FLAMELESS RADIANT BURNER

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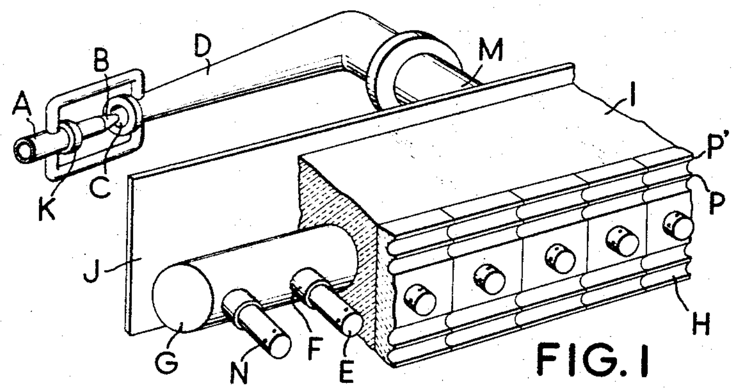

FIG. 1

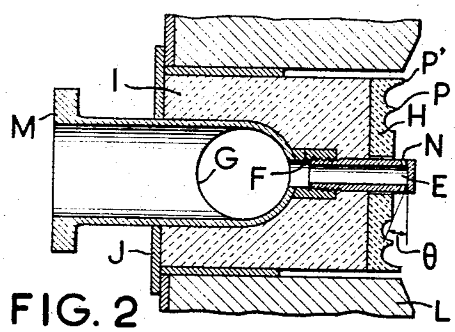

FIG. 2

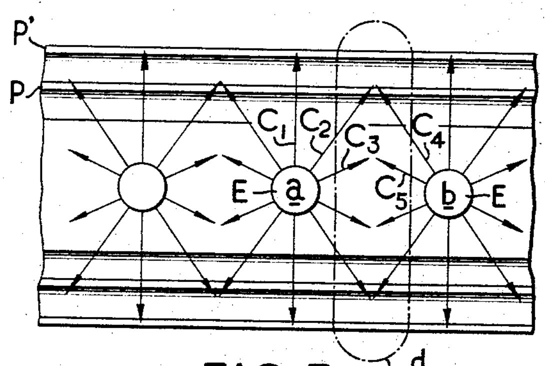

FIG. 3

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FLAMELESS RADIANT BURNER

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The present invention relates to a flameless radiant burner, and more particularly to a flameless radiant burner whereby materials are heated to a desired temperature over a wide range.

For heating a plane or linear substance uniformly and at a desired temperature gradient for the purpose of effecting chemical reactions involving heat absorption, or for carrying out a high temperature heat treatment of metallic material or the like, prior art devices, wherein a number of ordinary small diffusing flames are arranged in a belt form, are commercially available. But these devices are disadvantageous in that they are liable to cause a flash back or blow-off of flame where gas is insufficient or excessive in amount. Also available on the market are radiation burners for warming rooms or for other uses, wherein combustion of gas is effected in a flameless condition by ejecting pre-mixed gas from many small holes perforated through burner tiles and disposed in a belt-like pattern. But when they are used in a closed furnace, the backside of the burner tiles will be soon overheated, consequently causing a flashback. Also known is a radiation burner, wherein a burner tip is located in the center of a bowl-shaped burner tile and the pre-mixed gas is ejected radially from said burner tip to effect surface combustion in a concave surface of the burner tile. However, when a burner of this type is installed in a furnace, there will be too wide a space between burners, rendering it difficult to uniformly heat the material in a belt zone.

To eliminate the disadvantages of the conventional burners, the radiation type burner according to the present invention is provided. In the present invention, a cooling effect caused by feed gas is utilized and also a most effective method is employed to stabilize the flame and make it possible to eject fuel at a high speed. The present invention is also characterized in that, as will be described hereinbelow, the desired radiation heating is attained by controlling combustion over a wide range, with a wide variation of fuel, without causing a flashback or blow-off of flame.

An object of the present invention is to provide a flameless radiant burner whereby materials are heated uniformly and at a desired temperature for carrying out endothermic chemical reactions or high temperature heat treatments of metallic material, or the like. More particularly, the present invention is intended to provide a radiation type flameless burner whereby an amount of combustion is easily controlled over a wide range by preparing a combustible mixture of gas wherein a part or all of oxygen or air needed for combustion is pre-mixed by means of an aspirator, the latter being adapted to aspirate air in an amount which is dependent upon the kind and flow of fuel gas of a wide variation, and which is close to a theoretical value thereof for the combustion, or by other similar means. The mixture gas is then passed into a header of a unit burner and to a plurality of conduits branching off from said header, the gas being passed through the conduits at a high speed sufficient to cause a cooling effect thereon so as to prevent a flashback from occurring, after which the gas flame is ejected radially from a plurality of ejection openings arranged radially at the tip of said conduits, which openings extend at an

angle less than 30 degrees to the inner surface of refractories. The gas is ejected at a speed higher than that of flame propagation, causing these adjoining flames to impinge with each other, and thereby stabilizing the flames on a surface of a burner tile formed with plurality of grooves or projections, thereby completing the combustion rapidly.

In order that the invention may be understood, it will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view with one part broken away, showing a burner assembly according to the present invention;

FIG. 2 is a cross section view taken perpendicularly to the longitudinal axis of the header in FIG. 1; and

FIG. 3 is a view showing a part of the radiant surface on the refractories.

Referring to FIG. 1, an aspirator is jointly used with a burner according to the present invention. Fuel gas introduced through a fuel gas inlet A and ejected at a high speed through a fuel gas nozzle B enters an air absorbing and mixing tube D, wherein air necessary for combustion is aspirated from an air suction mouth. In said air fuel mixing tube, gas is mixed with air, increasing the static pressure thereof and then is passed through a header entrance M, whereupon it enters a header G of the burner. Thereafter, the mixed gas passes at a high speed through a plurality of replaceable conduits E mounted on said header G by threaded connectors F while cooling said conduits, is ejected at a high speed from a plurality of gas ejecting holes N provided radially on a tip of each of said conduits E, and is ignited to heat inner surface of burner tiles H. I designates a heat insulating material, and J a mounting plate for securing the burner block onto the furnace. The header G is large enough to dispense mixed gas uniformly to each conduit E, but the capacity thereof should be preferably small to allow for a possible hazard in case of the mixed gas in said header G being ignited and exploded.

The surface of burner tiles H is made of refractories and is provided with grooves, inclined planes or projections P, P′ spaced suitably from the ends of said conduits E, namely i.e., the burner tips. Those grooves and projections not only serve as a means for stabilizing the flame, but also provide an incandescent surface over the whole burner tile, that is, an effective radiant surface. The amount of air entering through the air suction mouth C of the aspirator is determined by a size of said nozzle B, irrespective of the flow of fuel in case the composition of fuel is not changed. The amount of air may also be adjusted by opening or shutting shutter K.

Referring to FIG. 2, the mixed gas fed into the burner may often have a composition of detonating gas. It enters from entrance M, passes through header G, threaded connector F and conduit E, and is then ejected from ejecting hole N, and completes combustion in the proximity of the surface of burner tiles H. The ejecting holes are perforated at an angle θ of 30 degrees or less to the surface perpendicular to the longitudinal axis of the conduits E. Insulating material I constitutes a part of the burner block and prevents heat from being conducted to the exterior of the furnace. The main body of the burner is incorporated into the furnace L by means of mounting plates J.

Referring to FIG. 3, reference characters "*a*" and "*b*" show the end surfaces of the burner tips, i.e., the conduits E. The reference characters C_1, C_2, C_3, C_4 and C_5 show the directions of the flames ejected radially out of ejection holes N shown in FIGURE 2. By locating the adjoining burner tips "*a*" and "*b*" at a proper spacing therebetween, and by properly selecting the angles of said ejection holes, a stabilizing zone "*d*" will be attained and flames from adjoining burner tips will impinge or interfere with each other to stabilize themselves over said zone, thereby prevent a blow-off due to overspeed.

The radiation type burner according to the present invention has several advantages.

The primary advantage is that a plurality of conduits E are arranged at an interval smaller than twice the length of each flame ejected from the ejection hole N, and that the flames ejected from the adjoining conduits are mutually impinged and interfered to stabilize themselves, the combustion therefore being completed in an extremely short time. By properly arranging said burner tips, luminous flames are almost completely suppressed and an uniformly radiating refractory surface will be obtained.

The second advantage is that the burner tips are separated from the header by means of conduits E having a proper section, and that by cooling said conduits E by means of cooled mixture gas passing therethrough at high speed, heat of said burner tips is prevented from being transferred to the header. In this case, a relationship between the bore and length of each conduit is determined in view of a flashback precaution and loss reduction, both of which are incompatible with each other, and therefore a suitable selection thereof is vitally important. In the present invention, even if a furnace temperature is in the order of 700° C., it is possible to maintain the header at a temperature below 150° C. At this temperature, there is almost no danger of inducing a flashback even if fuel gas containing 70% of hydrogen is used.

It is also possible with the present invention to reduce a loss of heat from the reader to an extremely small value, and hence thermal efficiency will be high.

The third advantage is that each of the burner tiles H is provided with a plurality of suitable grooves and projections P, P′. This causes gas to burn on the surface of projections P located close to the burner tips in case an amount of combustion gas is small. When combustion gas is increased, combustion is performed on the projection P′ more remote from the burner tips so as to stabilize the flames and to prevent the same from being extinguished. A proper spacing is maintained between burner tips and projections on the burner tile and an exposed portion of the metallic burner tips out of the tile surface is made extremely small. Further, ejection holes are provided in a direction away from the adjoining burner tip, so as to prevent adjoining burner tips from being overheated, thereby preventing a flashback.

The fourth advantage is that the burner tips can be arranged in a row or in other proper pattern on a plane or curved surface so as to be combined into one block of an unit burner, and that by fitting a plurality of said blocks onto the furnace and by regulating each of them to meet different combustion conditions, the material can be heated uniformly and at a desired temperature gradient. Therefore, the burner according to the present invention is most suited for the precise heating adjustments required in endothermic chemical reactions.

The fifth advantage is that the present burner is a radiation burner adapted to be adjusted over a wide range. It will therefore meet a variation of conditions of the material to be heated, will take a surprisingly short time in adjusting the temperature, will enable a prompt and precise thermal change, will cause no pulsating change to occur, and is therefore suitable for automation of heating.

Example

Some examples of the results obtained by applying the present invention on a linear burner will be shown hereinafter. Table 1 below shows a result of the test conducted on three different types of burners designated Type I, Type II and Type III, by changing a gas composition.

Table 2 shows a composition of four kinds of fuel gas A, B, C and D used for the combustion testing. A flashback point and blow-off point have been shown in terms of Kcal./hr.

It is noted that less heat is generated at a flashback point and more heat at a blow-off point, resulting in a wider operating range of the burner.

TABLE 1

Type of burner	I				II				III			
Shape of burner:												
Bore of conduit, mm.	16.1				16.1				16.1			
Number of conduits	12				12				24			
Diameter of ejecton hole, mm	2.8				3.6				2.8			
Number of ejection holes	120				120				240			
Burner tile, grooves	2				2				2			
Ejecting angle, deg	+10				+10				+10			
Fuel gas	A	B	C	D	A	B	C	D	A	B	C	D
Flash-back point—Heat generated, 10^3 Kcal./hr	5	8	------	[1]1	15	23	------	[2]2.8	11	17	------	[2]2
Blow-off point—Heat generated, 10^3 Kcal./hr	105	120	77	50	200	300	210	140	250	260	150	120

[1] Above.
[2] Below.

TABLE 2

	Kind of fuel gas			
	A	B	C	D
CO_2	14.8	4.8	----------	7.0
CH_4	6.53	21.0	LPG	----------
CO	28.5	11.0	----------	24.9
H_2	40.9	55.4	----------	14.0
N_2	2.7	7.2	----------	54.3
Others	6.5	0.6	----------	----------
Calorific value	10^3 Kcal./3 Nm.^{3}	10^3 Kcal./4.27 Nm.^{3}	10^3 Kcal./23.0 Nm.^{3}	10^3 Kcal./1.21 Nm.^{3}

It is noted from the following comparison testings that the results as shown in the above example are much better than those obtained from the conventional burners.

Comparison testing 1

(Effect of selection of conduit configuration)

A slit of 1 meter length and 7 mm. width was used in place of 12 pieces of conduits under a condition similar to that as shown in Table 1–A, the slits having the same size being disposed in two rows. Heat generated at a flashback point was found 20×10^3 Kcal./hr. Since heat generated at a flashback point was 5×10^3 Kcal./hr. in case of the present burner, it will be seen that a cooling of the conduits by selecting their configuration is very effective for preventing a flashback.

Comparison testing 2

(Effect of projections on burner tile)

The following three kinds of burner tiles have been used in a combustion testing under a condition similar to that as shown in Table 1–A,

(a) burner tiles each having a flat surface
(b) burner tiles each having many conical projections of 3–5 mm. width and 3–5 mm. height

(c) burner tiles each having two rows of grooves each having a semi-circular cross-section of 5–7 mm. depth.

Heat generated at a blow-off point was found to be

40×10^3 Kcal./hr. in case of (a),
100×10^3 Kcal./hr. in case of (b),
120×10^3 Kcal./hr. in case of (c).

It is noted from above testings that burner tiles having suitable grooves and projections are very effective for preventing a blow-off of the flame.

Comparison testing 3

(Effect of interference of adjoining flames)

In a burner combustion test conducted under the same conditions as described in I–A of Table 1, 80×10^3 Kcal./hr. of heat generation was observed at a blow-off point when a spacing between conduits was 100 mm. In view of the fact that the blow-off point was 105×10^3 Kcal./hr. in case of I–A in Table 1, wherein the conduit interval was 85 mm., it is understood that a proper selection of spacing between conduits, i.e. burner tips, provides a remarkable effect on preventing a blow-off or an extinguishing of fire by mutual interfering actions between adjoining flames.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described, but may be used in other ways without departure from its scope and other changes can be made which would come within the scope of the invention which is limited only by the appended claims.

What is claimed is:

1. A radiation type burner comprising an air-fuel mixing tube; a header embedded in refractory material and connected to one end of said tube; a plurality of parallel conduits in at least one row, one end of each of

said conduits being connected to said header in said refractory material, the other end of each of said conduits extending outwardly from said refractory material and having a plurality of air-fuel mixture ejecting openings formed therein; and a plurality of parallel grooves formed in the surface of said refractory material from which said other ends of the conduits extend, said grooves being spaced a predetermined distance from said conduits, extending at right angles thereto, and being of a semi-circular cross section; said openings extending towards said grooves at an angle with respect to the longitudinal axes of said conduits; and ejecting means to eject an air-gas mixture into said tube and through said openings at such a pressure that the air-gas mixture will impinge said refractory material substantially at said grooves; the spacing between two adjacent conduits in said one row being such that said mixture ejected out of said two conduits at the predetermined pressure will interfere with each other on said refractory material.

2. The burner according to claim **1**, wherein said ejecting means establishes a flame length at least one-half the distance between adjacent conduits.

3. The burner according to claim **1**, wherein the length of each conduit embedded in said refractory material is such that heat from said other end of each conduit is prevented from being transferred to the header.

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