Dec. 23, 1969 G. T. RIECKE 3,485,045

AFTERBURNER FOR BYPASS TURBINE ENGINE

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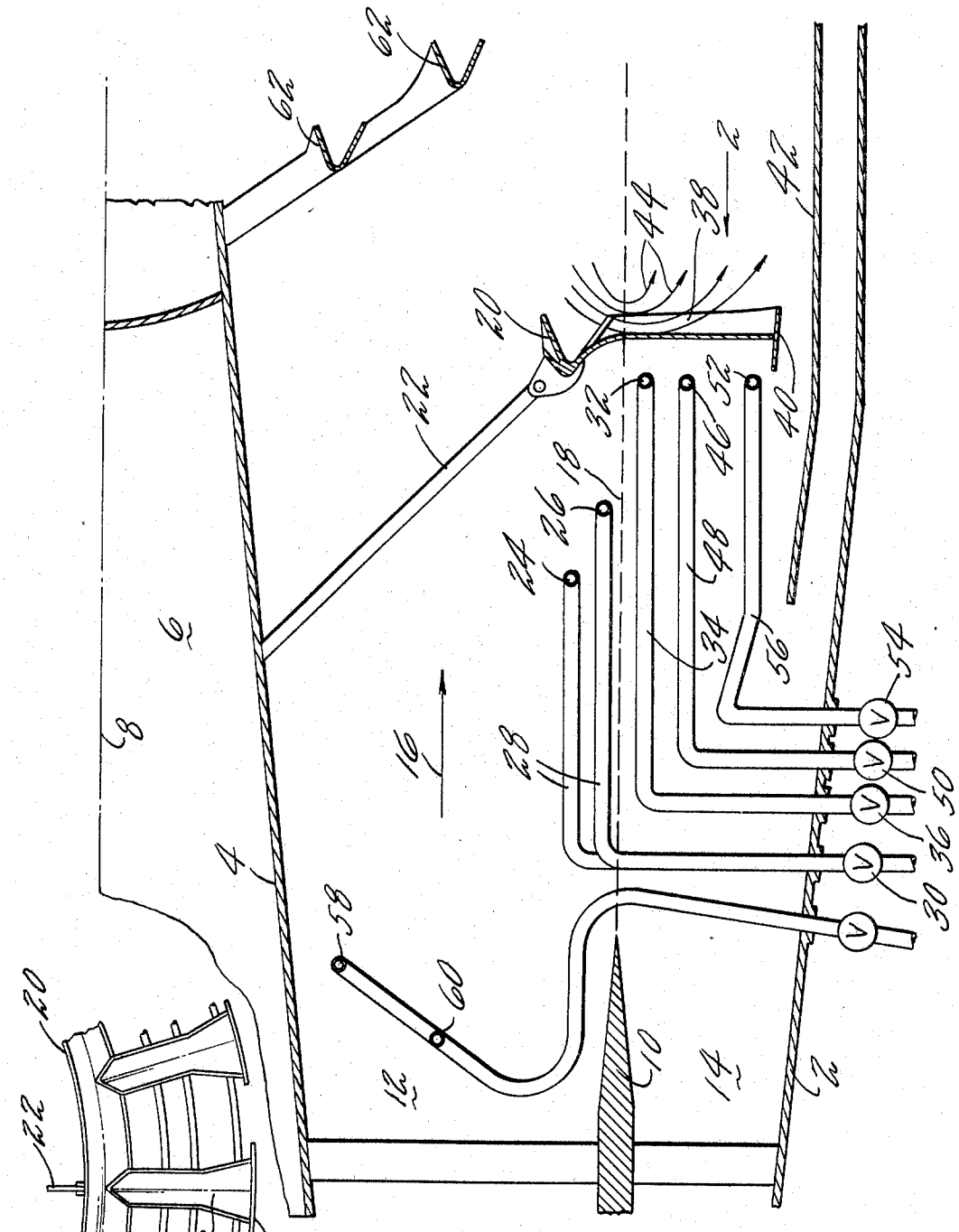


FIG. 2

FIG. 1

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FIG. 3

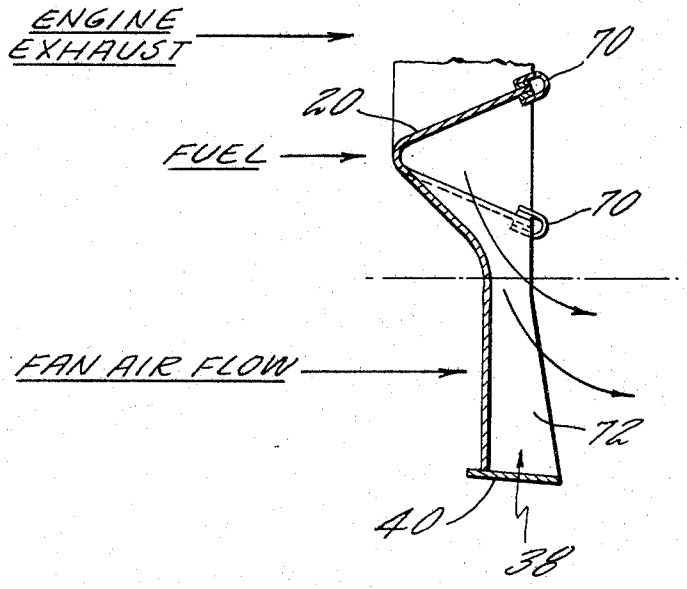
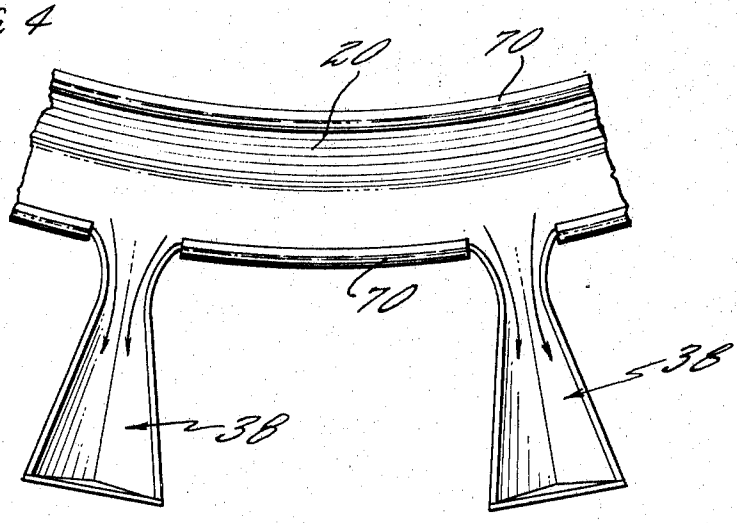


FIG. 4



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AFTERBURNER FOR BYPASS TURBINE ENGINE

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Continuation-in-part of application Ser. No. 632,144, Apr. 7, 1967. This application July 23, 1968, Ser. No. 747,783

Int. Cl. F02g 3/00

U.S. Cl. 60—39.72 5 Claims

ABSTRACT OF THE DISCLOSURE

An afterburner for a bypass gas turbine engine having primary and secondary fuel nozzles and means for controlling flow to each individual ring of fuel nozzles. Cooperating therewith for combustion in both the engine exhaust flow and the bypass flow is a flameholder construction comprising a circumferential primary or pilot flameholder and cooperating radially extending flameholders. The circumferential flameholders include a plurality of scoops which assist in the transfer of flame from the pilot or circumferential flameholder to the radial flameholders. The radially extending flameholders are positioned downstream of the rings of fuel nozzles, thus providing a construction of controllable combustion zones acorss the entire bypass flow.

This is a continuation-in-part of Riecke, Ser. No. 632,144, filed Apr. 7, 1967 and now abandoned.

This application is reported as a Subject Invention under Government contract NOW 65-0546f.

BACKGROUND OF THE INVENTION

The idea of afterburners for both the engine exhaust and the bypass flow is old, for example, in Nelson 3,269,115 in which the flameholding is accomplished by circumferentially arranged gutter-type flameholders concentric to one another, with one of the gutters located in the bypass flow. This is effective where there is only a single zone of burning in the cool bypass flow but flame propagation into this gutter has not been adequate in later concepts where there are several concentric zones of burning in the bypass flow. Further, when there is no burning in the bypass flow the gutter therein provides a series resistance to the flow that substantially reduces the efficiency of the powerplant.

Even with the relatively numerous flamespreaders projecting outwardly toward the bypass flameholder, the result has been unsatisfactory where multiple burning zones exist in the bypass since the combustion is not carried effectively radially outward into the several zones. These several zones of burning have been found necessary in improving the temperature profile at the thrust nozzle downstream of the afterburner in improving the efficiency of high-performance engines.

SUMMARY OF THE INVENTION

The principal feature of this invention is an arrangement of radial gutter-type flameholders mounted on and extending from the circular gutter-type flameholder in the primary combustion zone, these radial flameholders extending across a plurality of combustion zones in the bypass portion of the engine. Another feature, more broadly, is the use of radial gutters for the propagation of flame from one zone of gas flow in the duct to a second zone, with these radial gutters constituting the sole flameholding structure in the second zone. This is particularly useful where the second gas flow zone is relatively cool and the first zone gas flow is relatively hot.

In accordance with the invention, the duct in which there are two concentric zones of gas flow at different temperatures, has a circular gutter-type flameholder in the hotter zone where primary combustion occurs, with radial gutter-type flameholders extending from the circular flameholder into and across the other zone of gas flow to constitute a flame transfer device and to serve as the sole flameholding mechanism in the other zone when burning occurs therein. To assist in the flame transfer from the circumferential flameholder to the radial flameholder a scoop is positioned on the circumferential flameholder. These scoops provide a twofold purpose in that they improve the stability of the pilot or circumferential flameholder at lean fuel-air ratios by mechanically forcing the approaching fuel-air mixture into a recirculation zone, and secondly the scoops increase the pressure behind the radial flameholder thereby creating a positive pressure differential which assists in causing the gases to flow from the circumferential flameholder to the radial flameholder.

Positioned upstream of the flameholder construction is a plurality of concentric fuel nozzle rings. Each of these rings is suitably controlled by a sequence valve so that various combustion zones in different sequences may be employed.

The selection of the successive zones of burning, as above described, maintains under all conditions a favorable temperature profile at the thrust nozzle downstream of the afterburner.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is a diagrammatic view of an afterburner configuration embodying the invention.

FIGURE 2 is a fragmentary view looking axially in the direction of the arrow **2** of FIGURE 1.

FIGURE 3 is a fragmentary sectional view of the flameholder construction showing the scoops positioned on the circumferential flameholder.

FIGURE 4 is a fragmentary view looking axially in the direction of the arrow **2** of FIGURE 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention is shown in an afterburner for a bypass gas turbine engine as disclosed by way of example in the Nelson Patent No. 3,269,114, above referred to. For the purpose of this invention, it is sufficient to note that downstream of the turbine there is an outer afterburner casing **2** and an inner afterburner wall **4** formed on a central plug **6**. The centerline of the afterburner is shown at **8**. Between the casing or outer wall **2** and the inner wall **4** is the downstream end of an intermediate wall **10** which to this point in the engine has divided the inner passage **12** for engine exhaust gas from the outer passage **14** for the air bypassed around the engine. The gases in both of these passages are moving axially in the direction of the arrow **16** and there is effectively a boundary zone **18** between these two flows even though there is no mechanical wall dividing the flows. Obviously, further downstream, the two flows intermix to a substantial extent but through the portion of the afterburner shown the boundary remains very well established with the turbine exhaust gas having a substantially higher temperature than the gas outside of the bounary zone **18**.

For the purpose of combustion within the afterburner, a gutter-type flameholder **20** is supported in the exhaust gas duct closer to the boundary zone **18** than to the inner wall **4**, as shown. This flameholder may be supported by suitable struts **22** extending from the inner wall **4**. Upstream of the flameholder **20** are two rings of fuel nozzles **24** and **26** of the type shown, for example, in the Nelson Patent 3,269,115. Fuel is supplied to these rings **24** from

supply pipes 28 supported in the outer casing 2 and having a control valve 30 therein. Primary afterburning takes place within the afterburner when fuel is supplied to the rings 24 and 26 and combustion takes place downstream of the flameholder 20.

When more burning in the afterburner is desired than is supplied by the fuel from the rings 24 and 26, a third ring of nozzles 32 provides a second zone of combustion. This ring 32 is supplied with fuel through its supply pipe 34 with the control valve 36 therein. The ring 32 is just outside of the boundary zone 18 so that this necessitates combustion in the colder air bypassed around the engine. To provide effective combustion, the flameholder 20 carries a plurality of radially extending gutter-type flameholders 38 that extend outwardly from the gutter 20 and intercommunicate therewith, as shown. These radial gutters extend substantially the entire radial distance across the bypass air flow and terminate in end plates 40 which, as shown, are larger than the end of the gutter and are positioned in alignment with the air flow through the afterburner. The plate 40 preferably extends upstream from the gutter a short distance, as shown.

In the particular version of the afterburner shown in the drawing, there is a liner 42 which extends from a point upstream of the flameholder to a point downstream of and past the combustion chamber portion of the afterburner. This linear is closely spaced from the outer wall 2 and the end plate for the gutter would, as shown, be spaced inwardly from this liner.

The effect of the intercommunicating radial gutters 38 with the circumferential flameholder or gutter 20 is to cause a circulation of burning fuel and air out of the primary combustion zone as indicated by the arrows 44 and radially outward through the gutters 40 to flow downstream within the portion of the duct occupied by the bypassed air. Thus when fuel is admitted to the ring of nozzles 32, the fuel mixing with the cooler air is ignited by the products of combustion being circulated as the arrows 44 indicate. It may be noted that the radial afterburner or gutters increase in cross-sectional area toward the outer wall of the afterburner and thus become somewhat wider and deeper toward the outer ends.

For additional combustion within the afterburner there is a third zone of burning provided by a ring of nozzles 46 surrounding and radially outward of the ring of nozzles 32. The ring 46 is supplied by a pipe 48 having a valve 50 for controlling the admission of fuel to the nozzles.

A further row of nozzles 52 surrounds and is located radially outward of the row of nozzles 46. This ring of nozzles is closely adjacent to the end plates 40 and the radial gutters and provides a fourth zone of burning within the afterburner, being the third zone of burning within the bypassed air. A valve 54 controls the supply of fuel through the supply pipe 56 to the ring of nozzles 52. The fuel and air mixture from all of the rings 32, 46 and 52 will be ignited by the radial outward circulation of the products of combustion through the radial gutters, all as represented by the arrows 44.

In operation it will be obvious that the supply of fuel to the several nozzle rings will be suitably controlled from the pilot's compartment by a sequence valve or a sequence device which will first deliver fuel to the rings 24 and 26 and thereafter as additional power, if necessary, will open in sequence the valves 36, 50 and 54 so that zoning may occur in only the first zone or in the first zone with each of the zones 2, 3 and 4 added as is necessary.

Although not a part of the present invention, it may be noted that, for maximum afterburning within the engine, additional rings 58 and 60 of fuel nozzles may be provided within the inner duct 12 and radially inward of the rings 24 and 26 thereby supplying fuel to a greater portion of the width of the inner duct 12. Suitable flameholders 62 serve to provide the necessary turbulence for combustion of the fuel from the nozzle rings 58 and 60.

The selection of the successive zones of burning, as above described, maintains under all conditions a favorable temperature profile at the thrust nozzle downstream of the afterburner.

Referring now to FIGURES 3 and 4 the construction of the present invention is shown employing scoops 70 on the inner and outer diameter of the circumferential or primary flameholder 20. As illustrated in this embodiment, these scoops 70 extend around the entire circumference and serve a twofold purpose. First, they cause a positive transfer of flame to occur from the pilot or primary flameholder 20 to the radial flameholders 38, and secondly, scoops 70 improve the stability of the pilot flameholder at lean fuel-air ratios by mechanically forcing the approaching fuel-air mixture into recirculation zone 72. It has been determined that by placing scoop 70 on pilot flameholder 20 that the pressure behind the flameholder construction is increased and that a positive pressure differential is created which causes a positive flow of hot gases from the pilot flameholder 20 to the radial flameholder 38.

I claim:

1. Combustion equipment for a duct having two zones of gas flow therein, one gas flow being relatively cool and the other relatively warm, the equipment including a plurality of concentric rings of fuel nozzles, one ring, for a primary flow being located in the warm zone and relatively close to the boundary between the zones, the other rings, for secondary flow, being located in the cool zone, each ring having means for individually controlling the flow therefrom, and a flameholder including a flameholder ring positioned downstream of and substantially axial alignment with the primary nozzle ring, the ring having scoops on its inner diameter and outer diameter for assisting flame to be transferred from the flameholder ring to a plurality of radial gutter-type flameholders, the scoops being generally U-shaped in cross-section with the apex of the U facing downstream these latter flameholders being mounted on and extending from the flameholder ring, said radial gutters extending across the boundary between the zones and across the cool zone to be located directly downstream of said other rings.

2. Combustion equipment as in claim 1 in which the flameholder ring is gutter-type and the gutters of the radial flameholders intersect and communicate with the gutter of the flameholder ring.

3. Combustion equipment as in claim 1 in which the gutters of the radial flameholders increase in cross-sectional area with an increase in the distance from the flameholder ring.

4. Combustion equipment as in claim 1 in which the end of each radial flameholder remote from the flameholder ring is closed by a plate substantially larger than the gutter.

5. Combustion equipment as in claim 1 in which the fuel flow to each of the fuel rings is individually controlled such that the primary fuel ring may be in operation without the others.

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SAMUEL FEINBERG, Primary Examiner

U.S. Cl. X.R.

60—39.74