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ANNULAR COMBUSTION LINER HAVING CONICAL REENTRANT WALLS WITH FUEL REVERSING ELEMENTS

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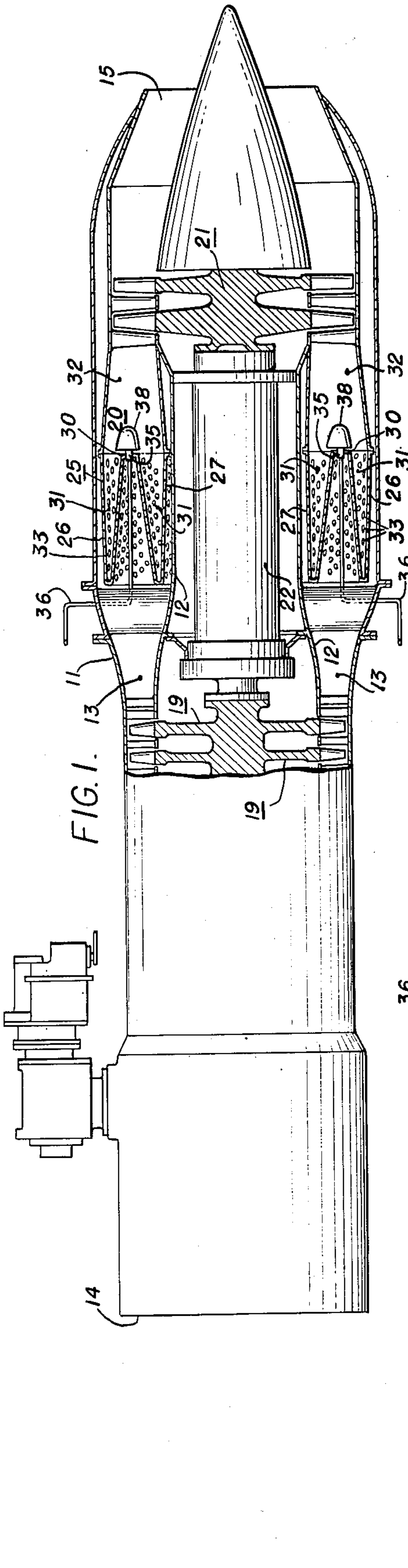

FIG. 1.

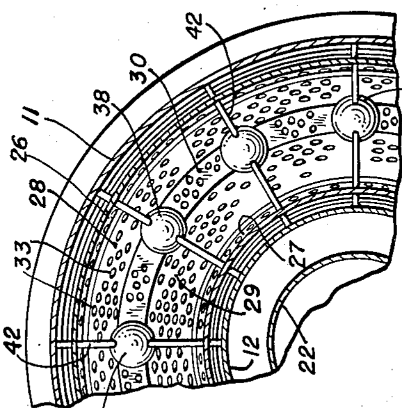

FIG. 3.

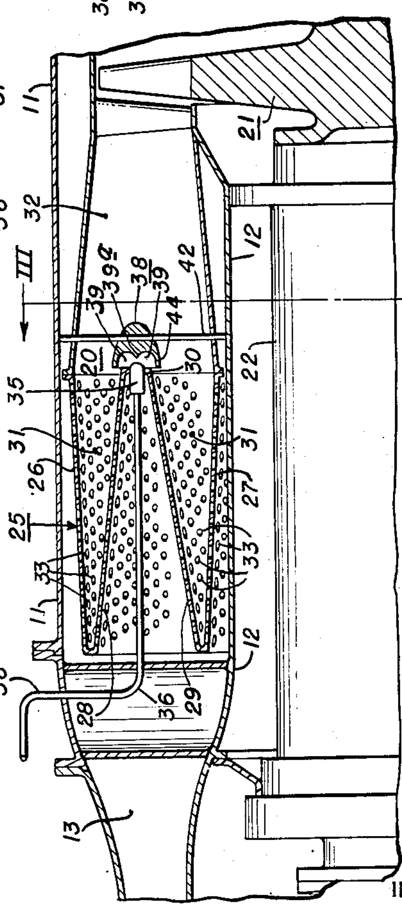

FIG. 2.

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ANNULAR COMBUSTION LINER HAVING CONICAL REENTRANT WALLS WITH FUEL REVERSING ELEMENTS

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3 Claims. (Cl. 60—39.71)

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This invention relates to combustion apparatus, and more particularly to combustion apparatus for a gas turbine power plant.

In order to facilitate the distribution and efficient combustion of fuel for the operation of an athodyd or of a gas turbine power plant of the type having a turbine-driven compressor operative to deliver air under pressure to a combustion chamber, it is considered desirable to provide means to effect counterflow of the air and fuel streams and to effect preheating of the fuel and air mixture immediately prior to combustion. It is a principal object of the present invention to provide improved combustion apparatus exhibiting these features of operation, utilizing a combustor structure having favorable volume and weight characteristics as well as high thermal efficiency, rendering it especially suitable for use in an aviation gas turbine engine.

A feature of the invention consists in employment of the counterflow principle to effect rapid supply of heat to fuel vapor through the medium of a heated reversing chamber or baffle member suspended in front of a fuel nozzle. This reversing chamber is adapted to heat the fuel to the desired degree in the very short interval that a liquid fuel particle is in contact with the reversing chamber surface and to effect discharge of fuel, either solid or gaseous, at sufficient velocity to effect uniform dispersion in the reversing chamber. The heated fuel and air mixture issuing from the reversing chamber is then introduced in counterflow relation into the air supplied into the combustion chamber to form the motive fluid for operating a gas turbine engine, and/or effecting a propelling jet.

A further object of the invention is the provision of improved combustion apparatus of the class described in which the fuel reversing chamber is operative to inject heat into the fuel and air mixture flowing through it, and to discharge such mixture at substantially any desired temperature into the air in the combustion chamber.

Features of the invention include provision of improved combustion apparatus suitable for effecting proper heating or vaporization of a fuel having a high boiling point, such as kerosene, without formation of carbon deposits. The fuel heating is accomplished in so short a time interval that the fuel does not have sufficient time in contact with a heated surface to produce "cracking."

Additional features of the invention include provision of an annular reversing chamber or body mounted in a high temperature zone adjacent the fuel nozzles of an annular combustion chamber structure having an apertured inner wall, through which primary air is supplied for combustion of the heated atomized fuel that is deflected from the reversing chamber.

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These and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawing, forming a part of this application, in which:

Fig. 1 is a diagrammatic view, partly in section, of a gas turbine engine having combustion apparatus constructed in accordance with the invention;

Fig. 2 is an enlarged detail, sectional view of a portion of the combustion apparatus shown in Fig. 1; and

Fig. 3 is a fragmentary sectional view taken along the line III—III of Fig. 2.

The essential elements of a typical aviation gas turbine power plant are illustrated diagrammatically in Fig. 1, comprising an outer casing structure **11**, which may be made up of a number of cylindrical sections and which has suitably mounted therein an inner sectional core structure **12** cooperating with the outer structure to form an annular flow passageway **13**, which extends longitudinally through the engine from a forwardly directed intake opening **14** to a rearwardly disposed discharge nozzle **15**. It will be understood that the casing structure **11** is adapted to be mounted in or on the fuselage or wing of an aircraft, with the inlet opening **14** pointed forwardly. Operating elements of the gas turbine engine are arranged in axial alignment in order to minimize the frontal area presented by the engine, and include an axial flow compressor **19**, annular combustion apparatus **20**, and a turbine **21**, which is operatively connected to the rotor of the compressor through the medium of an axially disposed shaft **22**.

In accordance with well known principles of operation of gas turbine power plants, air entering the annular intake opening **14** passes to the compressor **19**, which delivers the air under pressure through the passage **13** to the combustion apparatus **20** for supporting combustion of fuel, which may be admitted by means hereinafter described. Heated motive fluid thus generated in the combustion apparatus **20** is then expanded through the turbine **21** for driving the compressor, while the exhausted motive fluid is discharged to the atmosphere by way of the nozzle **15**, and may be in the form of a jet establishing a propulsive thrust.

According to the invention, the combustion apparatus 20, as best illustrated in Fig. 2, comprises an annular burner or basket structure 25 interposed in the passageway 13 and having an outer annular wall 26, an inner wall 27 of frusto-conical form, and two reentrant frusto-conical walls 28 and 29 joined by an annular, preferably perforated, apical section 30 to form a combustion chamber having dual upstream portions 31 which merge into a common downstream portion 32. In the embodiment shown in Fig. 2, the reentrant walls 28 and 29 are made of foraminous material or are provided with a plurality of openings 33, for admitting air under pressure from the passageway 13 to the dual upstream combustion chamber portions 31 defined between the walls. The walls 26 and 27 are spaced from the respective walls of the casing structures 11 and 12 to permit flow therepast of secondary or cooling air during operation of the engine. The apical section 30 has formed therein a plurality of spaced openings including apertures for receiving fuel nozzles 35, which may be secured to the section or otherwise supported in a suitable manner, and which are individually connected to the usual fuel supply system through the medium of conduits 36 communicating with a manifold (not shown).

Suspended in the downstream portion 32 of the combustion chamber, adjacent the nozzles 35 is an annular body or reversing chamber element 38 having an annular concavity 39 facing the associated nozzle 35. Each reversing chamber element 38 may be suitably supported on one of a number of radially arranged struts 42 carried by the casing structures 11 and 12. The concavity 39 of each element 38 terminates in a guide wall 44, which is adapted to direct the flow of atomized fuel issuing from the nozzles forwardly and substantially along the surfaces of the respective reentrant walls 28 and 29. It will be understood that the nozzles 35 are designed to eject fuel at a small angle, so that the fuel will have a relatively large component of axial velocity and such radial velocity as will promote uniform dispersion of fuel in the concavities 39. The concavities 39 have central elevations 39*a* for ensuring distribution of fuel into both combustion chamber portions 31.

In operation, fuel under pressure is discharged from the nozzles 35 and immediately atomized and mixed with air in the concavities 39 of the reversing chamber elements 38, air under pressure being supplied through the passageway 13 and through openings 33 of the burner 25. Since each element 38 is disposed in a zone in which temperatures ranging from 1200° to 3000° F. may prevail, it serves to transfer heat from the surrounding high temperature gases to the fuel and air mixture flowing through the concavity 39 to the combustion chamber portions 31. The reversing chamber element 38 thus not only serves to initiate counterflow of the air and gas streams entering the combustion chambers, but also promotes efficient combustion by rapidly injecting heat into the fuel and air mixture for promoting attainment of the most favorable condition for rapid combustion in association with the air jets issuing from the burner openings 33. The association of the fuel nozzles with the heated reversing chamber elements ensures rapid addition of heat to the fuel and air mixture, while effecting counterflow thereof for minimizing the combustion space and improving mixing of fuel vapor and air.

From the foregoing it will be apparent that an improved fuel combustion apparatus constructed in accordance with the invention, by effecting preheating of the fuel and air mixture and counterflow of the air and fuel streams, will ensure efficient vaporization and combustion of gasoline, or one of the more readily available fuels having high boiling points such as kerosene. Heating of the fuel and air mixture, during momentary contact thereof with the reversing chamber elements 38, is accomplished rapidly enough to prevent undesired cracking of the fuel, or depositing of carbon, while the flame propagation velocity, as well as the range of ignitible mixtures of air and hydrocarbon vapors, are extended and increased.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. Combustion apparatus constructed and arranged in an annular air flow passage having an upstream inlet for receiving air under pressure and a downstream outlet for delivery of hot motive fluid, said apparatus comprising outer and inner annular walls, annular reentrant walls having apertures and spaced within said outer and inner walls to form a dual combustion chamber closed at the upstream end and having a single downstream opening, at least one of said reentrant walls being of frusto-conical form converging from the upstream end toward the other reentrant wall, an annular apical section joining said reentrant walls at a point intermediate the upstream and downstream ends of said combustion chamber, a plurality of nozzles mounted in said apical section for discharging fuel in a downstream direction, and an annular group of reversing elements suspended from said outer and inner walls in a high temperature zone of said combustion chamber and in alignment with said nozzles, said element presenting concave surfaces to said nozzles for transferring heat to the fuel and air mixture while effecting counterflow thereof into the streams of air flowing into said dual combustion chamber by way of the apertures in said reentrant walls.

2. Combustion apparatus constructed and arranged in an annular air flow passage having an upstream inlet for receiving air under pressure and a downstream outlet for delivery of hot motive fluid, said apparatus comprising wall structure having air inlet apertures and including outer and inner annular walls spaced within said flow passage, frusto-conical reentrant walls having their upstream ends mounted in juxtaposed relation with the adjacent ends of said outer and inner walls, respectively, an annular apical section joining the converging downstream ends of said reentrant walls at a point intermediate the opposite ends of said outer and inner walls, said wall structure thus forming an annular combustion chamber having dual upstream portions diverging into a common downstream portion, fuel supply means extending through said passage between said reentrant walls and carrying a plurality of nozzles, said apical section having apertures for receiving the fuel discharging portions of said nozzles, and a plurality of deflecting bodies supported in spaced relation from said wall structure in the high temperature zone of said combustion chamber close-

ly adjacent said nozzles, respectively, said bodies having annular concavities for effecting heating and counterflow of fuel and air mixture into the streams of air flowing from said passage into said combustion chamber by way of the apertures in said wall structure.

3. Apparatus as set forth in claim 2 wherein the deflecting bodies have annular concavities with central elevations for ensuring rapid counterflow of fuel and air into both upstream portions of the combustion chamber.

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