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JET ENGINE BURNER CONSTRUCTION

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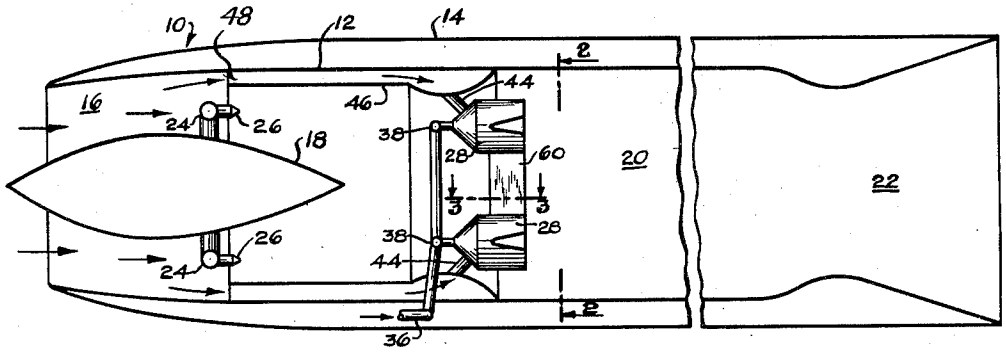


FIG. 1

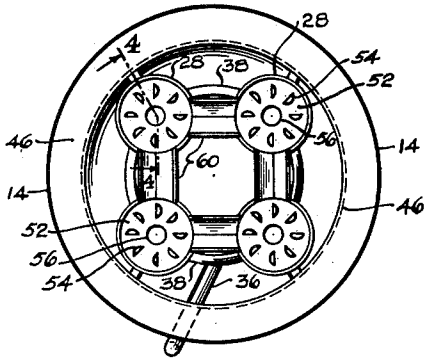


FIG. 2

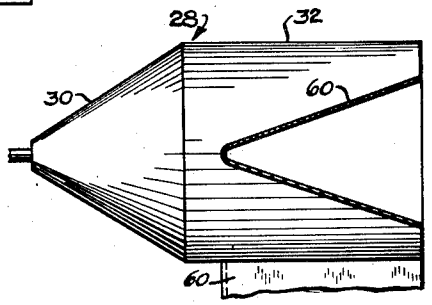


FIG. 3

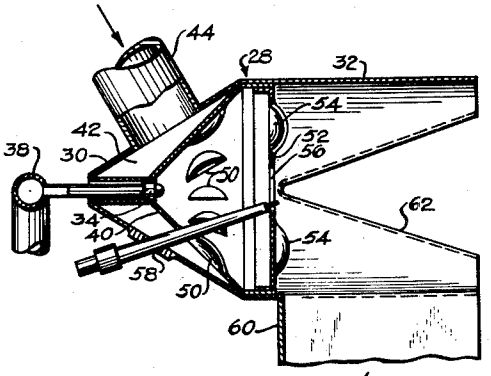


FIG. 4

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JET ENGINE BURNER CONSTRUCTION

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12 Claims. (Cl. 60—39.72)

This invention relates to combustion apparatus and is particularly directed to combustion apparatus for jet engines.

Because of the high velocity of flow through the combuston chamber of a jet engine, particularly through the combustion chamber of the ram jet engine, it is common to provide one or more pilot burners for igniting the main combustion mixture. Such pilot burners are generally interconnected by flame cross-over tubes whereby a flame at one pilot burner is propagated through a cross-over tube to another pilot burner to ignite or at least to help ignite this latter burner. The use of such flame cross-over tubes makes it unnecessary to provide a separate igniter for each pilot burner. On the other hand if a separate igniter is provided for each pilot burner then the flame cross-over tubes insure ignition or re-ignition of the pilot burners even if some of the igniters should fail to operate. With a conventional flame cross-over tube, however, the downstream wall of the tube may be exposed and subjected to burning gases on both its inner and outer sides with the result that said downstream wall tends to burn out.

An object of the present invention comprises the provision of new and improved means for propagating a flame across a combustion mixture. In accordance with the present invention, the conventional flame cross-over tubes of the prior art are replaced by V-shaped gutters or channel members disposed so that the apex of each V-shaped gutter is directed upstream in the flow path of the combustion mixture and in addition the two ends of the channel of said V-shaped gutter each open into a pilot burner tube with the apex of the channel disposed adjacent to the flame holder means of said pilot burner tubes. It is known that a V-shaped gutter having its apex directed upstream in the flow path of a combustible mixture will function as a flame holder. It has been found that a V-shaped gutter disposed in accordance with the present invention in addition to functioning as a flame holder will also function as a flame cross-over tube between the pilot burners at its ends. That is, each V-shaped gutter of the present invention has a dual function in that it functions both as a flame holder and as a flame cross-over tube thereby simplifying the structure of the combustion apparatus and eliminating the obstruction otherwise offered by conventional flame cross-over tubes to flow thereover. Furthermore unlike conventional flame cross-over tubes, a V-shaped gutter has no downstream wall to burn out.

Other objects of the invention will become apparent from reading the annexed detailed description in connection with the drawing in which:

Fig. 1 is a diagrammatic view of a ram jet engine embodying the invention;

Figs. 2 and 3 are sectional views taken along lines 2—2 and 3—3 respectively of Fig. 1; and

Fig. 4 is a sectional view taken along line 4—4 of Fig. 2.

Referring now to the drawing, a ram jet engine is

schematically indicated by reference numeral 10, said engine comprising an open-ended duct 12 disposed within an outer casing 14. The duct 12 has a forwardly directed annular air entrance opening 16 formed by a center body 18 co-axially supported within said duct adjacent to its forward end. Various auxiliary equipment of the engine, as for example fuel and oil pumps and their controls, are generally supported within the center body 18. The duct 12 also includes a combustion chamber 20 intermediate its ends and a nozzle 22 at its rear end from which the combustion chamber gases discharge to provide the power plant with forward propulsive thrust. Fuel is supplied from a manifold 24 through a plurality of fuel nozzles 26, said fuel mixing with the air entering the duct 12 to provide a combustible mixture for ignition in the combustion chamber 20.

A plurality of pilot burners 28 are supported at the entrance to the combustion chamber 20. Four such pilot burners are illustrated although the invention is obviously not limited to any particular number of pilot burners. The pilot burners 28 are laterally spaced relative to the direction of flow through the duct 12 and each pilot burner 28 comprises a conical upstream end 30 and a cylindrical tube 32 extending downstream therefrom. A fuel nozzle 34 is supported at the upstream end of each pilot burner and fuel is supplied to said nozzles from a supply conduit 36 and manifold 38. Each pilot burner 28 also has an internal conical wall 40 extending downstream from its fuel nozzle 34 thereby forming an annular space 42 about said nozzle. Combustion air for the pilot burners is supplied to each pilot burner space 42 through conduits 44 from an annular manifold 46. The annular manifold 46 is disposed at the outer periphery of the duct 12 and has an open upstream end 48 for receiving air from the duct 12. The open end 48 of the air manifold 46 for the pilot burners is disposed sufficiently far upstream so that fuel from the main fuel nozzles 26 does not enter said manifold.

The internal conical wall 40 of each pilot burner is provided with a plurality of circumferentially-spaced slots 50 through which air enters the pilot burner from its annular space 42 for mixture with the pilot burner fuel. Preferably, the slots 50 are arranged to impart a swirling motion to the entering air to help obtain a thorough mixture of pilot burner fuel and air. Each pilot burner also has a flame holder disc 52 disposed adjacent the upstream end of its tube 32. Each flame holder disc 52 has a plurality of slots 54 and a central opening 56 through which combustion mixture enters the pilot burner tube 32. The slots 54 are also arranged to impart a swirling motion preferably in a rotative direction opposite to that imparted by the slots 50. At least one of the pilot burners is provided with a spark plug 58 having an electrode projecting into the central opening 56 of a flame holder disc 52 for ignition of the associated pilot burner. As will appear, the invention is not limited to the specific pilot burner structure described. For example, other forms of flame holder means could be substituted for the flame holder discs 52.

Upon ignition of a pilot burner, its flame burns in the pilot burner tube 32 and out the open end of said tube for igniting the main combustion mixture. In accordance with the invention, the pilot burner tubes are interconnected by gutters or open-sided channel members 60 of V-shaped cross-section with the apex or closed side of each channel member being directed in an upstream direction. For this purpose, the side of each pilot burner tube 32 facing an adjacent tube 32 is provided with a V-shaped opening or slot 62 having its apex adjacent the flame holder disc 52 with the sides of said slot extending to the open end of said tube. The ends of each channel

member 60 are secured to their respective pilot burner tubes 32 in alinement with the V-shaped slots 62 in said tubes. In this way each pilot burner tube 32 is interconnected with the other tubes through said channel members. It has been found that such channel members function as flame cross-over tubes to propagate a flame therealong from one pilot burner to another. Thus upon ignition of one pilot burner, a flame will be propagated from said pilot burner through its V-shaped channel members 60 to the adjacent pilot burners for ignition of the adjacent pilot burners.

The main combustion mixture flows over the sidewalls of the V-shaped channel members 60 from the closed side or apex of said members whereby said members provide a sheltered region on their downstream or open sides and as a result they function as flame holders. The use of flame holders comprising V-shaped channel members extending laterally from a pilot burner or burners is well known in the art. In said prior art, however, separate flame cross-over tubes were provided, the V-shaped flame holder members although extending laterally from the pilot burners were disposed at the downstream ends of said pilot burners so that even if a flame were propagated along said V-shaped members from one pilot burner to another said flame could not function to ignite said latter pilot burner because of its distance from the flame holder means of said latter pilot burner. In accordance with the present invention, the V-shaped flame holder members 60 extend laterally from the pilot burner or burners and the apex or closed side of each V-shaped flame holder member 60 at a pilot burner is disposed adjacent the flame holder means 52 of said pilot burner. It has been found that with this arrangement the V-shaped members 60 not only function as flame holders but they also function as flame cross-over tubes in that a flame at one pilot burner is propagated along the channel of a V-shaped member 60 extending therefrom to a point adjacent the flame holder means of another pilot burner for igniting said latter pilot burner.

As illustrated the channel members extend at right angles to the direction of flow through the duct 12. If however one or more of the pilot burners were disposed farther downstream than the others then the interconnecting channel members would be inclined to said flow direction.

Although each V-shaped gutter of channel member is illustrated as having a sharp apex, it is obvious that other forms of open-sided channel members could be used, for example, one having a rounded apex or U-shape. The phrases "open-sided member" and "V-shaped" as used in the claims is intended to cover such variations.

While we have described our invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding our invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. We aim in the appended claims to cover all such modifications.

We claim as our invention:

1. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pilot burner tube disposed within said chamber and having means for supplying fuel to said tube separate from the fuel supplied to said chamber by said first mentioned means, for providing a pilot flame; and an open-sided channel member disposed within said chamber outside of said tube and extending across the flow path of said combustible mixture with its open side facing in a generally downstream direction relative to said flow path such that said mixture flows over both sidewalls of said channel member from its closed side, said channel member extending from and opening into said pilot burner tube through the side of said tube.

2. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pilot burner tube disposed within said chamber and having means for supplying fuel to said tube, separate from the fuel supplied to said chamber by said first mentioned means, for providing a pilot flame; and a plurality of open-sided channel members disposed within said chamber outside of said tube and extending across the flow path of said combustible mixture with their open-sides facing in a generally downstream direction relative to said flow path such that said mixture flows over both sidewalls of each channel member from its closed side, each said channel member extending from and opening into said pilot burner tube through the side of said tube for communication with the pilot burner flame within said tube.

3. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pilot burner disposed within said chamber and including means for supplying fuel to said pilot burner separate from the fuel supplied to said chamber by said first mentioned means and also including a tube having flame holder means therein inwardly of the open end of said tube from which the pilot burner flame emanates, said tube also having a V-shaped opening in its side wall on the pilot flame side of its flame holder means; and a channel member of V-shaped cross-section having one end of its channel in communication with said tube through said V-shaped opening and extending from said V-shaped opening outside of said tube and across the flow path of said combustible mixture such that said combustible mixture flows over both sides of said channel member from its apex.

4. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pilot burner disposed within said chamber and including means for supplying fuel to said pilot burner separate from the fuel supplied to said chamber by said first mentioned means and also including a tube having flame holder means therein inwardly of the open end of said tube from which the pilot burner flame emanates, said tube also having a plurality of V-shaped openings in its side wall on the pilot flame side of its flame holder means with the apex of each of said V-shaped openings disposed adjacent to said flame holder means; and a plurality of channel members of V-shaped cross-section, one for each of said V-shaped openings, the channel of each V-shaped channel member communicating with said tube through its associated tube opening and extending therefrom outside of said tube and across the flow path of said combustible mixture such that said combustible mixture flows over both sides of each channel member from the apex of said member.

5. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combustion therewith of means for igniting said combustible mixture; said means comprising a pilot burner disposed within said chamber and including means for supplying fuel to said pilot burner separate from the fuel supplied to said chamber by said first mentioned means and also including a tube having flame holder means disposed thereacross inwardly of the open end of said tube from which the pilot burner flame emanates, said tube having a V-shaped slot in its side wall on the pilot flame side of its tube flame holder means and with the sides of said slot extending to said open end of the tube; and a channel member of V-shaped cross-section having one end of its channel in communication with said tube through said

V-shaped slot and extending from said slot outside of said tube and across the flow path of said combustible mixture such that said mixture flows over both sides of said channel member from its apex.

6. In combustion apparatus for a jet engine having a tubular combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pilot burner disposed adjacent to the upstream end of said tubular chamber and including means for supplying fuel to said pilot burner separate from the fuel supplied to said chamber by said first mentioned means and also including a tube having an open end directed in a downstream direction from which the pilot burner flame emanates, said tube also having flame holder means therein inwardly of its open end and having a plurality of V-shaped openings in its side wall on the pilot flame side of its flame holder means with the apex of each V-shaped opening disposed adjacent to said flame holder; and a plurality of channel members of V-shaped cross-section, one for each of said V-shaped openings, the channel of each V-shaped channel member communicating with said tube through its associated tube opening and extending therefrom outside of said tube and across the flow path of said combustible mixture such that said combustible mixture flows over both sides of said V-shaped channel member from the apex of said member.

7. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pair of pilot burners disposed within said chamber at points spaced laterally across the flow path of said mixture, each of said pilot burners having means for supplying fuel thereto separate from the fuel supplied to said chamber by said first mentioned means and including a tube having an open end directed in a downstream direction from which the pilot burner flame emanates; and an open-sided channel member extending across the flow path of said combustible mixture from one of said pilot burners to the other, said channel member being disposed with its open side facing in a generally downstream direction relative to said flow path so that said combustible mixture flows over both sidewalls of said channel member from its closed side with each end of the channel of said channel member opening into the adjacent pilot burner tube through the side of said tube for communication with the flame of its adjacent pilot burner so that a flame propagated along said channel from either pilot burner is capable of igniting the other pilot burner.

8. In combustion apparatus having a combustion chamber and means for supplying full and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pair of pilot burners disposed within said chamber at points spaced laterally across the flow path of said mixture; each of said pilot burners including means for supplying fuel thereto separate from the fuel supplied to said chamber by said first mentioned means and also including a tube having an open end directed in a downstream direction from which its pilot burner flame emanates, each said tube having flame holder means therein inwardly of its open end and having a V-shaped opening in its side wall on the pilot flame side of its flame holder means with the apex of its V-shaped opening disposed adjacent to its flame holder means; and a channel member of V-shaped cross-section extending across the flow path of said combustible mixture from the V-shaped opening in the side wall of one pilot burner tube to the V-shaped opening in the side wall of the other pilot burner tube, said V-shaped channel member being disposed so that said combustible mixture flows over both sides of said channel member from its apex.

9. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a plurality of pilot burners disposed within said chamber at points spaced laterally relative to the flow path of said combustible mixture and each including means for supplying fuel to said pilot burner separate from the fuel supplied to said chamber by said first mentioned means and also including a tube having an open end directed in a downstream direction from which the pilot burner flame emanates, each said tube also having flame holder means therein inwardly of its open end and having a plurality of V-shaped openings in its side wall on the pilot flame side of its flame holder means with the apex of each V-shaped opening disposed adjacent to the flame holder means of its tube; and a plurality of channel members of V-shaped cross-section extending across the flow path of said combustible mixture and interconnecting said pilot burner tubes, each of said channel members extending from a V-shaped opening of one pilot burner tube to a V-shaped opening of another pilot burner tube and being disposed so that said combustible mixture flows over both sides of each V-shaped channel member from the apex of said member.

10. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a plurality of pilot burners disposed within said chamber at points spaced laterally relative to the flow path of said combustible mixture and each including means for supplying fuel to said pilot burner separate from the fuel supplied to said chamber by said first mentioned means and also including a tube having flame holder means disposed thereacross inwardly of the open end of the tube from which the pilot burner flame emanates, each said pilot burner tube having a plurality of V-shaped slots in its side wall on the pilot flame side of its flame holder means with the apex of each slot disposed adjacent to the flame holder means of said pilot burner tube and with the sides of said slot extending to the open end of said tube; and a plurality of channel members of V-shaped cross-section extending across the flow path of said combustible mixture and interconnecting said pilot burner tubes, each of said channel members being disposed so that said combustible mixture flows over both sides of each V-shaped channel member from the apex of said member and each of said channel members extending from a V-shaped slot of one pilot burner tube to a V-shaped slot of another pilot burner tube with the channel of said channel member disposed in communication with its associated pilot burner tubes through said V-shaped slots.

11. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pilot burner tube disposed within said chamber, said pilot burner tube having means for supplying fuel thereto separate from the fuel supplied to said chamber by said fired mentioned means and having an opening in its side wall; and an elongate open-sided channel member disposed within said chamber and extending laterally outwardly from a sidewall of said tube across the flow path of said combustible mixture with its open side facing in a generally downstream direction relative to said flow path such that said combustible mixture flows over both sidewalls of said channel member from the closed side of said member, said channel member having one end secured to said

tube in alinement with said tube opening in said tube sidewall.

12. In combustion apparatus having a combustion chamber and means for supplying fuel and air to said chamber to form a combustible mixture therein: the combination therewith of means for igniting said combustible mixture; said means comprising a pair of pilot burners disposed within said chamber at points laterally spaced across the flow path of said mixture, each of said pilot burners including means for supplying fuel thereto separate from the fuel supplied to said chamber by said first mentioned means and also including a burner tube having an opening in its side wall; and an open-sided channel member disposed within said chamber and extending across the flow path of said combustible mixture between said pilot burners with its open-side facing in a generally downstream direction relative to said flow path, one end of said channel member being secured to one of said pilot burner tubes in alinement with said tube sidewall opening and the other end of said channel member being secured to the other of said pilot burner tubes in alinement with the sidewall opening of said other pilot burner tube to provide communication between said pilot burner tubes via the channel of said member.

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