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[54] **FLUID MOTOR CONTROL CIRCUIT PROVIDING SELECTIVE FAST MOTION**

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[58] **Field of Search** ..... 91/420, 436, 411; 60/97 H

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[57] **ABSTRACT**

A system having a manually operated control valve for directing pressurized fluid to a pair of fluid motors while receiving fluid discharged therefrom also has a fast motion valve for causing the motors to outrun the fluid supplied through the control valve by returning a portion of the discharged fluid directly to the motors. The circuit shifts to provide fast motion on detecting a predetermined flow rate between the control valve and the motors. As the operator can modulate this flow rate, the fast motion is always subject to operator control. To assure operator control under all conditions, the fast motion valve is spring biased to the unoperated position and return of a portion of the motor discharge flow to the control valve is a necessary condition for operation of the fast motion valve. The system is further arranged to prohibit fast motion, under any condition, during reversed motion of the motors.

6 Claims, 2 Drawing Figures

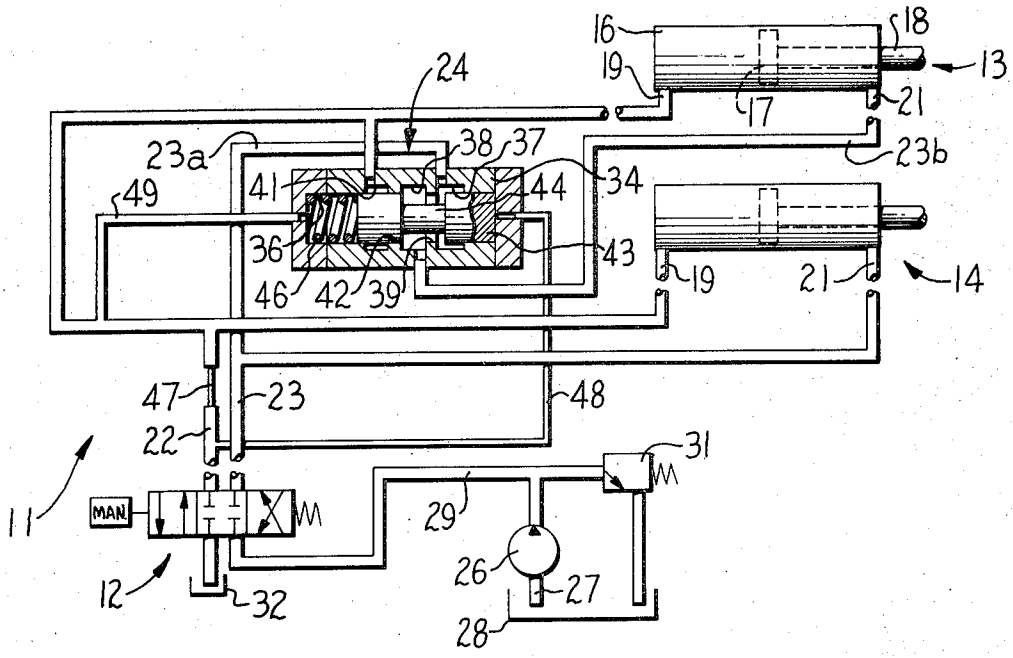


Fig. 1

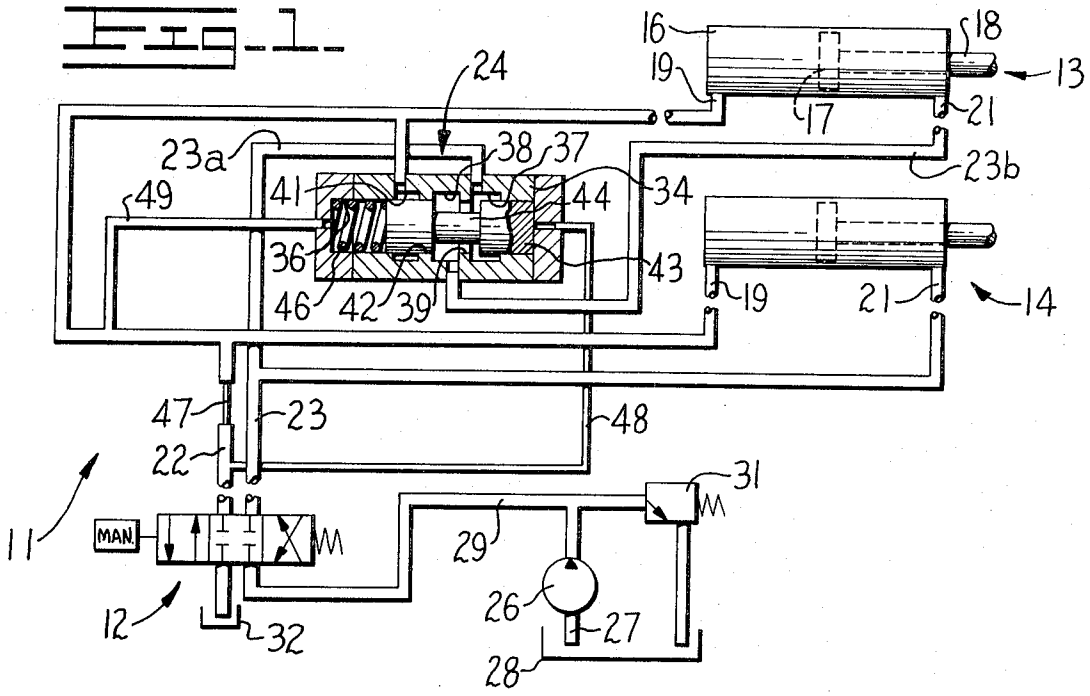
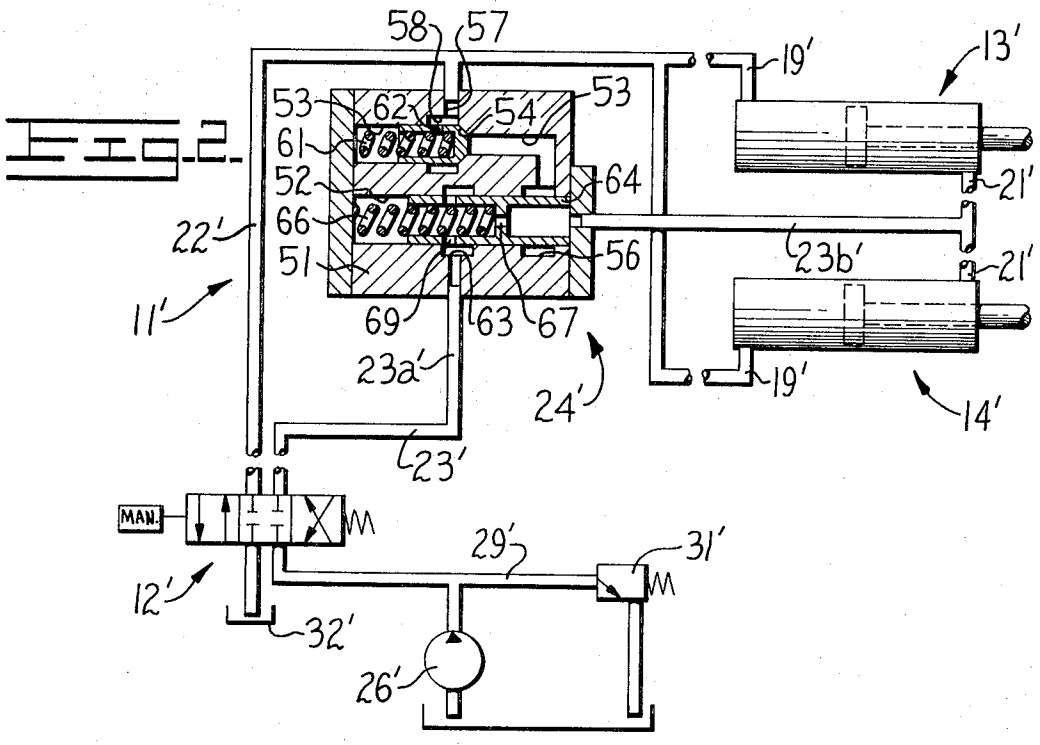


Fig. 2



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FLUID MOTOR CONTROL CIRCUIT PROVIDING SELECTIVE FAST MOTION

BACKGROUND OF THE INVENTION

This invention relates to fluid motors and more particularly to fluid circuits for controlling the operation of such motors.

Where fluid motors are utilized to manipulate loads, fast motion valves are often utilized to enable motor operation at a rate greater than is provided for by the incoming flow of pressurized fluid. Basically, this is accomplished by diverting discharged fluid directly back to the motors to supplement the supply of driving fluid from a pump or other source. This has the effect of increasing motor speed by reducing power output and may be advantageous when the motor is lightly loaded or in a state of incipient cavitation wherein the load is actually driving the motor due to gravity force, momentum or other causes.

Considering a specific example, loaders for moving earth or other materials have a pivotable bucket carried on pivoting lift arms attached to a tractor and usually use hydraulic cylinders for pivoting the bucket relative to the lift arms. Rotation of the bucket in a direction tending to dump material is commonly termed tilting of the bucket while rotation in the opposite direction is referred to as racking back of the bucket. During the tilting or dumping operation, the weight of the material in the bucket may offer little resistance to motor motion and may go over center to pull on the hydraulic cylinders in the same direction that the hydraulic cylinders are being driven with sufficient force that the cylinders tend to outrun the incoming supply of driving fluid. Under these circumstances, it may be desirable that the tilting or dumping action be accomplished faster than is provided for by the incoming driving fluid to the motor in order to increase efficiency of the loader operation.

It has long been recognized that this fast motion can be provided for by arranging for fluid which is discharged from the motors to be directed back to the incoming fluid ports so that the quantity of fluid supplied thereto exceeds the amount being provided by the pump or other source of pressurized driving fluid. The valve systems which provide this fast motion in response to a light load or an over-center load are variously known as make-up valves or quick drop valves and as heretofore constructed have not been fully controllable by the operator in the absence of excessive circuit complication for this purpose.

Generally the fast motion valves have been controlled by some means which senses fluid pressure within the motor circuit to detect a condition of light loading or an over-center load. Such systems activate automatically in response to load variations and may not provide for slowing or stopping of the fast motion when the operator deems it desirable unless complicated mechanisms are added to the circuit for this purpose. Many such systems may automatically establish fast motion for both directions of motor movement and this may not always be desirable. In the loader systems described above, for example, fast motion during the rack back operation can be undesirable because of a resultant loss of precision control during digging operations and also because most such loaders employ a pair of hydraulic cylinders to manipulate the bucket and the fast motion systems have the effect of inactivating one cylinder insofar as the work of moving the bucket is concerned thereby creating unbalanced stresses or "corner loading" of the bucket. The last mentioned condition may also obtain when the motors are stopped since the conventional make up or quick drop valves have a normal rest position at which both ports of one of the motors are in communication thereby rendering that motor ineffective for the purpose of immobilizing the bucket. Some prior systems of this kind have the further disadvantage in that once the fast motion is initiated, a regenerative action can occur which prevents the motor from being stopped under over-center loading, until such time as the driven mechanism reaches the limits of its travel.

SUMMARY OF THE INVENTION

The present invention resolves the several problems discussed above by providing for fast motion of fluid motors for one direction of motor motion only under conditions where an operator retains control of the action through his basic motor control valve.

This is accomplished by providing a fast motion valve which can only be activated under the condition that a portion of the fluid which is being discharged by the motor continues to return to the control valve and which is responsive to a fluid flow rate between the operator's control valve and the motor rather than being responsive to absolute pressure in some part of the system. Since the operator may control the flow rate with his control valve, he may modulate or stop the fast motion as he deems necessary. Thus the operator is provided with positive control over the motor without regard to loading conditions thereon and without requiring circuit complications for this purpose inasmuch as the control is accomplished through the lines which transmit fluid between the motors and his control valve.

Accordingly, it is an object of this invention to provide for more positive control of fluid motor operated systems of the form wherein motor motion exceeding that provided for by incoming driving fluid is desired under certain conditions.

It is another object of this invention to provide a simple economical fluid motor control circuit offering fast motor motion for one direction of motor movement only and wherein the fast motor motion may be modulated and stopped at the operator's discretion.

The invention together with further objects and advantages thereof will best be understood by reference to the following description of preferred embodiments in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a schematic diagram of a first fluid motor control circuit embodying the invention, and

FIG. 2 is a schematic diagram of a second form of fluid motor control circuit in accordance with the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings and more particularly to FIG. 1 thereof, a control circuit 11 is provided with a manually operated control valve 12 for controlling the motion of a pair of fluid motors which are hydraulic cylinders 13 and 14 in this example and which are in-

tended to undergo simultaneous extensions and retractions. the motors **13** and **14**, may, for example, be the tilt cylinders which manipulate the bucket of a loader of the general form hereinbefore discussed and described, for example, in U.S. Pat. No. 3,358,860, although it will be apparent that the system of FIG. **1** is applicable to many different mechanisms wherein fluid motor means are utilized to manipulate a load.

In typical systems of the form shown in FIG. **1**, the hydraulic motors **13** and **14** each have a closed cylinder **16** with a piston **17** therein and a rod **18** which extends axially from one end of the cylinder to couple the piston **17** to the load to be driven. Each such cylinder **16** has a head end port **19** into which pressurized fluid may be admitted to cause extension of the cylinder and each has a rod end port **21** through which fluid is discharged during extension and into which pressurized fluid may be admitted to cause contraction of the cylinder. A branched conduit **22** defines a first flow passage communicating control valve **12** with the head end ports **19** of both fluid motors **13** and **14** while a branched conduit **23** defines a second flow passage communicating the control valve with the rod end ports **21** of both fluid motors, a fast motion valve **24** being disposed in the branch of conduit **23** which connects with a single one of the motors, motor **13** in this instance.

To supply pressurized fluid to control valve **12**, a pump **26** has an intake **27** extending to a suitable fluid reservoir **28** and an outlet conduit **29** connected to the control valve. To limit the maximum fluid pressure delivered to the control valve, a relief valve **31** is connected between pump outlet conduit **29** and reservoir **28.**

Control valve **12** in this example is a four-way three-position manually operated valve having one position at which pump outlet conduit **29** is communicated with conduit **22** while venting conduit **23** to a drain **32.** Control valve **12** has a second position in which pressurized fluid from conduit **29** is communicated to conduit **23** while conduit **22** is vented to drain **32** and has a third position at which both of conduits **22** and **23** are closed to immobilize the two motors **13** and **14.** In this example, control valve **12** is spring biased towards the third position so that the motors are immobilized except when the operator manipulates the valve to produce motor extension or contraction.

The system of FIG. **1** as described to this point provides a manually controlled means for selectively causing extension, retraction or immobilization of the motors **13** and **14.** In the absence of the fast motion valve **24,** the speed of motor operation would be limited by the available flow of pressurized fluid from pump **26** except when cavitation occurs in which case the discharge flow is the limiting factor.

To provide for motion of the motors **13** and **14** at a greater speed, under appropriate conditions, the fast motion valve **24** acts to divert the motor discharge flow of rod end port **21** of a single one of the motors **13** from conduit **21** back into the head end ports **19** of both cylinders so that the cylinders may receive fluid at a greater rate than it is supplied from the pump **26.**

For this purpose fast motion valve **24** has a valve body **34** with a bore **36** therein. The section **23a** of conduit **23** which connects control valve **12** with fast motion valve **24** opens into an annular groove **37** of bore **36** while the conduit section **23b** which extends from the fast motion valve to the rod end port **21** of motor **13** is communicated with another groove **38** separated from groove **37** by an edge **39.** Bore **36** has still another groove **41,** separated from groove **38** by an edge **42,** which is communicated with the head end ports **19** of both motors **13** and **14** through conduit **22.** A spool **43** is disposed coaxially in bore **36** to function as a valve member for directing flow within the fast motion valve **24.** Spool **43** has a groove **44** defined by a central section of reduced diameter relative to the end sections of the spool which have a diameter corresponding to that of edges **39** and **42.** A compression spring **46** urges spool **43** towards one end of bore **36** at which position the spool groove **44** communicates bore grooves **37** and **38** to connect conduit sections **23***a* and **23***b.*

At this position of spool **43,** the fast motion valve **24** in effect acts only as a portion of conduit **23** and has no effect on the operation of the motors **13** and **14.** To provide for diversion of fluid discharging from the rod end port **21** of motor **13** back to the head end ports **19** of both motors **13** and **14,** spool **43** must be shifted axially against the force of spring **46** to communicate groove **38** with groove **41.** In contrast to most prior fast motion valves, this is not done by shifting the spool in response to a predetermined fluid pressure level at the motors. Instead, means are provided to create a fluid pressure differential, which is a function of flow rate, for the purpose of shifting the spool **43.** In particular, a flow restriction **47** is situated in conduit **22** whereby a pressure differential is created across the restriction which is a function of the rate at which fluid is being supplied to the head end ports **19** of the two motors **13** and **14.** The rate at which fluid is supplied to head end ports **19** of motors **13** and **14** is controllable by adjustment of control valve **12** and by adjustment of pump flow rate. Increasing the flow rate increases the pressure differential across restriction **47.** When the motors **13** and **14** are experiencing cavitation due to overcenter loading during the extension motions, flow to the head ends of the cylinders through conduit **22** also increases and thus such pressure differential increases under that condition also.

To cause a predetermined degree of pressure differential to shift valve spool **43** against the action of spring **46,** a conduit **48** connects the end of bore **36** remote from spring **46** with conduit **22** at a point between flow restriction **47** and control valve **12** and another conduit **49** connects the opposite end of bore **36** with conduit **22** at a point between flow restruction **47** and motors **13** and **14.** Accordingly, during the extension motions of the motors **13** and **14,** the pressure differential acts on opposite ends of spool **43** in a direction tending to shift the spool to return discharge fluid from motor **13** to the head ends of both motors **13** and **14.** As previously discussed, this direct return of discharge lfuid from motor **13** to the head ends of both motors **13** and **14** enables the motors to extend more rapidly than is provided for by the driving fluid supplied from pump **26** through control valve **12.**

This action is overridable by the operator in that the pressure differential across restriction **47** necessary to maintain the fast motor motion is a function of the fluid flow through conduit **22** and this flow is controllable by the operator by means of control valve **12.** This control is maintained in the presence of over-center loads on the motors since the discharge from one motor **14** must necessarily return to drain **32** through the control valve **12** during the fast motion period. The operator can

modulate or stop the fast motion during over-center loading since the fluid which must be discharged through control valve 12 during the fast motion is also controllable by manipulation of control valve 12. Accordingly the operator always has the option of controlling motor speed without regard to the load conditions on the motor. Further, the fast motion cannot occur during the retraction movement of the motors 13 and 14 since at that time the flow through restriction 47 is reversed and whatever pressure differential exists thereacross simply supplements the action of spring 46 in holding spool 43 at the position at which direct exchange of fluid between the ends of the motors is blocked.

Modifications of the system may be made while retaining basic features and advantages of the invention. FIG. 2, for example, illustrates a modified control circuit 11' wherein discharging fluid from both motors is returned to the opposite ends of both motors and wherein the pressure differential for controlling a modified fast motion valve 24' is obtained by sensing discharge flow rather than the flow of driving fluid into the motors, such system being suitable for controlling a single motor if desired.

The system of FIG. 2 may employ a control valve 12' identical to that previously described and which receives pressurized fluid from a pump 26' through a pump outlet conduit 29' also as previously described. A first flow passage defined by a branched conduit 22' extends from control valve 12' to the head end ports 19' of both motors 13' and 14' while a second flow passage defined by a branched conduit 23' exetnds from the control valve to the rod end ports 21' of both motors through the fast motion valve assembly 24' as will hereinafter be described in more detail. Control valve 12' has a first position at which pressurized fluid from pump outlet conduit 29' is communicated to conduit 22' while conduit 23' is vented to a drain 32' a second position at which the pressurized fluid is supplied to conduit 23' while conduit 22' is vented to the drain, and a third position at which conduits 22' and 23' are closed to immobilize the motors.

COnsidering now a suitable internal construction for the modified fast motion valve 24', a valve body 51 has a first bore 52 and a second parallel bore 53 which is stepped to provide a valve seat 54 that communicates with an annular groove 56 near one end of the first bore. A flow path 57 connects branched conduit 22' with a groove 58 in bore 53 situated adjacent valve seat 54. A cylindrical check valve member 59 is disposed in bore 53 to seat against valve seat 54 and a compression spring 61 disposed in bore 53 urges the check valve member against the seat. A radial aperture 62 in check valve member 53 communicates the region around spring 61 with groove 58 so that fluid pressure in conduit 22' also acts against the check valve member to supplement the force of the spring thereon. Thus the check valve provides a one-way by-pass flow path from groove 56 of bore 52 to the head ends of motors 13' and 14' while blocking any flow in the opposite direction.

The section 23*a*' of conduit 23' extending between control valve 12 and fast motion valve 24' communicates with a groove 63 at a central portion of bore 52 while the section 23*b*' of the conduit 23' which extends to the rod ends of both motors 13' and 14' communicates with the end of bore 52 adjacent groove 56. Thus bore 52 in effect constitutes a portion of the flow passage between control valve 12' and the rod ends of the two motors 13' and 14'. To provide for fast motion of the motors in response to a predetermined discharge flow rate from the rod ends of the motors through conduit 23', a tubular valve member 64 is disposed in bore 52 in coaxial relationship therewith and is movable therein in an axial direction. A compression spring 66 in bore 52 acts against a constriction 67 within the valve member 64 in a direction urging the valve member towards groove 56. Thus spring 66 tends to cause the valve member 64 to close groove 56 from communication with the rod end flow path between motors 13' and 14' and control valve 12'. With the valve member in this position, the flow path between the rod ends of the motors 13' and 14' and control valve 12' is through the valve member 64 and an orifice 68 formed by the flow constriction 67 and then through apertures 69 in the wall of the valve member which transmit the flow to groove 63. At this position no motor discharge fluid is diverted from the rod ends of the cylinders to the head ends through check valve 53.

During the contraction motions of the motors 13' and 14', the force of the fluid flow from control valve 12' to the rod ends of the motors acts to supplement the force of spring 66 on valve member 64 and thus no fast motion can occur at this time regardless of load conditions on the motor. However, during the extension motion of the motors 13' and 14' the flow through constriction 67 of valve member 64 establishes a pressure differential thereacross, which is a function of the magnitude of the flow, which acts to oppose the force of the spring 66 on the valve member. Accordingly, at a particular flow rate determined by the force of spring 66, the pressure differential acting on constriction 67 moves the valve member 64 against the spring to open communication between the rod ends of the motors and groove 56 whereby a portion of the discharging fluid is diverted to conduit 23' through check valve 53 and thus is returned back to the motors at the head ends thereof to provide for motor extension at a rate greater than that provided for by the incoming pressurized fluid supplied from pump 26'.

As in the first described embodiment of the invention, diversion of all of the discharging flow from the rod ends of the motors 13' and 14' back to the head ends of the motor cannot occur since some flow must always be returned to the control valve 12 through flow constriction orifice 68 to establish the pressure differential necessary to shift valve member 64. Since this return flow through conduit 23' necessary for fast motion may be throttled by manipulation of control valve 12', the operator always has positive control and may stop or modulate fast motion as he deems necessary.

While the invention has been described with respect to certain preferred embodiments, it will be apparent that many other modifications are possible and it is not intended to limit the invention except as defined in the following claims.

What is claimed is:

1. A control circuit for fluid motor means which has first and second flow passages communicated therewith and wherein application of pressurized fluid to said first flow passage operates said motor means in one direction while fluid is discharged through said second passage and the application of pressurized fluid to said second passage operates said motor means in a reverse di-

rection while discharging fluid through said first passage, comprising:

a source of said pressurized fluid;

a control valve connected between said source and said first and second flow passages to said motor means and having one position supplying said pressurized fluid to said first passage while receiving discharge fluid through said second passage, said control valve having an additional position supplying said pressurized fluid to said second flow passage while receiving discharge fluid through said first passage;

a valve body forming a portion of said second flow passage between said control valve and said motor means and having a flow path communicated with said first flow passage;

a valve member within said body and having a first position at which fluid flow in said second passage is confined to flow between said control valve and said motor means and having another position at which a portion only of said flow through said second flow passage is diverted to said flow path that communicates with said first flow passage;

resilient means for urging said valve member toward said first position thereof;

means forming a flow constriction in one of said flow passages for producing a fluid pressure differential across said constriction which is a function of the flow rate therethrough, and

means for causing said fluid pressure differential to act on said valve member to urge said valve member toward said additional position thereof while said motor means operates in said one direction.

2. The combination defined in claim **1** further comprising means for causing said pressure differential to act on said valve member in the same direction that said resilient means acts thereon while said motor means operates in said reverse direction.

3. The combination defined in claim **1** wherein said motor means comprises a pair of fluid motors and wherein said first and second flow passages are branched to communicate with each of said motors and wherein said second flow passage communicates said control valve directly with one of said motors and communicates with the other of said motors through said valve body.

4. The combination defined in claim **3** wherein said means forming a flow constriction is situated in said first flow passage and wherein said means for causing said fluid pressure differential to act on said valve member comprises a conduit connecting said valve body with said first passage at a point therein between said flow constriction and said fluid motors and another conduit connecting said valve body to said first flow passage at a point therein between said flow constriction and said control valve, and means for causing the fluid pressures within said conduits to act on opposite sides of said valve member within said valve body.

5. The combination defined in claim **1** wherein said fluid motor means comprises a pair of fluid motors and wherein said first and second flow passages are both branched to communicate with each of said fluid motors and wherein said valve body forms a portion of said second flow passage between said control valve and each of said motors, said means forming a flow restriction being situated in said second flow passage between said flow path to said first flow passage and said control valve.

6. The combination defined in claim **5** wherein said means forming a flow constriction forms a flow orifice through said valve member.

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