May 29, 1951 C. B. LIVERS ET AL 2,555,046

ELECTROMECHANICAL STROKE LIMIT CONTROL FOR HYDRAULIC MOTORS

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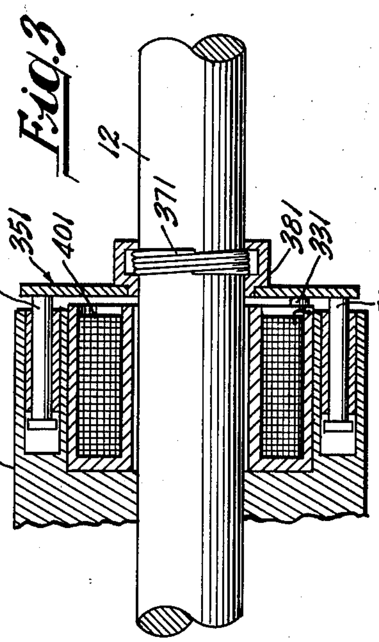

Fig. 3

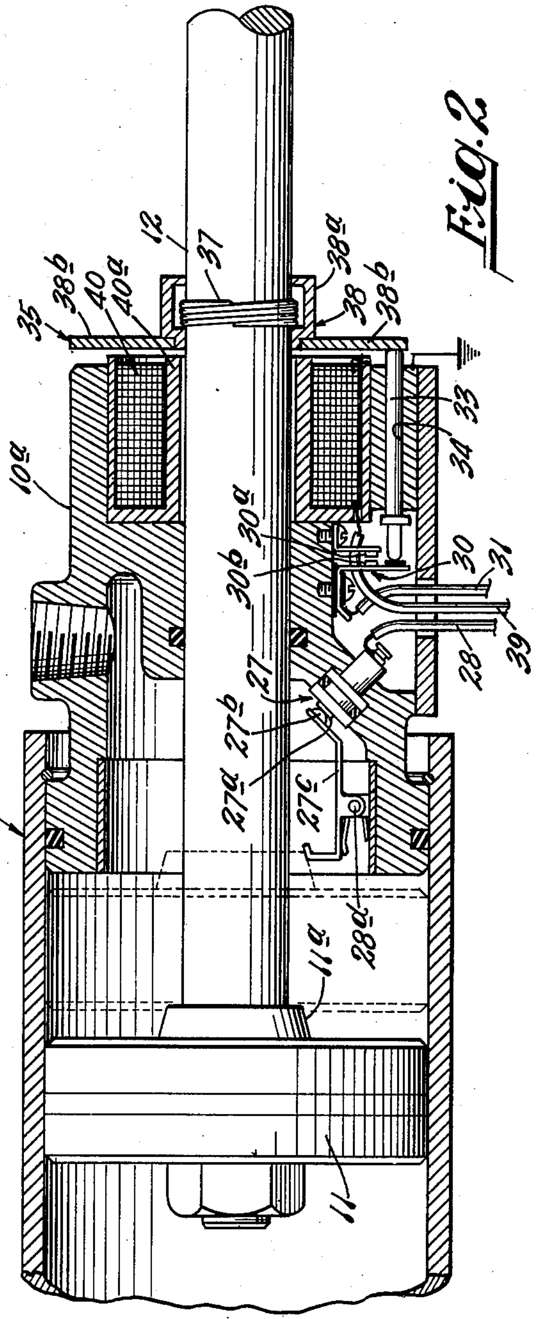

Fig. 2

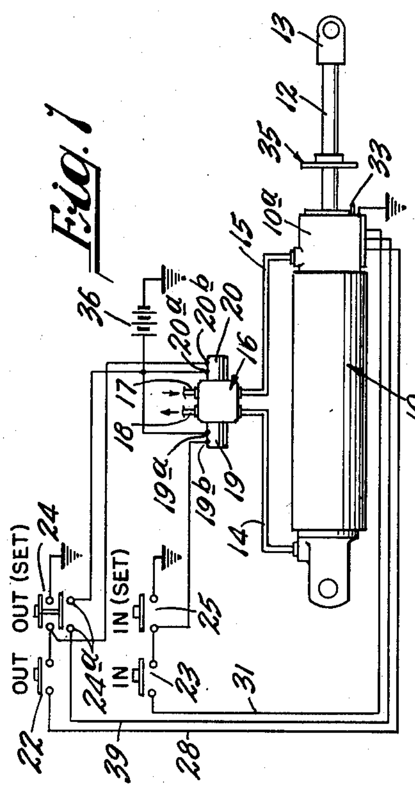

Fig. 1

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ELECTROMECHANICAL STROKE LIMIT CONTROL FOR HYDRAULIC MOTORS

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6 Claims. (Cl. 121—38)

This invention relates to hydraulic systems in which a hydraulic motor cylinder is to be actuated through a desired fraction of its full stroke and automatically stopped when it has moved the desired distance.

An object of the invention is to provide a simple and practicable stroke control for a hydraulic motor.

Another object is to provide a stroke control mechanism mounted on the motor cylinder that can be adjusted to vary the stroke from a remote point, and will retain its adjustment in service.

A specific object is to provide a system in which a stroke-control actuator on the piston rod of a hydraulic motor is readily adjustable along the rod by remote control without being subject to creeping in service.

Other more specific objects and features of the invention will appear from the description to follow.

It has been proposed by others to provide stroke length control of a hydraulic motor cylinder, by mounting an actuating collar on the piston rod in frictional enegagement therewith, the collar when moved near the cylinder engaging a trigger and actuating a trigger mechanism that closes a valve in the hydraulic circuit to stop the motor. It has further been proposed to enable setting of the collar from a remote point by providing an electro-magnetically controlled latch on the end of the motor cylinder to hold the collar against movement with the piston rod while the latter is shifted out of the cylinder, to thereby change the position of the collar on the rod.

The present invention contemplates providing an armature on the collar so that the latter can be directly held by an electro-magnet on the cylinder without resort to a latch. A problem with such a system is that if the trigger projects sufficiently from the cylinder to always stop the piston rod while the collar is appreciably spaced from the cylinder, the electro-magnet is unable to hold the collar against the friction of the rod, because of the air gap in the magnetic circuit. On the other hand, if the trigger is projected a lesser distance, the armature on the collar may sometimes strike the electro-magnet before the rod has stopped its inward movement, thereby shifting the collar out of its desired position of adjustment on the rod. The shift occurring on a single stroke is slight, but is cumulative during successive strokes and can soon become serious.

The described defect is eliminated in accordance with the present invention by providing a limited amount of lost motion between either the armature and the collar that is in frictional engagement with the piston rod, or in the magnet structure, so that although the trigger adjustment is such as to stop the piston rod before the collar can be shifted along the rod by abutment of the armature against the electro-magnet, the armature and electro-magnet are brought into close relation in response to energization of the magnet, thereby eliminating the air gap in the magnetic circuit and enabling the magnet to hold the collar against movement with the rod during the resetting operation.

Certain specific embodiments of the invention will now be described in detail with reference to the drawing, in which:

Fig. 1 is a schematic diagram of a hydraulic motor cylinder system incorporating the invention.

Fig. 2 is a detailed longitudinal section through one end of the hydraulic cylinder of Fig. 1; and

Fig. 3 is a sectional view showing an alternative arrangement to that of Fig. 2.

Referring to Fig. 1 there is shown a hydraulic motor cylinder **10** containing a piston which is connected to a piston rod **12** projecting from the right end of the cylinder, and having at its outer end the usual connector **13** for coupling it to a device to be operated thereby. The cylinder has hydraulic lines **14** and **15** extending from its respective ends to a 4-way valve **16**, which can be operated to connect either one of the lines **14** or **15** to a pressure supply line **17** while connecting the other to an exhaust or return line **18**.

The valve **16** is of the solenoid type whereby it can be electrically actuated from a distance. Thus it is provided with an "in" solenoid **19** and an "out" solenoid **20**. When the "in" solenoid **19** is energized the valve connects the motor line **15** to the pressure supply line **17** and connects the motor line **14** to the exhaust line **18**, thereby moving the piston rod **12** into the cylinder **10**. On the other hand, when the "out" solenoid is energized it connects the motor line **14** to the pressure line **17** and connects the motor line **15** to the exhaust line **18**, thereby moving the piston rod **12** out of the cylinder **10**.

A pair of regular control switches **22** and **23** are provided for normally controlling movement of the motor **10**, and a pair of stroke-setting switches **24** and **25** are provided for the purpose of readjusting the automatic stroke-limiting mechanism of the invention.

When the switch **22** or **23** is closed, the piston rod 12 moves a predetermined distance and opens a limit switch located in the cylinder 10 and connected in series with the switch 22 or 23 that was closed, thereby automatically returning the valve to neutral and stopping the motor.

When the switch 25 is closed, the solenoid 19 is energized independently of the limit switch to move the piston rod 12 inwardly until the switch 25 is opened. The switch 24 operates similarly to produce outward movement of the piston rod.

Referring to Fig. 2, one of the normally closed limit switches 27 is opened in response to movement of the piston rod 12 into a fixed, right limit position, and this switch completes a circuit from ground over a conductor 28 to the "out" switch 22. One contact 27*a* of the switch 27 is connected to the conductor 28, and the other contact 27*b* is grounded to the cylinder. However this contact 27*b* is mounted on a lever arm 27*c* fulcrumed on the cylinder at 28*d*, and the opposite end of the lever arm 27*c* is contacted by a cam surface 11*a* on the piston 11 of the motor as the latter approaches the right end of the cylinder 10, to open the contact 27*b* away from the contact 27*a*.

A limit switch 30 limits inward movement of the piston rod 12. This switch comprises a fixed contact 30*a* which is grounded to the cylinder, and a movable contact 30*b* which is insulatingly supported on the cylinder and is connected through a conductor 31 to the "in" switch 23. The switch contacts 30*a* and 30*b* are normally closed but are adapted to be opened by inward movement of a trigger 33 which consists of a rod slideably mounted in a passage 34 in the cylinder end. The trigger 33 projects beyond the outer face of the cylinder and is adapted to be contacted by a trigger actuator 35 mounted on the piston rod 12. When the actuator 35 contacts the trigger 33 as a result of the inward movement of the piston rod 12, it opens the contact 30*b* off the contact 30*a* thereby breaking the ground return circuit to the "in" switch 23 and closing the valve 16.

The operation of the electrical and hydraulic systems may be traced as follows: A battery 36 (Fig. 1) has one terminal connected to ground, and the other terminal connected to one terminal 19*a* of the solenoid 19 and to one terminal 20*a* of the solenoid 20, so that by connecting the other terminals 19*b* and 20*b* of the solenoids to ground they will be energized. The terminal 19*b* is connected to one terminal of the switch 25 and of the switch 23. The other terminal of switch 23 is connected, as previously described, by the conductor 31 to the limit switch 30 which is actuated by the actuator 35 on the piston rod 12, so that closure of switch 23 causes the piston rod to move inwardly a predetermined distance and automatically stop.

The "in set" switch 25, on the other hand, connects the solenoid terminal 19*b* directly to ground so that when this switch is closed the valve 16 will remain energized to continue to supply pressure fluid to the motor line 15 as long as the switch 25 is closed. Hence this switch is pressed when it is desired to move the piston rod 12 beyond the distance for which the actuator 35 is set. Ordinarily the switch 25 is used when it is desired to reset the actuator 35 outwardly along the piston rod.

The terminal 20*b* of the solenoid 20 is connected to one terminal of each of the switches 22 and 24. The other terminal of the "out" switch 22 is connected as previously described, by the conductor 28 to the switch 27, so that when the switch 22 is closed, the solenoid 20 is energized to supply pressure fluid to the motor line 14 and move the piston 11 to the right until the cam surface 11*a* thereon opens the switch 27 thereby automatically de-energizing the solenoid 20 and stopping the motor. When the "out set" switch 24 is closed, the terminal 20*b* of the solenoid 20 is connected directly to ground so that pressure fluid is supplied to the motor line 15 as long as the switch 24 remains actuated.

The switch 24 carries auxiliary contacts 24*a* which complete a circuit from the battery 36 over a conductor 39 to an electro-magnet 40 positioned in the end of the cylinder 10, the other terminal of this electro-magnet being grounded. The "out set" switch 24 is commonly used to reset the actuator 35 to a new position on the piston rod 12 during outward movement of the latter. The result is to reset the actuator 35 inwardly on the piston rod 12, but the switch 24 is referred to as the "outset" switch because it resets the actuator 35 during outward movement of the piston rod.

Let it be assumed that the "in" switch 23 was last actuated to move the piston rod 12 inwardly until the actuator 35 contacted the trigger 33 and opened the switch 30 to stop the motor, as shown in Fig. 2. Let it now be assumed that the operator desires to reset the actuator 35 to the left along the piston rod 12, so that the actuator 35 will contact the trigger 33 earlier and stop the piston 11 after a shorter stroke. The operator resets the actuator 35 by closing the switch 24 and holding it closed while the piston rod 12 travels to the right into the new position which is thereafter to constitute its left or inward limit position. Closure of the switch 24 simultaneously completes two circuits, one to the solenoid 20 to actuate the valve 16 and supply pressure fluid through the line 14 to the left end of the cylinder 10. The other circuit, which is completed over the contacts 24*a* of switch 24 and the conductor 39, energizes the electro-magnet 40, causing it to attract the actuator 35 and hold it against the cylinder while the piston rod 12 is moving outwardly. Obviously, in order to be effective, the magnetic pull of the electro-magnet 40 on the actuator 35 must be greater than the resistance to sliding movement of the actuator along the piston rod 12.

When the piston rod 12 has been moved into the desired new limit position, the "outset" switch 24 is opened and the "out" switch 22 is closed. Thereupon the electro-magnet 40 is de-energized so that during movement of the piston rod into its fixed outer end position the actuator 35 travels with the piston rod away from the trigger 33. During the next inward stroke produced by closure of the "in" switch 23, the actuator 35 contacts the trigger 33 and automatically stops the piston in the new limit position.

If it is desired to adjust the actuator 35 into a new position further out on the piston rod 12, this operation is performed by closing the "in set" switch which energizes the valve solenoid 19 independently of the limit switch 30, so that the rod 12 continues to travel after the actuator 35 has contacted the trigger 33 and the electro-magnet 40, until the operator opens the switch 25.

A system as so far described, if it had an actuator 35, the magnet-contacting armature portion of which was in direct frictional engagement with the piston rod 12, would have the defect that the actuator 35 would be subject to creeping along the rod 12. In other words, it would not retain its setting. The reason for this is that in order for the electro-magnet 40 to hold the actuator 35 during outward movement of the piston rod 12, there must be no air gap in the magnetic circuit between the magnet 40 and the actuator 35. Hence, the trigger 33 would have to be so short that it would not be depressed sufficiently to open the switch 30 until the actuator 35 was substantially against the face of the electro-magnet 40. This would result in a very critical adjustment of the length of the trigger 33. If it were slightly too long, the actuator 35 would be stopped a distance from the electro-magnet 40 such that the air gap in the magnetic circuit would prevent the magnet from holding the actuator during outward movement of the rod 12 during a resetting operation. In other words, the reset mechanism would become inoperable. On the other hand, if the trigger 33 was too short, the actuator 35 would abut against the electro-magnet 40 at the end of the stroke before the rod stopped, thereby shifting the actuator 35 outwardly a short distance on the rod. The amount of shift on each stroke might be very slight, but it would be cumulative and could soon displace the actuator 35 a substantial distance from its desired position.

The present invention deals with the mentioned defects and overcomes them by providing for some free movement in the magnetic system to permit the actuator 35 to closely contact the electro-magnet 40 when the latter is energized, without abutting against the electro-magnet during normal operation.

In the embodiment shown in Fig. 2 the desired result is obtained by forming the actuator 35 as two elements 37 and 38, the first of which is in tight frictional engagement with the rod, and the second of which is slideable freely on the piston rod 12. As shown, the first element 37 is in the form of a coil spring which tightly encircles the rod 12, and the length of element 37 is less than the groove 38a in the element 38 in which the element 37 is located.

During normal operation, the elements 37 and 38 remain in the relative positions shown in Fig. 2. Furthermore, the length of the trigger 33 is such that the switch 30 is opened to stop the left or inward movement of the rod 12 while the actuator element 38 is still substantially spaced from the electro-magnet 40, as shown in Fig. 2. This space is such as to insure that the element 38 will never contact the electro-magnet 40 in response to normal movement of the rod 12. However, when it is desired to reset the actuator 35 leftward along the rod 12 by actuation of the "out set" switch 24, the electro-magnet 40, when energized, is able to pull the actuator element 38 into direct contact because of the lost motion between the actuator elements 37 and 38. This lost motion between the parts 37 and 38 should be no greater than the gap between the face of the member 37 and the electro-magnet 40 during normal operation. The movement of the armature element 38 against the face of the electro-magnet further depresses the trigger 33 but the switch 30 has enough yield to permit it.

It is to be noted that the element 38 of the actuator 35 is formed in two parts brazed together. The center or collar portion 38a engages the piston rod 12, and is made of brass or other non-magnetic metal, whereas the armature portion 38b is made of iron or other para-magnetic metal. This prevents direct contact between the armature portion 38b and the piston rod 12. It has been found that if the portion of the actuator in direct contact with the piston rod (which is usually steel) was of para-magnetic material the magnetic attraction between the element 38 and the piston rod could be so strong as to cause them to adhere and interfere with the desired movement of the armature to close the air gap between it and the electro-magnet. It is also preferable to make the coil spring element 37 of non-magnetic material such as brass, so as not to increase the friction between it and the piston rod 12 by stray flux during the resetting operation when the electro-magnet is energized.

An alternative construction is shown in Fig. 3. In this instance, the actuator 351 has no lost motion with respect to the piston rod 12. Thus the inner, rod-gripping element 371 completely fills the space within the element 381, so that the two elements can move only as a unit along the rod. As in Fig. 2, the trigger 331 is of such length as to stop the actuator 351 a safe distance from the face of the electro-magnet 401 during normal operation, to prevent objectionable creeping of the actuator along the rod. However the electro-magnet structure is provided with slideable rods 50 of para-magnetic material which are projectable a limited distance beyond the face of the electro-magnet. When the electro-magnet is energized, these rods 50 are attracted to the actuator 351, and move outwardly until they contact it. The cross-sectional path provided by the rods 50 is sufficient to establish a strong flux. Since, as is well known, a flux path tends to shorten itself, the rods 50 will slide to the left permitting the actuator to abut against the electro-magnet so that it will be positively held against the frictional pull of the piston rod as the latter moves to the right.

It will be understood that the core 40a of the electro-magnet 40 is of iron or other para-magnetic material, to produce a strong flux and high holding power with a reasonable expenditure of power. The core 40a is spaced from the piston rod 12 to reduce leakage flux through the rod.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

We claim:

1. In a device of the type described: a motor cylinder containing a piston having a piston rod projecting from the cylinder; valve means for controlling fluid flow to and from said cylinder to move said piston rod in either direction; a trigger on said cylinder, a trigger actuator frictionally engaging said piston rod for actuating said trigger in response to predetermined movement of said rod into said cylinder, and means responsive to actuation of said trigger for closing said valve means to stop said piston rod; a selectively energizable magnet structure including a stationary electro-magnet and an armature on said actuator for selectively holding said actuator against said electro-magnet despite the frictional drag of said piston rod during outward movement thereof; said trigger being so proportioned as to be actuated by said actuator prior to contact of said armature with said electro-magnet; and means providing limited motion between portions of said magnet structure with less resistance than that afforded by said frictional engagement between said actuator and said piston rod, for enabling abutment of said armature

against said electro-magnet without slippage between said actuator and rod at said frictional engagement therebetween.

2. A device according to claim 1 in which said actuator comprises a first element in direct frictional engagement with said piston rod, and a second element having limited free longitudinal movement with respect to said first element, said armature being mounted on said second element.

3. Apparatus according to claim 2 in which said second element is of non-magnetic material and is freely slidable on said piston rod, and said armature is spaced from said piston rod.

4. A device according to claim 3 in which said armature contacts and actuates said trigger prior to contact of said armature with said electro-magnet, and said means responsive to actuation of said trigger is yieldable to permit movement of said armature against said electro-magnet in response to energization thereof.

5. A device according to claim 1 in which said actuator comprises a first element consisting of a helical spring encircling said piston rod in gripping relation therewith, and a second element freely slidable on said rod and defining with said rod a chamber containing said first element, said chamber being longer than said first element, and said armature being mounted on said second element.

6. A device according to claim 1 in which said electro-magnet comprises a paramagnetic core structure including a stationary portion having an armature-contacting face, and an auxiliary portion in longitudinal sliding contact with said stationary portion and having an armature-contacting face, said auxiliary portion being movable between a position in which its face is flush with said face of said main portion and a position in which its face is projected beyond the face of said main portion.

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No references cited.