Aug. 20, 1968 D. O. DAVIES ETAL 3,397,536

FUEL NOZZLE ASSEMBLY FOR GAS TURBINE ENGINES OR THE LIKE

Filed Oct. 24, 1966

FIG. 1.

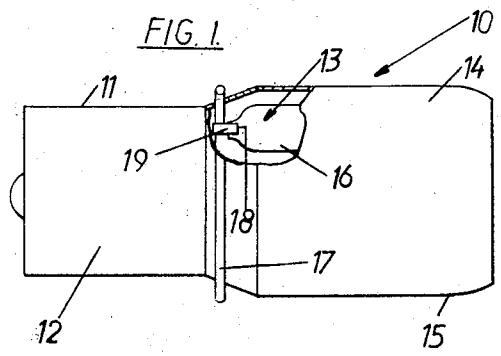


FIG. 2.

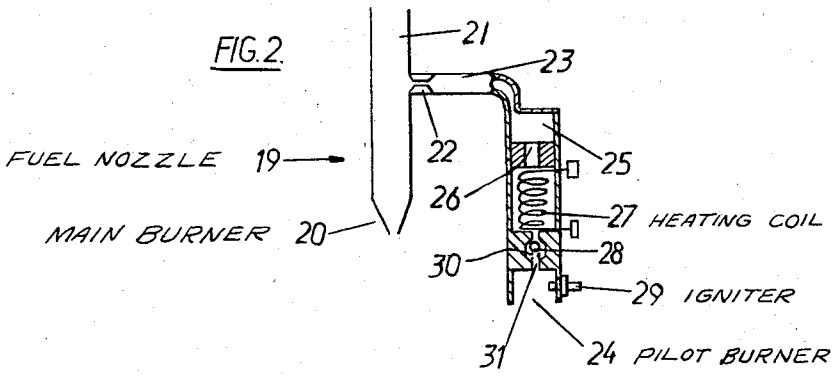
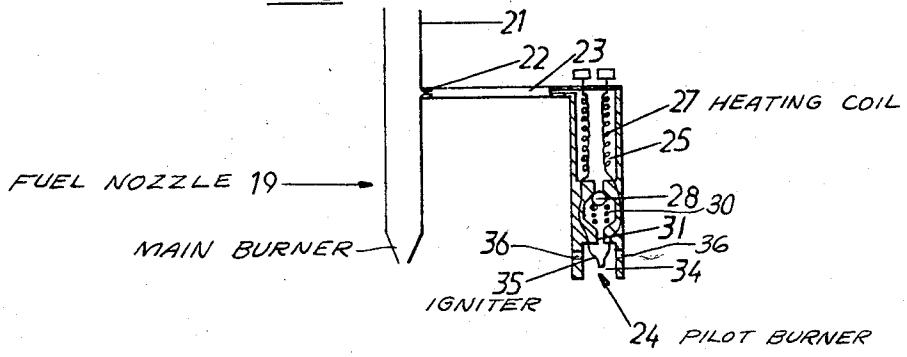


FIG. 3



Inventors
DAVID OMRI DAVIES
LESLIE BARNES
ARTHUR ALBERT BURROWS
By Cushman, Darby & Cushman
Attorneys

United States Patent Office 3,397,536 Patented Aug. 20, 1968

3,397,536

FUEL NOZZLE ASSEMBLY FOR GAS TURBINE ENGINES OR THE LIKE

David Omri Davies, Leslie Barnes, and Arthur Albert Burrows, Derby, England, assignors to Rolls-Royce Limited, Derby, England, a British company

Filed Oct. 24, 1966, Ser. No. 588,822
Claims priority, application Great Britain, Nov. 1, 1965, 46,218/65
9 Claims. (Cl. 60—39.71)

ABSTRACT OF THE DISCLOSURE

A fuel nozzle assembly has a pre-heating chamber connected to receive a small portion only of the fuel being supplied to the fuel nozzle and a heater is disposed within the pre-heating chamber for vaporizing the fuel. The vaporized fuel passes from the pre-heating chamber to a pilot burner from where it is discharged to a combustion zone adjacent the main burner of the fuel nozzle assembly. A valve prevents the discharge of fuel vapor from the pre-heating chamber except when the pressure in the latter is at least at a predetermined value, thus producing a high pressure flame.

This invention concerns a fuel nozzle assembly and, although the invention is not so restricted, it is more particularly concerned with a fuel nozzle for use in a combustion chamber of a gas turbine vertical lift jet engine.

The term "vertical lift engine" as used in this specification is to be understood to indicate an engine adapted to produce vertical lift forces on an aircraft independently of those generated aerodynamically by forward flight of the aircraft.

In the combustion chamber of such a vertical lift engine, ignition is normally initiated by means of a high energy electrical spark. This however, requires the use of a high energy igniter box of considerable size and weight and it is the object of the present invention either to dispense with or to reduce the size and weight of such an igniter box.

According therefore to the present invention, there is provided a fuel nozzle assemlby adapted to be supplied with fuel and having a pre-heating chamber connected to receive a small proportion only of the fuel being supplied to the fuel nozzle assembly, heating means disposed within said preheating chamber for vaporising the fuel therein, means for directing the vaporised fuel from the pre-heating chamber to a combustion zone adjacent the fuel nozzle assembly, and valve means which prevent the discharge of fuel vapour from the pre-heating chamber except when the pressure of the latter therein is at or above a predetermined value, said valve means being, in operation, arranged to intermittently open and close at a frequency within a selected range.

Igniter means may be provided for ensuring ignition of the vaporised fuel once the latter reaches the combustion zone.

The heating means preferably comprises an electrical heating element.

A portion of the heating element may extend through a nozzle through which the heated fuel flows, the said portion forming the said igniter means. Means may in this case be provided for directing air towards the said portion of the heating element.

Alternatively, the igniter means may comprise means for supplying a high frequency spark or arc to the heated fuel which has passed through the pre-heating chamber.

The fuel nozzle assembly may have a main fuel conduit which communicates with a pilot fuel conduit by way of at least one restriction or non-return valve, the pre-heating chamber forming part of the pilot fuel conduit.

Means may be provided for ensuring that only a drop of fuel at a time falls onto the said heating means in the pre-heating chamber.

The invention also comprises a combustion chamber provided with a fuel nozzle assembly as set forth above. Additionally, the invention comprises a gas turbine jet engine having such a combustion chamber.

The said engine may be a vertical lift engine having a thrust to weight ratio of at least 1:1 and preferably of at least 16:1.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:

FIGURE 1 is a diagrammatic view, partly in section, of a gas turbine vertical lift engine having a combustion chamber in which is mounted a fuel nozzle assembly in accordance with the present invention, and

FIGURES 2 and 3 are diagrammatic views showing two alternative forms of the said fuel nozzle assembly.

In FIGURE 1 there is shown a vertical lift jet engine **10** having a thrust to weight ratio of at least 16:1 and preferably of at least 20:1, the engine **10** being adapted to be mounted vertically in an aircraft (not shown).

The engine **10** has an engine casing **11** in which there are disposed in flow series a compressor **12**, a combustion chamber **13** and a turbine **14**, the turbine exhaust gases being directed downwardly to atmosphere through a short exhaust duct **15**. The compressor **12** may be of lightweight construction and may be made largely of synthetic resin materials.

The combustion chamber **13** comprises a plurality of angularly spaced apart flame tubes **16**. Each of the flame tubes **16** is arranged to receive combustion air, which has been compressed by the compressor **12**, and to receive liquid fuel from an annular manifold **17**, combustion of the said fuel and air occurring at a combustion zone **18** in the respective flame tube **16**.

As shown in FIGURE 2, each flame tube **16** may have a fuel nozzle assembly **19** which includes a main burner **20**, the fuel nozzle assembly **19** being supplied with fuel from the manifold **17** by way of a main fuel conduit **21**. The main fuel conduit **21** communicates by way of a restriction **22** (or by way of a non-return valve, not shown) with a pilot fuel conduit **23** which extends to a pilot burner **24**. The arrangement is thus such that the pilot burner **24** is supplied with only a very small proportion of the amount of fuel which is being supplied to the fuel nozzle assembly **19**.

The pilot fuel conduit **23** incorporates, upstream of the pilot burner **24**, a pre-heating chamber **25**. The latter communicates with the portion of the pilot fuel conduit **23** upstream of it by way of an attenuated passage **26**. Mounted in the pre-heating chamber **25** is an electrical heating element **27**, the attenuated passage **26** ensuring that only a drop of fuel at a time falls onto the heating element **27**. The heating element **27** is adapted to effect heating and vaporizing of the fuel falling onto it, the heating element **27** being connected to a battery (not shown) or other source of electrical energy.

The fuel which has been heated and vaporized in the pre-heating chamber **25** passes out of the latter via a non-return valve **28** which ensures that fuel vapour is not discharged from the pre-heating chamber **25** except when the pressure of the latter therein is at or above a predetermined value. The valve **28** is thus, in operation, intermittently opened and closed since, after it has opened to permit the escape of fuel vapour, it will be closed until the pressure in the pre-heating chamber **25** has risen sufficiently.

The frequency with which the valve **28** opens and closes can be selected to be at any desired frequency, e.g. of

up to 200 cycles per minute, by appropriate selection of its valve spring **30** and of the electrical energy supplied to the heating element **27**.

The vaporized fuel, which has passed through the valve **28**, is directed through a passage **31** to the pilot burner **24**. Ignition of the vaporized fuel will usually occur once it mixes with air at the pilot burner **24**. In order to ensure ignition, however, there is provided a high frequency electrical igniter **29** which is adapted to supply a high frequency electrical spark or arc to the heated vaporized fuel issuing from the pilot burner **24**. The igniter **29** need only, however, be a very small device as opposed to the 12 joule type igniters which are normally used in gas turbine engines.

Accordingly, in order to initiate ignition of the fuel supplied to a flame tube **16**, the respective heating element **27** is switched on (by means not shown). A very small quantity of fuel from the main fuel conduit **21** will pass through the restriction **22** (or non-return valve) and so to the pre-heating chamber **25** where it will be heated and vaporized. The restriction **22**, or non-return valve, will, however, prevent the pressurised fuel vapour from blowing back into the main fuel conduit **21**.

At such times as the pressure of the fuel vapour in the pre-heating chamber **25** is sufficient, the valve **28** will open so that a high pressure, high energy flame will be directed into the flame tube **16**. The vaporized fuel will normally ignite easily on being contacted by the air at the pilot burner **24**, but such ignition may be assisted, if desired, by operating the igniter **29**.

When ignition has started, the electrical heating element **27** is switched off and ignition will occur of the main flow of fuel which is passing to the main burner **20**.

The construction shown in FIGURE 3 is generally similar to that of FIGURE 2 and will not therefore be described in detail, like reference numerals indicating like parts.

In the construction shown in FIGURE 3, the vaporized fuel which passes the valve **28** and goes through the passage **31**, escapes at a nozzle **34** into which extends a portion **35** of the heating element **27**. The latter may be of the kind marketed under the trademark "Pyrotenex," the portion **35** being the hottest part thereof. Air is directed towards the portion **35** by apertures **36** in the nozzle **34**.

As will be appreciated, in the construction of FIGURE 3, only a very small quantity of vaporized fuel will be able to pass through the nozzle **34** and this will be ignited by the portion **35**, so that an igniter **29** does not need to be provided.

It will be no doubt appreciated that although the provision of the heating element **27**, together with the necessary battery or other electrical power source, will of course add to the weight of the engine **10**, nevertheless the space occupied by this construction and the weight thereof will be less than would have been involved if the initiation of the ignition in the flame tube **16** had been left entirely to the igniter **29**, since it would then be necessary to make the igniter relatively massive. It will be understood that the saving of weight and space in a vertical lift jet engine is of considerable importance.

We claim:

1. A fuel nozzle assembly comprising: a main burner; means to supply fuel to said nozzle assembly; a pre-heating chamber operatively connected to said fuel supply means for receiving a small proportion only of fuel being supplied thereby; heating means disposed within said pre-heating chamber for vaporizing the fuel therein; pressure responsive valve means for discharging fuel vapor from said preheating chamber each time the pressure of the fuel vapor therein reaches a predetermined value, said pressure responsive valve means being, in operation, arranged to intermittently open and close at a frequency within a selected range; and means including a pilot burner for receiving the discharged fuel vapor from said heating chamber and directing the same to a combustion zone adjacent the main burner.

2. A fuel nozzle as claimed in claim **1** in which said pressure responsive valve means comprises a valve member and resilient means normally urging said valve member to a closed position, said resilient means having a predetermined resiliency which in part determines the frequency of the intermittent opening and closing of the valve means.

3. A nozzle assembly as claimed in claim **1** in which said fuel supply means includes a main fuel conduit and in which said pre-heating chamber is operatively connected to said main fuel conduit by a pilot fuel conduit having at least one restriction therein.

4. A fuel nozzle assembly as claimed in claim **1** including means to supply only a drop of fuel at a time onto said heating means in said pre-heating chamber.

5. A nozzle assembly as claimed in claim **1** in which said means including a pilot burner also includes igniter means for ensuring ignition of the vaporized fuel once the latter reaches the combustion zone.

6. A nozzle assembly as claimed in claim **5** in which the heating means comprises an electrical heating element.

7. A nozzle assembly as claimed in claim **6** in which a portion of the heating element extends through said pre-heating chamber to adjacent said pilot burner, the said portion forming the said igniter means.

8. A nozzle assembly as claimed in claim **7** in which means are provided for directing air towards the said portion of the heating element.

9. A nozzle assembly as claimed in claim **5** in which the igniter means comprises means for supplying a high frequency spark to the vaporised fuel which has passed from the pre-heating chamber.

References Cited

UNITED STATES PATENTS

1,505,100	8/1924	Lightfoot.	
1,694,001	12/1928	Dana.	
2,498,263	2/1950	Goddard	60—39.82 XR
2,731,079	1/1956	Smits.	
2,897,649	8/1959	Reddy	60—39.82

JULIUS E. WEST, *Primary Examiner.*