Nov. 20, 1951 E. A. MAYNOR 2,575,824

FUEL INJECTOR FOR ROCKET DEVICES

Filed Jan. 31, 1948

Fig. 1.

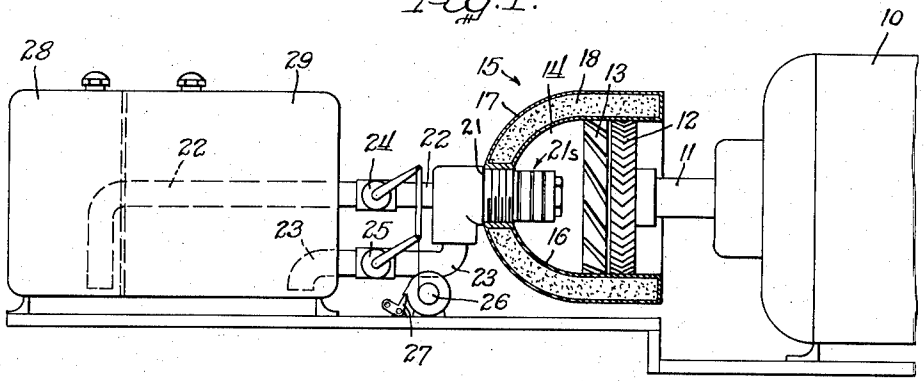


Fig. 2.

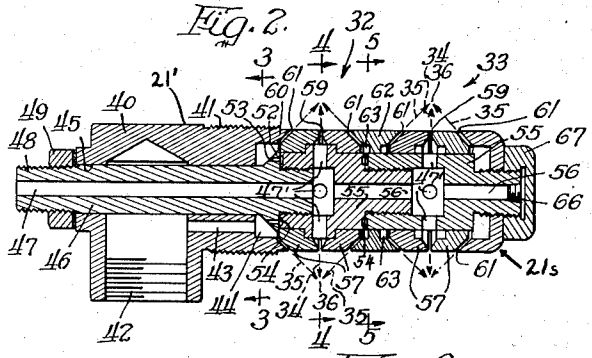


Fig. 3.

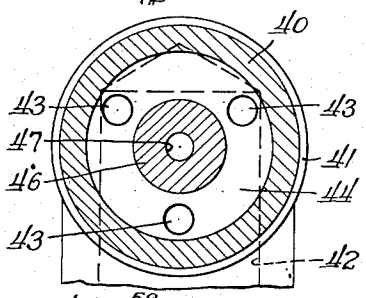


Fig. 6.

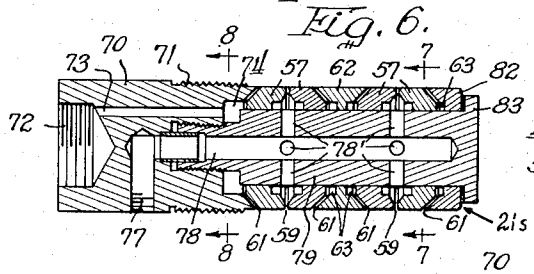


Fig. 4.

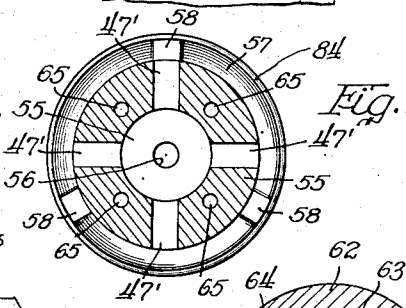


Fig. 7.

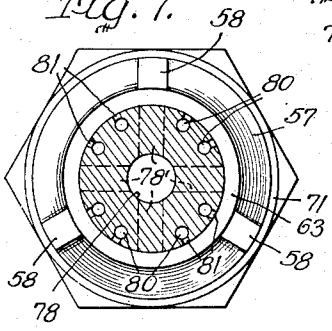


Fig. 8.

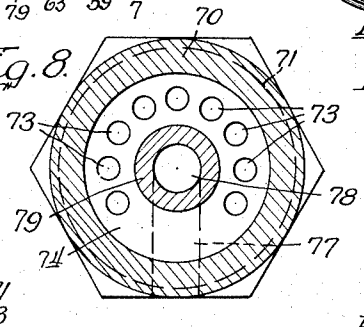
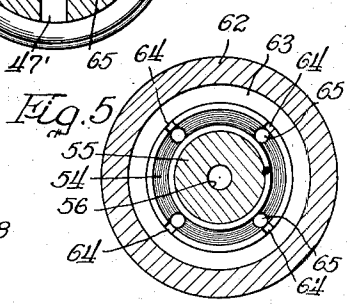


Fig. 5.



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FUEL INJECTOR FOR ROCKET DEVICES

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4 Claims. (Cl. 299—140)

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My invention relates, generally, to rocket devices and it has particular relation to fuel injectors for such devices.

In order to obtain a high degree of thermal efficiency in the combustion of rocket fuels there should be complete atomization and thorough mixing of the fluids which are burned in the combustion chamber. The more nearly that these conditions are approached, the more complete will be the resulting combustion. Conversely, where the atomization and mixture are not complete, there will be a corresponding reduction in the thermal efficiency. This is particularly true where hydrocarbons are concerned.

Where hydrocarbons are burned in the presence of oxygen, if there is a paucity of oxygen, the hydrogen will burn, thereby resulting in a deposit of carbon. The reason for this is that hydrogen ignites at a much lower temperature than does carbon.

It has been shown by tests that, if a small quantity of completely atomized hydrocarbon is ignited in the presence of the exact amount of oxygen necessary to effect complete combustion, such combustion will result in the hydrogen combining with the oxygen to form water and the carbon uniting with the oxygen to form carbon dioxide. In order to obtain this desired result, the oxygen atoms must be in the immediate vicinity of the carbon and hydrogen atoms and the mixture thereof must be accomplished under pressure. This is essential since the process of combustion tends to disperse the atoms rather than to expedite their molecularization, particularly where two elements are being oxidized.

Accordingly, among the objects of my invention are: To provide the exact number of atoms of fluids which, when intermixed, support combustion and to hold the same in close proximity until complete combustion results; to provide the exact number of atoms of hydrogen, carbon and oxygen in close proximity to effect complete combustion thereof; to cause the fluids which are to be atomized and intermixed for complete combustion to flow in intersecting annular configurations so as to obtain the complete atomization and intermixing; to direct one fluid to flow radially outwardly in an annular configuration and to direct another fluid to flow in a conical configuration which intersects the annular configuration; to cause the radially outwardly annular configuration of fluid flow to be intersected from opposite sides by fluid flows of conical configurations, the intersection of the three fluid flows taking place along a circle; and to arrange the

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nozzle means which direct the fluid flows in intersecting relationship in tandem so that there are two or more zones where the atomization and intermixing take place.

Other objects of my invention will, in part, be obvious and in part appear hereinafter.

For a more complete understanding of the nature and scope of my invention reference can be had to the following detailed description, taken together with the accompanying drawing, in which:

Figure 1 is a view, partly in side elevation and partly in section, illustrating how a nozzle constructed in accordance with my invention can be employed in a rocket device;

Figure 2 is a longitudinal sectional view of the nozzle shown in Figure 1, as modified to provide a second nozzle unit in tandem with the first nozzle unit;

Figures 3, 4 and 5 are detail sectional views taken, generally, along the lines 3—3, 4—4 and 5—5, respectively, of Figure 2;

Figure 6 is a longitudinal sectional view of a modified nozzle construction; and

Figures 7 and 8 are detail sectional views taken, generally, along the lines 7—7 and 8—8, respectively, of Figure 6.

Referring now particularly to Figure 1 of the drawing it will be observed that the reference character 10 designates a load device such as an electric generator, having a shaft 11 which supports at one end a turbine wheel 12 that may be driven by gas blast impinging thereon through a director 13. The director 13 is positioned at one end of a combustion chamber 14 that may be located in a housing which is indicated, generally, at 15. The housing 15 may comprise an inner shell 16 and an outer shell 17 of stainless steel having a layer 18 of carbon therebetween. While the invention disclosed herein is illustrated in connection with a turbine wheel driven load device, it will be understood that it may be employed in connection with a motor of the jet propulsion type wherein a forward thrust is provided by the reaction of the gas generated as a result of combustion of the propellant fluids.

At the other end of the housing 15 there is provided a fuel injector that is shown, generally, at 21. It will be understood that my invention is directed particularly to the construction of this fuel injector 21.

The fuel injector 21 comprises a substantially cylindrical nozzle shank 21s made up of nozzle rings and fittings, as I shall presently describe. This nozzle shank has fluid inlet conduits 22 and

23 connected thereto for supplying fluids which, when intermixed properly, support combustion in the chamber 14. Shutoff valves 24 and 25 may be provided in the conduits 22 and 23. They are shown in the closed position and are arranged to be opened simultaneously by a spring driven drum 26 which is restrained by a pawl 27. When the pawl 27 is released, the drum 26 rotates to open the valves 24 and 25.

It will be observed that the conduits 22 and 23 extend into fluid tanks 28 and 29, respectively. The tank 28 may contain a fuel such as aniline, ammonia, gasoline, benzene, etc. The tank 29 may contain an oxidizer such as nitric acid or picric acid. Hydrogen peroxide or liquid oxygen also may be used. It will be understood that any of the well known fluids, such as those specifically mentioned, may be employed in practicing my invention.

Referring now particularly to Figure 2 of the drawing there is shown a fuel injector 21' which is similar to the fuel injector 21 except that the nozzle shank 21s is made up of two nozzle units 32 and 33 in tandem in place of a single nozzle unit as shown in Figure 1. As will appear hereinafter more than two of the nozzle units 32 and 33 can be added in tandem as desired depending upon the power requirements. Since the nozzle units 32 and 33 are, for the most part, identical in construction, the same reference characters will be used for both.

Each of the nozzle units 32 and 33 is constructed so as to provide a fluid or fuel flow having a radial annular configuration or disc-like discharge 34 that is arranged to be intersected by two fluid or oxidizer flows of conical configurations or cone-like discharges 35, the arrangement being that the conical configurations 35 intersect the annular configuration 34 at 36. Since the configurations 34 and 35 intersect in the manner described at 36, in reality, the intersection thereof is a circle and it is around this circle that the carefully metered and proportioned quantities of fluids, i. e. fuel and oxidizer, meet, are atomized, and completely intermixed so that complete combustion thereof can take place as mentioned hereinbefore. It will be understood that the fluids from the tanks 28 and 29 flow in the configurations 34 and 35 under pressure. For example a pressure may be maintained in the tanks 28 and 29 on the order of 600 pounds per square inch.

The parts making up the fuel injector 21' are formed preferably of stainless steel. They will be described now in detail.

It will be noted that a body member 40 is provided having threads 41 which permit it to be screwed into the housing 15. The body member 40 also has a threaded passageway 42 for connection to the fluid inlet conduit 23. In this case the fluid oxidizer flows through the passageway 42 and also through longitudinally extending apertures 43 in the body member 40 to an annular distribution chamber 44.

The body member 40 also has a central longitudinal opening 45 in which a stem 46 is positioned. The stem 46 has an axial passageway 47 through which the fluid fuel flows from the conduit 22. The stem 46 is threaded at 48 to permit connection of the conduit 22. A nut 49 also is provided on the threads 48 for holding the stem 47 in position with respect to the body member 40.

At its right hand end the stem 46 has a conical flange 52 which serves, in part, to enclose the distribution chamber 44. The flange 52 has

transverse apertures 53 for placing an annular groove 54 in a fitting 55 in communication with the chamber 44. It will be noted that the fitting 55 has an axial passageway 56 which, in effect, constitutes an extension of the axial passageway 47 in the stem 46.

Surrounding the fitting 55 is a pair of nozzle rings 57 which, as shown more clearly in Figure 4, have spacing portions 58 to provide a radial nozzle opening 59 the width of which is fixed. In accordance with the present invention the radial nozzle opening 59 has a width of 0.002 inch. Except for the spacing portions 58, which constitute only a small portion of the circumferential length of the nozzle opening 59, it constitutes a radially opening passageway for directing the fluid fuel to flow radially outwardly in the annular configuration previously described and indicated at 34. It will be observed that radial apertures 47' serve to place the inside of the radial nozzle opening 59 in communication with the axial passageway 47. Similar radial apertures 47' serve to place the radial nozzle opening 59 of the nozzle unit 33 in communication with the axial passageway 56.

Now it will be noted that the forward end 60 of the body member 40 is spaced slightly from the adjacent shoulder of the adjacent nozzle ring 57 to provide a conical nozzle opening 61. A similar nozzle opening 61 is provided between the corresponding forward shoulder of the next nozzle ring 57 and an adjacent shoulder of a spacing ring 62. Preferably the conical nozzle openings 61 have a width of 0.003 inch and they are oppositely inclined, as shown, to provide the conical configurations 35 of fluid or oxidizer flow previously described.

As shown in Figures 2 and 5 of the drawing, the fluid reaches the conical nozzle opening 61 between the ring 57 and the ring 62 through a distribution chamber 63 which communicates through apertures 64 with the annular groove 54 near the forward end of the fitting 55. Longitudinally extending apertures 65, Figure 4, extend between the grooves 54 in the fitting 55 to place the same in communication.

It will be observed that the outer end of the axial passageway 56 in the fitting 55 of the nozzle unit 33 is closed by a plug 66 and that a cap 67 is threaded over the projecting threaded portion of the fitting 55. If it is desired to add other nozzle units, the cap 67 can be removed and the plug 66 unscrewed. Thereafter additional nozzle units can be added, as desired, with the plug 66 being positioned in the outermost unit and the cap 67 applied as will be understood readily.

From the foregoing description it will be apparent now that the oxidizer fluid flow through the passageway 42 in the body member 40 and through the apertures 43 to the distribution chamber 44. From this chamber 44 a portion of the fluid flows through the associated conical nozzle opening 61. The remaining portion of the fluid flows through the apertures 53 in the conical flange 52 to the annular groove 54 in the fitting 55 and thence through apertures 65 to the annular groove 54 in the forward end of the fitting 55. A portion of this fluid flows through the radial aperture 64 into the distribution chamber 63, which is annular in form, and thence out through the associated conical nozzle opening 61.

The fluid fuel flows through the axial passageway 47 and radial apertures 47' to the radial

nozzle opening 59. When more than one nozzle unit is employed, only part of the fluid fuel flows through the first radial nozzle opening 59, the balance of the fluid fuel flowing through the axial passageway 56 for like distribution by the additional nozzle unit or units.

The fuel injector 21' has been shown in Figure 2 at the same scale that a sample thereof has been constructed. Figures 3, 4 and 5 show the construction at double scale. The conical nozzle openings 61 are illustrated as inclined at an angle of 45° from the horizontal. It is understood that other angles of inclination can be employed. However, it is essential that the construction be such that the configurations 34 and 35 intersect along a circle in order to insure complete intermixing of the atoms of the two fluids.

In Figure 6 of the drawing there is illustrated a slightly modified form of construction of the fuel injector. It will be noted that the construction there shown includes a body member 70 which corresponds to the body member 40 shown in Figure 2. The body member 70 has threads 71 to permit its assembly in the housing 15. It also has a passageway 72 for connection to the fluid inlet conduit 23. It will be understood that a slightly different arrangement of the fluid inlet conduit 23 must be made to accommodate the construction shown in Figure 6. The body member 70 has apertures 73 for placing the passageway 72 in communication with the annular distribution chamber 74 which corresponds to the annular distribution chamber 44 shown in Figure 2. The apertures 73 are also shown in Figure 8.

The body member 70 also has a passageway 77 which corresponds to the axial passageway 47 in Figure 2. It will be understood that the passageway 77 is connected to the fluid fuel conduit 22 and a corresponding re-arrangement of the same is required from that shown in Figure 1 to accommodate the construction shown in Figure 6.

The passageway 77 communicates with an axial passageway 78 that extends through a fitting 79 whose length depends upon the number of nozzle units that are required. As shown in Figure 6, two nozzle units may be employed but it will be understood that, with a longer fitting 79, additional nozzle units may be accommodated. Radial apertures 78' in the fitting 79 serve to place the axial passageway 78 in communication with the radial nozzle openings 59 in each of the nozzle units.

In order to distribute the fluid oxidizer from the annular distribution chamber 74, apertures 80, shown more clearly in Figure 7, are provided in the fitting 79 parallel to the axial passageway 78 and near the periphery of the fitting 79. Radial apertures 81, Figure 7, serve to place the distribution chambers 63 in communication with the apertures 80 so as to direct the flow of fluid oxidizer through the corresponding conical nozzle openings 61.

At the outer end of the fitting 79 there is provided a ring 82 which cooperates with the adjacent shoulder of the adjacent nozzle ring 57 to provide the conical nozzle opening 61. The ring 82 is held in place by a head 83 that may be formed integrally with the fitting 79.

It will be observed that the nozzle rings 57, as shown in Figures 4 and 7 of the drawing, have a small radius surface at the periphery as indicated at 84. This construction is provided in order to obtain the desired radial annular con-

figuration 34 of the fluid fuel for proper intermixing with the intersecting conical configurations of the fluid oxidizer.

It will be understood that the conical nozzle openings 61 can be maintained at the proper dimension with respect to width by employing spacing portions thereon similar to the spacing portions 58 described in connection with the nozzle rings 57 for maintaining the proper spacing for the radial nozzle opening 59. In lieu of these integrally formed spacing portions 58, pins may be set into the nozzle rings 57 and ground off accurately to provide the desired spacing.

After combustion of fluids, such as nitric acid and a hydrocarbon, if the products of combustion do not leave the combustion chamber at the same time, a deposit of carbon or nitrogen will remain. Hydrocarbon fumes may pass backward into the nozzle openings 61 or nitric acid fumes may pass backward into the nozzle opening 59. Small amounts of nitric acid or hydrocarbon may adhere to the walls of these nozzle openings and incomplete combustion results in carbon and nitrogen deposits. Since the fuel injector 21', constructed as shown herein, can be removed and completely dismantled, the parts thereof can be cleaned readily and reassembled. This permits reuse of the same injector.

Since certain further changes can be made in the foregoing constructions and different embodiments of the invention can be made without departing from the spirit and scope thereof, it is intended that all matter shown in the accompanying drawing and described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a fuel injector of the class described, the combination of a supporting member, a nozzle shank of substantially cylindrical form extending therefrom, two separate fluid passageways extending through said nozzle shank for feeding two separate fluids adapted to be intermixed, a radial nozzle opening of substantially continuous circular form encircling said nozzle shank and connected with one of said fluid passageways to project one of said fluids in the form of a disc-like discharge, and two conical nozzle openings of substantially continuous circular form encircling said nozzle shank and connected with the other of said fluid passageways to project the other of said fluids in the form of two cone-like discharges, said conical nozzle openings being disposed on opposite sides of said radial nozzle opening and pointed to cause their cone-like discharges to intersect said disc-like discharge from opposite sides thereof.

2. In a fuel injector of the class described, the combination of a supporting member, a nozzle shank supported thereby, two separate passageways extending through said nozzle shank for feeding two separate fluids adapted to be intermixed, said nozzle shank comprising stem means, and a plurality of nozzle rings carried by said stem means and defining therebetween a radial nozzle opening of substantially continuous circular form encircling said nozzle shank and connected with one of said fluid passageways to project one of said fluids in the form of a disc-like discharge, and also defining therebetween a conical nozzle opening of substantially continuous circular form encircling said nozzle shank and connected with the other of said fluid passageways to project the other of said fluids in

the form of a cone-like discharge which intersects said disc-like discharge.

3. In a fuel injector for injecting two fluids into the combustion chamber of a rocket device to atomize and intermix the same, the combination of a supporting member, a substantially cylindrical nozzle shank supported thereby for extending into said combustion chamber, said nozzle shank comprising stem means, a first fluid passageway extending substantially axially of said stem means for feeding one of said fluids, a second fluid passageway extending longitudinally of said stem means in spaced relation to said first fluid passageway for feeding the other of said fluids, and a series of nozzle and spacing rings assembled over said stem means and defining therebetween a plurality of nozzle sets arranged in tandem relation along said nozzle shank, each of said nozzle sets comprising a substantially radial nozzle opening of substantially continuous circular form encircling said nozzle shank and connected with one of said fluid passageways to project one of said fluids in the form of a disc-like discharge, and a conical nozzle opening of substantially continuous circular form encircling said nozzle shank and connected with the other of said fluid passageways to project the other of said fluids in the form of a cone-like discharge which intersects said disc-like discharge.

4. In a fuel injector of the class described, the

combination of a supporting member, a nozzle shank of substantially cylindrical form extending therefrom, two separate fluid passageways extending through said nozzle shank for feeding two separate fluids adapted to be intermixed, a radial nozzle opening of substantially continuous circular form encircling said nozzle shank and connected with one of said fluid passageways to project one of said fluids in the form of a disc-like discharge, and a conical nozzle opening of substantially continuous circular form encircling said nozzle shank and connected with one of said fluid passageways to project one of said fluids in the form of a cone-like discharge which intersects said disc-like discharge at a point spaced apart from the perimeter of said shank.

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