

June 7, 1960

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2,939,283

SELF-CONTAINED POWER ACTUATOR

Filed Feb. 14, 1957

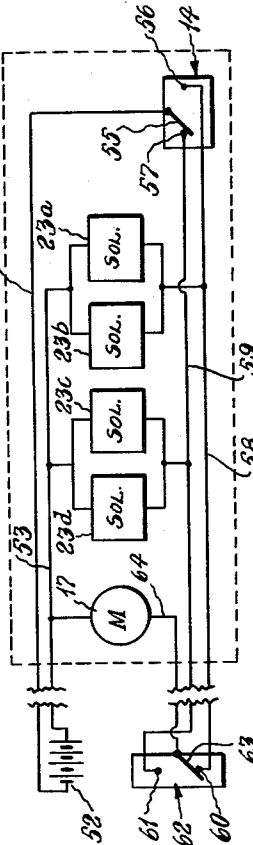
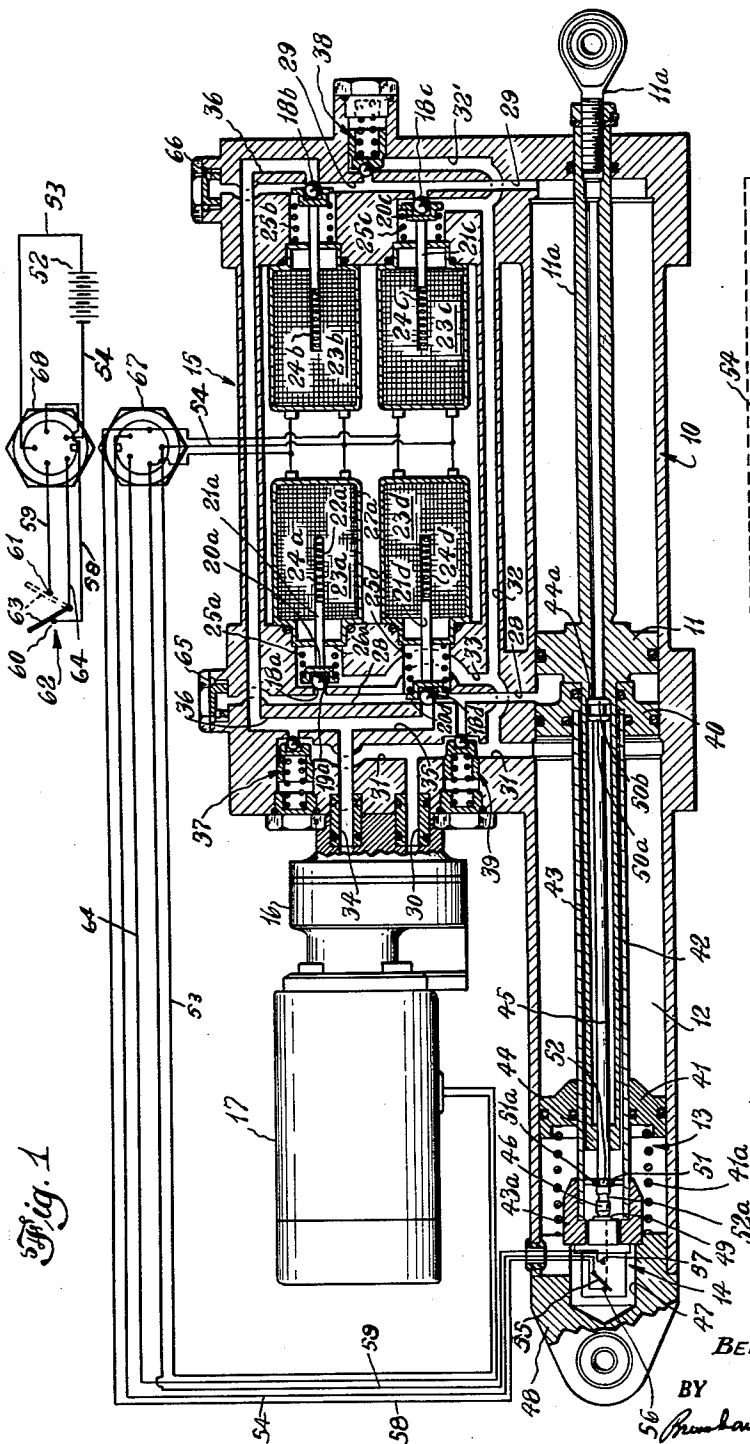


Fig. 2

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SELF-CONTAINED POWER ACTUATOR

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Filed Feb. 14, 1957, Ser. No. 640,124

6 Claims. (Cl. 60—52)

This invention relates to improvements in hydraulic actuators and more particularly to improvements in electromagnetically operated hydraulic actuators in which both electromagnetic and hydraulic components are incorporated in self-contained units.

Self-contained hydraulic actuators are used, for example, to operate control surfaces and other movable parts of airplanes, a number of actuators being provided for each plane. In this fashion, the planes are freed of extensive, complex networks of relatively delicate hydraulic tubing, the damaging of any part of which could possibly render an entire control system inoperative. Also, being controlled electrically, a large number of self-contained hydraulic actuators can be operated from one or more remote control centers without introducing prohibitive equipment bulk or weight at the centers. A representative self-contained hydraulic actuator is illustrated and described in U.S. Patent No. 2,672,731. The present invention represents an improvement in the form of simplification in both operation and construction of the actuator of said patent.

In accordance with the present invention an array of electromagnetically controlled selector valves are incorporated in a common housing with a hydraulic jack, a fluid reservoir, and a motor driven pump, all interconnected by ducts. The electrical control circuit is so arranged that the motor driven pump and the selector valves can be energized in either of two combinations of ways, depending upon the position the hydraulic jack is to assume. The cross-connected selector valves are so arranged that they are closed at all times, with electromagnetic means acting to relieve in part the spring forces normally imposed thereon. The pressure of the hydraulic fluid is utilized to overcome the spring forces remaining on the particular valves chosen for actuation by the control circuit. The jack and the electrical control system are coupled by a mechanical linkage which establishes the limit position for the jack, while the remote control switch means for initiating movement of the jack to either extreme is highly simplified to minimize remote wiring connections.

A representative embodiment of the invention in the form of a self-contained, electromagnetically controlled hydraulic actuator is described below having reference to the accompanying drawing in which:

Figure 1 is a view in side elevation partly broken away in vertical section, and also partly diagrammatic in form to show continuous duct paths in a common plane, of a hydraulic actuator; and

Figure 2 is a wiring diagram of the electromagnetic control circuit of the hydraulic actuator of Figure 1.

Referring to Figure 1, the hydraulic actuator formed in accordance with the present invention comprises a unitary housing assembly including a hydraulically driven motor such as a hydraulic jack 10, including a piston 11 and an output connecting rod 11a, a fluid reservoir or tank 12, including pressurizing means 13 and limit control

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switch means 14, a selector valve array 15, a hydraulic pump 16 and a motor 17.

The selector valve array 15 includes four valves 18a, 18b, 18c, and 18d, of which the former two are paired for complementary action as are the latter two. The actuating means for each of the four valves can be substantially identical, as shown, and only one actuating assembly is, therefore, described in detail. Like parts of the other valves are identified in part by like reference numbers modified, however, by appropriate sub-case letters. The valve 18a, which can take the form of a ball, is urged against its seat 19a, by a cup-shaped head 20a engaged by the outer end of a plunger 21a movable in and out of a core 22a of a solenoid winding 23a. The plunger 21a is urged outwardly of the core of the winding 23a by means of a compression spring 24a and also by means of a compression spring 25a compressed between the cup-shaped head 20a and the outermost surface 26a of the casing 27a for the solenoid.

The valves 18a and 18d are cross-connected by a duct 28 in opposed fashion so that positive hydraulic pressure in the duct will tend to unseat the valve 18a and seat the valve 18d. The valves 18b and 18c are similarly cross-connected by a duct 29, positive fluid pressure therein tending to seat the former and unseat the latter.

The pump 16 includes an inlet or suction connector 30 joined by a duct 31 to the fluid reservoir 12, by a duct 32 to the inner side of the valve 18c, and by a duct 33 to the inner side of the valve 18a (the duct 33 passing around the chamber of the valve 18d without connection thereto). The pump 16 has an outlet or pressure connector 34 connected by a duct 35 to the outer side of the valve 18d and by a duct 36 to the outer side of the valve 18b.

A pressure relief valve assembly 37 is provided between the ducts 31 and 35 to guard the pressure line against excessive pressure surges and a pair of thermal relief valve assemblies 38 and 39 are provided respectively between the ducts 29 and 32 and 28 and 31 to prevent excessive pressure rise due to thermal expansion of fluid on either side of the piston 11 in the cylinder of the jack 10. It will be observed that the duct 29 connects to the right hand side or out stroke space of the cylinder of the jack 10 whereas the duct 28 connects to the left hand or in stroke side. When the thermal relief valves 38 and 39 open, pressure is relieved via ducts 32 and 31, respectively, to the fluid reservoir 12.

The reservoir 12 is closed at its right hand end by a fixed barrier 40 and at its left hand end by means of a piston 41 urged to the right by a compression spring 41a. The piston 41 is slidably mounted on a fixed sleeve 42 joined to the barrier 40 at its right hand end and to a mounting fitting 43a for the limit switch means 14 at its left. Suitable seals are provided throughout to prevent the passage of fluid. The tank 12 thus acts as a pressurized reservoir in which fluid pressure is continuously maintained through the action of the spring 41a.

The piston 11 has connected to its right hand side the connecting rod 11a and to its left hand side a hollow tube or sleeve 43 which passes slidably through the fixed barrier 40 in fluid tight relationship of terminate within the sleeve 42 in an apertured, shouldered head 44. The sleeve 43, which is concentrically and slidably received within the fixed sleeve 42, receives in turn a switch-actuating rod 45 having a head 46 for operating the limit switch means 14. The limit switch means 14 can take the form of a double-throw push button switch having one pair of contacts, as described below, normally closed by spring action and another pair normally open. The switch 14, which is carried by the fitting 43a, is received in a chamber 47 in an end cap 48 for the pressurizing means 13 and includes a push button 49 adapted to be

engaged by the head 46 of the rod 45 to close its normally open contacts when the jack 10 is disposed in its in-stroke position as shown in the drawing.

The rod 45 includes a pair of closely spaced flanges 50a and 50b at its right hand end, the latter of which is adapted to be engaged by a shoulder 44a formed on the inside right hand end of the slidable sleeve 43 when the jack is in its in-stroke position (as shown). The shoulder 50a is adapted to be engaged by the shouldered head 44 on the inside left hand end of the sleeve 43 when the jack is moved to its out-stroke position, thereby to shift the rod 45 to the right to release the push button 49 of the switch 14, reversing the contacts thereof. The rod 45 is held releasably in either of its two positions by a pair of locking wires 51, 51a which are strung across the tube 42 and engage releasably in the grooves 52, 52a to retain it in either of two positions. The wires 51, 51a and the grooves 52, 52a serve as spring detents to retain the rod in either switch plunger depressing position when the wires engage in groove 52 as shown in Figure 1 or switch releasing position when the wires 51, 51a engage in the groove 52a.

In order to remove air from the system a pair of bleed plugs 65 and 66 are respectively connected to the ducts 28 and 29, thereby protecting both the out-and-in-stroke spaces of the cylinder of the hydraulic jack 10.

Referring, in particular, to the wiring diagram of Figure 2, there is shown a suitable source of electrical power such as a battery 52, one terminal of which is connected by a conductor 53 to one terminal of the motor 17 and to one terminal of each of the four solenoid windings 23a, 23b, 23c, and 23d, and other terminal of which is connected by a conductor 54 to the movable contact 55 of the double-throw push button-type limit switch means 14. The limit switch means 14 includes a stationary contact 56, to which the movable contact 55 is normally biased by the inherent spring pressure, and a second fixed contact 57 to which the movable contact 55 is forced by the action of the switch actuating rod 45 on the push button 49 (Figure 1). The fixed contacts 56 and 57 of the switch means 14 are connected by conductors 58 and 59 respectively to fixed contacts 60 and 61 of a remote control switch 62 which can take the form of a simple double-throw toggle switch. The conductor 58 is also connected to the second terminals of the solenoid windings 23a and 23b and the conductor 59 is also connected to the second terminals of the solenoid windings 23c and 23d. The double-throw toggle switch 62 includes a movable contact 63 connected by a conductor 64 to the second terminal of the motor 17 which, it will be recalled, drives the hydraulic pump 16.

In operation, assuming the hydraulic jack 10 to be disposed at its in-stroke extreme, as indicated in the drawing, in which the contacts 60 and 63 of the toggle switch 62 are closed and contacts 55 and 57 of the push button switch 14 are also closed, action is initiated to drive the piston 11 to the right by throwing the movable contact 63 of the toggle switch 62 to the contact 61 to complete a circuit across the terminals of the motor 17 and across the terminals of the solenoid windings 23c and 23d. The plungers 21c and 21d are thus drawn into their corresponding solenoid windings against the action of the compression springs 24c and 24d, respectively. The valves 18c and 18d remain urged against their seats only by the action of the second compression springs 25c and 25b acting on the cup-shaped, ball-engaging members 20c and 20d, respectively, the plungers 21c and 21d having been withdrawn from the cup-shaped members.

The gear pump 16, driven by the energized electric motor 17 sucks fluid from the reservoir 12 through the duct 31 and the inlet connector 30 and delivers it through the pressure connector 34 to the ducts 35 and 36. The fluid pressure opens the valve 18d, which has been relieved of part of its spring biasing pressure, but does not open the valve 18b (to which the duct 35 also communicates)

because the latter valve is held closed by the combined forces of the springs 24b and 25b. The opening of the valve 18d admits fluid under pressure to the inner or left hand side of the piston 11 through the duct 28, driving the piston to the right. The fluid disposed on the outer or right hand side of the piston 11 is forced through the duct 29 against the unseating side of the valve 18c, which it will be recalled, has been relieved of part of its spring closing force due to the energization of the solenoid winding 23c. The opening of the valve 18c establishes a flow of fluid through the duct 32 to the duct 31 and back to the suction connector 30 of the operating pump 16. Extra quantities of fluid can flow to the reservoir via the duct 31 or a deficiency can be made up from the reservoir.

At the end of the out-stroke of the piston 11, the shouldered head 44 on the sliding sleeve 43, which moves with the piston 11, engages the shoulder 50a on the switch actuating rod 45 and moves it to the right to release the push button 49 of the limit switch means 14. This results in movement of the contact 55 of that switch from the contact 57 to the contact 56 to deenergize the motor 17 as well as the solenoid windings 23c and 23d.

The hydraulic jack 10 will, therefore, remain in its extended position until such time as the toggle switch 63 is thrown back to the contact 60 to energize the motor 17 and the solenoid windings 23a and 23b through the then closed contacts 55 and 56 of the double-throw push button switch 14. The pressure in the duct 36 is then able to lift the valve 18b, because the force of the spring 24b has been relieved therefrom, to direct a flow of fluid under pressure through the duct 29 to the out-stroke side of the piston 11 driving it to the left. Movement of the piston 11 to the left drives the fluid on that side of the piston through the duct 28 to the unseating side of the valve 18a which, relieved of part of its spring closing pressure, unseats to pass the fluid flow through the duct 33 to the duct 31 from which point it flows, as needed, to the suction connector 30 of the pump 16. Surplus fluid can return to the reservoir through the duct 31 or a deficiency obtained from the reservoir through the same duct. Movement of the jack continues until such time as the shoulder 44a of the right hand end of the sleeve 43 engages shoulder 50b on the push rod 45 to force its head 46 against the push button 49 to close the contacts 55 and 57 of the switch 14 to deenergize the motor 17 and the solenoid windings 23a and 23b, thereby conditioning the system for the next action of the toggle switch 62.

It will be understood, therefore, that a highly simplified self-contained hydraulic actuator is provided in accordance with the invention which can be remotely controlled by means of a simple double-throw toggle switch and in which the valve action is controlled partly hydraulically and partly electromagnetically. It will be understood also that the installation of the hydraulic actuator requires, in addition of course to the physical attachment of the actuator frame adjacent the movable part to be driven thereby, only the connection of an electrical cable through suitable fittings 67 and 68. This cable need include only five wires, two from the power source 52 and three from the remote control toggle switch 62.

The general arrangement of the elements of the hydraulic actuator can be modified to conform to the conditions under which it is used and it can be made in various sizes and forms without departing from the invention, which should not, therefore, be regarded as limited except as defined by the following claims.

I claim:

1. In a hydraulic actuator, a hydraulically driven motor, and means to establish a fluid pressure differential across the motor comprising, a source of fluid pressure differential, first and second ducts respectively connecting the same side of said source to opposite sides of said motor, first and second selector valve means dis-

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posed respectively in the first and second ducts, each selector valve means including at least two mutually independent spring means to close the valve against the fluid pressure differential, and control means to selectively release one of the spring means from either one of the valves to enable that valve to be opened by the pressure differential.

2. A hydraulic actuator as set forth in claim 1, each of said valves comprising a movable valve member, said first spring means urging the valve member to its closed position, a plunger to detachably engage the valve member, said second spring urging the plunger toward the valve to close the latter, and a solenoid winding to urge the plunger away from the member.

3. A hydraulic actuator as set forth in claim 1, including third and fourth duct means respectively connecting the other side of the pressure differential source to opposite sides of the motor, third and fourth selector valve means disposed respectively in the third and fourth duct means, each selector valve means including at least two mutually independent spring means to close the valve against the fluid pressure differential, said control means being operative to selectively release one of the spring means from either the first and third valve means or the second and fourth valve means to enable fluid under pressure to pass in either of two directions through the motor.

4. A hydraulic actuator as set forth in claim 3, said means to establish the source of pressure differential including a pump and said hydraulically driven motor comprising a cylinder and piston, means to energize the pump, and means responsive to completion of a stroke of the piston to deenergize the pump and to reapply the released spring means.

5. A hydraulic actuator as set forth in claim 4, each of said four valve means comprising a movable valve member, said first spring means urging the valve mem-

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ber to its closed position, a plunger to detachably engage the valve member, said second spring urging the plunger toward the valve to close the latter, and a solenoid winding to urge the plunger away from the member.

6. In a hydraulic actuator, a hydraulically driven motor, and means to establish a fluid pressure differential across the motor comprising a source of fluid pressure differential, first and second ducts respectively connecting the same side of said source to opposite sides of said motor, first and second selector valve means disposed respectively in the first and second ducts, third and fourth duct means respectively connecting the other side of the pressure differential source to opposite sides of the motor, third and fourth selector valve means disposed respectively in the third and fourth duct means, each of said selector valve means including double spring means to close the valve against the fluid pressure, and control means to selectively relieve the pressure of one of the spring means from either said first and third valve means and either the second and fourth valve means to enable those valve means having spring pressure relieved thereon to be opened by the fluid pressure differential.

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