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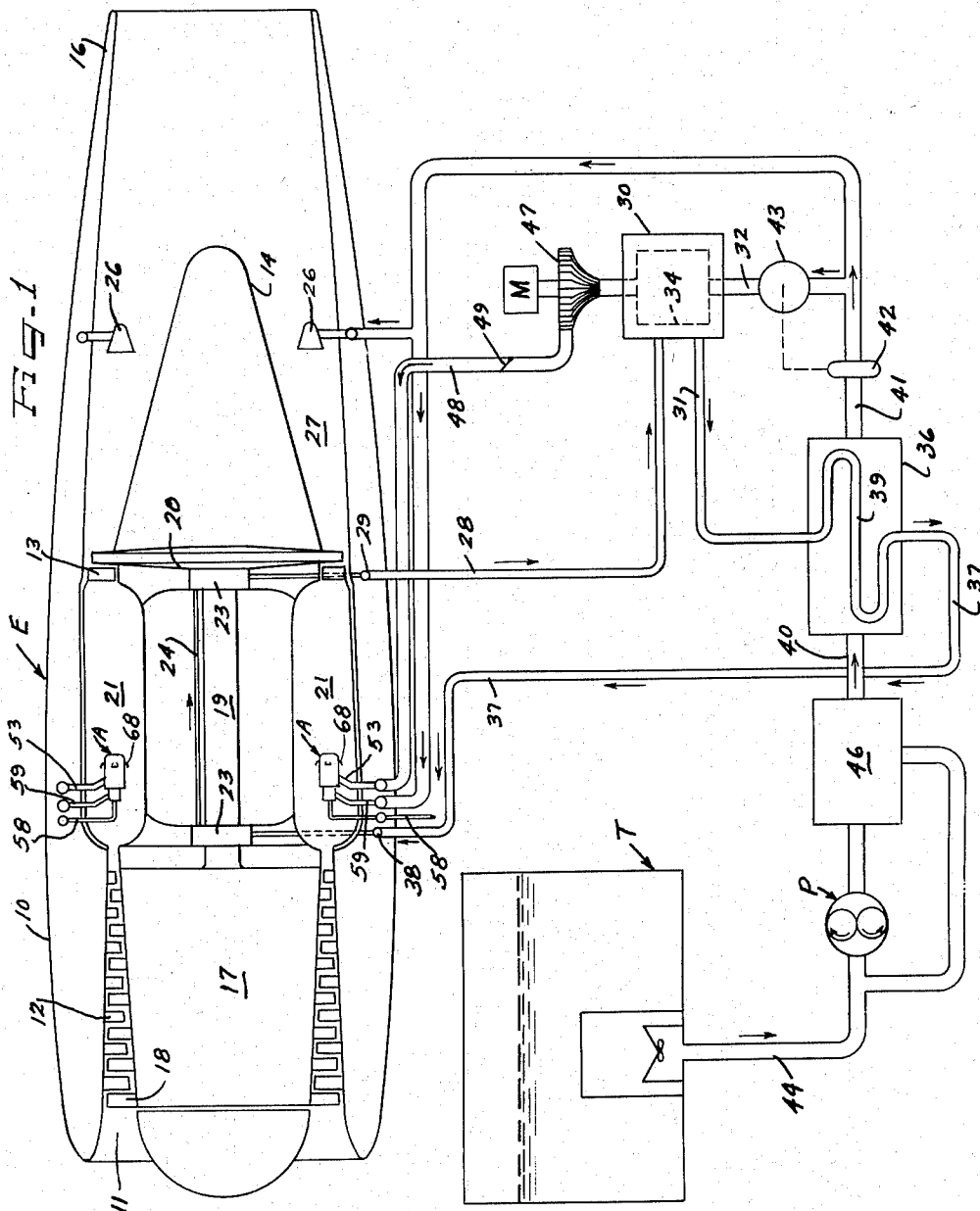
R. L. CUMMINGS

2,907,527

NOZZLE

Filed April 10, 1956

2 Sheets-Sheet 1



Inventor
ROBERT L. CUMMINGS

Wm. Sherman, Merion, Chad & Simpson Attys.

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2 Sheets-Sheet 2

Fig-2

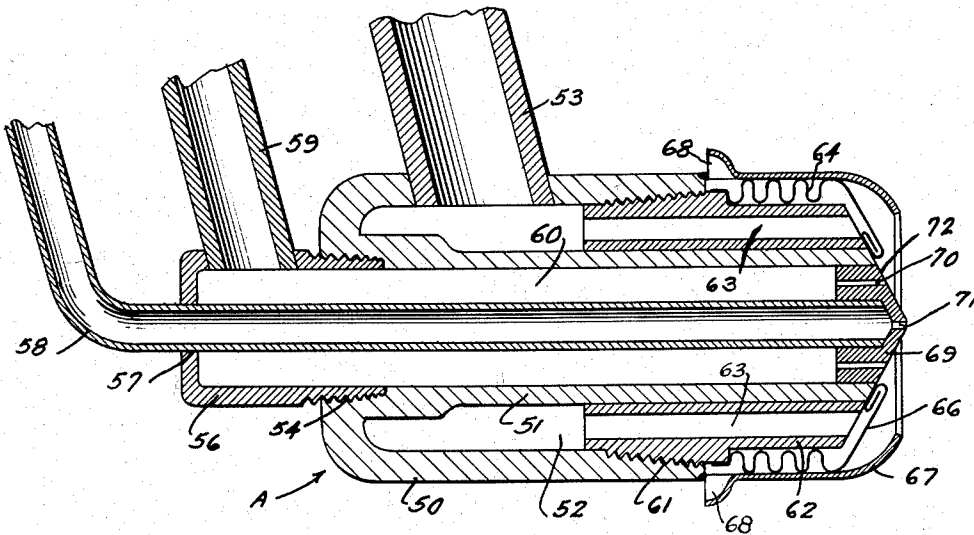
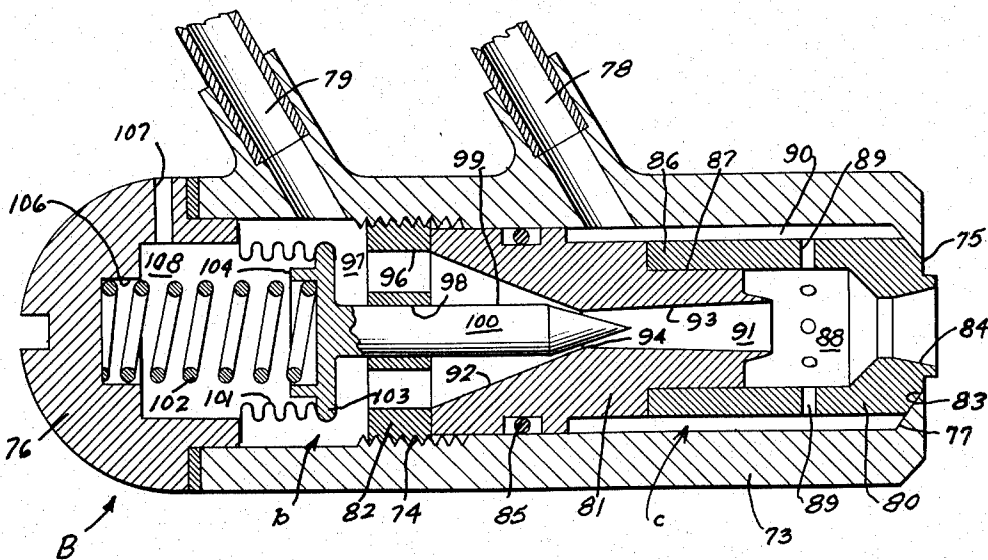


Fig. 3



Inventor
ROBERT L. CUMMINGS

Att. Sherman, Merriam, Chase & Simpson
by Attys.

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2,907,527

NOZZLE

Robert L. Cummings, Berea, Ohio, assignor to Thompson Ramo Wooldridge Inc., a corporation of Ohio

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11 Claims. (Cl. 239—135)

This invention relates to a fluid atomizing nozzle. Specifically, this invention relates to a vaporous fuel atomizing nozzle in which pressurized vaporous fuel is utilized as the atomizing gas to obtain a finer dispersion of liquid fuel particles.

The current development in turbojet engine fuel cooling systems, such as are employed to cool hot lubricating engine oil, has resulted in the production of a hot vaporous fuel by-product, which has been utilized as a supplement to the conventional liquid fuel flow through the main and after burner assembly fuel nozzles. As an incident of the use of vaporous fuel to supplement the main liquid fuel system, it has been found that the hot vaporous fuel by-product such as is generated by fuel-oil heat exchangers, could also be used to perform the same function as compressed bleed air as a means of inducing atomization of the liquid fuel passing through the main and after burner fuel nozzles.

Several important advantages are realized from the substitution of vaporous fuel for compressed bleed air in the atomizing nozzles, namely, a more efficient combustion of the fuel is obtained, and the vaporous fuel such as is generated by a typical fuel oil heat exchanger is at a sufficiently high pressure to permit a direct utilization in the main combustion chamber burners or after burners, without additional pressurization. The latter mentioned advantage correspondingly results in a simplification of the plumbing and associated control systems, with a corresponding reduction in weight and unit cost of the system.

The present invention discloses one means of beneficially exploiting the pressurized vaporous fuel by-product of a typical fuel oil heat exchanger, in the form of a vapor atomizing fuel nozzle, in which the hot pressurized vaporous fuel is utilized to augment atomization and dispersion of liquid fuel that is being sprayed into the main combustion chamber or through the after burner nozzles.

Briefly described, the present invention contemplates a nozzle structure having a liquid fuel passage and a vaporous fuel passage. Liquid fuel orifices are provided to initially meter the liquid fuel supply into a fine stream or vortex of discrete particles. A vaporous fuel orifice is also provided to direct an intersecting jet or flow of pressurized vaporous fuel into and through the stream or vortex of liquid fuel, to thereby disperse and atomize the liquid fuel flow.

The nozzle structure of the present invention also contemplates a means for maintaining a unidirectional metered flow of hot vaporous fuel, thereby assuring a proportionate flow of atomized fuel from the nozzle and the prevention of any reverse flow of vaporous fuel or flame flash back, during periods of low vapor fuel pressure.

In addition to the economic advantages resulting from the present invention, greater fuel combustion chamber efficiencies will be realized, as a result of the impingement of a high velocity and temperature jet of vaporous fuel into the liquid fuel stream, to utilize thermodynamic as well as a fluid dynamic atomization of the liquid fuel.

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It is an object then of the present invention to provide an improved nozzle structure.

Another object of the present invention is to provide an improved type of vapor atomizing fuel nozzle.

Yet another object of the present invention is to provide an improved type of atomizing fuel nozzle which utilizes pressurized vaporous fuel as the atomizing gas.

A further object of the present invention is to improve the combustion efficiency of a turbojet engine, or other internal combustion engine utilizing a liquid fuel, by augmenting the atomization of the liquid fuel through the impingement of an intersecting jet of hot vaporous fuel into a flow of the liquid fuel.

A still further object of the present invention is to effectively utilize the hot vaporous fuel by-product of a typical fuel-heat exchanger in a turbojet engine, in the form of augmenting the atomization of liquid fuel in the burners of a turbojet engine.

Many other objects and advantages of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows and the accompanying sheets of drawings.

On the drawings:

Figure 1 is a schematic elevational view of a turbojet engine and vaporous fuel producing fuel-oil heat exchanger, in which the hot vaporous fuel by-product is utilized to augment vaporization of the liquid fuel in the burners of the engine, according to the principles of the present invention.

Figure 2 is an enlarged cross-sectional view, with parts in elevation, of a variable area vapor atomizing fuel nozzle, according to the principles of the present invention; and

Figure 3 is an enlarged cross-sectional view, with parts in elevation, of a swirl type variable area vapor atomizing nozzle, according to the principles of the present invention.

As shown on the drawings:

In Figure 1, a typical turbojet engine oil cooling system is illustrated, in which a fuel-oil heat exchanger oil cooling system, is shown producing a pressurized vaporous fuel by-product which is effectively utilized to augment atomization of liquid fuel in the main burner assembly of a turbojet engine E.

The turbojet engine E, is comprised generally of an engine body 10 which includes an inlet 11, a compressor-stator vane assembly 12, a turbine wheel rotor-stator vane assembly 13, a diffuser cone 14, and a discharge tail pipe 16. A compressor rotor assembly 17 is enclosed by the turbine body 10 and comprises a compressor rotor vane assembly 18, drive shaft 19, and a turbine wheel 20. A plurality of combustors 21 are positioned between the compressor assembly 18 and turbine wheel 20, and contain a plurality of vapor atomizing nozzle assemblies A, which supply a pressurized flow of high velocity air and liquid fuel to the combustors 21, preparatory to ignition.

The compressor rotor assembly 17 is suitably journaled, for example, by a bearing assembly 23, and a connecting oil conduit 24 maintains a flow of cool lubricating oil to the respective bearing assemblies 23.

An after burner nozzle assembly 26 is positioned in a downstream diffusion passage 27 to augment thrust from the engine E, during emergency flight conditions, or whenever additional thrust is required.

The oil cooling system for the turbojet engine E, is comprised generally of a hot oil outlet conduit 28, which receives a flow of hot lubricating oil from an outlet 29 on the engine body 10. The hot oil conduit 28 supplies hot engine lubricating oil to a boiling cooler 30.

The boiling cooler 30 receives a flow of hot oil from a conduit 28 and discharges cool oil through a conduit

31. The boiling cooler 30 also receives a supply of heated fuel through a conduit 32 and discharges hot vaporous fuel through a conduit 33. A thermal energy transfer conduit 34 is provided within the boiling cooler 30 to permit a vaporization of the fuel, due to the intimate contact of the liquid fuel with the hot lubricating oil.

A fuel-oil heat exchanger 36 receives the initially cooled oil from the conduit 31 and discharges cold oil through a conduit 37 to a cool oil return inlet 38 on the engine body 10.

The fuel-oil heat exchanger 36, includes an internal heat transfer conduit system 39 which permits a transfer of thermal energy from the hot oil to surrounding cool fuel.

A conduit 40 supplies the cool fuel to the heat exchanger 36, and a discharge conduit 41 delivers heated fuel to the burner assembly 22 in the engine E.

A thermal sensing unit 42 on the conduit 41, selectively activates a throttle valve 43 which permits a by-pass flow of hot fuel from the conduit 41 through the by-pass conduit 32 to the boiling cooler 30, whenever the fuel temperature in the conduit 41 reaches a predetermined maximum value.

The fuel oil heat exchanger 36, receives a flow of cooled fuel through the conduit 40 from a connecting conduit 44 and fuel tank T. A main pump P, maintains a flow of fuel from the fuel tank T, through a fuel control assembly 46 to the fuel oil heat exchanger 36.

When the temperature of the fuel in the conduit 41 rises to a sufficient value to activate the by-pass throttle valve 43, the hot lubricating oil in the boiling cooler 30, will vaporize the hot fuel in the heat transfer passages 34, from which the hot vaporous fuel will be withdrawn from the boiling cooler 30 through the connecting conduit 33, by a vapor pump 47.

The vapor pump 47 is driven, for example, by an electric motor M, and withdraws and recompresses vaporous fuel from the heat transfer passages 34 in the boiling cooler 30, and selectively delivers a pressurized flow of hot vaporous fuel through a conduit 48 to the main burner vapor atomizing fuel nozzle assemblies A. A control valve assembly 49 is provided in the conduit 48 to control the flow of hot vaporous fuel to the nozzle assemblies A.

Thus it will be appreciated that the fuel-oil heat exchanger system, shown in Figure 1, while primarily serving to cool the hot lubricating oil from the engine E, incidentally produces a hot pressurized vaporous fuel by-product, which, according to the present invention, is effectively utilized to augment the atomization of the liquid fuel delivered by the main burner nozzle assemblies A.

It should further be appreciated, that while I have illustrated a typical turbojet engine fuel-oil heat exchanger system as a source for producing pressurized vaporous fuel, any other system having a hot pressurized vaporous fuel by-product could be utilized to practice the principles of my invention.

Referring now to Figure 2, a more detailed view of the combination liquid and variable area vapor atomizing fuel nozzle A of Figure 1, is illustrated, such as is utilized in the main combustors 21 in the turbojet engine E, shown in Figure 1.

The liquid vapor atomizing fuel nozzle A, is comprised of a generally hollow nozzle body 50 in which is formed a concentric liquid fuel conduit 51. An annular vaporous fuel chamber 52 is thus formed between the nozzle body 50 and concentric liquid fuel conduit 51. An intersecting conduit 53 in the nozzle body 50, supplies pressurized fuel to the chamber 52.

The cylindrical liquid fuel conduit 51 is internally threaded as at 54 to receive a liquid fuel flow fitting 56. The liquid fuel flow fitting 56 is axially bored as at 57 to receive a liquid fuel starting conduit 58.

The liquid fuel fitting 56 is transversely intersected by a main liquid fuel flow conduit 59 which supplies a flow of pressurized liquid fuel to a liquid fuel chamber 60 which is formed between the liquid fuel conduit 51 and starting liquid flow conduit 58. The flow of liquid fuel through the starting conduit 58 is initiated and regulated by a suitable control device, not shown.

The nozzle body 50 is internally threaded as at 61 to receive a vaporous fuel flow fitting member 62 which is provided with a plurality of vaporous fuel discharge flow passages 63. These passages can be a plurality of bores such as from 4 to 12 bores in the fitting 62. The vaporous fuel passages 63 are in communication with the vaporous fuel chamber 52, and form a flow conduit for vaporous fuel delivered by the conduit 53.

An annular bellows assembly 64 circumscribes the vaporous fuel flow fitting member 62, and has one end secured to the fitting and the other end provided with an integral lip portion 66 overlying the discharge end of the fitting to selectively close the vaporous fuel flow passages 63. A radiation shield 67 encloses the bellows assembly 64, and cooling air louvers such as 68 are provided on the shield to divert a circulating flow of combustion chamber air around the bellows assembly 64 and radiation shield 67 to prevent excessive heating of the bellows assembly 64 and other parts of the nozzle A.

It will be understood that when the vapor pressure in passages 63 is great enough to stretch the bellows 64, the lip 66 will be shifted toward the open end of the shield 67 and a flow path around the bellows in the shield from the louver openings to the open end of the shield is created. The atomized stream from the nozzle will aspirate air through this path to cool the end of the nozzle A.

The downstream end of the main liquid fuel passage 60 and starting liquid flow conduit 58, are closed by a flow plug member 69. The flow plug member 69 is provided with a plurality of circumferentially spaced axial flow orifices 70 which communicate with the main liquid fuel chamber 60. A centrally disposed starting flow orifice 71 communicates with liquid fuel in the starting conduit 58 to provide a metered flow of liquid fuel during starting.

The downstream faces of the vaporous fuel flow fitting member 62 and orifice plug member 69 are conically tapered to form a surface 72 which determines the corresponding angular relationship of the lip 66 to the vaporous fuel flow passages 63.

It should be noted that the angular relationship of the lip 66 and co-planar surface 72 is such that when a sufficient fuel vapor pressure is obtained in the chamber 52 to unseat the lip 66, a flow of pressurized vaporous fuel will issue out of the vaporous fuel passages 63 and be deflected centrally inwardly toward fine liquid fuel streams issuing from the orifices 70. The angular position of the lip 66 is such as to divert the vaporous fuel streams from the flow passages 63 into an optimum intersecting path with the fine streams of liquid fuel issuing from the flow orifices 70 and 71, to obtain optimum atomization and dispersion of the liquid fuel.

It will thus be appreciated that the bellows assembly 64 and lip 66 form a combination check valve, flow regulator, and deflecting surface for the vaporous fuel flow, which permits a high degree of control as to the flow rate and atomization of pressurized liquid fuel passing through the flow orifices 70 and 71.

Referring now to Figure 3, an alternative swirl type variable area vapor atomizing fuel nozzle B, is illustrated, which is comprised generally of a hollow cylindrical nozzle body 73 having an internally threaded portion 74 to position and retain a vaporous fuel flow metering assembly b, the nozzle body 73 being closed at one end by a cap 76 and having an inturned beveled lip 77 at the other end to form a centrally disposed opening

75. A pressurized liquid fuel conduit 78 and vaporous fuel conduit 79, intersect a side wall of the nozzle body 73 to deliver a pressurized flow of liquid and vaporous fuel to the nozzle assembly B.

A centrally disposed liquid-vaporous fuel mixing assembly c is positioned in the hollow nozzle body 73 abutting the lip 77, and is comprised generally of a thimble member 80, a cooperatively abutting variable area vaporous fuel jet flow passage member 81 and a liquid-vaporous fuel flow assembly retaining member 82.

The thimble-shaped liquid-vaporous fuel mixing member 80, includes a beveled end portion 83 which engages the lip 77 on the nozzle body 73 to retain and centrally position the liquid-vaporous fuel mixing assembly c in the nozzle body 73.

The dome end of the thimble 80 has an outwardly flared discharge orifice opening 84 therethrough and an extended skirt portion 86, which circumferentially engages the flow passage forming member 81 around a reduced diameter end portion 87 to form a centrally disposed liquid fuel swirl chamber 88 therebetween.

A plurality of circumferentially spaced liquid fuel orifices 89 in the skirt portion 86 of the liquid-vaporous fuel mixing member 80 feed a swirling flow of pressurized liquid fuel from a liquid fuel chamber 90 formed between the liquid vaporous fuel mixing assembly c and nozzle body 73 to the swirl chamber 88. The orifices 89 preferably have tangential outlets to establish a rotation or swirl of fuel in the chamber 88. An annular O-ring seal assembly 85 prevents any leakage of pressurized liquid fuel from the chamber 90 between the vaporous fuel flow passage member 81 and nozzle body 73. The fuel discharge orifice 84 is in communication with the liquid fuel swirl chamber 88, and receives a fine stream or atomized fluid flow therethrough.

The vaporous fuel flow passage member 81 is provided with a centrally disposed vaporous fuel flow passage 91, which includes an axially convergent bore 92 and an axially divergent bore 93 from a centrally disposed throat 94. The vaporous fuel flow passage 91 is in communication with the liquid fuel swirl chamber 88 and in axial flow alignment with the discharge orifice 84, thus permitting a substantially uninterrupted axial jet flow of pressurized vaporous fuel through the swirl chamber 88 and discharge orifice 84.

The liquid fuel mixing member 80 and vaporous fuel flow passage member 81 are axially positioned in the nozzle body 73 by the retaining member 82. The retaining member 82 is provided with a plurality of axially extending vaporous fuel passages 96 which are in communication with the vaporous fuel chamber formed by the retaining member 82, nozzle body 73, cap 76 and flow metering assembly b. The retaining member 82 is bored as at 98 to slidably journal a shaft portion 99 of a flow metering needle valve assembly 100 which is reciprocally positioned in the throat 94 of the vaporous fuel flow passage 91.

Thus it will be appreciated that the needle valve assembly 100 provides a variable flow of vaporous fuel through the flow passage 91, swirl chamber 88 and flow discharge orifice 77, by varying the area of the throat 94 in response to the degree of axial movement of the needle valve assembly 100.

The vaporous fuel flow metering assembly b, is comprised of the needle valve assembly 100, a bellows 101, between the valve and cap 76, and a coil spring 102. The flow needle valve assembly 100 includes a flanged end portion 103 receiving one end of the bellows thereover, and an annular spring retaining sleeve 104 centering the coil spring 102. A recess 106 is formed in the cap 76 to retain the coil spring 102 in axial operative alignment with the needle valve assembly 100.

A passage 107 is formed in the cap 76, to communicate pressure from some downstream point of utilization

to a chamber 108 formed by the needle valve assembly 100, bellows 101 and closure cap 76.

The compression rating of the coil spring 102 is sufficiently high to urge the needle valve assembly 100 into an axially closed position in the throat 94 of the vaporous fuel flow passage 91, whenever vaporous fuel pressure falls below a predetermined minimum value, or below the reference pressure in the chamber 108.

It will further be appreciated that the proportionate axial movement of the needle valve assembly 100 in the throat 94 provides a variable area flow orifice which permits a substantially uniform flow of vaporous fuel through the flow passage 91, even during periods of low liquid fuel flow rate, which produces a finely atomized mist or stream of atomized fuel through the orifice 84, due to the shearing action of the high velocity jet of vaporous fuel through the liquid fuel vortex in the swirl chamber 88.

By way of operative summary of the nozzle assembly B, pressurized liquid fuel is supplied to the liquid fuel chamber 90 in the nozzle assembly B through the liquid fuel conduit 78. Liquid fuel in the chamber 90 is then communicated through the orifices 89 in the vaporous liquid fuel mixing member 80 to the swirl chamber 88.

Pressurized vaporous fuel is supplied to a pressure responsive chamber 97 from which it is communicated through the flow passages 96 in the retaining member 82, through the variable area throat 94 of the vaporous fuel flow passage 91. In addition, pressurized vaporous fuel in the chamber 97 acts on the flange 103 to compress the coil spring 102 in the chamber 108 and collapse the bellows 101.

Reference pressure from some point of utilization is communicated through the passage 107 to the chamber 108, to thereby exert an opposing force in addition to the compression of the coil spring 102 to axially urge the needle valve assembly 100 into a closed position in the throat 94, whenever the vaporized fuel pressure in the chamber 97 falls below a certain predetermined minimum value.

It will thus be appreciated that the degree of axial movement of the needle valve assembly 100, and corresponding change in orifice area at the throat 94 of the vapor flow passage 91, is controlled as a function of the differential pressure between the vaporous fuel in the chamber 97 and the combined pressure of the coil spring 102 and the reference pressure from the point of utilization in the chamber 108.

While only two embodiments of the present invention have been described in Figures 2 and 3, it should be understood that many other modifications and variations may be effected without departing from the scope of the novel concepts herein disclosed.

I claim as my invention:

1. A swirl type fuel nozzle structure comprising a nozzle body having a flow orifice formed therein, said nozzle body including a liquid fuel chamber, conduit means delivering pressurized liquid fuel to said liquid fuel chamber, said liquid fuel chamber supplying pressurized liquid fuel to a swirl chamber provided by said nozzle body, said swirl chamber being in communication with said flow orifice, said nozzle body also having a fuel vapor chamber formed therein, conduit means delivering pressurized vaporous fuel to said fuel vapor chamber, and a connecting passage directing a jet of pressurized fuel vapor through said swirl chamber and flow orifice, to thereby atomize and disperse said liquid fuel into a finely divided spray.

2. A swirl type fuel nozzle structure comprising a nozzle body having a flow orifice formed therein, said nozzle body including a liquid fuel chamber, conduit means delivering pressurized liquid fuel to said liquid fuel chamber, said liquid fuel chamber supplying pressurized liquid fuel to a swirl chamber provided by said

nozzle body, said swirl chamber being in communication with said flow orifice, said nozzle body also having a fuel vapor chamber formed therein, conduit means delivering pressurized vaporous fuel to said fuel vapor chamber, a connecting passage directing a jet of pressurized fuel vapor through said swirl chamber and flow orifice, and means for regulating the flow of said pressurized fuel vapor through said swirl chamber and flow orifice to atomize said liquid fuel.

3. A swirl type fuel nozzle structure comprising a nozzle body having a flow orifice formed therein, said nozzle body including a liquid fuel chamber, conduit means delivering pressurized liquid fuel to said liquid fuel chamber, said liquid fuel chamber supplying pressurized liquid fuel to a swirl chamber provided by said nozzle body, said swirl chamber being in communication with said flow orifice, said nozzle body also having a fuel vapor chamber formed therein, conduit means delivering pressurized vaporous fuel to said fuel vapor chamber, a connecting passage directing a jet of pressurized fuel vapor through said swirl chamber and flow orifice, a slidable needle valve assembly cooperatively positioned in said connecting passage to meter the flow rate of said pressurized fuel vapor a pressure responsive means secured to said needle valve assembly controlling the amount of movement thereof, and means referencing pressure from a point of utilization of said fuel to said pressure responsive means to thereby control the flow of said pressurized fuel vapor through said swirl chamber and prevent a reversal in flow direction during periods of relatively low fuel vapor pressure.

4. A nozzle structure adapted to atomize a liquid by utilizing a flow of pressurized vapor of the liquid to be atomized comprising a nozzle body having a liquid chamber and a vapor chamber, said liquid chamber having a plurality of annularly arranged liquid flow orifices in communication therewith, said vapor chamber having at least one variable area vapor metering orifice in communication therewith and positioned to direct a flow of vapor to intersect a flow of liquid from said liquid orifices, means positioned to controllably vary the flow area through said vapor metering orifice, and means connected to said vapor chamber and responsive to the pressure of said vapor and connected to said orifice flow area control means for varying the flow area of said vapor metering orifice to direct a controlled intersecting flow of vapor into jets of said liquid discharging from said liquid orifices and to control the flow rate of said vapor and prevent a backflow thereof.

5. A nozzle structure adapted to atomize a liquid by utilizing a pressurized flow of vapor of the liquid to be atomized comprising a generally cylindrical cup-shaped nozzle body having a liquid and a vapor passage, conduit means supplying pressurized liquid and vapor of said liquid to said liquid and vapor passages, respectively, a vapor flow fitting member having a plurality of annularly arranged longitudinally extending vapor flow orifices formed therein carried in the open end of said cup-shaped nozzle body, a plug member having a plurality of annularly arranged longitudinally extending liquid flow orifices formed therein carried in the open end of said nozzle body and circumscribed by said vapor flow fitting member, said flow fitting member and plug member having their end faces outwardly conically tapered, a combination bellows check valve and flow regulator member carried by said vapor flow fitting member and having an annular conically tapered deflection lip formed therewith congruently engageable with the conically tapered end faces of said vapor flow fitting member and plug member to prevent reverse flow through said vapor flow orifices when engaged therewith, said deflection lip also being operable to deflect a vapor flow from said vapor orifices into jets of liquid flowing from said liquid orifices to cause atomization thereof and to vary the area of said vapor orifices to control the flow rate

therethrough, a shield carried on the open end of said nozzle body enclosing said vapor flow fitting member and said plug member to protect said members from high ambient temperatures, and louvers on said shield for circulating cool fluid through said shield and around said vapor flow fitting member and plug member to cool the same.

6. A nozzle structure comprising a nozzle body having a liquid passage means formed therein, conduit means supplying pressurized liquid to said liquid passage means, liquid flow orifices connected to said liquid passage emitting streams of liquid, vapor conduit means conducting a flow of vapor, orifice means leading from said vapor conduit and positioned to direct a flow stream of vapor intersecting said liquid streams, valve means controlling the flow of vapor, and a pressure responsive valve operator connected to said valve means and opening with vapor pressure and biased to automatically close with an absence of vapor pressure and prevent reverse flow of liquid through said vapor orifice means.

7. A fuel supply system for a combustion chamber or the like comprising a liquid fuel conduit, means connected to said conduit for supplying pressurized liquid fuel thereto, a gaseous fuel conduit, means connected to said gaseous fuel conduit for supplying pressurized gaseous fuel thereto, a nozzle member having a liquid fuel chamber connected to said liquid fuel conduit, a gaseous fuel chamber connected to said gaseous fuel conduit, a plurality of small spaced liquid fuel outlets connected to said liquid fuel chamber and positioned to dispense separated streams of finely divided liquid particles, and a vapor dispensing means having a vapor outlet spaced from said liquid fuel outlets and connected to said gaseous fuel conduit, said vapor outlet positioned to emit a stream of vapor in a path to intersect said streams of liquid and cause them to break up into finer particles and mix with the vapor.

8. A fuel supply system for furnishing fuel in a combustible form to a combustion zone comprising a first liquid fuel supply conduit for connection to a supply of fuel, a pressure pump in said supply conduit, a second fuel conduit for supplying fuel in gaseous form for connection to a source of liquid fuel, a heater converter in said second conduit converting the liquid fuel to a gaseous fuel, pump means in said second fuel conduit downstream of said heater converter for pressurizing said gaseous fuel, a nozzle body member defining a liquid fuel chamber therein connected to said first fuel conduit and a vaporous fuel chamber therein connected to said second fuel conduit for receiving gaseous fuel, means defining a plurality of annularly arranged liquid fuel atomizing orifices in communication with said liquid fuel chamber and positioned to direct streams of fuel particles, and means defining a vaporous fuel metering orifice in communication with said vaporous fuel chamber and opening in a direction to emit a stream of fuel vapor intersecting the streams of liquid fuel to break up into finer particles and mix with the vapor.

9. A nozzle structure comprising a nozzle body having liquid passage means formed therein, conduit means connected to said liquid passage for supplying pressurized liquid to said liquid passage means, closure means for said nozzle body having a plurality of annularly arranged liquid flow orifices communicating with said liquid passage means, said flow orifices directing jets of pressurized liquid from said nozzle body to a mixing zone outside of said body, means in said body for directing an intersecting annular flow of pressurized vapor of said liquid directly inwardly into said jets of pressurized liquid in said mixing zone outside said nozzle body to thereby atomize and disperse said liquid, and conduit means connected to said vapor directing means for supplying vapor thereto.

10. A nozzle structure comprising a nozzle body having a liquid passage means formed therein, conduit means

connected to said liquid passage supplying pressurized liquid to said liquid passage means, a liquid fuel flow orifice means having a plurality of liquid fuel openings therein to emit broken streams of liquid fuel into a mixing zone and connected to said liquid fuel passage, a plurality of annularly arranged openings for emitting a flow of gaseous fuel annularly surrounding said liquid fuel orifice means, conduit means connected to said gaseous fuel openings for supplying fuel thereto, and an annular deflector means having a circular deflector edge positioned to be engaged by said gaseous fuel emerging from said gaseous fuel openings and for deflecting said gaseous fuel into said mixing zone whereby an annular flow stream of gaseous fuel will intersect the stream of liquid fuel to cause a mixing and dispersion thereof.

11. A burner and nozzle structure for a combustion zone comprising a nozzle body having a liquid fuel passage means formed therein, conduit means connected to said liquid fuel passage for supplying pressurized liquid fuel to the fuel passage means, closure means for said nozzle body having a plurality of annularly arranged liquid fuel flow orifices communicating with said liquid fuel passage means, said flow orifices directing jets of pressurized liquid fuel from said nozzle body to a mixing zone outside of said body, means in said body for direct-

ing an intersecting annular flow of pressurized vaporous fuel directly inwardly into said jets of pressurized liquid fuel in said mixing zone outside of said nozzle body to thereby atomize and disperse said liquid fuel, conduit means connected to said vaporous fuel directing means for supplying vaporous fuel thereto, and a liquid starting fuel orifice in said nozzle closure means centrally located with respect to said annularly arranged liquid fuel orifices for supplying a starting fuel to the mixing zone and positioned to direct a jet of starting fuel to be intersected by the annular flow of pressurized vaporous fuel.

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