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Fig. 4.

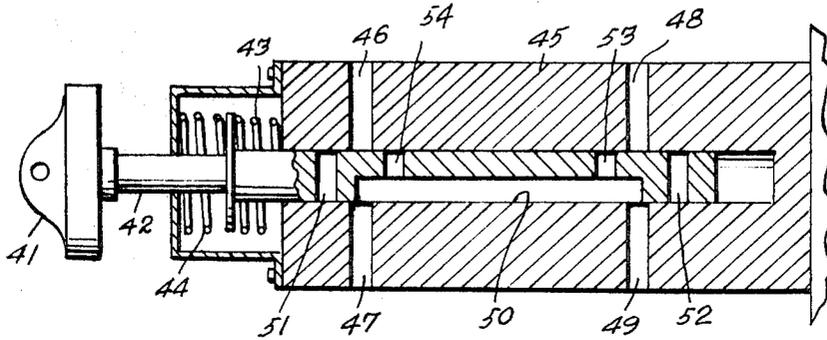
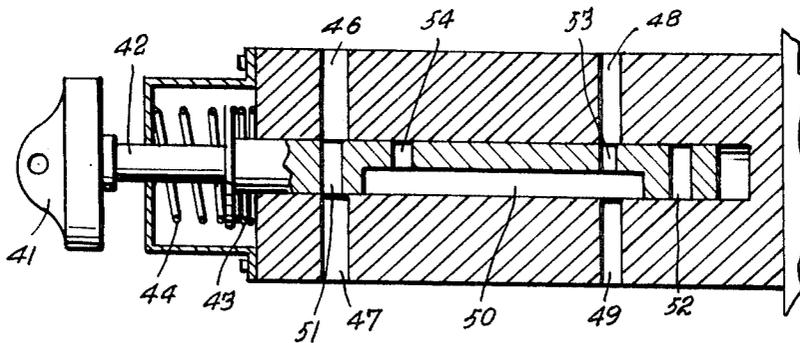


Fig. 5.



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MULTIPLE AREA HYDRAULIC ACTUATOR

BRIEF SUMMARY

The terms "positive" and "negative" are used herein to designate opposite forces such as pushing versus pulling, or clockwise versus counterclockwise, or lifting versus lowering, and so on.

In many fluid pump-and-motor systems the pump is driven at a constant rate of speed, thereby yielding a constant volumetric output of pressurized fluid. Therefore, the expandable chamber motor driven thereby has a substantially constant speed. At times this is very wasteful of time and power as the operator sits waiting for the motor to "take up the slack" or "guns the engine" to speed up movement of the tool being driven by the motor. Example: The operator of a hydraulically powered back hoe or other digging or shoveling machine operates a valve or valves to bring the digging tool or shovel to the point of contact with the load. This requires little force and little power, but a large amount of liquid, and a waste of time, as he sits waiting for the tool to move to the point where the load is encountered. If he wants to save time he "guns" the driving engine to increase the rate of liquid flow and consequent hydraulic motor movement. Fuel is wasted and parts are worn excessively as the engine roars. Extra power is not needed but faster speed is needed during the low-force part of the cycle. Then the tool encounters the load and high force is needed to "dig in." But, the mechanical advantage of the system remains the same and extra force is not available unless additional power is supplied to the driving engine and pump. In some installations the driving engine is a constant speed device, such as a conventional electric motor, and the rates of speed of the pump and the hydraulic motor are constant, too slow under no load conditions, or not enough force for high load conditions, or both.

In many instances, upon retraction of the hydraulic motor, very little force and power are needed. Therefore, a similar loss of time, or inefficient use of power, or excessive wear and wasting of fuel due to "gunning the engine" is experienced. Many other examples could be cited to illustrate a need for improvement in pressurized fluid systems of the class described hereinabove.

The present invention teaches a simple, automatic, solution to the problem discussed above. Simple, inexpensive, automatic valving provides the automatic transfer from high-speed—low-force operation to high-force—low-speed operation. And, this is true during the forced reversal of the motor, as well as during the main force delivering part of the cycle.

IN THE DRAWING

FIG. 1 is a sectional view through a form of the invention;
 FIG. 2 is a view of a modification;
 FIG. 3 is a sectional view of a further modification;
 FIGS. 4 and 5 are sectional views of the valve in FIG. 3, illustrating two positions thereof.

FIG. 1 illustrates a power or force delivering actuator rod 1 projecting from a dual, concentric, piston and cylinder arrangement. Springs 2 and 3 resiliently urge inner piston-valve 4 and rod 1 attached thereto, toward the neutral position illustrated. Cylinder piston 5 surrounds inner piston-valve 4 and cylinder 6 surrounds cylinder piston 5. Valve ports 7, 8, 9 and 10 are provided in cylinder piston 5. Valve ports 12, 13 and 14 in inner piston-valve 4, and fluid passages 15 and 16 in cylinder piston 5 provide for fluid intercommunication in a manner to be described hereinafter. Pressurized fluid is introduced at line 17 into chamber 19 while line 18 acts as a low-pressure outlet from chamber 20, for a positive load on actuator rod 1, or vice versa for retraction of actuator rod 1. Other fluid chambers are provided at 21 and 22 with areas for fluid pressure actuation being designated as 23, 24 and 25.

OPERATION OF FIG. 1

In order to advance actuator rod 1 to the right (positive force) against a load, pressurized fluid is introduced into chamber 19 by way of line 17. As the cylinder piston device 5 is forced to the right, fluid from chamber 20 is expelled through line 18. Also, fluid from chamber 22 flows to chamber 21 by way of passages 12, 15, 13 and 11, 16, 14. Piston-valve 4 and rod 1 are forced to the right by spring 3, normally counterbalanced by spring 2. The pressurized fluid acts against areas 23 and 24 inside of chamber 19. These areas are designedly less than the total inside cross-sectional area of cylinder 6. Therefore, cylinder piston 5, piston-valve 4, and rod 1, are advanced at a rapid rate if the positive force against rod 1 is insufficient to compress spring 3. If rod 1 meets a high resistance (positive load) spring 3 is compressed as piston-valve 4 is forced there against. As piston-valve 4 is pushed toward the left fluid in chamber 21 may pass to chamber 22 by way of passages 13, 14, 15, 16 11 and 12. Then, as piston-valve 4 compresses spring 3, passages 13 and 14 no longer communicate with passages 15 and 16, but align with passages 7 and 8 instead. Therefore, fluid in chamber 19 may pass into chamber 21 through passages 7, 13 and 8, 14. This results in pressurized fluid being applied to face 25 of piston 4, thereby adding that area and increasing the force on rod 1 although the rate of movement is decreased.

Upon retraction of actuator rod 1 the force may be either positive or negative. An example of a positive force during retraction is the lowering of an object which was held up by the rod. The entire load that was raised may be lowered, in which event piston-valve 4 remains tight against compressed spring 3 and all of areas 23, 24 and 25 support the load. Controlled release of pressure through line 17 permits the load to be lowered gradually.

If a portion of the load on rod 1 should be dumped off, or if the load otherwise becomes lighter than the force exerted by compressed spring 3, then piston-valve 4 would shift to the neutral position. The pressure being bled off through line 17 no longer acts on area 25. Therefore, rod 1 retracts faster, under light positive loads, again reducing waste of time under low load conditions.

There is a slight volume differential between chambers 21 and 22, or a slight difference between their rates of change as cylinder piston 5 moves relative to piston-valve 4 and cylinder closures 21a and 22a. This is due to the volume occupied by actuator rod 1 inside of chamber 22. This differential may be accommodated in several well-known ways, such as by valving, or an accumulator as diagrammatically illustrated at 22b, or other.

As it is being retracted, rod 1 may undergo a negative loading and, instead of pushing, it may pull the load toward the assembly. Under these conditions pressurized fluid is introduced into chamber 20 through line 18. Under light load conditions ports 9 and 10 are closed and rod 1 is retracted rapidly a low force. However, if the load becomes large piston-valve 4 compresses spring 2. Passages 11 and 12 become aligned with ports 9 and 10 thereby introducing pressurized fluid to the right side of piston-valve 4. Here again the overall piston area is thereby increased and the force available for retraction of rod 1 is increased although the speed is decreased. When the negative force on rod 1 drops below the force exerted by spring 2 piston-valve 4 again automatically shifts to achieve low pressure-high speed movement of rod 1 and the load being actuated thereby.

FIG. 2 illustrates a modification wherein fluid is first introduced into the inner cylinder instead of the outer cylinder as in FIG. 1. Fluid in chamber 21' presses against face 25' and rapidly advances actuator rod 1' through the intermediary of spring 2', cylinder piston 5' and yoke 1''.

When rod 1' meets a load greater than the force of spring 2' piston-valve 4' continues forward compressing spring 2' but cylinder piston 5' pauses. Fluid from chamber 20' flows through ports 28, 29, passages 15', 16', and ports 26, 27 to

chamber 19'. Change of volume differential between chambers 19' and 20' may be accommodated by accumulator 22c. As piston-valve 4' shifts, passages 13' and 14' come into registration with ports 26 and 27 and permit pressurized fluid to pass out into chamber 19' to act against additional piston areas 23' and 24'. This automatically yields greater increased force, although at a slower rate of movement. Fluid in chamber 20' passes out through ports 32, 33 and passages 11' and 12' to chamber 22' and line 18'.

Retraction to rod 1 in FIG. 2 is brought about by lowering the pressure in line 17' while pressurizing line 18'. The sequence of events and advantages are similar to those described in detail in regard to FIG. 1.

FIG. 3 illustrates a modification wherein two more-or-less conventional piston-cylinders are teamed up to achieve results similar to those achieved in the FIG. 1 and FIG. 2 modifications. Cylinders 35 and 36 have pistons and piston rods 37 and 38 projecting therefrom, interconnected by crosshead 39 driving actuator rod 40. At the opposite end attachment member 41 is connected to a valve member 42, spring urged to a neutral position by opposing compression springs 43 and 44. Valve body member 45 contains passages 46, 47, 48 and 49. Valve member 42 (as illustrated in FIGS. 4 and 5) contains passages 50, 51, 52, 53 and 54. The chambers of cylinder 35 are designated 55 and 56 while those of cylinder 36 are designated 57 and 58. Fluid is supplied and expelled through lines 59 and 60. Chambers 57 and 58 are connected to valve body ports 47 and 49 by lines 61 and 62. As piston rod 38 is reciprocated the rate of volume change in chambers 57 and 58 is unequal because of piston rod 38 in chamber 58. If the fluid being used is a noncompressible liquid an accumulator 63 may be provided, or suitable valving may be used, or other well-known expedient may be utilized to compensate for this difference in volumes.

OPERATION OF FIG. 3

Assuming piston rods 37 and 38 to be extended, pressurized fluid is supplied to line 59 and line 60 is open to drain. As illustrated in FIG. 4, port 46 is closed and fluid from line 59 can only enter chamber 55 to push piston rod 37 to the right, taking with it crosshead 39, piston rod 38 and actuator rod 40. Fluid in chamber 56 may escape through line 60. Fluid in chamber 58 may pass through line 62 to port 49, through passage 50, port 47 and line 61 to chamber 57. Makeup fluid for chamber 57, as it increases in size faster than chamber 58 decreases, may come from accumulator 63.

While there is light compressional or positive loading between actuator rod 40 and attachment member 41 pressurized fluid is fed only to chamber 55 to extend rod 40 at a rapid rate. However, when (or if) the load increases to a point sufficient to compress spring 43, valve member 42 shifts to the position illustrated in FIG. 5. Passage 51 is then aligned with ports 46 and 47 permitting pressurized fluid to pass from line 59 to line 61 and to chamber 57. This increases the total piston area against which pressurized fluid is working, and the force exerted by rod 38 plus rod 37 is much greater. (The rate of movement is decreased.) Fluid from chamber 58 is expelled through line 62, port 49, passage 53, port 48 and line 60.

When it is desired to retract or negatively load rods 37, 38 and 40, line 60 is pressurized and line 59 is vented. Pressurized fluid in chamber 56 retracts rod 37, and carries with it rod 38, crosshead 39 and rod 40. Fluid in chamber 57 flows (see FIG. 4) by line 61, port 47, passage 50, port 49 and line 62 to chamber 58. Excess fluid from rapidly decreasing chamber 57 may flow into accumulator 63. Movement is rapid if the negative load is light. When (F) the negative load becomes heavy, valve member 42 is pulled outwardly against the force of compression spring 44. This aligns passage 52 with ports 48 and 49 and aligns passage 54, 50 with ports 46 and 47. Therefore, pressurized fluid can flow from line 60 through 48, 52, 49 and 62 to chamber 58 to assist in retracting rod 40, at a slower rate but with much higher force. Fluid in chamber 57 may exhaust through 61, 47, 50, 54, 46 and 59.

I claim:

1. A multiple-area fluid actuator comprising a plurality of

reversible expandable chamber motor devices operator to deliver positive and negative forces for moving an object, a force-delivering element driven by said motor devices, fluid conduit means connected to a first of said motor devices to supply pressurized fluid to one side of said first motor during production of a positive force and to vent said side of said first motor during production of a negative force by said actuator, fluid conduit means connected to a second of said motor devices to supply pressurized fluid to one side of said second motor during production of a positive force and to end said side of said second motor during production of a negative force by said actuator, valve means blocking fluid passage in said second conduit means when said valve is in its normal neutral position and means to automatically open said valve means to said one side of said second motor and to vent said other side when said force-delivering element encounters a predetermined resistance to its positive force-delivering movement to thereby automatically feed pressurized fluid to said second motor device to assist in delivering positive force and to automatically open said valve means to said other side of said second motor and to vent said one side when said force-delivering element encounters a predetermined resistance to its negative force-delivering movement to thereby automatically feed pressurized fluid to said second motor device to assist in delivering negative force.

2. Apparatus as set forth in claim 1 wherein said motor devices comprises a substantially concentric cylinder piston assembly with said first motor device substantially surrounding said second motor device.

3. Apparatus as in claim 2 wherein said second motor device comprises a piston-valve connected to said force-delivering element, and wherein said fluid conduit means comprises fluid conduits adjacent to opposing ends of said first motor device, and additional fluid conduits between said first and second motor devices comprising ports and passages from said first motor device to and through said second motor device.

4. Apparatus as in claim 3 wherein said additional fluid conduits comprise passages in said first motor device and ports in said second (piston-valve) motor device, said passages and ports being spaced to prevent alignment therebetween during normal high-speed—low-force movement while permitting fluid communication between opposing sides of said second motor device, and said ports, upon being shifted by said force-delivering element, being registrable with said passages to permit high-pressure fluid from said first motor device to act on one side of said second motor device and to vent the other side, while blocking fluid communication between opposing sides of said second motor device.

5. Apparatus as in claim 1 wherein said motor devices comprise a substantially concentric cylinder piston assembly with said second motor device substantially surrounding said first motor device.

6. Apparatus as in claim 5 wherein said first motor device comprises a piston-valve connected to said force-delivering element, and wherein said fluid conduit means comprises fluid conduits adjacent to opposing ends of said first motor device, and additional fluid conduits between said first and second motor devices comprising passages in said first motor device registrable with ports in said second motor device.

7. Apparatus as in claim 6 wherein said passages and ports are spaced to prevent fluid flow between said first and second motor devices when in the normal high-speed—low-force movement and to permit fluid communication between opposing sides of said second motor device, and wherein said passages and ports, upon being shifted by said force-delivering element, permit high-pressure fluid from said first motor device to act on said second motor device, while blocking fluid communication between opposing sides of said second motor device.

8. Apparatus as in claim 1 wherein said motor devices comprise substantially parallel side-by-side units with rigidly interconnected cylinders and rigidly interconnected piston rods, and wherein said fluid conduit means comprises a valve assembly mounted on the device.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3584536 Dated 15 June 1971

Inventor(s) Benny M. Hillberry

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Filed: January 13, 1970

Signed and sealed this 19th day of October 1971.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents