

Nov. 25, 1969

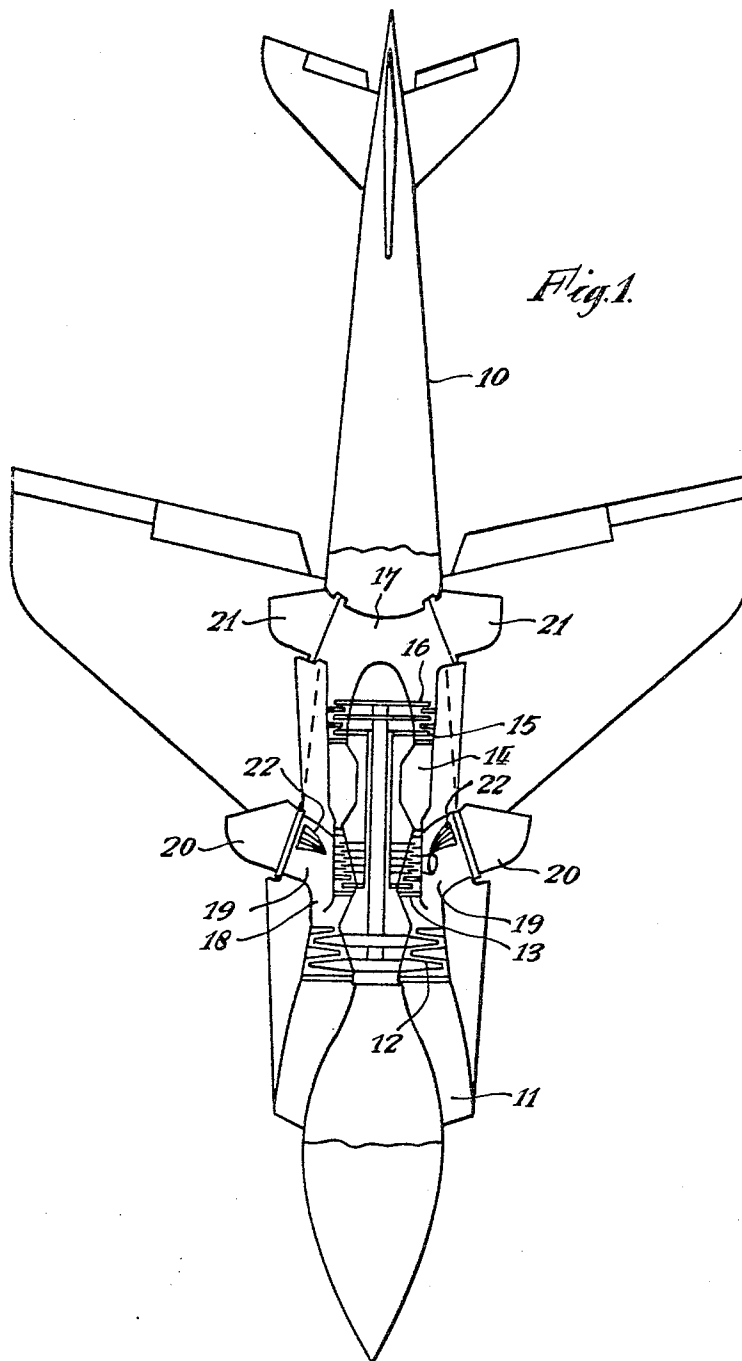
D. H. PARNELL ET AL

3,479,823

COMBUSTION APPARATUS

Filed June 27, 1967

3 Sheets-Sheet 1



Nov. 25, 1969

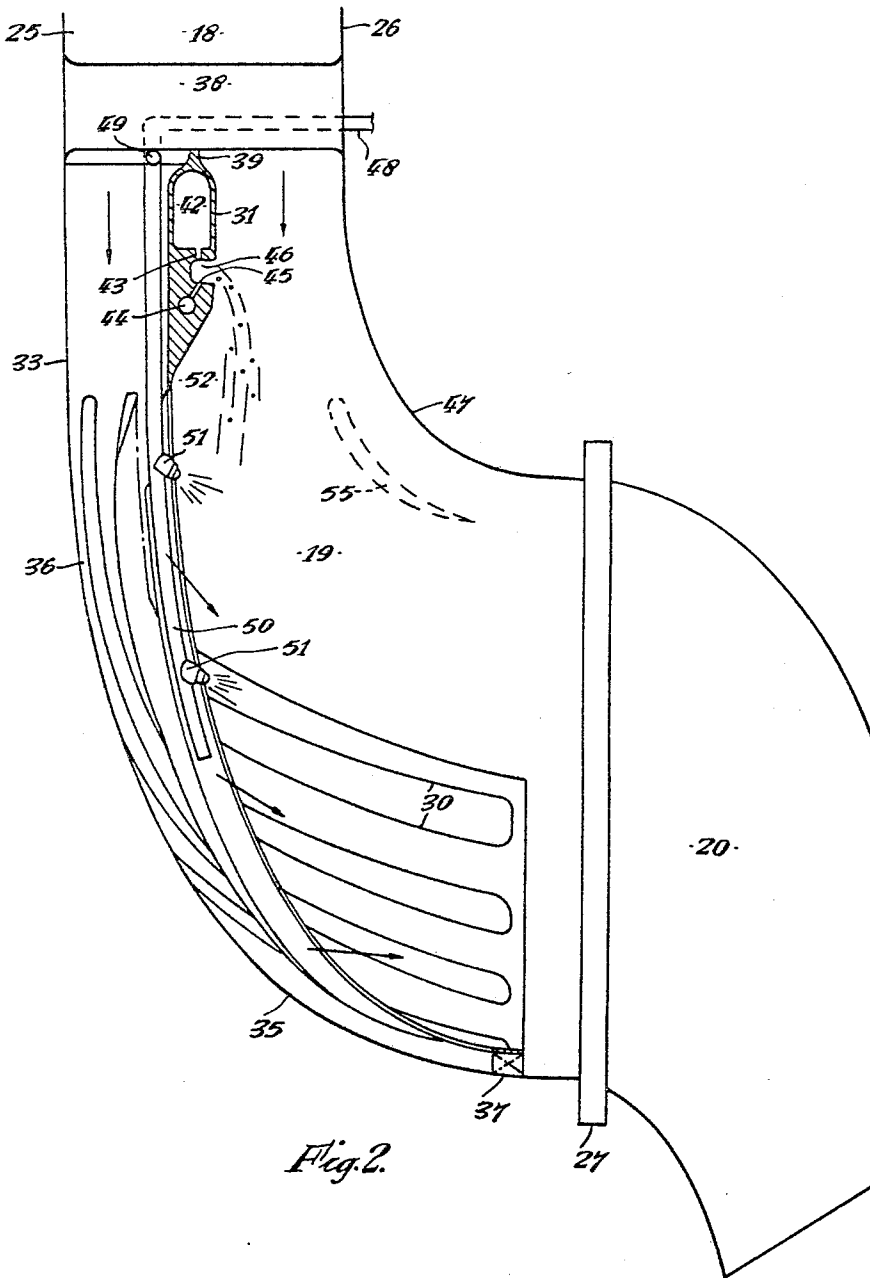
D. H. PARNELL ET AL

3,479,823

COMBUSTION APPARATUS

Filed June 27, 1967

3 Sheets-Sheet 2



Nov. 25, 1969

D. H. PARNELL ET AL

3,479,823

COMBUSTION APPARATUS

Filed June 27, 1967

3 Sheets-Sheet 3

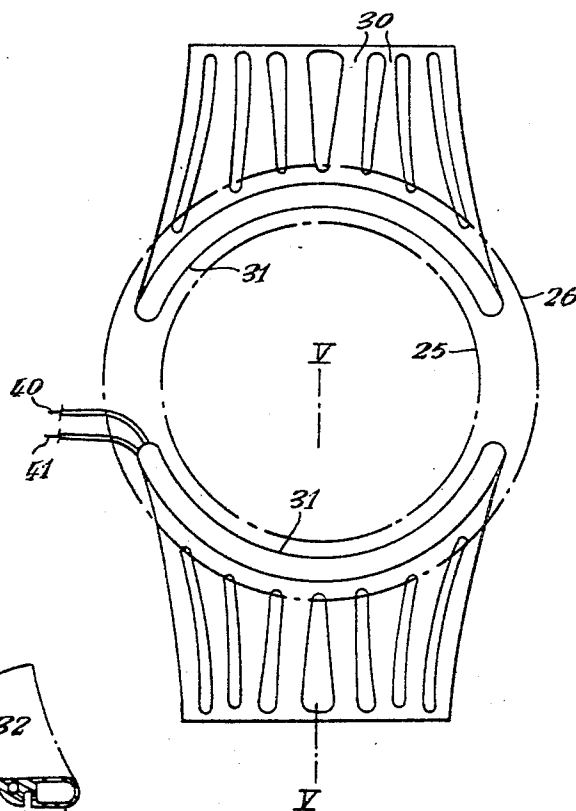


Fig. 3.

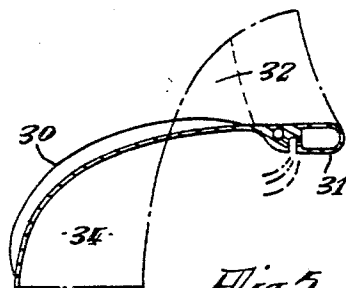


Fig. 5.

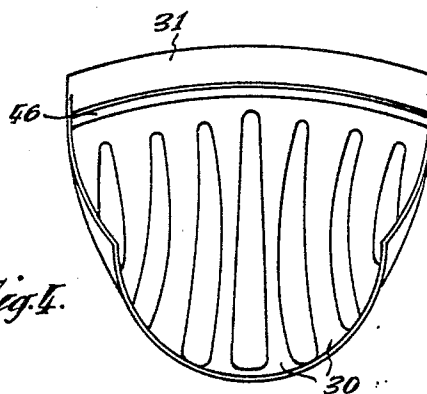


Fig. 4.

1

3,479,823

COMBUSTION APPARATUS

David Harding Parnell and Arthur Sotheran, London
England, assignors, by mesne assignments to Rolls-
Royce Limited, Derby, England, a British company

Filed June 27, 1967, Ser. No. 649,314

Claims priority, application Great Britain, July 1, 1966,
29,673/66

Int. Cl. F02k 3/08; F02c 3/04

U.S. Cl. 60—224

8 Claims

ABSTRACT OF THE DISCLOSURE

The disclosure of this invention relates to combustion apparatus for a bypass duct of a bypass gas turbine jet propulsion engine for aircraft in which a grid of longerons is provided at one end with a nose member in alignment with the adjacent ends of the longerons shaped to allow substantially laminar flow past it. The nose member has means for providing selectively a sheltered zone in the laminar flow and ducting is provided with at least one fuel injector for supplying pilot fuel to the sheltered zone. Ducting and at least one fuel injector are provided for supplying main fuel between the longerons which constitute continuous channels for flame propagation.

This invention relates to apparatus for burning liquid or vapourised fuel in a flow of combustion-supporting gas along a duct. In this specification what is meant by "longerons" is long narrow members which extend across a duct or flow path in a generally upstream/downstream direction. The longerons must be wide enough to provide a blockage in the flow path so that a stable zone is formed in their wake.

The invention may be applied to a flow of compressed air in a bypass duct of a gas turbine jet propulsion engine for increasing the engine thrust.

According to one aspect of the invention, combustion apparatus comprises a grid of longerons provided at one end with a nose member which is in alignment with the adjacent ends of the longerons and shaped to allow substantially laminar flow past it, the nose member having means for providing selectively a sheltered zone for pilot combustion.

Preferably, the said means comprises internal ducting in the nose member which connects with an outlet, which outlet is arranged to deliver a curtain-like discharge at substantially right angles to the adjacent end of the grid.

According to another aspects of the invention, there is provided in a gas duct combustion apparatus comprising a grid of longerons provided at one end with a nose member which is in alignment with the adjacent ends of the longerons and shaped to allow substantially laminar flow past it, the nose member having means for providing selectively a sheltered zone for pilot combustion, and wherein the grid of longerons extends along the duct, the grid lying nearer one wall portion of the duct than an opposing wall portion and being arranged to define with the nearer wall portion a convergent minor passage and with the opposing wall portion a major passage.

By way of example the invention will now be described with reference to the accompanying diagrammatic drawings of which:

FIGURE 1 is a view from beneath of an aircraft having a gas turbine jet propulsion engine including port and starboard bypass air ducts, each equipped with combustion apparatus according to the present invention,

FIGURE 2 is, on a larger scale, a section through the port bypass duct,

FIGURE 3 is a cross-section through the engine show-

2

ing the port and starboard combustion apparatus, with certain parts omitted,

FIGURE 4 is a view at right angles to FIGURE 3 of one of the combustion apparatus, and

FIGURE 5 is a section along the plane V—V of FIGURE 3.

Referring to FIGURE 1, the fuselage 10 of an aircraft houses a gas turbine jet propulsion engine having a forward-facing air intake 11, a low pressure compressor 12, a high pressure compressor 13, a main combustor 14, a high pressure turbine 15 which drives the compressor 13, a low pressure turbine 16 which drives the compressor 12, and a forked jet pipe 17. The inner portion of the air from the compressor 12 enters the compressor 13 while the outer portions enters an annular plenum chamber 18 formed around the compressor 13 which has two outlets in the form of short lateral ducts 19. Each duct 19 is bent outwards and communicates downstream with a swivelling pipe bend propulsion nozzle 20. Thus each duct 19 is a bypass duct for air compressed by the compressor 12 which bypasses the compressor 13, combustor 14 and turbines 15, 16. The jet pipe 17 delivers the turbine exhaust gas to a rear pair of swivelling pipe bend propulsion nozzles 21.

For normal forward flight, the nozzles 20, 21 are swivelled to discharge their respective jets rearwards. For vertical take-off, both pairs of nozzles are swivelled to discharge downwards, and fuel may be burned in the air flowing through the bent ducts 19 in order to provide increased thrust. For this purpose, combustion apparatus 22 according to the present invention is provided in each duct 19.

Referring to the other figures, the plenum chamber 18 has radially inner and outer wall 25, 26 and the two nozzles 20 which are fed by the bent ducts 19 are swivelably mounted on bearings in housings 27.

Each duct 19 is provided with a single two-dimensional wall of transversely-spaced longerons 30 of shallow trough-section constituting a grid which extends along the duct, the grid being provided with a hollow nose member 31 which extends transversely in an arc across its upstream end. The grid has a compound curvature, firstly it is curved longitudinally to bend with the duct and secondly its upstream portion 32 is curved transversely to extend partially around the cylindrical wall part 33 of the duct whilst its downstream portion 34 is curved transversely in the opposite sense to match the curvature of the wall part 35 which constitutes the outer half of the duct bend.

The grid is spaced from the wall part 35 to define therein a convergent minor passage 36 and for this purpose the downstream end of the grid is mounted on transversely-spaced supports 37 secured to the wall part 35 whilst the nose member 31 is provided with an axial location pin 39 which engages in a hollow supporting vane 38 in the plenum chamber.

Compressed air, which may be bled from the high pressure compressor 13, and fuel for pilot combustion are conveyed by pipes 40, 41 respectively to one end of the nose member 31 where air pipe 40 communicates with an arcuate chamber 42 provided with a series of transversely-spaced outlets 43 whilst fuel pipe 41 communicates with an arcuate pipe 44 provided with a like series of outlets 45. The two series of outlets face one another across a long transverse recess 46 formed in the side of the nose member which faces the inner wall 47 of the duct bend.

A main fuel pipe 48 which enters the vane 38 is arranged to deliver fuel to a transverse pipe 49 which communicates with the upstream ends of a series of branch pipes 50 each of which extends downstream between a pair of adjacent longerons to support and feed a number

of fuel injectors 51 which are arranged to discharge fuel between the longerons in the direction indicated in FIGURE 2.

In normal engine operation, there is no burning in the bypass ducts 19 and it is important therefore to ensure that the obstruction to normal flow in the ducts caused by the combustion apparatus 22 is as low as practicable. The present invention seeks to reduce such obstruction, firstly by providing a nose member which points upstream and is shaped to permit the oncoming air to divide and flow past it without undue disturbance of the flow, i.e. in a laminar fashion, and secondly by providing adjacent the outer wall of the duct bend a single grid of longerons which is curved to follow the curvature of the outer wall and the general direction of flow through the duct bend. A major portion of the air flow which reaches the combustion apparatus will flow unobstructedly through the major passage between the grid and the inner wall 47 whilst only a minor portion will enter the convergent passage 36.

However, this arrangement by itself does not provide a pilot combustion zone which is sufficiently shielded for stable combustion. Accordingly, when duct burning is required, valves are opened so that air and fuel under sufficiently high pressure is discharged through the opposing outlets 43, 45 into the transverse recess 46, whence an arcuate curtain of fuel and air is injected into the main air flow in the direction of the inner wall 47 of the duct bend. This fuel and air not only provides the combustible mixture for pilot combustion in the zone 52 but also provides a fluid obstacle behind which pilot combustion can be stabilised. An igniter is provided in the zone 52.

For duct burning each combustion apparatus operates in the following manner. A mixture of air and fuel discharged from the recess 46 is ignited to provide a shielded pilot combustion in zone 52. At the same time fuel delivered to the main injectors 51 is discharged through the slots between the longerons to provide the main combustion downstream of the pilot zone 52. Most of that portion of the air which passes into the convergent passage 36 is forced out through the slots, taking up fuel discharged by the injectors 51 and enveloping the longerons which provide continuous flame propagation channels for the main combustion zone. The air pressure in the main combustion zone increases downstream due to the diffuser effect of the duct 19, thus reducing the pressure difference across the slots of the grid. Consequently in order to promote a more uniform mass flow through the grid slots and thus assist combustion, the slots are shaped to increase in width as shown in FIGURES 3 and 4. The remainder of the air which has entered the passage 36 flows along the wall 35 to provide film cooling thereof and escapes downstream between the end supports 37. The grid and the minor flow of air, which enters the passage 36 and either flows rearwards to the end or transversely through the grid slots, together shield the wall 35 from the burning fuel and from overheating.

If desired, a guide vane 55 is provided to combat air flow separation from the inner wall 47 of the bend.

In one embodiment of the invention, compressed air bled from the engine compressor system is used to drive the air turbine of a fuel turbopump. After passage through the air turbine the air may then be further utilised by supplying it through pipe 40 and chamber 42 to the outlets 43 of the nose member in order to provide the stabilising air curtain.

In another modification of the invention, the grid is provided at its upstream end with a device which is adjustable between an inoperative position in which it offers low obstruction to the oncoming gas flow and an operative position for duct burning in which it is expanded to constitute a flame stabiliser. For example the device may comprise a pair of plates which are hinged at their upstream ends along a transverse axis to provide a stabiliser of adjustable V-shape.

What we claim is:

1. In a gas duct, combustion apparatus comprising a grid of longerons provided at one end with a nose member which is in alignment with the adjacent ends of the longerons and shaped to allow substantially laminar flow past it, the nose member having means for providing selectively a sheltered zone for pilot combustion, ducting and at least one fuel injector for supplying pilot fuel to the sheltered zone, ducting and at least one fuel injector for supplying main fuel between the longerons, the fuel injector for the main combustion being supported between the longerons, and wherein the grid of longerons extends along the duct, the grid lying nearer one wall portion of the duct than an opposing wall portion and being arranged to define with the nearer wall portion a convergent minor passage and with the opposing wall portion a major passage, the longerons constituting continuous channels for flame propagation.

2. Combustion apparatus comprising a grid of longerons provided at one end with a nose member which is in alignment with the adjacent ends of the longerons and shaped to allow substantially laminar flow past it, the nose member having means for providing selectively a sheltered zone in said flow, ducting and at least one fuel injector for supplying pilot fuel to the sheltered zone, ducting and at least one fuel injector for supplying main fuel between the longerons, the longerons constituting continuous channels for flame propagation, said main fuel injector being disposed between said longerons.

3. Combustion apparatus comprising a grid of longerons provided at one end with a nose member which is in alignment with the adjacent ends of the longerons and shaped to allow substantially laminar flow past it, the nose member having means for providing selectively a sheltered zone in said flow, ducting and at least one fuel injector for supplying pilot fuel to the sheltered zone, ducting and at least one fuel injector for supplying main fuel between the longerons, the longerons constituting continuous channels for flame propagation, said main fuel injector being disposed between said longerons, the nose member being provided with internal ducting which is selectively connected to a source of compressed air, said ducting connecting at its downstream end with an outlet in the nose member which is arranged to deliver a curtain-like air discharge into the flow, the nose member lying to one side of the grid and including a tapered tail portion through which it is joined to the grid, the discharge outlet being located near the tapered tail portion.

4. In a gas turbine jet propulsion engine including a compressor system, a propulsion nozzle located alongside the compressor system and ducting connecting the compressor system with said propulsion nozzle, combustion apparatus comprising a grid of longerons provided at one end with a nose member which is in alignment with the adjacent ends of the longerons and shaped to allow substantially laminar flow past it, the nose member having means for providing selectively a sheltered zone in said flow, at least one fuel injector for supplying pilot fuel to the sheltered zone, ducting and at least one fuel injector for supplying main fuel between the longerons, the longerons constituting continuous channels for flame propagation, and means for supporting said main fuel injector between said longerons.

5. Combustion apparatus according to claim 1, wherein the said means comprises internal ducting in the nose member which is selectively connected to a source of compressed air, which ducting connects downstream with an outlet which is arranged to deliver a curtain-like air discharge into the major passage.

6. Combustion apparatus according to claim 5, where the nose member has a transverse recess facing the major passage, the wall of the recess being provided with the outlet for the discharge of compressed air and with a further outlet for the discharge of fuel.

5

7. In a gas duct including a bend, combustion apparatus according to claim 1, wherein the apparatus lies in the duct bend nearer to the outer wall of the bend than the inner wall, and the grid of longerons is curved to follow the duct bend.

8. Combustion apparatus according to claim 2, wherein the nose member is provided with internal ducting which is selectively connected to a source of compressed air, which ducting connects at its downstream end with an outlet in the nose member which is arranged to deliver a curtain-like air discharge into the flow.

References Cited

UNITED STATES PATENTS

2,417,445	3/1947	Pinkel	60—39.72	15
2,715,813	8/1955	Holmes	60—39.72	

6

2,780,916	2/1957	Collins	60—39.72
2,799,991	7/1957	Conrad	60—39.72
2,974,488	3/1961	Eggers	60—39.72
3,181,293	5/1965	Orchard	60—224
3,245,218	4/1966	Marchant	60—39.72
3,292,375	12/1966	Wilde	60—224
3,300,976	1/1967	Coplin	60—224

FOREIGN PATENTS

723,010	2/1955	Great Britain.
---------	--------	----------------

CARLTON R. CROYLE, Primary Examiner
D. HART, Assistant Examiner

U.S. Cl. X.R.

60—39.65, 39.72, 39.74