

[54] FLUID MOTOR CONTROL CIRCUIT WITH
OVERSPEED LIMITING MEANS

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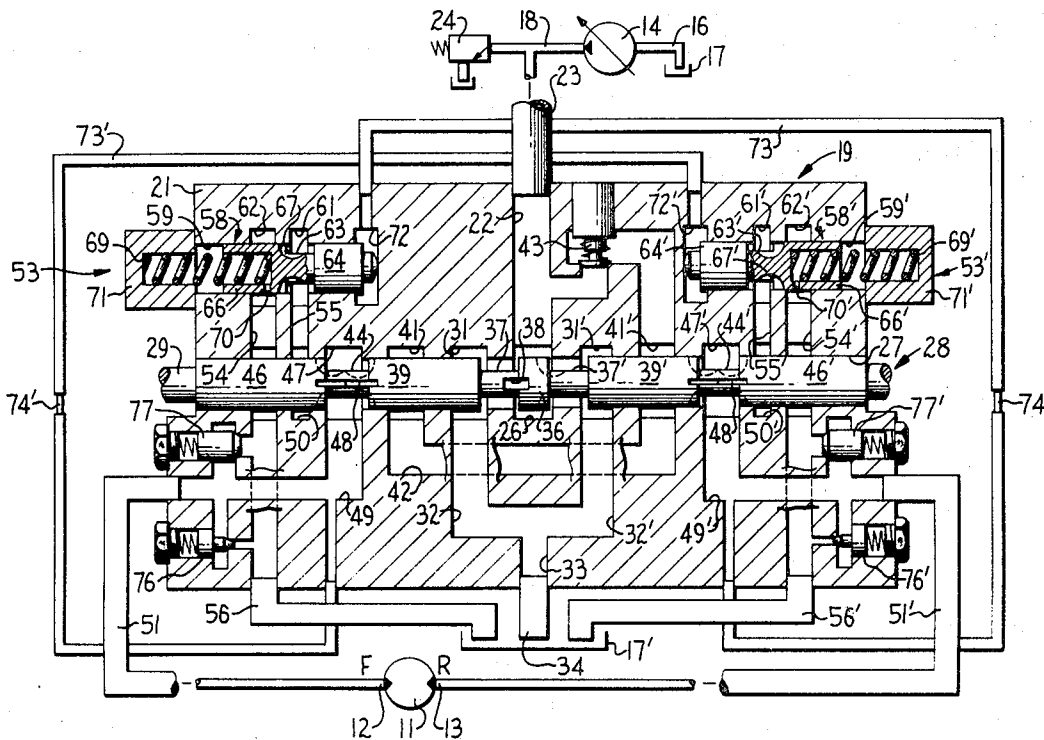
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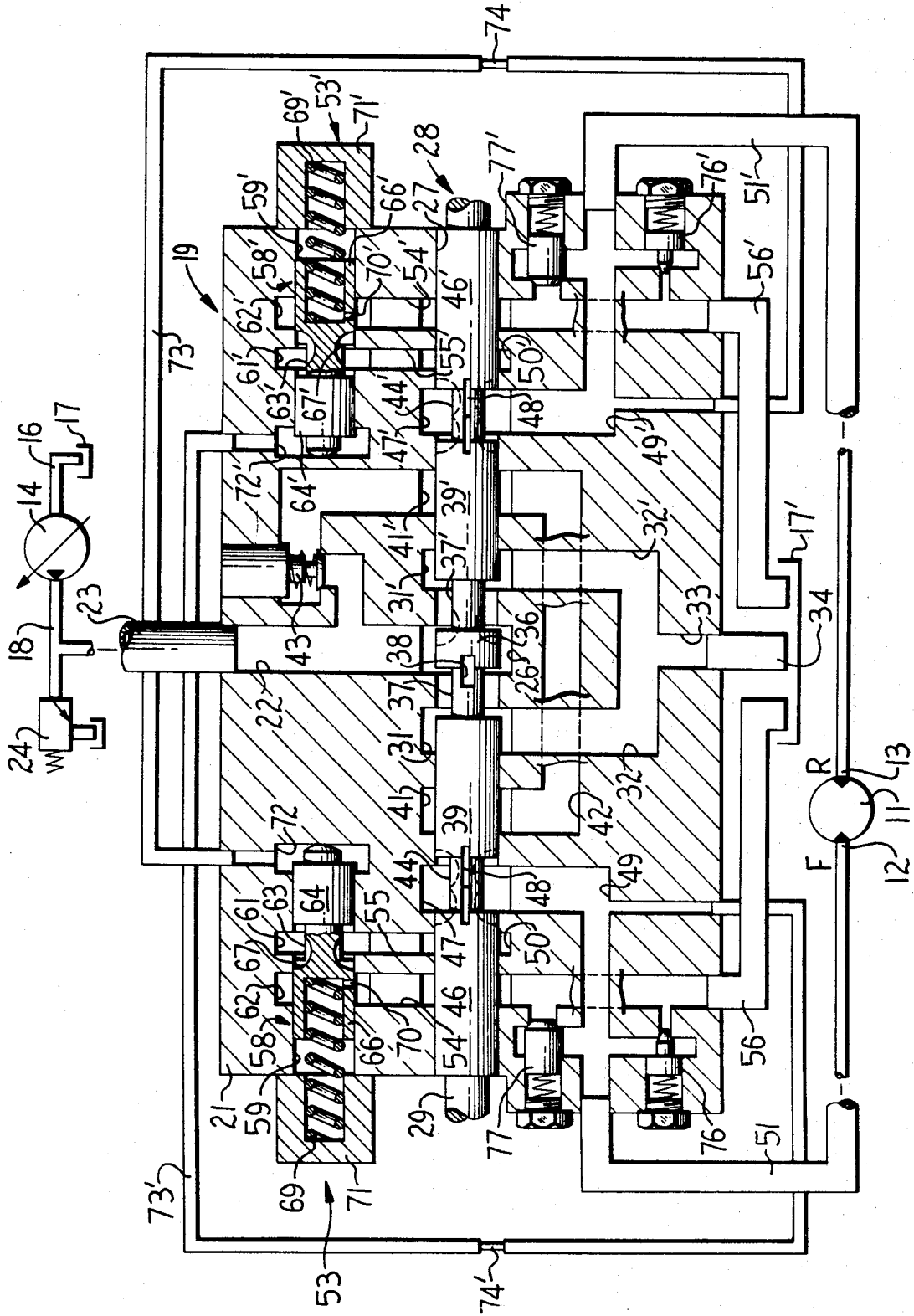
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[57] ABSTRACT

Pressurized fluid is supplied to a reversible fluid motor through a motor control valve which may be shifted to direct fluid to either port of the motor while communicating the other motor port with an individual exhaust passage for that port thereby providing for motor operation in either direction. A separate overspeed inhibiting valve is disposed in each of the two exhaust passages and each responds to a pressure decrease in the fluid entering the motor by reducing the flow passage for fluid exhausting from the motor thereby maintaining a constant speed determined by the setting of the motor control valve. Disposition of the overspeed valves in the motor control valve exhaust passages rather than between the motor control valve and the motor avoids any need for a bypass check valve at each overspeed valve.

5 Claims, 1 Drawing Figure





FLUID MOTOR CONTROL CIRCUIT WITH OVERSPEED LIMITING MEANS

BACKGROUND OF THE INVENTION

This invention relates to fluid motors and more particularly to valve assemblies for controlling the operation of a fluid motor.

To control the operation of a fluid motor, it is customary to dispose a motor control valve between the two ports of the motor and the source of pressurized driving fluid. The motor control valve may be shifted between a plurality of positions including a forward drive position at which fluid is directed to one motor port while the other motor port is communicated with a drain and a reverse drive position for transmitting pressurized fluid to the other port while connecting the first port to drain. In most systems there are various other operational contingencies to be provided for or controlled and thus several other valve means are typically associated with the basic motor control valve. One of the more common supplementary valve means are overspeed valves which are designed to prevent the motor from operating faster than the rate selected by the setting of the motor control valve which effect might otherwise occur as a result of external load forces reacting on the motor. If, for example, the fluid motor drives a vehicle a situation can arise where the vehicle is traveling down a steep incline in which the gravity induced motion of the vehicle tends to exceed that deliberately provided for by the setting of the motor control valve. Other conditions can act to produce overspeed, in the absence of corrective measures, in other usages of fluid motors both of the rotary and linear form.

One advantageous form of overspeed valve reacts to incipient overspeed by restricting the flow passage for fluid being discharged from the motor with the degree of restriction being a function of the magnitude of the external forces on the motor which are tending to produce to the overspeed condition. The overspeed valves are shifted for this purpose by pilot means which sense pressure changes that take place at the motor ports when overspeed is about to occur. In particular, incipient overspeed is accompanied by a reduction of pressure at the side of the motor to which driving fluid is being supplied and an increase of pressure at the discharging side of the motor and the overspeed valves may be arranged to respond to either of these pressure changes depending on whether the overspeed valves are of a normally closed or normally opened construction.

While it is possible to utilize a single overspeed valve for both directions of motor motion, this necessitates circuit complications such as shuttle valves or the like to switch fluid connections between the single overspeed valve and other components of the system. Accordingly it is more customary to utilize a pair of overspeed valves only one of which is operational during any given direction of motor motion. Heretofore, it has been the practice to dispose the pair of overspeed valves in the flow passages between the motor control valve and the motor ports. This practice has itself resulted in some undesirable circuit complications. Most notably, since the overspeed valves associated with each particular motor port blocks the flow passage to that port when the flow direction is from the motor control valve into that port, it has been necessary to by-

pass each overspeed valve with a check valve of sizable capacity. The requirement for two large additional check valves in the system contributes significantly to the size, cost and complexity of the motor control circuit as a whole.

SUMMARY OF THE INVENTION

The present invention achieves a very desirable reduction of complication in a fluid motor control circuit of the form having a pair of overspeed inhibiting valves by utilizing a motor control valve having separate exhaust passages for each port of the motor and by situating each overspeed valve in a separate one of these exhaust passages. The disposition of the overspeed valves between the motor control valve and drain rather than between the motor control valve and the motor itself, eliminates the need for bypass check valves. In a preferred form, the overspeed valves are contained within a unitary valve housing together with other valve means for controlling and regulating motor actions and the above described circuit configuration contributes to a compact and efficient assembly.

Accordingly it is an object of this invention to provide a simplified, compact and reliable fluid motor control circuit with means for inhibiting motor speeds exceeding a preselected value.

The invention, together with further objects and advantages thereof, will best be understood by reference to the following description of a preferred embodiment and by reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing is a schematic diagram of a fluid motor and source of pressurized fluid together with a valve assembly, shown in section, which constitutes a control circuit for the motor.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawing, a rotary fluid motor 11 is operated by supplying pressurized fluid to one of a pair of ports 12 and 13 while discharging fluid from the other. In this example ports 12 and 13 are respectively designated the forward and reverse ports since the system was designed to drive a vehicle and port 12 receives pressurized fluid during forward motion of the vehicle. To supply pressurized fluid, a pump 14 has an intake 16 communicated with a suitable fluid supply tank 17. Both motor 11 and pump 14 may be of conventional construction and it should be understood that while the motor 11 of this embodiment is shown as being of the rotary form, the invention is also applicable to linear fluid motors such as hydraulic jacks or the like. To provide for control of the operation of motor 11, the outlet 18 of pump 14 is connected with the motor through a valve assembly 19 which embodies the control circuit of the present invention.

Valve assembly 19 may, if desired, be contained within a single unitary housing 21 having an inlet passage 22 which is communicated with the pump outlet 18 by a suitable conduit 23. To maintain a predetermined maximum pressure at inlet passage 22, a relief valve 24 is connected between conduit 23 and the tank.

Inlet passage 23 terminates within housing 21 at an annular groove 26 in the wall of a bore 27 which extends through the housing at right angles to passage 22. A motor control valve spool 28 is disposed within bore 27 and is shiftable in an axial direction therein to any

of a series of positions, to be hereinafter described, for purposes of controlling the actions of the motor 11. Spool 28 has an extension 29 at at least one end which may be connected to manually operated control linkage of any of the various forms known to the art.

One of a pair of outlet grooves 31 and 31' is formed in bore 27 at each side of groove 26 and in spaced relation therefrom and each such outlet groove communicates with one of a pair of branches 32 and 32' of an outlet passage 33 and a conduit 34 connects outlet passage 33 with a tank 17' which may be the supply tank 17. Spool 28 has a pair of grooves 37 and 37' separated by a land 36 which is centered within bore groove 26 when the spool is shifted to an intermediate position within bore 27. Land 36 is of slightly less length in the axial direction than the groove 26 and has metering slots 38 whereby when the spool is at the intermediate position inlet passage 22 is communicated with outlet passage 33 by way of spool grooves 37 and 37', bore grooves 31 and 31' and outlet passage branches 32 and 32'. Thus with the spool 28 at the intermediate position, fluid from pump 14 is returned to tank 17 and as will hereinafter be described in more detail, both ports of motor 11 are blocked and the motor is stopped.

Adjacent each groove 37 and 37', spool 28 has lands 39 and 39' which act in conjunction with land 36 to block fluid flow from inlet groove 26 to the outlet grooves 31 and 31' when the spool is shifted away from the intermediate position. To receive the pressurized fluid when the spool 28 is shifted away from the intermediate position, a bore 27 has a first service groove 41 spaced outwardly from groove 31 and a second service groove 41' spaced outwardly from groove 31', the two service grooves being communicated by a service passage 42. Service passage 42 communicates with inlet passage 22 through an inlet check valve 43 oriented to admit fluid from the input passage into the service passage while blocking flow in the opposite direction. Inlet check valve 43 acts in the conventional manner to prevent a reversed flow of fluid, accompanied by an unwanted reversal of the motor, if the pump output pressure fails for any reason while the motor is in operation.

Movement of spool 28 away from the above described intermediate position acts to meter fluid into one of the motor ports 12 or 13 while providing for discharge of fluid from the other motor port and thereby provides for actuating the motor in a selected direction at a selected speed. Considering now the means by which movement of the valve spool 28 accomplishes these results, bore 27 has a pair of motor fluid grooves 47 and 47' situated outward from service grooves 41 and 41' respectively. Groove 47 is communicated with forward motor port 12 through a motor fluid passage 49 and conduit 51 while groove 47' is communicated with reverse motor port 13 through a motor fluid passage 49' and conduit 51'. Spool 28 has an additional pair of grooves 44 and 44' defined by lands 39 and 39' and additional lands 46 and 46' with metering slots 48 being provided in the adjacent edges of each pair of lands at each groove 44 and 44'. Groove 44 is positioned on spool 28 to meter fluid from service groove 41 into motor fluid groove 47 as the spool is shifted rightwardly from the intermediate position as viewed in the drawing. Similarly groove 44' is positioned on spool 28 to meter fluid from service groove 41' into motor fluid groove 41' as the spool 28 is shifted leftwardly

from the intermediate position as viewed in the drawing.

To provide for discharge of fluid from the motor 11 concurrent with the above described movements of the control valve spool 28 away from the intermediate position, bore 27 is provided with additional grooves 50 and 50' spaced outwardly from grooves 47 and 47' respectively. Groove 50 communicates with an input passage 55 to a first overspeed valve 53, which will hereinafter be described in more detail, while groove 50' communicates with an input passage 55' to a second similar overspeed valve 53'. Overspeed valve 53 discharges fluid into an exhaust passage 54 in housing 21 which is communicated with tank 17' by means of a conduit 56 and overspeed valve 53' discharges fluid into a second exhaust passage 54' which is communicated with the tank through a conduit 56'. Owing to the position of groove 50 adjacent motor fluid groove 47 the above described movement of spool 28 to the reverse drive position causes spool groove 44 to communicate motor fluid groove 47 with groove 50 to meter fluid therebetween and thereby provide a discharge path for fluid from the forward port 12 of the motor. Similarly, movement of the control valve spool 28 to the above described forward drive position causes groove 44' of the spool to communicate motor fluid groove 47' with groove 50' to provide a discharge path for fluid from the reverse port 13 of the motor.

Accordingly valve spool 28 has an intermediate or neutral position at which motor 11 is locked against motion in either direction in that both motor ports are blocked within housing 21 while driving fluid from pump 14 is transmitted to tank 17'. Spool 28 also has a forward drive position at which the pressurized fluid is transmitted to motor port 12 while discharge fluid from motor port 13 is transmitted to tank 17' and further has a reverse position at which the motor port 13 receives driving fluid while motor port 12 is communicated with tank. In either of the two drive positions of motor 11, the fluid which is discharging from the motor must pass through one of the overspeed valves 53 or 53' in passage between the motor control valve defined by valve spool 28 and bore 27 and the drain or tank 17'. The speed at which motor 11 operates may be regulated by adjusting spool 28 owing to the presence of metering slots 38 and 48.

In either of the drive positions of the spool 28, one of the overspeed valves 53 or 53' acts to limit the motor 11 to the desired speed by restricting the discharge flow passage from the motor if the motor attempts to operate at a greater rate because of external load forces on other causes. If overspeed is incipient, the pressure at the one of the motor ports 12 and 13 which is receiving fluid begins to decrease while discharge pressure rises. At such times the overspeed valves 53 and 53' act to reduce the discharge flow passage to hold motor speed constant by sensing the pressure decrease in the flow into the motor.

The two overspeed valves 53 and 53' are essentially similar and each has a spool 58 and 58' respectively disposed in a bore 59 and 59' respectively. Bores 59 and 59' are preferably parallel to bore 27 and are aligned along a single axis and situated at opposite sides of the inlet passage 22.

Considering overspeed valve 53 in particular, bore 59 has an inlet groove 61 communicated with passage 55 and has a spaced apart groove 52 communicated

with exhaust passage 54. Spool 58 has a groove 63 separating a land 64 from a land 66 and positioned whereby the adjacent edge of land 66 isolates groove 61 from 62 when the spool is shifted fully to the right as shown in the drawing. Metering slots 67 are provided in the edge of land 66 adjacent groove 63 whereby a metered flow from groove 61 to groove 62 occurs when the spool 58 moves leftwardly. A compression spring 69 is situated between land 66 of spool 58 and a cap 71 which closes the end of bore 59 at the side of housing 21 and urges the spool towards the position at which communication between grooves 61 and 62 is blocked. Spring 69 extends into a sleeve formed by land 66 and to vent the spring chamber, a radial passage 70 is provided in the sleeve and opens into exhaust passage 54. Thus in the absence of a force on spool 58 sufficient to overcome spring 69, the motor discharge path through overspeed valve 53 is blocked.

To provide a pilot means for opening overspeed valve 53 when fluid is to be discharged therethrough, land 64 extends into a groove 72 at the inner end of bore 59 which groove is communicated with motor fluid passage 49' through a pressure signal conduit 73 that includes a flow restriction 74. It should be observed that motor passage 49' is part of the flow path through which driving fluid is supplied to motor 11 when discharge fluid is to pass through the subject overspeed valve 53. Thus pressure proportional to the pressure of fluid being supplied to motor 11 is caused to act against spool 58 in a direction opposite to the force of spring 69 thereon. As long as the pressure of the fluid entering motor 11 is sufficiently high, spool 58 is shifted against spring 69 to provide an exhaust path for fluid being discharged from the motor. If the motor 11 attempts to operate at a speed greater than that provided for by the supply of incoming driving fluid, the pressure in groove 72 drops and spring 69 then acts to reduce the discharge flow passage at metering slots 67 by an amount proportional to the magnitude of the pressure drop. Thus the effect of the overspeed valve 53 is to hold the speed of motor 11 at a selected value determined by the position of motor control valve spool 28. Flow restriction 74 act to suppress shifting of the overspeed valve in response to minor transitory pressure fluctuations which are not necessarily indicative of overspeed.

The other overspeed valve 53' may be of essentially similar construction and operation and thus bore 59' has an inlet groove 61' spaced from an outlet groove 62' with the two grooves being respectively communicated with passage 55' and exhaust passage 54'. Spool 58' has a groove 63' with metering slots 67' separating lands 64' and 66' and a compression spring 69' acts between land 66' and a cap 71' at the outer end of bore 59' to urge the spool towards the position at which groove 62' is isolated from groove 61'. Land 64' extends into a pilot pressure groove 72' at the other end of bore 59' and a conduit 73' having a flow restriction 74' communicates groove 72' with motor fluid passage 49. The action of overspeed valve 53' in limiting the speed of the motor 11 during forward motor operation is similar to that described above with respect to the action of overspeed valve 53 in limiting motor speed during reverse operation.

To accommodate to certain other possible occurrences during motor operation, valve assembly 19 includes a pair of line relief valves 76 and 76' to protect the valve assembly against severe overpressures and a

pair of make-up valves 77 and 77' for avoiding cavitation under certain conditions.

Relief valve 76 is operative between motor fluid passage 49 and exhaust passage 54 and opens to relieve excess pressure from the port 12 side of motor 11 to drain 17' in the event that pressure at that side of the motor rises to a dangerous level above the normal range of operating pressures. This condition can arise, for example, if an extraordinary heavy external load should be applied to the motor 11. Similarly relief valve 76' is operative between motor fluid passage 49' and exhaust passage 54' for similar purposes. While the overspeed valves 53 and 53' act to prevent cavitation in motor 11 under normal conditions, the overspeed valves may not serve this function under all circumstances owing to the presence of the line relief valves 76 and 76'. When the relief valves 76 or 76' open as described above, a motor fluid discharge path exists which is independent of either of the overspeed valves and thus additional means are needed to avoid cavitation. The make-up valves 77 and 77' serve this purpose in that each is operative between one of the exhaust passages 54 and 54' and the adjacent one of the motor fluid passage 49 and 49'. Each such make-up valve 77 is essentially a spring biased check valve which blocks communication between the associated passages 49 and 54 and 49' and 54' except when the pressure in one of the exhaust passage 54 or 54' exceeds the pressure in the adjacent one of the motor fluid passages 49 or 49' which condition occurs in the presence of incipient cavitation. Under this condition, the appropriate one of the make-up valves 77 or 77' opens to enable a direct return of motor discharge fluid to the input side of the motor to supplement the incoming fluid being supplied by pump 14.

The above described arrangement of circuit components within housing 21 is readily adaptable to expansion into a unitary valve assembly having a plurality of motor control spools for a plurality of fluid motors and such a system is described in copending application Ser. No. 207,028 of Donald L. Bianchetta and Kenneth R. Lohbauer entitled HYDRAULIC CONTROL VALVE ASSEMBLY and filed Dec. 13, 1971.

While the invention has been described with respect to a particular example, it will be apparent that many 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 fluid motor control circuit for interconnecting a source of fluid under pressure and drain means and a reversible fluid motor having first and second fluid ports, comprising:

a valve assembly having an inlet passage for receiving fluid from said source and having a first and second exhaust passages for returning fluid to said drain means and having first and second motor fluid passages respectively communicating with said first and second ports of said motor, and having motor control valve means shiftable to a forward drive position at which said first motor fluid passage is communicated with said inlet passage while said second motor fluid passage is communicated with said second exhaust passage, said motor control valve means being shiftable to a reverse drive position at which said second motor fluid passage is communicated with said inlet passage while said first motor

fluid passage is communicated with said first exhaust passage, and
 first and second overspeed valves situated in the fluid exhaust flow path between said control valve means and said drain, said first overspeed valve having a fluid inlet means and fluid outlet means forming a portion of said first exhaust passage for transmitting exhaust flow from said motor control valve means to said drain means, said second overspeed valve having a fluid inlet means and fluid outlet means forming a portion of said second exhaust passage for transmitting exhaust flow from said motor control valve means to said drain means, each of said overspeed valves having pilot means for restricting the flow passage therethrough in response to pressure changes at said motor ports which accompany incipient overspeeding of said motor.

2. The combination defined in claim 1 wherein each of said overspeed valves has a spool and spring means urging said spool toward a position at which said inlet means of each overspeed valve is isolated from said outlet means thereof and wherein said pilot means comprises means for causing fluid pressure from said second motor fluid passage to act against said spool of said first overspeed valve in opposition to the force of said spring thereof and for causing fluid pressure from said first motor fluid passage to act against said spool of said second overspeed valve in opposition to the force of said spring thereof.

3. The combination defined in claim 2 wherein said means for causing fluid pressure to act against said spools of said first and second overspeed valves comprises means forming a first pressure signal passage between said spool of said first overspeed valve and said second motor fluid passage and having a flow restriction, and means forming a second pressure signal passage between said spool of said second overspeed valve and said first motor fluid passage and having a flow restriction.

4. A fluid motor control valve assembly for interconnection to a source of pressurized fluid and to drain means and to a reversible fluid motor having forward and reverse fluid ports comprising:

valve housing means having a fluid inlet passage for connection to said source of pressurized fluid and having an outlet passage for connection to said drain means, said outlet passage having branches extending adjacent each side of said inlet passage in spaced relation therefrom, said housing means having a service fluid passage communicating with said inlet passage and extending adjacent both branches of said outlet passage in spaced relation therefrom and having a pair of motor fluid passages for connection to separate ones of said motor ports and extending adjacent said service passage at opposite sides thereof in spaced relation therefrom, said housing further having a pair of overspeed

valve inlet passages each extending adjacent a separate one of said motor fluid passages in spaced relation therefrom and having a pair of exhaust passages for connection to said drain means and each extending adjacent a separate one of said overspeed valve inlet passages in spaced relation therefrom, said housing being further provided with a motor control valve bore transmitting each of said above named passages and being provided with a pair of overspeed valve bores each transecting a separate one of said overspeed valve inlet passages and the adjacent one of said exhaust passages,

an axially movable motor control valve spool disposed in said motor control valve bore and having an intermediate position therein and a forward drive position and a reverse position, said motor control valve speed having groove means thereon for communicating said inlet passage with said branches of said outlet passage while blocking said motor fluid passages while said spool is at said intermediate position, said spool having land means for blocking said inlet passage from said branches of said outlet passage at either of said forward and reverse positions, said motor control valve spool having additional groove means for communicating said service passage with one of said motor fluid passages while communicating the other of said motor fluid passage with the adjacent one of said overspeed valve inlet passages when said spool is at said forward drive position and for communicating said other motor fluid passage with said service passage while communicating said one motor fluid passage with the adjacent one of said overspeed valve inlet passages when said spool is at said reverse drive position,

a pair of overspeed valve spools each disposed in a separate one of said overspeed valve bores, each of said overspeed valve spools being spring biased to a position at which the adjacent exhaust passage is isolated from the adjacent overspeed valve inlet passage and each having a groove for communicating said adjacent passages upon being moved against said spring biasing, and

pilot means for causing fluid pressure from the most remote one of said pair of motor fluid passages to act against each of said overspeed valve spools in opposition to the force of said spring biasing thereon.

5. The combination defined in claim 4 further comprising an inlet check valve disposed in said housing between said inlet passage and said service passage, a pair of line relief valve means disposed in said housing each being between a separate one of said exhaust passages and the adjacent one of said motor fluid passages, and a pair of make up valves disposed in said housing each being between a separate one of said motor fluid passages and the adjacent one of said exhaust passages.

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