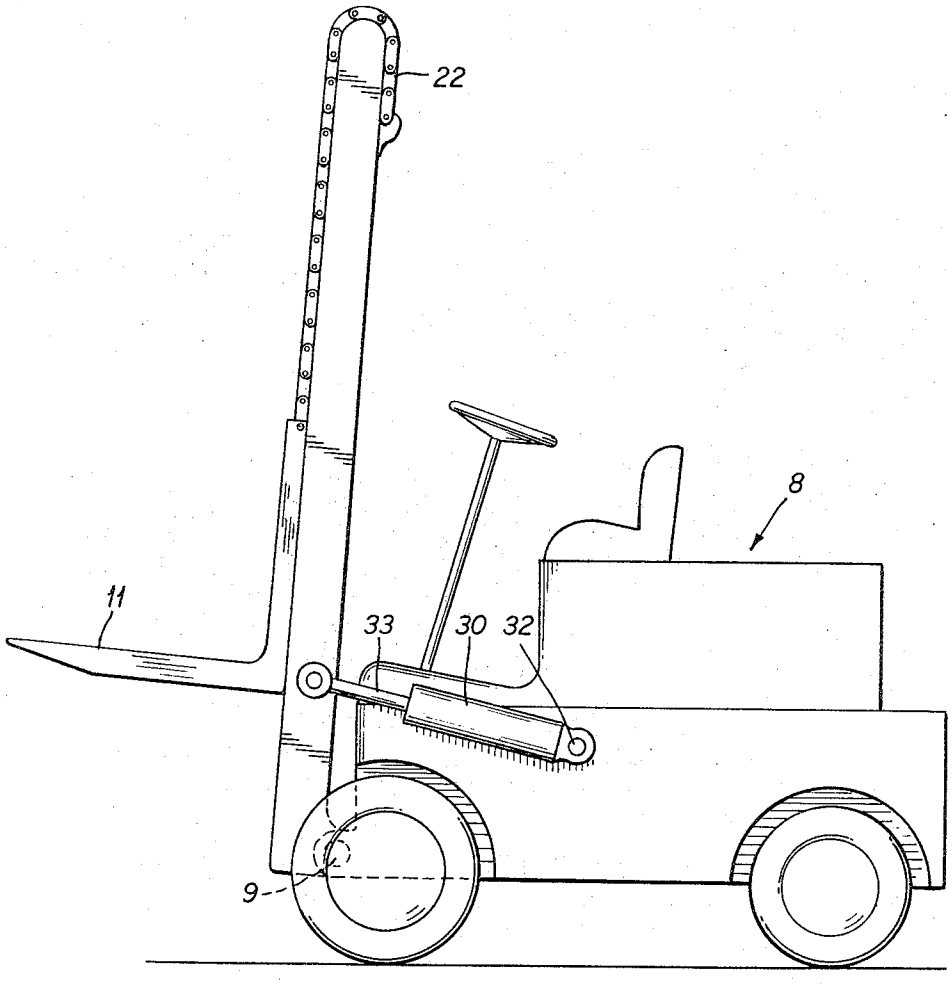
Aug. 29, 1967 J. C. E. FLINT 3,338,441

HYDRAULIC APPARATUS

Filed Sept. 22, 1965 2 Sheets-Sheet 1

FIG. 1



INVENTOR

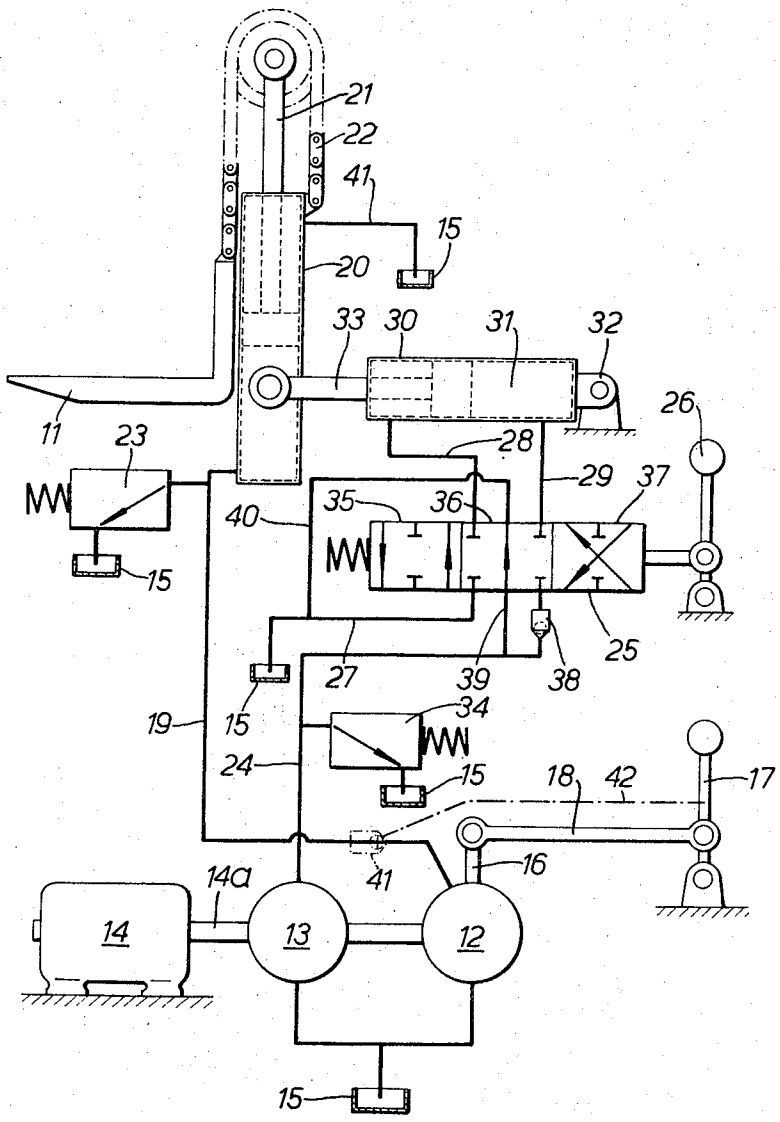
JOHN C. E. FLINT

Aug. 29, 1967 J. C. E. FLINT 3,338,441

HYDRAULIC APPARATUS

Filed Sept. 22, 1965 2 Sheets-Sheet 2

FIG. 2



INVENTOR
John C. E. Flint
BY
Orland M. Christensen
ATTORNEY

United States Patent Office 3,338,441
Patented Aug. 29, 1967

3,338,441
HYDRAULIC APPARATUS

John C. E. Flint, Chalford, England, assignor to Dowty Technical Developments Limited, Cheltenham, England, a British company

Filed Sept. 22, 1965, Ser. No. 489,195
Claims priority, application Great Britain, Sept. 26, 1964, 39,319/64
6 Claims. (Cl. 214—674)

This invention relates to hydraulic apparatus suitable for raising and lowering the load-carrying forks of a forklift device.

According to this invention, an hydraulic apparatus suitable for raising and lowering the forks of such a device includes a variable-delivery hydraulic pump arranged to be driven from a power source, and a liquid-pressure operable servomotor, the output member of which is mechanically connected to load-carrying forks, the motor being so hydraulically connected to the variable-delivery hydraulic pump as to be operable thereby, at least for raising of the forks, at a rate which is dependent upon the pump delivery condition selected. The forks are substantially vertically guided on a tiltable support and the apparatus further includes a fixed-delivery hydraulic pump, arranged to be driven from the same power source as the variable delivery hydraulic pump, which fixed-delivery pump supplies liquid under pressure for the operation of a further servomotor or servomotors which control the attitude of the support, thereby to change the tilt and/or the reach of the forks, suitable control valves being provided for control of these further servomotors. Suitable relief valves may also be provided in the hydraulic circuits associated with the fixed-delivery pump and with the variable-delivery pump.

Both the variable-delivery pump and the fixed-delivery pump may draw their liquid from a common reservoir.

The servomotor associated with the variable-delivery pump is of single-acting telescopic type, the pump charging the cylinder thereof for raising of the forks, but being effectively caused to operate under reverse flow for contraction of the motor and lowering of the forks. Accordingly, the variable-delivery pump may have a delivery-varying mechanism of such nature that, by a suitable operator's control, it can be moved from a zero delivery position, in which the servomotor is substantially held in the position it has attained, progressively to a maximum delivery position in which the servomotor is extended in the forks-raising direction at a maximum rate. Conversely, the delivery-varying mechanism may also be moved from the zero delivery position progressively to the maximum reverse flow condition in which the servomotor is contracted in the forks-lowering direction at a maximum rate.

In cases where leakage through the variable-delivery pump is such as to prevent the required loads from being held satisfactorily when the delivery-varying mechanism is in its neutral condition, a lock valve is provided on the outlet side of the pump, this being released automatically when the delivery-varying mechanism is moved into the reverse flow condition.

The variable-delivery and fixed-delivery pumps are driven together through the same shaft by an electric motor, itself powered by batteries carried upon the forklift device. Alternatively, the two pumps may be driven by an internal combustion engine.

One embodiment of the invention will now be particularly described by way of example with reference to the accompanying diagrammatic drawings wherein:

FIGURE 1 is a diagrammatic illustration of a forklift truck having the inventive hydraulic apparatus embodied therein; and

FIGURE 2 is a diagrammatic illustration of the hydraulic apparatus.

Referring to the drawings, an hydraulic apparatus forming part of a forklift truck **8** and intended for the raising, lowering and tilt control of the forks or load-carrying member **11** of the truck, includes a variable-delivery pump **12** and a fixed-delivery pump **13**, both arranged to be driven by a common electric motor **14** itself powered by batteries (not shown) carried upon the vehicle **8**. Both pumps **12** and **13** are driven by the same shaft **14***a* and draw their hydraulic liquid for operation from a common reservoir **15**.

The variable-delivery pump **12** is constructed in accordance with that described in the specification of co-pending United States patent application Ser. No. 429,409. The input member **16** of the delivery-varying mechanism of this pump is operated by a manual control lever **17** and connecting rod **18**. The lever **17** is movable from the zero flow position shown to the right in FIGURE 2 for progressive increase in the pump delivery flow and to the left for progressive increase in reverse flow.

The variable-delivery pump **12** is connected to deliver liquid under pressure through a pipe **19** to one side of a servomotor for raising the load-carrying member **11**. This motor is in the form of a lift jack **20** of single-acting telescopic type. The output member or piston rod **21** of this lift jack is connected by a chain mechanism **22** of conventional form to the load-carrying member **11** of the forklift truck. A relief valve **23** is provided in the pipe **19** at a position adjacent the cylinder of the jack **20**, this relief valve spilling to tank **15**.

The fixed-delivery pump **13** delivers through a pipe **24** to a tilt control valve **25** of open-centre spool type. This valve is provided with a manual control lever **26** and as well as having a pipe connection **27** back to the reservoir **15**, it also has pipes **28** and **29** respectively connecting with either side of a tilt control servomotor in the form of a telescopic jack **30**. The cylinder **31** of the jack **30** is pivotally connected at **32** to the body of the forklift truck while the output member or piston rod **33** is pivotally connected to the cylinder of the lift jack **20**. This cylinder is pivotally mounted on the body of the truck at **9** so that, as well as affording raising and lowering control of the load-carrying member, it is capable of imparting to the member the tilt controlling adjustment afforded by the tilt control jack **30**.

The pipe **24** is provided with a relief valve **34**, which like the relief valve **23** also spills to the reservoir **15**.

The tilt control valve **25** is of such construction that when it is in the neutral position its spool is in the position diagrammatically shown in FIGURE 2 with the diagrammatic centre portion **36** placing a branch pipe **39** from the pipe **24** in communication with a pipe **40** which connects with the pipe **27** and thus with reservoir **15**. A one-way check valve **38** is ineffective in the circuit when the spool is in the equilibrium position, but the section **36** provides open-centre characteristics for the valve when in this equilibrium position.

When the manual control lever is moved to the right in FIGURE 2 the section of the spool shown diagrammatically at **35** is also moved to the right so that the pipes **27** and **28** are placed in communication as also are the pipes **29** and **24**. This results in movement to the left of the piston rod **33** of the jack **30**, the liquid passing into the jack cylinder doing so through the check valve **38**.

When the manual control lever **26** is moved to the left in FIGURE 2 on the other side of the equilibrium position, the section of the spool shown diagrammatically at **37** is brought into effect so that the pipe **29** is brought into communication with the pipe **27** and thus with drain, and the pipe **24** is brought into communication with the pipe **28**. In consequence, pressure liquid is able to pass through the pipe **28** to the left-hand side of the piston of the jack **30** so that the jack moves to the right in FIG-

URE 2, liquid exhausting from the other side of the jack passing through the pipes **29** and **27** to drain. During such operation the check valve **38** is operative again in the supply line to the jack.

In operation of the hydraulic circuits associated with the load-carrying member **11**, when the control lever **17** is moved to the right from its neutral position, the variable-delivery pump **12** commences to deliver liquid under pressure through the pipe **19**, the amount of flow being dependent on the extent of movement of the lever to the right. This results in an upward movement in the drawing of the piston and piston rod **21** of the lift jack **20**. When the lift jack reaches its upper limit of travel, if the lever **17** is still held in a positive delivery position, pressure in the pipe **19** is relieved to reservoir through the relief valve **23**. Otherwise, when the load-carrying member **11** has reached its desired height, the lever **17** is moved back to the neutral position, there being substantially no inherent leakage within the variable-delivery pump **12** so that the load-carrying member **11** and the load it carries are held in the raised position by the column of oil extending between the pump **12** and the jack **20** with the relief valve **23** maintained closed.

When it is desired to lower the load-carrying member **11**, the lever **17** is moved from its neutral position to the left in FIGURE 2, whereupon the operation of the variable-delivery pump **12** is reversed, thereby affording reverse flow through the pump. Hence, the jack **20** contracts at a rate dependent upon the extent to which the lever is moved to the left, contraction of course being assisted by the effective weight of the member **11**.

Since the variable-delivery pump **12** and the fixed-delivery pump **13** are driven by the same electric motor **14**, then during lift operation of the member **11**, the fixed-delivery pump **13** is also being driven, but the tilt control valve **25** associated therewith is in the neutral position so that the delivery of the pump **13** is allowed to flow through the unloading passage formed by the pipe **39**, section **36** of the spool and pipe **40** back to the reservoir **15**.

However, when the manual control lever **26** of the tilt control valve **25** is moved either to the left or to the right, liquid under pressure in the pipe **24** is caused to pass either through the pipe **28** or the pipe **29**, as explained above, to the left or right-hand sides of the jack **30** so that the jack is either contracted or extended, as the case may be. Tilt is thus imparted to the member **11** by way of the jack **20**.

The variable-delivery pump **12** is of somewhat larger capacity than the fixed-displacement pump. When the delivery-varying mechanism of the variable-delivery pump is in a partial flow condition, the power wasted corresponds only to the leakage in the pump in operation, whereas in the case of a fixed-delivery pump, partial flow can only be achieved by discharging the balance of the pump flow to reservoir at high pressure, which wastes a corresponding fraction of pump power. However, the fixed-delivery pump **13** is of such smaller capacity than the variable-delivery pump **12** that heat generated when its output is throttled by the unloading passages in the valve structure under restrictive flow conditions, is tolerable.

Since in the system above-described the lifting and tilting circuits are separate, operation at different pressure levels cannot cause power wastage.

The above system is so arranged that there is no interaction between lift and tilt circuits so that these can easily be operated simultaneously.

The control of the variable-delivery pump is such that there is very little dead travel on the pump stroke control, and it would also be possible to reduce the dead travel on the lever **26** of the tilt control valve **25** by suitably incorporating a cam on the operating spindle thereof.

Further, with the variable-delivery pump, the problem of inching, otherwise evident in spool valves associated with fixed-delivery pumps and there overcome by the introduction of inching slots which can be designed for one pressure only, does not arise because inching with the variable-delivery pump is hardly dependent upon pressure.

In another embodiment of the invention the apparatus includes a further spool valve for the direction of fluid derived from the fixed-delivery pump to a further servomotor in the form of a telescopic jack. This jack is so geometrically arranged in relation to the tilt control jack and the lifting jack as to afford reach control for the load-carrying member **11**.

In other embodiments, further circuits are powered by the fixed-delivery pump, or jointly by additional fixed-delivery pumps driven from either the same power source or a separate power source.

In another embodiment of the invention, where the construction of the variable-delivery pump is such that when the delivery-varying mechanism is in the neutral position a small amount of leakage back through the pump might occur to prevent a load from being satisfactorily held, a lock valve shown in dotted detail at **41** is provided in the line **19** upon the outlet side of the variable-delivery pump **12**, automatic release linkage **42**, also shown in dotted detail, being provided and operable when the lever **17** of the delivery-varying mechanism is moved to the left in FIGURE 2 for the reverse flow condition.

Thus, by the invention, difficulty of manipulation of at least two services at the same time and in which pump flow must be shared, is avoided, as is a system of preferences which of necessity would have otherwise been built in to ensure that the important services are not starved of operating liquid. Further, there is no interaction between the separate lift and tilt circuits and there is no effect by the tilt circuit upon the more important lift circuit. However, as in the above embodiment where a reach circuit is combined with a tilt circuit it is still unlikely that more than one would be used simultaneously with lift.

The invention is in no way limited to driving of the pumps by an electric motor, as in other embodiments, they are driven by internal combustion engines.

I claim as my invention:

1. In a forklift device having a vehicular body, a tiltable support thereon, and load-carrying forks substantially vertically guided on the support, hydraulic control apparatus comprising a power source, fixed and variable delivery hydraulic pumps driven by the power source, and a pair of liquid-pressure-operated servomotors, one of which is carried on the tiltable support and operatively interconnected with the forks to raise and lower the forks in use, the one servomotor being of the single acting type and there being a hydraulic interconnection between the one servomotor and the variable delivery pump whereby the variable delivery pump operates the one servomotor at a rate determined by the delivery selected therefor, and the other of which servomotors is carried on the body of the device and operatively interconnected with the tiltable support to vary the attitude of the support in use, there being a hydraulic interconnection between the aforesaid other servomotor and the fixed delivery pump, and valve means in the latter hydraulic interconnection, whereby the fixed delivery pump operates the aforesaid other servomotor at times determined by operation of the valve means.

2. A forklift device according to claim **1**, wherein relief valves are provided in the hydraulic circuits associated with the fixed-delivery pump and with the variable-delivery pump.

3. A forklift device according to claim **1**, wherein the variable-delivery pump and the fixed-delivery pump are so connected as to draw their liquid from a common reservoir.

4. A forklift device according to claim **1**, wherein the variable-delivery pump has a delivery-varying mechanism

which is movable from a zero delivery position wherein the aforesaid one servomotor is substantially held in the position it has attained, progressively to a maximum delivery position wherein the one servomotor is extended in the forks-raising direction at a maximum rate.

5. A forklift device according to claim 4, wherein the delivery-varying mechanism is also movable from the zero delivery position progressively to a maximum reverse flow condition in which the one servomotor is contracted in the forks-lowering direction at a maximum rate.

6. A forklift device according to claim 1, wherein leakage through the variable-delivery pump is such as to prevent the required load from being held in position when the delivery-varying mechanism is in its neutral condition, and a lock valve is provided on the outlet side

of the variable-delivery pump, which lock valve is so constructed as to be releasable automatically when the delivery-varying mechanism is moved into the reverse flow condition.

References Cited

UNITED STATES PATENTS

2,008,687	7/1935	Dean.	
2,389,164	11/1945	Payne	60—52
2,914,922	11/1959	Gibson	60—52
3,146,593	9/1964	Stacey	60—52
3,163,008	12/1964	Hansen	60—52 X
3,219,259	11/1965	Horton	60—52 X

EDGAR W. GEOGHEGAN, *Primary Examiner.*