

United States Patent

Schuning et al.

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[54] FUEL COOLED FUEL INJECTORS

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[51] Int. Cl. F02g 1/00

[58] Field of Search 60/39.74; 239/145; 431/328

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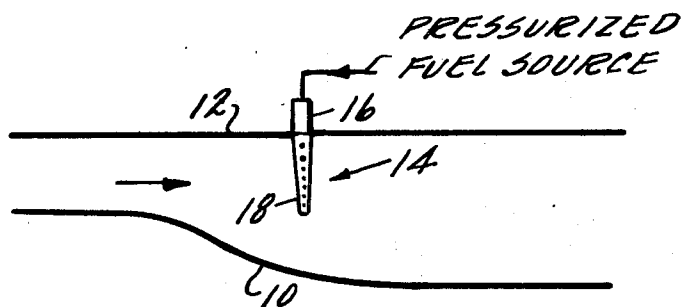
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ABSTRACT

The disclosure shows two forms of injectors for supplying fuel to an ultra high temperature gas stream. One form of fuel injector provides a cooling film of fuel by reason of its porous construction. The other form of injector provides the same type of cooling film through the use of small holes disposed at a low angle to the outer, exposed surface of the injector.

1 Claim, 7 Drawing Figures



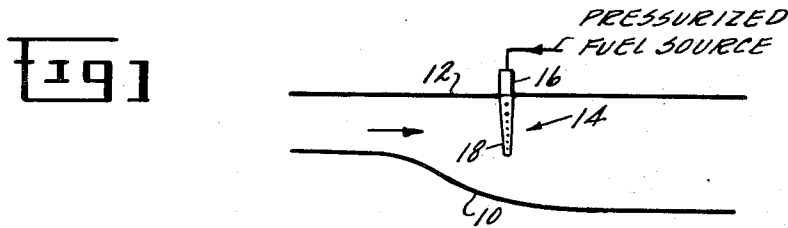
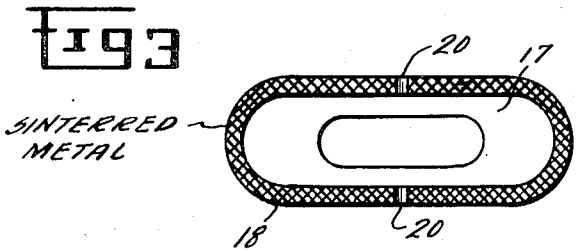
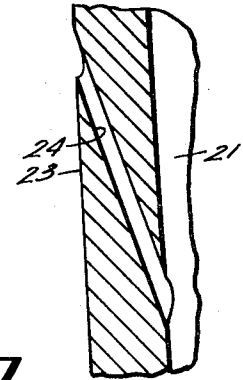
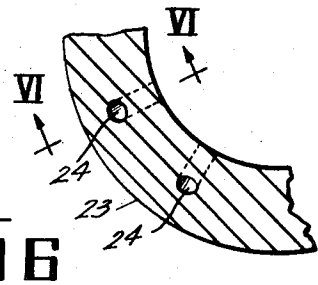
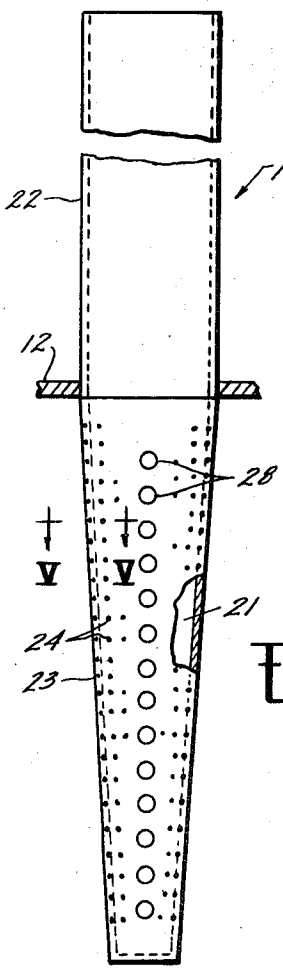
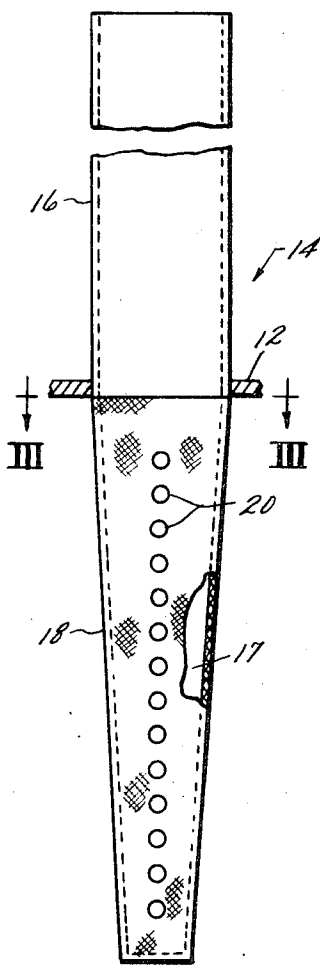


Fig 2 **Fig 4** **Fig 5**



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FUEL COOLED FUEL INJECTORS

The present invention relates to improvements in injectors for supplying fuel to air streams, in ultra high temperature environments, in which combustion is to be maintained and, more particularly, to improvements in the cooling of such injectors.

In reaction type engines such as gas turbine engines, turbo ramjet and ramjet engines, any element exposed to the motive fluid stream is subject to high temperatures which frequently exceed the physical capabilities of available metals or other materials.

This is particularly true of fuel injectors for supplying fuel to an ultra high temperature, gas stream, as found in ramjet engines being developed for hypersonic propulsion.

The object of the invention is to provide improved means for cooling such fuel injectors and, particularly, fuel injectors of this type which are intended for use in engines having hypersonic propulsion capabilities.

These ends are attained by a fuel injector having an internal plenum chamber which is connected to a pressurized fuel supply. The injector is characterized by relatively small passageways from the plenum chamber to the outer surface of the injector which is exposed to the air stream to thereby form a fuel film on this exposed surface of the injector shell and thus provide a cooling mechanism therefor. Larger passageways may also be provided through the shell to inject additional quantities of fuel into the air stream.

The above and other related objects and features of the invention will be apparent from a reading of the following description of the disclosure found in the accompanying drawing and the novelty thereof pointed out in the appended claims.

In the drawing:

FIG. 1 diagrammatically illustrates the disposition of a fuel injector in a high velocity pressurized air stream;

FIG. 2 is a view of a fuel injector, with portions in section, embodying the present invention;

FIG. 3 is a section, on an enlarged scale, taken on line III—III in FIG. 2;

FIG. 4 is a view of an alternate embodiment of the invention, with portions in section;

FIG. 5 is a section, on an enlarged scale, taken on line V—V in FIG. 4;

FIG. 6 is a section, taken on line VI—VI in FIG. 5; and

FIG. 7 illustrates coolant fuel flow from holes in the alternate injector.

In FIG. 1 duct walls 10 and 12 define the flow path of a high velocity, pressurized air stream, as found in a ramjet engine. Generally, there are a plurality of fuel injectors 14 (one of which is shown) connected to a pressurized fuel source. These injectors supply fuel to the air stream where it is ignited by known means to generate a high energy gas stream for propulsive purposes.

FIG. 2 shows the injector 14 in detail. It has a solid metal, tubular end portion 16 which is adapted to be disposed outside the air stream. The end portion 16 also facilitates, as by welding or brazing, connection of the fuel injector to a supply conduit (not shown in FIG. 2) leading to the pressurized fuel source. Pressurized fuel is thus directed to a plenum chamber 17 within the other end portion 18 of the fuel injector, which is to be disposed in the hot gas stream and is formed of porous

metal. The porous metal may be formed of sintered powdered metal or sintered woven wire mesh and the porosity may be controlled by known manufacturing techniques such that when in operation, as illustrated in FIG. 1, there is a continuous flow of fuel through the minute passageways of the porous structure from the inner plenum chamber 17 to the outer surfaces of the porous portion disposed in the air stream. The passageways formed by the porous structure are minute and open onto the outer surface, at varying angles in the case of sintered powdered metal, or at controlled angles in the case of sintered woven wire mesh. This combination results in an essentially continuous film of fuel being formed on the outer surface so that it can function as an insulator and thereby maintain the injector at a relatively low temperature. Fuel is, of course, carried away from the outer surface into the gas stream and will be ignited and burned at a downstream point in the duct. The porosity of the sintered material is controlled so that there is a sufficient fuel flow to continuously resupply or maintain an effective cooling or insulating film.

For purposes of better fuel distribution in the air stream, larger holes 20 are provided in the injector. These holes are sized relative to the plenum chamber area and the pressure of the fuel supply source so that there will be choked flow of fuel through the holes 20. This maintains a uniform pressure throughout the plenum chamber so that fuel will flow through all portions of the sintered metal sections to provide the cooling film previously described.

FIG. 4 shows an alternate injector 14' which has a tubular end portion 22 for connection with the pressurized fuel source. Pressurized fuel is thus directed to a plenum chamber 21 within the other end portion 23 of this injector, which is to be disposed within the air stream. Means are provided for supplying the same type of cooling film to this exposed end portion described in connection with FIG. 2. The portion 23 of the injector 14' intended to be disposed within the air stream is delineated by the phantom showing of the duct wall 12. A plurality of relatively small holes or passageways 24 (FIGS. 5, 6, and 7) are formed in this exposed portion of the injector from the plenum 21 to its outer surface. These passageways are characterized by a diameter ranging between 0.010 inch and 0.100 inch. They are further characterized by a relatively low angle between their axes and the outer surface of the injector. Preferably this angle will be maintained between about 10° and 30°. Holes of this angular disposition and size range, particularly where their axes are disposed generally normal to or in a downstream direction relative to the direction of air flow, provide a distributed film of fuel over the outer surface of the injector. Fuel from a single hole is effective in cooling an area several times greater than the area of the hole itself (FIG. 7). This enables the use of a minimum number of holes 24 to preserve the structural integrity of the injector. The majority of the fuel may be injected into the air stream through larger holes 28 and distributed over a greater portion of the air flow path. The small cooling holes 24 are arranged in a pattern which provides the necessary film thickness over all areas of the injector to properly cool it and maintain the metal temperature at a proper operating level.

The described injectors are ideally suited for use with pressurized, gaseous fuels such as hydrogen and methane, since these fuels do not present the difficulties of coking and gumming normally associated with liquid hydrocarbon fuels. However, such problems do not necessarily preclude the use of the described injectors with liquid hydrocarbon fuels.

The described embodiments of the invention are illustrative, and the inventive concepts are defined and limited solely by the appended claims.

Having thus described the invention, what is claimed as novel and desired to be secured by Letters Patent of the United States is:

- 1. A fuel injector having,
an interior plenum chamber connected to a source of pressurized fuel,
said injector having a portion disposed in a pressurized air stream which is provided to support combustion of the fuel,
characterized by passageway means for providing

fuel flow from said chamber to form a continuous fuel film over substantially all of the surface area of said injector which is exposed to said air stream, said film being continually maintained by fuel flow through said passageway means as fuel is carried into said air stream, said passageway means comprising a plurality of holes having a diameter between 0.010 and 0.100 inch and inclined at an angle between 10° and 30° relative to the exposed surface of the injector, and
additional, relatively large passageways for injecting further fuel into the gas stream under choked flow conditions to maintain the plenum chamber pressure, said additional passageways being spaced apart along the length of said exposed portion with their axes normal to the direction of air stream flow
whereby the injector is effectively cooled by the fuel.

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