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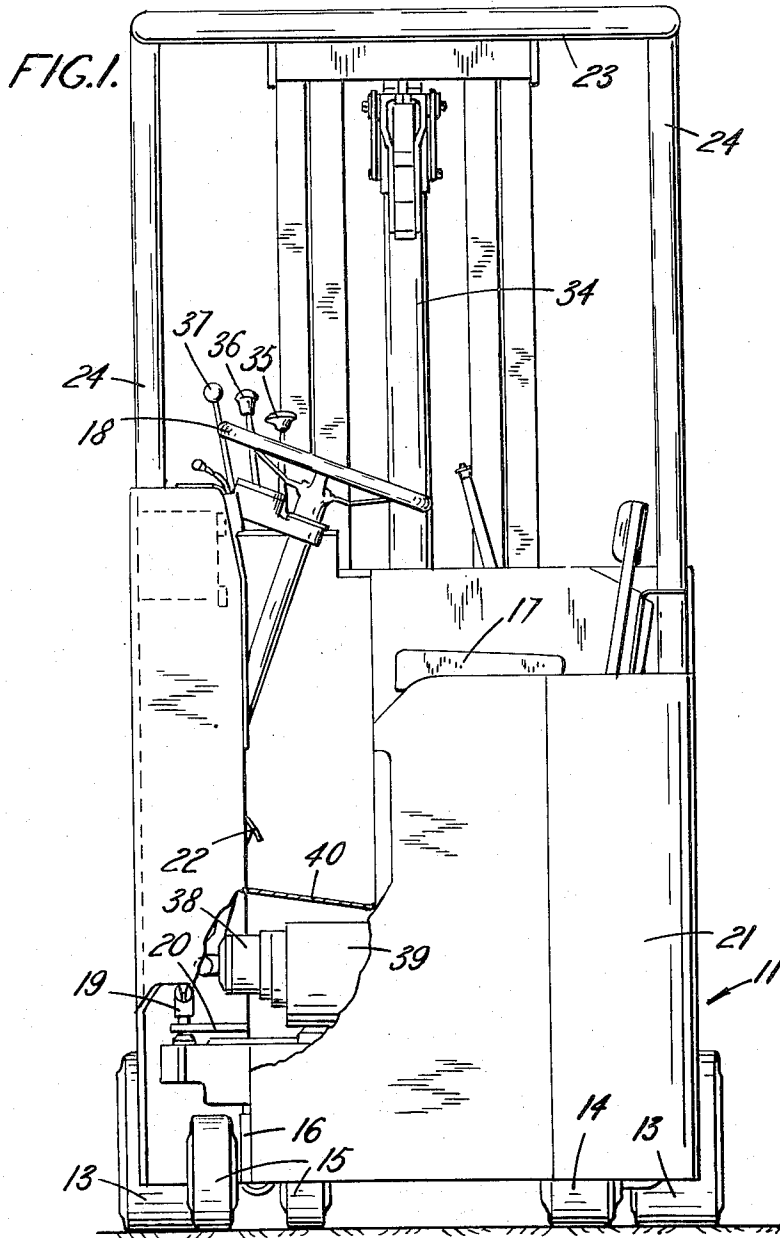
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3,014,344

CONTROL-GEAR FOR HYDRAULIC CIRCUITS

Filed June 25, 1959

4 Sheets-Sheet 1



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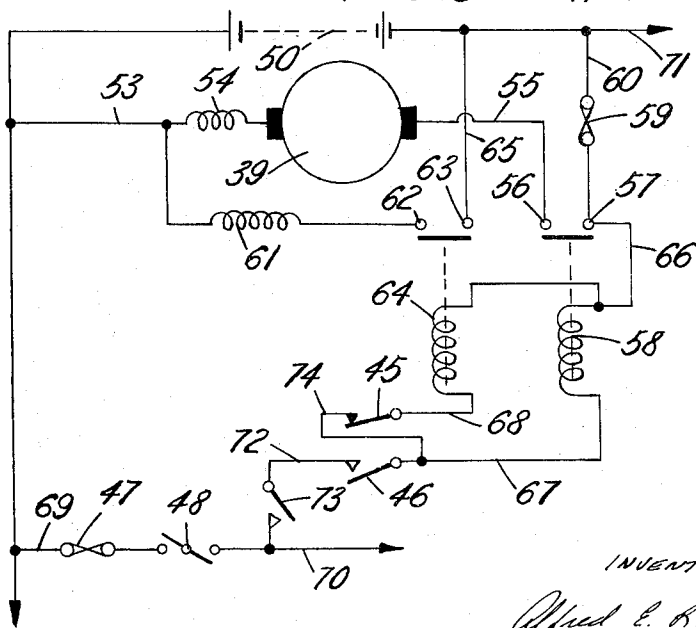
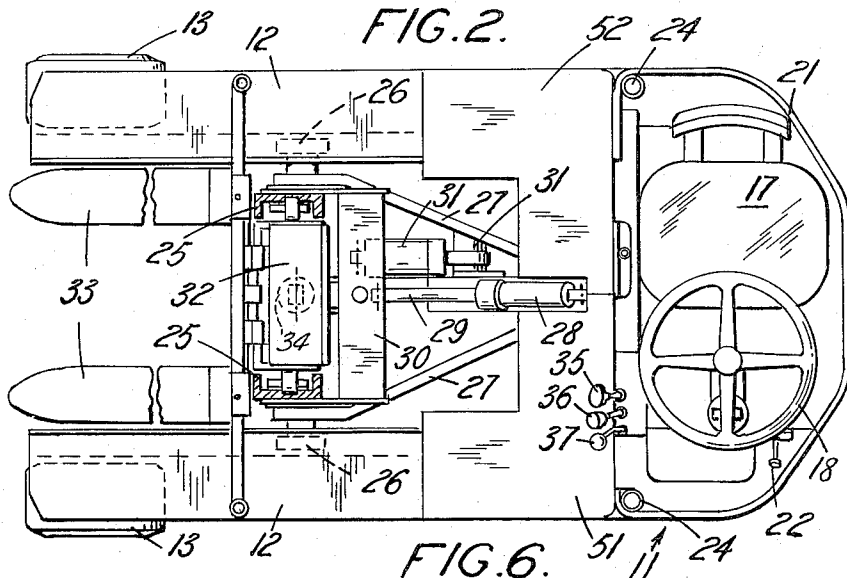
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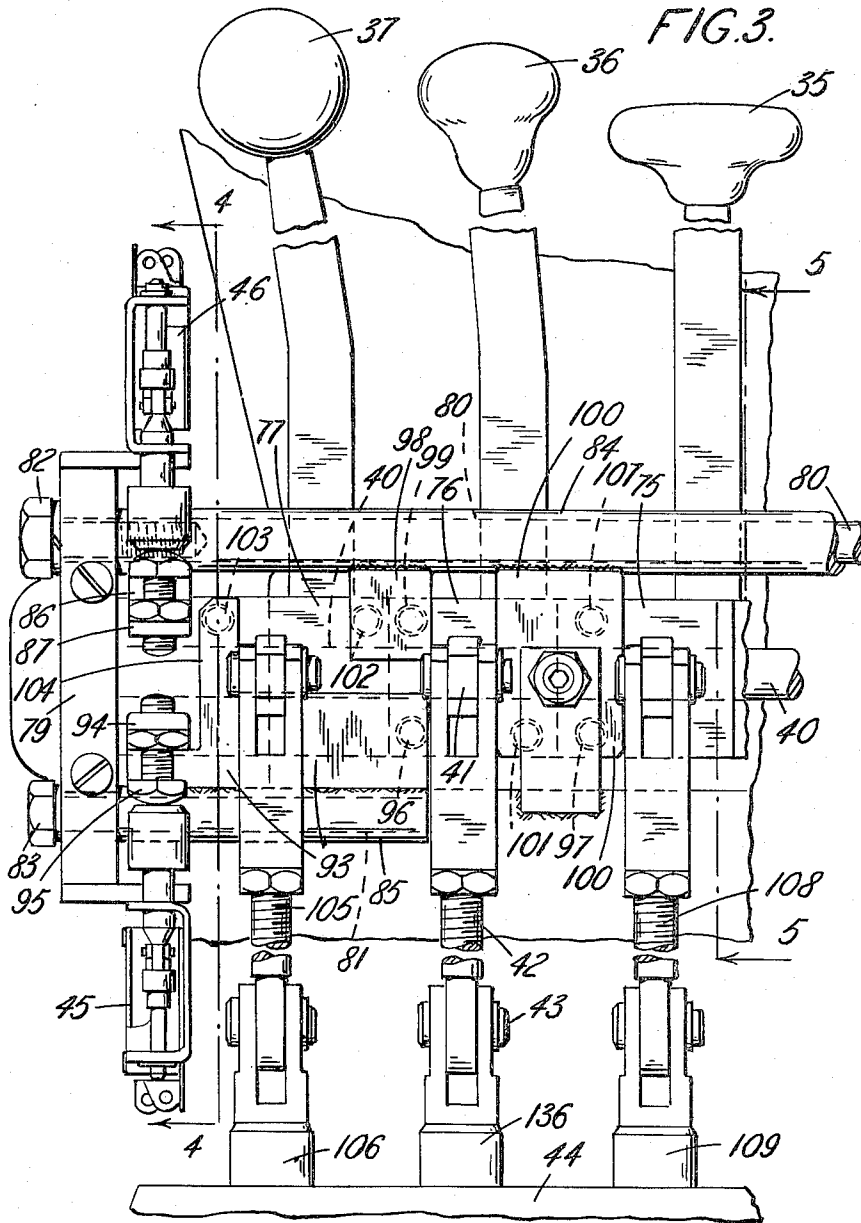
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FIG. 4.

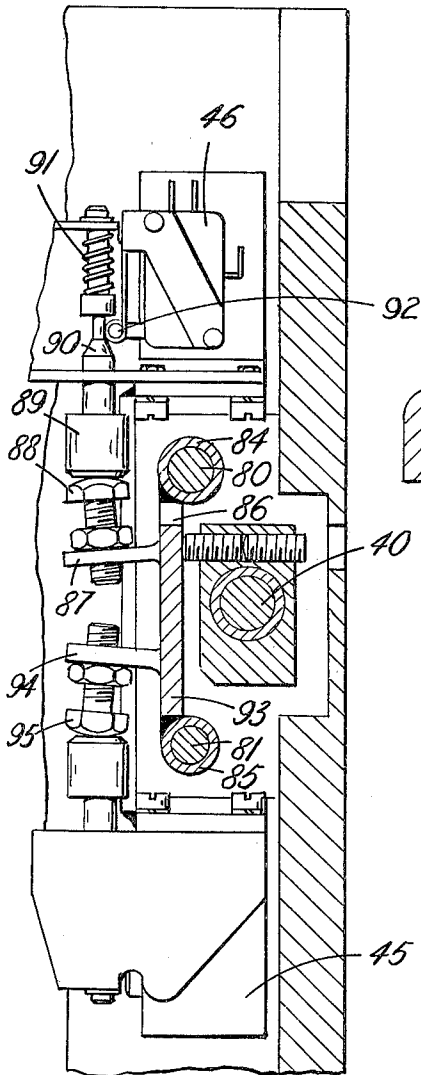
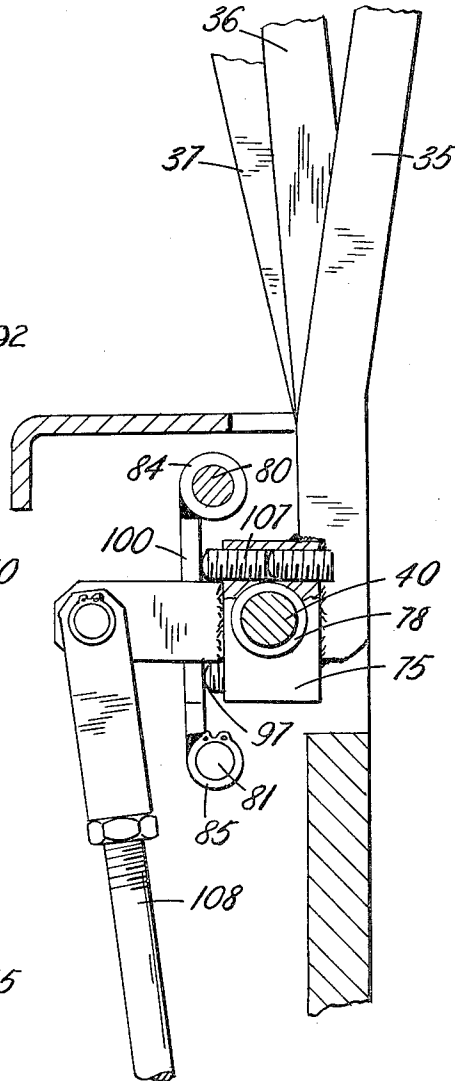


FIG. 5.



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CONTROL-GEAR FOR HYDRAULIC CIRCUITS

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3 Claims. (Cl. 60—52)

This invention comprises improvements in or relating to control-gear for hydraulic circuits.

The invention relates to hydraulic circuits of the kind in which a pump actuates a device for utilising hydraulic fluid, in accordance with the operation of a control-valve which can be moved to determine the utilisation. For example a jack may serve to utilise fluid by moving a part to and fro and the control valve may determine the direction and vary the speed of operation of the jack.

It is an object of this invention to provide an improved system of control for a hydraulic circuit in which less power is wasted than is usual. Usually pumps have a constant delivery and when the control valve is closed to reduce the rate of utilisation, the excess pump delivery is shunted off by a relief valve. This system is very wasteful of energy and places unnecessary loadings on the pump, driving motor, and relief valve which may reduce their useful working life.

According to the present invention a system of control for an hydraulic circuit of the kind described comprises in combination a means for controlling the pump to vary its rate of delivery, a control valve or valves between the pump and the circuit in which the delivery is utilised and connections between the control valve or valves and the means for controlling the pump, said connections being operative to vary the delivery of the pump according to the rate of utilisation selected by the control valve or valves. The extent to which the delivery is varied may be such that a small excess pressure is normally maintained and is conducted away by a relief valve. In the embodiment hereinafter described the means for controlling the pump to vary its rate of delivery operates by varying its speed. An electrical drive for the pump is provided and the connections between the hydraulic control valve or valves and the means for controlling the pump comprises switch means operated by the control valve or valves, and electrical connections from the switch means to an electromagnetic speed control device for the pump drive. The means for controlling pump delivery may however comprise connections to the accelerator of a driving engine or the control lever of a variable delivery pump.

Normally, a jack piston has greater effective area for one direction of movement than for the other, owing to the piston-rod reducing the effective area of one face of the piston, and will tend to move faster in the direction for which the area is least, as the rate of supply is normally constant. It is one object of the present invention to provide means to compensate for this tendency. The invention may however be employed, not merely for compensation, but to ensure a desired speed or rate of utilisation in any device.

The following is a description by way of example of one arrangement in accordance with the invention, as applied to an industrial reach truck.

In the accompanying drawings:

FIGURE 1 is a rear-elevation of the truck with certain parts broken away;

FIGURE 2 is a plan of the same;

FIGURE 3 is an elevation of the hydraulic control mechanism;

FIGURE 4 is a section on the line 4—4 of FIGURE 3;

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FIGURE 5 is a section on the line 5—5 of FIGURE 3; and

FIGURE 6 is a diagram of electrical connections.

The truck comprises a body 11 having forwardly-extending parallel straddle-legs 12 close to the ground supported on front wheels 13, power-driven steerable rear wheel 14 and a pair of castoring rear wheels 15, mounted on an equalising castor mounting 16.

A driver's seat 17 is set across the truck with a steering wheel 18 facing the driver, which is connected to a steering linkage 19 which governs the orientation of the power in the wheel 14 through a link 20.

The power-driven steering wheel 14 is operated by an electric motor in the casing 21 below the driver's seat and the motor is controlled by an accelerator pedal 22 which operates an electric controller in known manner.

Over the driver there is a guard rail 23 which is supported on tubular metal columns 24 which rise from the body 11.

Between the straddle-legs 12 there is a mast 25 which is supported on guides in the legs by rollers 26 and has also rearwardly-extending frame-members 27 which meet one another beneath the body 11 and carry rollers to run in a central horizontal guide. The mast is moved fore and aft on the straddle-legs by a jack 28 having a jack-rod 29 which engages a cross-member 30 behind the mast. The mast itself is tiltable relatively to the frame-members 27 which carry the rollers 26 and tilting is effected by jack 31, one end of which is connected to the cross-member 30 attached to the mast and the other end of which is connected to a leg 31 attached to one of the members 27. The effect is that the mast could be tilted forwardly or rearwardly by operating the jack 31. On the mast is a rising carriage 32 which carries fork arms 33 and the carriage can be elevated or lowered by jack 34 between the sides of the mast and connected thereto by chains. Thus there are three jacks for controlling the movements of the load-carrying forks 33, namely the jack 34 for raising and lowering it, the jack 31 for tilting the mast and the jack 28 for moving the carriage which supports the mast forwardly or backwardly. The three jacks are controlled by three levers 35, 36, 37 in front of the operator on the line of the steering wheel, the lever 35 which is nearest to the operator controlling the tilt-jack 31, the lever 36 controlling the reach-jack 28 and the lever 37 controlling the lift-jack 34.

Power for the jacks which are controlled by these levers is supplied by a pump 38 driven by an electric motor 39 below the foot-plate 40 in front of the driver. It is the pump 38 which is controlled according to the present invention so as to vary the rate of delivery and the means of control are shown in FIGURES 3, 4 and 5, taken in conjunction with the electrical circuit of FIGURE 6.

It will be appreciated that the jack-cylinder 28 and piston rod 29 which projects forwardly from the cylinder into engagement with the travelling mounting of the mast, constitute a construction in which the front end of the jack cylinder is of smaller capacity than the rear end and if operated by a motor-driven pump such as 38 through a normal control valve, the movement of retraction will be faster than the movement of advance, but this is undesirable as, if goods are deposited on the fork arms 33 of the carriage 28 and the retraction movement is started too fast, the goods may slip off the fork arms or tip over.

The reach valve plunger 136 is of normal type and is operated by the control lever 36 which is pivoted on a cross bar 40 and can be moved towards the front of the truck for advancing the mast 25 and towards the rear for retracting it. The lever 36 has a horizontal arm 41 which operates a connecting-rod 42 pivoted to the plunger 136 at 43. The plunger 136 serves to operate lift valves in

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the interior of the valve casing 44 which valves direct the output of the pump 38 in the first case to the rear end of the jack 28 and in the second case to the front end.

According to the present invention, the motor 39 provided for driving the pump 38, is capable of running at two different speeds proportioned respectively to the output required for the forward movement and the lower output required for the retraction.

Adjacent to the operating lever 36 are two micro-switches 45, 46, the latter closed when the lever is moved to the forward position and the former closed when it is moved to the retraction position. The connections are shown in FIGURE 6. In FIGURE 6 the battery 50 which operates the truck (and which is located in 2 L-shaped battery cases 51, 52, seen in FIGURE 2) is connected each to one terminal by a line 53 to one terminal of the motor 39 which has a series field winding 54. The other terminal of the motor is connected by a line 55 to the contacts 56, 57 and a solenoid switch 58 and then through a fuse 59 and line 60 to the other terminal of the battery. The motor has also a shunt field winding 61 connected to the contacts 62, 63 of a second solenoid switch 64 and the contacts of the solenoid switch are connected by a line 65 to the other terminal of the battery. Thus the solenoid switch 58 can switch the motor on to run as a series motor and the solenoid switch 64 can bring into circuit the additional shunt winding 61 to reduce the motor speed. The solenoid windings of the switches 58 and 64 are connected on the one hand by a line 66 to the line 60 and one side of the battery and on the other hand by lines 67, 68 to the micro-switches 46, 45, respectively.

Connected to the same terminal of the battery as the line 53 there is a line 69 which extends through a fuse 47 and main switch 48 to a line 70 running to the circuit of the traction motor of the truck. There is also a line 71 to the other terminal of the traction motor which extends from the line 60 before-mentioned. The circuit of the traction motor does not here concern us but there is a branch 72 from the line 69 through a switch 73 to one terminal of the micro-switch 46. Similarly, there is a branch 74 from the line 67 to a terminal of the micro-switch 45. In operation, the micro-switch 45 is normally closed and the micro-switch 46 is normally open. The mechanical connections between the micro-switches and the levers will now be described, taking first the connections from the lever 36 so that the operation of the reach-mechanism can be followed out completely. Each of the levers 35, 36, 37 has a hub made of a rectangular piece of metal and the hubs are numbered in FIGURE 3, 75, 76, 77. Each of the levers proper is welded to its hub as can be seen in FIGURE 5, where the connection of the lever 35 to its hub 75 appears. The hub has an anti-friction bush 78 and rocks on the cross-bar 40 which extends between a fixed frame member 79 at one side of the apparatus and another frame-member (not shown) at the other side of the apparatus. Above the cross-bar 40 there is a cross-bar 80 and below it there is another cross-bar 81. The cross-bar 80 is secured in the frame-member 79 by a set-screw 82 and extends right across the apparatus to the second frame-member to which the bar 40 is attached at its right-hand end, as viewed in FIGURE 3. The cross-bar 81 is similarly secured by a set-screw 83 but does not extend right across the apparatus. On the contrary it is overhung and stops just short of the valve-operating member 42. On the cross-bars 80, 81 there are mounted rocking sleeves 84, 85 respectively. Immediately below the micro-switch 46 the sleeve 84 carries a depending plate 86 which has a lateral shelf 87 (best seen in FIGURE 4). The shelf 87 carries an adjustable tappet 88 which operates a sliding head 89 on the micro-switch 46. The head 89 is mounted on a cam-rod 90 which is urged downwardly by a spring 91 and which has a sloping cam face to engage the operating lever 92 of the micro-switch 46. Thus, if the sleeve 84 is rocked clock-

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wise, as viewed in FIGURE 4, it will operate the micro-switch. In a similar way the sleeve 85, which is below the crossbar 40, carries an upwardly extending plate 93 having a shelf 94 in which is a tappet 95 for operating the micro-switch 45. The plate 93 extends along the whole length of the rocking sleeve 85 and one corner of it is in front of a screwed stop 96 carried on the hub 76 below the bar 40. The stop 96 is seen in dotted lines in FIGURE 3 of the drawing and a similar stop 97 on the hub 75 appears in FIGURE 5 of the drawing. The effect of the screwed stop 96 is, if the lever 36 is rocked toward the front of the truck, to engage and tilt over the plate 93 on the rocking sleeve 85 and to operate the switch 45. On the rocking sleeve 84 there is a downwardly depending plate 98 which lies in front of the screwed stop 99 on the upper part of the hub 76 of the lever 36 and, if the lever is rocked towards the rear of the truck, the effect is to tilt the plate 98 and rock the sleeve 84 so that it operates the micro-switch 46 to close it. There is a further downwardly depending plate 100 on the rocking sleeve 84 which depends from it further than the plate 98 and can be engaged by a screwed stop 101 on the lower part of the hub 76 of the lever 36. The effect of the screwed stop 101 is to engage the plate 100 and rock the sleeve 84 when the lever 36 is moved toward the front of the truck for advancing the reach-jack 28 and thereby to close the micro-switch 46 at the same time that the valve plunger 136 is operated to move the reach jack in the direction to advance the mast to the front end of the truck. Thus, whether the lever 36 is moved forwardly or rearwardly, the micro-switch 46 is closed either by the stop 101, acting on the plate 100, or by the stop 99, acting on the plate 98, but in the event of the lever being moved further forward, the stop 96 also rocks the plate 93 and the rocking sleeve 85 and operates the micro-switch 45.

We are now in a position to consider the operation of the connections, which are shown in FIGURE 6. If the lever 36 is rocked forwardly, the micro-switch 46 will first be closed and on further movement the switch 45 will be opened. Consequently, current will follow through the line 69, fuse 47, switch 48, switch 73 and line 72 to the micro-switch 46, which, being closed, will energise the line 67 and the solenoid winding of the electro-magnetic switch 58 thereby closing the contacts 56, 57 and starting up the motor 39. If the micro-switch 45 is opened, the contacts 62, 63 will not be closed and the pump will run to a higher speed to advance the jack 28 at its full rate. If, on the other hand, the lever 36 is moved rearwardly to retract the jack 28 the stop 99 will act on the plate 98 to rock the sleeve 84 and close the micro-switch 46. At the same time the stop 96 on the hub 76 of the lever 36 will move away from the plate 93 and the micro-switch 45 will not be operated, but will remain closed and will energise the solenoid switch 64 and close the circuit of the shunt winding 61, thus ensuring that the motor runs at the lower speed, which is necessary on account of the smaller area of the piston of jack 28 on its retraction stroke. The shunt winding 61 is calculated to give the appropriate speed.

The lever 37 which operates the lift-jack 34 has on its hub two screwed stops 102, 103. The stop 102 rocks the plate 98 and operates the micro-switch 46 and the stop 103 rocks an upward extension 104 of the plate 93 and operates the micro-switch 45. If the lever 37 is moved rearwardly it will therefore operate both the micro-switch 45, 46 and the pump motor 39 can run at its highest speed for raising the ram of the jack 34 and lifting the forks 33. This is necessary on account of the higher capacity of this jack. On the other hand, if the lever 37 is moved towards the forward part of the truck, it will not operate either of the micro-switches, the pump will not work and the mast with its fork will be allowed to descend by gravity. As will be obvious, the lever 37

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operates a connecting rod 105 which operates a valve member 106.

The lever 35 has on its hub two stops, one of which 97 has already been referred to and the other of which is numbered 107. These appear in FIGURE 5 of the drawing and they both operate on the plate 100 which has previously been described. Therefore, they both serve to close the micro-switch 46, leave the micro-switch 45 untouched, and in whichever direction the lever 35 is moved, the motor will be operated at a slower speed. This lever is for operating the tilt-jack 31 by a connecting rod 108 and valve-member 109 and the tilting of the mast is therefore effected by a slow movement; this is desirable in either direction.

It will be apparent from the above that the mechanism shown enables any lever so to be interlocked with the micro-switches that the movement effected by its valve in either direction is a preferred rate. Thus the motor 39 is run automatically at the appropriate speed to produce a pump output which will cause the desired movements to be as required in either direction.

If it were desirable to retract more slowly than to advance, the motor speed control would be adjusted accordingly.

I claim:

1. A hydraulic system comprising a hydraulic pump, a plurality of devices connected in parallel to the pump for utilizing the pump output, a separate hydraulic control-valve in series with each device, levers for operating each control-valve, an electric motor for driving the pump, a motor-starting micro-switch and a motor-regulating micro-switch connected to the electric motor for starting the motor and for regulating the speed of the motor, two rock-shafts adapted to actuate the two micro-

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switches respectively, plates rigidly secured to the rock-shafts and tappets mounted on the control-valve levers to engage the plates so that the micro-switches are actuated by movement of the control-valve levers.

2. A hydraulic system as claimed in claim 1 wherein the control-valve levers are pivoted about an axis and wherein tappets are mounted on the levers above and below the axis so that the micro-switches are actuated by pivotal movement of the levers about the axis in both directions.

3. A hydraulic system comprising a hydraulic pump, a device for utilizing the pump output, a hydraulic control valve connected in series between the pump and said device, control-valve operating means, an electric motor for driving the pump, said motor having a field-modifying winding, an electro-magnetically actuated switch for bringing said field-modifying winding into operation, motor-starting switch-means actuated by said control-valve operating means and motor-regulating switch means also actuated by said control-valve operating means for controlling said electro-magnetically actuated switch to modify the motor speed.

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