Dec. 2, 1958 E. W. SPEARS, JR 2,862,359

FUEL MANIFOLD AND FLAMEHOLDER IN COMBUSTION APPARATUS FOR JET ENGINES

Filed Oct. 28, 1952 3 Sheets-Sheet 1

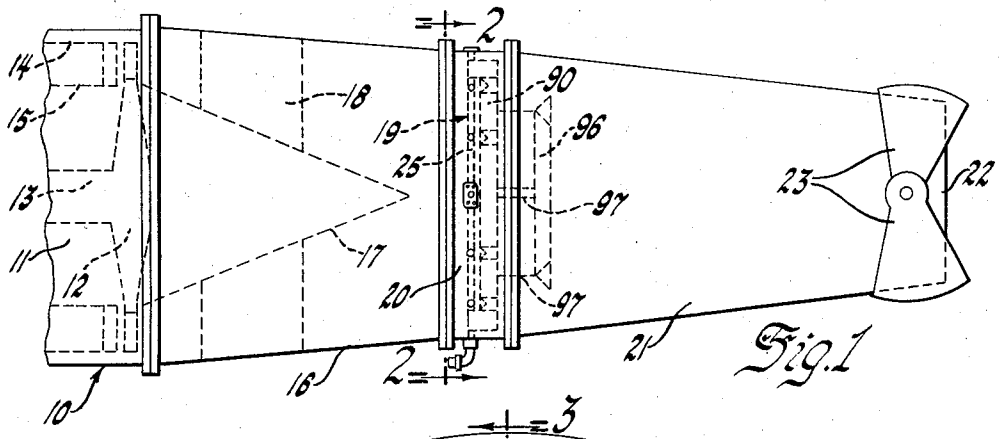


Fig. 1

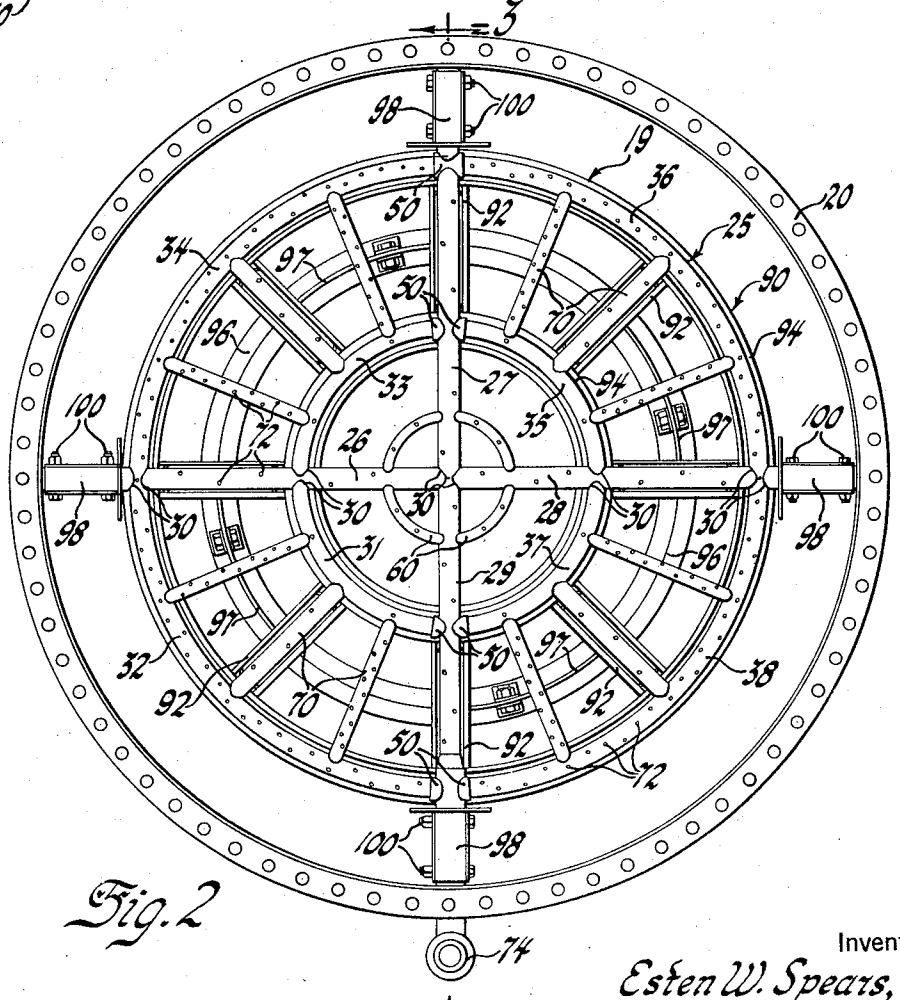


Fig. 2

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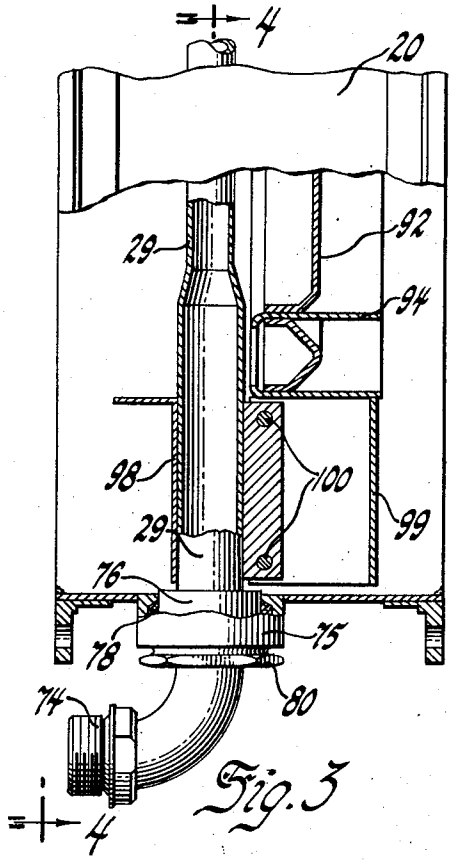


Fig. 3

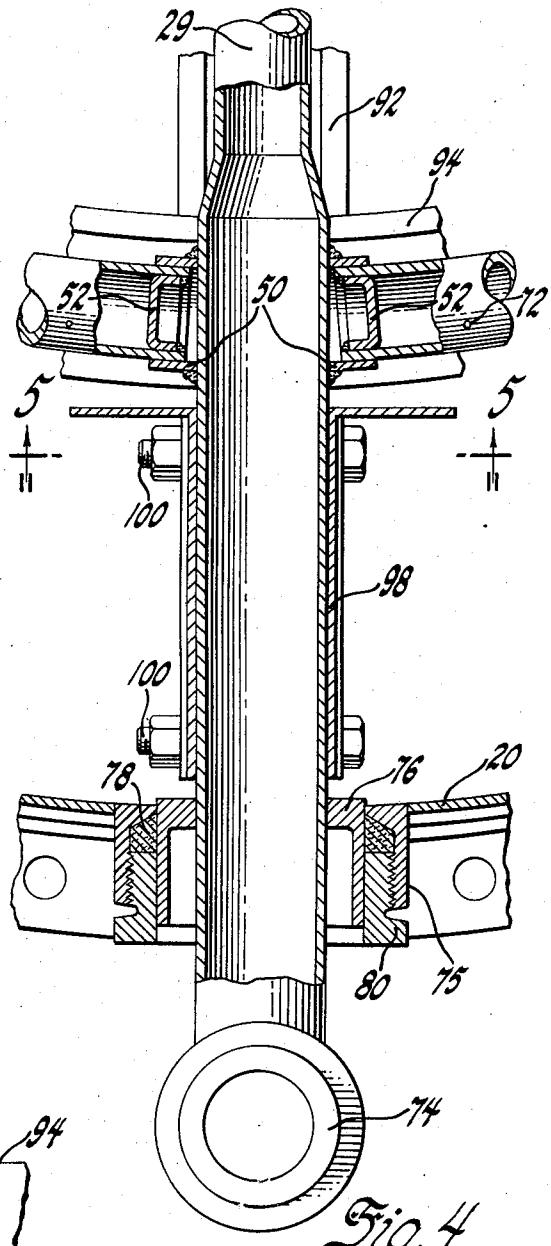


Fig. 4

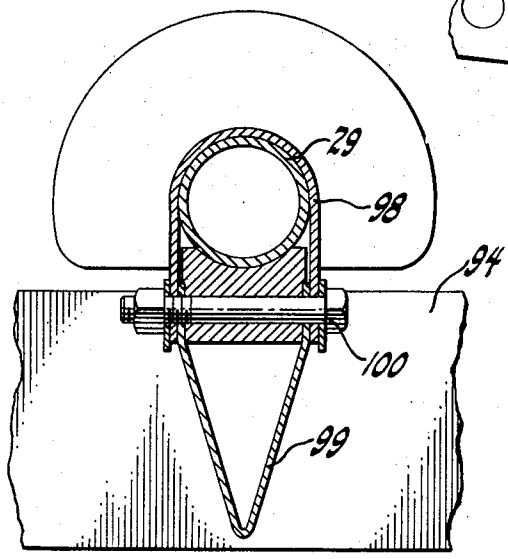


Fig. 5

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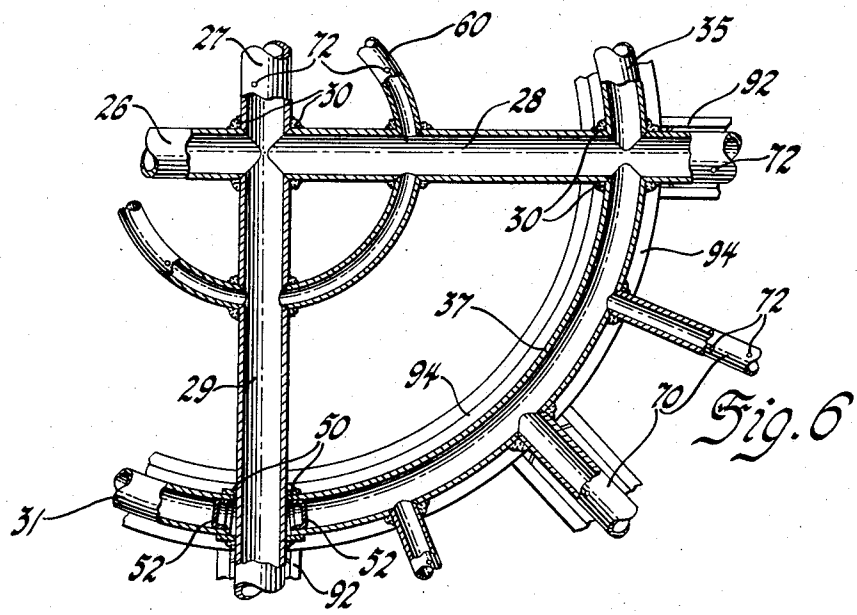


Fig. 6

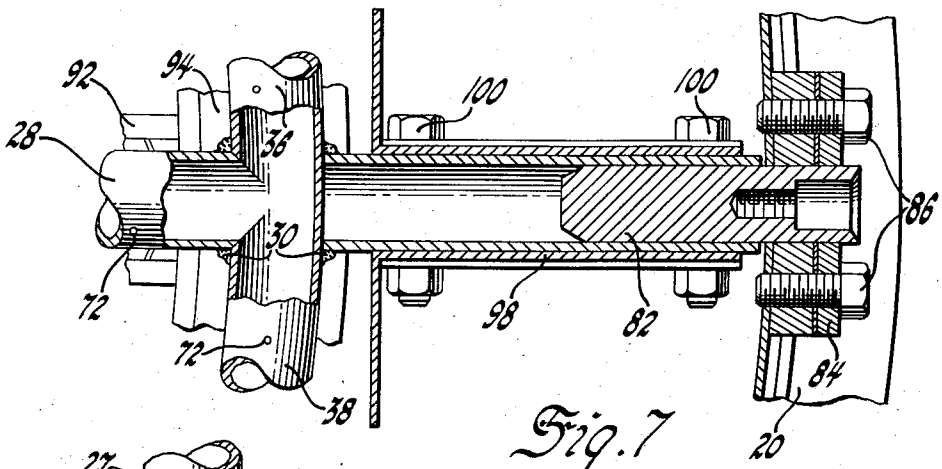


Fig. 7

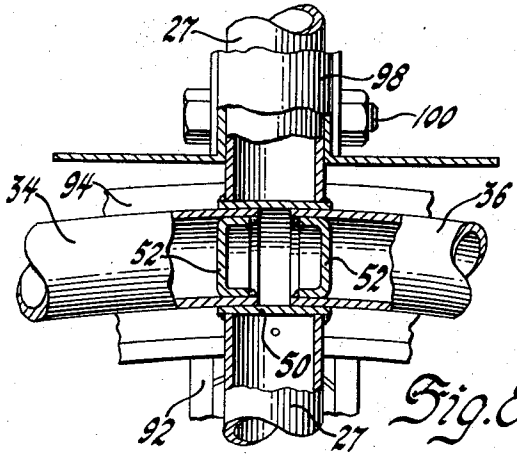


Fig. 8

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United States Patent Office

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FUEL MANIFOLD AND FLAMEHOLDER IN COMBUSTION APPARATUS FOR JET ENGINES

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Application October 28, 1952, Serial No. 317,221

2 Claims. (Cl. 60—39.72)

This invention relates to combustion apparatus and is particularly adapted for use in afterburners for gas turbine jet propulsion engines. The invention will be described in terms of its embodiment in an afterburner although the invention is not limited to this field of application.

The exhaust gases of a gas turbine jet engine contain large quantities of free oxygen, and the thrust of the engine may be very considerably increased by burning fuel in these exhaust gases so as to increase the temperature and thereby the velocity of the exhaust gases.

The provision of suitable afterburners presents problems of great difficulty. Since the gases entering the afterburner may be at temperatures of the order of 1300° F., and the afterburner structure is subjected to heat radiation from the flame in the burner, many failures of afterburner structures have been experienced in practice. Troubles with afterburner failures arise not only from the high temperatures but from rapid temperature changes as the engine goes into or out of service, or when flameouts occur. These radical temperature changes are particularly pronounced in the fuel manifold, as will be apparent when it is considered that cold fuel is suddenly poured into a manifold at perhaps 1300° F. when the afterburner is put into operation. The invention is particularly concerned with the provision of a structure such that the parts are free to expand relatively as such temperature changes occur and in which destructive stresses are avoided.

This invention is directed to an afterburner which is highly advantageous from the standpoint of good combustion, long life, and light weight, and which offers a minimum of obstruction to gas flow.

The principal objects of the invention are to improve the performance of jet propulsion engines and to provide an improved combustion apparatus adapted for jet propulsion power plants, particularly as an afterburner for turbojet engines. More specific objects are to provide such an apparatus which opposes a minimum resistance to gas flow, which is light in weight, and which is particularly adapted to withstand the high temperatures, rapid temperature changes, and vibration encountered.

The manner in which these objects are accomplished and the advantages of the invention will be apparent to those skilled in the art from the succeeding detailed description of the preferred embodiment of the invention.

Referring to the drawings:

Fig. 1 is a partial side elevation of a turbojet engine illustrating the installation and environment of the afterburner.

Fig. 2 is a front elevation of the afterburner taken on the plane indicated by line 2—2 of Fig. 1.

Fig. 3 is an enlarged partial side elevation partially broken away to the plane indicated by line 3—3 of Fig. 2.

Fig. 4 is an enlarged partial front elevation partially broken away to the plane indicated by line 4—4 of Fig. 3.

Fig. 5 is a sectional view taken on the plane indicated by line 5—5 of Fig. 4.

Figs. 6, 7 and 8 are enlarged partial elevations partially broken away of Fig. 2.

Referring first to Fig. 1, a turbojet engine 10 is illustrated as comprising a cylindrical duct 11 within which is mounted a turbine wheel 12 on a shaft 13. Combustion gases are supplied to the turbine from a suitable combustion apparatus through an annular duct including a outer wall 14 and an inner wall 15.

The gases exhaust from the turbine through an exhaust duct including an annular outer wall 16 and an inner conical wall 17 supported therefrom by radial struts 18. The exhaust passage thus increases in area downstream of the turbine to decelerate the exhaust gases. In a turbojet engine without an afterburner the exhaust duct ordinarily terminates in a fixed converging nozzle from which the propulsive jet issues.

In order to augment the thrust of the engine for emergency conditions, an afterburner or reheat burner generally indicated at 19 is provided to introduce and burn fuel in the exhaust gases to increase the temperature of the gases. As illustrated, the afterburner 19 is secured in a cylindrical casing 20 which is bolted to a cylindrical casing 21 and to the exhaust duct 16 of the turbine. The duct 21 provides a combustion chamber in which fuel introduced by the afterburner 19 is burned, and terminates in a jet exhaust nozzle 22. Hinged valves 23 or other means are provided in accordance with known practice to vary the effective area of the exhaust nozzle to accommodate the engine to normal operation or afterburning operation.

Since this general configuration is known to those skilled in the art and the details of the structures illustrated in Fig. 1 other than the afterburner assembly are immaterial to the invention, they will not be further described.

As is understood by those skilled in the art, the afterburner operates on hot turbine exhaust gases, only a small part of the oxygen of which has been combined with fuel, which gases are flowing at a relatively rapid rate such as to require special provisions for the maintenance of a flame in the exhaust. While various structures for maintaining combustion in turbine exhaust have been proposed, I believe that to be described to be particularly advantageous for this purpose.

Referring now to Figs. 1 and 2, the casings 20 and 21 are seen to be circular, which is the preferred form. The flanges of the casing 20 not only serve as means for mounting the afterburner in the exhaust ducting but also strengthen the casing, which is of large diameter, usually of the order of two or three feet. The afterburner 19 includes a fuel manifold 25 secured to the casing 20 and a flameholder 90 secured thereto, the fuel manifold being so constructed and supported by the casing as to have free differential thermal expansion and contraction relative thereto and the flameholder being similarly supported by the fuel manifold. The fuel manifold 25 primarily comprises four regularly spaced radial conduits 26 through 29 which are fixed together at their

inner ends by welds **30** for fuel transfer therebetween, and eight concentric arcuate conduits **31** through **38** each of which is welded at one end by welds **30** to one of the radial conduits for fuel transfer therefrom and each of which is slidably supported at its other end by a socket **50** welded on an adjacent one of the radial conduits for free differential thermal expansion and contraction relative thereto. The free ends of the arcuate conduits are sealed by welding in plugs **52** (Figs. 4, 6 and 8). A loose-slip fit is provided between the free ends and the sockets **50**, and an expansion clearance is provided between the free ends and the radial conduits. The arcuate conduits are thus free to expand and contract but will not be bent out of the plane of the manifold due to the gas load. Four small arcuate conduits **60** interconnect the radial conduits near their common center, and twelve short radial conduits **70** interconnect the arcuate conduits **31** to **38** without any special provision for differential thermal expansion therebetween, such special provision having been found unnecessary by actual test.

The radial and arcuate conduits are provided with a multiplicity of drilled passages or outlet orifices **72** through their upstream and downstream walls so that fuel may be sprayed over substantially the entire flow area of the turbine exhaust. Fuel is introduced into the afterburner through a threaded coupling **74** formed on the outer end of the radial conduit **29** which extends through the wall of casing **20** as best seen in Figs. 3 and 4. The radial conduits **26** through **29** are slidably supported at their outer ends by casing **20** for free differential thermal expansion relative thereto so that they may expand and contract radially, the radial conduits forming a cross that will remain centered in the casing. The radial conduit **29** is slidably supported in a boss **75** on the casing by a ring **76**, asbestos crush seal **78**, and a threaded sleeve **80** while the radial conduits **26** through **28** are slidably supported in the casing by radial pins **82** (Fig. 7) which are provided with flanged ends **84** secured to the casing by bolts **86**. The radial conduits **26** through **28** are closed at their outer ends by the outer arcuate conduits or sockets **50** to prevent fuel leakage at the slidable pin support.

Referring to Figs. 1 and 2, the flameholder **90** is located in the casing **20** immediately downstream of the fuel manifold **25** and is of substantially the same configuration including radial channels **92** and concentric ring channels **94**. The channels **92** and **94** are of substantially U or W-shaped section with the closed side of the channel section facing upstream and the channels create sufficient turbulence behind the fuel manifold conduits to hold combustion. An auxiliary ring channel **96** (Fig. 1) of V-shaped or similar section may be supported from the radial channels **92** by brackets **97** to promote additional downstream turbulence if desired. The flameholder **90** is slidably supported by the fuel manifold **25** for free differential thermal expansion relative thereto, the flameholder being supported by the radial conduits **26** through **29**. The flameholder includes extensions **99** secured to the radial conduits by radially extending straps **98** and bolts **100** as best seen in Figs. 3 through 5. The straps **98** are loose enough to permit free radial expansion and contraction of the flameholder while maintaining it centered in the turbine exhaust duct.

The operation of the afterburner is as follows: With the gas turbine engine in operation and the exhaust gases flowing through the afterburner, and with the jet nozzle flaps in their small area position, fuel under pressure is introduced to the fuel manifold and sprayed therefrom. The fuel is ignited by the heat of the turbine exhaust gases or a suitable igniter, the flameholder creating turbulence to hold the flame which burns rearwardly thereof. Immediately upon initiation of afterburner combustion, the jet nozzle flaps are opened by suitable means to their full area position. The added energy imparted by the afterburner combustion increases the thrust of the jet propulsion engine. To terminate afterburning, the fuel supply is shut off and the jet nozzle flaps are returned to their minimum area position.

Any suitable manual or automatic control means for the fuel supply, ignition, and variable area nozzle may be employed. My invention is not concerned with such controls. The afterburner may be constructed of stainless steel or similar high strength and temperature resistant material such as are generally employed in jet engine construction.

While the invention has been specifically described as an afterburner for a turbojet engine, it will be apparent that the principles, and, to a large extent, the structure illustrated, may be applied to other combustion apparatus. Fields for which the invention seems particularly suited include combustion apparatus for industrial gas turbines employing combustion chambers of large diameter, and ramjet aircraft engines.

It will be apparent that the invention, and particularly the preferred embodiment described above, is particularly well suited to withstand temperature changes in gas turbine engines and the like and to provide efficient combustion with a minimum of interference to gas flow.

While the preferred embodiment of the invention has been described fully in order to explain the principles of the invention, it is to be understood that modifications in structure may be made by the exercise of skill in the art within the scope of the invention, which is not to be regarded as limited by the detailed description of the preferred embodiment.

I claim:

1. A combustion apparatus comprising, in combination, an annular duct adapted for flow of combustion-supporting gas, a fuel manifold in said duct comprising a plurality of regularly spaced radial conduits welded together for fuel transfer therebetween at their inner ends, said radial conduits being slidably supported at their outer ends by said duct for free differential thermal expansion relative thereto so that said radial conduits may expand and contract radially, said radial conduits forming a cross in said duct, at least one of said outer ends extending slidably through said duct and open for fuel introduction and the remaining outer ends being closed and being slidably supported by radial pins extending inwardly from said duct, a plurality of concentric arcuate conduits each having an open end welded to an intermediate portion of one of said radial conduits for fuel transfer therefrom and a closed end slidably supported by the next of said radial conduits in a circumferential sense whereby said arcuate conduits may expand and contract transversely of said radial conduits and thus have free differential thermal expansion relative thereto despite said rigid open end weldments with said radial conduits, said arcuate conduits forming a pair of radially spaced rings in said duct, and means defining fuel outlets on said conduits.

2. A combustion apparatus comprising, in combination, an annular duct adapted for flow of combustion-supporting gas, a fuel manifold in said duct comprising a plurality of regularly spaced radial conduits welded together for fuel transfer therebetween at their inner ends, said radial conduits being slidably supported at their outer ends by said duct for free differential thermal expansion relative thereto so that said radial conduits may expand and contract radially, said radial conduits forming a cross in said duct, at least one of said outer ends extending slidably through said duct and open for fuel introduction and the remaining outer ends being closed and being slidably supported by radial pins extending inwardly from said duct, a plurality of concentric arcuate conduits each having an open end welded to an intermediate portion of one of said radial conduits for fuel transfer therefrom and a closed end slidably supported by the next of said radial conduits in a circumferential sense whereby said arcuate conduits may

expand and contract transversely of said radial conduits and thus have free differential thermal expansion relative thereto despite said rigid open end weldments with said radial conduits, said arcuate conduits forming a pair of radially spaced rings in said duct, means defining fuel outlets on each said conduits, and a flameholder in said duct immediately downstream of said fuel manifold, said flameholder being of U-shaped channel section with the closed side of said channel section facing upstream, said flameholder being aligned with said fuel manifold and of substantially the same configuration including radial channels and ring channels, said flameholder being slidably supported by straps on said radial conduits for free differential thermal expansion relative thereto so that said flameholder may expand and contract radially.

References Cited in the file of this patent

UNITED STATES PATENTS

1,302,778	Drewry	May 6, 1919
2,540,594	Price	Feb. 6, 1951
2,701,444	Day	Feb. 8, 1955
2,714,287	Carr	Aug. 2, 1955