Jan. 23, 1968 P. A. MUTCHLER 3,364,968

COMBUSTION CHAMBER

Filed July 30, 1965 3 Sheets-Sheet 1

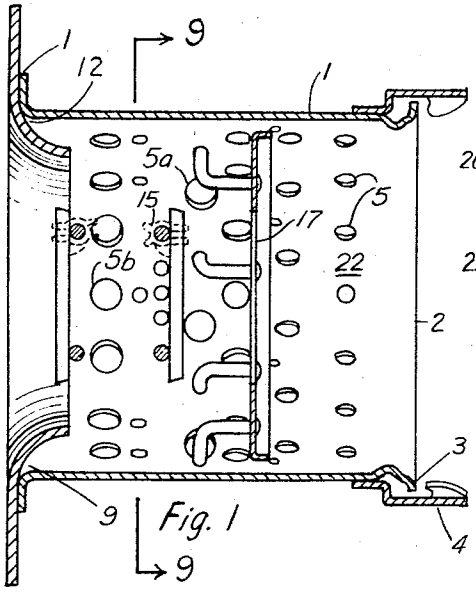



Fig. 1

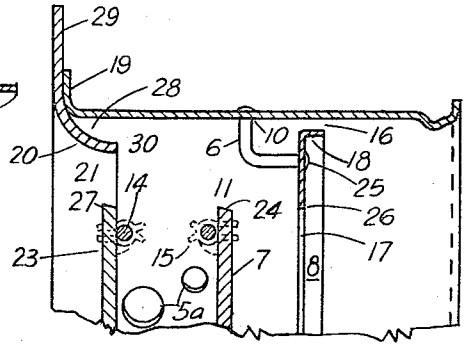



Fig. 2

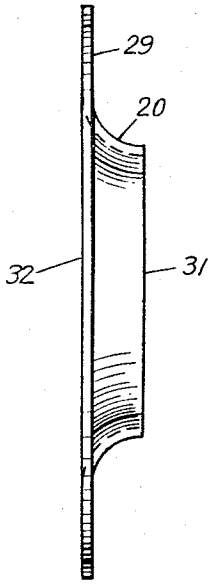



Fig. 3

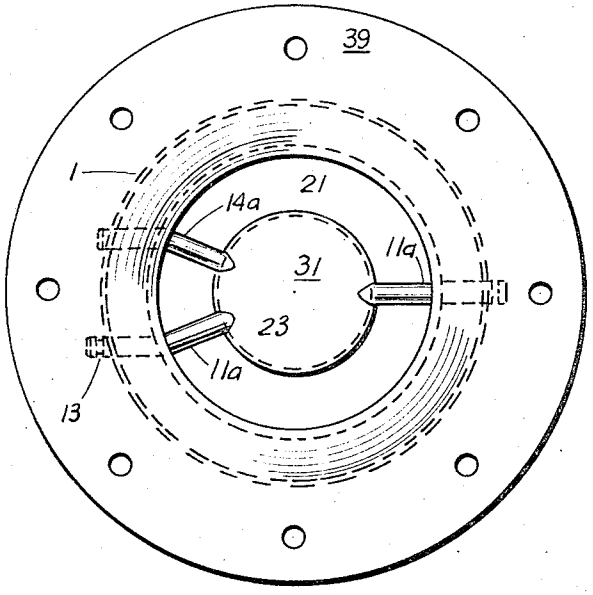



Fig. 4

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COMBUSTION CHAMBER

Filed July 30, 1965 3 Sheets-Sheet 2

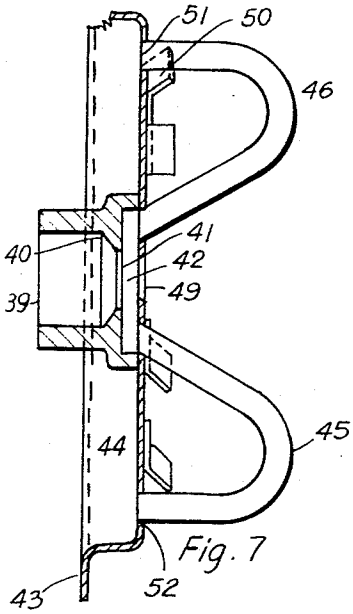



Fig. 7

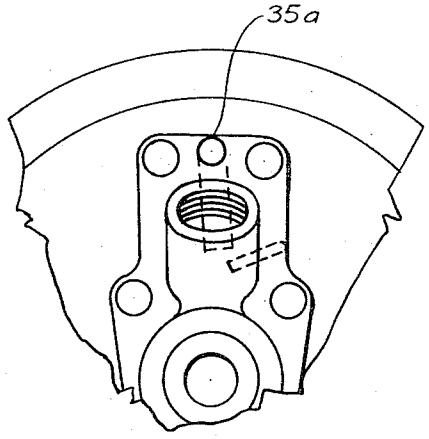



Fig. 8

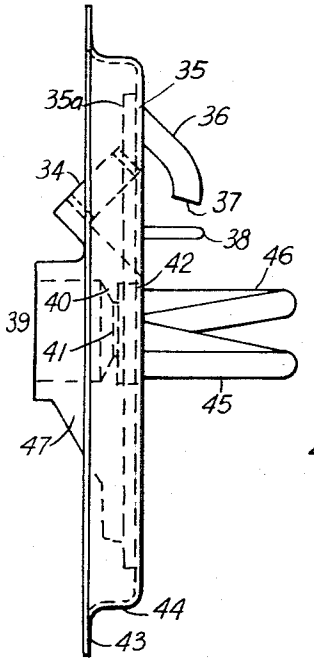



Fig. 6

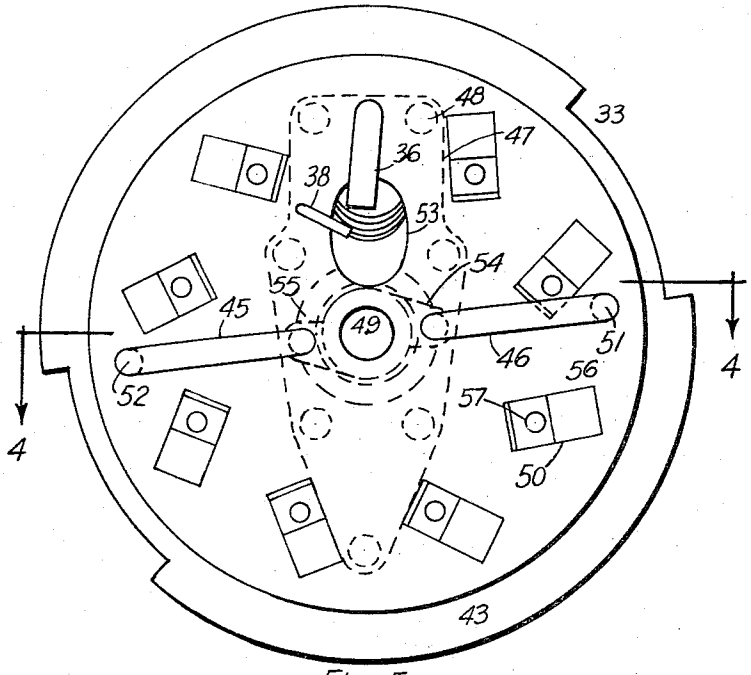



Fig. 5

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Jan. 23, 1968 P. A. MUTCHLER 3,364,968

COMBUSTION CHAMBER

Filed July 30, 1965 3 Sheets-Sheet 3

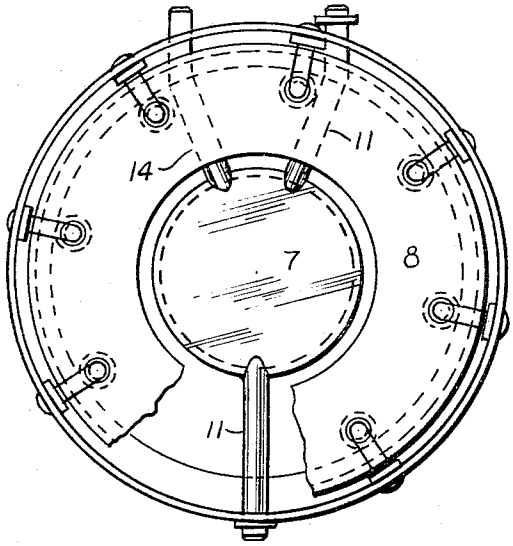



Fig. 9

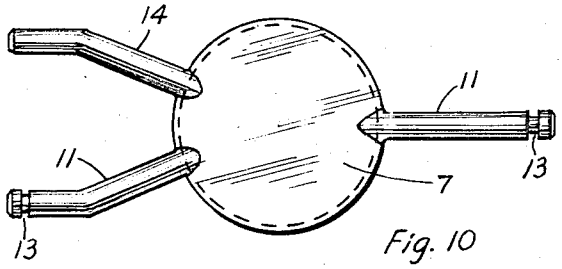



Fig. 10

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3,364,968

# COMBUSTION CHAMBER

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8 Claims. (Cl. 158—4)


## ABSTRACT OF THE DISCLOSURE

A fuel burning combustor including a housing having an annular flame skimmer means at the outlet of the housing and a target baffle disposed within the flame skimmer to form an annular hot gas outlet from the housing. The combustor can also include combustion air inlet means adjacent the baffle supports to direct air to the supports to prevent carbon deposition thereon.


### *Background of the invention*

In previous combustion chambers, the type of fuel to be utilized generally has been determined by the ambient temperature of the proposed use, by the relative volatility and chemical composition of the fuel, and by limitations imposed by the design of the combustion chamber itself. In most of these past combustion chambers it has been imperative that only select fuel be burned to prevent the formation of carbon deposits within the combustion chamber. For operation in extremely low ambient temperatures it is known that cold, incoming combustion air chills the partially burned fuel, causing it to condense within the combustion chamber facilitating formation of carbon deposits. Carbon deposition is also encountered where fuel with a high carbon-to-hydrogen ratio is burned in the absence of a required amount of combustion air. These carbon deposits, among other disadvantages, cause localized "hot spots" and lead to subsequent corrosion and failure of the combustion chamber in the areas of the hot spots.

Even though operation conducive to the formation of carbon deposits occurs for only a short period of time, when carbon deposition is initiated the presence of such carbon deposits acts as a nucleus for further carbon deposition which would not have occurred if there had been no initial carbon deposits to serve as the nucleus.

Efforts to develop a combustion chamber capable of satisfactory operation with heavy organic fuels as well as light volatile fuels have been frustrated by flame instability in previous burners designed for such service.

Another difficulty with previous combustion chambers occurs from designs which allow the escape of flame and unburned fuel from the combustion chamber to adjacent heat exchanger equipment resulting in damage to the equipment by erosion and/or corrosion from impinging flames and burning fuel.

### *Summary of the invention*

The present invention, recognizing the disadvantages of previous combustion chambers, provides a novel method for recycling or returning a portion of the flames generated within the combustion chamber to the main portion of the combustion chamber to increase the heat intensity within the combustion chamber and to eliminate the formation of carbon deposits therein. The present invention also prevents the escape of flames and unburned fuel from the combustion chamber and provide means whereby the pressure in the various sectors of the combustion chamber is more nearly uniform. The uniform pressure unexpectedly improves flame stability in the combustion chamber and decreases the average pressure drop



suffered by combustion air entering the combustion chamber.

In addition, the present invention provides means for preventing the deposition of carbon upon various internal elements of the combustion chamber.

Various other features of the present invention will become obvious to one skilled in the art upon reading the disclosure set forth hereinafter.

More particularly, the present invention provides for an improved combustion chamber for a fluid heater comprising an elongate outer housing, an outlet from the combustion chamber, air inlet means for the combustion chamber, fuel inlet means disposed at one end of the combustion chamber, an ignition means disposed in adjacent relation to the fuel inlet means and cooperating with fuel inlet means to ignite the fuel entering the combustion chamber, and an inwardly-directed flame skimmer means disposed adjacent the outlet of the chamber. In addition, the present invention provides a target baffle disposed in cooperative and adjacent spaced relation to the flame skimmer functioning to confine flames generated within the combustion chamber, the skimmer and baffle reflecting or recycling the flames to intensify the heat within the combustion chamber and improve the operability of the combustion chamber.

Further, the present invention provides openings for combustion air to be introduced adjacent the support means provided for various internal elements by the combustion chamber to introduce combustion air to selected elements of the combustion chamber to prevent the formation of carbon deposits thereon.

It is to be understood that various changes can be made in the arrangement, form and construction of the apparatus disclosed herein without departing from the scope or spirit of the present invention.

Referring to the drawings which disclose one advantageous embodiment of the present invention:

FIGURE 1 is a plan view in section of the combustion chamber showing the arrangement of the internal components thereof;

FIGURE 2 is a fragmentary plan view of the combustion chamber showing the details of the baffle assembly support means;

FIGURE 3 is a side elevation of the novel outlet flame skimmer;

FIGURE 4 is a front elevational view of the outlet of the combustion chamber showing the novel arrangement of the flame skimmer and outlet target baffle;

FIGURE 5 is a view of that face of the combustion chamber cover plate exposed to the inside of the combustion chamber;

FIGURE 6 is a side view of the combustion chamber cover plate of FIGURE 5;

FIGURE 7 is a sectional view of the cover plate assembly taken in a plane passing through line 4—4 of FIGURE 5;

FIGURE 8 is a fragmentary section of the end of the cover plate and the igniter-fuel spray assembly taken from outside the combustion chamber;

FIGURE 9 is a view within the combustion chamber taken in a plane passing through line 9—9 of FIGURE 1; and

FIGURE 10 is a detail of the front elevation of a target baffle plate.

Referring to FIGURE 1, the combustion chamber housing 1, having fuel inlet end 2 and spaced and aligned outlet 9, contains therein relatively small, spaced apertures 5 adjacent inlet end 2 for the introduction of air to the combustion chamber to support the combustion occurring therein. Intermediate the center portion of the combustion chamber and the inlet end 2 of the combustion chamber 2 is mounted annular baffle plate 8 ex-

tending diametrically across the chamber and having its flanged outer edge 18 spaced from the chamber housing as indicated at 16. Plate 8 can be constructed of any one of a number of suitable heat resistant alloys. For example, Hastelloy X, which is an alloy of chromium, nickel, and silicon can be used. Baffle 8 is supported from the housing of the combustion chamber by a series of angular rods 6 attached to the housing as, for example, at 10 and to the annular baffle plate, for example, as 25. Plate 8 has disposed therein an opening 17 which is so located in the plate and is of such size as to allow part of the fuel from the fuel inlet means hereinafter described to pass therethrough with a portion thereof impinging against the plate so that the portion of the chamber between the plate 8 and the inlet end 2 of the chamber provides a forward combustion zone 22 in which air entering through the relatively small holes 57 in the cover plate 47 hereinafter described and the relatively small holes 5 in the forward combustion zone is mixed with the incoming fuel and ignited. The flames and hot gases resulting from combustion of the fuel in the forward combustion zone 22 pass thence through the aperture 17 and around the annular baffle plate 8 through space 16 toward the outlet of the combustion chamber.

Downstream of annular baffle plate 8 in axial alignment with opening 17 in the plate is positioned imperforate target plate 7. Plate 7 is beveled as at 24 and is supported from the housing of the combustion chamber by rods 11 and 14 which extend through openings in said housing. The plate 7, like annular plate 8, can be constructed of a suitable heat-resistant alloy, such as, for example, Hastelloy X referred to above. The rods 11, as illustrated in FIGURE 10 of the drawings, are grooved as indicated at 13 to receive a spring clip 15 to hold the rods in place on the housing (FIGURE 1). The third rod 14 floats free to allow for temperature contraction or expansion changes. The imperforate plate 7 advantageously is of a peripheral configuration corresponding with that of the aperture 17 in the annular baffle plate 8. Moreover, it is desirable that the diameter of plate 7 approximate that of aperture 17 and advantageously, as illustrated in FIGURE 9 of the drawing, it is shown as slightly smaller than the diameter of aperture 17.

Openings 5 of housing 1 disposed intermediate the annular baffle plate 8 and the combustion chamber fuel inlet end 2 are made relatively small. In contradistinction therewith, at least a plurality of the apertures 5*b* disposed in the portion of the housing on the downstream side of baffle plate 8 are made appreciably larger, as illustrated in FIGURES 1 and 2 of the drawings, to permit the major portion of the combustion air to be introduced downstream of annular baffle plate 8. It will also be noted from FIGURES 1 and 2 of the drawings that a set of apertures 5*a* are provided adjacent baffle plate support rods 6, 11, and 14. The position of these apertures adjacent the rods serves to introduce combustion air at such location to prevent the formation of carbon deposits on the rods, eliminate localized "hot spots" and reduce failure.

Located in the outlet 9 of combustion chamber 1 is an inwardly-turned flame skimmer 20 of generally arcuate cross section which, as illustrated in FIGURES 1 and 2 of the drawings, is attached as at 12 to peripheral flange 19 surrounding the outlet end 9 of the combustion chamber by welding or other suitable means. Flame skimmer 20 terminates in a plane at an upstream edge 30 to form an aperture 31 within the combustion chamber. It will be noted that a secondary chamber 28 functioning as a flame reversal area is formed between flame skimmer 20 and combustion chamber housing 1 to recycle flames to the combustion chamber to intensify the heat within the combustion chamber; to prevent build-up of carbon deposits at the point of juncture 12 between the combustion chamber wall and the flame skimmer by inducing turbulent flame flow in this area; to improve the efficiency of the combustion chamber; to prevent the escape



of flames and partially burned fuel from the chamber and impart additional heat to the emitted gases from heat transferred through said flame skimmer from the flames in the flame reversal area to the hot gases passing the surface of the flame skimmer.

Disposed within aperture 31 formed by the termination of flame skimmer 20 is imperforate circular outlet target baffle 23. The shape of baffle 23 conforms generally to the description of the target baffle 7 hereinbefore described. Target baffle 23 is supported by rod means 11*a* and 14*a* which correspond to rod means 11 and 14 which support target baffle 7 as hereinbefore described. Imperforate baffle 23 advantageously is of a peripheral configuration generally corresponding with that of aperture 31. Moreover, it is desirable that the diameter of plate 23 be less than the diameter of aperture 31 to form annular opening 21 between outlet target baffle 23 and flame skimmer 20, providing emission passage for the products of combustion and hot gases formed within the combustion chamber. It will also be noted that the outlet flame baffle is beveled as at 27 to provide a smooth flow passage.

The combination flame skimmer and target baffle outlet restriction, among other advantages, confines the flames generated in the combustion chamber, intensifies the heat within the combustion chamber, effects a more uniform pressure through the various sectors of the combustion chamber which contributes to improved flame stability, and decreases the average pressure drop encountered in providing combustion air to the combustion chamber.

Referring to FIGURE 5, a dish-shaped cover plate 44, hereinafter described, sized to conform to the combustion chamber fuel inlet end 2, has a flange portion 43 to facilitate sealably attaching the cover plate to the combustion chamber outer casing 1 in cooperation with the peripheral flange 3 surrounding the inlet end of combustion chamber housing 1. Cover plate 44 is attached to combustion chamber housing 1 by means of latches 4 attached to the housing, nesting in cooperative relation with notches 33 and engaging against flange portion 43 of cover plate assembly 44. Cover plate 44 of the combustion chamber housing 1 has casting 47 attached thereto by means of rivets 48. Casting 47 provides a central opening 41 to receive a fuel nozzle, not shown, and has an upper threaded portion 34 to receive a spark plug, also not shown. An electrode 38 is carried by casting 47 for cooperation with the spark plug. A set of circumferentially spaced, sloping baffles 50 are welded to the inside surface of the cover plate to deflect air entering relatively small holes 57 in the cover plate centrally toward the nozzle. The opening 39 has a tapered seat 40 at its end against which the fuel nozzle abuts. A portion of said nozzle passes through opening 41 in the casting and extends partly into a chamber 42 contained in the casting. The fuel nozzle directs fuel through the opening 49 in cover plate 47 and into the combustion chamber. Chamber 42 also has recesses 54 and 55 as seen in FIGURE 5 of the drawings which merge tangentially with the chamber and the purpose of which will be hereinafter described.

Cover plate 44 has an opening 51 and a generally U-shaped tube 46 has one end in this opening secured thereto as by welding, the other end of the tube passing through an opening in the cover into recesses 54 of the chamber 42. A similar U-shaped tube 45 extends from opening 52 in the cover plate through the other opening in the cover plate into chamber 42 at 55. It will be seen that tubes 45, 46 extend into the combustion chamber so combustion air enters the tubes through openings 51, 52 and is heated as it passes through the tubes. The air thus heated is discharged into chamber 42 to provide heat to the fuel nozzle tip to prevent ice build-up on the nozzle as a result of cooling from the expansion of the fuel through the nozzle. By having the heated air enter the chamber 42 more or less tangentially, the interference from the spray issuing from the fuel nozzle is minimized and the heated air has a better and more extensive wiping action. A tube 36 is

provided having its inlet 35 in an opening through the cover plate and the opening in the casting 35*a* and its outlet 37 directed toward the gap between the electrode 38 and the spark plug (not shown). Air supplied through inlet 35 is directed through the outlet 37 of tube 36 to the gap between the electrode 38 of the casting 47 and the spark plug (not shown) thus cooling the electrodes and preventing deposition of carbon thereon which would eventually result in the failure of the electrodes.

The invention claimed is:

1. In a fluid heater, an improved combustion chamber comprising: an elongate combustion chamber housing, a hot gas outlet in said housing, air inlet means for said housing, fuel supply means cooperatively disposed within said housing, full ignition means disposed in said housing in cooperative relation with said fuel supply means, flame skimmer means disposed adjacent the outlet of said housing extending radially inwardly from the periphery of said outlet into said combustion chamber housing and terminating in a hot gas outlet to define a secondary chamber between said flame skimmer means and said housing which functions as a flame reversal area to reverse the direction of flow of flame adjacent said housing and, target baffle means disposed within said flame skimmer means, to provide an annular opening between the periphery of said target baffle and said hot gas outlet of said flame skimmer means for passage of a portion of the combustion products therethrough and to reflect a portion of the flame generated in said combustion chamber housing back into said housing.

2. The apparatus of claim 1 wherein said target baffle means is disposed adjacent the hot gas outlet defined by said flame skimmer substantially perpendicular to the longitudinal axis of said housing and is contoured to the general shape of said hot gas outlet but of lesser area than said hot gas outlet to provide an area between said baffle and said hot gas outlet which functions as a passage for combustion products generated within said combustion chamber, said target baffle reflecting a portion of the flame generated in said combustion chamber housing back into said housing.

3. The apparatus of claim 1 wherein one edge of said flame skimmer means conforms to and is attached to the periphery of said outlet housing, said flame skimmer means being of arcuate cross section extending radially from the periphery of said outlet toward the longitudinal axis of said housing and axially inwardly into said combustion chamber to provide as an inwardly-turned partition within said combustion chamber housing and define a secondary flame reversal area and heat exchange chamber between said flame skimmer and said combustion chamber housing, said flame skimmer terminating at an upstream edge within said combustion chamber to define a generally circular aperture for the passage of combustion products therethrough, said aperture being of lesser area than the area of said housing outlet.

4. In a fluid heater an improved combustion chamber assembly comprising: an elongate cylindrical combustion chamber housing, an outlet in said housing, air inlet means for said housing, a fuel inlet means disposed at one end of said housing, ignition means disposed within said housing in adjacent cooperative relation with said fuel inlet means, a flame skimmer means disposed adjacent the outlet of said housing wherein the downstream edge of said flame skimmer means conforms to, and is attached to, the periphery of said outlet, said skimmer means being of arcuate cross section extending from said downstream edge toward the longitudinal axis of said combustion chamber inwardly into said combustion chamber housing, serving as a partition within said combustion chamber to form a secondary flame reversal and heat exchange chamber between said flame skimmer and said housing; said flame skimmer terminating at an upstream edge within said housing to define a generally circular aperture at the upstream edge of said flame skimmer for the passage of combustion products therethrough, said aperture being of lesser area than the area of said outlet; a target baffle of shape generally conforming to the shape of the upstream aperture of said flame skimmer and disposed adjacent thereto, said target baffle being of lesser area than the area of the aperture formed by the upstream edge of said flame skimmer and disposed perpendicular to the longitudinal axis of said housing in generally centered relation with said aperture to form an annular opening between the outer edge of said target baffle and the inner edge of said aperture in said flame skimmer for the passage of combustion products therethrough.

5. In a fluid heater, an improved combustion chamber assembly comprising: an elongate cylindrical combustion chamber housing, spaced apertures therein for the introduction of air to said combustion chamber housing; cover plate means attached to one end of said housing, said cover plate means including fuel spray means disposed within said cover plate in substantially central alignment with the longitudinal axis of said housing, and fuel ignition means adjacent to and in cooperative relation with said fuel spray means; said combustion chamber housing having an outlet in the end opposite said cover plate means; flame skimmer means disposed adjacent said outlet wherein the downstream edge of said flame skimmer means conforms to, and is attached to, the periphery of said outlet, said skimmer means being of circular cross section extending from said downstream edge toward the longitudinal axis of said housing and inwardly into said housing, serving as a partition within said housing to form a secondary flame reversal and heat exchange chamber between said flame skimmer and said combustion chamber housing, said flame skimmer terminating at an upstream edge within said housing to define a circular aperture in generally centered relation with said combustion chamber housing of lesser diameter than the diameter of said outlet; a circular target baffle disposed within said aperture formed by the upstream edge of said inwardly-directed flame skimmer, said circular target baffle being of lesser diameter than the diameter of said aperture and disposed substantially perpendicular to the longitudinal axis of said combustion chamber housing in centered relation therewith to form an annular opening intermediate the inner edge of said aperture and the outer edge of said circular target baffle for the passage of combustion products therethrough; an annular baffle plate disposed substantially perpendicular to the longitudinal axis of said housing intermediate said cover plate means and the center portion of said housing; said annular baffle plate positioned to provide a peripheral space intermediate its outer edge and said combustion chamber housing, said baffle plate serving to intercept and deflect a portion of the fuel emitted from said fuel inlet means to maintain said portion of fuel in the segment of said housing between said cover plate and said annular baffle plate and having a central aperture to permit a portion of said fuel to pass therethrough; and a second baffle plate sized to approximate the size of said aperture in said annular baffle plate and disposed substantially perpendicular to the longitudinal axis of said chamber and spaced from said annular baffle plate to intercept a portion of the flame and fuel passing through said central aperture.

6. The apparatus of claim 5 wherein the ignition means includes an electrical spark igniter and air conduit means for cooling the electrodes of said electrical spark igniter to prevent the formation of carbon deposits thereon, said air conduit means comprising: a tube extending through said cover plate with the outlet of said tubes directed toward the electrodes of said spark igniter, the inlet of said tubes communicating with fresh air source to provide a constant source of fresh air to the tube, thence to said electrodes.

7. The apparatus of claim 5 wherein said target baffle plate, said annular baffle plate, and said second baffle plate are supported within said combustion chamber by rod

means extending from said baffle plates to the wall of said combustion chamber wherein, in addition to spaced apertures in said combustion chamber wall, there are apertures adjacent the points of connection of said baffle support rod means to said housing for the introduction of combustion air adjacent said points of connection to prevent deposition of carbon on said rod means.

8. In a fuel burning combustor of the type including a combustion chamber housing having outlet means, combustion air inlet means, fuel supply means and fuel ignition means, an improved outlet assembly comprising: annular flame skimmer means extending radially inwardly from the periphery of said housing outlet means and terminating in a hot gas outlet within said housing for the emission of hot gas from said chamber; and, target baffle means having an area less than the area of said gas outlet of said flame skimmer means where said target



baffle is disposed in generally aligned relation within said outlet means of said flame skimmer means to define an annular passage between said target baffle and said flame skimmer.

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