United States Patent

Hapgood

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[54] COMPACT HEAT EXCHANGER WITH HIGH INTENSITY BURNER

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[73] Assignee: **Raytheon Company,** Lexington, Mass.

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[52] **U.S. Cl.** .....**126/116 R,** 126/92 R, 126/109, 122/356, 431/329

[51] **Int. Cl.** **F24c 3/04**

[58] **Field of Search**...126/116, 110, 110 B, 92, 92 B, 126/91, 109; 122/356, 367; 431/10, 328, 329

[56] **References Cited**

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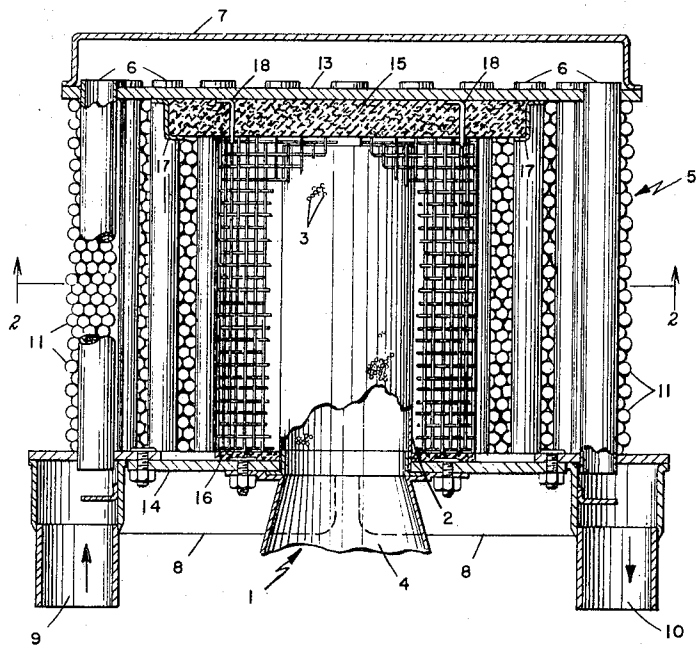
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Attorney—Milton D. Bartlett, Joseph D. Pannone and Elmer J. Gorn

[57] **ABSTRACT**

A high intensity burner for burning a carbonaceous fuel in an oxygen containing atmosphere has one or more ports through which the fuel emerges and adjacent which complete combustion of the fuel occurs within a limited combustion region at a temperature above the dissociation temperature of CO_2. A heat exchanger, which is maintained at a temperature below the recombination temperature of CO and O_2, is located outside the limits of said combustion region but sufficiently close to the burner ports so that, at the normal operating velocity of the burned gases these gases would reach the heat exchanger before the temperature of the gases had dropped below the dissociation temperature and into the recombination temperature range, except for the fact that a screen is located between the limits of the combustion region and the heat exchanger, and is heated by the gases, thereby extracting heat from the gases, to a temperature at which it radiates energy, thus reducing the temperature of such gases into the recombination temperature range before they reach the heat exchanger.

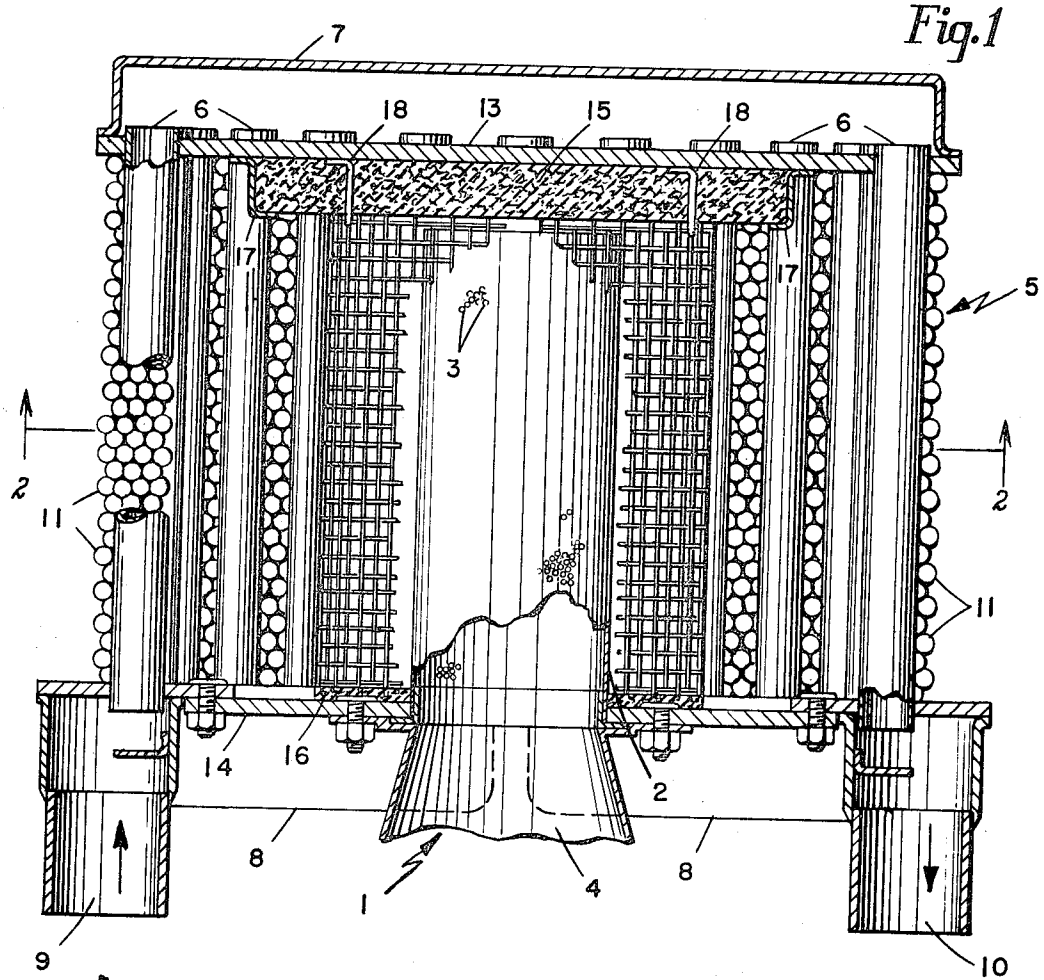
6 Claims, 2 Drawing Figures



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Fig.1



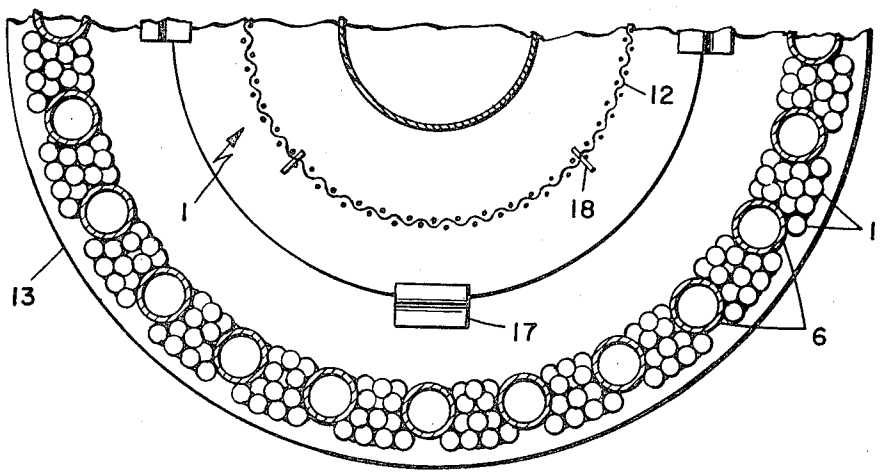


Fig. 2

By M. D. Bartlett

COMPACT HEAT EXCHANGER WITH HIGH INTENSITY BURNER

BACKGROUND OF THE INVENTION

1. Field of the Invention

Compact heat exchangers with high intensity burners and with low CO output.

2. Description of the Prior Art

A demand has arisen for very compact heat exchanger devices which operate in conjunction with high intensity burners so as to provide the capability of handling large amounts of heat energy within limited spaces. While such high intensity burners can be made to be very efficient, whereby all of the carbon content of the fuel normally supplied to such burners is converted into CO_2, nevertheless, it has been found that if a relatively low temperature heat exchanger is placed too close to the burner the combustion products of the device will contain an undesirably high CO content. If it were attempted to avoid this adverse result by removing the heat exchanger to a greater distance from the burner, compactness of the device would be sacrificed.

SUMMARY OF THE INVENTION

In the present invention the defects of the prior art have been eliminated, without sacrificing the compactness of the structure, by interposing at a critical location between the burner and the heat exchanger, a screen made of a refractory material, such as a refractory metal. The location is selected beyond the point at which complete combustion of the fuel first occurs and sufficiently ahead of the surface of the heat exchanger to permit complete recombination of any dissociated CO_2 to occur before the hot gases reach such surface. The burner is operated at such high intensity that at the point at which complete combustion is first achieved, the temperature of the burned gases exceeds the dissociation temperature of CO_2. As the hot gases proceed beyond that point they contact the screen which is heated by a combination of conduction from the impacting gases and by radiation from the hot gases in the combustion zone. The temperature of the screen is such that it radiates substantial quantities of energy which is absorbed by surrounding structures, thus dropping the temperature of the screen to below such dissociation but still well within the temperature range in which recombination of CO and O_2 occurs. The burned gases are reduced in temperature by the screen so that they likewise drop into the recombination temperature range and do not rise above the CO_2 dissociation temperature during the passage of such gases to the heat exchanger. Once the gases drop into the recombination temperature range, recombination of CO and O_2 occurs with extreme rapidity so that the screen may be placed quite close to the heat exchanger without sacrificing the complete recombination of these elements. The heat exchanger itself is maintained at a temperature below said recombination temperature range. Therefore, if the hot gases were permitted to reach the heat exchanger while still containing a substantial amount of CO, the gases would be quenched and the desired recombination would not occur.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIG. 1 is a vertical sectional view of a heat exchanger structure incorporating this invention; and

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

The burner 1 as shown in the drawings is a highly efficient, high power burner which may be of the type as described and claimed in the copending application of William H. Hapgood and Donald G. Protopapas, Ser. No. 2,584 filed Jan. 13, 1970, now abandoned. Such burner consists of a cylindrical shell 2, provided with a large number of perforations 3 which serve as ports through which gas to be burned issues. That gas, which may be a mixture of air and any carbonaceous combustible material such as natural gas, gasoline, methane, propane or the like, is supplied to the burner through an inlet conduit 4. By any suitable system, such as that described in said copending Hapgood-Protopapas application, the air-gas mixture, preferably with up to 30 percent excess of air over the stociometric level, is pumped into the conduit 4. Burners of this type are capable of delivering large amounts of heat energy, for example, at a rate in excess of 20,000 BTU per hour for each square inch of burner surface. At upper levels of operation, the velocity of the gas-air mixture as it emerges from the parts 3 may be in excess of 1600 cm. per sec. Throughout the range of operation of a burner of this type the outer limit of the flame structure of the burner 1 will typically be one quarter inch to about one half inch away from the surface of the burner. Whatever type of burner is used, the outer limit of the flame structure is that at which combustion of the fuel is first completed. What that distance is, will depend upon the design of the burner and will be a definite characteristic of the burner. The volume between the burner and such characteristic distance will be designated as the "characteristic combustion region" of the burner in the present specifications and claims.

The heat generated by the burning of the fuel supplied to burner 1 is transferred to any convenient type of heat exchange structure such as that designated generally at 5. This consists of a plurality of tubes 6 arranged in a concentric cylindrical array around the burner 1. These tubes 6 connect at their upper ends with a header structure 7 and at their lower end with a header structure 8 provided with inlet and outlet pipes 9 and 10, whereby water to be heated may be passed up and down in serial fashion through the tubes 6. In order to increase the effectiveness and efficiency of the transfer of heat from the hot gases into the water in the tubes 6, the tubes are embedded in a matrix 11 consisting of small pellets of steel soldered to each other and to the tubes 6 and filling the space between the tubes. The particular details of the matrix 11 and of the header structures 7 and 8 form no part of this invention and will not be described in greater detail herein. A heat exchange structure of this kind is described in detail and is claimed in my copending application Ser. No. 10,334, filed Feb. 11, 1970. The rate at which water is supplied through the heat exchange structure is such that the maximum temperature reached by any part of the structure will be well below the temperature range within which CO will spontaneously combine

with O_2 to form CO_2. Such a temperature may be, for example, of the order of several hundred degrees Farenheit and below about 1000°F. While a particular type of heat exchanger has been described, it will be understood that any of the well-known types of heat exchangers whose normal temperature of operation is below the recombination temperature range of CO and O_2 may be used.

With a high intensity burner, such as that described above, the temperature of the gas within the characteristic combustion region of the burner will reach a value of about 2800°F or greater which is above the temperature at which CO_2 dissociates into CO and O_2. Therefore, as the hot gases pass out of the characteristic combustion region, they will include a substantial quantity of CO even though during the combustion process all of the carbon in the gas will have been converted into CO_2 which is what occurs in a high efficiency, high intensity burner of the type described above. Heretofore, the only way in which the hot gases could lose energy before coming into contact with the heat exchanger, was by radiation. However, the rate at which loss occured was so slow that, at the normal velocities of the gas in passing from the characteristic combustion region to the heat exchanger, the temperature of the hot gas remained above the recombination temperature of CO and O_2 which is about 2500°F. At that point, the heat exchanger extracted energy from the hot gases so rapidly that the temperature of these gases dropped through the recombination range so rapidly that there was insufficient time for any substantial recombination to occur. This could be considered a quenching action in which any recombination tendency was quenched by the comparatively low temperature heat exchanger.

In accordance with this invention the foregoing quenching action is eliminated by mounting a perforated or grid-like screen **12** in the space between the burner and the heat exchanger **5**. The screen **12** is made of coarse mesh of a refracting metal alloy such as that know as "Kanthal" which is chrome-iron-aluminum-molybdnum alloy containing about 65 percent iron, 30 percent chromium, 5 percent aluminum and a trace of molybdenum. Of course, any refractory material formed into a perforate screen around the burner **1** might be used. For example, ceramic rods could be used as the material of the screen **12**.

The screen **12** is located just beyond the characteristic combustion region of the burner **2**. Where the depth of that region is about one half inch, as in the example given above, the screen **12** may be located about seven eighths inch from the surface of the member **2**, while the inner surface of the heat exchanger **5** might be about another seven eighths inch beyond the screen. Thus, a convenient location for the screen **12** is about half way between the outer surface of the shell **2** and the inner surface of the heat exchanger **5**, provided such location is outside of the characteristic combustion region of the burner.

The combustion products of the burner **1** are forced to pass through the heat exchanger by having the space between the burner **1** and the heat exchanger **5** closed off by an upper plate **13** and a lower plate **14**. The screen **12** is supported between these plates by means of a refractory low heat conductivity block **15** secured to the plate **13** and another block **16** of similar material supported on the lower plate **14**. A convenient material for the blocks **15** and **16** is asbestos, which also functions as a sound absorbing material to absorb any undesired noises generated by the passage and burning of the gases through the structure. The block **15** may be supported in place by a plurality of clips **17** welded to the plate **15**. The screen **12** is hung from the block **15** by means of a plurality of hooks **18** extending through the block **15**. In this way very little, if any, heat is conducted from the screen **12** by the supporting structure, since it is desirable for the screen **12** to be maintained at a substantially uniform temperature throughout. The lower end of the screen **12** is stabilized by wires **19** projecting from the bottom of screen **12** and lightly piercing the upper surface of the block **16**. It may not be necessary to secure the block **16** to the plate **14** but, if desired, it can be secured in a manner similar to that used for block **15**.

The screen **12** receives some heat by radiation from the hot gases in the characteristic combustion region, but it is heated principally by the hot gases which emerge from that region and pass through the perforations in the screen. As already indicated substantially no heat is lost from the screen **12** by conduction to any adjacent members and so it must lose heat by radiation. Therefore, the temperature of screen **12** rises to a temperature of about 2500°F which is substantially uniform throughout the screen. This is the temperature at which the amount of heat supplied by hot gases equals the heat lost from screen **12** by radiation. Thus, it will be seen that the screen **12** uniformly cools the hot gases by about 300°F as they pass through the screen. This is sufficient to drop the temperature of these gases to about 2500°F which is within the recombination temperature range for CO and O_2. As a result, any CO in the hot gases rapidly recombines with the O_2 which was released by the previous dissociation of CO_2 and within a very short distance beyond the screen **12** all the CO is thus been recombined, so that the hot gases which reach the heat exchanger **5** are virtually free of CO.

By virtue of the present invention, very compact, high power density, highly efficient heat exchanger systems have been made practicable with no loss in compactness or efficiency and which are virtually free of any CO in their exhaust gases.

What is claimed is:

1. In combination:

a burner adapted to burn a carbonaceous fuel, said burner having a characteristic combustion region adjacent said burner, and a heat exchanger adjacent said burner, said heat exchanger being adapted to operate at a temperature below the recombination temperature of carbon monoxide and oxygen, wherein the improvement comprises:

means intermediate said characteristic combustion region and said heat exchanger for extracting heat energy from the combustion products of said fuel to reduce the temperature of said products to the recombination temperature of carbon monoxide and oxygen, whereby, during operation of said combination, substantially all carbon monoxide and oxygen in said products recombine to form carbon dioxide before reaching said heat

exchanger, said means comprising a refractory perforate member interposed in the path of the flow of said products from said combustion region to said heat exchanger.

2. The combination of claim 1 in which the heat exchanger structure presents heat conductive members adjacent said refractory member and said refractory member is substantially insulated against any high heat conductivity paths between it and all adjacent heat conductive members, whereby said refractory member during operation is heated by said products to a temperature at which it loses heat substantially solely by radiation.

3. The combination of claim 1 in which said burner, said refractory member and said heat exchanger are cylindrical in form and concentrically arranged with respect to each other.

4. The combination of claim 1 in which said refractory member is comprised of a refractory metal alloy.

5. The combination of claim 2 in which said refractory member is supported by one or more heat insulating, sound absorbing members supported by the adjacent heat exchange structure.

6. The combination of claim 5 in which said heat insulating members are comprised of asbestos.

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