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REMOTELY OPERATED HYDRAULIC SERVOMOTOR

Filed Sept. 17, 1947

3 Sheets-Sheet 1

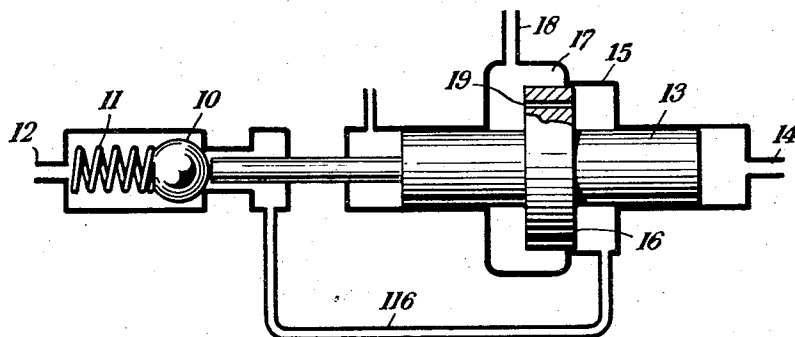


Fig. 1.

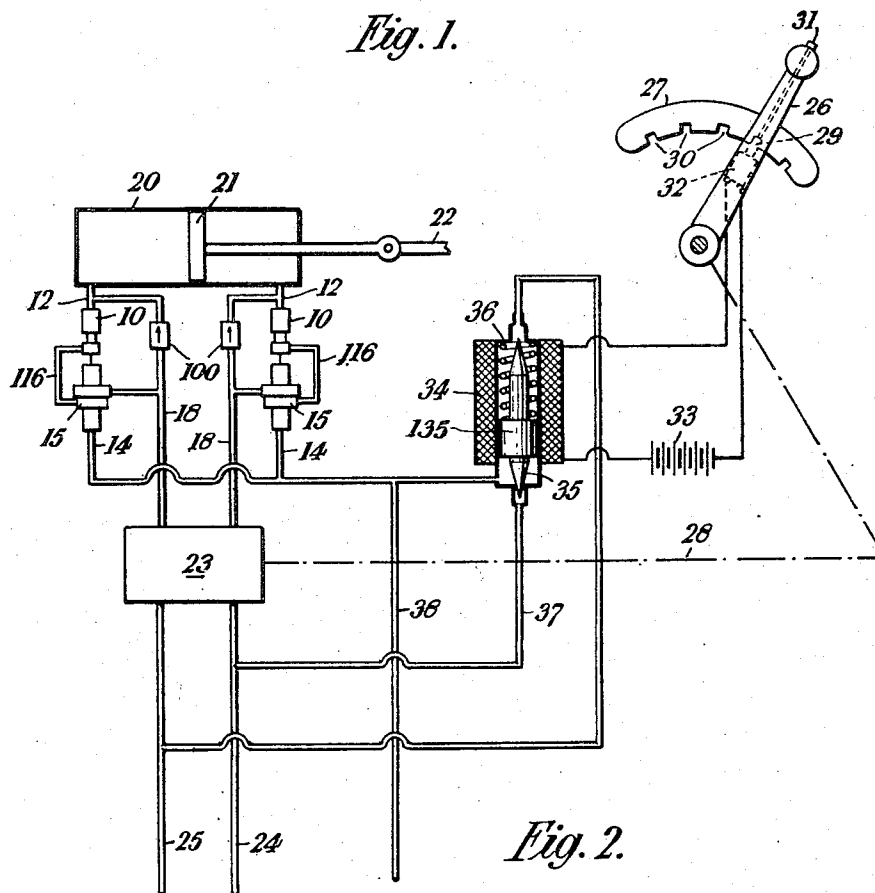


Fig. 2.

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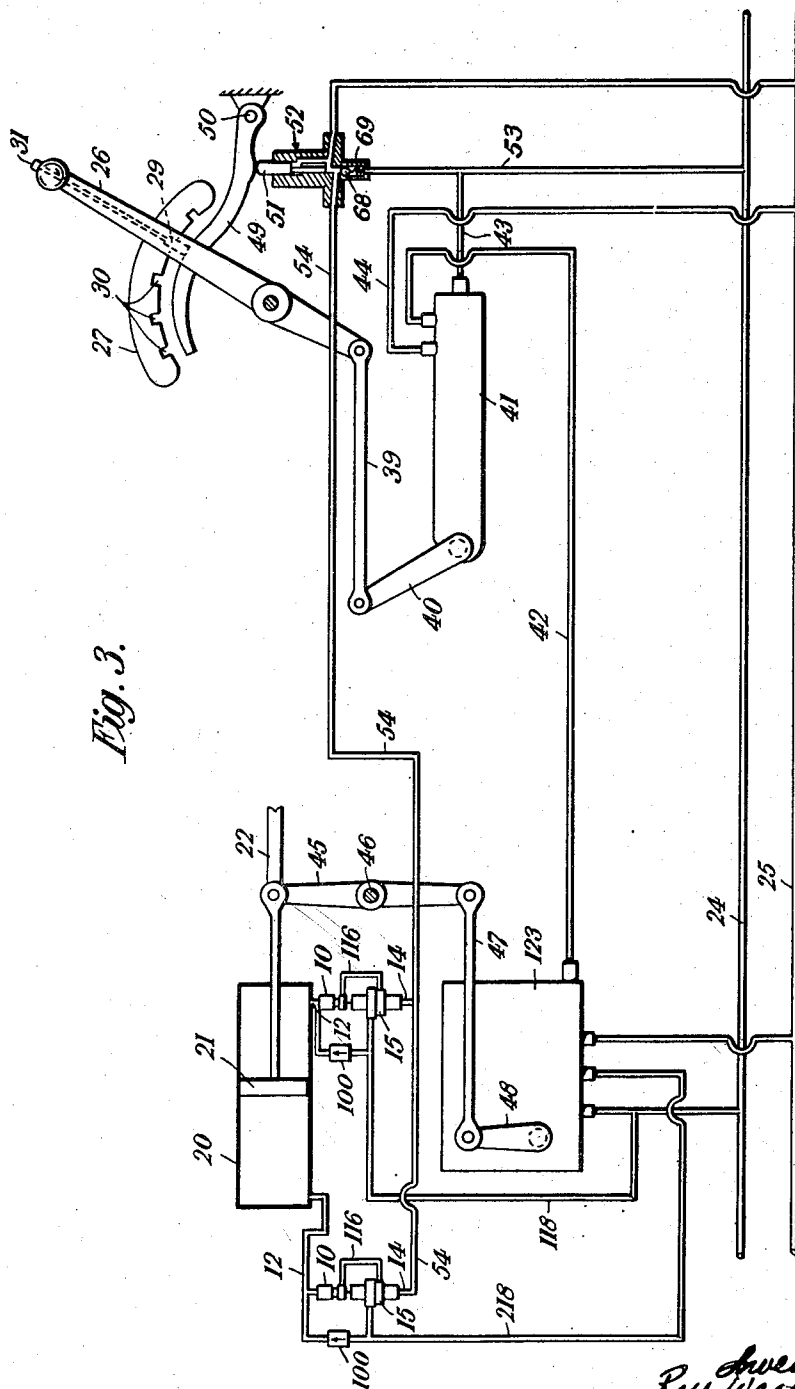
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3 Sheets-Sheet 3

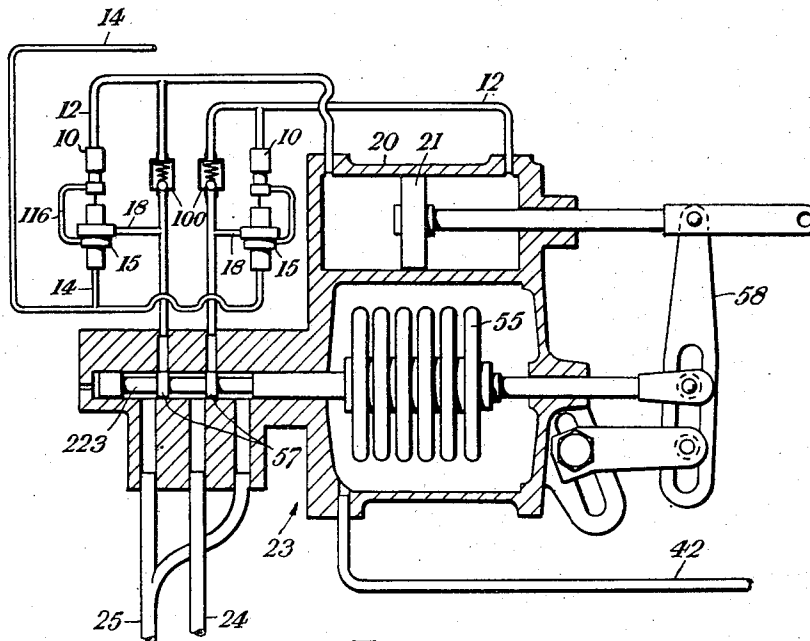


Fig. 4.

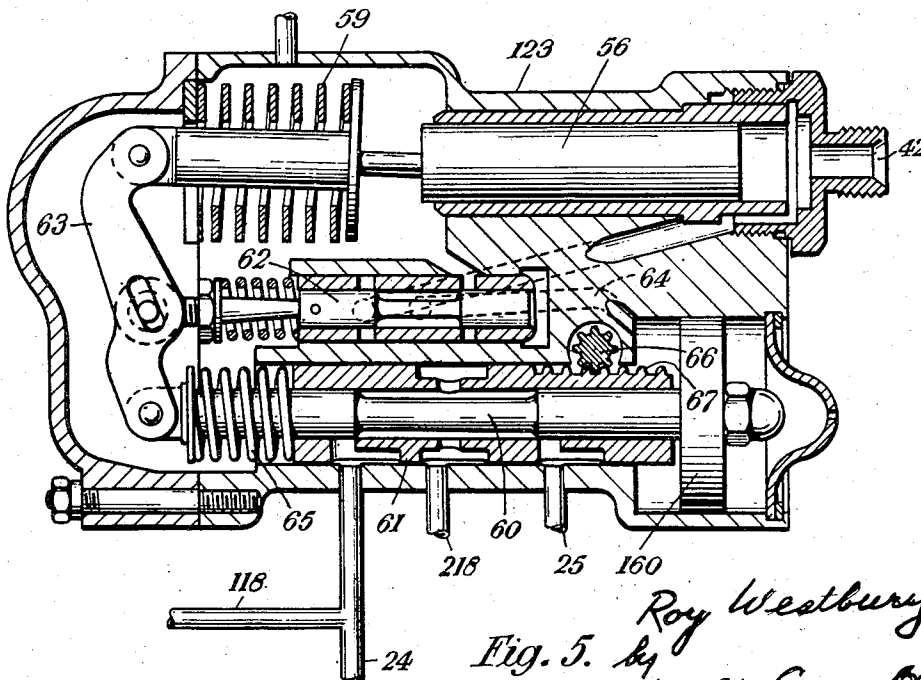


Fig. 5. by
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UNITED STATES PATENT OFFICE

2,563,295

REMOTELY OPERATED HYDRAULIC
SERVOMOTOR

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11 Claims. (Cl. 121—40)

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This invention relates to hydraulically operated servomotors, of the kind comprising a servo cylinder and associated piston, a control valve operable by variations in fluid pressure established in a signal line between the control valve and a sender unit having an operating member which can be adjusted to control the pressure in the signal line, the control valve normally occupying a neutral position in which the servo piston is maintained at rest in its cylinder but moving, in response to variations in pressure in the signal line, to cause relative movement of the servo piston and cylinder, said movement being terminated by return of the control valve to neutral position when the piston has attained a position in relation to the cylinder determined by the pressure in the signal line.

Such servomotors have been used for operating the landing flaps of aircraft, and it is known to provide hydraulic locks for positively locking the flap in the position to which it has been set, such locks consisting of non-return valves placed in the pipes leading from the control valve to the servo cylinder and normally arranged to permit liquid to flow only from the valve to the cylinder. Each non-return valve is under the control of a small lock piston, and when pressure is applied to the pipe line connecting the control valve and one end of the servo cylinder, tending to move the piston towards the other end of the cylinder, this pressure is also applied to the lock piston associated with the non-return valve in the pipe leading from the other end of the cylinder to the control valve. This lock piston is then displaced into position to hold the non-return valve open, thus permitting the servo piston to move in its cylinder.

A hydraulic lock of this kind provides irreversibility and safeguards the aircraft against accidental rapid movement of the flap should a failure occur in the pipe line by which operating pressure is supplied from the control valve to the servo cylinder. Being fully automatic, it does not, however, guard against a fault in the signal line. Should the sender unit, due to such a fault, fail to select the correct position of the control valve, the non-return valves will automatically be opened by reason of movement of the control valve from neutral position, thereby allowing the flap to move to the wrong position. Furthermore, the above form of lock is not applicable to the three-line system of servomotor in which the minor side of the servo piston is always subjected to pressure, the major side being connected to

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pressure or exhaust according to the control valve position.

An object of this invention is to provide a hydraulic servomotor of the above kind in which the servo piston cannot be set to a wrong position in relation to its cylinder by reason of a fault in the signal line, and in which the lock will only open to allow of displacement of the servo piston in its cylinder in response to actuation of the operating member.

A further object is to provide a hydraulic servomotor of the above kind in which hydraulic pressure to free the lock is supplied only on movement from operative position of a retaining device for holding the operating member in set position.

Premature release of the retaining device to allow the same to return to operative position after the operating member has been moved to a position selecting a new position of the servo piston in its cylinder, would release the hydraulic lock and so prevent the servo piston from reaching the newly selected position. A further object of the invention therefore is to provide for immediate opening of the hydraulic lock on actuation of the retaining device, and to prevent closing of the lock until the servo piston has ceased to move as a result of return of the control valve to neutral position.

The invention will now be described in detail, by way of example, with reference to the accompanying drawings, in which—

Fig. 1 is a diagrammatic detail view of the hydraulic lock, showing the non-return valve and associated lock piston,

Fig. 2 is a diagram showing the application of the hydraulic lock to a four line remote control system for an aircraft flap,

Fig. 3 is a diagram showing the application of the hydraulic lock to a three line remote control system for an aircraft flap, and

Figs. 4 and 5 are respectively sections through the control valves of the servomotors shown in Figs. 2 and 3.

Like reference numerals designate like parts throughout the figures.

Referring first to Fig. 1, each hydraulic lock comprises, in association with a ball valve 10, loaded by a spring 11 and oriented so as to prevent liquid from flowing out of the servo cylinder through a conduit 12, a lock piston 13 which is movable, to the left as seen in Fig. 1, to open the ball valve 10 when lock control pressure is applied to its right hand end through a conduit 14. Liquid can then flow, in the case of the lock

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on the outlet side of the servo cylinder, through the open ball valve 10 and a pipe 116 into a cylinder 15 surrounding the piston 13. Forward movement of the piston to open the ball valve causes a large diameter section 16 of the lock piston, fitting this cylinder 15, to open communication between the rear end of this cylinder and an annular space 17 communicating with a pipe 18 leading to the servo control valve. Free movement of the servo piston is thus permitted.

On release of the lock control pressure on the right hand end of the lock piston 13, the ball valve 10 cannot close, so long as liquid is flowing from the cylinder 15 to the annular space 17, since the pressure difference across the larger section 16 of the lock piston will retain the same in position to maintain open the communication between the cylinder and annular space. When however the flow of liquid ceases, due to closing of the control valve, the ball valve 10 will reseal under the pressure of its spring 11, an orifice 19 being provided in the larger section 16 of the lock piston to allow of leakage of liquid from one side to the other as it is returned by the ball valve spring 11 to the initial position illustrated in which it cuts off communication between the cylinder 15 and annular space 17.

A lock of this character possesses therefore the desirable property that the non-return valve 10 will not close immediately the lock control pressure is relieved, unless in the meantime the servo piston has reached the end of its permitted travel. The non-return valve remains open until the servo piston movement has ceased.

Fig. 2 shows the application of the hydraulic lock of Fig. 1 to a four line system for the remotely controlled operation of an aircraft flap.

In this figure the servo cylinder is shown at 20, the servo piston is shown at 21, and a link 22 transmits the movement from the servo piston, in conventional fashion, to the flap, not shown. 23 is a control valve which is movable in known manner to connect pipes 18 alternatively to pressure and exhaust lines 24, 25 respectively. The control valve 23 is remotely controlled from a pilot's lever 26, movable over a quadrant 27, by a fluid pressure operated remote control system of the kind described in British patent specification No. 483,049. This system embodies a sender unit operable under control of the lever 26 to establish a variable signal pressure in a line 42 shown in Fig. 4. The sender unit of the remote control system is not shown in Fig. 2 but may be of the same type as sender unit 41 of Fig. 3. As shown in Fig. 4, the valve member 223 of control valve 23 normally occupies the neutral position illustrated, in which its lands 57 interrupt communication between the conduits 12, the pressure line 24 and the exhaust line 25. The right hand end of the valve member 223 is connected to a capsule 55 exposed to the pressure in the signal line 42 and connected at its other end, by a follow-up link 58, to the piston rod of the servo piston 21. If the pressure in the signal line 42 increases, the bellows 55 collapses drawing the valve member 223 to the right, and so connecting to pressure line 24 the conduit 12 leading to the right hand end of the servo cylinder and connecting the other conduit 12 to exhaust line 25. If the change in pressure in signal line 42 is due to a fault, the non-return valves 10 will remain closed and the servo-piston 21 will be unable to move in its cylinder despite movement of the valve member 223 away from neutral position. Provided, however, the change

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in pressure in signal line 42 arises as the result of operation of the pilot's lever 26 to select a new flap position, the non-return valves 10 will be opened, as later described, and in response to the above-described movement of the valve member 223 to the right the servo piston 21 will move to the left in its cylinder until the follow-up link 58 has moved the valve member 223 back to neutral position. It will be readily seen that on movement of the pilot's lever 26 to a position selecting a lower signal line pressure, the bellows 55 will expand, moving the valve member 223 to the left and causing the servo piston 21 to move to the right in its cylinder until the follow-up link 58 has returned the valve member 223 to neutral position.

It will be noted that a hydraulic lock of the kind shown in Fig. 1 is shown in Fig. 2 between each of the pipes 18 and the associated conduit 12, the parts of the hydraulic locks in Fig. 2 being denoted by the same references as in Fig. 1 can be readily identified. In parallel with each hydraulic lock is a non-return valve 100 which opens to allow pressure fluid to flow directly from pipe 18 to conduit 12, when the associated pipe 18 is connected to the pressure line 24 by the control valve 23. Each valve 100, however, remains closed when fluid is flowing from the servo cylinder 20 through the associated conduit 12.

The pilot's lever 26 has a ratchet tooth 29 which engages one of a number of notches 30 in quadrant 27 to retain the lever 26 in adjusted position. When a button 31 is depressed to release the ratchet tooth 29, a switch 32 is closed to complete a circuit from battery 33 to a solenoid 34. Energisation of the solenoid causes a normally closed valve 35 to lift, against a spring 36, to allow lock pressure to flow to the inlets 14, from pressure line 24, over line 37. A line 38 then supplies lock pressure to the hydraulic locks associated with a flap on the other wing of the aircraft. As already explained, the lever 26 may be moved rapidly to its new position and despite the return of the ratchet tooth 29, by a spring (not shown) to engage the newly selected notch 30, and consequent opening of switch 32, de-energisation of solenoid 34, closure of valve 35 and removal of lock pressure from the inlets 14, the non-return valve 10 will not close until the servo piston 21 has ceased to move in its cylinder by reason of its having attained its new position and closed the control valve 23 through the agency of the follow-up link. The plunger 135 of valve 35 is loose in the solenoid 34 so that liquid may flow from line 14 to exhaust line 25 after the valve 35 has closed.

Fig. 3 shows the application of the hydraulic locks to a three line system of the kind described in United States application Serial No. 685,594. The pilot's lever 26 operates, through link 39, on the control lever 40 of a sender unit 41 which, according to the position of lever 26, establishes as described in said application a variable signal pressure in a signal line 42 communicating with a receiver unit 123. The pressure inlet to the sender unit is shown at 43 and the exhaust outlet at 44. The line 113 normally connects the minor side of the servo piston 21 to pressure, since the associated non-return valve 100 will normally be open. The line 118 leading to the other end of the servo cylinder is connected alternatively to the pressure line 24 or the exhaust line 25, on movement from neutral position of a control valve in the receiver unit 123 in accordance with

variations in the signal pressure in line 42, all as fully described in United States application Serial No. 685,594. The follow-up linkage, for returning the control valve to neutral position, when the servo piston 21 has assumed the selected position, is constituted by a lever 45, pivoted centrally at 46, a link 47 and a lever 48.

The receiver unit 123 is shown in Fig. 5 but will be described but briefly herein as it is fully described in U. S. application Serial No. 685,594. It comprises a piston 56, balanced against the pressure in the signal line 42 by a spring 59, a control valve for the servomotor constituted by a piston-valve 60 and associated sleeve 61, and a relay valve 62. As fully described in the above-noted application, movement of the piston 56 in response to variations in signal line pressure effects, through a link 63, movement of a relay valve 62 in the same direction to connect a conduit 64 either to exhaust or to signal line pressure. If the signal line pressure increases, the relay valve 62 moves to the left to supply, via conduit 64, signal pressure to the left hand face of a piston 160 fixed to the piston valve 60, moving valve 60 to the right against a spring 65. This connects line 218 to the exhaust line 25 and causes movement of the servo piston 21 to the left as seen in Fig. 3. The follow-up link 48 (Fig. 3) rotates a pinion 66 (Fig. 5) coacting with a rack 67 on the sleeve 61, moving the sleeve 61 in the same direction as the valve 60 to cut-off line 218 from the exhaust line 25 when the servo piston 21 has reached the newly selected position. When the pressure in the signal line 42 is reduced, the relay valve 62 connects the left hand face of piston 160 to exhaust, and the piston valve 60 is moved, by its spring 65, to the right. This connects line 218 to the pressure line 24 and causes servo-piston 21 to move to the right as seen in Fig. 3, the movement ceasing when the follow-up gear has moved sleeve 61 (Fig. 5) sufficiently to the left to cut off line 218 from the pressure line 24.

When the button 31 (Fig. 3) is depressed, it rocks an arm 49 clockwise about a pivot 50 to depress the tappet 51 of a pilot valve 52, thereby moving down a ball 68 against the action of a spring 69. This allows pressure fluid to flow from the pressure line 24, through lines 53, 54 to apply lock pressure to the inlets 14. When the pressure on button 31 is released, and the ratchet tooth 29 engages a new notch 30, the spring 69 in the valve 52 lifts tappet 51 and arm 49 to their initial positions and the ball 68 is likewise lifted to cut off the lock pressure. As already explained the non-return valves 10 do not, however, close until the servo piston 21 has completed its movement.

When the lever 26 is moved so as to cause the control valve 123 to connect line 218 to the pressure line 24, the associated non-return valve 100 opens to apply pressure to the left hand face of the servo piston 21. As the servo piston moves to the right, the normally open non-return valve 100 associated with line 118 closes. However, before lever 26 can be so moved, the button 31 must have been depressed so supplying, through valve 52, pressure to line 54 to the inlets 14 to open both non-return valves 10 as already described. Notwithstanding, therefore, that the right hand non-return valve 110 closes as the servo piston 21 moves to the right, the right hand non-return valve 10 remains open to allow liquid to be expelled from the right hand end of the cylinder 20 to line 118. As already noted, this valve 10 is unable to close despite release of pressure on the

button 31, until the movement of the servo piston ceases. The valve 100 reopens when the movement of the servo piston has ceased, thus once more connecting the minor side of the servo piston to pressure. Similarly, when the lever 26 is moved to cause the control valve 123 to connect the line 218 to the exhaust line 25, the left hand valve 100 will close as liquid seeks to flow out of the left hand end of the cylinder to line 218 as the piston 21 tends to move to the left under the pressure supplied to it from line 118 through right hand valve 100. Left hand valve 10 is open at this time, due to the application of lock pressure to line 54, so allowing liquid to flow out of the cylinder to line 218, and remains open, as already explained, until the movement of the piston 21 ceases.

While the locking devices according to the invention have been primarily described with reference to hydraulic servomotor for operating flaps, they are equally applicable in any other installations in which a remotely located hydraulic servomotor is controlled from a distant sender unit by variations in pressure in a pipe line connecting the sender unit with a receiver unit associated with the control valve of the servomotor.

What I claim as my invention and desire to secure by Letters Patent is:

1. In a hydraulic servomotor comprising a servo cylinder, a servo piston in the cylinder, an output member operable by relative movement of the servo piston and servo cylinder, a control valve responsive to fluid pressure in a signal line, a remote manual operating member for establishing a variable fluid pressure in the signal line, said control valve normally occupying a neutral position, in which it prevents movement of the servo piston in relation to the cylinder, but responding to change in said variable fluid pressure to cause relative movement between said servo piston and cylinder to move the output member to a position determined by the pressure in the signal line, the combination with hydraulic locks for normally preventing relative movement of the servo piston and servo cylinder, of a fluid pressure operated remote control system controlled by said operating member and independent of said signal line, said remote control system operating, on actuation of said operating member to change the fluid pressure in said signal line, to release said hydraulic locks.

2. In a hydraulic servomotor comprising a servo cylinder, a servo piston in the cylinder, a control valve responsive to fluid pressure in a signal line, a remote manual operating member for establishing a variable fluid pressure in the signal line, said control valve normally occupying a neutral position, in which it prevents movement of the servo piston in relation to the cylinder, but responding to change in said variable fluid pressure to cause sympathetic movement of said servo piston in relation to said servo cylinder to an extent determined by the change in said variable fluid pressure, the combination with a pair of non-return valves each controlling and normally closing a conduit constituting the sole outlet for liquid from one end of the servo cylinder, of a lock piston associated with each non-return valve, a pressure conduit independent of the signal line and a valve operating, on actuation of the operating member to change the fluid pressure in said signal line, to supply lock-releasing hydraulic pressure through said pressure

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conduit to both lock pistons to cause them to open their associated non-return valves.

3. A hydraulic servomotor as claimed in claim 2, wherein each lock piston comprises a portion of smaller cross section to receive the hydraulic lock-releasing pressure, and a portion of larger cross section movable in a housing forming part of the associated outlet conduit from the servo cylinder and located in said outlet conduit beyond the associated non-return valve, each lock piston being normally retained by its non-return valve in position to seal said outlet conduit but being movable, when subject to hydraulic lock-releasing pressure not only to open its associated non-return valve, but also to permit of restricted flow of liquid through said housing past its larger portion, said restricted flow of liquid past said larger portion of said lock piston maintaining said lock piston in moved position, notwithstanding removal of said lock releasing pressure, until said flow of liquid has ceased.

4. A hydraulic servomotor as claimed in claim 2, comprising a retaining device for retaining said operating member in any position to which it has been moved, and means controlled by said retaining member and operable, on movement of said retaining member to position to free said operating member, to open said valve to supply hydraulic pressure to said pressure conduit.

5. A hydraulic servomotor as claimed in claim 2, comprising a retaining device for retaining said operating member in any position to which it has been moved, a solenoid operatively associated with the valve for supplying hydraulic pressure to said pressure conduit, and a switch operable by movement of the retaining device to the free position to energise said solenoid and thereby to open said valve.

6. In a fluid pressure operated remote control system comprising a servo cylinder, a servo piston in said servo cylinder, a pair of conduits, each allowing liquid to flow to and from one end of said servo cylinder, a non-return valve in each of said conduits which normally prevents liquid from flowing out of said cylinder through its conduit, a control valve normally occupying a neutral position in which said control valve seals both said conduits, a remote operating member, a signal line, a sender unit for maintaining in said signal line a fluid pressure corresponding to and determined by the position of said operating member, said control valve being movable in response to changes in the fluid pressure in said signal line to establish in said conduits a differential hydraulic pressure and thereby to cause relative movement of said servo piston and servo cylinder in a direction determined by the direction of movement of said control valve from neutral position, said control valve returning to neutral position on arrival of said servo piston at a position in relation to said servo cylinder determined by the fluid pressure in said signal line, the combination with said non-return valves of a pair of lock pistons, one associated with each of said non-return valves, a lock pressure conduit for supplying operating fluid pressure to said lock pistons, a valve normally closing said lock pressure conduit and mechanism operable by said operating member to open said valve to apply pressure through said lock pressure conduit to said lock pistons and thereby to open said non-return valves.

7. In a hydraulic servomotor, comprising a servo cylinder, a servo piston in said servo cylinder, an output member operable by relative

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movement of said servo piston and servo cylinder, a control valve which normally occupies a neutral position in which it prevents said servo piston from moving in relation to said servo cylinder, a manual operating member which is operable to displace said control valve from neutral position and thereby to cause relative movement of said servo piston and servo cylinder to move said output member to a position determined by said operating member, the combination with locks for normally preventing movement of said servo piston in relation to said servo cylinder of a manually operable retaining device for retaining said operating member in any position to which it has been moved, and lock-releasing means, operable by movement of said retaining device into position to release said operating member for movement, to release said locks to allow movement of said servo piston in said servo cylinder.

8. In a hydraulic servomotor comprising a servo cylinder, a servo piston in said servo cylinder, an output member operable by relative movement of the servo piston and servo cylinder, a control valve responsive to fluid pressure in a signal line, a remote manual operating member for establishing a variable fluid pressure in the signal line, said control valve normally occupying a neutral position, in which it prevents movement of the servo piston in relation to the cylinder, but responding to change in said variable fluid pressure to cause relative movement between said servo piston and cylinder to move the output member to a position determined by the pressure in the signal line, the combination with a pair of non-return valves each controlling and normally closing a conduit constituting the sole outlet for liquid from one end of said servo cylinder, a pair of lock pistons one associated with each of said non-return valves, each lock piston being operable by hydraulic pressure to open its associated non-return valve, a pressure conduit, a source of hydraulic pressure, a valve normally shutting off said source from said pressure conduit so that said lock pistons are deprived of lock-releasing pressure, a manually operable retaining device for retaining said operating member in any position to which it has been moved, and an operative connection between said retaining device and said valve operable, by movement of said retaining device to free said operating member, to actuate said valve to connect said pressure conduit to said source.

9. A hydraulic servomotor as claimed in claim 8, wherein said operative connection comprises a solenoid associated with said valve and a switch, operable by movement of said retaining device to the free position to energise said solenoid and thereby to actuate said valve.

10. A hydraulic servomotor as claimed in claim 8, wherein each lock piston comprises a portion of smaller cross section to receive the hydraulic lock-releasing pressure, and a portion of larger cross section movable in a housing forming part of the associated outlet conduit from the servo cylinder and located in said outlet conduit beyond the associated non-return valve, each lock piston being normally retained by its non-return valve in position to seal said outlet conduit but being movable, when subject to hydraulic lock-releasing pressure, not only to open its associated non-return valve, but also to permit of restricted flow of liquid through said housing past its larger portion, said restricted flow of liquid past said larger portion of said lock piston maintaining

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said lock piston in moved position notwithstanding removal of said lock-releasing pressure, until said flow of liquid has ceased.

11. A hydraulic servomotor, comprising a servo cylinder, a servo piston in said servo cylinder, conduits communicating with opposite ends of the servo cylinder, a control valve movable in opposite directions from neutral position to connect said conduits alternatively to pressure and exhaust and thereby to effect relative movement of the servo piston and cylinder, a non-return valve in each conduit orientated so as to normally prevent liquid from flowing out of the cylinder through the conduit, a lock piston associated with each non-return valve and operable to open said non-return valve when subject to hydraulic lock pressure, each lock piston comprising a section of smaller diameter to receive the hydraulic lock pressure and a section of larger diameter movable in, and normally preventing the flow of liquid through, a cylinder forming part of the associated conduit and located on the side of the non-return valve remote from the servo cylinder, each of said lock pistons moving to open its non-return valve and also to allow flow of liquid

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through its cylinder when subject to lock-pressure and the lock piston in the conduit through which liquid is flowing from the servo cylinder being prevented from returning, on release of the lock pressure, by virtue of the pressure difference across the portion thereof of larger diameter until the servo piston has ceased to move in relation to the servo cylinder.

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