June 5, 1956 J. F. CAMPBELL 2,749,182

NOZZLE CONSTRUCTION

Filed Jan. 27, 1953 4 Sheets-Sheet 1

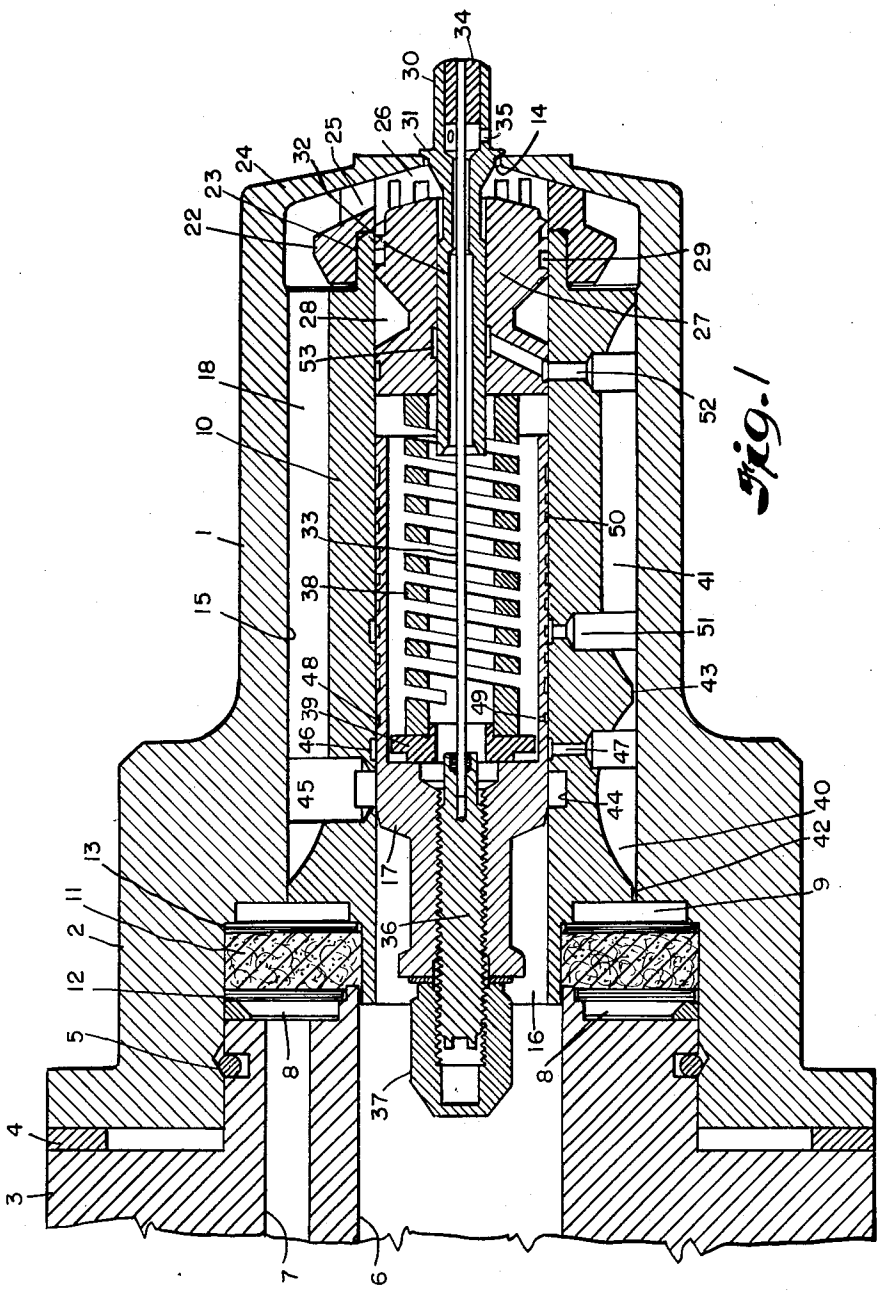



Fig. 1

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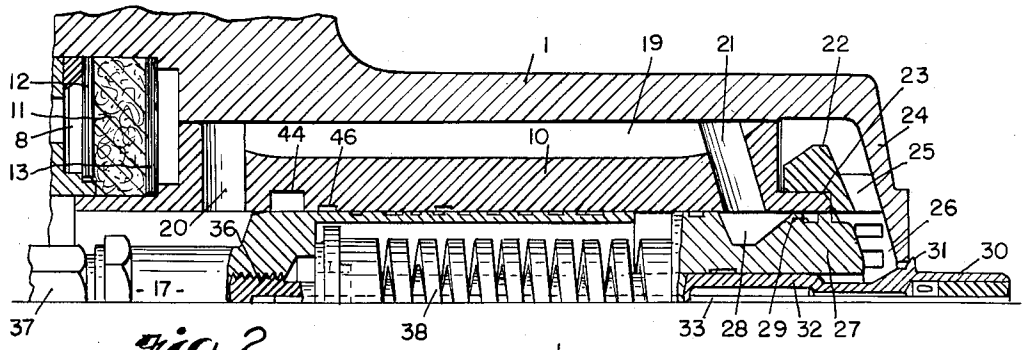



Fig. 2

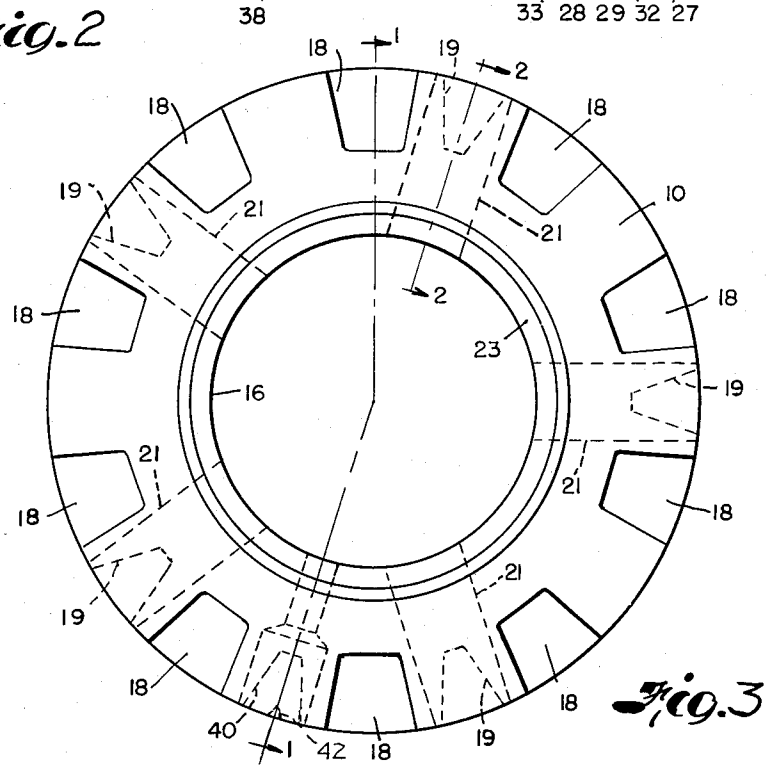



Fig. 3

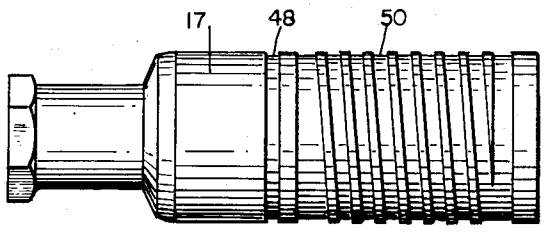



Fig. 4

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NOZZLE CONSTRUCTION

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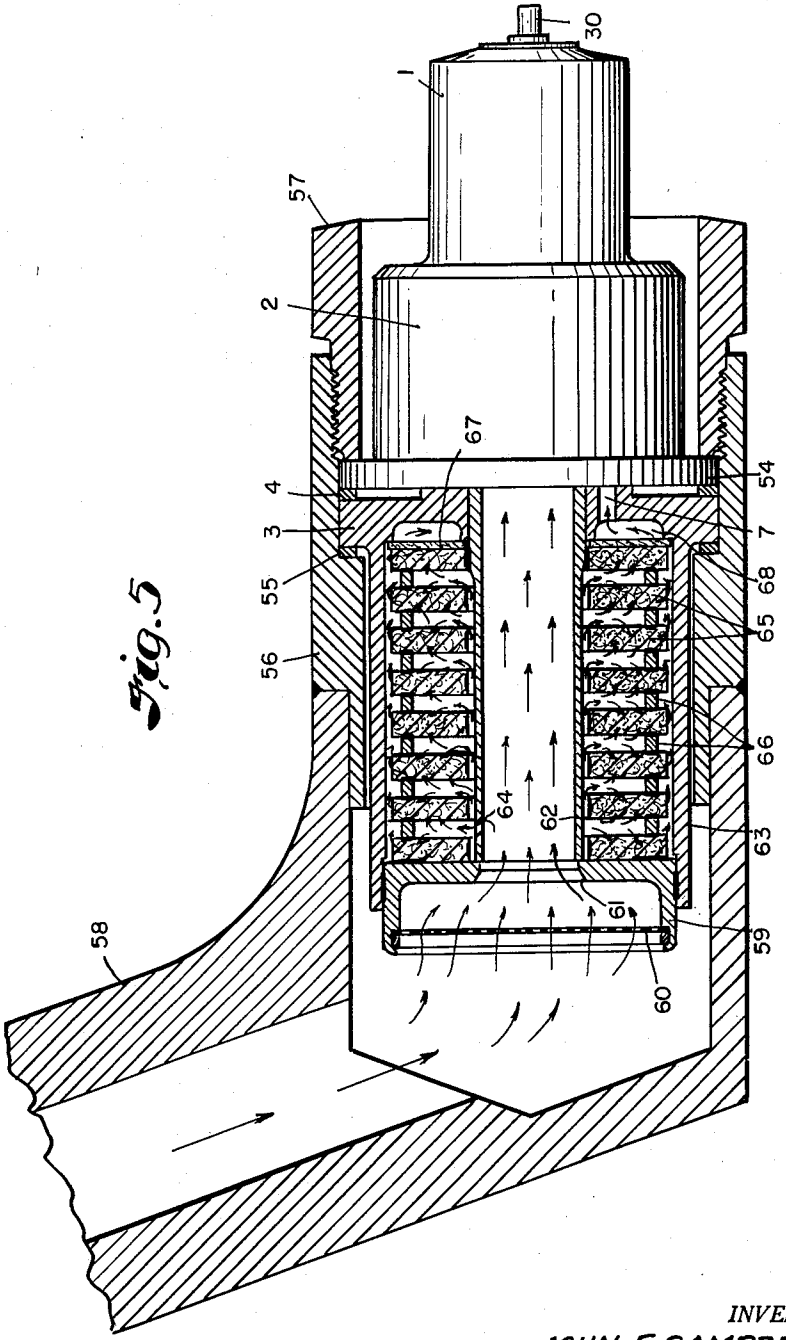



Fig. 5

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NOZZLE CONSTRUCTION

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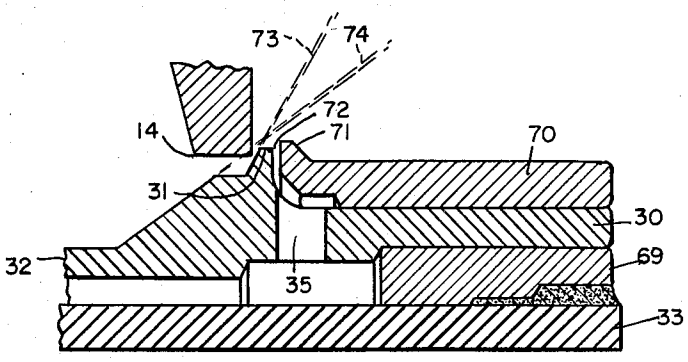



Fig. 6

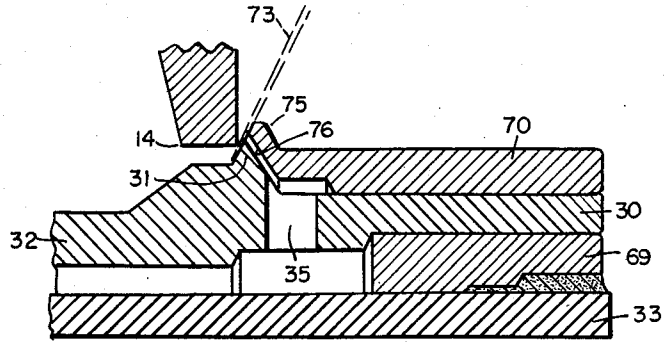



Fig. 7

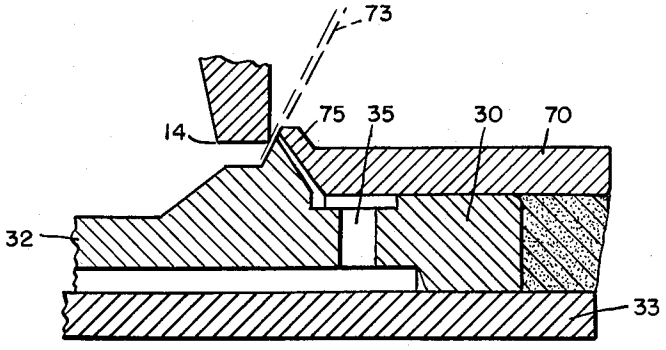



Fig. 8

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2,749,182

# NOZZLE CONSTRUCTION

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Application January 27, 1953, Serial No. 333,569

19 Claims. (Cl. 299—107.6)

This invention relates as indicated to nozzles, and more particularly to nozzles especially adapted for the injection of liquid fuels into combustion chambers of various types of engines. A generally similar type of nozzle is disclosed in my co-pending application Serial No. 105,975, filed July 21, 1949, now Patent 2,656,218, and this invention involves certain improvements in my prior nozzle construction, as explained below.

There are at present several different types of engines employing liquid fuels which require to be injected into the combustion chambers of the same, such engines including the well-known automotive internal combustion engine, diesels, the turbo-jet, prop-jet, and ram-jet engines and the like. While such latter types of engines are at present largely employed in aircraft, it is expected that they will shortly find application in railway locomotives and ships. In certain of such engines it is necessary to provide for a wide range of fuel flow between selected minimum and maximum limits while at the same time maintaining a low over-all pressure drop through the nozzle between the fuel intake manifold and the combustion chamber.

Open orifice type nozzles have been employed in the past in such applications but without any great measure of success, principally because of their limited flow range of approximately 10 to 1. The flow range which must be obtainable for continuously efficient operation of certain of the more modern jet engines is in some cases as much as 125 to 1. The usual open orifice nozzles are not capable of any such range of performance since in such nozzles when the rate of flow is increased by a stated factor the corresponding line pressure will generally require to be increased by such factor squared. To attempt to provide for any great range of flow with this latter type of nozzle is therefore wholly impracticable as leading to impossibly high line pressures in the upper range of flow. In my aforesaid prior application Serial No. 105,975, I disclose a new form of nozzle capable of a wide flow range, having but a small increase in pressure loss from low to high rate of flow, capable of maintaining the spray envelope at a substantially constant angle over such large flow range, capable of atomizing the liquid with slight penetration, i. e. quickly, before the liquid spray cone extends very far, and to the point where an almost dry vapor is obtained, and adapted to close automatically when the inlet pressure drops below some designated value.

It is sometimes desired to operate spray nozzles of the general type indicated at quite high rates of flow but using contaminated fuels. Such contaminants are usually present in the form of extremely fine particles which, however, when they enter the very precisely finished sliding fits of the relatively movable nozzle parts, may cause sticking of such parts or at least render the parts less sensitive to changes in fluid pressure, etc., with resultant malfunctioning. Various filtering devices may, of course, be employed to filter the fuel delivered to the nozzle, but there are certain objections to this arrangement. For one thing, if the entire fuel supply delivered to a particular nozzle must be filtered, the filter will naturally tend to obstruct the flow of the fluid, this difficulty being particularly serious when high rates of flow are desired. Also, if the entire supply of fuel delivered to a nozzle be thus filtered, the filter will tend to clog relatively rapidly and will require frequent maintenance and replacement.



It is accordingly a principal object of the present invention to provide a spray nozzle of the general type disclosed in my aforesaid application Serial No. 105,975 but especially adapted to handle contaminated fuels without the necessity of filtering or otherwise cleaning the larger portion of the fuel passing through the nozzle.

Another object is to provide means for introducing clean fuel between sliding parts of the nozzle assembly at higher pressures than the pressures of the contaminated fuel or other liquid passing through the nozzle, so that entry of such contaminated liquids between such relatively movable parts is prevented.

A further object is to provide such anti-clogging means which will be automatic in operation and require very little attention.

Other objects of the invention will appear as the description proceeds.

To the accomplishment of the foregoing and related ends, said invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

Fig. 1 is a longitudinal sectional view of one embodiment of my new nozzle taken along the line 1—1 on Fig. 3;

Fig. 2 is a similar longitudinal sectional view of the same nozzle taken along a different radius thereof on the line 2—2 on Fig. 3;

Fig. 3 is an end view on an enlarged scale of the inner liner member of the valve assembly;

Fig. 4 is an elevational view of the sliding valve member which fits inside such liner on the same scale as Fig. 1;

Fig. 5 is a longitudinal sectional view of typical nozzle mounting means and showing an auxiliary filter assembly likewise sectioned; and

Figs. 6, 7 and 8 are much enlarged fragmentary longitudinal sectional views of the exit valve member having modified forms of vent passages therein.

The general resemblance to the construction of my new nozzle disclosed in my co-pending application Serial No. 105,975 will be noted. Referring now more particularly to the drawing, the embodiment of my invention there illustrated comprises an outer nozzle body 1 of general cylindrical form having an enlarged base portion 2 adapted to be threaded or otherwise secured to a tubular shell 3 extending from the intake manifold (not shown) of an engine. Gasket 4 and snap ring 5 serve to make a fluid-tight connection. Boss 3 is formed with a central axial passage 6 therein and one or more smaller passages such as 7 radially outwardly therefrom but in communication therewith, either internally of such boss or through common communication with the same intake manifold and therefore the same fuel supply. Passage 7 leads into an annular recess 8 opposed to a corresponding annular recess 9 formed in said outer body member 1 and the inner liner member 10 press fitted therein. An annular filter 11 which may be of asbestos fiber, for example, held between layers of filter cloth 12 and 13 is interposed between such annular recesses 8 and 9 and

firmly clamped between members 1 and 3 so that fuel or other liquid entering recess 8 through passage 7 can only reach annular cavity 9 through such filter.

The other end of the nozzle body is closed except for an axially disposed orifice 14. All parts of the nozzle may desirably be of stainless steel, for example.

As above indicated, the inner liner member is press fitted within cylindrical nozzle body 1, such liner being provided with a plurality of longitudinally extending grooves in its outer surface adapted to form channels or passages in conjunction with the inner cylindrical wall 15 of nozzle body 1. As shown in Fig. 3 of the drawing, liner 10 is likewise of cylindrical shape, its inner periphery 16 defining the axial bore within which valve member 17 is adapted to slide. In the embodiment illustrated, ten equally spaced grooves 18 are provided in the outer periphery of member 10 opening to the end of such member toward exit orifice 14 but closed at their other ends (see Fig. 1). Five somewhat smaller grooves 19 are similarly formed in the outer periphery of liner 10 intermediate every other pair of such grooves 18, but such grooves 19 do not extend quite to either end of liner 10 (see Fig. 2). Instead, generally radial passages 20 and 21 lead therefrom to the inner bore 16 of the liner.

For convenient manufacture and assembly, a separate annular member 22 is fitted over end flange 23 of liner 10, being interposed therebetween and the outer end 24 of the nozzle body. As shown, such member is thereby spaced from the inner cylindrical wall of nozzle body 1 and is formed with a plurality of tangential slots 25 opening into a swirl chamber 26 immediately upstream of the exit orifice 14. Accordingly, fluid admitted to channels 18 by reciprocation of valve member 17 is caused to enter chamber 26 through such diagonal slots 25 in communication therewith, imparting an accelerating swirling action to the fluid within chamber 26 immediately prior to and during its escape through orifice 14.

Passages 20 are at all times in communication with the main axial intake passage 6. An inner plug and guide member 27 is press fitted within bore 16 of liner 10, joining in defining such swirl chamber 26. Member 27 is also provided with an annular groove 28 communicating with such swirl chamber by means of a plurality of helical passages 29 formed by helical grooves in the outer periphery of member 27 opposed to the inner bore 16 of liner 10. The passages 21 lead from channels 19 to such annular channel 28 so that even when valve member 17 has not been reciprocated to admit fluid from intake passage 6 to channels 18, fluid may flow through passages 20, channels 19, passages 21, annular channel 28 and small helical grooves 29 to swirl chamber 26.

Valve member 17 comprises a cylindrical shell closed toward the fuel inlet end of the nozzle but open toward member 27. Such valve member fits closely within bore 16 of liner 10 for axial reciprocation therewithin.

Exit valve member 30 extends through exit orifice 14 and is provided with a radially outwardly flaring flange 31 adapted to engage and seat against the outer edge of such orifice. An inner stem 32 fits closely for axial reciprocation within a central bore in member 27.

Slide valve member 17 and poppet valve member 30 are interconnected for movement together by means of a rod 33 (a fine spring wire, which in one case had a diameter of .014 inch) which extends through tubular valve stem 32 and is secured as by brazing at its outer end to a plug 34 in the outwardly protruding portion of exit valve member 30. Such tubular stem 32 is open at its inner end to the interior of bore 16 of liner 10, and at its outer end communicates with a small chamber within valve member 30 having small exit orifices such as 35 leading to the exterior of the nozzle. The other end of rod 33 is secured to an adjusting screw 36 threaded within the end of valve member 17, the protruding end of screw 36 being engaged and enclosed by a lock nut 37. A compression spring 38 is seated at one end against a washer 39 bearing against the end of valve member 17 and at the other end bears against inner plug 27. It will thus be seen that by turning screw 36, valve member 17 may be drawn toward plug 27 with attendant further compression of spring 38 and more forceful seating of poppet valve member 30.

Steel rod 33, although slender, is straight and therefore capable of causing both valve members 17 and 30 to reciprocate in unison. Such rod is, however, flexible to permit a slight degree of misalignment of such two valve members without tending to cause the latter to bind. It is important in nozzles of this type that they be quite sensitive and responsive to changes in fluid pressure. By securing the ends of rod 33 in adjusting screw 36 and the extreme outer end of valve member 30 respectively, as by low temperature brazing, a relatively long rod may be employed facilitating such slight deflection of the same. It may be kept in mind that frequently nozzles of the type here under consideration are only an inch or so long and the various moving parts are accordingly on a very small scale. Compression spring 38 may desirably be formed from a length of tubing slotted by two helical slots terminating at diametrically opposite points in the annular end portions thereof. A spring thus formed is adapted to transmit pressure directly axially without canting. Any tendency of valve member 17 to bind on this account is accordingly avoided.

As shown in Figs. 1 and 3, another longitudinally extending channel is provided formed by grooves 40 and 41 in the outer periphery of liner 10, groove 40 communicating with annular passage 9 through the constricted relief 42 and communicating with groove 41 through a similar relief 43.

An annular recess 44 in inner bore 16 of liner 10 communicates through passages 45 with the several longitudinally extending channels 18 so that when valve member 17 is reciprocated sufficiently to the right as viewed in Fig. 1, fluid from intake passage 6 will be admitted thereto for delivery at the exit orifice of the nozzle. A smaller annular groove 46 in bore 16 of member 10 closely adjacent groove 44 is in communication with groove 40 through passage 47 so that filtered fuel from annular recess 9 may be delivered thereto. As best shown in Fig. 4, valve member 17 is provided with an annular groove 48 having a small passage 49 leading to the cylindrical interior of the valve member and such valve member is also provided with a helical groove 50 extending the greater part of its length, or preferably two or more such helical grooves equally spaced to afford symmetry of distribution of clean fluid pressure. A passage 51 leads from longitudinally extending groove 41 to the interior of bore 16 in the region of such helical groove 50. Another similar passage 52 likewise leads from groove 41 through member 27 to an annular groove 53 in the inner bore of such latter member within which stem 32 of poppet valve 30 is adapted to reciprocate.

It will now be seen that filtered fluid under pressure after having passed through filter 11 is conducted through relief 42 to groove 40 and passage 47 to annular groove 46. Contaminated fluid in the region of groove 44 is thereby prevented from entering into the fit between valve member 17 and bore 16 since the filtered fluid will be at somewhat higher pressure (there is, of course, a considerable pressure drop from passage 6 to groove 44 when valve member 17 is reciprocated sufficiently to admit fluid to the latter). The filtered fluid likewise serves to flush out any minute particles which may under some circumstances become interposed between the relatively sliding surfaces and which would tend to reduce the sensitivity of the device. Filtered fluid also flows through clearance 43 into groove 41 and thence through passage 51 into spiral groove 50 where it serves the same purpose. Any fluid which reaches annular groove 48 may escape through passage 49 to the interior of valve member 17 and thence through tubular valve stem 32 and

orifices 35 to the exterior of the nozzle. This assists in seeing to it that only filtered fuel reaches the interior of valve member 17. Filtered fluid also, of course, enters passage 52 and annular groove 53 surrounding valve stem 32 and entering the fit between such valve stem and member 27 escapes slowly both to the interior of bore 16 and valve member 17 and also in the opposite direction to swirl chamber 26. Contaminated fluid is accordingly likewise prevented from entering the sliding fit in this region. It will be seen that the operation of this anti-clogging means is wholly automatic and requires no maintenance other than very occasional cleaning or replacement of filter 11. Since the fluid flow through such filter is very slow, a long period will elapse before the filter will become clogged. Moreover, the nozzle, considered as a whole, is now enabled to accommodate itself to contaminated fuels without any special treatment of the latter passing therethrough and without any consequent reduction in flow.

The bevelled shoulder of cylinder valve member 17 is adapted to provide a variable degree of communication with annular chamber 44 when the cylinder is moved inwardly against the force of compression spring 38. Such reciprocable cylinder accordingly acts as a regulating valve. The setting given adjusting screw 36 in conjunction with the thickness of washer or shim 39 will determine the fluid pressure required thus to reciprocate valve member 17 to admit fluid past such bevelled contour into chamber 44. Of course, the opposed surface of bore 16 may be contoured in the region adjacent chamber 44 to determine the change in rate of fluid flow as the valve member is reciprocated instead of bevelling valve member 17 as shown, or both may be contoured.

The operation of my nozzle may now be understood, being generally similar to that described in my aforesaid co-pending application Serial No. 105,975. Liquid fuel enters the nozzle from the fuel manifold and is discharged through exit orifice 14 into a relatively low pressure exterior chamber. When the fuel pressure bearing against the end of regulator valve 17 exceeds that in such exterior chamber by an amount barely sufficient to overcome the preload of spring 38, then exit valve 31 will open. The fluid pressure bearing directly against the much smaller effective area of valve 31 is of relatively little consequence. This opening of valve 31 permits fuel to flow through channels 19 (Fig. 2) to annular chamber 28 and through spiral passages 29 into swirl chamber 26 and through orifice 14 past exit valve 31 into the exterior chamber (normally a combustion chamber which may be at substantially atmospheric pressure or in some cases at pressures considerably in excess of atmospheric). Since the cross-sectional areas of spiral channels 29 are quite small and are selected to achieve a relatively large pressure differential between the fuel inlet end of the nozzle and the exterior chamber into which such fuel is discharged thereby, sufficient pressure is built up effective to move valve member 17 and open exit valve 31 to a relatively large extent. Consequently, the fluid pressure bearing against regulator valve 17 is sufficient to shift the latter to move exit valve 31 from its seat in orifice 14 to a degree much greater than would be obtained by the action of fluid pressure bearing against the inner side of valve 31 alone. The area of valve member 31 subject to fluid pressure tending to open the exit valve is of course considerably greater than the area of the shoulder of stem 32 subject to fluid pressure tending to close such valve. Helical channels 29 give the fuel a high spinning rate in chamber 26 even at low fuel flows, and excellent atomization in the fuel spray envelope is obtained even at such low flows. The spinning inertia of fuel particles in the envelope formed at the opening of exit valve 31 causes such particles to break away and disintegrate the envelope into a finely atomized mist which then further disintegrates into a relatively dry vapor.

Constricted helical channels 29 prevent a high fluid pressure from developing in chamber 26 when the exit valve has been thus initially rather widely opened, and accordingly the initial fluid discharge of the nozzle will be at a relatively low rate. Such constricted helical channels likewise ensure that substantial intake pressure is maintained against regulator valve 17.

As the rate of fuel flow is increased, regulator valve 17 is gradually shifted from left to right, as viewed in Fig. 1, bringing the bevelled shoulder of the same past the edge of chamber 44. Fuel accordingly enters such chamber to an increasing extent as such valve opens and passes therefrom through channels 18 and swirl slots 25 into chamber 26 and thence out orifice 14. Exit valve 31 has, of course, been correspondingly opened as regulator valve 20 was opened, due to reciprocation of the flexible resilient rod 33 connecting the two valve members. There continues to be a certain amount of fuel flow through channels 19 and spiral passages 29, but this soon becomes relatively inconsequential when compared to the very much larger flow entering through annular chamber 44 and thence passing through channels 18.

The bevel or contour of valve member 17 will ordinarily be selected so that at maximum rated fuel flow the pressure drop between annular chamber 44 and chamber 26 will be as low as possible and still afford sufficient swirling action through slots 25 to provide satisfactory atomization of the fuel at the orifice. Such "bevelled" contour need not necessarily be a straight line and other curves may be employed when suitable. Swirl slots 25 afford the same result at higher rates of flow as do spiral passages 29 at low fuel flow, but the pressure loss through slots 25 is much less since they are of relatively large cross-section.

While the fuel entering from passage 7 must pass through filter 11 to reach filtered fuel channel 40, 41, there will be very little pressure drop involved inasmuch as such filtered fuel can escape from channel 40, 41 only very slowly through the close sliding fits of the relatively movable parts of the nozzle assembly. Consequently, the filtered fuel introduced into such sliding fits is at higher pressures than the unfiltered fuel flowing through corresponding regions of the nozzle and such unfiltered fuel is accordingly prevented from entering the interstices between such moving parts. The filtered fuel, moreover, flushes out any minute particles which may be mechanically carried into such interstices by reciprocation of the parts and also serves to lubricate the same.

A preferred manner of mounting my new nozzle assembly is illustrated in Fig. 5 of the drawing which also shows a preferred form of filter cartridge desirably utilized in conjunction with filter 11 so that a minimum of attention and maintenance will be necessary. The base flange portion 54 of the nozzle is seated against copper washer 4 which in turn presses against the peripheral flange portion of inner tubular shell 3 which bears against copper washer 55 seated against a shoulder of cylindrical nozzle holder 56. A nut 57 threadedly engages the end portion of holder 56 and bears against flange 54 to clamp the nozzle firmly within the holder. A laterally offset conduit and bracket member 58 leads from the intake manifold of the engine (not shown) to the intake end of shell 3.

A holder 59 is tightly fitted in the end of shell 3 and is provided with a filter screen 60 which may, for example, have .003 inch to .004 inch particle retention and afford a pressure drop of approximately .17 pound per square inch at maximum fuel flow. Such member 59 has an inner central opening 61 leading directly to central axial passage 62 which corresponds to passage 6 of Fig. 1 and leads directly to the intake end of the nozzle proper. The fuel which flows through channels 18 and 19 of the nozzle accordingly has relatively unrestricted flow so far as filtering is concerned, screen 60 being of relatively large size and large mesh whereas filter 11 and the supplemental filters about to be described are designed to re-

move even very small particles from the fuel and consequently considerably restrict the rate of fuel flow therethrough.

A very small portion of the fuel entering passage 62 enters the annular space between the wall 63 of shell 3 and the wall of central passage 62 through one or more apertures 64 in such inner wall. Within the annular cavity thus defined and closed at the left-hand end as viewed in Fig. 5 by member 59 are arranged a plurality of asbestos filter discs 65 held in spaced relationship between interposed stainless steel rings 66. Such rings are cemented to the asbestos discs, preferably with "Araldite" sealing compound to hold the same in the indicated relationship spaced from one another and also from inner and outer walls 62 and 63 respectively. The fuel is accordingly enabled to circulate between all such filter discs but must pass therethrough radially outwardly thereof to reach the peripheral space defined between wall 63 and such discs and rings. When the filtered fuel has reached such region, it passes through a screen seepage washer 67 supporting the last filter disc of the series and enters an annular channel 68 communicating with passage 7 (see also Fig. 1).

It will be seen from the foregoing that the filter cartridge within shell 3 joined to the intake end of my new nozzle affords a relatively large filter area for passage of fuel despite the fact that the filter discs are designed to filter out even extremely small particles. In view of this fact and in view of the fact that the flow through filtered fuel passages 40 and 41 is very low, there is but relatively small pressure drop to the filtered fuel passages in comparison to the pressure drop in passages 18 and 19 and later in the swirl chamber through which the unfiltered fuel flows.

As previously explained, most of the filtered fuel delivered to passages 47, 48, 49, 50 and 53 eventually seeps to the central cavity interiorly of liner member 10 and cylindrical valve member 17 (see Fig. 1) from which it escapes to the exterior through tubular valve stem 32 and exit orifices 35 in valve member 30 exteriorly of the nozzle. It is preferred that such seepage should escape in a manner to be combined with the spray cone of the nozzle and three modified forms of exit valve members 30 are shown in Figs. 6, 7 and 8 designed for this purpose. It will be understood that in such fragmentary figures the valve member is shown on a much enlarged scale but with only one-half diameter. In Figs. 6 and 7 the tubular outer end portion 30 is apertured with vents 35 in a manner generally similar to that illustrated in Fig. 1, and the resiliently flexible wire or rod 33 is brazed within an inner tubular press fitted plug member 69. An outer cylindrical member 70 is then press fitted over member 30 as shown with its inner outturned end portion 71 defining a restricted circumferential passage 72 with flange portion 31 of the exit valve member. Filtered fuel which escapes through tubular stem 32 is accordingly directed into the spray cone which may have an angle as illustrated at 73 when the valve is substantially closed and an angle as indicated at 74 when the valve is widely opened. In Fig. 7 the inner lip 75 of member 70 corresponding to lip 71 cooperates with a bevelled flange 31 of member 30 to define a narrow circumferential passage 76 generally similar to passage 72 but better adapted to deliver the seepage directly into the spray cone 73. The Fig. 8 modification is generally similar to that of Fig. 7 except that the end of member 30 is of a size to fit rod 33 so that no plug 69 is required. I have found the Fig. 7 construction to be particularly satisfactory.

As indicated above, the principal reason for the pressure differential between the filtered fuel passage and the passages 18 and 19 resides in the much lower flow capacity of such filtered fuel passage. Of course, all such passages derive their fluid initially from the same fluid intake and accordingly have the same initial fluid pressure. The complete filtered fuel passage and the complete unfiltered fuel passage are so proportioned relative to one another that at any given inlet pressure the total flow through the filtered fuel passage is but a very small fraction of the total flow through the unfiltered fuel passage. Moreover, the pressure drop through those portions of the filtered fuel passage leading to particular sliding fits is much less than the pressure drop in the corresponding portions of the unfiltered fuel passage having access to the same fits. Accordingly, the filtered fuel will enter such fits, but the unfiltered fuel will not. Should some small quantity of contaminant be mechanically carried into a sliding fit, it will tend to be flushed out subsequently by the seepage of the filtered fluid. While this invention relates particularly to fuel nozzles and the like and particularly such nozzles of small size having valves with moving parts of particularly close fit, it will nevertheless be appreciated that certain principles of my invention may likewise be employed in conjunction with valves other than those utilized in such nozzles.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In a liquid fuel injection nozzle having a fuel intake end adapted for connection with an intake manifold and a relatively small exit orifice in its other end, a channel extending longitudinally from the intake end of said nozzle to an annular chamber therein, a plurality of small helical passages leading from such chamber to a swirl chamber immediately upstream of such exit orifice, a cylindrical valve member mounted for reciprocation in an inner cylindrical chamber axially within said nozzle, a valve stem within said nozzle mounted for reciprocation in a bore axially of such orifice, an outwardly opening exit valve member carried by said stem adapted to seat in and close such orifice, said stem and exit valve member having a bore therethrough adapted to vent such inner cylindrical chamber closed by said cylindrical valve member, a flexible resilient rod inserted in such bore within said stem with clearance relative to the wall of the latter and connected at its ends to said exit valve member and said cylindrical valve member respectively for reciprocation together, a compression spring interposed between said latter valve member and the end of such cylindrical chamber effective normally to hold said exit valve member firmly seated in such orifice, an annular chamber surrounding said cylindrical valve member and normally sealed thereby, one of the opposed surfaces of said cylindrical valve member and such inner cylindrical chamber being peripherally beveled on desired contour adjacent said last-named annular chamber toward the intake end of said nozzle, whereby, upon movement of said cylindrical valve member under influence of fluid intake pressure thereon to open said exit valve, such beveled contour will be effective after predetermined movement to admit an increasing flow of fluid to said annular chamber surrounding said cylindrical valve member, a plurality of channels extending longitudinally of said nozzle from said latter annular chamber and communicating with the chamber immediately within such exit orifice by means of tangentially disposed swirl slots, said last-named channels and slots being dimensioned for much greater fluid flow therethrough than the aforesaid helical channels, another annular chamber in the intake end portion of said nozzle, a fluid intake passage leading to said latter chamber, a similar annular chamber opposed to said last-named annular chamber and separated therefrom by an annular filter, a filtered fuel passage leading from said similar annular chamber longitudinally of said nozzle, an annular groove in the inner peripheral surface of such inner cylindrical chamber adjacent said annular chamber normally sealed by said cylindrical valve member

on the side away from the intake end of the nozzle, a passage leading from said longitudinally extending filtered fuel passage to said annular groove, an annular groove in the outer surface of said cylindrical valve member spaced from said last-named annular groove toward the exit end of the nozzle, a small passage leading from said annular groove in said cylindrical valve member through the side wall of the latter to the interior of the same, a helical groove in the outer surface of said cylindrical valve member extending from a region spaced from said annular groove therein to a point slightly spaced from the end of said cylindrical valve member toward the exit valve end of the nozzle, a passage leading from said filtered fuel passage to said helical groove, an annular groove in the bore enclosing and fitting said exit valve stem, and a passage leading from said filtered fuel passage to said latter groove, whereby filtered fuel will thus be delivered to the interstices between the closely fitting relatively sliding parts of the nozzle at greater pressure than unfiltered fuel from the intake end of the nozzle passing said cylindrical valve member and exit orifice reaches such interstices.

2. In a liquid fuel injection nozzle having a fuel intake end and an exit orifice in its other end, a swirl chamber within said nozzle directly axially of and in communication with such orifice, an exit orifice poppet valve member adapted to seat in and close such orifice, a stem for said valve member mounted for reciprocation in a bore axially aligned with and spaced from such orifice and said chamber, a fuel intake passage in said intake end, a constricted normally open passage leading from said intake passage to said swirl chamber, another relatively large passage leading from said intake passage to said swirl chamber, a cylinder valve member mounted for reciprocation in an axial bore within said nozzle to open and close communication of said large passage with said fuel intake passage, means venting the interior of said cylinder valve member to the exterior, and means connecting said cylinder valve member and said stem of said poppet valve member for reciprocation together; means adapting said nozzle to handle contaminated fuels comprising an annular chamber in the intake end of said nozzle encircling said fuel intake passage, a fuel intake passage leading to said annual chamber, an annular filter in said latter chamber adapted to filter fuel passing from one end thereof to the other, a filtered fuel passage extending longitudinally of said nozzle from said latter chamber, said filtered fuel passage being locally constricted intermediate its ends, an annular groove in the inner peripheral surface of such axial bore in which said cylinder valve member is fitted adjacent the region of communication between said fuel intake passage and said large passage leading to said swirl chamber and on the side thereof toward such exit orifice, a passage leading from said filtered fuel passage in advance of such constriction therein to said annular groove, an annular groove in the outer surface of said cylinder valve member adjacent said annular groove in such bore toward the exit orifice end of said nozzle, a small passage leading from said groove in said valve member through the latter to the interior thereof, a helical groove in the outer surface of said cylinder valve member extending from a region spaced from said annular groove therein to a point slightly spaced from the end of said cylinder valve member toward the exit orifice end of the nozzle, a passage leading from said filtered fuel passage beyond such constriction therein to said helical groove, an annular groove in the bore enclosing and fitting said exit valve stem, and a passage leading from said filtered fuel passage beyond such constriction therein to said latter groove, whereby filtered fuel will thus be delivered to the interstices between the closely fitting relatively sliding parts of the nozzle at greater pressure than unfiltered fuel from the intake end of the nozzle passing said cylindrical valve member and exit orifice reaches such interstices.

3. In a liquid fuel injection nozzle having a fuel intake end and an exit orifice in its other end, a swirl chamber within said nozzle directly axially of and in communication with such orifice, an exit orifice poppet valve member adapted to seat in and close such orifice, a stem for said valve member mounted for reciprocation in a bore axially aligned with and spaced from such orifice and said chamber, a fuel intake passage in said intake end, a constricted normally open passage leading from said intake passage to said swirl chamber, another relatively large passage leading from said intake passage to said swirl chamber, a cylinder valve member mounted for reciprocation in an axial bore within said nozzle to open and close communication of said large passage with said fuel intake passage, means venting the interior of said cylinder valve member to the exterior, and means connecting said cylinder valve member and said stem of said poppet valve member for reciprocation together; means adapting said nozzle to handle contaminated fuels comprising a filter chamber containing a filter, another fuel intake passage leading to said filter chamber, a filtered fuel passage leading from said filter chamber, said filtered fuel passage being locally constricted intermediate its ends, a branch passage leading from said filtered fuel passage in advance of such constriction therein to the sliding fit between said cylinder valve member and its bore adjacent the region of communication between said first-mentioned fuel intake passage and said large passage leading to said swirl chamber, another branch passage leading from said filtered fuel passage beyond such constriction therein to the sliding fit between said cylinder valve member and its bore, a small passage through the wall of said cylinder valve member intermediate said two branch passages adapted to conduct filtered fuel seepage to the interior of said cylinder valve member, and another branch passage leading from said filtered fuel passage beyond such constriction therein to the sliding fit between said poppet valve stem and its bore, whereby filtered fuel will thus be delivered to the interstices between the closely fitting relatively sliding parts of the nozzle at greater pressure than unfiltered fuel from the intake end of the nozzle passing said cylindrical valve member and exit orifice reaches such interstices.

4. In a nozzle having an intake end and an exit orifice in its other end, an exit orifice poppet valve member adapted to seat in and close such orifice, a fluid intake passage in the intake end of said nozzle, a constricted normally open passage leading from said intake passage to such exit orifice, another relatively large passage leading from said intake passage to said exit orifice, a valve member mounted for reciprocation within said nozzle to open and close communication of said large passage with said fuel intake passage, and means connecting said latter valve member and said poppet valve member for reciprocation together; means adapting said nozzle to handle contaminated fuels without unduly restricting the rate of flow comprising a filter chamber within the intake end of said nozzle and in communication with a supply of fluid common with that of the aforesaid intake passage, a filtered fluid passage leading from said filter chamber and constricted in a local region intermediate its ends, a branch passage leading from said filtered fuel passage to the sliding fit between said valve member adapted to open and close communication of said large passage with said fuel intake passage, and a branch passage leading from said filtered fuel passage to the sliding fit of said poppet valve member, whereby filtered fluid will thus be delivered to the interstices between the closely fitting relatively sliding parts of the nozzle at greater pressure than unfiltered fluid from the intake end of the nozzle passing said two valve members.

5. In a spray nozzle having a large and a small passage leading from the intake end of such nozzle each adapted to deliver a swirling fluid flow at the nozzle discharge orifice, a regulating valve member reciprocable in re-

sponse to nozzle intake pressure operative to open said large passage as such pressure increases and close said passage when such pressure falls below a predetermined figure, an exit valve member for such orifice connected to said regulating valve member for reciprocation therewith, and resilient means urging said exit valve member and regulating valve member to closed positions; means adapting said nozzle to handle contaminated fluid without appreciable reduction of rate of flow comprising a filter in communication on one side with the nozzle intake and on the other side having a filtered fluid passage leading therefrom, said filtered fuel passage having a narrow constriction therein intermediate its length, a passage leading from said filtered fluid passage to a relief in the sliding fit of said regulating valve member, and a passage leading from said filtered fluid passage to a relief in the sliding fit of said exit valve member, the pressure drop in said filtered fuel passage being low relative to the pressure drop in said first two passages due to the relatively low rate of flow through said filtered fuel passage whereby filtered fluid will be introduced into such fits at greater pressure than the pressure of the contaminated fluid flowing through said nozzle past the same.

6. In a nozzle having an exit orifice, a large and a small passage each leading from the intake end of such nozzle to such orifice, a regulating valve member operative to open said large passage in response to increase in fluid intake pressure, and an exit valve member for such orifice connected with said regulating valve member for movement therewith; means adapting said nozzle to handle contaminated fluid without substantial reduction of rate of flow comprising a filter in communication on one side with the nozzle intake and on the other side having a filtered fluid passage leading therefrom, a passage by-passing said regulating valve and leading from said filtered fluid passage to the sliding fit of said regulating valve member, and a passage leading from said filtered fuel passage to the sliding fit of said exit valve member, the pressure drop in said filtered fuel passage being low relative to the pressure drop in said first two passages due to the relatively low rate of flow through said filtered fuel passage whereby filtered fluid will be introduced into such fits at greater pressure than the pressure of the contaminated fluid flowing through said nozzle past the same.

7. In a nozzle having an exit orifice, a poppet valve member adapted to seat in and close such orifice, a stem for said member fitted for reciprocation in an axial bore in said nozzle, a cylindrical valve member fitted for reciprocation in an axial bore in said nozzle and adapted to control fluid flow from the intake end of said nozzle to such orifice, means interconnecting said two valve members for reciprocation together, a vent for the interior of said cylindrical valve member through said poppet valve member, resilient means urging said poppet valve member to closed position, filter means in said nozzle in communication with the nozzle intake and adapted to filter a small portion only of the fluid flow, a filtered fluid passage leading from said filter means and adapted to receive filtered fluid therefrom having a first constriction adjacent said filter means, an annular groove in such bore in which said cylindrical valve member is fitted, a passage leading from said filtered fluid passage beyond said first constriction to said groove, a second constriction in said filtered fluid passage, another annular groove in such bore in which said cylindrical valve member is fitted, a helical groove in the outer surface of said cylindrical valve member opposed to said latter annular groove, a passage leading from said filtered fluid passage beyond said second constriction to said latter annular groove, an annular groove in the outer surface of said cylindrical valve member intermediate said two annular grooves in said bore, a passage leading from said groove in said valve member to the interior of the latter, an annular relief in the fit of said valve stem in its bore, and a passage leading from said filtered fuel passage beyond said second constriction to said relief, whereby filtered fuel will be introduced into such fits at greater pressure than the pressure of the contaminated fluid flowing through said nozzle past the same.

8. In a nozzle having a valve with a cylindrical valve member fitted for reciprocation in a bore to control the flow of fluid through said nozzle, filter means adapted to filter a portion only of the fluid intake of the nozzle, a helical relief about the outer surface of said cylindrical valve member fitting in such bore, said relief terminating short of the ends of said member, and a passage by-passing said valve and adapted to conduct filtered fluid to said relief from said filter means at greater pressure than the pressure of unfiltered fluid passing through said nozzle past the sliding fit of said member.

9. In a nozzle, a first passage therethrough, said passage including an inlet, a movable valve member adapted to open and close said first passage and having a relative fit with a part of the nozzle, one end of the fit being exposed to fluid in said first passage where passing through the valve, a second passage leading from the inlet, the side of said fit being exposed to fluid in the second passage, a filter in the second passage between the inlet and the fit, said first passage being adapted for very much greater rates of flow than said second passage at operational inlet pressures, said movable valve member affording a greater pressure drop between the inlet and fit than the pressure drop in the second passage between the inlet and the fit at its respective lower flow rate.

10. In a valve having a sliding valve member adapted to regulate the flow of fluid therethrough, filter means at the intake side of said valve adapted to filter a portion only of the fluid flow, and a passage adapted to conduct such filtered portion of the fluid flow directly laterally into the sliding fit of said valve member, said filter and passage being adapted together with said fit to restrict the rate of filtered fluid flow to afford a smaller pressure drop from such intake to said fit than is afforded the unfiltered fluid flow by said valve member so that such filtered fluid will enter said fit to the exclusion of such unfiltered fluid.

11. In a nozzle having a fluid intake end and an exit orifice end, a small channel leading from such intake end to such orifice end and adapted to deliver a limited fluid flow thereto, an inner chamber axially disposed within said nozzle, said chamber being closed toward such orifice end of said nozzle, a regulating valve member axially reciprocable therein, a large channel leading from the side of said chamber to such orifice end and adapted to deliver a large fluid flow thereto when uncovered by said regulating valve member, an exit valve member adapted to close such orifice and carried by a stem axially reciprocably mounted in the closed end of said chamber, and means connecting said two valve members for reciprocation together, a vent to the outer atmosphere being provided for said chamber through said stem and exit valve member, such vent opening circumferentially of said exit valve member immediately exteriorly of such exit orifice to discharge uniformly radially outwardly into the nozzle discharge.

12. In a nozzle having an exit orifice, a passage leading from the intake end of said nozzle to such orifice, a regulating valve member axially reciprocable in a closed inner chamber within said nozzle and adapted to open said passage under influence of fluid intake pressure when such pressure exceeds a predetermined figure and to close said passage when such pressure drops below such figure, resilient means urging said regulating valve member to closed position, a poppet valve member for such exit orifice carried by an axially reciprocable stem, and means connecting said two valve members for reciprocation together, a vent for such chamber passing through said stem and poppet valve member and opening circumferentially of the latter immediately exteriorly of such exit orifice to

discharge uniformly generally radially outwardly into the nozzle discharge.

13. In a poppet valve including an exit orifice and a poppet valve member adapted to seat therein to close the same and when unseated to permit a conical fluid discharge through such orifice, said valve member having an axially reciprocable stem mounted in the valve body with a sliding fit; a vent passage extending from a region communicating with the sliding fit of said stem through said valve member and opening circumferentially generally radially outwardly thereof immediately exteriorly of such orifice, such vent opening being in a circumferential surface region of said valve member generally toward such orifice to discharge directly into such conical discharge.

14. In a nozzle having an exit orifice, a passage leading from the intake end of said nozzle to such orifice, a regulating valve member axially reciprocable in a closed inner chamber within said nozzle and adapted to open said passage under influence of fluid intake pressure when such pressure exceeds a predetermined figure and to close said passage when such pressure drops below such figure, resilient means urging said regulating valve member to closed position, a poppet valve member for such exit orifice carried by an axially reciprocable stem; a vent for such chamber passing axially through said stem and opening circumferentially of said poppet valve member immediately exteriorly of such orifice, and a flexible resilient wire connecting said two valve members for reciprocation together passing through said vent in said stem and secured to said poppet valve member in a region exteriorly of such exit orifice, such vent opening being in a circumferential surface of said poppet valve member generally toward such exit orifice to discharge uniformly directly into the nozzle discharge exiting from such orifice.

15. In a nozzle having an intake end and an exit orifice in its other end, an exit orifice poppet valve member adapted to seat in and close such orifice, a fluid intake passage in the intake end of said nozzle, a constricted normally open passage leading from said intake passage to such exit orifice, another relatively large passage leading from said intake passage to said exit orifice, a valve member mounted for reciprocation within said nozzle to open and close communication of said large passage with said fuel intake passage, and means connecting said latter valve member and said poppet valve member for reciprocation together; means adapting said nozzle to handle contaminated fuels without unduly restricting the rate of flow comprising a filter chamber within the intake end of said nozzle and in communication with a supply of fluid common with that of the aforesaid intake passage, a filtered fluid passage leading from said filter chamber and constricted in a local region intermediate its ends, a branch passage leading from said filtered fuel passage to the sliding fit between said valve member adapted to open and close communication of said large passage with said fuel intake passage, a branch passage leading from said filtered fuel passage to the sliding fit of said poppet valve member, whereby filtered fluid will thus be delivered to the interstices between the closely fitting relatively sliding parts of the nozzle at greater pressure than unfiltered fluid from the intake end of the nozzle passing said two valve members, an inner chamber in said nozzle adapted to receive filtered fuel escaping from such fits, and a vent passage for said chamber passing through said poppet valve member and opening circumferentially of the latter immediately exteriorly of the exit valve orifice, such vent opening being in a circumferential surface of said poppet valve member generally toward such exit orifice to discharge uniformly directly into the nozzle discharge exiting from such orifice.

16. In a nozzle having a fluid intake end, an exit orifice end, an outwardly opening poppet valve member therefor, and a stem for said valve member mounted with a sliding fit for reciprocation within said nozzle to reciprocate said valve member to open and close such orifice; filter means at the intake end of said nozzle adapted to filter a small portion only of the fluid intake, a passage adapted to conduct such filtered portion of the fluid flow into the sliding fit of said valve member, said filter and passage being adapted together with said fit to restrict the rate of filtered fluid flow to afford a smaller pressure drop from such intake to said fit than is afforded the unfiltered fluid flow by said valve member so that such filtered fluid will enter said fit to the exclusion of such unfiltered fluid, an enclosed inner chamber within said nozzle adapted to receive filtered fluid escaping from such fit, and a vent passage through said stem and valve member communicating with said chamber and opening to the exterior of said nozzle.

17. In a nozzle having a sliding valve member adapted to control the flow of fluid therethrough, filter means adapted to filter a portion only of the fluid intake of said nozzle, means adapted to introduce filtered fluid therefrom to the sliding fit of said valve member, an enclosed inner chamber within said nozzle completely separate from the main fluid flow adapted to receive filtered fluid escaping from such fit, and a vent passage separate from the main fluid flow leading from said chamber directly to the exterior of said nozzle.

18. In a nozzle having a sliding valve member shiftable in direct response to fluid intake pressure thereagainst, a restricted by-pass leading from the intake end of said nozzle into the sliding fit of said valve member, filter means for said by-pass effective to filter that portion of the fluid flow passing therethrough, the area of said valve member subject to direct pressure from the unfiltered fluid being larger than any area opposed thereto subject to pressure by such filtered fluid.

19. In a nozzle having a sliding valve member shiftable in a direct response to fluid intake pressure thereagainst, a restricted by-pass leading from the intake end of said nozzle into the sliding fit of said valve member intermediate the ends of such fit, filter means for said by-pass effective to filter that portion of the fluid flow passing therethrough, the area of said valve member subject to direct pressure from the unfiltered fluid being larger than any area opposed thereto subject to pressure by such filtered fluid.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 949,294 | Collin | Feb. 15, 1910 |
| 1,098,616 | Creveling | June 2, 1914 |
| 1,160,910 | Laing | Nov. 16, 1915 |
| 2,569,033 | Wise | Sept. 25, 1951 |
| 2,590,772 | Joyce | Mar. 25, 1952 |
| 2,656,218 | Campbell | Oct. 20, 1953 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 474,978 | Germany | Apr. 18, 1929 |
| 499,937 | Germany | June 14, 1930 |