United States Patent [19]

Guzdar et al.

[11] **3,763,847**

[45] **Oct. 9, 1973**

[54] **RADIANT HEATER**

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[73] Assignee: **Foster-Miller Associates,** Waltham, Mass.

[22] Filed: **Sept. 7, 1972**

[21] Appl. No.: **286,940**

[52] **U.S. Cl.** .... **126/92 B,** 126/91
[51] **Int. Cl.** **F23c 3/04**
[58] **Field of Search** .... 126/91, 92, 92 B

[56] **References Cited**

UNITED STATES PATENTS

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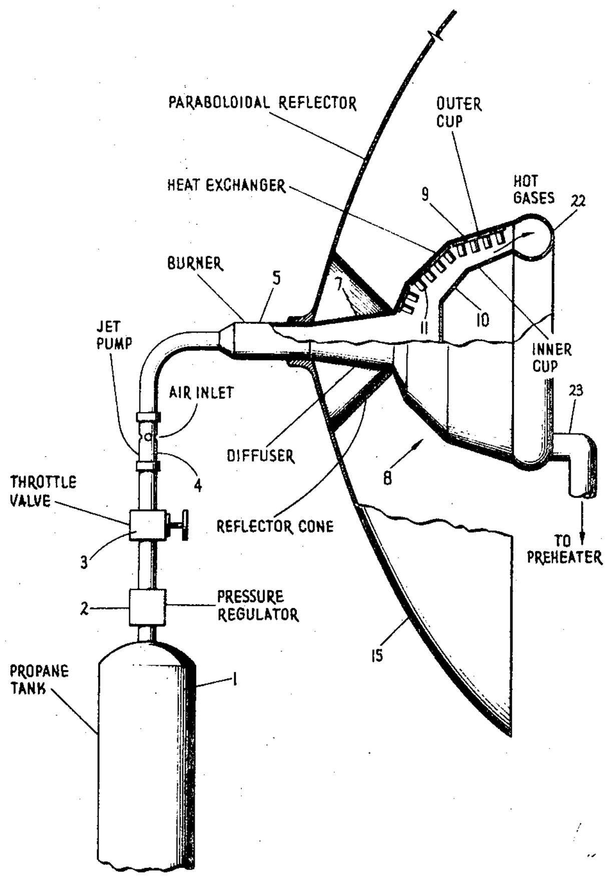
Primary Examiner—Carroll B. Dority, Jr.
Attorney—Louis Orenbuch

[57] **ABSTRACT**

A radiant heater employs a jet pump to force a fuel-air mixture into a burner at high velocity. The hot gases generated in the burner are passed at high velocity into a heat exchanger having an elongate passage where heat is convectively extracted from the gases by fins disposed in the path of the gas flow. The extracted heat is transferred by conduction through the fins to a radiant energy emitter surface. The infrared radiation emanating from the emitter surface is directed by a parabolic reflector upon the area to be heated.

4 Claims, 8 Drawing Figures



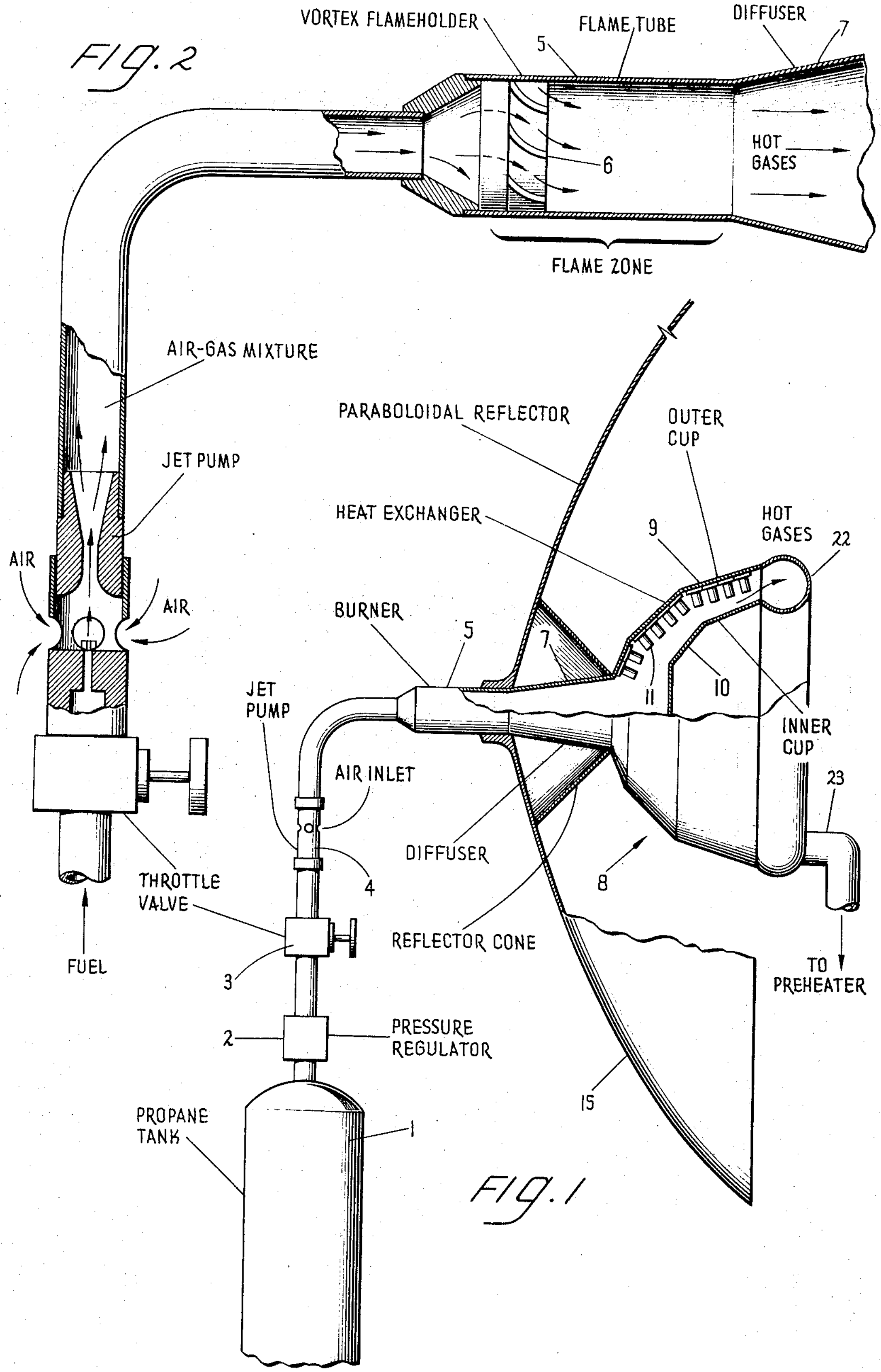
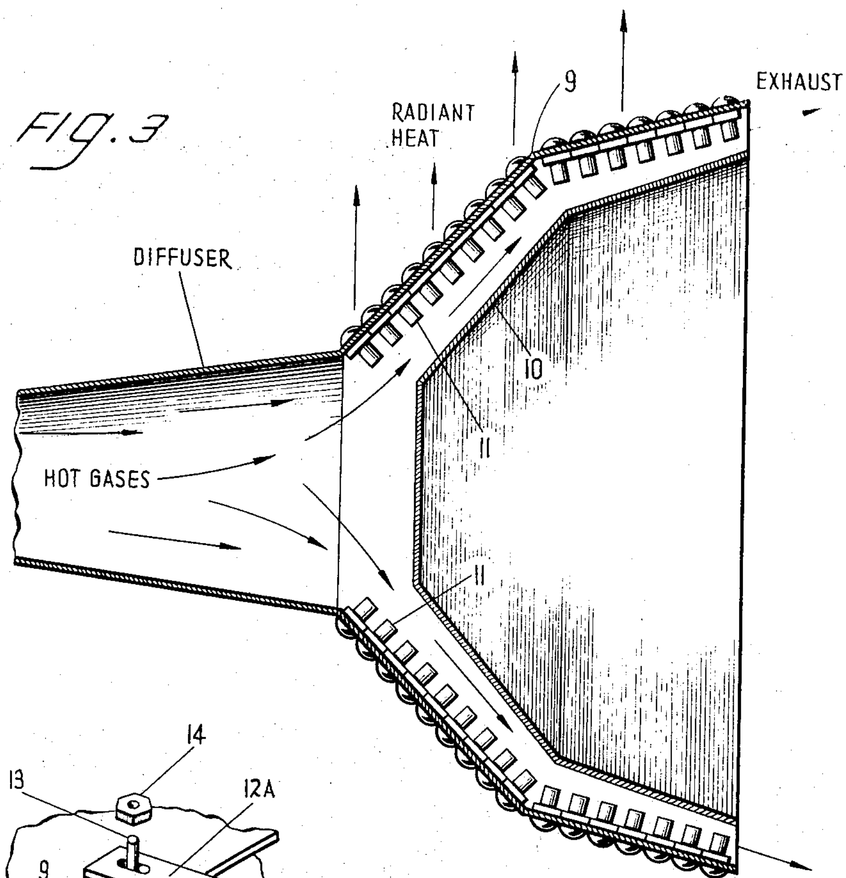

VORTEX FLAMEHOLDER
FLAME TUBE
DIFFUSER
5
7
6
HOT GASES
FLAME ZONE
AIR-GAS MIXTURE
JET PUMP
AIR
AIR
THROTTLE VALVE
FUEL
PARABOLOIDAL REFLECTOR
OUTER CUP
HEAT EXCHANGER
9
HOT GASES
22
BURNER
5
7
11
10
JET PUMP
INNER CUP
AIR INLET
23
DIFFUSER
4
8
REFLECTOR CONE
3
TO PREHEATER
2
PRESSURE REGULATOR
15
PROPANE TANK
1

FIG. 2

FIG. 1

FIG. 3



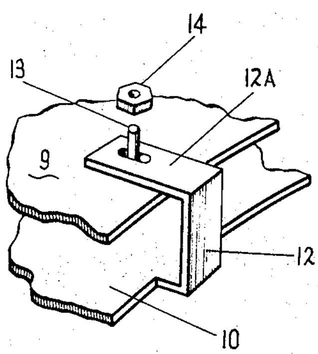


FIG. 5

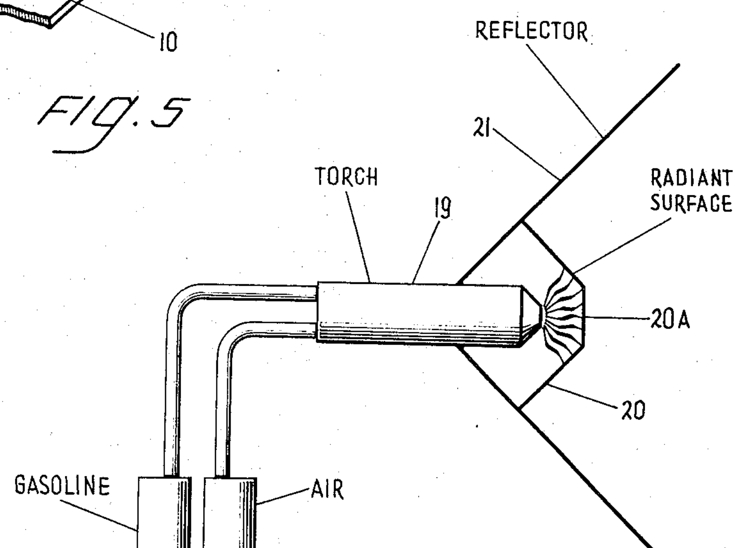


FIG. 4 (PRIOR ART)

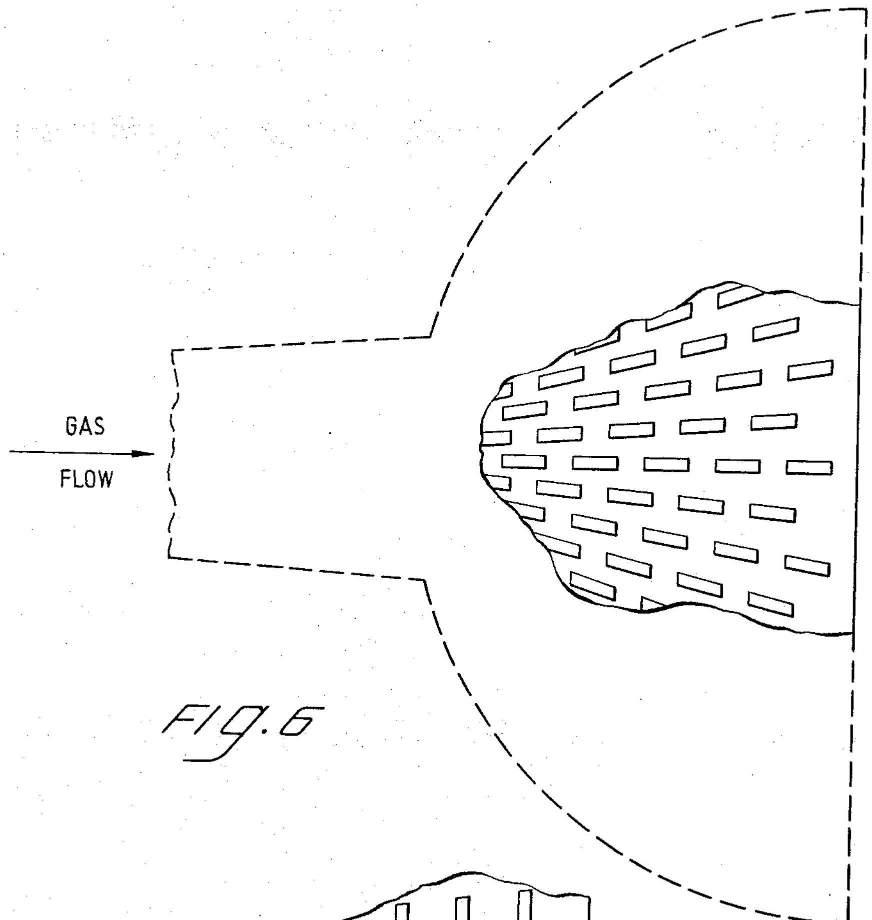


FIG. 6

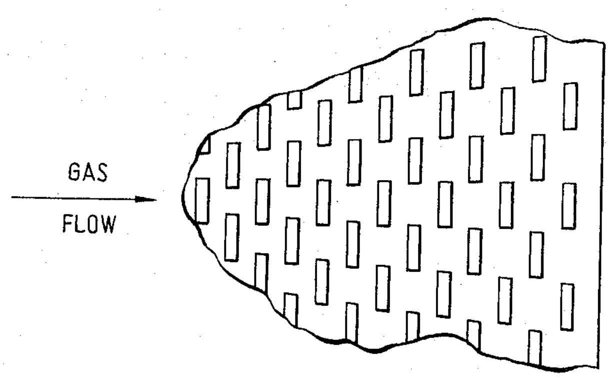


FIG. 7

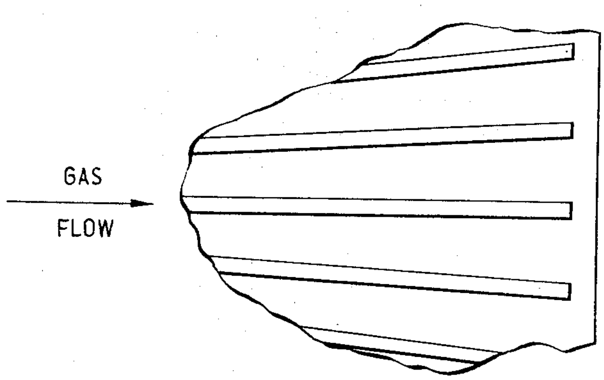


FIG. 8

RADIANT HEATER

FIELD OF THE INVENTION

This invention relates in general to heating apparatus for generating radiant heat energy. More particularly, the invention pertains to a light and rugged portable radiant heater which is capable of operating in drafty environments or outdoors where the heater is exposed to the wind. The invention is particularly applicable to use outdoors where it is desired to heat objects or persons without heating the intervening space. For this purpose, an infrared heater is especially suitable because the infrared radiation heats only opaque objects in its path and the infrared radiation can be directed or concentrated upon a small area focussing means such as a suitably shaped reflector.

BACKGROUND OF THE INVENTION

In general, a heating system that generates infrared radiation by the combustion of a fuel employs (1) a mechanical energy source which mixes the fuel with air and forces the mixed gases through the system; (2) a burner in which the fuel is burned and in which the position of the flame is stabilized; (3) a heat exchanger which extracts the heat from the combustion products and transfers the heat to an emitter surface and (4) an emitter which radiates the heat to the receiver. At present, most commercially available gas-fired radiant heaters combine the burner, heat exchanger and emitter functions in a single unit. In such heaters, the fuel-air mixture is usually premixed in a manifold and the mixture is distributed through a flameholder or burner which is made of either a porous ceramic or an inconel wire mesh. Combustion usually occurs at the front face of the burner and the hot gases transfer heat by convection to the burner. The burner surface is thereby heated and emits infrared radiations. This type of radiant heater is subject to a number of undesirable limitations among which are the following:

A. The gas velocity through the flameholder must be kept low enough to maintain stable combustion at the burner surface and consequently wind effects can cause a severe degradation of performance and because of the low velocity burning the flame at the face of the burner may even be extinguished (viz. flame-out) where it is not shielded from the wind.

B. The need for the burner surface to perform the dual functions of extracting heat from the hot gases (i.e., acting as the heat exchanger) and emitting infrared radiation (i.e., acting as the emitter) imposes conflicting requirements which make optimization of either function difficult. For example, with an inconel wire mesh design high rates of convective heat transfer are attained with wire of small diameter. However, such a wire mesh is a poor emitter due to its low solidity and poor aspect as seen from the direction in which it is desired to have the radiation directed. A solid emitter surface is preferred but cannot be achieved since the mesh must be porous or perforate to enable the fuel to penetrate to the front face.

C. The temperature of the hot gases leaving the burner is necessarily higher than the emitter temperature. Consequently, the higher the emitter temperature, the greater is the loss of heat in the exhaust gases and the lower is the burner efficiency.

D. Poor convective heat transfer because the hot gases are but momentarily in contact with the burner surface before the gases are exhausted.

SUMMARY OF THE INVENTION

In the invention the hitherto combined functions of extraction of heat from the hot gases and radiant heat emission are separated. The separated functions are performed in the invention by (1) a convective heat exchanger which extracts heat from the hot gases and (2) an emitter which receives heat by conduction from the energy extractor and radiates the heat from an emitter surface. The hot gases are generated in a burner and flow through the heat exchanger where the heat is extracted by a multitude of fins disposed in the gas flow path. The heat transferred by convection to the fins are conducted through the fins to a radiant energy emitter surface. The invention conduces to a very high efficiency heater because almost separate optimization of the energy extractor and the emitter is permitted. The emitter can be designed to have a varying temperature profile which permits the energy exchanger to extract the maximum energy from the hot gases. The mean temperature of the emitter can thus be higher than the exhaust temperature of the exiting gases. Unlike conventional radiant heaters, the invention permits the construction of a compact and efficient heater which provides a high temperature source of radiant energy. The heater is capable of operation in drafty or windy environments because (1) combustion is essentially complete before the hot gases enter the heat exchanger and (2) the velocity of the gases emerging from the heat exchanger is high. For example, where the velocity of the emerging gases is approximately 100 ft./sec., even a 20 mph head-on wind has little effect on the flow of the hot gases through the heat exchanger or combustion in the burner.

THE DRAWINGS

The invention, both as to its construction and mode of operation, can be better understood from the detailed exposition which follows when it is considered together with the accompanying drawings in which:

FIG. 1 diagrammatically depicts the scheme of invention;

FIG. 2 shows the jet pump and burner with portions broken away to reveal the internal construction;

FIG. 3 is a cross-sectional view showing an embodiment of the heat exchanger and radiation emitter;

FIG. 4 is a schematic depiction of a prior art radiant heater;

FIG. 5 shows a detail of the arrangement permitting the inner cup to be adjusted relative to the outer cup;

FIGS. 6, 7, and 8 show alternative fine arrangements.

DETAILED DESCRIPTION

The scheme of the invention is diagrammatically depicted in FIG. 1 where a conventional tank 1 of fuel is shown having a pressure regulator 2 which controls the pressure of the gas supplied from the tank. Propane is the preferred fuel because it is completely stable and, when stored in aluminum tanks, is one of the lightest weight portable torch fuels available. Further propane is widely available and is economical relative to other fuels such as acetylene. Other fuels can be used with the invention, if desired. Where propane is employed as the fuel, the pressure regulator is preferably set to about 20 p.s.i.

The fuel is admitted through a throttle valve **3** to the inlet of a jet pump **4.** The jet pump **4,** as shown in FIG. **2,** has apertures through which air is drawn into the pump and is mixed with the fuel. In the jet pump advantage is taken of the Bernoulli effect to reduce pressure by causing a high velocity jet of fuel to flow through a venturi tube. Consequently, air is drawn into the pump and is entrained in the high velocity fuel jet. The proportion of entrained air to fuel is such that complete combustion can occur without requiring additional air. Combustion of the air-fuel mixture takes place entirely within a burner tube **5.** At the entrance to the burner is a vortex member **6** having pitched vanes which swirl the gas-air mixture as it ignites. Complete combustion occurs in the burner tube where the ignited gases attain velocities of over 100 m.p.h. The hot gases emerge at high velocity from the burner into a flaring diffuser tube **7** which gradually decelerates the flow to raise the static pressure at the diffuser's outlet to the level required to force the gases through the heat exchanger at the desired rate. The diffuser tube **7** is not an essential component of the invention and is not needed where the pump is of sufficient power to raise the static pressure at the inlet to the heat exchanger to the level required to force the gases through the heat exchanger at the desired rate.

The structure **8** depicted in FIG. **1** is an embodiment of the heat exchanger and radiation emitter constructed in accordance with the principles of the invention. An enlarged view of a slightly modified form of the heat exchanger and radiation emitter is depicted in FIG. **3.** The heat exchanger has an annular passage formed between an outer cup **9** attached to the wide end of diffuser tube **7** and an inner cup **10** spaced from the outer cup. In the annular passage are a plurality of fins which are convectively heated by the hot gases flowing from the inlet of the passage to the exhaust port. In the illustrated embodiment, the fins are a multitude of small cylindrical pins **11** which are attached to the outer cup **9** and protrude inwardly normal to the gas flow. The pins are spaced apart and are staggered to present the maximum area to the hot gases flowing in the passage. Heat is transferred to the fins by convection as the gases flow past toward the exhaust port. The annular passage is of a flaring shape such as hemispherical or conical so that the passage progressively increases in diameter as the gases flow from the inlet toward the exhaust port. Where the pins are uniformly spaced there are many more fins at the exit end of the passage than at the inlet to the passage. In the embodiment depicted in FIG. **3** the pasaage is of generally hemispherical shape. The cross-sectional flow area of the passage is designed to maximize the exit velocity with minimum pressure drop. To compensate for the decreasing gas temperature along the flow path, the flow velocity is higher at the outlet than at the inlet. This is accomplished by suitably shaping the cross sectional flow area along the passage. From FIG. **3** it can be seen that the walls of the cups become closer together to narrow the passage and thus reduce the cross-sectional flow area as the gases flow toward the exhaust port.

The hot gases pass through the heat exchanger at high velocity and in doing so heat the fins by convection. The fins conduct the heat to the outer surface of cup **9** for emission by radiation. For efficient conduction of heat, the fins must have an adequate cross-sectional area. Cylindrical pins are preferred for the fins because they provide a large exposed area for convective transfer of heat from the hot gases and provide an adequate cross-sectional area for transfer of the heat by conduction along the pin to the radiation emitter. The fins, however, can be of varied shapes and can be spaced in various arrangements along the flow path. For example, the fins can be rectangular posts arranged in the staggered patterns depicted in FIGS. **6** and **7.** As yet another example, the fins can be splines extending along the interior of the passage in the direction of the flow path as indicated in FIG. **8.**

The fins near the inlet of the heat exchanger are heated to a higher temperature than the fins nearer to the exit of the heat exchanger due to the progressive convective transfer of heat which occurs as the gases flow from the inlet along the path toward the exhaust port. By adjusting the flow velocity, the length of penetration into the passage of the fins and the spacing of the fins, the convective heat transfer rate can be altered to vary the spacial temperature distribution along the emitter surface of outer cup **9.** The heat exchanger, by extracting energy from the hot gases as they flow along the passage, causes the average emitter temperature to be higher than the exhaust gas temperature so that increased fuel efficiency is achieved. The emitter surface of the outer cup is, in the preferred embodiment of hemispherical form to provide a larger emitter surface area. The heat exchanger passage, in the preferred embodiment, is of a conforming shape because it is desired to keep the conductive transfer path along the fins to the emitter surface as short as possible consistent with adequate extraction of heat from the hot gases by convection.

The inner cup **10** serves principally to confine the hot gases within the heat exchange passage and therefore that cup provides one wall of the passage. In contrast to the infrared energy from the emitter surface of outer cup **9** which is directed by reflector **15** upon the area to be heated, infrared energy emitted from the surface of the inner cup radiates directly into space and hence may be largely wasted. Inasmuch as the radiant energy emissions of the inner cup may not be effectively utilized, it is preferable to have as little heat as possible transferred to the inner cup. Thus, the inner cup is preferably a heat barrier rather than a heat conductor. To insure that as little heat as possible is transferred to the outer cup, the fins in the passage do not extend completely across the passage so that heat transmitted along the fins does not cross the gap between the ends of the fins and the inner cup but rather flows along the fins to the emitter surface of the outer cup. The inner cup **10** may be fixed in relation to the outer cup where the heater unit is designed for a specific fuel. However, where it is desired to provide an adjustment of the cross-sectional flow area in the passage, the inner cup **10** is mounted so that it can be moved in or out relative to the outer cup. For this purpose, the inner cup has tabs, such as the tab **12** shown in FIG. **5,** bent to extend over the outer cup. The upper arm **12A** of each tab has a slot **12B** through which a threaded stud **13** protrudes to accommodate a nut **14.** By tightening the nut, the upper arm **12A** is clamped against the outer cup **9** and holds the inner cup in place relative to the outer cup. Loosening the nuts **14** permits the inner cup to be moved to change the cross-sectional flow area between the cups and thus provides a means for adjusting the gas velocity. By adjusting the gas velocity, the temperature distribution of the emitter surface of the outer cup can be altered to obtain an optimum match with the reflector 15.

The reflector 15 is of a suitable shape, such as a paraboloid. For a parabolic reflector the ideal source of radiation is a point source. However, as it is not feasible to obtain the intensity of radiation desired from a point source, the source of radiation employed in the invention is the hemispherical outer cup because it provides the maximum usable emitter surface area for the most compact size. The effectiveness of reflector 15 is increased by the employment of a reflective inner cone 16 to direct radiations emitted from those areas nearest the axis CL onto the paraboloidal reflector 15 and thence outwardly.

In contrast to the invention which permits the mean emitter temperature to be higher than the exhaust gas temperature, the mean temperature of the radiant surface of "prior art" heaters, such as the radiant heater schematically depicted in FIG. 4, must be lower than the temperature of the exhaust gases. In the radiant heater shown in FIG. 4, gasoline from a tank 17 is mixed with air from a tank 18 and the mixture is burned in a torch 19 which plays its flame upon a perforated nickel steel sheet 20 having a conical emitting surface which radiates heat to a reflector 21. Sheet 20 is, essentially, a truncated cone of which only the conical surface is effective as a source of radiation for the reflector. The flat lid 20A closing the apex of the truncated cone principally radiates directly into space and hence little of its radiation impinges on the reflector. The hot gases in the interior of the cone are exhausted through the perforations in the sheet 20. Perforations in the conical surface reduce the area of the emitter surface and detract from its effectiveness as the radiant source for the reflector. Further the dispersion of the exhaust gases issuing through the perforations makes it difficult to collect the gases where it is desired to recover their heat.

Reverting now to the embodiment of the invention disclosed in FIGS. 1 to 3, assuming propane is the fuel and complete combustion occurs in the burner, the temperature of the hot gases entering the heat exchanger is about 3,450°F. The temperature of the gases exhausted from the heat exchanger is, of course, greatly reduced by the heat transferred to the protruding pins. Inasmuch as there is a large temperature difference between the entering gases and the exhaust gases, the radiation emitter has a mean radiant temperature that is higher than the temperature of the exhaust gases. An embodiment of the invention was constructed employing propane as the fuel, in which the mmitter was designed to have a mean radiant temperature of 1,540°F. Using a hemispherical outer cup about 6½ inches in diameter and a maximum outlet gas velocity of 100 ft./sec., a convective surface area equal to 1.5 times the radiant surface area was obtained by employing cylindrical pins of 1/16 inch diameter which protruded five thirty-seconds inch into the gas stream and were spaced 45 pins per square inch. The pins and the outer cup were of mild steel.

To increase the surface area of the emitter, that surface can, as shown in FIG. 3, be provided with a multiitude of rounded protrusions. In the usual case, a smooth hemispherical or conical emitter surface is adquate. The fins are preferably integral extensions of the outer cup 9. However, it is obvious that the emitter surface can be made of a material different from the material of the fins or the underlying material of cup 9.

The exit of the gas flow passage in the heat exchanger may be left open, as in FIG. 3, to permit the exhaust gases to escape directly to the atmosphere. Alternatively, the exhaust gases may be collected, as illustrated in FIG. 1, by a header 22 secured to the inner and outer cups. The header provides an annular chamber around the entire exit from the heat exchanger into which the exhaust gases flow. The collected gases are drawn off by a duct 23. Preferably, the gases are conveyed through the duct to a preheater where the gases are utilized to preheat the air and the fuel used in the combustion process. It is, of course, obvious that the collected exhaust gases may be used for other heating purposes. In the event the heater is used in a confined environment where the exhaust gases would be detrimental, the collected exhaust gases may be vented by connecting duct 23 to a flue.

Because the invention may be embodied in varied structures, it is not intended that the patent be limited to the forms here illustrated or described. Rather, it is intended that the patent be construed to embrace those structures which, in essence, utilize the invention defined in the appended claims.

We claim

1. Heating apparatus comprising;
a source of fuel,
pump means for mixing fuel from the source with air and accelerating the mixture to high velocity,
a burner having its inlet connected to receive the air-fuel mixture emitted from the pump means whereby combustion of the fuel-air mixture occurs in the burner and hot gases are emitted at high velocity from the burner's outlet,
a heat exchanger into which the high velocity hot gases are admitted, the heater exchanger having an outer cup and an inner cup spaced therefrom whereby an annular passage is provided between the cups for the flow of the hot gases therethrough, the annular passage progressively increasing in diameter from the inlet of the passage toward its outlet, the outer cup having an emitter surface and having a plurality of fins protruding from its opposite surface into said passage whereby said fins are heated by convection by the hot gases and conduct the heat to the emitter surface for radiation therefrom, and
focussing means arranged to direct the radiation from the emitter surface of the outer cup upon a target area.

2. Heating apparatus according to claim 1, wherein the cross-sectional area of the passage progressively decreases from the inlet end toward the outlet end whereby the exit velocity of the hot gases is higher than the entering velocity.

3. Heating apparatus according to claim 1 wherein the emitter surface is of hemispherical shape,
and the focussing means is a reflector arranged to receive the radiation from the emitter surface.

4. Heating apparatus according to claim 1, further comprising,
a header for collecting the exhaust gases exiting from the heat exchanger, and
duct means connected to the header for drawing off the exhaust gases.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,763,847 Dated October 9, 1973

Inventor(s) Adi R. Guzdar and Andrew C. Harvey

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 15 after "area" insert -- by --.
Column 4, line 50, change "outer" to -- inner --.
Claim 1, line 39 (column 6) change "heater" to -- heat --.

Signed and sealed this 23rd day of April 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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