March 25, 1969 T. S. CHMURA 3,434,667

FUEL INJECTION NOZZLE

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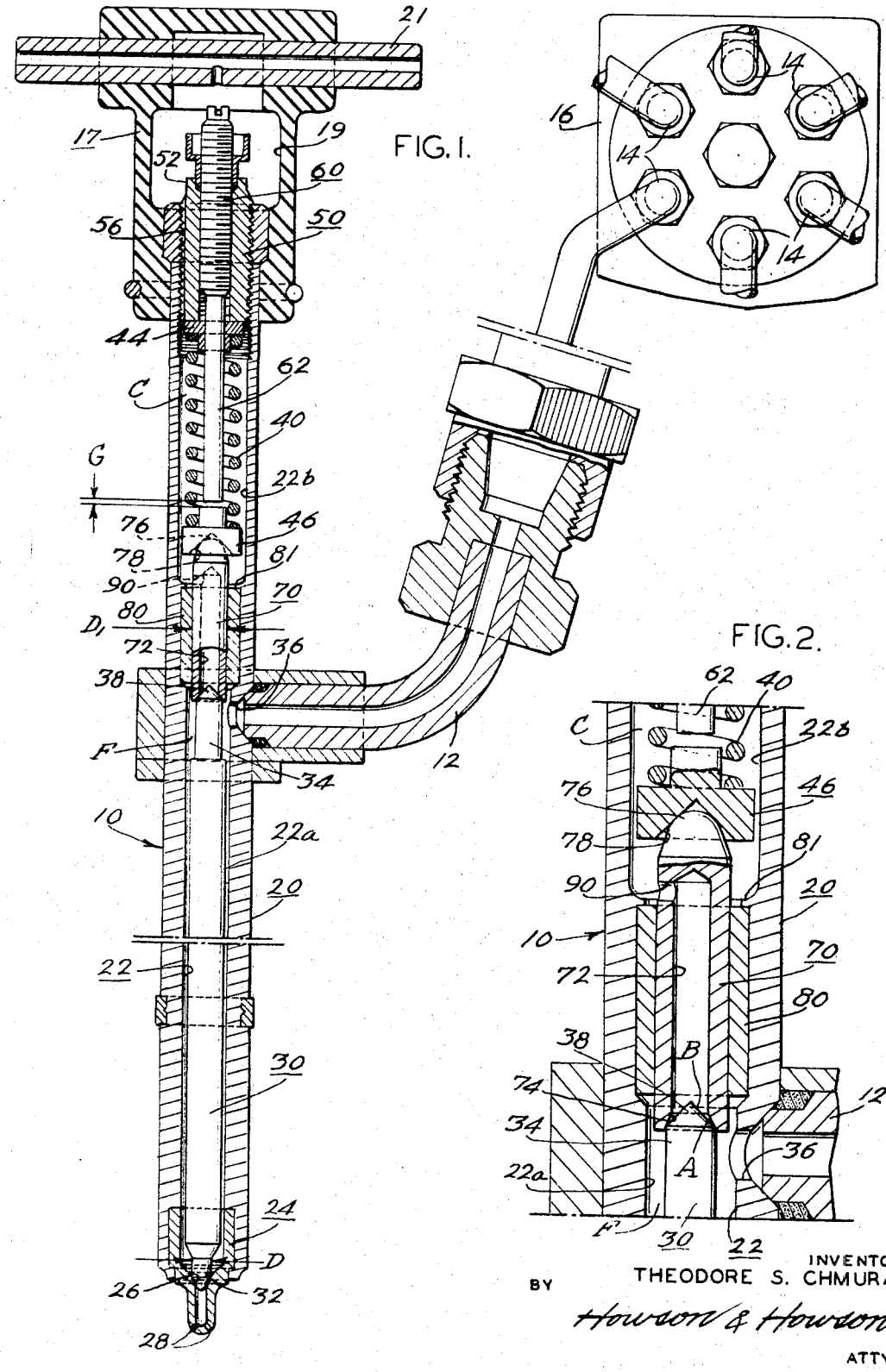


FIG. 1.

FIG. 2.

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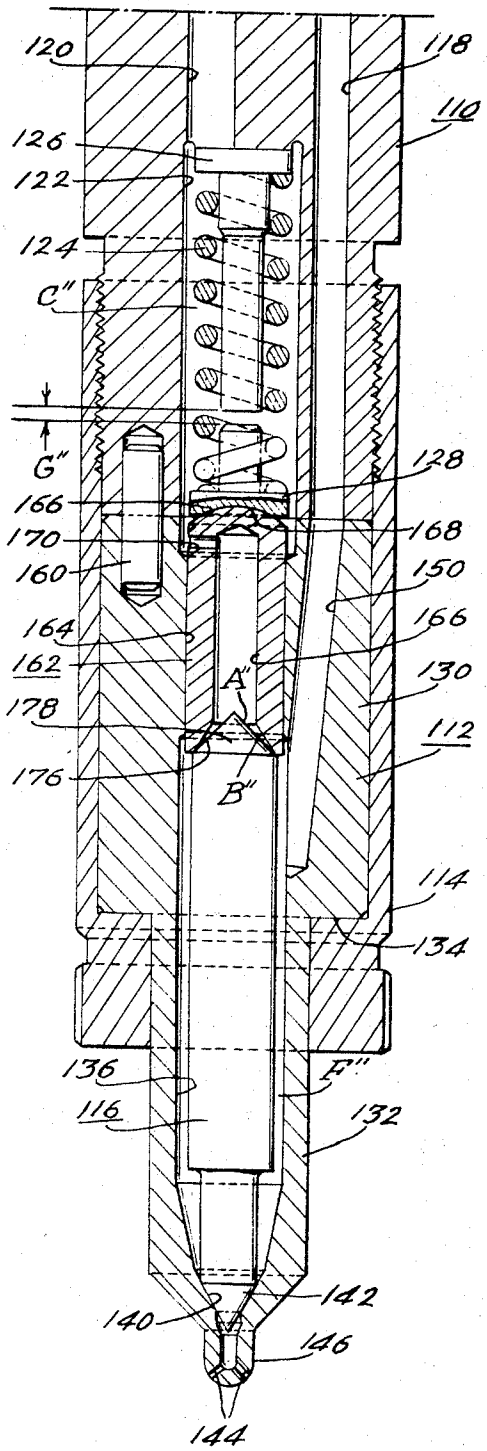
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FIG.3.



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FUEL INJECTION NOZZLE

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11 Claims

ABSTRACT OF THE DISCLOSURE

A fuel injection nozzle with an elongated valve body with an orificed tip at one end, an elongated, spring biased needle valve in the body, a valve guide above the needle valve engaging the upper end of the valve and having a leak off bore leading to a leak off chamber.

A fuel injection nozzle assembly comprising an elongated valve body having a nozzle tip at one end with a plurality of spray orifices therein, an elongated needle valve mounted in an axial bore in the valve body, spring biasing means normally urging the needle valve to a closed position engaging the valve seat in the nozzle tip and a valve guide member engaging between the spring biasing means and inner terminal end of the needle valve. The valve guide member has an axially extending bore open at one end to seat against the conical inner terminal end of the needle valve and has a rounded head at its opposite end normally engaging the conical face of the lower spring seat. Thus, in normal operation the valve guide and needle valve move together as a unit. The lower edge of the bore of the valve guide member is preferably tapered at a different angle than the conical tail of the needle valve to provide for accurate seating of the needle valve on the valve seat. Further the valve guide member is provided with an opening or port communicating with the fuel leak-off chamber, which port is of a flow area substantially equal to the total flow area of the spray orifices so that if the valve guide member sticks in an open position and the needle valve assumes a closed position, the charge of fuel delivered by a fuel injection pump serving a plurality of fuel injection nozzle assemblies will be discharged through the port in the valve guide to the fuel leak-off passage.

The present invention relates to improvements in fuel injection nozzles.

Conventionally, fuel injection nozzle assemblies are mounted in an elongated bore in the engine cylinder head, at least one nozzle being provided for each cylinder of the engine and a fuel pump delivers predetermined metered quantities of fuel to each nozzle in a predetermined firing order to supply fuel to the cylinders of the engine. In some of these fuel injection nozzle assemblies, particularly the very long pencil type, a serious problem has been the difficulty of providing perfect concentricity of the valve seat and the needle valve tip to insure tight seating of the valve. Tight seating of the valves in the closed position is essential for the reason that if the valve is not tightly seated, fuel dripping occurs between injections causing carbon build up on the nozzle tip and producing poor engine combustion and excessive exhaust smoke. One remedy to overcome this problem is to precision machine the valve seat concentric with the valve bore. However, this increases the cost of the entire assembly considerably.

In accordance with the present invention, the above problem of valve seating is overcome by providing a two-piece valve including a valve guide member having a conical or spherical face engaging a conical or spherical inner terminal end of the needle valve, there preferably being a small differential angle between the angle of taper

of the seat and the inner terminal end of the needle valve. By this arrangement even if there is a slight misalignment of the nozzle seat and the valve guide, the needle valve will still be able to seat tightly at the body seat adjacent the orifices without binding the guide member, thus minimizing sluggish valve action.

Notwithstanding the above arrangement, it has been found that in some cases over a period of prolonged use, the conventional needle valve will still tend to stick in an open position. Thus, where the nozzle assembly is one of a plurality being supplied from a single positive displacement fuel injection pump, this results in over fueling of the other normally operating valves and excessive smoke is produced. In accordance with the present invention, this condition is eliminated by providing a port in the valve guide member communicating with the leak-off chamber having a flow area substantially equal to the total flow area of the spray orifices. By this arrangement, if the needle valve guide member sticks in an open position and the needle valve remains seated in a closed position, uniformity of fuel metered to the other engine cylinders will not be changed since the precise quantity which would be passed through the spray orifice of the jammed nozzle assembly, discharges through the control port in the valve guide member with the result that the remaining fuel injection nozzles operate in a normal fashion.

With the foregoing in mind, an object of the present invention is to provide a fuel injection nozzle assembly incorporating means for insuring self seating or centering of the needle valve.

Another object of the present invention is to provide a new and improved fuel injection nozzle which is of relatively simplified construction and fully effective in operation.

A further object of the present invention is to provide a nozzle leak-off arrangement whereby if one of the nozzle assemblies in a group delivering fuel to the cylinders of an engine from a common fuel injection pump sticks closed, the operation of the remaining nozzles which do not stick is not adversely affected.

These and other objects of the present invention, various features and details of the operation and construction thereof are hereinafter more fully set forth with reference to the accompanying drawings, wherein:

FIG. 1 is a transverse sectional view through a fuel injection nozzle assembly constructed in accordance with the present invention;

FIG. 2 is an enlarged sectional view of the valve guide member; and

FIG. 3 is an enlarged sectional view of another embodiment of fuel injection nozzle asembly in accordance with the present invention.

Referirng now to the drawings and particularly to FIG. 1 thereof, there is illustrated a fuel injection nozzle assembly generally designated by the numeral **10** connected through a high pressure supply line or conduit **12** to one of a plurality of fuel discharge ports **14** of a fuel injection pump **16**. The fuel injection pump **16** is a conventional type and may be a positive displacement pump of the type shown in Patent Number 2,518,473 issued Aug. 15, 1950. In the operation of this type pump, metered quantities of fuel are delivered in a predetermined sequence or cycle to a plurality of fuel injection nozzles for delivering fuel to the combustion chambers of a multi-cylinder engine. The nozzle assembly is supported in and depends from a leak-off boot **17** having a leak-off chamber **19** communicating with an outlet opening in a leak-off by-pass line **21** which in turn may be connected back to the main fuel supply.

Considering now the structural details and arrangement of the nozzle assembly, the nozzle assembly pin

comprises an elongated nozzle body **20** having, in the present instance, an axial bore **22** extending the entire length thereof, the lower section **22***a* defining a fuel chamber F and the upper section **22***b* defining a spring chamber C, a tip insert **24** mounted in the lower terminal end of the nozzle body having a valve seat **26** and a plurality of spray orifices **28** and a needle valve **30** mounted in the lower bore section **22***a* adapted for axial movement therein between a closed position and an open position to permit pressurized fuel to be discharged through the spray orifices **28**. As illustrated the needle valve **30** has a double tapered lower tip portion **32**, the terminal end of the stem having a shape to conform to and snugly engage the valve seat in the closed position and the opposite upper terminal end of the needle valve has a section of reduced diameter as at **34** adjacent the fuel inlet port **36**, the reduced section **34** terminating in a pointed conical pilot portion **38**.

The needle valve **30** is normally biased to a closed position by means of a compression spring **40** housed in the spring chamber C between an upper spring seat **44** and a lower spring seat **46**. The force of the compression spring may be selectively varied to regulate the fuel pressure at which the needle valve opens. In the present instance this is accomplished by means of an externally threaded pressure screw **50** which is threaded in the upper terminal end of the spring chamber C and has a head **52** to receive an adjusting tool such as a wrench so that it may be threaded inwardly or outwardly thereby changing the compression of the spring. The adjusting screw **50** has an axially extending groove **56** in its outer surface to provide fluid communication between the spring chamber C and the leak-off line whereby fuel leakage into the spring chamber C may be vented to the leak-off line and then to the main fuel supply.

The nozzle assembly further includes means to adjust the valve lift comprising, in the present instance, a valve stop screw **60** having a threaded portion which engages internally of the pressure adjusting screw **50** and has an elongated shank portion **62** of reduced cross section depending from the threaded portion and spaced from the upper end of the lower spring seat **46** to provide a gap or spacing G therebetween. Thus, by simply adjusting the stop screw **60** axially, this gap G may be varied and thus the lift of the needle valve **30** also varied. The diameter D of the needle valve tip is smaller in cross section than the diameter D_1 of the valve guide member tail section **34**. By this arrangement, build up of fuel pressure in the fuel chamber F results in axial movement of the needle valve **30** upwardly against the bias of the compression spring to open the valve and permit discharge of a measured quantity of fuel through the spray orifices.

In accordance with the present invention, the nozzle assembly includes a valve guide member **70** which, as illustrated, has an axial bore **72** therein open at its lower end with a circumferentially extending tapered inner edge **74** which seats on the conical inner tip portion **38** of the needle valve **30** and a rounded head portion **76** which engages interiorly of a conical seat **78** in the lower face of the lower spring seat **46**. The valve guide member **70** which is generally cylindrical and circular in cross section is slidably fitted in a bushing **80** held in the lower end of the spring chamber by a shoulder **81** which may be formed by crimping or spinning after insertion of the bushing **80**.

In nozzle assemblies it has been found that it is difficult to achieve perfect concentricity of the nozzle valve seat and the needle valve tip to assure tight seating of the valve. If the valve tip is not tightly seated in the closed position of the valve, fuel dripping results between injections causing carbon build up on the needle valve tip which in turn results in poor engine combustion and excessive exhaust smoke. The present invention provides an arrangement which insures tight seating of the needle valve in the closed position even if the valve seat and valve are not precisely concentric. To this end the inner edge **74** of the valve guide member **70** and the conical inner tip portion **38** of the needle valve **30** are made with a differential angle of taper. Preferably the angle of taper A of the inner edge **74** is a few degrees less than the angle of taper B of the conical inner tip portion **38** of the needle valve. Thus, in the present instance, even if the nozzle seat and valve guide are slightly misaligned, the needle valve **30** still seats tightly against the valve seat without binding the guide member **70** and thus minimizes sluggish valve action.

In some instances it has been found that the valve guide member will stick in an open position and the needle valve remains in a closed position. In the past this resulted in over-fueling and excessive smoke for the reason that sticking of one nozzle assembly of a plurality of nozzles operating from a single pump adversely affects the quantity of fuel delivered to the remaining normally operating nozzle assemblies.

Another important feature of the present invention is the provision of means for eliminating the over-fueling and excessive smoke condition resulting when one nozzle assembly of a plurality sticks in a closed position. To this end, the valve guide member **70** is provided with a control port **90** connecting the spring chamber C and the axial bore **72**, the axial bore **72** and control port **90** in effect defining a by-pass passageway. In the normal operation of the valve, the fuel chamber F is the high pressure side and the spring chamber, leak-off by-pass and leak-off manifold in the leak-off port are the low pressure side. Accordingly, in the present instance, the spring chamber C forms in effect part of the leak-off system. The flow area of the control port **90** is substantially equal to the total flow area of the spray orifices **28** so that in the event the needle valve **30** separates and assumes a closed position, fuel pressure build up acting on the lower axial end face of the guide member **70** effects movement of the guide member upwardly against the bias of the compression spring and permits the fuel charge to be vented through the axial bore **72** and control port **90** and through the remainder of the leak-off system. In this manner, the operation of other fuel injection nozzles supplied from a common pump will not be adversely affected, that is, since the complete fuel charge for the inoperative nozzle is accommodated, the charge to the remainder of the operative nozzles is not changed.

There is shown in FIG. 3 another embodiment of fuel injection nozzle assembly in accordance with the present invention which is generally designated by the numeral **100**. The assembly includes an elongated nozzle holder **110**, a fuel injection nozzle **112** mounted at the lower axial end of the holder by means of a cap nut **114**, and a valve member **116** mounted in an axial bore in the nozzle.

The holder **110** is an elongated, generally cylindrical member having a fuel inlet at its outer axial end (not shown) and an axial fuel passage **118** communicating with the fuel inlet, an axial channel **120** providing a fuel leak-off which may be connected to a leak-off line (not shown) to convey fuel leakage, for example, to the main fuel supply system. The lower end of the channel **120** is enlarged as at **122** to define a spring chamber C''. Housed in the spring chamber C'' is a compression spring **124** engaging between an upper spring seat **126** and a lower spring seat **128**. The seats **126** and **128** have projecting rod portions which are spaced apart to define a gap G'' determining valve lift.

The nozzle **112** comprises a generally cylindrical body portion **130** and an elongated shank **132** of reduced cross section depending from the body portion defining a shoulder **134** which the lower end of the cap nut engages. The nozzle has an axial bore **136** which defines a fuel chamber F'' which, as illustrated, is of a larger cross section than the largest cross section of the needle valve **116**. The lower end of the fuel chamber F'' tapers inwardly to

define a conical seat **140** engageable by the tip **142** of the needle valve in the closed position to prevent fuel in the fuel chamber from being discharged through the spray orifices **144** in the nose section **146**. The body portion has an angled fuel passageway **150** which is maintained in alignment with the fuel passage **118** in the holder by means of a locating pin **160**. Thus, in operation, fuel under high pressure delivered by a conventional fuel distribution pump passes to the fuel chamber F'' through the passage **118** and passageway **150**. Fuel pressure build up raises the needle valve **142** against the bias of the compression spring **124** to permit a predetermined charge of the fuel to be delivered through the spray orifices **144**.

In accordance with this embodiment of the invention there is also provided a valve guide member **162** of generally cylindrical shape which engages in an axial opening **164** in the body portion of the nozzle, the guide member **162** having a rounded head portion **166** which engages in an arcuate seat **168** in the lower spring seat **128**. The guide member has a central axially extending bore **166** which is open at its lower end and which at its opposite end has a radial control port **170** communicating with the spring chamber C'' and the leak-off passage **120**. In the present instance, the axial opening **164** in the body portion is enlarged as at **165** to form an extension of the spring chamber C'' providing fluid communication between the control port **170** and the leak-off system. This control port **170** has substantially the same flow area as the total flow area of the spray orifices **144** so that in the event the valve **116** sticks in a closed position, fuel pressure build up acting on the lower axial end face of the guide member will raise the guide member **162** upwardly against the bias of the compression spring and permit the predetermined fuel charge to be vented to the low pressure side of the valve, that is through the spring chamber C'' and leak-off bypass. In this manner, the operation of other fuel injection nozzles being supplied from a common pump will not be adversely affected as discussed previously in greater detail.

In accordance with this embodiment of the invention, the lower edge **176** of the guide member is tapered and the inner terminal end of the needle valve is provided with a conical head **178**, the head **178** preferably having an included angle of taper A'' greater than the angle of taper B'' of the inner edge **176** of the guide member. The differential between the angles of taper A'' and B'' is preferably a few degrees. This arrangement insures tight seating of the needle valve against the seat even if the bore for the guide member is not precisely concentric with the seat **140**. Furthermore, this mating arrangement insures tight seating of the needle valve even if a difference in concentricity develops in the nozzle assembly due to warpage, for example, over a period of use.

While particular embodiments of the present invention have been illustrated and described herein, it is to be understood that changes and modifications may be made herein within the scope of the following claims.

I claim:

1. A fuel injection nozzle assembly comprising an elongated body having an axial bore including an upper bore section defining a leak-off chamber and a lower bore section therein, means defining a valve seat at one axial end of the body and at least one spray orifice, a valve member having a needle mounted for axial movement in said lower bore section between a closed position wherein the valve member needle engages said seat and an open position spaced from said seat to permit discharge of fuel through said spray orifice, a valve guide member mounted interiorly of said body and normally adapted for movement with said valve member, said valve guide member having a bypass passageway therein with an outlet port communicating with said leak-off chamber of the valve, said outlet port having a flow area substantially equal to the flow area of the spray orifice.

2. A fuel injection nozzle assembly as claimed in claim **1** wherein the terminal end of the said needle valve opposite said tip is provided with a conical head and the valve guide member is provided with a circumferentially extending tapered edge at its lower end which seats on said conical head, the taper of said conical head and said lower edge of the valve guide member being different.

3. A fuel injection nozzle assembly as claimed in claim **2** wherein the included angle of taper of said conical head of the needle valve member is a few degrees greater than the included angle of taper of the lower edge of said guide member.

4. A fuel injection nozzle assembly as claimed in claim **1** including a bushing mounted in said body having an axial bore within which the guide member is mounted for axial movement.

5. A fuel injection nozzle assembly as claimed in claim **1** including a tip insert mounted in the lower end of the body.

6. A fuel injection nozzle assembly as claimed in claim **1** including biasing means engaging said guide member to normally maintain the valve member in a seated position.

7. A fuel injection nozzle assembly as claimed in claim **6** wherein said biasing means comprises a compression spring mounted between upper and lower spring seats and including selectively adjustable means for controlling valve lift.

8. A fuel injection nozzle assembly as claimed in claim **7** including a pressure adjusting screw member mounted in the upper axial end of the body abutting said upper spring seat and which may be actuated axially of the body to vary the biasing force of the compression spring.

9. A fuel injection nozzle assembly as claimed in claim **8** wherein said adjusting screw member has an axially extending groove to permit fuel leak off from the spring chamber.

10. A fuel injection nozzle assembly comprising a holder having a leak-off chamber therein, a nozzle having an axial bore mounted at one axial end of the holder, said nozzle comprising a body portion and an elongated shank of reduced cross section depending from the body portion having a valve seat at its outer terminal end and at least one spray orifice, a valve member mounted in said bore, a valve guide member mounted in said body portion and normally adapted for movement with said valve member, biasing means normally urging said valve member to a closed position, said valve guide member having a bypass passageway therein with an outlet port communicating with said leak-off chamber, said outlet port having a flow area substantially equal to the flow area of the spray orifice.

11. A fuel injection nozzle assembly as claimed in claim **10** wherein said axial bore in the nozzle is enlarged adjacent the leak-off chamber in said holder to provide fluid communication between the outlet port and said leak-off chamber in all positions of said valve member.

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