May 13, 1969 H. C. SIMMONS 3,443,760

FAIL-SAFE FUEL INJECTION NOZZLE

Filed April 26, 1967

FIG. 2

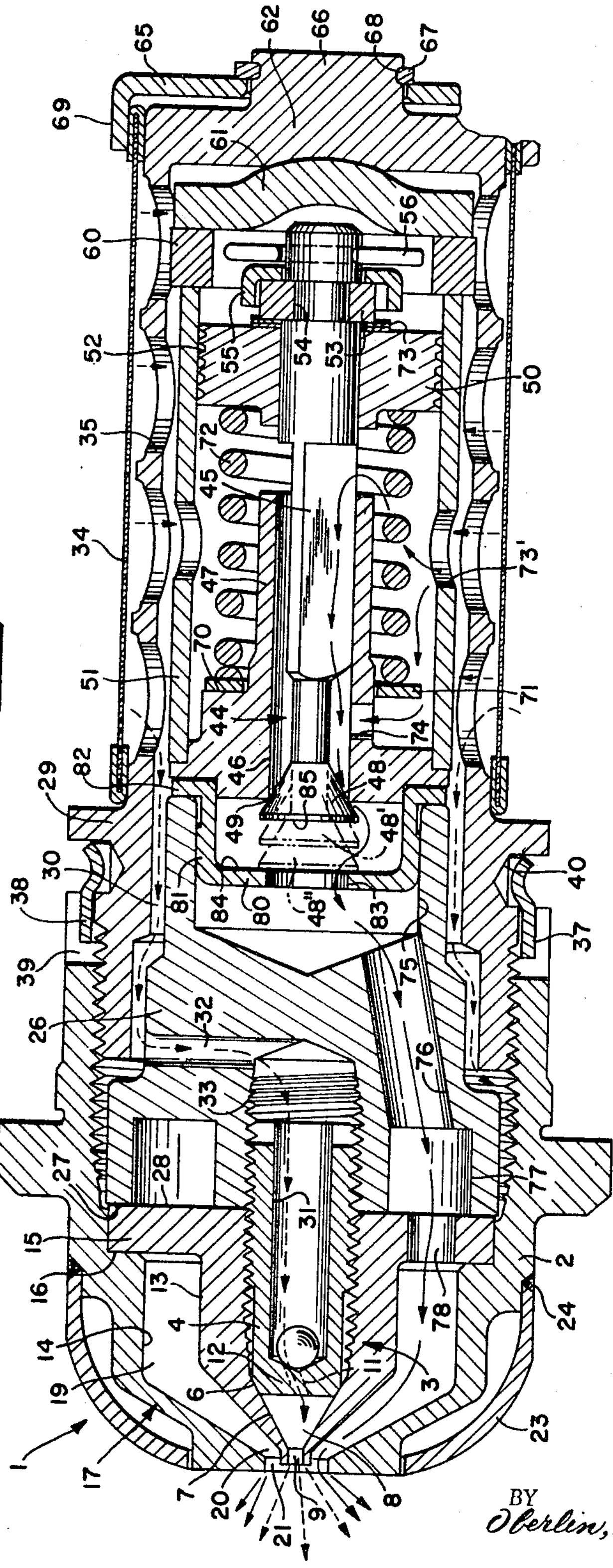

FIG. 1

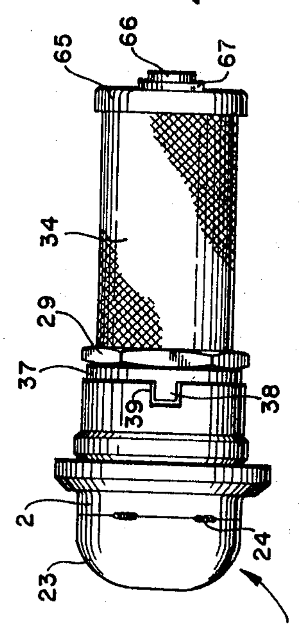

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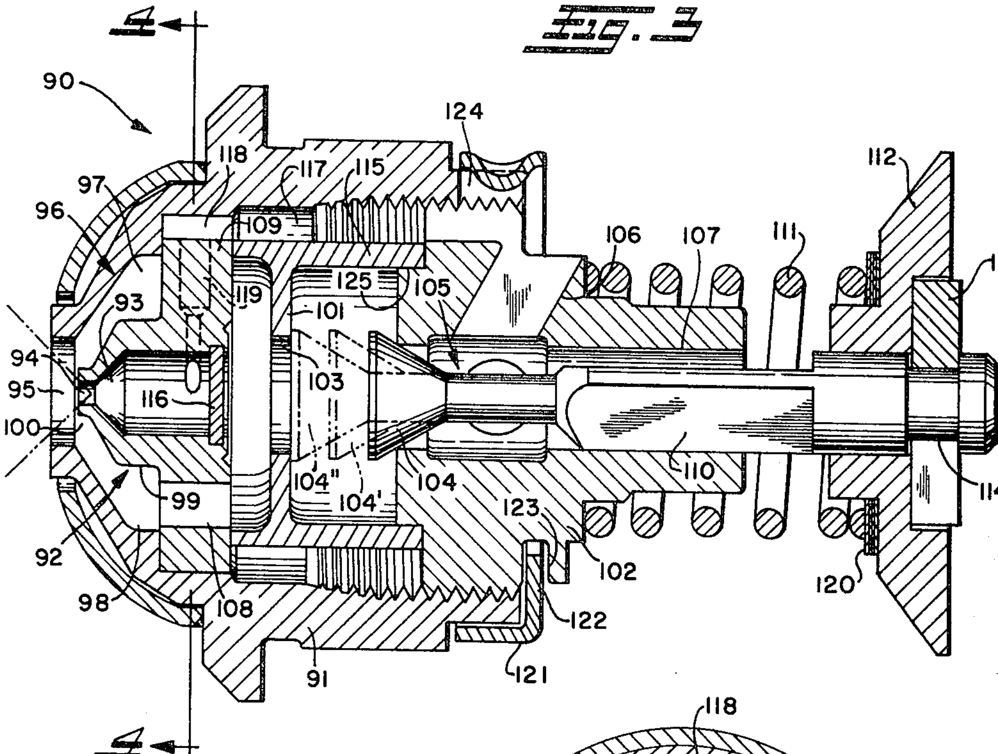
FIG. 3



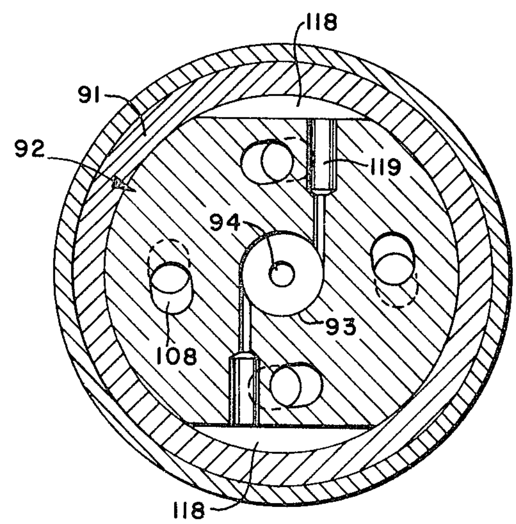


FIG. 4

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FAIL-SAFE FUEL INJECTION NOZZLE

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ABSTRACT OF THE DISCLOSURE

A fuel injection nozzle having primary and secondary flow passages leading to primary and secondary discharge orifices. A pressure responsive valve controls the flow through the secondary discharge orifice in accordance with the inlet pressure except when the valve stem or other such valve part fails and the valve engages a shutoff plate in the secondary flow passage closing off an opening therethrough which precludes further secondary flow.

Background of the invention

The present invention relates generally, as indicated, to a fail safe fuel injection nozzle and more particularly to a dual orifice fuel injection nozzle having means for blocking the flow through the secondary discharge orifice in the event of breakage or failure of the secondary flow control valve stem, valve biasing spring, or retainer therefor.

Dual orifice nozzles, as the name implies, are usually provided with two separate nozzles; a primary nozzle having a primary discharge orifice through which fuel is discharged at low fuel pressures for low fuel flow; and a secondary nozzle having a secondary discharge orifice through which fuel is additionally discharged at higher fuel pressures for greater rates of fuel flow. There are, of course, many dual orifice nozzle designs which have been developed for controlling the cut-in point of the secondary nozzle and providing the desired sensitivity of flow to pressure with proper atomization of the fuel throughout the useful flow range of the nozzle under normal operating conditions, but heretofore no provision has been made to check the flow through the secondary nozzle when due to breakage of the secondary flow control valve stem or failure of the valve biasing spring or other such part the secondary nozzle is not operating properly. Under these circumstances, the secondary valve ordinarily remains fully open even at low fuel pressures whereby the total fuel flow through the nozzle is much higher than desired and the fuel is not suitably broken up into fine droplets for efficient combustion.

Summary of the invention

With the dual orifice nozzle of the present invention, the secondary flow is completely shut off by the head of the secondary flow control valve in the case of breakage or failure of the valve stem or other associated parts to prevent such overflow and improper atomization of the fuel. These and other objects of the present invention are achieved by providing a shutoff plate in the nozzle body having a central aperture in fluid communication with the secondary flow passage which is closed by engagement of the head of the secondary flow control valve with the plate when such breakage or failure occurs.

Another object is to provide such a nozzle with a novel adaptor for supporting the shutoff plate in the nozzle body and including separate passages communicating with the primary and secondary orifices of the nozzle.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the 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 principles of the invention may be employed.

Brief description of the drawing

In such annexed drawing:

FIG. 1 is a side elevation view of one form of fuel injection nozzle constructed in accordance with this invention;

FIG. 2 is an enlarged central longitudinal section through the nozzle of FIG. 1 in which the secondary flow control valve is shown in phantom lines in both the normal full open position and flow blocking position seated against the secondary nozzle shutoff plate;

FIG. 3 is an enlarged central longitudinal section similar to FIG. 2 but of another form of nozzle in accordance with this invention; and

FIG. 4 is a transverse section through the nozzle of FIG. 3 taken on the plane of the line 4—4 thereof.

Description of the preferred embodiments

Referring now to the details of the various forms of fuel injection nozzles shown by way of example in the drawing and first of all to the FIGS. 1 and 2 form, such fuel injection nozzle is generally indicated at **1** and comprises a body member **2** in which there is received a primary nozzle **3** having a primary plug **4** partially threaded into the primary nozzle **3** from the rear. The forward end of the primary plug **4** is of reduced diameter and chamferred at **6** for establishing fluid tight engagement with the correspondingly tapered wall **7** of a spin chamber **8** located forward of the primary plug **4**. Fluid is supplied to the spin chamber **8** for discharge from the primary discharge orifice **9** through angularly disposed swirl slots **11** in the forward end wall **12** of the primary plug **4** which impart a swirling motion to the fuel in known manner for better atomization.

The outer wall **13** of the primary nozzle **3** is concentrically located in spaced relation from the inner wall **14** of the body member **2** by an outwardly directed flange **15** on the rear end of the primary nozzle **3** closely slidably received in a counterbore **16**. Such outer and inner walls **13**, **14** extend forwardly in a longitudinal direction and then taper inwardly to define therebetween a secondary nozzle **17** comprising a secondary spin chamber **19** and secondary discharge orifice **20** surrounding the primary discharge orifice **9**. Moreover, both such discharge orifices **9** and **20** communicate with a common exit orifice **21** in the body member **2**. A shroud **23** may be provided on the body member **2** outwardly of the exit orifice **21** and secured thereto in suitable manner, as by welding at **24** or the like.

The primary plug **4** extends rearwardly beyond the primary nozzle flange **15** and has threaded thereon an adaptor **26** whose forward end face **27** is flush against the back face **28** of such flange to provide a fluid seal therewith. A generally cylindrical strainer support **29** having threaded engagement with the rearward end of the body member **2** surrounds the adapter **26** in spaced relation to define therebetween an annular flow passage **30** which communicates with the interior **31** of the primary plug **4** via one or more radial passages **32** in the adapter **26** and an internally threaded central recess **33** in the adapter into which the primary plug **4** is threadedly received. Accordingly, fuel entering the fuel injection nozzle **1** through the cylindrical strainer **34** surrounding the strainer support **29** and apertures **35** in the strainer support will provide uninterrupted flow from the primary discharge orifice **9** via passages **30**, **32**, recess **33**, swirl slots **12** and spin chamber **8**. A ring **37** having tabs **38** for receipt in axial slots **39** in the rear end of the body member **2** may be crimped radially inwardly into circumferentially spaced recesses **40** in the outer surface of the strainer support **29** to lock these two members together.

For controlling the flow of fuel to the secondary discharge orifice **20** there is provided rearwardly of the adapter **26** a pintle valve **44** having a stem **45** telescopically received in the bore **46** of a sleeve **47**. The forward end or head **48** of the pintle valve **45** is tapered outwardly to permit engagement with a seat **49** on the sleeve **47**, and there is a piston **50** on the valve stem **45** adjacent the rear end thereof which is closely slidably received in a liner **51** surrounding the sleeve **47** for guiding the valve **44** during its movement toward and away from the seat **49**. A helical groove **52** in the outer surface of the piston **50** permits the escape of stagnant fuel which may become trapped behind the piston.

The piston **50** may be retained on the valve stem **45** by a C-washer **53** received in a peripheral groove **54** on the valve stem **45** and a retaining cap **55** which fits over the C-washer **53** and is held in place by a cotter pin **56** inserted through a transverse bore in the stem **45**.

A spacer element **60** and spring support washer **61** may be disposed between the rearward end of the liner **51** and bottom wall **62** of the strainer support **29** for maintaining the adaptor **26**, primary nozzle flange **15**, and body member **2** in firm sealing engagement with each other. An end cap **65** slidably received on an extension **66** of the strainer support **29** and held in place by a retaining ring **67** engaged in a groove **68** in such extension has a forwardly directed flange **69** which overlies one end of the cylindrical strainer **34** to hold the same in place.

The sleeve **47** has a rearwardly facing shoulder **70** which is engaged by a washer **71**, and there is a compression spring **72** disposed between the washer **71** and piston **50** for yieldably maintaining the valve head **48** in seating engagement with the seat **49**. Shims **73** of different thicknesses may be interposed between the piston **50** and C-washer **53** to vary the compressive force exerted by the spring **72** on the pintle valve **44**.

Fuel passing through the strainer **34**, strainer support **29** and radial openings **73'** in the liner **51** enters the sleeve bore **46** in which the pintle valve **44** is disposed through radial apertures **74** in the sleeve **47** and through the open rear end of the sleeve. However, at low fuel pressures the pintle valve **44** will remain closed and the flow will only be through the primary nozzle **3**. Then, as the fuel pressure acting on the valve head **48** increases to a predetermined level, the bias of the spring **72** will be overcome and the pintle valve **44** will move away from its seat **49** to provide for additional fuel flow through the secondary discharge orifice **20** via a central recess **75** in the adaptor **26** into which the pintle valve **44** projects, a generally axially extending passage **76** in the adaptor **26** communicating with an annular chamber **77** in the forward end face **27** of such adaptor, and holes **78** in the primary nozzle flange **15** which may be angularly disposed to provide a swirling motion to the fuel as it enters the secondary spin chamber **19**.

As the fuel pressure increases, the valve head **48** will be lifted progressively away from its seat **49** for additional secondary fuel flow which varies automatically with changes in fuel pressure and may be as much as ten times the primary fuel flow. However, should the valve stem **45** break or the spring **72** or retainer cap **55** fail or become disengaged from the valve stem, even at low fuel pressures the pintle valve **44** would remain wide open resulting in uncontrolled flow through the secondary discharge orifice **20** and improper atomization of the fuel except for the shutoff plate **80** which is disposed in the recess **75** in the adaptor **26**. As clearly shown in FIG. 2,

the shutoff plate **80** has an annular side wall **81** terminating in an outturned flange **82** which extends between the adjacent ends of the adaptor **26** and sleeve **47** to provide a fluid seal precluding primary fuel in the annular passage **30** from entering the recess **75**. The length of the side wall **81** is such that the shutoff plate **80** is located a sufficient distance from the adjacent end face of the sleeve **45** to provide the necessary clearance for movement of the pintle valve from the fully closed position shown in solid lines to the intermediate or normal full open position indicated in phantom lines at **48'** without restricting the flow around the valve head **48** and through the central opening **83** in the shutoff plate. Preferably, the distance between the rear face **84** of the shutoff plate **80** and the flat front face **85** of the valve head **48** when in the fully closed position is slightly more than twice the distance that the valve moves between the fully closed and fully open positions.

With the plate **80** in the position shown, should the valve stem **45** break or the spring **72** fail, the fuel acting on the valve head **48** will force the same into engagement with the plate as illustrated in phantom lines at **48''** thereby closing off the central opening **83** in the plate and completely eliminating secondary fuel flow. Thus, in effect the shutoff plate **80** acts as a valve seat for the pintle valve **45** which is engaged by the flat front face **85** of the valve when it comes into contact with the shutoff plate **80** because of a broken valve stem or the like.

In FIGS. 3 and 4 there is shown another form of fuel injection nozzle **90** which like the fuel injection nozzle **1** of FIGS. 1 and 2 has a body member **91** in which there is concentrically disposed a primary nozzle **92** having a spin chamber **93** therein and a primary discharge orifice **94** communicating with the exit orifice **95** of the body member **91**. Also like the nozzle **1**, the nozzle **90** has a secondary nozzle **96** surrounding the primary nozzle **92** which comprises a secondary spin chamber **97** defined between the inner and outer walls **98** and **99** of the body member **91** and primary nozzle **92**, respectively, communicating with a secondary discharge orifice **100** which continues into the exit orifice **95**.

Similarly, there is a shutoff plate **101** interposed between the primary nozzle **92** and valve housing **102** having a central opening **103** therethrough which is closed off by engagement of the head **104** of the pintle valve **105** with the plate **101** as seen in phantom lines at **104''** to halt secondary flow to the secondary discharge orifice **100** via radial passages **106** and longitudinal bore **107** in the valve housing **102** in which the valve **105** is disposed and angularly disposed slots **108** in the outturned flange **109** of the primary nozzle **92** in the event of failure of the valve stem **110**, valve biasing spring **111**, or spring retainer **112**. A C-washer **113** received in a groove **114** in the rear end of the valve stem **110** holds the spring retainer **112** in place, and shims **120** may be interposed between the spring **111** and spring retainer **112** for varying the compressive force exerted by the spring on the pintle valve. However, the adaptor **26** of the nozzle **1** has been eliminated and instead the shutoff plate **101** has an outer sleeve portion **115** which extends axially beyond both faces of the shutoff plate **101** to establish a fluid seal with the adjacent faces of the primary nozzle **92** and valve housing **102** and provide the necessary spacing between the shutoff plate and valve head **104** when in the full open position (**104'**) for unrestricted flow through the central aperture **103** and secondary discharge orifice **101**. A plug **116** adjacent the rear end of the primary spin chamber **93** precludes the secondary flow from entering the primary nozzle **92**.

Primary flow is continually supplied to the primary nozzle **92** through an annular passageway **117** surrounding the sleeve portion **115** which communicates with a pair of oppositely disposed chambers **118** between the primary nozzle **92** and valve body **91**, and through tangential holes **119** in the primary nozzle flange **109**.

Proper sealing engagement between the contacting surfaces of the valve housing **102**, sleeve portion **115**, primary nozzle flange **109**, and body member **91** is established by tightening the valve housing **102** which has threaded engagement with the body member **91**. A lock ring **121** having tabs **122** projecting into circumferentially spaced slots **123** in the valve housing **102** may be crimped at circumferentially spaced zones into slots **124** in the body member **91** for locking such valve housing and body member together. The sleeve portion **115** overlies a shoulder **125** on the forward end of the valve housing **102** for concentrically locating the plate **101** with respect to the valve **105**.

The operation of the fuel injection nozzle **90** is substantially the same as the nozzle **1**. Thus, at low fuel pressures, the flow is only through the primary discharge orifice **94** via the annular passageway **117**, chambers **118**, holes **119**, and spin chamber **93**. However, when the fuel pressure acting on the valve head **104** is sufficiently high to overcome the bias of the spring **111**, there is additional fuel flow through the secondary discharge orifice **100** via the central aperture **103** in the shutoff plate **101**, slots **108**, and spin chamber **97** which flow automatically varies in accordance with the fuel pressure. Moreover, should the valve stem **110** or other such part of the valve **105** break, the valve head **104** will close off the central aperture **103** much in the same manner that the aperture **83** is closed off by the valve head **48** of the nozzle **1** previously discussed.

I claim:

1. A dual orifice flow nozzle having a fluid inlet passage and primary and secondary flow passages through which fuel from said inlet passage is adapted to flow through the primary and secondary discharge orifices of primary and secondary discharge nozzles, and a pressure actuated valve means in said secondary flow passage effective when closed at low pressures to cut off flow of fluid to said secondary nozzle whereby fluid flows only through said primary nozzle at such low pressures, and effective when opened by higher pressures to permit flow of fluid to said secondary nozzle to supplement the flow through said primary nozzle; wherein the improvement comprises providing a shutoff plate, means for supporting said shutoff plate in said secondary flow passage downstream of said valve means, said shutoff plate having an opening through which the secondary fluid flows when said valve means is opened as aforesaid, said valve means when moved beyond full open position due to failure of any part of said valve means being adapted to engage said plate and close off said opening for blocking such secondary fluid flow, said primary flow passage bypassing said valve means and shutoff plate and said primary discharge orifice being spaced downstream from said shutoff plate, whereby continued flow will be permitted through said primary passage regardless of the position of said valve means in said secondary flow passage.

2. The dual orifice flow nozzle of claim **1** wherein the improvement further comprises providing a flat forward end face on said valve means which when brought into engagement with the adjacent flat face of said shutoff plate blocks such secondary fluid flow as aforesaid.

3. The dual orifice flow nozzle of claim **1** wherein the improvement further comprises a spring means and spring retainer operatively connecting said spring means to said valve means for yieldably maintaining said valve means in closed position, said valve means in the event of failure of said spring means or retainer being adapted to engage said plate and close off said opening therein for blocking such secondary fluid flow as aforesaid.

4. The dual orifice flow nozzle of claim **1** wherein said means for supporting said shutoff plate comprises an adaptor disposed between said discharge nozzles and said shutoff plate, said adaptor having first and second flow passages therein which constitute a part of said primary and secondary flow passages, respectively, said adaptor also having a recess in the rear face thereof in said secondary flow passage, said shutoff plate being disposed in said recess intermediate the inner and outer ends thereof to provide sufficient clearance between said shutoff plate and both the inner end of said recess and said valve means when in the full open position so as not to restrict the flow through the opening in said shutoff plate and into said second flow passage.

5. The dual orifice nozzle of claim **4** wherein the improvement further comprises a sleeve having a bore in which said valve means is slidably receiver, an apertured liner surrounding said sleeve, and an apertured support member surrounding said liner having threaded engagement with the body of said nozzle, said sleeve having an outwardly extending shoulder interposed between said adaptor and liner, and said support member having an end wall which forces said adaptor and sleeve into sealing contact with each other through said liner upon tightening of said support member to preclude primary fluid flow from entering said secondary flow passage via said recess in said adaptor.

6. The dual orifice nozzle of claim **5** wherein the improvement further comprises an annular side wall on said shutoff plate which terminates in an outturned flange extending between said adaptor and shoulder on said sleeve for supporting said shutoff plate in said recess.

7. The dual orifice nozzle of claim **4** wherein the improvement further comprises a plug having threaded engagement with both said primary nozzle and said adaptor, and a passage through said plug communicating said primary discharge orifice with said first flow passage in said adaptor.

8. The dual orifice nozzle of claim **1** wherein the improvement further comprises a valve housing having an axial bore in which said valve means is slidably disposed said shutoff plate being located between said primary nozzle and said housing and having an annular sleeve portion extending axially beyond opposite faces of said shutoff plate to provide sufficient clearance of said shutoff plate with said primary discharge nozzle and said valve means when in the full open position so as not to restrict the flow through the opening in said shutoff plate.

9. The dual orifice nozzle of claim **8** wherein the improvement further comprises an annular shoulder on the forward end of said valve housing over which one end of said annular sleeve portion is slidably received for concentrically locating said annular sleeve portion and thus said shutoff plate with respect to said valve means, said valve housing having threaded engagement with the body of said dual orifice flow nozzle whereby said valve housing is tightened, the adjacent surfaces of said valve housing, annular sleeve portion, and primary nozzle are held in sealing engagement with each other.

10. The dual orifice nozzle of claim **9** wherein the improvement further comprises an annular passage surrounding said annular sleeve portion and communicating with circumferentially spaced chambers around said primary nozzle, said annular passage and circumferentially spaced chambers constituting part of said primary flow passage.

11. A dual orifice nozzle comprising a body member having a primary nozzle including a primary spin chamber and primary discharge orifice disposed therein and a secondary nozzle including a secondary spin chamber and secondary discharge orifice concentrically disposed about said primary nozzle, a fluid inlet, primary and secondary flow passages communicating said inlet with said primary and secondary spin chambers, respectively, a pressure actuated valve means in said secondary flow passage effective when closed at low pressures to cut off flow of fluid to said secondary discharge orifice whereby fluid flows only through said primary discharge orifice at such low pressures, and effective when opened by higher pressures to permit flow of fluid to said secondary discharge orifice to supplement the flow through said primary discharge orifice, and a shutoff plate in said secondary flow passage downstream of said valve means, said shutoff plate having an opening therein through which the secondary fluid flows when said valve means is opened as aforesaid, said valve means when moved beyond full open position due to failure of a part of said valve means being adapted to engage said shutoff plate and close off said opening for blocking such secondary fluid flow, said primary flow passage bypassing said valve means and shutoff plate and said primary discharge orifice being spaced downstream from said shutoff plate, whereby continued flow will be permitted through said primary passage regardless of the position of said valve means in said secondary flow passage.

12. The dual orifice nozzle of claim **11** wherein said primary nozzle has an outwardly directed flange adjacent the rear thereof for supporting the forward end of said primary nozzle in spaced relation from the inner wall of said body member to define therebetween said

secondary nozzle, said outturned flange being in sealing engagement with said body member, and there are slots through said flange communicating said secondary flow passage with said secondary spin chamber.

13. The dual orifice nozzle of claim **12** further comprising radial holes in said outturned flange communicating said primary flow passage with said primary spin chamber.

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U.S. Cl. X.R.

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