

## **HIGH PRESSURE FLUID SPRAY NOZZLE INCORPORATING A FLOW CONTROLLED SWITCHING VALVE**

### **BACKGROUND OF THE DISCLOSURE**

**[0001]** Traction nozzles are used in sewer pipe lines and other piping systems to assist in pulling high pressure hose into the pipe to reach obstructions requiring removal. These traction nozzles have jet tips oriented at an angle rearward in order to generate thrust in the nozzle within the pipe to assist in pulling the hose through and along long stretches of pipe and around pipe bends. These nozzles have forward directed jet tips to ablate the obstructions encountered. However, the forward directed jet tips produce a counter force against forward travel of the nozzle through the pipe. This counterforce hinders effective deployment of the high pressure hose and reduces the net pulling force produced by the traction nozzle on the high pressure hose. Thus there is a need for a switching mechanism that does not generate a counterforce during traction operation, yet facilitates operation of an effective fluid jet nozzle during actual cleaning operations.

### **SUMMARY OF THE DISCLOSURE**

**[0002]** The present disclosure directly addresses this problem. A switching valve in accordance with a first embodiment in the present disclosure provides a simple valve device that switches, or redirects fluid flow between a first flow path such as to rearwardly directed nozzle jets and a second flow path, such as to forwardly directed cleaning jets, remotely. This is accomplished simply by decreasing fluid flow through the valve below a predetermined threshold level and then increasing fluid flow above the threshold level. The valve can provide full pressure and fluid flow to each of the flow paths separately.

**[0003]** A valve in accordance with the present disclosure essentially has at least two operative positions, analogous to operation of a retractable ball point pen. One exemplary use of the valve is in sewer pipe cleaning with water jet nozzles. In such a configuration the valve in accordance with the present disclosure is installed between a cleaning nozzle assembly and a high pressure fluid hose sized to be inserted into a sewer or other piping system.

**[0004]** The valve preferably includes a plurality of tractor nozzles arranged to provide maximum pulling force to advance the hose, to which the valve is connected, through the sewer piping system to a distant area needing cleaning. When the cleaning

nozzle, attached to the front end of the valve, arrives at the area needing cleaning, a temporary flow interruption by the operator causes the valve to automatically switch from a first position directing fluid flow to the rearwardly directed tractor nozzles to an intermediate position. The valve automatically switches from the intermediate position to a second position directing fluid flow to the forwardly directed cleaning nozzle or nozzles when flow is restored. Another flow interruption causes the valve to reposition again to an intermediate position. Restoration of fluid flow above the threshold again switches the valve back to the first position directing fluid flow to the rearwardly directed tractor nozzles. A further flow interruption causes the valve to return to the intermediate position. Restoration of fluid flow above the threshold causes the valve to again switch to the second position as above described. Thus each time the flow is interrupted and then restored causes the valve to switch positions and hence flow paths.

**[0005]** One exemplary embodiment of the flow actuated flow path switching valve includes a hollow valve body having an inlet end, an outlet end, a mid portion, and a central axial bore through the inlet end, the mid portion, and the outlet end. The mid portion has at least one passage therein leading from the central axial bore through the valve body to at least one external port having a tractor nozzle mounted therein. An elongated poppet member is received, or carried, in the central axial bore of the valve body.

**[0006]** The poppet member has an open tubular rear end portion, a spool portion and a closed valve disc end portion. The poppet member can move axially back and forth in the central axial bore. The poppet member has an axial bore extending through the rear portion and at least part of the spool portion of the poppet member. The spool portion has one or more radial arms extending outward to abut against the mid portion of the valve body. The valve disc portion selectively closes the central axial bore through the outlet end of the valve body when contact is made with a seat formed in the outlet end of the valve body.

**[0007]** A biasing member such as a spring is preferably positioned between the valve body and the poppet member such that it resiliently biases the poppet member toward the inlet end of the valve body. The spring is held and compressed between a flange around the rear end portion of the poppet member and a shoulder in the central axial bore through the valve body. Fluid pressure and flow exerted on the rear end portion

of the poppet member compresses the spring to move the poppet member forward, away from the inlet end of the valve body. Reduction of fluid pressure/flow below a threshold permits the spring to push the poppet member rearward.

**[0008]** The valve further includes a guide in the valve body that engages a corresponding feature on the rear end portion of the poppet member to change orientation of the poppet member each time fluid flow through the valve drops below a threshold value. Specifically, at a first position of the poppet member, this guide and corresponding feature cooperate to align the radial arm on the spool portion with the at least one passage in the mid portion of the valve body and open the central axial bore through the outlet end of the valve body when fluid flow is introduced into the inlet end of the valve body at the first position.

**[0009]** This guide also causes the poppet to rotate and misalign the radial passage in the spool portion away from the at least one passage in the mid portion of the valve body when fluid flow is reduced below the predetermined flow rate threshold, to an intermediate position. The guide is configured to align the arm of the spool portion at a second position different from the first position, also closing the central axial bore through the outlet end, when fluid flow is next introduced in the inlet end of the valve body above the flow rate threshold. In this second position, fluid flowing around the arm of the spool portion enters and passes through the at least one passage in the mid portion of the valve body.

**[0010]** One exemplary embodiment of the valve has four radial arms on the spool portion of the poppet and four passages through the mid portion of the valve body leading to four rearwardly directed tractor nozzles. These tractor nozzles exit the valve body at a rearward angle. The reaction force of the fluid jet exiting these nozzles pulls the valve and the hose connected thereto into the piping system. Fluid flows through these nozzles when the valve is in the second position. When an obstruction is reached in the piping system, the operator simply turns off the flow, thus reducing flow below the threshold and the valve poppet moves rearward to an intermediate, or mid, position.

**[0011]** When flow is again restored by the operator turning flow back on, the poppet moves forward, rotating via the guide, to the first position. In the first position, the radial arms are aligned with the passages through the mid portion of the valve body, thus closing the passages. At the same time, the poppet is prevented from closing the

outlet portion, thus permitting fluid flow past the poppet and out the outlet end of the valve to the cleaning nozzle attached to the front end of the switching valve.

**[0012]** In a preferred embodiment, the poppet spool portion has a central bore and a passage leading from the central bore through each of the radial arms. In each passage through the radial arm is a stopper ball which, due to fluid pressure, completely plugs the passage through the mid portion of the valve body such that no fluid can flow to the tractor nozzles. These stopper balls ensure complete stoppage of fluid flow through the tractor nozzles when flow is being directed through the valve outlet to the cleaning nozzle.

**[0013]** Another embodiment is a nozzle configuration that incorporates a flow controlled switching valve in accordance with the present disclosure operationally similar to the one as described above directly into the nozzle head itself. The hollow nozzle head has a central blind bore that carries within it an entire switching valve cartridge. This switching valve cartridge in the blind bore includes a valve cartridge case into which the valve poppet slides, a spring around a stem portion of the poppet, and a poppet guide pin ring. The cartridge comprising the guide pin ring, the poppet, spring and cartridge case are captured in the blind bore in the nozzle head by a threaded inlet bushing. The inlet bushing is in turn fastened to the shaft of a rotary bearing coupling, which is, in turn, attached to a distal end of a high pressure fluid supply hose.

**[0014]** One exemplary nozzle includes a hollow body having a central bore and a plurality of ports extending through the body from the central bore; and a switching valve cartridge disposed in the central bore. The cartridge is operable to direct fluid flow from its inlet to at least one of the plurality of ports upon application of fluid flow above a predetermined threshold into the inlet and direct fluid flow from the inlet to at least a different one of the plurality of ports upon fluid flow having subsequently dropped below the predetermined threshold and then re-established to a level exceeding the predetermined threshold. The axially movable poppet is located at a first position in the case when fluid flow is directed through the at least one of the plurality of ports and is located at a second position when fluid flow is directed through the at least one different port. The poppet is moved via the spring to a third axial position whenever fluid flow drops below the predetermined threshold. More preferably, the poppet at the first position directs fluid flow through a first set of ports

and directs fluid flow through a second set of ports at the second position. Each transition below the predetermined threshold causes the fluid flow to alternate between the first and second set of ports.

**[0015]** The nozzle head in accordance with this alternative embodiment preferably has at least two axially spaced sets of nozzle ports passing from the central blind bore to the peripheral surface of the nozzle head. One set of nozzle ports is aligned via the cartridge within the central blind bore when fluid pressure is applied to the nozzle head setting the poppet in a first operating position within the cartridge. A second set of nozzle ports is aligned via the cartridge when fluid pressure is stopped and then reapplied to the nozzle head. The next fluid pressure stoppage and reapplication then realigns the poppet to a next set of nozzle ports. With two sets of nozzle ports, each cycle of stopping fluid pressure and reapplication of fluid pressure changes the set of nozzle ports through which fluid can pass.

**[0016]** More particularly, one exemplary valve cartridge includes a generally tubular valve cartridge case. This case has an inlet end, an outlet end, a mid portion, and a central axial bore through the inlet end and at least the mid portion. The mid portion has at least one first opening leading from the central axial bore out through the mid portion of the cartridge case. The outlet end has at least one second opening leading from the central axial bore out through the end portion of the cartridge case.

**[0017]** A generally tubular valve poppet having a central passage therethrough is movably disposed axially in the central axial bore of the cartridge case. This poppet has an open tubular rear end portion, a central portion and a front end portion. The central portion of the poppet has an external peripheral annular flange between the rear end portion and the central portion. The central portion has at least a first passage leading out of the poppet through a side wall and at least a second passage spaced from the first passage leading out of the poppet through the side wall of the poppet.

**[0018]** A biasing member, preferably a coil or Bellville spring, is positioned around the central portion between the valve cartridge case and the flange. The spring biases the poppet member axially away from the inlet end of the cartridge case.

**[0019]** A stationary guide member is positioned around the tubular rear end portion of the poppet. This guide member is fastened in the central bore to the hollow nozzle body at a fixed distance from the cartridge case. The guide member engages a

corresponding feature on the rear end portion of the poppet to align the first passage of the central portion of the poppet with the at least one opening of the cartridge at a first position of the poppet when fluid flow is introduced into the rear end of the poppet, misalign the first passage with the at least one opening when fluid flow is reduced below a predetermined flow rate threshold, and align the second passage of the central portion of the poppet with the other opening in the valve cartridge case when fluid flow is next introduced in the inlet end of the poppet above the flow rate threshold.

**[0020]** Further features, advantages and characteristics of the embodiments of this disclosure will be apparent from reading the following detailed description when taken in conjunction with the drawing figures.

### **DESCRIPTION OF THE DRAWINGS**

**[0021]** FIG. 1 is an external perspective view of one exemplary embodiment of a switching valve in accordance with this disclosure connected between a fluid hose and a cleaning nozzle.

**[0022]** FIG. 2 is a separate exploded perspective view of the switching valve shown in Fig. 1.

**[0023]** FIG. 3 is a longitudinal cross sectional view of the assembled switching valve body shown in Fig. 1 in accordance with the present disclosure, with the poppet and guide shown in perspective, in the first position.

**[0024]** FIG. 4 is a view as in FIG. 3 with the poppet in the second position.

**[0025]** FIG. 5 is a view as in FIG. 3 with the poppet in the mid, or low flow, position.

**[0026]** FIG. 6 is separate perspective view of the poppet shown in FIGS. 2-5, shown without the stopper balls in place, in accordance with the present disclosure.

**[0027]** FIG. 7 is an exploded view of a switching nozzle head assembly in accordance with present disclosure.

**[0028]** FIG. 8 is an enlarged exploded view of the switching nozzle head assembly shown in FIG. 7.

**[0029]** FIG. 9 is a separate rear end axial view of the nozzle head in accordance with the present disclosure.

**[0030]** FIG. 10 is an axial cross sectional view through the nozzle head taken along the line 10-10 in FIG. 9.

**[0031]** FIG. 11 is an axial cross sectional view through the nozzle head taken along the line 11-11 in FIG. 9.

**[0032]** FIG. 12 is a separate perspective view of the cartridge shown in FIGS. 7 and 8 in accordance with the present disclosure.

**[0033]** FIG. 13 is a front end view of the cartridge shown in FIG. 12.

**[0034]** FIG. 14 is an axial longitudinal sectional view of the cartridge shown in FIG. 12 taken along the line 14-14 in FIG. 13.

**[0035]** FIG. 15 is an axial longitudinal sectional view of the cartridge shown in FIG. 12 taken along the line 15-15 in FIG. 13.

**[0036]** FIG. 16 is a separate perspective view of the valve poppet shown in FIGS. 7 and 8.

**[0037]** FIG. 17 is a rear end view of the valve poppet shown in FIG. 16.

**[0038]** FIG. 18 is an axial cross sectional view of the valve poppet shown in FIG. 16 taken along the line 18-18 in FIG. 17.

**[0039]** FIG. 19 is an axial cross sectional view of the valve poppet shown in FIG. 16 taken along the line 19-19 in FIG. 17.

**[0040]** FIG. 20 is an axial cross sectional view of the complete nozzle assembly shown in FIG. 8 in accordance with the present disclosure when fluid pressure is initially off.

**[0041]** FIG. 21 is an axial cross sectional view of the complete nozzle assembly shown in FIG. 20 in accordance with the present disclosure when fluid pressure is first applied on.

**[0042]** FIG. 22 is an axial cross sectional view of the complete nozzle assembly shown in FIG. 21 in accordance with the present disclosure when fluid pressure is next applied after being shut off.

## **DETAILED DESCRIPTION**

**[0043]** An exemplary embodiment of a switching valve 100 is shown in FIG. 1 connected to a high pressure fluid hose 102 and to a cleaning nozzle 104. The switching valve 100 essentially has a generally cylindrical compact outer shape so

that it can be inserted into pipes and other tubular passages. A separate exploded perspective view of the valve **100** is shown in FIG. 2. As shown in FIG. 2, the valve **100** includes a hollow main valve body **106** and an inlet end guide cap **108**. Inserted into the main valve body **106** is a spring **110** and a poppet member **112**. Inserted into the inlet end guide cap **108** is a guide collar **114** which carries four equally spaced guide pins **116**. The inlet end guide cap **108** is sealed with an O-ring **118** and threaded onto the valve body **106**, thus capturing together the poppet member **112**, spring **110**, guide collar **114** with guide pins **116**.

**[0044]** The inlet end cap **108**, at its rear, may have internal threads **120** as shown or alternatively may have external threads to mate with corresponding high pressure hose thread connections. The forward portion of the inlet end cap **108** has a recess to receive the guide collar **114** and has internal threads so as to be screwed onto the rear portion of the main valve body **106**.

**[0045]** The guide collar **114** is a tubular sleeve that has a pair of alignment notches **122** which engage corresponding projections **124** on the rear portion of the main valve body **106**. The engaged projections **124** prevent rotation of the collar **114** when assembled in the inlet end cap **108**. The guide collar **114** also has four radial bores **126** therethrough each receiving a guide pin **116** press fit therein. When the guide collar **114** is assembled into the end cap **108**, a portion of each of the guide pins **116** projects radially inward toward the axial centerline of the end cap **108**.

**[0046]** The main valve body **106** is shown in cross section in FIGS. 3, 4 and 5. The valve body **106** is generally symmetrical about a central axis A. The valve body **106** has an inlet end **128**, an outlet end **130**, a mid portion **132**, and a central axial bore **134** through the inlet end **128**, the mid portion **132**, and the outlet end **130**. The mid portion **132** has an enlarged flange external shape and has at least one passage **136** therein leading from the central axial bore **134** through the valve body **106** to at least one external port **138**. In the exemplary embodiment of the valve **100** shown, there are four passages **136**, equally spaced radially apart by 90°, leading to four external ports **138**. Threaded into each external port **138** is a nozzle jet tip **140**. Each of the external ports **138** is rearwardly directed at an angle such that forward thrust is exerted on the valve **100** when high pressure fluid is ejected through the nozzle jet tips **140** to push the valve, attached hose **102**, and cleaning nozzle **104** through piping to the location needing to be cleaned. Note that, in the exemplary embodiment

shown, there are four passages **136**. Other valve body configurations are also envisioned, such as a valve body having any number of radial passages in the mid portion **132** of the valve body **106** leading to a corresponding number of ports **138**, each having an appropriate nozzle jet tip **140** attached thereto.

**[0047]** The bias member **110** is a spring, such as a coil spring, and more preferably a flat wire wave compression spring that is captured between an internal shoulder **142** in the mid portion **132** of the valve body **106** and an annular flange **144** on the poppet member **112**. This spring bias member **110** urges the poppet member **112** rearward toward the inlet end of the valve **100** in the absence of fluid pressure and flow. When fluid flow is introduced into the valve **100**, the spring bias member **110** is compressed, urging the poppet member **112** forward as is described in more detail below.

**[0048]** The poppet member **112** is separately shown in FIG. 6. The poppet member **112** is a generally elongated body generally symmetrical about a central axis A. The poppet member **112** has an open tubular rear end portion **146**, a spool portion **148** and a closed end valve disc portion **150**. The disc **151** of the valve disc portion **150** selectively closes the central axial bore **134** through the outlet end **130** of the valve body **106**. The poppet member **112** has an axial bore **152** extending through the rear portion **146** and part of the spool portion **148** of the poppet member **112**. The spool portion **148** has one or more radial arms **154**, preferably an even number, and in the illustrated exemplary embodiment, four radial arms **154**, extending outward radially from a central stem **156** of the spool portion **148** to the inner wall of the mid portion **132** of the valve body **106**. The spool portion **148** of the poppet member **112** also has several ports **158** leading forward from the bore **152** out of the rear portion **146**. These ports **158** permit fluid flow through the bore **152** and around the arms **154** to and past the disc **151** of the closed end valve disc portion **150** of the poppet **112** and through the outlet **130** of the valve body **106** when the poppet **112** is in the second position.

**[0049]** Each of the radial arms **154** has a central passage **160** therethrough. Furthermore, each of the passages has a ball **162** disposed therein (shown in FIGS. 2 & 3). When the valve **100** is in the first position, shown in FIG. 3, the radial arms **154** are aligned with the passages **136**. As fluid flows through the passages **160** into the passages **136**, the balls **162** seat to close and block any further flow through passages **136**. Fluid also flows through the axial bore **152** and through the ports **158**,

around the radial arms **154**, and then to the outlet end **130** of the valve body **106** around the closed end valve disc portion **150**. This configuration is shown in FIG. **3**.

**[0050]** Turning back now to FIG. **6**, and the separate view of the exemplary poppet **112**, the open rear end portion **146** of the poppet **112** will be described. The end portion **146** has a tubular side wall **164** that has a zig-zag pattern annular cam groove **166** formed in the tubular wall **164**. This cam groove **166** is sized complementary to the diameter and depth of the pins **116** and has forward notches or vertices **168** each rotationally spaced, for example, about 45° apart, or approximately 1/8 of a rotation, along the groove **166**. The cam groove **166** also has rear notches **170** spaced alternately with four axial grooves **172** spaced, for example, about 90° apart. These axial grooves **172** merge with the cam groove **166** at an angular rotation position between the rear notches **170** in the groove **166**.

**[0051]** Each of the four guide pins **116** ride in the cam groove **166** when the valve **100** is fully assembled. The sides of the cam groove **166** are angled toward the sequential forward and rear notches or vertices **168** and **170** of the groove **166** such that when the poppet moves forward and back as flow is applied or reduced, the poppet **112** has to rotate about 22.5° clockwise in this example, i.e., approximately 1 1/16 of a rotation, each time as it moves forward or back with each change in flow above and below the predetermined threshold rate. It is to be understood that the embodiment shown is merely exemplary. The precise rotational angles shown are approximate, and may differ from that shown depending on design configurations and tolerances.

**[0052]** When fluid flow is off, or at least reduced below the predetermined threshold, established by the spring rate of the spring **110**, the poppet **112** moves rearward to one of the intermediate positions as is shown in FIG. **5**. In this intermediate, or mid position, the radial arms **154** of the spool portion **148** are offset from alignment with the passages **136** rendering the passages **136** open to the bore **134** through the main valve body **106**. Also, the disc portion **150** is spaced from the seat of the outlet end **130** of the valve body **106**.

**[0053]** If the position of the poppet **112** before flow decrease had been as shown in FIG. **3**, (flow through the outlet to the cleaning nozzle **104**), then, when fluid flow is again turned on, the poppet **112** again is moved forward by the fluid flow against the inlet end portion **146**, but this time moves the poppet **112** to the position shown in FIG. **4**. This is the second position, in which the arms **154** are not aligned with the

passages **136** through the mid portion of the valve body **106**, and the disc **151** of the closed end valve disc portion **150** closes the outlet **130**. Fluid flow thus is free to pass through the axial bore **152** in the rear end portion of poppet **112**, through the passages **158** out of the stem **156** of spool portion **148**, around the arms **154**, and through the passages **136** to the external ports **138** and tractor nozzle jet tips **140**.

**[0054]** When flow is subsequently reduced below the predetermined threshold, such as by the operator turning off flow, the poppet **112** rotates rearward to a position similar to that shown in FIG. **5**, except rotated one notch **168** further by 45° than that shown. When flow is again restored, the poppet **112** continues to rotate, forward this time, to a position identical to that shown in FIG. **3**.

**[0055]** It is to be understood that various changes can be made to the switching valve **100** in accordance with the present disclosure. For example, the valve body may be configured with 2, 3, 4, 5, or 6 radial passages **136**, and the corresponding poppet would thus have an equal number of properly spaced radial arms **154**. Furthermore, if sufficiently close tolerances are maintained, the need for balls **162** and passages **160** through the radial arms **154** may be eliminated. In such a configuration, the radial arms **154** would be solid and configured to substantially close off the passages **136** to the external traction ports **138**.

**[0056]** Alternatively different sets of ports could be provided in the valve body **106** to provide additional flow paths as may be needed for a particular application. For example, rather than having only two separate flow paths, a configuration that has three flow paths could be designed without departing from the scope of the present disclosure. In such a configuration the zig-zag guide groove would have a different number of notches **168** and **170** as would be required for such a configuration. The passages **136** could alternatively lead to a separate nozzle assembly fastened to the valve rather than having integral tractor jet tips **140** mounted directly to the valve body **106**. Furthermore, jet tool nozzle configuration and/or patterns can be selected to control speed or direction.

**[0057]** Fluid flow may alternatively be directed to other end components rather than nozzles. For example, in other applications of the valve **100** disclosed herein, the fluid flow could be directed not to nozzles, but to actuators which could perform functions such as centralizing, clamping, bending, crushing, expanding, or plugging. Thus the

implementation to which the switching valve **100** is applied may be substantially modified.

**[0058]** Another embodiment of a switcher valve assembly in accordance with the present disclosure is a switcher valve cartridge **200** shown incorporated into a nozzle body **204** in an exemplary pipe cleaning assembly **202** described below with reference to FIGS. 7-22. The cartridge **200** may be incorporated into any number of nozzle configurations. Nozzle body **204** is merely exemplary of one such configuration.

**[0059]** An exploded view of a pipe cleaning assembly **202** is shown in FIG. 7. An enlarged exploded view of the cartridge **200** is shown in FIG. 8. The assembly **202** includes a nozzle head or nozzle body **204** that houses the cartridge **200**. The nozzle head **204** is in turn threaded or otherwise fastened to a distal end of a rotating bearing coupling assembly **206** such as is disclosed in US Patent No. 6,059,202, which is, in turn, fastened to the distal end of a high pressure fluid hose **208**.

**[0060]** The nozzle head, or body, **204** in this exemplary embodiment, is generally symmetrical about its longitudinal axis "A" and has a set of four arcuately spaced apart tractor ports **210**, a set of four cleaning ports **212**, and a front cleaning port **214**. Each of these ports **210**, **212**, and **214** passes into a central blind bore **216**, shown in FIGS. 9, 10 and 11, into which the cartridge **200** is installed. Each of these ports is positioned at an angle from, or displaced off center from the longitudinal axis **A** of the nozzle body **204** so as to impart a rotational moment to the nozzle body **204** during device operation. The angle from the axis causes forward traction, or neutral (no pulling), or retarding in the case of a forward cutting nozzle. It is only the radial offset that imparts a rotational moment to the nozzle body. As a result, during operation of the assembly **202**, the nozzle body **204** spins on the bearing assembly **206**. The bearing assembly **206** typically is designed to allow spinning at a controlled rate.

**[0061]** Although not completely shown in FIGS. 9, 10 and 11, the ports **210** each extend through the body **204** (shown as dashed lines in FIGS. 10 and 11) to intersect the generally flat bottom **218** of the central bore **216**. This bottom **218** has a pair of axially extending sockets **220** and a central hole **222** communicating with front port **214**.

**[0062]** The choice of and direction of ports **210**, **212**, and **214** may be modified in different nozzle heads **204**, depending on the particular cleaning application for which the nozzle **204** is designed. For example, the precise angular position, number and

offset of each of the ports may be changed as well as the number of sets of ports depending on operational needs for a specific application. Provided the same radial spacing of the port openings into the central blind bore **216** remains the same, a variety of nozzle head configurations may utilize the same cartridge **200** as described below. Furthermore, all of the wear parts in the switching valve are contained in the cartridge **200** such that repair is simplified by simple cartridge replacement when required.

[0063] Referring back now to FIGS. **7** and **8**, the cartridge **200** comprises a cartridge case **230**, a tubular poppet **232**, a biasing spring **234**, a set of stopper balls **236** and a guide pin collar or ring **238**. The cartridge **200** is assembled into the central blind bore **216** in the nozzle body **204** and captured therein via a threaded bushing **240**. The threaded bushing **240** has a peripheral groove holding a seal O-ring **242**. Similarly, the cartridge case **230** carries a pair of spaced O-rings **242** in corresponding peripheral grooves to seal the cartridge **200** in place in the bore **216**.

[0064] The cartridge case **230** is shown in separate perspective view in FIG. **12**. An outside bottom end view of case **230** is shown in FIG. **13**. FIGS. **14** and **15** are longitudinal sectional views through the case **230**. FIG. **20** is a longitudinal sectional view through the assembled cartridge **200** in nozzle body **204** when fluid flow is either off or at least below a predetermined fluid flow/pressure threshold.

[0065] Cartridge case **230** is a generally tubular cup, preferably made of a hardened stainless steel material, with a cross or X shaped exterior channel **244** formed in the bottom **248** of the cup between and separating a pair of spaced, axially extending, locating pins **246**. At the end of each leg of the cross channel **244** is a corner recess **250** that passes into the interior of the cartridge case **230** through the bottom **248**. The bottom **248** has a central circular raised portion that forms a valve disk **252**.

[0066] The tubular side wall **254** of the case **230** has a wide peripheral channel **256** spaced between two narrow grooves **258** for receiving the O-rings **242**. The side wall **254** in the bottom of the peripheral channel **256** has a set of four spaced radial openings **260**, spaced 90° apart, that extend through the side wall **254**. When the cartridge case **230** is fully seated in the blind bore **216** in the nozzle head **204**, the locating pins **246** fit within the sockets **220**. This ensures that openings **260** are aligned with the ports **212** as is shown, for example, in FIG. **20**.

**[0067]** Furthermore, when the cartridge case **230** is fully inserted into the bore **216** and pins **246** engaged in the sockets **220**, four passages from the case interior to the bottom **218** of the blind bore **216** are formed between the case **230** interior and the cross shaped channel **244** via corner recesses **250**. As can partially be seen in FIGS. **10** and **11**, these passages intersect with the bottom inner ends of the bores forming each of traction ports **210**.

**[0068]** The poppet **232** is separately shown in a rear perspective view in FIG. **16**. A normal rear end view of the poppet **232** is shown in FIG. **17**. Different longitudinal sectional views of the poppet **232** are shown in FIGS. **18** and **19**. Poppet **232** is basically a tubular body with a rear portion **262**, a central portion **264** and a front end portion **266**. The rear portion is separated from the central portion **264** by an exterior peripheral annular flange **267**. This annular flange **267** engages one end of the biasing spring **234** as is shown in FIGS. **20-22**.

**[0069]** The tubular poppet **232** internally tapers and thickens in the central portion **264** to form at a shoulder **270** in the central portion **264** a small central axial passage **268** through the central portion. The small central passage **268** continues through the front end portion **266** and ends at an annular valve seat **272**. The central portion **264** has a set of four angled passages **274** spaced equally apart and extending outward from the shoulder **270** through the central portion **264** to and through the exterior surface of the central portion **264**. The central portion **264** also has a set of four radial passages **276** equally spaced around the central portion **264** and angularly positioned 45° apart from the passages **274**. Each of the radial passages **276** receives and holds one of the balls **236** therein.

**[0070]** The guide pin ring or collar **238** in this embodiment is similar to the guide collar **146** described above with reference to the first embodiment **100** except that guide collar **238** is a tubular sleeve that has a pair of exterior alignment flats **280** which mate with corresponding flats **282** in the central bore in the nozzle head **204**. These alignment flats **280** and **282** can be seen in FIGS. **8** and **9**. The engaged flats **280** and **282** prevent rotation of the collar **238** when assembled in the nozzle body **204**. Furthermore, these flats ensure proper alignment of the collar **238** with the cartridge case **230**. The guide collar **238** also has four radial bores therethrough each receiving a guide pin **284** press fit therein. When the guide collar **238** is assembled into the

nozzle body **204**, a portion of each of the guide pins **284** projects radially inward toward the axial centerline of the nozzle body **204**.

[0071] Turning now to FIG. **16**, and the separate view of the exemplary poppet **232**, the open rear end portion **262** of the poppet **232** will be described. The end portion **262** has a tubular side wall **286** that has a zig-zag pattern annular cam groove **288** formed in the tubular wall **286**. This cam groove **288** is sized complementary to the diameter and depth of the pins **284** that project radially inward from the guide collar **232**. When the cartridge **200** is fully assembled, the pins **284** ride in the cam groove **288**. This cam groove **288** has forward notches or vertices **290** each rotationally spaced about 45° apart along the groove **288**. The cam groove **288** also has rear notches **292** spaced alternately with four axial grooves **294** spaced about 90° apart. These axial grooves **294** merge with the cam groove **288** at an angular rotation position between the rear notches **292** in the groove **288**.

[0072] Each of the four guide pins **284** ride in the cam groove **288** when the valve cartridge **200** is fully assembled. The sides of the cam groove **288** are angled toward the sequential forward and rear notches or vertices **290** and **292** of the groove **288** such that when the poppet **232** moves forward and back as flow is applied or reduced, the poppet **232** has to rotate about 22.5° clockwise each time as it moves forward or back with each change in flow above and below the predetermined threshold rate.

[0073] When fluid flow is off, or at least reduced below the predetermined threshold, established by the spring rate of the spring **234**, the poppet **232** moves rearward to one of the intermediate positions as is shown in FIG. **20**. Although the guide pins **284** are not visible in FIG. **20**, they are in the same position, resting against the forward notches **290** as is shown for the first embodiment in FIG. **5**.

[0074] In this intermediate position, the flange **267** rests against the collar guide **238**. In this position, passages **274** are blocked as are openings **276**. The central bore through the poppet **232** is open to all the passages, i.e. the bottom passages through openings **250** to the tractor nozzle ports **210** and the ports **212**. However, fluid pressure is either off or low at this point.

[0075] If the position of the poppet **232** before flow decrease had been as shown in FIG. **22**, i.e., flow through the passages **274** outlet to the cleaning nozzle ports **212**, then, when fluid flow is again turned on, the poppet **232** again is moved forward by the fluid flow against the inlet end portion **262**, but this time moves the poppet **232** forward

only to the position shown in FIG. 21. In this position, the passages 274 are not aligned with the cleaning ports 212 through the mid portion of the nozzle head 204, and the disc 252 of cartridge case 230 is spaced from the seat 272 of the poppet 232. Fluid flow thus is free to pass directly through the poppet 232, out the openings 250 in the bottom of the cartridge case 230 to the traction ports 210, as well as along the channel 244 to the front port 214. At the same time, the openings 276 are directly aligned with the cleaning ports 212. However, the balls 236 carried in each of the openings 276 are forced outward by fluid pressure so as to plug the ports 212. Thus when poppet is in the position shown in FIG. 21, full fluid flow is permitted to the front port 214 and the traction ports 210 while flow is positively prevented through cleaning ports 212.

[0076] When flow is subsequently reduced below the predetermined threshold, such as by the operator turning off flow, the poppet 232 rotates about 22.5° as the spring 234 pushes the poppet 232 rearward to engage stationary guide pins 284 to cause rotation and axial movement to an intermediate position similar to that shown in FIG. 20, except rotated one notch 290 further by 22.5°. This rotation is caused by the interaction between the stationary guide pins 284 riding in the groove 288 forcing rotation of the poppet 232 as the spring 234 pushes the poppet rearward, in a similar manner as described above with reference to poppet 112 in the description of the first embodiment 100.

[0077] Then, when flow is increased above the predetermined threshold, the poppet 232 rotates about 22.5° again as fluid flow pushes the poppet 232 forward, to the position shown in FIG. 22. When the poppet 232 is in this position, the openings 276 are misaligned with the ports 212, the valve disk 252 plugs the seat 272 of the poppet 232, and the passages 274 are directly aligned with the cleaning ports 212. Since the outlet end of the poppet 232 is closed off, there is no flow available to the traction ports 210. Thus, while flow is directed through the cleaning ports 212, flow is positively prevented through the traction ports 210. Each cycle of fluid flow/pressure application causes about a 45° rotation of the poppet 232 and hence an alternation between fluid flow being directed to traction ports 210 and cleaning ports 212. Since all of these ports are preferably offset from a direct radial orientation, a rotational torque is applied to the nozzle to cause nozzle head rotation. Finally, each of the ports 210 and 212 preferably has a threaded jet tip 298 installed. These jet tips 298 may also be of different configurations depending on the task to be performed.

**[0078]** It is to be understood that various changes can be made to the nozzle **204** and to the switching valve cartridge **200** in accordance with the present disclosure. For example, the nozzle head body **204** may be configured with a different number of ports **210** and **212** and the corresponding poppet **232** and case **230** in the cartridge **200** would thus have a different number of openings and passages. The same cartridge **200** may be utilized in a variety of nozzle head bodies **204** each with a different set of angled ports. The angles and offsets utilized may be tuned to achieve specific rotational torques at designed pressures and flow rates. Furthermore, if sufficiently close tolerances are maintained, the need for balls **236** could be eliminated.

**[0079]** Alternatively different sets of ports could be provided in the nozzle body **204** to provide additional flow paths as may be needed for a particular application. For example, rather than having only two separate flow paths, a configuration that has three flow paths could be designed without departing from the scope of the present disclosure. In such a configuration the zig-zag cam groove **288** would have a different number of notches **290** and **292** as would be required for such a configuration. In both of the embodiments **100** and **200** shown, the grooves **166** and **288** are shown as being rectangular channels. Other configurations could also be used, depending on the types and number of guide pins in the guide pin collar used.

**[0080]** All such changes, alternatives and equivalents in accordance with the features and benefits described herein, are within the scope of the present disclosure. Such changes and alternatives may be introduced without departing from the spirit and broad scope of my invention as defined by the claims below and their equivalents.

## CLAIMS

What is claimed is:

1. A flow actuated flow path switching valve comprising:

a hollow valve body having an inlet end, an outlet end, a mid portion, and a central axial bore through the inlet end, the mid portion, and the outlet end, the mid portion having at least one passage therein leading from the central axial bore through the valve body to at least one external port;

a poppet member received in the central axial bore, the poppet member having an open tubular rear end portion, a spool portion and a closed end valve disc portion, the valve disc portion selectively closing the central axial bore through the outlet end of the valve body, the poppet member having an axial bore extending through the rear portion and the spool portion of the poppet member, the spool portion having at one or more radial arms extending to the mid portion of the valve body;

a biasing member between the valve body and the poppet member biasing the poppet member toward the inlet end of the valve body; and

a guide in the valve body engaging a corresponding feature on the rear end portion of the poppet member to align the radial arm on the spool portion with the at least one passage in the mid portion of the valve body at a first position of the poppet member and open the central axial bore through the outlet end of the valve body when fluid flow is introduced into the inlet end of the valve body, misalign the radial passage in the spool portion away from the at least one passage in the mid portion of the valve body when fluid flow is reduced below a predetermined flow rate threshold, and align the arm of the spool portion at a second position different from the first position closing the central axial bore through the outlet end when fluid flow is next introduced in the inlet end of the valve body above the flow rate threshold.

2. The flow actuated valve according to claim 1 wherein the valve disc of the poppet member engages a complementary valve seat in the valve body closing the central axial passage when the poppet member is in the second position.

3. The flow actuated valve according to claim 2 wherein when fluid flow is again reduced below the predetermined threshold the valve disc of the poppet member disengages the valve seat and opens the central passage through the outlet portion of the valve body.

4. The flow actuated valve according to claim 3 wherein when fluid flow is again increased above the predetermined threshold the guide causes the poppet member to again return to the first position.

5. The flow actuated valve according to claim 1 wherein the arm includes a radial passage from the axial bore to the end of the arm.

6. The flow actuated valve according to claim 5 further comprising a ball disposed in the radial passage for sealing the passage through the mid portion of the valve body when the poppet member is in the first position.

7. The flow actuated valve according to claim 1 wherein the poppet member has a plurality of bypass passages leading from the rear end portion around the axial bore in the spool portion.

8. The flow actuated valve according to claim 3 wherein the poppet portion has a plurality of bypass passages through the rear end portion around the central axial bore in the spool portion.

9. The flow actuated valve according to claim 1 wherein the first position blocks fluid flow through the passage through the mid portion of the valve body and permits fluid flow through the valve body from the inlet end, around the spool portion of the poppet member, and out through the valve body outlet end.

10. The flow actuated valve according to claim 1 wherein the second position permits fluid flow through the passage in the mid portion of the valve body.

11. The flow actuated valve according to claim 1 wherein the guide causes the poppet member to rotate when moving between the first and second positions.

12. The flow actuated valve according to claim 1 further comprising the poppet member is held at a third position when flow is reduce below the threshold.

13. The flow actuated valve according to claim 1 wherein the guide includes a stationary pin projecting radially inward from an inside surface of the valve body into a complementary groove formed in the rear end portion of the poppet member.

14. The flow actuated valve according to claim 13 further comprising at least two spaced stationary pins projecting into complementary grooves formed in the rear end portion of the poppet.

15. The flow actuated valve according to claim 14 wherein the guide includes two or more spaced stationary pins projecting radially inward from an inside surface of the valve body into a complementary groove formed in the rear end portion of the poppet member.

16. The flow actuated valve according to claim 15 wherein the guide includes four equally spaced stationary pins and the complementary groove causes the poppet body to rotate about 45 degrees between each of the first and second positions.

17. In a piping cleaning apparatus having a high pressure fluid cleaning nozzle attached to a flexible hose for passage through a length of piping to a location requiring cleaning, a flow actuated switching valve connected between the hose and the cleaning nozzle, the switching valve comprising:

a valve body having an inlet portion configured to be connected to the hose, a mid portion, an outlet portion configured to be connected to the cleaning nozzle, and a central axial bore therethrough, the mid portion having a plurality of rearwardly directed ports connected by passages to the central axial bore;

an elongated poppet member slidably disposed in the central axial bore, the poppet member having a rear portion, a spool portion for selectively opening and closing the passages in the mid portion of the valve body and a closed end portion forming a valve disc for closing the outlet portion of the valve body;

a bias member between the poppet member and the valve body biasing the poppet member rearward; and

a guide member between the rear portion of the poppet member and the valve body for guiding the poppet member between first and second rotary positions when fluid flow through the valve drops below a predetermined flow rate threshold and then returns above the flow rate threshold.

18. The valve according to claim 17 further comprising the guide member having at least two spaced stationary pins projecting into complementary grooves formed in the rear end portion of the poppet.

19. The valve according to claim 17 wherein the guide member includes two or more spaced stationary pins projecting radially inward from an inside surface of the valve body into a complementary groove formed in the rear end portion of the poppet member..

20. The valve according to claim 19 wherein the guide member includes four equally spaced stationary pins and the complementary groove causes the poppet body to rotate about 45 degrees between each of the first and second positions.

21. A nozzle comprising:

a hollow body having a central bore and a plurality of ports extending through the body from the central bore; and

a switching valve cartridge disposed in the central bore operable to direct fluid flow from an inlet to at least one of the plurality of ports upon application of fluid flow above a predetermined threshold to the inlet and direct fluid flow from the inlet to at least a different one of the plurality of ports upon fluid flow having subsequently dropped below the predetermined threshold and then exceeding the predetermined threshold.

22. The nozzle according to claim 21 wherein the cartridge includes a poppet located at a first position when fluid flow is directed through the at least one of the plurality of ports and at a second position when fluid flow is directed through the at least one different port.

23. The nozzle according to claim 22 wherein the poppet is at a third position whenever fluid flow drops below the predetermined threshold.

24. The nozzle according to claim 22 wherein the poppet at the first position directs fluid flow through a first set of ports and directs fluid flow through a second set of ports at the second position.

25. The nozzle according to claim 24 wherein each transition below the predetermined threshold causes the fluid flow to alternate between the first and second set of ports.

26. A nozzle comprising:

a hollow body connectable to a high pressure fluid supply, the body having a central bore, a first plurality of ports extending out of the body from the central bore and a second plurality of ports extending out of the body from the central bore; and

a switching valve cartridge assembly disposed in the central bore operable to direct fluid flow from an inlet to one or more of the first plurality of ports upon application of fluid flow above a predetermined threshold to the inlet and direct fluid flow from the inlet to one or more of the second plurality of ports upon fluid flow dropping below the predetermined threshold and then exceeding the predetermined threshold.

27. The nozzle according to claim 26 wherein the cartridge assembly comprises:

a generally tubular valve cartridge case disposed in the central bore of the hollow body, the case having an inlet end, an outlet end, a mid portion, and a central

axial bore through the inlet end and at least the mid portion, the mid portion having at least one first opening leading from the central axial bore out through the mid portion of the cartridge case, and the outlet end having at least one second opening leading from the central axial bore out through the end portion of the cartridge case;

a generally tubular valve poppet having a central passage therethrough, the poppet being movably disposed in the central axial bore of the cartridge case, the poppet having an open tubular rear end portion, a central portion and a front end portion, the central portion of the poppet having an external peripheral annular flange between the rear end portion and the central portion, the central portion having at least a first passage leading out of the poppet and at least a second passage spaced from the first passage leading out of the poppet;

a biasing member between the valve cartridge case and the flange around the central portion, the poppet member biasing the poppet member axially away from the inlet end of the cartridge case; and

a guide member positioned around the tubular rear end portion of the poppet and fastened to the hollow nozzle housing at a fixed distance from the cartridge case, the guide member engaging a corresponding feature on the rear end portion of the poppet to align the first passage of the central portion of the poppet with the at least one opening of the cartridge at a first position of the poppet when fluid flow is introduced into the rear end of the poppet, misalign the first passage with the at least one opening when fluid flow is reduced below a predetermined flow rate threshold, and align the second passage of the central portion of the poppet with the other opening in the valve cartridge case when fluid flow is next introduced in the inlet end of the poppet above the flow rate threshold.

28. The nozzle according to claim 27 wherein the outlet end of the poppet engages a complementary seat in the outlet end of the cartridge closing the central axial passage when the poppet member is in the second position.

29. The nozzle according to claim 28 wherein when fluid flow is again reduced below the predetermined threshold the valve disc of the poppet member disengages the valve seat and opens the central passage through the outlet portion of the poppet.

30. The nozzle according to claim 29 wherein when fluid flow is again increased above the predetermined threshold the guide causes the poppet to again return to the first position.

31. The nozzle according to claim 27 wherein the guide member and bias member cooperate to position the poppet at a common axial position whenever fluid flow decreases below the predetermined threshold.

32. A switching valve cartridge assembly comprising:

a generally tubular valve cartridge case having an inlet end, an outlet end, a mid portion, and a central axial bore through the inlet end and at least the mid portion, the mid portion having at least one first opening leading from the central axial bore out through the mid portion of the cartridge case, and the outlet end having at least one second opening leading from the central axial bore out through the end portion of the cartridge case;

a generally tubular valve poppet having a central passage therethrough, the poppet being movably disposed in the central axial bore of the cartridge case, the poppet having an open tubular rear end portion, a central portion and a front end portion, the central portion of the poppet having an external peripheral annular flange between the rear end portion and the central portion, the central portion having at least a first passage leading out of the poppet and at least a second passage spaced from the first passage leading out of the poppet;

a biasing member between the valve cartridge case and the flange around the central portion, the poppet member biasing the poppet member axially away from the inlet end of the cartridge case; and

a guide member positioned around the tubular rear end portion of the poppet at a fixed distance from the cartridge case, the guide member engaging a corresponding feature on the rear end portion of the poppet to align the first passage of the central portion of the poppet with the at least one opening of the cartridge at a first position of the poppet when fluid flow is introduced into the rear end of the poppet, misalign the first passage with the at least one opening when fluid flow is reduced below a predetermined flow rate threshold, and align the second passage of the central portion of the poppet with the other opening in the valve cartridge case when fluid flow is next introduced in the inlet end of the poppet above the flow rate threshold.

33. The cartridge assembly according to claim 32 wherein the outlet end of the poppet engages a complementary seat in the outlet end of the cartridge closing the central axial passage when the poppet member is in the second position.

34. The cartridge assembly according to claim 33 wherein when fluid flow is again reduced below the predetermined threshold the valve disc of the poppet

member disengages the valve seat and opens the central passage through the outlet portion of the poppet.

35. The cartridge assembly according to claim 34 wherein when fluid flow is again increased above the predetermined threshold the guide causes the poppet to again return to the first position.

36. The cartridge assembly according to claim 32 wherein the guide member and bias member cooperate to position the poppet at a common axial position whenever fluid flow decreases below the predetermined threshold.

37. The cartridge assembly according to claim 36 further comprising a ball disposed in the at least one second passage for sealing the second opening through the cartridge case when the poppet is in the first position.

38. The cartridge assembly according to claim 32 wherein the cartridge case has four first openings and four second openings.

39. The cartridge assembly according to claim 38 wherein the poppet has four first passages and four second passages.

40. The cartridge assembly according to claim 39 further comprising four balls, one in each of the second passages.