Aug. 19, 1958 J. N. GLADDEN 2,847,829

POWER BRAKING SYSTEM

Filed Nov. 21, 1955 2 Sheets-Sheet 1

Fig. 1.

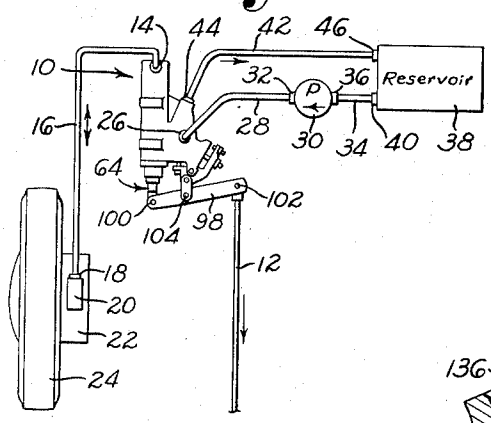


Fig. 2.

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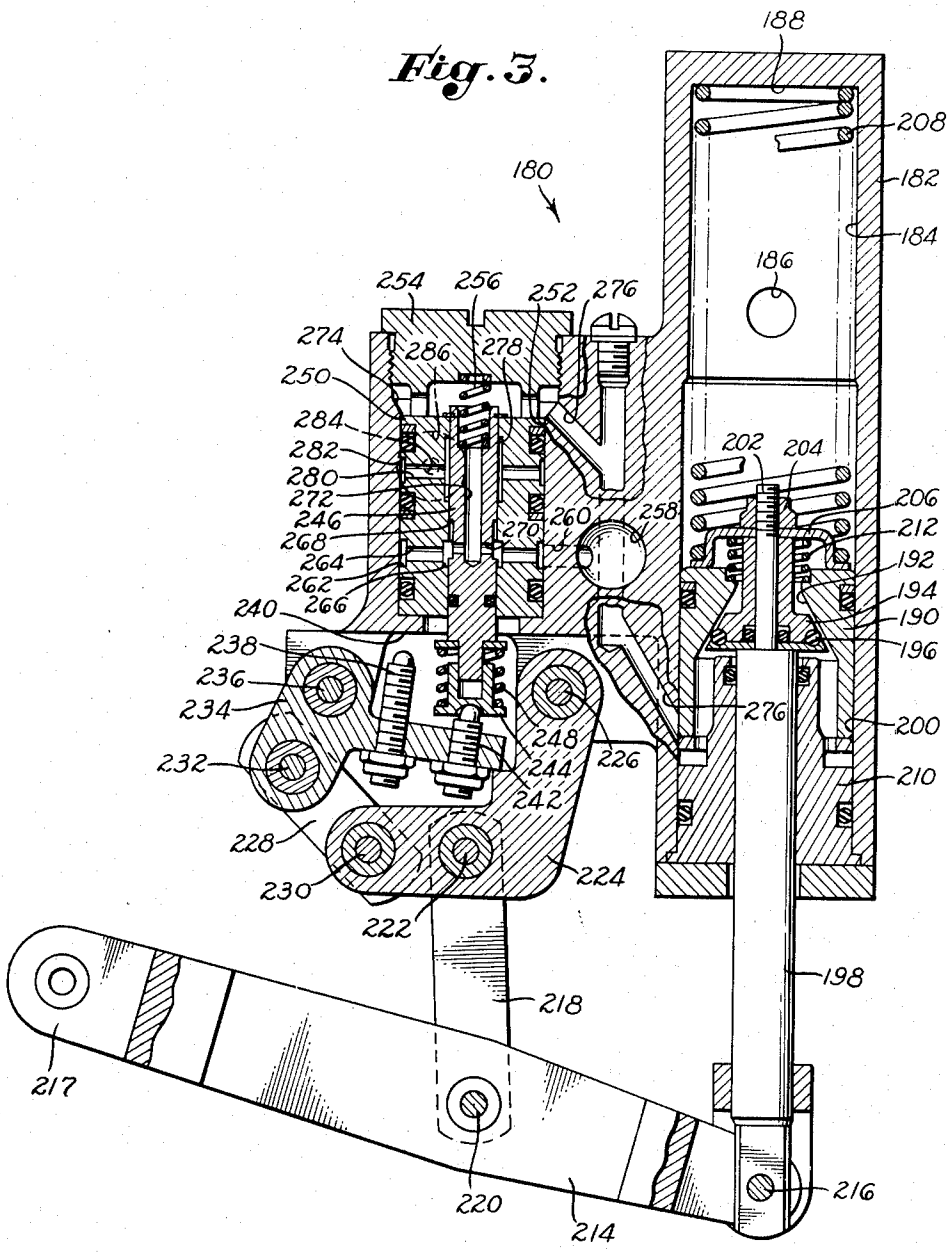
BY HIS ATTORNEYS.
HARRIS, KIECH, FOSTER & HARRIS

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Fig. 3.



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2,847,829

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2,847,829

POWER BRAKING SYSTEM

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Application November 21, 1955, Serial No. 548,059

15 Claims. (Cl. 60—54.6)

The present invention relates to a hydraulic actuator and, more particularly, to an apparatus for delivering an actuating fluid under pressure to a hydraulic device actuable by such fluid, in response to the application of an operating force, such as a manual operating force, to the apparatus. The hydraulic actuator of the invention may, for example, be utilized in a power braking system to deliver actuating fluid under pressure to the cylinder of a hydraulically-braked wheel in response to the application of a manual operating or braking force thereto, the invention being considered in connection with a power braking system hereinafter for convenience.

My Patent No. 2,676,465, granted April 27, 1954, discloses a hydraulic actuator which includes a housing providing a piston capable of delivering an actuating fluid under pressure to the cylinder of a hydraulically-braked wheel, the piston being displaced both by a manual operating or braking force applied thereto, and by fluid pressure applied thereto by a selector valve means responsive to the application of the manual operating force. The selector valve means, upon application of the operating force, is moved from a return position, wherein it connects the cylinder of the actuator to a reservoir, to a pressure position, wherein it connects such cylinder to a source of fluid under pressure, such as a pump, thereby displacing the piston to deliver an actuating fluid to the wheel cylinder through an actuating port. In the hydraulic actuator disclosed in my aforementioned patent, the movement of the selector valve means in response to the application of the operating force is produced by so mounting the housing that it moves in response to the application of the operating force to the piston, and by providing means for moving the selector valve means to its pressure position in response to such movement of the housing. Thus, the floating mounting of the housing is responsible for the movement of the selector valve means from its return position to its pressure position in response to the application of an operating or braking force to the piston of the device.

In the light of the foregoing, an object of the present invention is to provide a hydraulic actuator which includes a selector valve means movable from a return position to a pressure position to deliver fluid under pressure to a cylinder containing a piston without utilizing a floating housing, the hydraulic actuator of the present invention being provided with a housing which is stationary so that flexible fluid lines between the actuator and other components of the system, such as a reservoir and a pump, are unnecessary.

More particularly, an important object of the invention is to provide a hydraulic actuator having an operating means to which the operating force is applied and to which both the selector valve means and the piston are connected in such a manner that an operating force applied to the operating means moves the selector valve means from its return position to its pressure position and moves the piston in its cylinder toward an actuating port at one end thereof, the actuating port being connected to a hydraulic device to be actuated, such as the cylinder of a hydraulically-braked wheel. With this construction, the housing of the actuator is stationary and rigid fluid lines may be utilized to connect the actuator to the other components of the system.

Another object is to provide such an operating means in the form of a floating operating lever connected only to the piston and the selector valve means of the hydraulic actuator of the invention, and connected thereto in such a manner that the application of an operating force to the floating operating lever results in movement of the selector valve means toward its pressure position and in movement of the piston toward the actuating port in its cylinder.

Another object is to provide means for connecting the floating operating lever to a piston rod projecting axially from the cylinder and connected to the piston therein, and to provide means for connecting the floating operating lever to a valve lever pivotally mounted on the housing and engaging the selector valve means. With this construction, the connections between the piston and the selector valve means serve as fulcrums for the floating operating lever with no necessity for pivotally connecting this lever directly to the housing.

Another object of the invention is to provide a hydraulic actuator wherein the selector valve means alternatively connects pressure and return ports in the housing to the cylinder between the piston and the actuating port leading to the hydraulic device to be actuated, the pressure port being connected to a source of fluid under pressure such as a pump, and the return port being connected to a reservoir, or the like. With this construction, the piston is displaced manually to deliver actuating fluid to the hydraulic device to be operated until the operating force applied to the operating means attains a magnitude sufficient to move the selector valve means to its pressure position, whereupon the selector valve means delivers fluid under pressure to the cylinder between the piston and the actuating port. Thereafter, fluid under pressure from the source of supply flows directly to the hydraulic device to be actuated, the piston thus being inoperative under such conditions. However, with this construction, in the event of failure of the pump or other means for supplying fluid under pressure to the hydraulic actuator of the invention, the piston may be displaced by the operating force alone to deliver fluid to the hydraulic device to be actuated, which is an important feature of the invention.

Another important object of the invention is to provide a hydraulic actuator capable of being operated with a pumping action to deliver actuating fluid to a hydraulic device which may have been drained of fluid, or which may be leaking. In a power braking system, this feature of the invention permits the use of hydraulic brakes having much larger displacements than would otherwise be permissible under emergency conditions since such brakes may be pumped full of fluid in the event of draining or leakage thereof.

Another object in connection with the aforementioned pumping action is to provide a passage connecting the return port with the cylinder on the opposite side of the piston from the actuating port and to provide in this passage a check valve preventing flow from the cylinder to the return port, the piston having check valve means for preventing flow therepast in response to movement of the piston toward the end of the cylinder adjacent which the actuating port is located. With this construction, displacement of the piston toward the actuating port draws fluid from the return port into the cylinder through the passage mentioned, while movement of the piston in a direction away from the actuating port permits such fluid to flow past the piston through the check valve means

carried thereby. Consequently, successive strokes of the piston pump up the system with which the hydraulic actuator of the invention is used in the event that fluid has drained from the system for any reason.

Another object of the invention is to provide a yielding connection between the piston and the operating means, this connection yielding as pressure is developed in the cylinder between the piston and the actuating port to provide the operator of the system with an artificial "feel" indicative of the braking or other force being developed by the hydraulic device to which the actuator of the invention is connected. A related object is to provide such a yielding connection between the piston and the operating means in the form of a piston rod having two telescopically related elements resiliently biased apart.

While the hydraulic actuator of the invention has been discussed in the preceding with reference to delivering fluid under pressure directly from the source to the actuating port, many of the hereinbefore-discussed features of the invention are also applicable to an embodiment of the invention wherein the fluid under pressure supplied to the cylinder when the selector valve means is moved to its pressure position is applied to the piston, instead of being delivered directly to the actuating port, to provide a boosting action, another object of the invention being to provide an embodiment of this nature.

Another object is to provide a hydraulic actuator wherein the selector valve means is located alongside the cylinder and adjacent one end thereof to provide the actuator with an L-shaped configuration, the latter resulting in a compact structure which may be installed in locations wherein the space available is severely limited.

The foregoing objects, advantages, features and results of the present invention, together with various other objects, advantages, features and results thereof which will become evident to those skilled in the art in the light of this disclosure, may be attained with the exemplary embodiments of the invention illustrated in the accompanying drawings and described in detail hereinafter.

Referring to the drawings:

Fig. 1 is a diagrammatic view on a reduced scale illustrating one embodiment of a hydraulic actuator of the invention incorporated in a power braking system;

Fig. 2 is an enlarged sectional view of the hydraulic-actuator embodiment illustrated in Fig. 1; and

Fig. 3 is a sectional view similar to Fig. 2, but illustrating an alternative embodiment of the invention.

Hydraulic actuator 10

Referring particularly to Fig. 1 of the drawings, the numeral **10** designates a hydraulic actuator which is presently regarded as the preferred embodiment of the invention, the actuator **10** being incorporated in a power braking system in the particular environment illustrated and being rigidly connected to the frame of a vehicle, such as an airplane, not shown, in any suitable manner. Connected to the hydraulic actuator **10** is a brake rod **12** which may be connected to a brake pedal, or the like, not shown. Connected to the actuator **10** by a fitting **14** is an actuating line **16** which, in turn, is connected by means of a fitting **18** to a wheel cylinder **20** of a hydraulic brake **22** associated with a wheel **24**. Connected to the actuator **10** by a fitting **26** is an inlet or pressure line **28** which is connected to the discharge side of a pump **30** by a fitting **32**. The intake side of the pump **30** is connected to an intake line **34** by a fitting **36**, the intake line also being connected to a reservoir **38** by a fitting **40**. An outlet or return line **42** is connected to the actuator **10** by a fitting **44** and to the reservoir **38** by a fitting **46**. The pump **30** preferably delivers fluid, such as oil, from the reservoir **38** to the actuator **10** at a constant pressure.

Considering the general operation of the hydraulic braking system illustrated in Fig. 1 of the drawings, a pull force applied to the brake rod **12** causes the actuator **10** to deliver actuating fluid under pressure to the wheel cylinder **20** through the actuating line **16**, the pump **30** drawing fluid from the reservoir **38** through the intake line **34** and delivering it to the actuator **10** through the pressure line **28** to produce the aforementioned delivery of actuating fluid to the wheel cylinder. Upon relaxation of the axial pull force applied to the brake rod **12**, the actuator **10** is connected to the reservoir **38** through the return line **42** so as to dissipate the actuating fluid pressure developed in the wheel cylinder **20** and thus render the brake **22** inoperative. With the foregoing general description in mind, the details of the hydraulic actuator **10** will now be considered, primarily with reference to Fig. 2 of the drawings.

The hydraulic actuator **10** includes a housing **50** which provides a cylinder **52**, the housing having therein an actuating port **54** which communicates with the cylinder **52** adjacent one end **56** of the cylinder and into which the fitting **14** may be threaded. Reciprocable within the cylinder **52** is a tubular piston **58** which provides a tapered seat **60** for a valve member **62** carried by a piston rod **64** projecting axially from the other end, **66**, of the cylinder, the seat **60** converging toward the end **56** of the cylinder. The valve member **62** is provided with an annular sealing element **68** for engagement with the tapered seat **60** to provide a fluid-tight seal preventing fluid flow through the tubular piston **58**. The valve member **62**, which is formed in two parts with the sealing element **68** therebetween, is mounted on a stud **70** which projects from the inner end of the piston rod **64** toward the end **56** of the cylinder **52**, the two-part valve member **62** being held on the stud **70** by a nut **72** and a spring seat **74** being clamped between the valve member and the nut. A relatively heavy compression spring **76** is seated at one end against the end **56** of the cylinder **52** and is seated at its other end against the spring seat **74**, the spring seat being engageable with the piston **58** so that the spring **76** biases the piston toward the end **66** of the cylinder, movement of the piston in this direction being limited by engagement thereof with a bushing **78** which closes the end **66** of the cylinder and through which the piston rod **64** extends. Encircling the stud **70** and engaging the piston **58** and the spring seat **74** is a relatively light spring **80** which acts to bias the piston **58** in a direction such as to bring the valve member **62** and its seat **60** into engagement, this occurring in response to movement of the piston rod **64** toward the end **56** of the cylinder **52** a distance sufficient to disengage the piston from the bushing **78**.

As will be discussed in more detail hereinafter, the hydraulic actuator **10** provides the operator thereof with a "feel" indicative of the braking force being developed at the brake **22**. For this purpose, the piston rod **64** includes telescopically related, inner and outer elements **82** and **84** biased axially apart by a compression spring **86** which forms a yieldable, compression-transmitting connection therebetween. The spring **86** is heavier than the spring **76**, i. e., the spring **86** is characterized by a higher spring force than the spring **76**, whereby an axial push force applied to the inner element **82** of the piston rod **64** will begin to move the outer element **84** thereof to seat the valve member **62** and displace the piston **58** toward the end **56** of the cylinder **52**, all before the spring **86** is compressed to its maximum extent. Considering the piston rod **64** in more detail, the outer element **84** thereof carries the stud **70** and is slidable in the bushing **78**. The inner element **82** of the piston rod **64** is provided with a stem **88** which is engageable with a transverse wall **90** of the outer element **84** to limit the extent of compression of the spring **86**, the spring being seated against this wall. The inner element **82** carries a transverse pin **92** the ends of which are disposed in longi-

tudinal slots 94 in the outer element 84 to prevent relative rotation of the inner and outer elements.

The outer or projecting end of the inner element 82 of the piston rod 64 provides a clevis 96 to which one end of a floating operating lever 98 is pivotally connected at 100. The brake rod 12 is pivotally connected to the opposite end of the floating operating lever 98 at 102, Fig. 1.

Intermediate its ends, the operating lever 98 is connected, by means of a pivot 104, to one end of a tension link 106. The opposite end of this link is pivotally connected, at 108, to a valve lever 110 which is connected to a housing 50 by a pivot 112. When the operating lever 98 is in the position shown in Fig. 2 of the drawings, which corresponds to zero tension in the brake rod 12, the various components of the piston 58 and the piston rod 64 are in the positions shown, and the valve lever 110 is at the counterclockwise end of its pivotal movement about the pivot 112, pivotal movement of the valve lever 110 in the counterclockwise direction being limited by engagement of an adjustable stop 114 thereon with a stop 116 on the housing 50. Under such conditions, it will be noted that the pivot 108 between the link 106 and the valve lever 110 is offset to one side of a line connecting the pivot 104 between the operating lever 98 and the link 106 and the pivot 112 connecting the valve lever 110 and the housing 50. With the offset shown for the pivot 108, an axial pull force applied to the brake rod 12 will cause the valve lever 110 to rotate in the clockwise direction about the pivot 112, pivoting of the valve lever in the clockwise direction being limited by engagement of an adjustable stop 118 thereon with a stop 120 on the housing 50. As will be discussed in more detail hereinafter, such an axial pull force applied to the brake rod 12, in addition to rotating the valve lever 110 in the manner discussed, also moves the inner element 82 of the piston rod 64 toward the end 56 of the cylinder 52, such movement of the element 82 ultimately being communicated to the element 84 through the spring 86 to produce movement of the piston 58 toward the end 56 of the cylinder upon engagement of the valve member 62 with its seat 60 in the piston.

Such clockwise rotation of the valve lever 110 in response to an axial pull force applied to the brake rod 12 to pivot the operating lever 98, is utilized to actuate a selector valve means 122 in a manner to be described. Considering the selector valve means 122, the housing 50 is provided with a recess 124 for a tubular bushing 126 in which the selector valve means 122 is reciprocable, the selector valve means being movable from a return position, shown in Fig. 2 of the drawings, toward the right into a pressure position, not shown. Such movement is opposed by a compression spring 128 between the bottom of the recess 124 and one end of the selector valve means 122. The outer end of the selector valve means 122 carries a spring seat 130 for one end of a compression spring 131, the other end of the spring being seated against a follower 132 which is telescopically related to the selector valve means. The follower 132 is engaged by an adjustable actuator 134 on the valve lever 110, it being apparent that clockwise pivoting of the valve lever will cause the actuator 134 to act through the spring 131, which is heaver than the spring 128, to move the selector valve means 122 from its return position to its pressure position.

The housing 50 is provided therein with a return port 136 into which the fitting 44 is adapted to be threaded. Communicating with the return port 136 is a passage 138 which leads to an external annular groove 140 in the bushing 126. This bushing is provided with radial ports 142 therein which connect the groove 140 to an internal annular groove 144 in the bushing. When the selector valve means 122 is in its return position, an external annular groove 146 in the selector valve means 122 registers with the groove 144 in the bushing 126. The groove

146 in the selector valve means 122 communicates with radial ports 148 therein, the latter, in turn, communicating with an axial passage 150 in the selector valve means which leads to the bottom of the recess 124. A passage 152 in the housing 50 connects the bottom of the recess 124 to the cylinder 52, this passage communicating with the cylinder between the actuating port 54 and the piston 58 when the latter is at the end 66 of the cylinder. Thus, when the selector valve means 122 is in its return position, it connects the cylinder 52, between the piston 58 and the actuating port 54, to the return port 136 leading to the reservoir 38.

When the selector valve means 122 is in its pressure position, the external annular groove 146 therein registers with an internal annular groove 154 in the bushing 126. The groove 154 communicates with radial ports 156 leading to an external annular groove 158, this groove communicating with a passage 160 in the housing 50 leading to a pressure port 162 in the housing. This pressure port is adapted to have the fitting 26 threaded thereinto. Thus, when the selector valve means 122 is in its pressure position, the pressure port 162 is connected to the passage 152 leading to the cylinder 52.

A second passage 164 communicating with the return port 136 leads through the housing 50 to an annular groove 166 in the bushing 78, this groove communicating with the end 66 of the cylinder 52 through ports 168 in the bushing 78. In the passage 164 is a check valve means 170, shown as comprising a ball valve 172 biased into engagement with a tapered seat 174 by a compression spring 176, for preventing flow from the end 66 of the cylinder 52 to the return port 136, while permitting flow in the opposite direction.

Operation of actuator 10

Considering the operation of the hydraulic actuator 10, it will be assumed that the pump 30 is operating to provide a supply of fluid under pressure at the pressure port 162. If, under such conditions, a braking force, in the form of an axial pull force, is applied to the brake rod 12, the floating operating lever 98 is pivoted both about the pivot 100 associated with the piston 58 and the pivot 104 associated with the selector valve means 122, each of these pivots thus serving as a fulcrum for the other. Such pivoting of the floating operating lever 98 causes movement of the inner element 82 of the piston rod 64 toward the end 56 of the cylinder 52, and causes clockwise pivoting of the valve lever 110. As the operating force applied to the floating operating lever 98 by the brake rod 12 is increased, the spring 86 between the elements 82 and 84 of the piston rod 64 is eventually compressed sufficiently to cause the valve member 62 to engage its seat 60 and to cause the piston 58 to be displaced toward the end 56 of the cylinder 52. Also, the valve lever 110 is rotated in the clockwise direction sufficiently to move the selector valve means 122 out of its return position, thereby cutting off communication between the passage 152 and the return port 136, into its pressure position, thereby establishing communication between the passage 152 and the pressure port 162. The rate at which the fluid discharged by the pump 30 will flow from the pressure port 162 into the cylinder 52 by way of the passage 152 depends upon the degree to which the external groove 146 in the selector valve means 122 registers with the internal groove 154 in the bushing 126, and thus depends on the magnitude of the operating force applied to the floating operating lever 98. Consequently, the pressure developed in the cylinder 52 between the piston 58 and the end 56 of the cylinder will depend on the magnitude of the operating force applied to the floating lever 98, whereupon the pressure transmitted to the wheel cylinder 20 will depend upon the operating force applied to the floating lever.

It will be apparent that for each operating force applied to the floating operating lever 98, an equilibrium

condition is attained with respect to the extents to which the various springs associated with the piston 58, the piston rod 64 and the selector valve means 122 are compressed. In other words, the greater the operating force applied to the floating lever 98, the greater will be the extents of compression of the springs 128 and 131 associated with the selector valve means 122 and the greater will be the extents of compression of the springs 76 and 86 associated with the piston 58 and the piston rod 64, a condition of equilibrium or balance being attained for each operating force.

With the selector valve means 122 in its pressure position so that communication between the pressure port 162 and the cylinder 52 between the piston 58 and the actuating port 54 is established to an extent dependent upon the magnitude of the applied operating force, the pressure developed in the cylinder 52 opposes the force applied to the piston 58 through the piston rod 64. The pressure force thus applied to the piston 58, and the spring force applied thereto by the spring 76, are opposed by the axial push force applied to the piston rod 64 by the floating operating lever 98 to compress the spring 86 incorporated in the piston rod to an extent proportional to the applied operating force. In other words, a force is developed in the spring 86 which is proportional to the operating force applied to the hydraulic actuator 10 by the operator thereof. Since the reactive force developed in the spring 86 is thus always proportional to the applied operating force, the operator is provided with an artificial "feel" indicative of the braking force being developed at the wheel 24, this following because of the fact that the reactive force produced by the spring 86 is proportional to the pressure developed in the cylinder 52 between the piston 58 and the actuating port 54. Thus, the operator of the hydraulic actuator 10 is always required to apply to the floating operating lever 98 a force which is proportional to the braking force developed at the wheel 24, which is an important feature.

It will be noted from the foregoing that the hydraulic actuator 10 provides a straight power system when the pump 30 is in operation. However, in the event of failure of the pump 30, or failure of the motor, or the like, not shown, for driving same, the hydraulic actuator 10 may be utilized as a master cylinder for developing pressure at the wheel cylinder 20. Considering the conditions obtaining when no pressure is available at the pressure port 162, it will be apparent that movement of the selector valve means 122 to its pressure position will not result in the development of any pressure in the cylinder 52 between the piston 58 and the actuating port 54. However, an operating force applied to the floating operating lever 98 will result in displacement of the piston 58 toward the end 56 of the cylinder 52 to develop pressure at the actuating port 54, dissipation of such pressure through the passage 152, the selector valve means 122 and the pressure port 162 being prevented either by the employment of a pump 30 having therein check valve means, not shown, for preventing reverse flow, or by the provision of check valve means, not shown, in the pressure line 28. In the event that movement of the piston 58 toward the end 56 of the cylinder 52 to the limit of its travel does not result in the development of the necessary pressure at the actuating port 54, or in the event that fluid has drained from the system between the actuator 10 and the wheel cylinder 20 due to leakage, or otherwise, the piston 58 may be operated with a pumping action to develop the necessary pressure. In other words, the operator pumps the pedal, or the like, connected to the brake rod 12 until the necessary pressure is developed, such pumping of the pedal producing reciprocatory movement of the piston 58 in its cylinder 52. As will be apparent, movement of the piston 58 toward the end 56 of the cylinder 52 results in seating of the valve member 62 and opening of the check valve means 170 to draw fluid from the reservoir 38 into the end 66 of the cylinder by way of the return line 42, the return port 136, the passage 164, the groove 166 and the ports 168. When the operating force is relaxed, the valve member 62 and the seat 60 on the piston 58 disengage as the spring 76 returns the piston to the end 66 of the cylinder, thereby permitting the fluid previously drawn in through the check valve means 170 to flow past, i. e., through, the piston into the space between the piston and the end 56 of the cylinder, the check valve means closing to prevent back flow to the reservoir. As will be apparent, by repeatedly pumping the brake pedal, or the like, connected to the brake rod 12, the foregoing sequence of events is repeated to pump fluid from the reservoir 38 to the wheel cylinder 20 until the necessary pressure is developed at the wheel cylinder, thereby replenishing any fluid which may have drained away, due to leakage, or otherwise. Thus, the present invention permits the use, in aircraft, for example, of brakes having much larger displacements for emergency purposes than is normally permissible, which is an important feature.

Hydraulic actuator 180

Referring now to Fig. 3 of the drawings, illustrated therein is a hydraulic actuator 180 of the invention which includes a housing 182 providing a cylinder 184 having an actuating port 186 therein adjacent one end 188 thereof. Reciprocable in the cylinder 184 is a tubular piston 190 providing a tapered seat 192 for a valve member 194. This valve member carries an annular sealing element 196 which is engageable with the seat 192 to provide a fluid-tight seal, the seat 192 tapering toward the end 188 of the cylinder 184. The valve member 194 is carried by a piston rod 198 which projects axially from the other end, 200, of of the cylinder 184. The valve member 194, which is formed in two parts with the sealing element 196 disposed therebetween, is mounted on a stud 202 projecting axially from the piston rod 198 toward the end 188 of the cylinder 184. A nut 204 threaded on the stud 202 retains the two-part valve member 194 and also retains a spring seat 206 clamped between the valve member and the nut. A relatively heavy spring 208 is seated at one end against the end 188 of the cylinder 184, and at its other end against the spring seat 206, this spring biasing the piston 190 toward the end 200 of the cylinder and seating the piston against a bushing 210 when the piston rod 198 is in the position shown. A relatively light spring 212 encircles the valve member 194 and is seated against the piston 190 and the spring seat 206 to cause the tapered seat 192 on the piston to engage the valve member 194 upon axial movement of the piston rod toward the end 188 of the cylinder. Thus, when the piston 190 and the piston rod 198 are in the positions shown, fluid may flow through the piston, but when the piston rod is displaced axially to move the valve member 194 into engagement with its seat, flow through the piston is prevented.

The piston rod 198, which projects through and is axially slidable in the bushing 210, is connected at its outer end to one end of a floating operating lever 214 by a pivot 216. The opposite end, 217, of the floating operating lever 214 is adapted to have an operating force, such as a braking force, applied thereto, as by a brake rod corresponding to the brake rod 12. A tension link 218 is connected to the operating lever 214 intermediate its ends by a pivot 220, the link also being connected, by a pivot 222, to a lever or crank 224 which is connected to the housing 182 by a pivot 226. The pivot 222 is located intermediate the ends of the lever 224, and the pivot 226 is located at one end thereof. The opposite end of the lever 224 is connected to one end of a link 228 by a pivot 230, the other end of this link being connected, by a pivot 232, to one end of a valve lever 234. This valve lever is pivotally connected, intermediate its ends, to the housing 182 by a pivot 236 and carries an adjustable stop 238 engageable with a stop 240 on the

housing 182 to limit counterclockwise rotation of the valve lever.

Mounted on the opposite end of the valve lever 234 from the pivot 232 is an adjustable actuator 242 engageable with a follower 244 telescopically related to a selector valve means 246, a compression spring 248 being interposed between the follower 244 and the selector valve means 246. The selector valve means 246 is reciprocable in a bushing 250 disposed in a recess 252 in the housing 182, one end of this recess being closed by a plug 254. A compression spring 256 is seated at one end against the plug 254 and at its other end against the selector valve means 246 and acts to bias the selector valve means to a return position, shown in Fig. 3 of the drawings. Counterclockwise rotation of the valve lever 234 acts to displace the selector valve means 246 from the return position shown to a pressure position, as will be described.

The housing 182 is provided with a return port 258 and a passage 260 connecting the return port to an external annular groove 262 in the bushing 250. Radial ports 264 in the bushing connect the external groove 262 to an internal annular groove 266 therein. When the selector valve means 246 is in its return position, an external annular groove 268 therein registers with the internal groove 266 in the bushing. Radial ports 270 in the selector valve means 246 connect the external groove 268 to an axial passage 272 in the selector valve means which leads to a space 274 in the recess 252 adjacent the plug 254. This space communicates with a passage 276 leading to the cylinder 184 at the end 200 thereof. Thus, when the selector valve means 246 is in its return position, it connects the end 200 of the cylinder 184 to the return port 258, this port being adapted to be connected to a reservoir, or the like.

When the selector valve means 246 is in its pressure position, the external annular groove 268 therein registers, at least partially, with an internal annular groove 278 in the bushing 250. This groove 278 is connected by radial ports 280 to an external annular groove 282 in the bushing 250, the groove 282 registering with a passage 284 in the housing which leads to a pressure port 286 therein. This pressure port is adapted to be connected to a source of fluid under pressure, such as a pump corresponding to the pump 30. Thus, when the selector valve means 246 is in its pressure position, the end 200 of the cylinder 184 is placed in communication with the pressure port 286.

Operation of actuator 180

Basically, the operation of the hydraulic actuator 180 differs from that of the actuator 10 in that the actuator 180 is of the boosting type, the fluid pressure being utilized to supplement a manual operating force applied to the piston 190.

When a force is applied to the end 217 of the operating lever 214 in the downward direction, as viewed in Fig. 3 of the drawings, such an operating force, due to the floating mounting of the operating lever, is resolved into a force applied to the piston rod 198 tending to displace the piston 190 toward the end 188 of the cylinder 184, and into a force which acts through the link 218, the lever 224, the link 228 and the valve lever 234 to move the selector valve means 246 from its return position toward its pressure position. Such axial movement of the piston rod 198 toward the end 188 of the cylinder 184 results in seating of the valve member 194 on its seat 192, and subsequently results in movement of the piston 190 toward the end 188 of the cylinder, thereby developing pressure in the cylinder which may be transmitted from the actuating port 186 to any hydraulic device to be actuated. Upon application of an operating force to the end 217 of the floating operating lever 214 of sufficient magnitude, the selector valve means 246 is moved into its pressure position, the extent to which the external groove 268 in the selector valve means registers with the groove 278 depending upon the magnitude of the applied operating force. This results in the delivery of fluid under pressure from the pressure port 286 to the end 200 of the cylinder 184, the pressure developed in the end 200 of the cylinder depending upon the magnitude of the applied operating force. This pressure in the end 200 of the cylinder 184 acts on the piston 190 to aid or supplement the manual force applied thereto through the piston rod 198 and the floating operating lever 214, the actuator 180 thus operating with a boosting action.

As soon as the operating force applied to the floating operating lever 214 is released, the various parts return to the positions shown in Fig. 3 of the drawings, thereby re-establishing communication between both ends of the cylinder 184 and the return port 258. This insures that no residual pressure will be applied to the hydraulic device being actuated.

It will be noted that in the hydraulic actuator 10, the selector valve means 122 and the valve lever 110 for actuating it are located alongside of the cylinder 52 adjacent one end thereof, thereby providing the actuator 10 with a substantially L-shaped configuration. Similarly, in the hydraulic actuator 180, the selector valve means 246 and the valve lever 234 for actuating it are located alongside the cylinder 184 adjacent one end thereof to provide the actuator 180 with a substantially L-shaped configuration. These L-shaped configurations for the actuators 10 and 180 render same extremely compact for use in installations where space limitations are severe, which is a feature of the invention.

Although I have disclosed exemplary embodiments of my invention herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiments without departing from the spirit of the invention as defined by the claims hereinafter appearing.

I claim as my invention:

1. In a hydraulic actuator, the combination of: a housing providing a cylinder and having actuating, pressure and return ports therein, said actuating port communicating with said cylinder adjacent one end thereof; selector valve means carried by said housing adjacent and spaced laterally from said cylinder for selectively connecting said pressure and return ports to said cylinder; piston means including a piston reciprocable in said cylinder toward and away from said actuating port and a piston rod projecting axially from the other end of said cylinder; a valve lever pivotaliy connected to said housing adjacent and spaced laterally from said other end of said cylinder and spaced laterally from said piston rod and engageable with said selector valve means to cause said selector valve means to connect said pressure port to said cylinder in response to pivotal movement of said valve lever toward and into engagement with said selector valve means; a floating operating lever pivotally connected at one end to the outer end of said piston rod; and tension means pivotally connecting said operating lever to said valve lever, said tension means being connected to said operating lever between said one end of said operating lever and the other end thereof and being connected to said valve lever at a point spaced laterally from the pivotal connection of said valve lever to said housing, whereby an operating force applied to said other end of said operating lever along a line paralleling the axis of said cylinder in a direction from said one end of said cylinder toward said other end thereof causes said operating lever to apply a compressive force to said piston rod to move said piston from said other end of said cylinder toward said one end thereof and toward said actuating port, and causes said operating lever to apply a tensile force to said tension means to pivotally move said valve lever into engagement with said selector valve means to cause said selector valve means to connect said pressure port to said cylinder.

2. A hydraulic actuator as defined in claim 1 wherein

said selector valve means is located adjacent said other end of said cylinder to provide said hydraulic actuator with a substantially L-shaped configuration.

3. In a hydraulic actuator, the combination of: a housing providing a cylinder and having actuating, pressure and return ports therein, said actuating port communicating with said cylinder adjacent one end thereof, said housing having therein a passage which communicates with said cylinder at a point spaced axially of said cylinder from said actuating port and toward the other end of said cylinder; selector valve means carried by said housing and movable between pressure and return positions for connecting said pressure port in fluid communication with said passage when said selector valve means is in said pressure position and for connecting said return port in fluid communication with said passage when it is in said return position; a piston reciprocable in said cylinder; a piston rod connected to said piston and projecting axially from said cylinder, said piston being movable toward said one end of said cylinder by an axial force applied to said piston rod; a valve lever pivotally connected to said housing and engaging said selector valve means for moving said selector valve means toward said pressure position; a floating operating lever pivotally connected to said piston rod; and means pivotally connecting said operating lever to said valve lever.

4. In a hydraulic actuator, the combination of: a housing providing a cylinder and having actuating, pressure and return ports therein, said actuating port communicating with said cylinder adjacent one end thereof, said housing having therein a passage which communicates with said cylinder at a point spaced axially of said cylinder from said actuating port and toward the other end of said cylinder; selector valve means carried by said housing and movable between pressure and return positions for connecting said pressure port in fluid communication with said passage when said selector valve means is in said pressure position and for connecting said return port in fluid communication with said passage when it is in said return position; means for biasing said selector valve means toward said return position; a piston reciprocable in said cylinder; means for biasing said piston toward said other end of said cylinder; a piston rod connected to said piston and projecting axially from said cylinder, said piston being movable toward said one end of said cylinder by an axial force applied to said piston rod; a valve lever pivotally connected to said housing and engaging said selector valve means for moving said selector valve means toward said pressure position; a floating operating lever pivotally connected to said piston rod; and means pivotally connecting said operating lever to said valve lever.

5. A hydraulic actuator as defined in claim 1 wherein said tension means pivotally connecting said operating lever to said valve lever includes a tension link pivotally connected at one end to said valve lever and at its other end to said operating lever.

6. A hydraulic actuator according to claim 1 wherein said tension means pivotally connecting said operating lever to said valve lever includes: another lever pivotally mounted on said housing; a tension link pivotally connected at one end to said operating lever and at its other end to said other lever; and another tension link pivotally connected at one end to said other lever and at its other end to said valve lever.

7. A hydraulic actuator according to claim 4 wherein said point of communication between said cylinder and said passage is intermediate said one and said other ends of said cylinder.

8. A hydraulic actuator according to claim 4 wherein said point of communication between said cylinder and said passage is intermediate said one and said other ends of said cylinder, said housing being provided with another passage therein which communicates with said return port and which communicates with said cylinder adjacent said other end thereof, said hydraulic actuator including check valve means in said other passage for preventing flow therethrough from said cylinder to said return port, and including check valve means carried by said piston and operable in response to the application of an axial force to said piston rod to move said piston toward said one end of said cylinder for preventing flow past said piston.

9. In a hydraulic actuator, the combination of: a housing providing a cylinder and having actuating, pressure and return ports therein, said actuating port communicating with said cylinder adjacent one end thereof, said housing have therein a first passage which communicates with said cylinder intermediate the ends thereof, and having therein a second passage which communicates with said return port and which communicates with said cylinder adjacent the other end thereof; selector valve means carried by said housing for selectively connecting said return and pressure ports in fluid communication with said first passage; means for actuating said selector valve means; a piston in said cylinder; means for moving said piston from said other end of said cylinder towards said one end thereof; check valve means in said second passage for preventing flow therethrough from said cylinder to said return port; and check valve means carried by said piston and operable in response to movement thereof from said other end of said cylinder toward said one end thereof for preventing flow past said piston.

10. In a hydraulic actuator, the combination of: a housing providing a cylinder and having actuating, pressure and return ports therein, said actuating port communicating with said cylinder adjacent one end thereof; means for alternatively connecting said pressure port and said return port in fluid communication with said cylinder at a point intermediate the ends thereof; passage means connecting said return port in fluid communication with said cylinder adjacent the other end thereof; check valve means in said passage means for preventing flow therethrough from said cylinder to said return port; a piston reciprocable in said cylinder between a point adjacent said other end thereof and said point intermediate the ends thereof; and check valve means carried by said pison and operable in response to movement of said piston from said other end of said cylinder toward said one end thereof for preventing flow past said piston.

11. In a hydraulic actuator, the combination of: a housing providing a cylinder and having an actuating port therein which communicates with said cylinder adjacent one end thereof, said housing having therein another port adapted to be connected to a source of fluid supply, and having therein a passage connecting said other port to said cylinder adjacent the other end thereof; check valve means in said passage for preventing flow therethrough from said cylinder to said other port; a picton reciprocable in said cylinder; and check valve means carried by said piston and operable in response to movement of said piston from said other end of said cylinder toward said one end thereof for preventing flow past said piston.

12. A hydraulic actuator as defined in claim 11 including a piston rod connected to said piston and projecting axially from said cylinder, said piston rod including two telescopically related elements and resilient means biasing said elements apart.

13. In a hydraulic actuator, the combination of: a housing providing a cylinder and having actuating, pressure and return ports therein, said actuating port communicating with said cylinder adjacent one end thereof, said housing having therein a passage which communicates with said cylinder at a point intermediate said one end of said cylinder and the other end thereof; means for alternatively connecting said pressure and return ports with said passage; a piston reciprocable in said

cylinder between said other end thereof and said point of communication between said passage and said cylinder; and a piston rod connected to said piston and projecting axially from said cylinder, said piston rod including two telescopically related elements and including resilient means biasing said elements apart.

14. In a hydraulic actuator, the combination of: a housing providing a cylinder and having actuating, pressure and return ports therein, said actuating port communicating with said cylinder adajcent one end thereof, said housing having therein a passage which communicates with said cylinder at a point intermediate said one end of said cylinder and the other end thereof; selector valve means carried by said housing and movable between pressure and return positions for connecting said pressure port in fluid communication with said passage when said selector valve means is in said pressure position and for connecting said return port in fluid communication with said passage when it is in said return position; means for biasing said selector valve means toward said return position; a piston reciprocable in said cylinder between said other end thereof and said point; means for biasing said piston toward said other end of said cylinder; a piston rod connected to said piston and projecting axially from said cylinder, said piston rod including two telescopically related elements one of which is connected to said piston, said piston rod including means for biasing said elements axially apart; and means interconnecting said selector valve means and the other end of said elements of said piston rod for moving said piston toward said one end of said cylinder and for moving said selector valve means toward said pressure position.

15. In a hydraulic actuator, the combination of: a housing providing a cylinder and having an actuating port communicating with said cylinder adjacent one end thereof; a piston in said cylinder and movable from the other end thereof toward said one end thereof; operating means adapted to have an operating force applied thereto; valve means connected to said operating means and responsive to an operating force applied thereto for admitting fluid under pressure into said cylinder between said piston and said one end of said cylinder; and connecting means projecting axially from said other end of said cylinder and connecting said piston to said operating means for moving said piston toward said one end of said cylinder in response to an operating force applied to said operating means, said connecting means including resilient means providing a yielding connection between said piston and said operating means.

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