United States Patent

Nelson

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[54] **HYDRAULIC DIRECTIONAL CONTROL VALVE**

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Related U.S. Application Data

[63] Continuation of Ser. No. 840,647, July 10, 1969, abandoned.

[52] **U.S. Cl.** **137/624.27**

[51] **Int. Cl.** **F16k 11/02**

[58] **Field of Search** 137/624.27, 625.69; 251/73, 251/94

[56] **References Cited**

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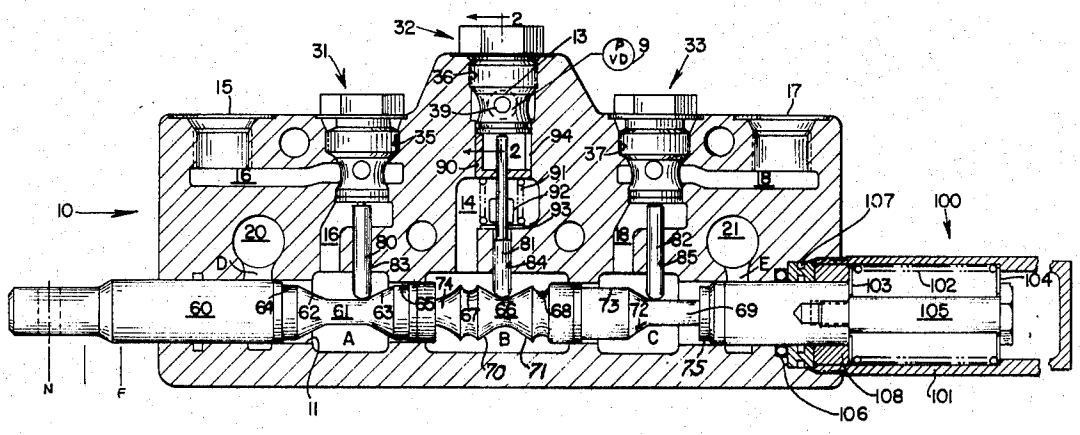
2,276,979	3/1942	Jacobi	137/624.27
2,644,429	7/1953	Waterman	137/512.1 X
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[57] **ABSTRACT**

A directional flow control valve for controlling fluid flow between a source of fluid energy and a hydraulic motor having a valve housing, intake ports, motor ports, and exhaust ports, control means movable within said valve housing so as to selectively interconnect the ports of said valve housing, and flow responsive means within one of said ports, engageable with the control means for holding same in the selected position until flow ceases.

8 Claims, 2 Drawing Figures



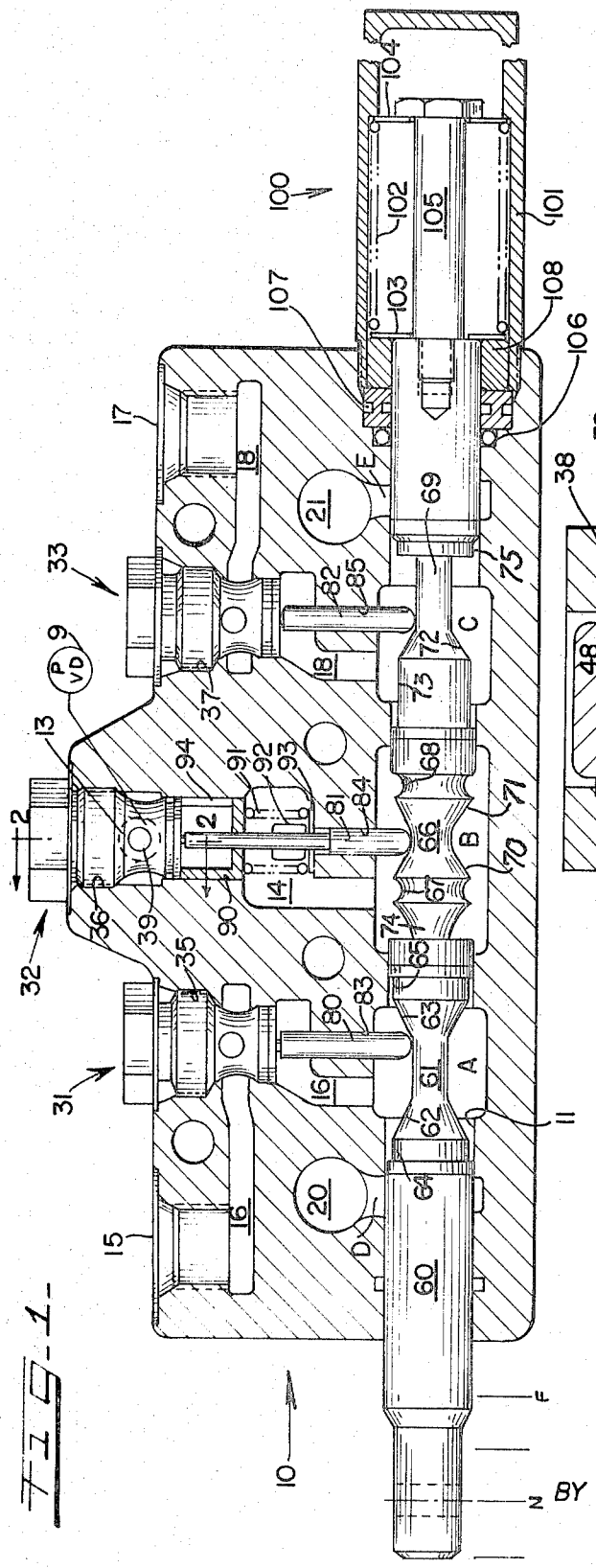


FIG-1-

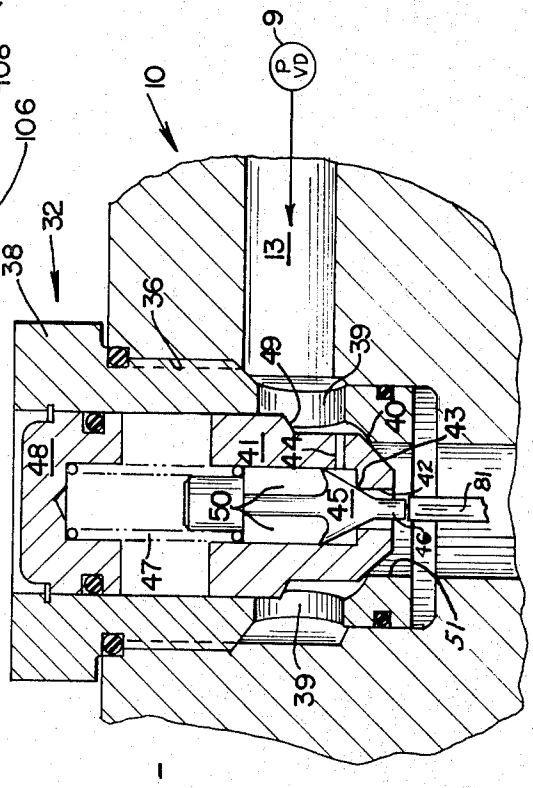


FIG-2-

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HYDRAULIC DIRECTIONAL CONTROL VALVE

This application is a continuation of application Ser. No. 840,647 filed July 10, 1969 and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to a directional flow control valve primarily utilized for controlling the movement of a hydraulic motor including a continuously rotating motor, a double acting hydraulic ram or a rotary actuator. Incorporated within the valve is a flow sensitive detent mechanism which will hold a valve in the flow position regardless of pressure and will thus permit a hydraulic ram to complete its stroke eliminating the need for the operator of the valve to hold same engaged. Upon cessation of flow, the valve will return to neutral. Further, this invention similarly relates to a directional flow control valve for a hydraulic motor which combines in one valve housing the features of check valves which preclude leakage of fluid from the motor back through the valve, and features for overriding these check valves whenever it is desirable to put the hydraulic motor into a float operation.

With reference to the prior art which discloses flow responsive detent mechanisms, reference may be had to U.S. Pat. Nos. 2,276,979 and 2,689,585, both of said valves having a flow responsive detent mechanism. Broadly speaking, these references disclose a directional flow control valve having a spool reciprocable therein for controlling fluid flow to and from an associated hydraulic motor. Once the spool of said valves is shifted, a piston having a plunger attached thereto responds to the pressure differential on both sides of said piston so as to engage the reciprocable spool and hold same in the flow position, cessation of flow releasing the plunger from its detent position.

These prior art devices do present some deficiencies with regard to both the operating characteristics of said valve, and with regard to manufacturing cost and assembly of the valve.

SUMMARY OF THE INVENTION

In order to overcome these manufacturing and operating disadvantages of the prior art, I have by a unique structural relationship disclosed herein a directional flow control valve, having a spool reciprocable therein to direct a flow of fluid from the intake port of the valve housing to one of two motor ports while exhausting fluid from the other motor port through an exhaust port. In one of these ports I propose a utilization of a novel flow sensitive mechanism, which upon actuation will act as a spring bias to hold the spool in the flow position selected. Further, cartridge type pilot operated poppet valves are incorporated directly into each of the motor ports as well as the intake port which will function as check valves in their closed position to preclude leakage of the flow into the valve housing, and controllable by the reciprocable spool whereby these poppets may be selectively opened so as to control fluid flow to and from the motor or opened simultaneously so as to obtain a float condition of an hydraulic ram or rotary actuator.

OBJECTS OF THE INVENTION

Accordingly, it is an object of my invention to provide a novel and unique flow sensitive detent

mechanism for holding a directional flow control valve in one of its selected flow positions until a hydraulic motor has reached the end of its stroke. Similarly, a spool type valve is proposed in which the spool has opposing spring biases, one of which is responsive to flow within said valve to override the other bias until flow ceases. A major object of this invention is to provide a detent mechanism for holding a directional flow control valve in a flow position regardless of any pressure buildup within an external hydraulic motor, and to provide a detent mechanism which is responsive only to flow within said valve. Another unique object which has been obtained is the provision of a very simple and economical directional flow control valve having a detent mechanism combined therewith which entirely eliminates the more rigid tolerance requirements in manufacture of known hydraulic directional flow control valves. Finally, it is an object of my invention to provide a directional flow control valve incorporating pilot operated poppet valves within the motor ports which in the first instance serve as a check valve in precluding flow from said motor back through the valve and yet having provision for controlling the pilot operated poppet valves by the spool whereby a float position can be maintained which allows fluid to flow from either end of the hydraulic motor to the other or back to the reservoir.

DESCRIPTION OF THE DRAWINGS

The manner in which these and other objects of the invention is obtained will be made clear by consideration of the following specification and claims when taken in conjunction with the accompanying drawings in which:

FIG. 1 is an elevational view taken in section through the longitudinal center line of the valve; and

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1.

DETAIL DESCRIPTION

As disclosed in the preferred embodiment of FIGS. 1 and 2, the unique advantages of my invention are incorporated into a valve for the well known closed center type hydraulic system. Essentially, the invention includes a valve housing **10** having an elongated bore **11** extending therethrough with a spool **60** reciprocable within said bore. This elongated bore **11** has enlarged chambers therein denoted by the letters A, B, C, D, and E normally separated from one another by the normal diameter of the spool as clearly depicted. Reduced diameters of the spool **61**, **66**, and **69** are utilized to interconnect certain of these chambers with one another so as to permit fluid flow therebetween upon reciprocation of the spool **60**.

The valve housing is also provided with an intake port **13**, and two motor ports **15** and **17** which may, for example, be connected to a double acting hydraulic ram. Associated cartridge units **32**, **31**, and **33** within these ports may be employed to control flow to the chambers B, A, and C. As later explained, these cartridge units are actuated by reciprocation of the spool **60**, but with respect to the control action of the spool alone, it should be noted that fluid energy from pump **9** is directed to intake port **13**, through channel **14** to chamber B. Depending upon the direction of recipro-

cation of the spool 60, this fluid may be selectively delivered to chamber A, channel 16, and out motor port 15, or to chamber C, channel 18, and out motor port 17. Thus, assuming that the spool 60 is shifted to the right, fluid may flow from the intake porting 13 through the channel 14, chamber B, chamber A, and channel 16 to the motor port 15 and simultaneously (subject to operation of pilot operated poppet valves hereinafter explained) fluid may be returned from the opposite end of the hydraulic ram through motor port 17, channel 18, chamber C, chamber E, and out an exhaust port 21. Upon reciprocation of the spool to the left, the opposite direction of fluid flow occurs with fluid from the hydraulic ram being exhausted via channel 16, chamber A, chamber D, and exhaust port 20.

With the invention as disclosed, this directional flow control is also dependent upon three cartridge type pilot operated poppet valves 31, 32, and 33 which are inserted into chambers 35, 36, and 37 by threaded means so as to intersect and further control the flow of fluid to and from the intake port 13 as well as each of the motor channels 16 and 18. Since each of these cartridge units 31, 32, and 33 are substantially identical in structure and function, reference may be had to FIG. 2 for a more complete description of one of said units, in this case cartridge unit 32. A cylindrical housing 38 having radial apertures 39 and an open lower end 51 is threadably engaged in chamber 36 which is incorporated into the valve housing 10.

When inserted, each of the cartridges normally preclude flow of fluid into chambers A, B, and C from the respective ports 15, 13, and 17 as hereinafter explained. The lower end of the housing 38 is provided with a seat 40 for a poppet element 41. Within the poppet is a pilot operated valve 45 having a stem 46 thereon and its lower end being conical so as to reciprocate within aperture 42 in the bottom of poppet 41 and seat itself against surface 43. A spring 47 biases this pilot member 45 against the seat 43, a reaction surface being provided by closure 48 of the cartridge unit which itself is held in place by a snap ring as indicated. The unit 38 as well as the closure 48 is suitably provided with sealing elements where indicated. A small aperture 44 allows pressurized fluid to communicate with the interior of poppet 41 and may pass freely through the fluted sections 50 of the pilot member 45 to act against the rear surface area of the pilot member 45 and poppet member 41. This pressurized fluid acting downwardly on the poppet together with spring 47 normally maintains the poppet in a seated position. In view of this construction, fluid energy acting against either the intake port 13, or either of the motor ports 15 and 17 will normally be precluded from flowing into the valve by this poppet member 41 which acts as a check valve unless opened.

In order to permit fluid to flow from a hydraulic ram through either of the motor ports 15 or 17, or to permit flow from the pump 9 into the valve housing 10, the pilot member 45 must be reciprocated upwardly. Suitable plungers 80, 81, and 82 reciprocating respectively within cylindrical openings 83, 84, and 85 serve as actuating elements to open each of the poppet valves 31, 32, or 33 upon movement of the spool 60 which is provided with cam surfaces (later explained) for effecting such reciprocation. Thus, as plunger unit 81 engages the stem 46 of the pilot member 45, this pilot member will be moved upwardly and fluid from the intake port 13 will flow through the apertures 39, the aperture 44 of the poppet member 41, aperture 42, and into channel 14. This flow of fluid will then reduce the force acting upon the upper face area of poppet member 41 and the pilot member 45 whereby the fluid pressure within intake port 13 acting upon surface area 49 of the poppet will cause the said poppet to further open. Further, as the plunger is withdrawn and the pilot element 45 is urged toward its seat 43 by resilient member 47, fluid pressure will again act upon the upper face of the pilot member 45 and the poppet 41 to cause the force acting on said members to overcome the force resulting from the intake pressure acting upon surface 49 and the valve will again close.

The reciprocation of the plungers 80, 81, and 82 is effected by reciprocating movement of the spool 60. Thus, inclined cam surfaces 62, 63, 70, 71, and 72 which extend from the reduced diameters of the spool 61, 66, and 69 will engage the plungers to cam them upwardly upon appropriate shifting of the spool 60. Once the plungers have been shifted upwardly, a holding surface 64, 65, 67, 68, or 73 will operate to hold the plungers in their upward position. The cam surfaces 63, 70, 71, and 72 should be so positioned that upward movement of plunger 81 will simultaneously cause upward reciprocation of the plunger within the port to which fluid is to be admitted to bore 11 leaving the opposite poppet to be opened by fluid flow. For example, if fluid is to be directed out of port 15 and returned to the exhaust 21 via port 17, movement to the right of spool 60 should open the poppets of cartridges 32 and 33 with fluid pressure opening poppet of cartridge 31.

As is well known in the art, I have additionally provided a centering mechanism 100 which will normally maintain the spool 60 in the neutral position in which all of the poppet valves are closed. This centering mechanism comprises a housing 101 threadably attached to the valve housing 10 as clearly indicated, and a compression spring 102 is employed in the housing 101 to act against suitable washers 103 or 104 maintained in place by abutment 108 and bolt 105 as disclosed so as to increase the bias of the spring at any time the spool 60 is reciprocated in either direction. The bolt 105 acting against washer 104 extends into the spool 60 to connect the spring bias forces to the spool. A seal assembly 107 disposed about spool 60 precludes leakage from the centering mechanism.

One of the primary objects of the instant invention is accomplished by providing a spring biased flow responsive device within preferably the intake porting consisting of intake 13 and channel 14. Thus, a spring 91 is interposed between a disc washer 93, and a flow responsive cup shaped element 90. Consequently, if the spool 60 is reciprocated either to the right or to the left, the plunger 81 will be caused to move upwardly and seat itself either in detent position 67 or 68. This upward reciprocation of plunger 81 then opens the pilot member 45 of cartridge 38, and due to a pressure unbalance, the poppet 41 will also be caused to open. Flow from the variable displacement pump 9 will then pass through the cartridge housing 38 and impinge against the upper surface of cup shaped member 90 causing same to move downwardly to an extent

whereby the fluid may pass through several vents **94** in the side walls of the cup **90**. This downward movement of member **90** in turn increases the bias of spring **91** which will act against washer **93**, and an enlarged diameter of plunger **81** which has been elevated by either cam surface **70** or **71**. Preferably, the bias of spring **91** together with the detent holding surfaces which include the bottom of plunger **81** and the detent surfaces **67** and **68** are sufficient to overcome the opposing bias of the centering mechanism **100** which would otherwise return the spool to its neutral position.

Assuming that the spool is shifted to the right, the plunger **81** is reciprocated upwardly to open the cartridge **32**, and the bottom of plunger **81** enters detent **67** and is held in that position by the flow sensitive cup shaped member **90** increasing the bias of spring **91**. Thus, fluid will flow through channel **14**, chamber B, chamber A, and out channel **16** and motor port **15** and as long as such fluid continues to flow, cup shaped member **90** will be in its downward position so as to enable the detent mechanism to overcome the biasing force of the centering mechanism **100**, but as soon as flow ceases and the hydraulic ram has travelled to the end of its stroke, the cup shaped member **90** will return to its original position with the centering mechanism **100** returning the spool **60** to its neutral position. However, since only a resilient bias is imposed on spool **60**, its position remains subject to manual control which may override the flow imposed bias.

Utilization of the pilot operated poppet valves within my disclosure also lends to a unique advantage in that a system is produced whereby check valves may be incorporated into a directional flow control valve and yet obtain a float condition for an associated hydraulic motor. This disclosure relates more specifically to my copending application Ser. No. 837,527 Filed June 30, 1969 now U.S. Pat. No. 3,595,271 granted July 27, 1971. As therein pointed out, the cartridges **31**, **32**, and **33** preclude the flow of fluid from either of the motor ports or the intake port into the elongated bore **11** of the valve housing **10**. Thus, while flow alone will cause the valves to open to supply fluid to either end of a hydraulic ram, positive reciprocating movement of the spool must be made in order to permit flow in the opposite direction. Such is a preferred way of precluding leakage from a hydraulic motor back through the valve in the neutral position. However, in many hydraulic ram applications, it is often desirable to obtain a float condition for the ram in which fluid will be free to flow from one end of the ram to the opposite end of the ram or back to the reservoir. Thus, in the instant application, if the spool is reciprocated to the far right and held in the position, indicated by the letter F, plunger **81** will enter a reduced diameter **74** of the spool in which cartridge **32** is closed and plungers **80** and **82** will be cammed upwardly by cam surfaces **62** and **72** and rest upon holding surfaces **64** and **73**. In this condition, the normal diameters of the spool are entirely within the enlarged chambers and fluid may flow between motor port **17** and motor port **15**, both of the poppets being opened by the raised position of the plungers **80** and **82**. Similarly, fluid may also freely flow to a reservoir through exhaust **21**. In order to hold the spool in the reciprocated float position, a tensioned garter spring **106** will engage reduced diameter **75** to overcome the bias of centering mechanism **100** and maintain a float condition,, subject however to manual override.

MODE OF OPERATION

The above described structure when operated will result in several unique operating capabilities for a hydraulic directional flow control valve. As the spool is shifted to the right, plunger **81** is elevated into detent position **67** causing the pilot operated poppet **41** to open and fluid from the variable displacement pump **9** acts against the flow responsive element **90** to overcome the bias of the centering mechanism **100**. The spool will maintain this position as long as fluid flows in a manner to maintain the increased spring bias of resilient means **91** and will flow into chambers B, A, and out motor port **15**, the flow being sufficient to open the poppet. However, plunger **82** is also reciprocated at this time to open the check of poppet valve of cartridge **33** and fluid is exhausted from one end of the hydraulic cylinder into the motor port **17**, channel **18**, chambers C, E, and back to a reservoir through exhaust port **21**.

Reciprocation in the opposite direction will merely reverse flow to and from the hydraulic ram. However, if the spool is reciprocated to its rightmost position it should be observed that plunger element **81** will seat itself in the reduced diameter **74** of the spool **60** which is insufficient to open cartridge **32** while both plungers **80** and **82** will be reciprocated upwardly by cam surfaces **62** and **72** and onto holding surfaces **64** and **73**. At this time fluid may clearly communicate between chambers C, B, and A about reduced spool diameters **61**, **66**, and **69** and thus motor ports **15** and **17** thereby placing the hydraulic valve into a float condition.

It should be readily appreciated that my instant invention discloses several unique structural and operating characteristics. It may easily be adopted to be incorporated into an open centered type valve structure and the flow responsive means herein disclosed might appropriately be placed within any of the ports, including the exhaust ports as well as either of the motor ports. By including the flow sensitive control means directly within one of these ports, manufacturing procedures are facilitated as well as the responsiveness of the valve. By comparing the strength of the opposing biasing members, the valve will always be maintained in its proper position according to desires of the operator. Most importantly, it should be appreciated that if high operating pressures are created by heavy loads, my particular invention will overcome the disadvantages of the prior art in that the detent mechanism will positively hold until the ram has reached the end of its stroke. The entire system being substantially insensitive to high pressures. Finally, a valve has been disclosed in which check valves may be used and yet a float condition may be obtained. As specifically indicated by the fact that the sub-components herein disclosed may be incorporated into either an open or a closed center system, it should be well appreciated that the present embodiment is merely illustrative and not restrictive.

What is claimed is:

1. A directional flow control valve comprising:

a. a valve housing having an elongated bore therein, two motor ports, two exhaust ports, and an intake port, each of said ports being communicatable with said elongated bore,

b. a poppet valve means within each of said motor ports and said intake port for controlling flow from said ports to said elongated bore,

c. a spool means reciprocable within said bore and having cam means thereon,

d. plunger means disposed in between said poppet valve means and said spool means for reciprocation by said cam means to selectively open or close said poppet valve means upon reciprocation of said spool means,

e. flow sensitive means disposed in at least one of said ports and operative upon at least one of said plungers so as to impose force upon said spool to hold same in a reciprocated position until flow ceases.

2. An apparatus as defined in claim 1 in which:

a. centering means are operatively connected to said spool so as to urge same in a position such that none of the poppet valve means are open.

3. An apparatus as defined in claim 1 in which said flow responsive means comprises:

a. detent means actuated by flow within said intake porting so as to act upon said spool to overcome its spring bias to said neutral position.

4. An apparatus as defined in claim 1 in which said flow responsive means comprises:

a. resilient biasing means operable against said plunger, and

b. a seat within said intake porting which is movable by fluid flow so as to bias said biasing means therefor against said plunger to hold the spool in said second position until flow ceases and said spring seat returns to its original position.

5. In a directional flow control valve having a housing intake and motor ports, one of which is controlled by a poppet type valve, and a moveable member therein for selectively opening said intake and motor ports, an improved detent mechanism associated with said poppet controlled valve port comprising:

a. plunger means interconnecting said moveable member and said poppet valve controlled port for actuating said valve therein,

b. flow sensing means within said housing operatively connected with said interconnecting means for maintaining said moveable member in an actuating position until flow ceases.

6. An apparatus as recited in claim 5 in which said flow sensing means comprises:

a. a valve member in the path of fluid flow for shifting in response to flow,

b. elastic means interposed between said valve member and said plunger means for imposing a force upon said moveable member to hold same in an open position until flow ceases.

7. In a directional flow control valve having a housing intake and motor ports, one of which is controlled by a poppet type valve, and a moveable member therein for selectively opening said intake and motor ports, an improved detent mechanism associated with said poppet controlled valve port comprising:

a. cam operated plunger means interconnecting said moveable member and said poppet valve controlled port for actuating said valve therein,

b. flow sensing means within said housing operatively connected with said interconnecting means for maintaining said moveable member in an actuating position until flow ceases.

8. An apparatus as recited in claim 7 in which said flow sensing means comprises:

a. a valve member in the path of fluid flow for shifting in response to flow,

b. elastic means interposed between said valve member and said plunger means for imposing a force upon said moveable member to hold same in an open position until flow ceases.

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