat emitting elements; and

FIG. 6 is a partial cross section of the separating member.

Generally, the objects of this invention are achieved by providing radiation emitting elements positioned below the aperture plate.

More specifically, referring to FIG. 2, a gas orifice **10** along with a conventional venturi **11** forms an assembly which is mounted into a metal plenum **12** which forms an open mouth chamber. Plate **15** is mounted into the plenum, supported therein by brackets **26** and insulation material **17**, and forms a volume **13** to receive the gas air mixture from venturi **11**. Plate **15** contains apertures or ports **16** to allow passage of the gas air mixture into the insulated combustion zone **19** which is formed below plate **15** and above radiating heat means **21**. The exact geometry of the apertures is not of importance as they may be around, square, oblong, etc. A conventional pilot light or electric ignitor, not shown, ignites this mixture in the combustion zone. Zone **19** is completely insulated on all of the sides at **17** and the top by plate **15**. The insulation material and plate **15** are composed of Fibrofax, manufactured by the Carborundum Company, which is ceramic fibers pressed into a flexible sheet composition. It has low thermal conductivity, excellent resistance to thermal shock and an extremely low coefficient of expansion. Due to these properties, the apertures can be placed in the sheet composition after it has been formed. This is an excellent advantage over the fragile ceramic material generally used in the radiant burners of the prior art as the apertures or ports must be formed in the fragile ceramic as it is manufactured. Thus, the energy created by the flame in the combustion zone is all concentrated against radiant elements **21** which are supported in the plenum by a frame **20** which is supported by brackets **23**.

Frame **20** is of conventional design for example two support surfaces, one on each side of said plenum, at the open end.

Radiant heat emitting elements **21** are fabricated out of various types of stainless steel, or a nickel chromium alloy, depending upon the desired temperature limits which may vary from as low as around 1,000° F. to as high as 2,100° F. and above, depending upon the desired use of the radiant burner. These elements are positioned below and as close to the plate **15** as around about one half inch to around about three inches. The elements may vary in height from around about one fourth of an inch to around about two inches. They can be of many shapes as shown, for example, in FIGS. 3, 4 and 5. The exact element geometry is not of importance. As shown in FIG. 2, these elements are positioned on clips or brackets which created a partially enclosed area **25** in the bottom of the plenum below the elements. There are openings **22** between and among the emitting elements so the products of combustion which occurs in zone **19** will exit the combustion zone; therefore, adding their heat energy to the radiating elements. Thus, with the burner of this invention, not only the heat energy from the combustion zone is given to the radiating elements, but the heat energy of the combustion products themselves are added to the radiating elements thereby greatly increasing the efficiency of this burner over the burners of the prior art.

Gas is discharged through orifice **10** and primary air for combustion is entrained at this point and the gas air mixture is discharged into volume **13**. This mixture of gas and air then passes through apertures **16** into combustion zone **19** where it is ignited by a conventional pilot light. The combustion or burning of this mixture is contained within the zone **19**. The total aperture area of plate **15**, somewhat less than 29 percent, is such that the velocity of the mixture passing through the apertures is greater than the rate of flame propagation, thus removing the problem of flame retrogressing into volume **13**. Plate **15** is present in the radiant burner to provide a base for the apertures as well as dividing the gas air mixture volume from the combustion chamber, and also insulation for the top of the combustion zone. As it is fabricated from a material of low thermal conductivity, it prevents the heat energy produced in the combustion zone from escaping into volume area **13** where it would be wasted. Thus, it is not of importance that the combustion of the gas air mixture does not occur on the surface of plate **15** as is necessary in the radiant burners of the prior art. The flow of hte heat energy of combustion zone **19** is restricted by the insulation properties of plate **15** and the side insulation **17** and channeled to flow only downwardly to radiation emitting elements **21**.

The radiant burner of this invention is so designed that one hundred percent of the air necessary for complete combustion is available in zone **19** without the requirement of secondary air. Combustion occurs in this zone or chamber and all of the internal surfaces are heated to a high temperature, from 1,000° F. to around 2,100° F., depending upon operating requirements. The radiating elements **21** are heated by their internal surfaces being directly exposed to the combustion zone and by absorption of radiation from this zone. The products of combustion passing through openings **22** also add heat to the radiating elements. As the combustion is confined in zone **19**, it is not necessary to have intimate flame contact with plate **15** in order for it to be heated as in conventional burners. Obviously, all of the internal surfaces of combustion zone **19** are exposed to the high temperatures of combustion and to the high temperatures from the combustion products. The entire zone or area is filled with products of combustion approaching the flame temperature as the products of combustion have not been diluted by excess air. Thus, all the internal surfaces of the combustion zone are heated to a high temperature; there-

fore, heat energy will be emitted from plate separator **15** as well as the heat emitting elements. This is advantageous as the burner of this invention will emit heat energy from two surfaces probably of different temperatures. This gives a wider range of heat.

The gas air mixtures velocity through the apertures **16** be much higher than in the conventional burners where surface combustion is essential. Due to this increased velocity, the size of the individual apertures can be much larger than where retrogression is prevented by the quenching phenomena. Thus, due to the combination of large apertures and high velocities, the radiant burner of this invention almost totally eliminates the problem of clogging due to dust particles entrained in the air. These particles pass through the large apertures and are consumed in the combustion zone. In addition, due to the design of the radiant burner of this invention, it may operate under pressure as low as 3 inches water column gas pressure and as high as 40 inches water column gas pressure and above. These pressures with the proper burner aperture area will cause a gas air mixture velocity to be greater than the rate of flame propagation thereby preventing retrogression of the flame into volume **13**.

The design of the radiant burner of this invention provides for considerable thermal inertia, retention of heat, in the radiating elements. This combined with the fact that the combustion zone is partially protected by the radiation elements results in the burner being resistant to wind disturbances than the conventional burners employing surface combustion. In addition, where wind is prevalent, there is a distinct advantage in having high thermal inertia in the radiating elements to prevent rapid cooling under gusty or momentarily high velocity wind conditions. Further, as the combustion is confined in zone **19**, considerable radiation can be emitted from both the flame and the products of combustion. The products of combustion are confined in a thick layer in the combustion zone by the geometry of the burner, whereas, in conventional burners, they are rapidly expelled from the surface in a very thin layer. After these products of combustion, exhaust gases, pass through openings **22** in the radiation element assembly, the elements then become protected against cooling from free convention by the hot layer of exhaust gases contained under them in zone **25**. If free convention currents cannot readily reach the radiating elements, the energy in these elements can then only escape by radiation. Consequently, high radiation efficiencies are achived in the radiant burner of this invention.

In FIG. 5, the radiation elements are so arranged that all radiation is omitted from these elements. There is only an indirect opening into the combustion zone and the burner is thus given additional protection against wind. The emitting elements may also be coated with various substances, for example a high temperature liquid ceramic that will effect the quality of radiation in special applications where this may be an advantage.

The operating versatility offers tremendous advantages in process application. This versatility allows the radiant burner of this invention to operate over a wide range of temperatures, for example from around 1,000° F. to around 2,100° F. The design of the radiant burner of this invention represents the first departure from surface combustion for this type of radiating device. It is believed that the high temperature achieved on the internal surfaces of combustion zone **19** is due to both the flame contact and the high temperature of the products of combustion. The pressure in combustion zone **19** can be controlled by varying the total area of openings **22**. Obviously, as the openings increase in size, the pressure in zone **19** will decrease. The gas air mixture velocity through apertures **16** is dependent on the difference in the pressure of zone **13** and **19**. Since the pressure of zone **19** can be controlled by the openings **22**, an excellent method is provided for balancing the pressures throughout the entire system. In addition, the heat radiating elements of this invention are so constructed and arranged as to emit a substantial portion of the total heat emitted from the burner, with the small balance coming from he separation member.

It will be obvious to those skilled in the art that many variations and modifications may be made in the above without departing from the true scope and spirit of the invention as defined in the appended claims.

I claim:

1. A radiant burner including an open faced housing defining a plenum, a perforated separating member in the form of a flat plate dividing the plenum into a fuel supply area and a combustion area, the area of the perforations in the said member forming less than twenty nine percent of the area of its perforated surface, a heat radiating means extending across the combustion area and spaced from the separating member by a distance substantially greater than the thickness of that member, the heat radiating means having a thickness at least as great as that of the separating member and comprising a pair of spaced support members and a series of equally spaced parallel heat emitting elements extending between said support members, and means to supply a combustible mixture of air and fluid fuel under pressure to the fuel supply area, the means for supplying air and fuel supplying them at such pressure that they will pass through the openings in the separating member at a velocity greater than the rate of flame propagation so that the flame will be spaced from the surface of said separating member; and the heat emitting elements being generally V-shaped but with one leg of the V extending higher than the other and bent outwardly at its upper portion, the elements being so arranged that the bent portion of each one extends over the shorter leg of the adjacent element to provide an outlet passage; thus providing a circuitous passage for protection against wind.

2. A radiant burner including an open faced housing defining a plenum, a perforated separating member in the form of a flat plate dividing the plenum into a fuel supply area and a combustion area, the area of the perforations in the said member forming less than twenty nine percent of the area of its perforated surface, a heat radiating means extending across the combustion area and spaced from the separating member by a distance substantially greater than the thickness of that member, the heat radiating means having a thickness at least as great as that of the separating member and comprising a pair of spaced support members and a series of equally spaced parallel heating emitting elements extending between said support members, and means to supply a combustible mixture of air and fluid fuel under pressure to the fuel supply area, the means for supplying air and fuel supplying them at such pressure that they will pass through the openings in the separating member at a velocity greater than the rate of flame propagation so that the flame will be spaced from the surface of said separating member; the perforations in the separating member being of uniform shape and area throughout their extent and being of sufficient size to prevent clogging by dust or other particles.

3. A radiant burner including an open faced housing defining a plenum, a perforated separating member in the form of a flat plate dividing the plenum into a fuel supply area and a combustion area, the area of the perforations in the said member forming less than twenty-nine percent of the area of its perforated surface, a heat radiating means extending across the combustion area and spaced from the separating member by a distance substantially greater than the thickness of that member, the heat radiating means having a thickness at least as great as that of the separating member and comprising a pair of spaced support members and a series of equally spaced parallel heat emitting elements extending between said support members, and means to supply a combustible mixture of air and fluid fuel under pressure to the fuel supply area, the means for supplying air and fuel supplying them at such pressure that they will pass through the openings in the separating member at a velocity greater than the rate of flame propagation so that the flame will be spaced from the surface of said separating member, the heat emitting elements being in the form of V-shaped bars of stainless steel coated with a high temperature liquid ceramic.

4. A radiant burner including an open faced housing defining a plenum, a perforated separating member in the form of a flat plate dividing the plenum into a fuel supply area and a combustion area, the area of the perforations in the said member forming less than twenty-nine percent of the area of its perforated surface, a heat radiating means extending across the combustion area and spaced from the separating member by a distance substantially greater than the thickness of that member, the heat radiating means having a thickness at least as great as that of the separating member and comprising a pair of spaced support members and a series of equally spaced parallel heat emitting elements extending between said support members, and means to supply a combustible mixture of air and fluid fuel under pressure to the fuel supply area, the means for supplying air and fuel supplying them at such pressure that they will pass through the openings in the separating member at a velocity greater than the rate of flame propagation so that the flame will be spaced from the surface of said separating member; the perforations in the separating member being in the form of slots extending parallel to each other, and the heat emitting elements of the heat radiating member being in the form of generally V-shaped bars extending in a direction at right angles to the longitudinal dimension of said slots.

5. A radiant burner including an open faced housing defining a plenum, a perforated flat separating member dividing the plenum into a fuel supply area and a combustion area, the perforations being in the form of parallel slots of uniform cross sectional area throughout and of sufficient area to prevent clogging by dust, the combined area of the perforations being less than twenty-nine percent of the area of the member, a heat radiating means of a thickness at least as great as that of the separating member and spaced from the member by a distance as great as the thickness of the member, to form the combustion area, a refractory lining for the walls of the housing between said separating member and heating element, the separating member being supported by such lining, the heat radiating means comprising a pair of spaced support members and a series of equally spaced elongated parallel heat emitting elements extending between said support members in a direction at right angles to the greater dimension of the slots in the separating members, said heat emitting elements being formed of metal coated with a high temperature liquid ceramic and being generally V-shaped in cross section but with one leg of the V extending higher than the other and bent outwardly at its upper portion, the elements being so arranged that the bent portion of each one extends over the shorter leg of the adjacent element to provide an outlet portion, thus forming a circuitous outlet passage for protection against wind, and means for supplying a combustible mixture of gas and air to the fuel supply area under such pressure that it will pass through the openings in the separating member at a velocity greater than that of flame propagation, thus causing the flame to be spaced from the said member and close to the heat radiating means.

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EDWARD G. FAVORS, Primary Examiner