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Stacey

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[54] **DIRECTIONAL CONTROL VALVE**

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[52] **U.S. Cl.**..... **137/596.12,** 137/271, 137/491, 137/504, 91/414, 91/451

[51] **Int. Cl.**..... **F16k 11/00**

[58] **Field of Search**..... 137/596.12, 596.13, 137/565, 504, 271, 269, 491; 60/52; 91/414, 404, 468, 451

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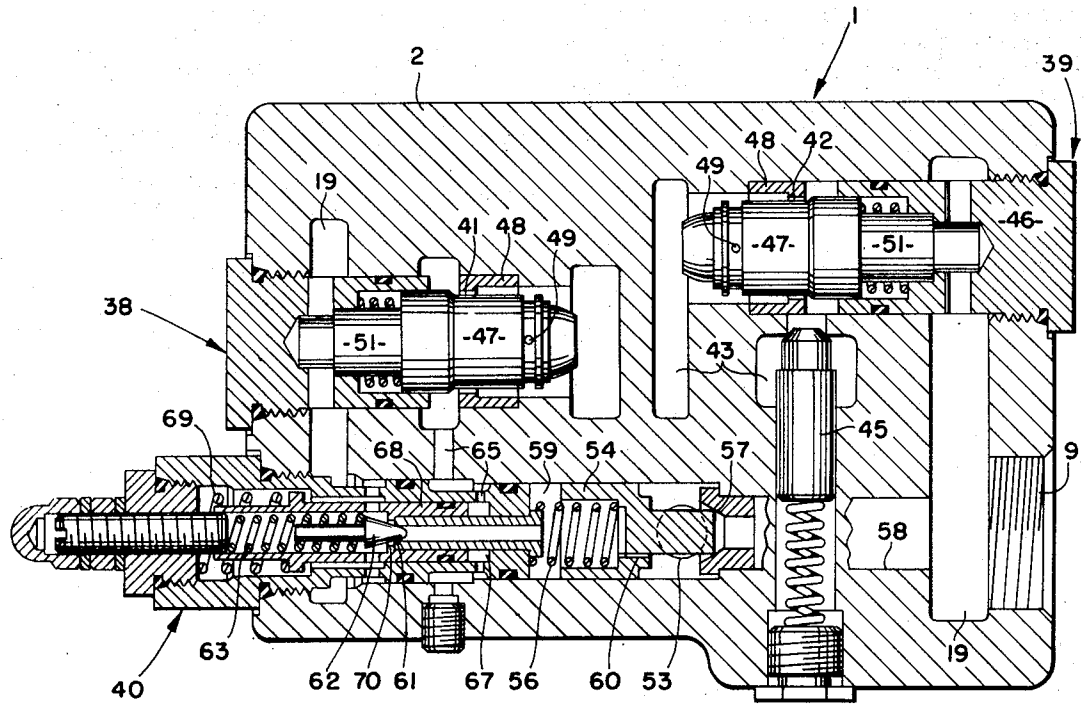
[57] **ABSTRACT**

A multi-spool directional control valve for controlling the operation of the lift, mast tilt, and auxiliary cylinders of a lift truck or the like characterized in the provision of a main valve housing having therein the spools for controlling the actuation of the lift and mast tilt cylinders, and having clamped thereto by a cap member the housings of one or more auxiliary spool valves for controlling the actuation of, for example, a load rotating cylinder and/or a load clamping cylinder. Said auxiliary spool valve housings have bypass and return passages registering with each other and with corresponding passages of the main valve housing, and said cap member by which said auxiliary valve housing (or housings) are clamped to the main valve housing defines with the juxtaposed face of the adjacent auxiliary valve housing a passage or chamber which communicates the bypass passage with the return passages. The main valve housing is further characterized in that it has therein (1) an auxiliary flow control valve in the portion of the bypass passage which is between the lift and tilt spools to control the rate of fluid flow to an auxiliary valve when the spool therein is shifted to an operating position blocking its bypass passage portion; (2) a tilt flow control valve upstream of the tilt spool to control the rate of fluid flow to the tilt cylinder when the tilt spool is shifted to an operating position; and (3) a two-stage relief valve having a higher relief pressure when the lift spool is in operating position than when one of the other spools is in operating position.

The directional control valve herein is further characterized in that the auxiliary valves are compact, not only in stack height, but in length as well and are otherwise of simple construction with load check valves embodied within the hollow spools thereof.

Yet another characterizing feature of this invention is that each spool thereof has associated therewith a switch which energizes the pump drive motor when the spool is shifted to an operating position, the pump drive motor being started without load upon initial movement of the spool toward operating position while the bypass passage through the valve assembly is yet open.

13 Claims, 2 Drawing Figures



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SHEET 1 OF 2

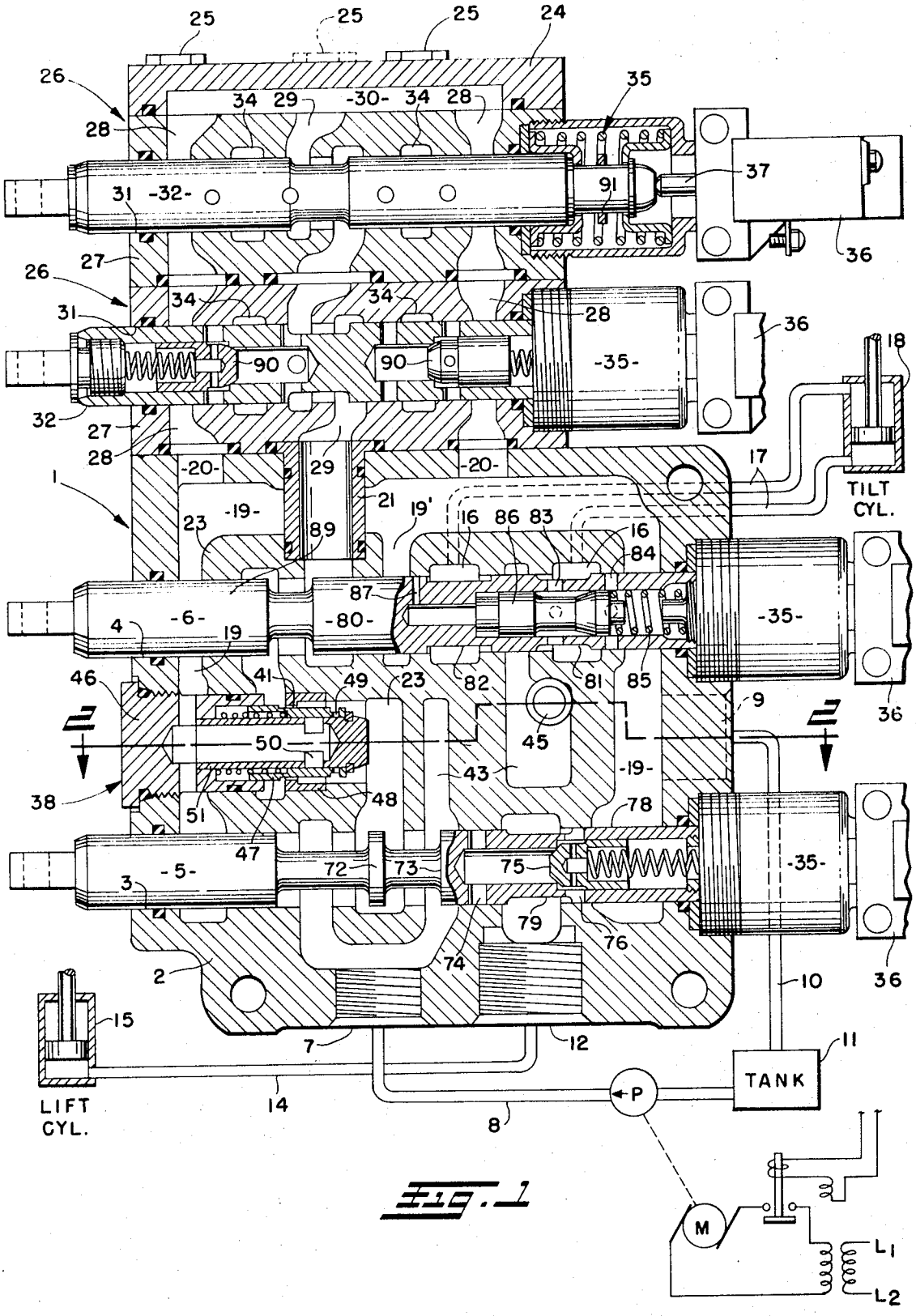


Fig. 1

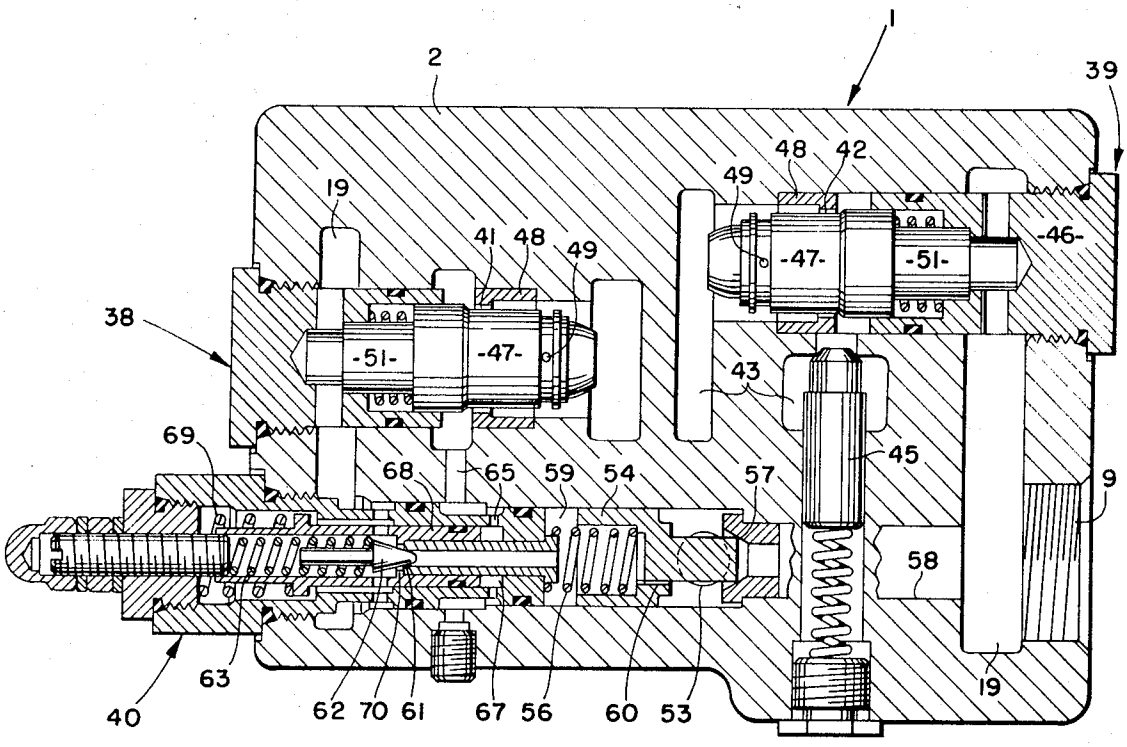

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Fig. 2

DIRECTIONAL CONTROL VALVE

BACKGROUND OF THE INVENTION

In the actuation of the fluid motors of a forklift truck or the like, it is known to provide a unitary directional control valve housing having a plurality of spools corresponding in number to the number of fluid motors to be actuated and generally having open center type construction with wishbone type passages and with load check valves disposed in bores parallel to the respective spool valve bores. In addition to the parallel spool bores, the housing is generally provided another parallel bore upstream of the first spool in which a relief valve is disposed. Furthermore, if flow control valves are required, the entire valve assembly may be of such large size and high cost as not to lend itself for use in connection with small lightweight forklift trucks.

Another known expedient is to connect two conventional double spool directional control valves in tandem by means of conduits for pressure flow of fluid from the upstream valve to the downstream valve and for return flow to a tank from the respective valves. It is also known to provide a two-stage relief valve in the upstream valve arranged to have two relief settings according to which valve is actuated. For an example of that type of directional control valve assembly, reference may be had to the Markovich U.S. Pat. No. 3,023,584, granted Mar. 6, 1962. For other forms of two-stage relief valves reference may be had also to the Martin U.S. Pat. Nos. 3,160,076, granted Dec. 8, 1964, and 3,212,523, granted Oct. 19, 1965.

When such self-contained directional control valve assemblies are employed and when it is desired to embody flow control valves therein, the latter may be provided by attaching to the directional control valve housing a manifold housing such as disclosed in the Stacey U.S. Pat. No. 3,251,277, granted May 17, 1966, and in Hajma U.S. Pat. No. 3,272,085, granted Sept. 13, 1966.

It is also known to provide a spool valve with an electric switch to energize the pump drive motor only when the spool is shifted from a neutral position to an operating position, thus to reduce power demand of the system and to avoid the necessity of maintaining constant circulation of hydraulic fluid through a bypass passage in the valve housing. For an example of such pump drive motor switch at the end of a spool, operative to start the motor under low load as soon as the spool movement commences, reference may be had to the Schmiel et al. U.S. Pat. No. 3,228,193, granted Jan. 11, 1966.

SUMMARY OF THE INVENTION

The directional control valve herein for use as in actuating the fluid motors of a forklift truck has a main valve housing having therein a three-way open center lift spool; an open center four-way mast tilt spool; an auxiliary flow control valve; a mast tilt flow control valve; and a two-stage relief valve. If the forklift truck has auxiliary fluid motors such as a load rotating motor and a load clamping motor, individual simple and compact spool valves having plate-like housings are clamped by means of a cap member to the main valve housing to receive fluid under pressure from the main valve housing via the aforesaid auxiliary flow control valve.

In the present directional control valve, the lift spool and the mast tilt spool are preferably arranged in parallel i.e., either or both of said spools may be shifted to operating position to actuate the respective motors. The auxiliary spools are preferably connected together in series-parallel arrangement i.e., only one spool at a time may be actuated to receive pressure fluid through the auxiliary flow control valve. The two-stage relief valve herein is preferably arranged so that the maximum pressure of the system is applicable for maximum load lifting capacity only when the lift spool is in operating position, whereas when any of the other spools are in operating position, the relief pressure is at a lower value.

The directional control valve herein is further characterized in that the lift spool has therewithin a load check valve to prevent load dropping in the event of drop in inlet pressure, said load check valve being so arranged in relation to a flow groove in the lift spool that rapid lowering of the unloaded lift fork may be achieved even when of lightweight construction owing to return flow not only through the spool groove, but through the load check valve.

Another characterizing feature of the present invention is that the mast tilt spool has therein a piston valve which prevents cavitation of the mast tilt fluid motor when the load thereon tends to run away by demanding fluid under pressure approaching the capacity of the pump. Yet another characterizing feature of the present invention is that the auxiliary spools have load check valves built therewithin thus to enable the use of compact auxiliary housings.

Yet another characterizing feature of the present invention is that the lift spool and mast tilt spool have control sections to block fluid flow to the auxiliary spools via the auxiliary flow control valve when either the lift spool or the mast tilt spool is in an operating position.

Other objects and advantages of the present invention will appear hereinafter.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross-section view of a directional control valve embodying the present invention, such cross-section having been taken in a plane passing through the axes of the several spools; and

FIG. 2 is a cross-section view on slightly enlarged scale taken substantially along the line 2—2, FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

The directional control valve assembly **1** comprises a main valve housing **2** having parallel bores **3** and **4** therethrough in which the respective lift and mast tilt spools **5** and **6** are reciprocable. The housing **2** has a pressure inlet port **7** connected by conduit **8** to pump P, a return port **9** connected by conduit **10** to tank **11**, a cylinder port **12** connected by conduit **14** to the lift cylinder **15**, and a pair of cylinder ports **16** connected by conduits **17** to the ends of the mast tilt cylinder **18**. A return passage **19** intersects both spool bores **3** and **4** adjacent the ends of the latter and communicates with the return port **9** and the upper end of the housing **2** terminates in two openings **20** which communicate with the return passage **19** and an opening through a tubular carry-over sleeve **21** which communicates with the downstream portion of a bypass passage **23** which

intersects both spool bores 3 and 4 and which communicates with the inlet port 7 at its upstream end.

Clamped to the upper end of the housing 2 by means of the cap member 24 and bolts 25 are auxiliary valves 26 which comprise plate-like auxiliary valve housings 27 having return passages 28 communicating with each other and with the openings 20 in the housing 2, and having bypass passages 29 communicating with each other and with the opening in the carry-over sleeve 21, the cap member 24 defining a passage or chamber 30 which communicates the downstream portion of the bypass passage 29 with the return passages 28. Each auxiliary valve housing 27 has a bore 31 therethrough in which a spool 32 is movable to control the actuation of a cylinder (not shown) connected to the cylinder ports 34, such cylinders being, for example, a load rotating cylinder and a load clamping cylinder in the case of a forklift truck or the like.

Each spool 5, 6, and 32 herein has a spring centering mechanism 35 of well known form associated therewith and secured to the housing of each spring centering mechanism 35 is a switch 36 having a plunger 37 engaged with the respective spool which opens the pump drive motor M circuit when the spool is in neutral position as shown in FIG. 1. When the respective spool is moved to the left or to the right from neutral position, contacts within the switch 36 are closed to energize the motor M to drive the pump P and because the switch contacts are closed at the beginning portion of the spool movement, the bypass passage 23,29 through the valve assembly is yet open so that the starting of the pump P is effected under substantially no load.

In the specific application of the invention herein the lift and tilt spools 5 and 6 are disposed in parallel circuit arrangement wherein either spool 5 or 6 may be actuated to operating position or wherein both spools 5 and 6 may be simultaneously actuated to operating position whereas the auxiliary spools 32 are preferably disposed in series-parallel circuit arrangement wherein but one spool 32 at a time may be actuated to operating position, provided that the tilt spool 6 is in neutral position and provided that the lift spool 5 is either in neutral position or in lowering position so that fluid under pressure is conducted through the bypass passage 23 and through the carry-over sleeve 21 to the passage 29 which becomes a pressure feed passage up to the actuated auxiliary spool 32.

The main valve housing 2 has in three bores thereof which are parallel to the spool bores 3 and 4 an auxiliary flow control valve 38, a tilt flow control valve 39, and a two-stage relief valve 40. The auxiliary flow control valve 38 defines with housing 2 an annular orifice 41 in the portion of the bypass passage 23 between the spool bores 3 and 4, and the tilt flow control valve 39 defines with housing 2 an annular orifice 42 in the pressure feed passage 43 which at its upstream end communicates with inlet port 7 and which at its downstream end intersects the tilt spool bore 4 between the cylinder ports 16. Downstream of the flow control orifice 42 the housing 2 has a load check valve 45 therein which prevents reverse flow in feed passage 43, and consequent load dropping, in the event of loss of pressure in the inlet port 7 and passage 43.

By way of example, in a 25 GPM valve assembly 1 it is desired to provide a 11 GPM flow through the auxiliary flow control valve 38, and an 8 GPM flow through the tilt flow control valve 39, and to provide a 2,000 p.s.i. relief pressure when the lift spool 5 is actuated to operating position and a 1,500 p.s.i. relief pressure when any one of the other spools 6 or 32 is moved to operating position.

Each flow control valve 38 and 39 comprises a body 46 screwed into the main valve housing 2 and has slidable thereon a spring-biased flow control valve member 47 which defines the aforesaid orifice 41 or 42 with a sleeve 48 in the housing 2 and when the pressure drop across the orifice 41 or 42 increases to a value indicating a flow greater than 11 or 8 GPM, the flow control member 47 will be moved against the spring bias to divert excess flow through the openings 49 in the control valve member 47 to the return passage 19 via openings 50 in the support sleeve 51 for said control valve member and, of course, when the pressure drop further increases, the end of the flow control valve member 47 will establish increased bypass flow through the openings 50 thus to maintain approximately constant flow of 11 or 8 GPM through the orifice 41 or 42. Since both flow control valves 38 and 39 may be of the same construction except for flow capacity, only one of them, namely 38, has been shown in cross-section in FIG. 1.

The two-stage relief valve 40 has a passage 53 communicating with the inlet port 7 and pressure feed passage 43, and comprises a main relief valve member 54 which is biased by the spring 56 against the seat 57 and, as apparent, when the main relief valve member 54 is moved away from the seat 57, excess pressure in the inlet passage 53 is conducted to the return passage 19 by way of the relief passage 58 in the housing 2. The relief valve assembly 40, except for the second stage, is of the conventional pilot operated type in which the main valve member 54 is seated by spring 56 pressure and by fluid pressure which enters the chamber 59 behind the main valve member 54 through the orifice 60 therein and, when the pressure in the chamber 59 acting on the area of the seat 61 against which the pilot valve member 62 is seated by the adjustable spring 63, the pilot valve member 62 will be moved away from the seat 61 to vent the chamber 59 to the return passage 19 faster than fluid under pressure can be replenished into such chamber 59 through the orifice 60 whereupon the then predominant pressure acting on the main relief valve member 54 will urge the same away from the seat 57 to relieve such excess pressure through passage 58. As aforesaid, when the lift spool 5 is moved from neutral position to operating position, it is desired that such relief pressure be 2,000 p.s.i., for example. When the lift spool 5 is in neutral position as shown in FIG. 1 and when any one of the other three spools 6 or 32 is actuated, the fluid pressure in the bypass passage 23 flows through the orifice 41 and through the passages 65 into the piston chamber 67 to urge the piston 68 to the left as viewed in FIG. 2 against its relatively weak spring 69 to cause the seat 70 thereof to engage the pilot valve member 62 and to urge the pilot valve member out of engagement with the smaller seat 61. The area of the seat 70 is larger than the 2,000 p.s.i. seat 61 by an amount such that the slight additional compression of the spring 63 yet provides a second lower relief pressure setting for the two-stage relief valve 40 since in that case the pressure in the chamber 59 acts on the larger area of the pilot valve member seat 70 whereby a lower pressure such as 1,500 p.s.i. in passage 53 and chamber 59 will result in opening of the main relief valve member 54.

Referring now to the operation of the directional control valve **1** herein, when the lift spool **5** is shifted to the left from neutral position the motor M will be energized to drive the pump P by closing of contacts in the switch **36** thus to start the operation of the pump under substantially no load and upon continued movement of the lift spool **5** to the left the lands **72** and **73** will block the bypass passage **23** to prevent flow of fluid to the auxiliary flow control valve **38.** Fluid under pressure thus will be conducted to the lift cylinder **15** via the passages **74,** the load check valve **75,** the passages **76,** the cylinder port **12,** and the conduit **14.** In this way a load on the lift cylinder **15** will be lifted and, since the bypass passage **23** to the piston chamber **67** is closed, the relief pressure will be controlled by the pilot valve member **62** being engaged with the smaller seat **61.** When the lift spool **5** is allowed to be moved back to neutral position by the spring centering mechanism **35,** the pump motor M will be de-energized by the opening of switch **36** and the load will be held in raised position by the spool lands **74** and **78** and by the load check valve **75.** When the lift spool **5** is shifted to the right from neutral position, the motor M is again energized to start the pump P and the cylinder port **12** is communicated with the return passage **19** not only through the groove **79** of the spool **5,** but also through passages **74,** check valve **75,** and passages **76** thus to enable rapid lowering of the lift cylinder **15** even when there is no load thereon. Because the lift spool **5** is of the three-way type and consumes no power during the lowering operation, the bypass passage **23** through the auxiliary flow control valve **38** remains open for actuation of one or the other of the auxiliary spools **32** provided that the mast tilt spool **6** is in the neutral position whereat the bypass passage **23** is open to the auxiliary valves **26.**

Now, with respect to the mast tilt spool **6,** which is of the four-way, open center type and which is arranged in parallel circuit with the lift spool **5,** the bore **4** thereof is intersected by the pressure feed passage **43** and by the pair of cylinder ports **16** which are connected by conduits **17** to the tilt cylinder **18.** The pressure feed passage **43** at the spool bore **4** is communicated with the pressure inlet port **7** by way of the orifice **42** of the flow control valve **39** and by way of the load check valve **45.** When the mast tilt spool **6** is shifted to the left from the neutral position, the land **80** thereof closes the bypass passage **23** and the pressure feed passage **43** is communicated with the right cylinder port **16** via the groove **81** in the spool **6** thus to conduct fluid under pressure to actuate the tilt cylinder **18** in one direction i.e. upward as viewed in FIG. **1,** and the left cylinder port **16** is communicated with the return branch **19'** via the spool groove **82** whereby fluid displaced from the upper end of the tilt cylinder **18** is conducted to the tank **11** via the return passages **19'** and **19,** return port **9,** and conduit **10.** As previously mentioned, the initial movement of the mast tilt spool **6** to the left energizes the motor M and of course the load check valve **45** prevents load dropping. When the mast tilt spool **6** is moved to the right from neutral position the pump drive motor M is again energized and the pressure feed passage **43** is communicated by way of orifice **42** and check valve **45** with the left cylinder port **16** through the spool groove **82** thus to introduce fluid under pressure at prescribed flow rate into the upper end of the tilt cylinder **18.** When the spool **6** is in its right-hand operating position, return flow of fluid from the lower end of the cylinder **18** through the right cylinder port **16** into the return passage **19** via the openings **83** and **84** in the spool **6** will be blocked by the spring **85** biased piston valve **86** unless the pressure in the left cylinder port **16** acting on valve **86** through orifice **87** is sufficient to move the valve **86** to the right against spring **85** to open the passages **84.** The piston valve **86** thus prevents cavitation of the upper end of the cylinder **18** due to load thereon tending to actuate the cylinder **18** at a rate exceeding the 8 GPM flow as controlled by the flow control valve **39.**

If, at the time that the mast tilt spool **6** is actuated to one of its operating positions, the lift spool **5** is either in the neutral position or in the lift cylinder **15** lowering position, the pressure conducted to the mast tilt spool **6** will pass through the auxiliary flow control orifice **41** to gain access to the piston chamber **67** to shift the piston **68** to the left to engage its large seat **70** with the pilot valve member **62** and to move the latter away from the small seat **61** whereby the relief valve member **54** will open at say, 1,500 p.s.i. instead of 2,000 p.s.i.

The auxiliary spool valves **26** are, as aforesaid, preferably of identical construction and are arranged for series-parallel operation so that only one spool **32** at a time may be actuated from neutral position to an operating position. In order for fluid under pressure to flow to the auxiliary valves **26,** the mast tilt spool **6** must be in neutral position otherwise the bypass passage **23** which becomes the pressure feed passage will be closed either by land **80** or **89,** and the lift spool **5** must be either in the neutral position as shown or in the load lowering position otherwise the bypass passage **23** will be closed by the lands **72** and **73.**

Each auxiliary spool **32** is preferably of the four-way open center type and in order to conserve space with reference to the length of each auxiliary housing **27,** the zigzag bypass **29** arrangement is employed as distinguished from the usual wishbone arrangement of bypass and pressure feed passages. Furthermore, to decrease the lateral dimensions of each housing **27** load check valves **90** are incorporated coaxially within each auxiliary spool **32.** The valve **1** utilizes conventional spring centering mechanisms **35** with washers **91** of necessary thickness to take care of the shorter strokes of the spools **5, 6** and **32.**

In summary therefore, it can be seen that the present directional control valve **1** is of simple, compact and inexpensive form and in cases where the forklift truck or the like has only two fluid motors **15** and **18** for example for control by corresponding spools **5** and **6** the carry-over sleeve **21** may be omitted and the cap member **24** may be clamped directly by bolts **25** on the upper side of the main valve housing **2.** The two spool main base valve has the versatility that when the forklift truck or the like has one or more auxiliary motors, a corresponding number of auxiliary spool valves **26** are simply clamped between the upper end of the main valve housing **2** and the cap member **24** by means of bolts **25** which extend through aligned holes in the cap member **24** and the auxiliary housings **27** and which have threaded engagement in the upper end of the main valve housing **2.**

I, therefore, particularly point out and distinctly claim as my invention:

1. A directional control valve comprising a main housing having first and second bores each intersected axially therealong by inlet, motor, and return passages

respectively adapted for connection with a pump, a fluid motor, and a tank, and having a bypass also intersecting said bores communicating at one end with said inlet passage and terminating at the other end in an opening in one face of said main housing; said return passage being common to said bores and including a portion extending generally parallel to said bores between such one face and said second bore; a spool reciprocable in each bore from a neutral position whereat said bypass passage is open to said inlet passage and whereat communication of said motor passage with said inlet and return passages is blocked to operating positions whereat said motor passage is selectively communicated with said inlet passage or return passage thus to control actuation of such fluid motor; said spool, when in one operating position communicating said inlet and motor passages with each other, being operative to close said bypass passage; said main housing having a pair of openings in such one end face which communicate with said portion of said return passage; an auxiliary valve having a housing secured to such one end face of said main housing and having therein a bore intersected axially therealong by auxiliary bypass, motor, and return passages of which said auxiliary bypass and return passages register respectively with said opening and said pair of openings in such one end face of said main housing; said auxiliary return passage having a pair of branches registering with said pair of openings and a connecting portion into which said auxiliary bypass passage opens downstream of said auxiliary housing bore; an auxiliary spool reciprocable in said auxiliary housing bore from a neutral position whereat said auxiliary bypass passage is open to said connecting portion and whereat communication of said auxiliary motor passage with said auxiliary bypass and return passages is blocked to operating positions whereat said auxiliary motor passage is selectively communicated with said auxiliary bypass passage or one of said auxiliary return passage branches, said auxiliary spool in one of said operating positions being operative to close said auxiliary bypass passage for flow of pressure fluid in said auxiliary bypass passage upstream of said auxiliary spool bore to said auxiliary motor passage, the downstream portion of said auxiliary bypass passage being communicated with said auxiliary return passage connecting portion whereby said bypass passages in said main housing and in said auxiliary housing are open to said main housing return passage via said pair of openings in said main housing when said spools are in neutral position.

2. The directional control valve of claim **1** wherein said auxiliary housing is clamped between said main housing and a cap member by fastening means engaged with said cap member and said main housing, said cap member and auxiliary housing defining therebetween said connecting portion which intercommunicates the downstream portion of the auxiliary bypass passage with said auxiliary return passage branches.

3. The directional control valve of claim **1** wherein said main housing has therein a flow control valve which provides a flow control orifice in said bypass passage downstream of said first bore; said flow control valve having a movable flow control member which communicates said bypass passage with said return passage to divert excess flow to said return passage.

4. A directional control valve comprising a main housing having a bore therein intersected axially therealong by inlet, motor, and return passages respectively adapted for connection with a pump, a fluid motor, and a tank, and having a bypass passage also intersecting said bore communicating at one end with said inlet passage and terminating at the other end in an opening in one face of said main housing; a spool reciprocable in said bore from a neutral position whereat said bypass passage is open to said inlet passage and whereat communication of said motor passage with said inlet and return passages is blocked to operating positions whereat said motor passage is selectively communicated with said inlet passage or return passage thus to control actuation of such fluid motor; said spool, when in one operating position communicating said inlet and motor passages with each other, being operative to close said bypass passage; said main housing having another opening in such one end face which communicates with said return passage; an auxiliary valve having a housing secured to such one end face of said main housing and having therein a bore intersected axially therealong by auxiliary bypass, motor and return passages of which said auxiliary bypass and return passages register respectively with said opening and said another opening in such one end face of said main housing; an auxiliary spool reciprocable in said auxiliary housing from a neutral position whereat said auxiliary bypass passage is open and whereat communication of said auxiliary motor passage with said auxiliary bypass and return passages is blocked to operating positions whereat said auxiliary motor passage is selectively communicated with said auxiliary bypass passage or said auxiliary return passage, said auxiliary spool in one of said operating positions being operative to close said auxiliary bypass passage for flow of pressure fluid in said auxiliary bypass passage upstream of said auxiliary spool bore to said auxiliary motor passage, the downstream portion of said auxiliary bypass passage being communicated with said auxiliary return passage whereby said bypass passages in said main housing and in said auxiliary housing are open to said main housing return passage via said another opening in said main housing when said spools are in neutral position; said main housing having a relief valve therein which is operative to communicate said inlet passage with said return passage when said inlet passage pressure exceeds a predetermined value during the time that said spool is in said one operating position; said relief valve having plunger means exposed to fluid pressure in said bypass passage downstream of said spool when said auxiliary spool is in said one operating position effective to increase the effective seat area of said relief valve thus to relieve pressure in said inlet passage at less than such predetermined value.

5. The directional control valve of claim **4** wherein said relief valve is of the pilot operated type in which the pilot relief valve member engages a seat of prescribed area; and wherein said plunger means has a seat of larger area which engages said pilot relief valve member and moves it away from the seat of such prescribed smaller area.

6. A directional control valve comprising a main housing having a bore therein intersected axially therealong by inlet, motor, and return passages respectively adapted for connection with a pump, a fluid motor, and a tank, and having a bypass passage also intersecting said bore communicating at one end with said inlet passage and terminating at the other end in an opening in

one face of said main housing; a spool reciprocable in said bore from a neutral position whereat said bypass passage is open to said inlet passage and whereat communication of said motor passage with said inlet and return passages is blocked to operating positions whereat said motor passage is selectively communicated with said inlet passage or return passage thus to control actuation of such fluid motor; said spool, when in one operating position communicating said inlet and motor passages with each other, being operative to close said bypass passage; said main housing having another opening in such one end face which communicates with said return passage; an auxiliary valve having a housing secured to such one end face of said main housing and having therein a bore intersected axially therealong by auxiliary bypass, motor and return passages of which said auxiliary bypass and return passages register respectively with said opening and said another opening in such one end face of said main housing; an auxiliary spool reciprocable in said auxiliary housing from a neutral position whereat said auxiliary bypass passage is open and whereat communication of said auxiliary motor passage with said auxiliary bypass and return passages is blocked to operating positions whereat said auxiliary motor passage is selectively communicated with said auxiliary bypass passage or said auxiliary return passage, said auxiliary spool in one of said operating positions being operative to close said auxiliary bypass passage for flow of pressure fluid in said auxiliary bypass passage upstream of said auxiliary spool bore to said auxiliary motor passage, the downstream portion of said auxiliary bypass passage being communicated with said auxiliary return passage whereby said bypass passages in said main housing and in said auxiliary housing are open to said main housing return passage via said another opening in said main housing when said spools are in neutral position; said main housing having a second bore therein and having a second spool reciprocable in said second bore to control actuation of a second fluid motor; said second bore being intersected axially therealong by said bypass passage and by said inlet and return passages and by a motor passage adapted for connection to such second motor; said second spool being reciprocable in said second bore from a neutral position whereat said bypass passage is open and whereat communication between said motor passage and said inlet and return passages is blocked to operating positions whereat said motor passage thereof is selectively communicated with said inlet passage or said return passage, said second spool in one of said operating positions blocking said bypass passage for buildup of pressure in said inlet passage for flow to said motor passage; said main housing having a flow control valve therein defining a flow control orifice in said bypass passage between said main housing spool bores and comprising a movable flow control valve member which opens communication between said bypass passage and said return passage to divert excess flow to said return passage when said main housing spools are in neutral position thus to control flow of fluid to said auxiliary valve.

7. The directional control valve of claim **6** wherein said main housing has another flow control valve therein providing a flow control orifice in the inlet passage to said second spool and comprising a movable flow control member which opens communication between said inlet passage and said return passage to divert excess flow to said return passage.

8. The directional control valve of claim **1** wherein said motor passage intersecting said first bore in the other of said operating positions is communicated with said return passage via two separate paths of flow including a groove in said spool and openings in said spool and a load check valve within said spool; said spool in said first bore being of the three-way type for actuating a single acting fluid motor whereby fluid is rapidly exhausted from such single acting motor under conditions of a small load thereon.

9. A directional control valve comprising a main housing having a bore therein intersected axially therealong by inlet, motor, and return passages respectively adapted for connection with a pump, a fluid motor, and a tank, and having a bypass passage also intersecting said bore communicating at one end with said inlet passage and terminating at the other end in an opening in one face of said main housing; a spool reciprocable in said bore from a neutral position whereat said bypass passage is open to said inlet passage and whereat communication of said motor passage with said inlet and return passages is blocked to operating positions whereat said motor passage is selectively communicated with said inlet passage or return passage thus to control actuation of such fluid motor; said spool, when in one operating position communicating said inlet and motor passages with each other, being operative to close said bypass passage; said main housing having another opening in such one end face which communicates with said return passage; an auxiliary valve having a housing secured to such one end face of said main housing and having therein a bore intersected axially therealong by auxiliary bypass, motor and return passages of which said auxiliary bypass and return passages register respectively with said opening and said another opening in such one end face of said main housing; an auxiliary spool reciprocable in said auxiliary housing from a neutral position whereat said auxiliary bypass passage is open and whereat communication of said auxiliary motor passage with said auxiliary bypass and return passages is blocked to operating positions whereat said auxiliary motor passage is selectively communicated with said auxiliary bypass passage or said auxiliary return passage, said auxiliary spool in one of said operating positions being operative to close said auxiliary bypass passage for flow of pressure fluid in said auxiliary bypass passage upstream of said auxiliary spool bore to said auxiliary motor passage, the downstream portion of said auxiliary bypass passage being communicated with said auxiliary return passage whereby said bypass passages in said main housing and in said auxiliary housing are open to said main housing return passage via said another opening in said main housing when said spools are in neutral position; said main housing having a second bore therein and having a second spool reciprocable in said second bore to control actuation of a second fluid motor; said second bore being intersected axially therealong by said bypass passage and by said inlet and return passages and by a motor passage adapted for connection to such second motor; said second spool being reciprocable in said second bore from a neutral position whereat said bypass passage is open and whereat communication between said motor passage and said inlet and return passages is blocked to operating positions whereat said motor

passage thereof is selectively communicated with said inlet passage or said return passage, said second spool in one of said operating positions blocking said bypass passage for buildup of pressure in said inlet passage for flow to said motor passage; said second spool having therein a pressure actuated plunger valve which is exposed to pressure in said inlet passage to block return flow through said motor passage to said return passage except when said inlet pressure is of prescribed minimum value thus to prevent cavitation of a double acting fluid motor connected to said second spool.

10. A directional control valve comprising a main housing having a bore therein intersected axially therealong by inlet, motor, and return passages respectively adapted for connection with a pump, a fluid motor, and a tank, and having a bypass passage also intersecting said bore communicating at one end with said inlet passage and terminating at the other end in an opening in one face of said main housing; a spool reciprocable in said bore from a neutral position whereat said bypass passage is open to said inlet passage and whereat communication of said motor passage with said inlet and return passages is blocked to operating positions whereat said motor passage is selectively communicated with said inlet passage or return passage thus to control actuation of such fluid motor; said spool, when in one operating position communicating said inlet and motor passages with each other, being operative to close said bypass passage; said main housing having another opening in such one end face which communicates with said return passage; an auxiliary valve having a housing secured to such one end face of said main housing and having therein a bore intersected axially therealong by auxiliary bypass, motor and return passages of which said auxiliary bypass and return passages register respectively with said opening and said another opening in such one end face of said main housing; an auxiliary spool reciprocable in said auxiliary housing from a neutral position whereat said auxiliary bypass passage is open and whereat communication of said auxiliary motor passage with said auxiliary bypass and return passages is blocked to operating positions whereat said auxiliary motor passage is selectively communicated with said auxiliary bypass passage or said auxiliary return passage; said auxiliary spool in one of said operating positions being operative to close said auxiliary bypass passage for flow of pressure fluid in said auxiliary bypass passage upstream of said auxiliary spool bore to said auxiliary motor passage, the downstream portion of said auxiliary bypass passage being communicated with said auxiliary return passage whereby said bypass passages in said main housing and in said auxiliary housing are open to said main housing return passage via said another opening in said main housing when said spools are in neutral position; said spools having switches associated therewith to energize a pump drive motor upon actuation of either spool from neutral position to an operating position.

11. The directional control valve of claim **1** wherein said spool in said first bore in said main housing is of three-way type to control actuation of a single acting motor; and wherein said bypass passage remains open in the other operating position whereby said auxiliary valve may receive fluid under pressure from said bypass passage upon movement of said auxiliary spool to said one operating position.

12. The directional control valve of claim **2** wherein a duplicate auxiliary valve is interposed between said cap member and said auxiliary housing with registering bypass passage and return passage branches therethrough.

13. The directional control valve of claim **1** wherein said opening is disposed between said pair of openings and is constituted by a sleeve which extends through said portion of said main housing return passage to define the portion of said main housing bypass passage downstream of said second bore.

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