

June 1, 1954

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2,679,727

HYDRAULIC POWER UNIT

Filed April 16, 1951

4 Sheets-Sheet 1

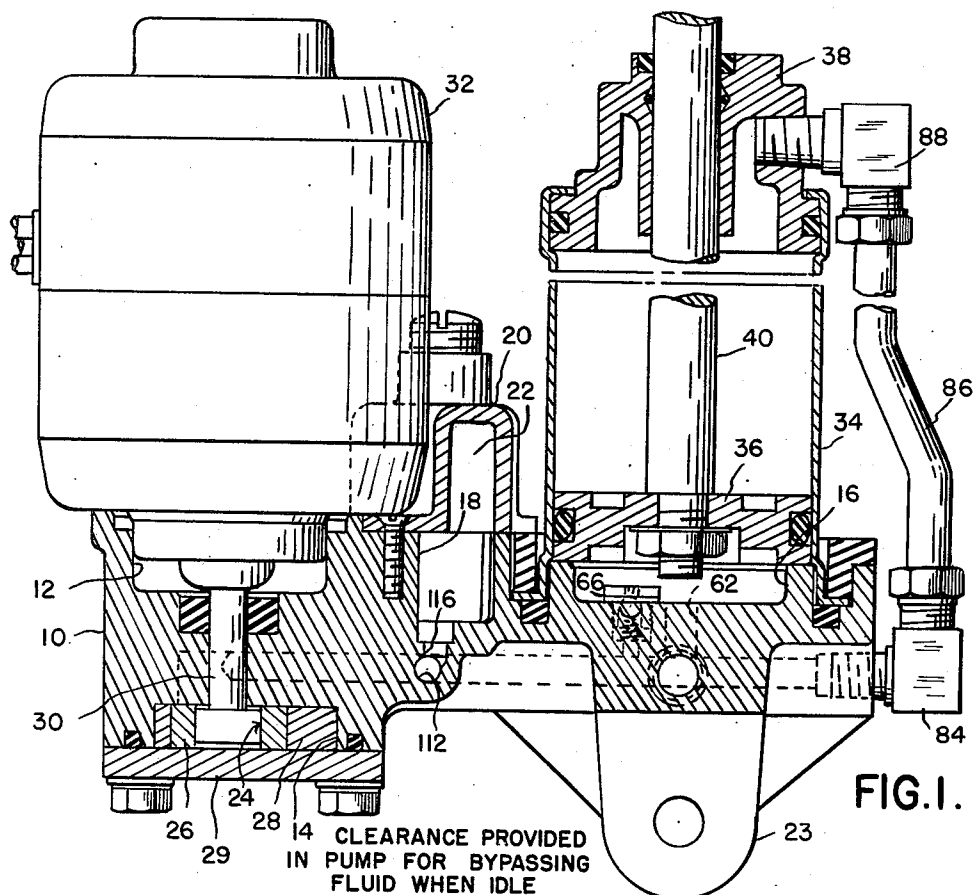
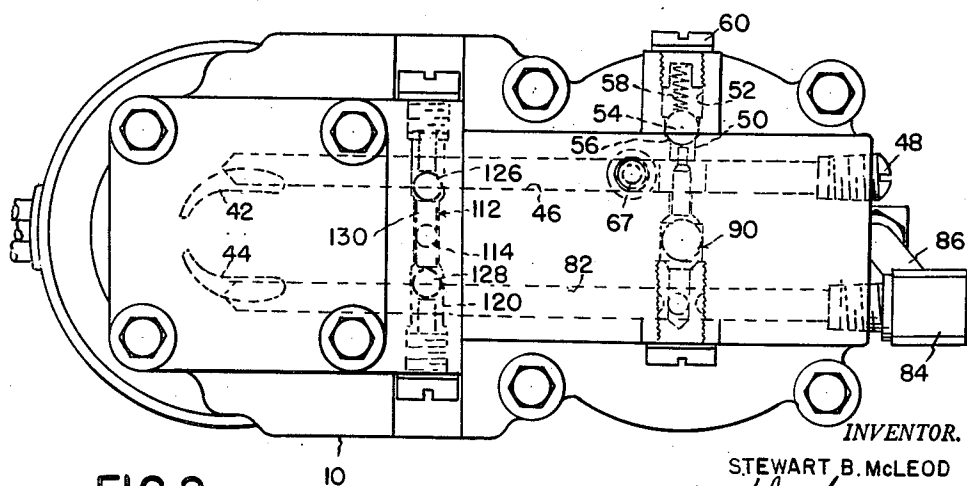


FIG. 2.

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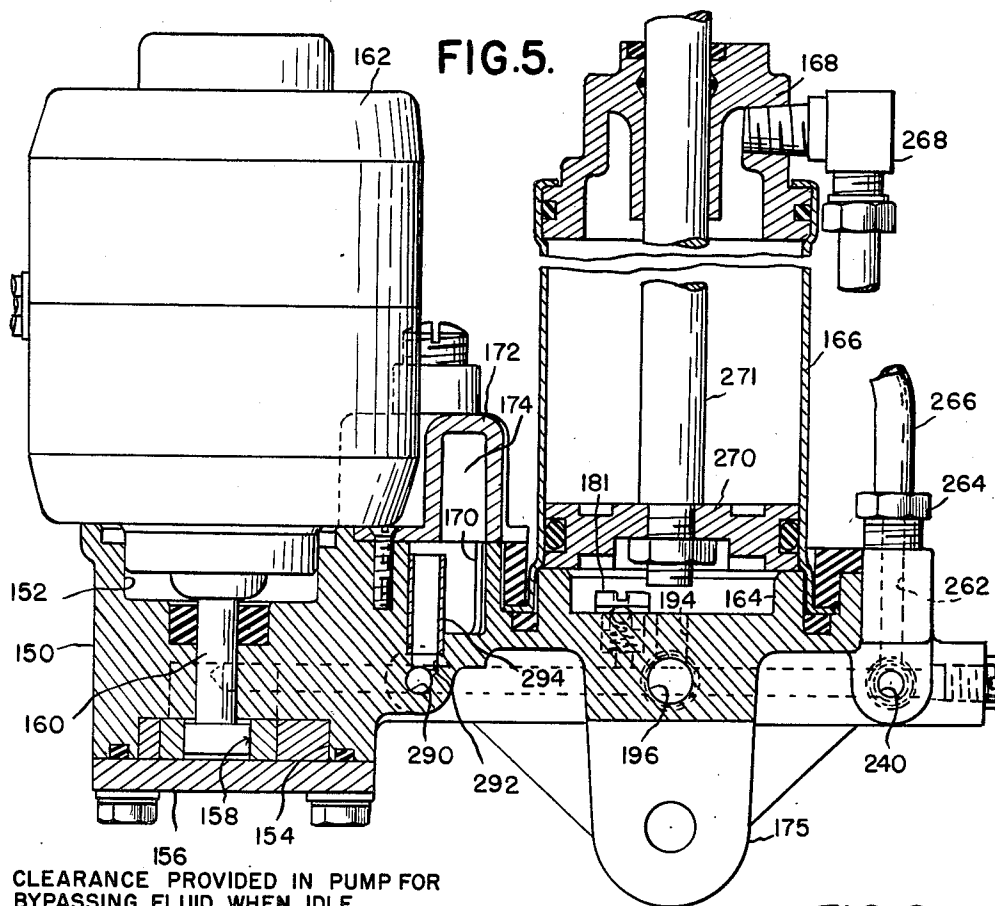
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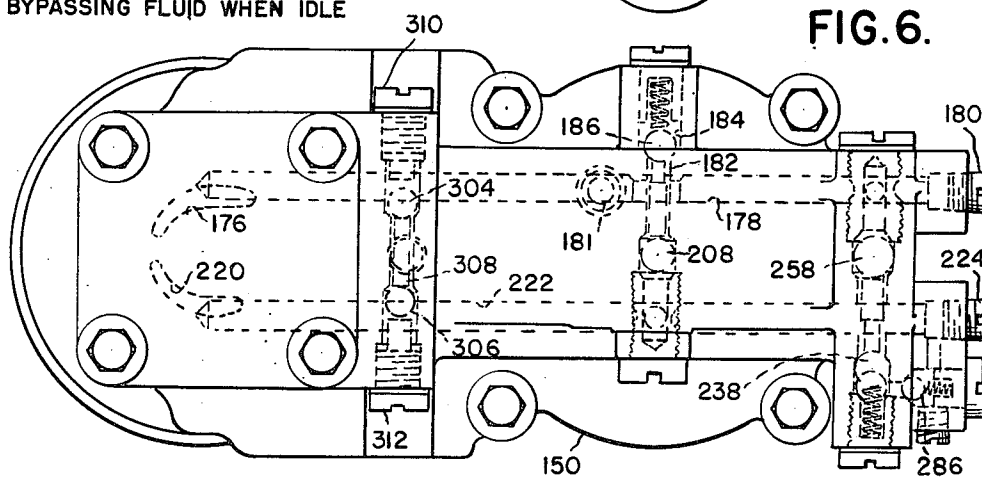
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4 Sheets-Sheet 3



CLEARANCE PROVIDED IN PUMP FOR
BYPASSING FLUID WHEN IDLE



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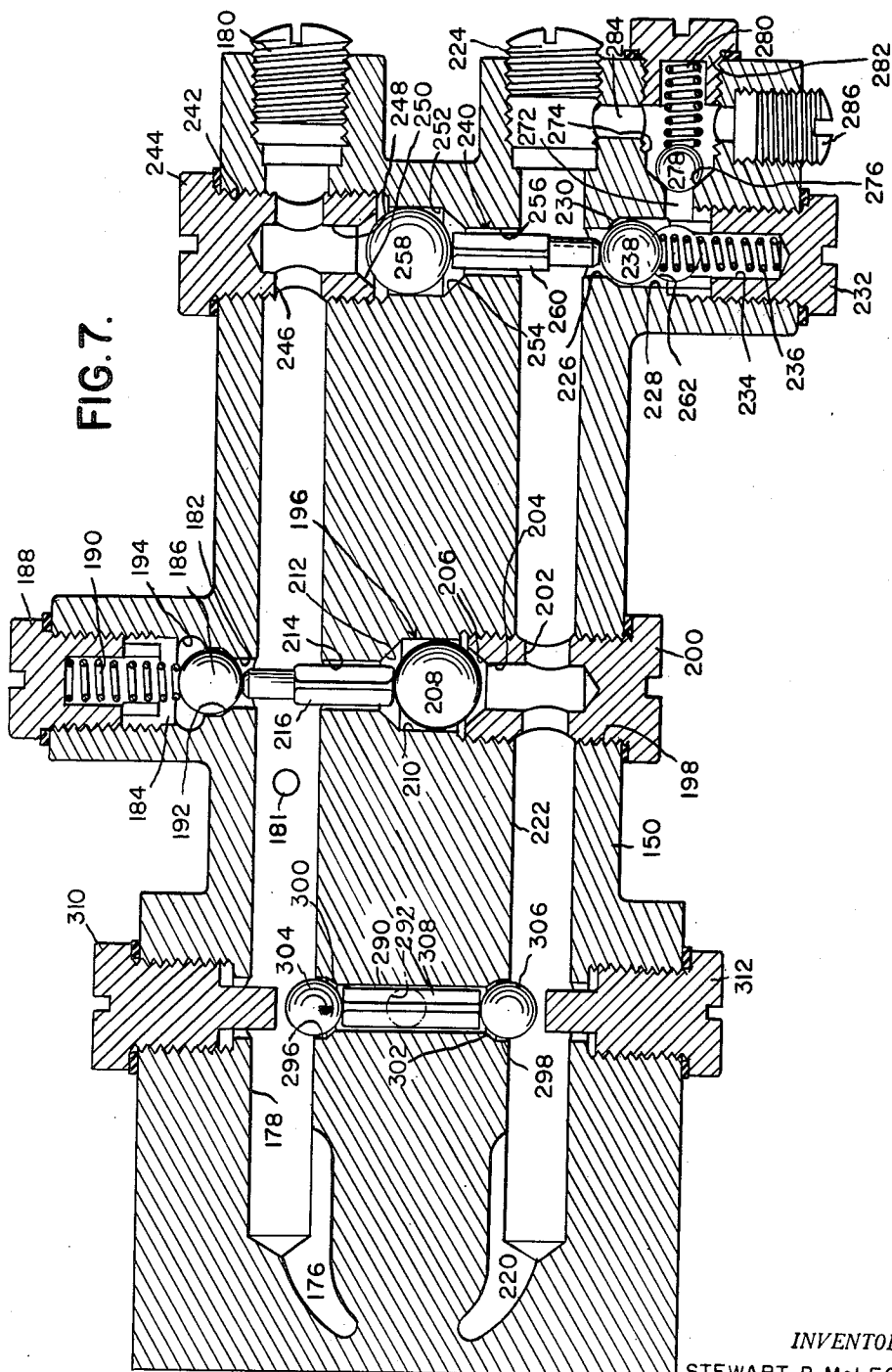
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,679,727

HYDRAULIC POWER UNIT

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Application April 16, 1951, Serial No. 221,273

8 Claims. (Cl. 60—52)

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The present invention relates to a power unit and more particularly to a self-contained pump and hydraulic motor unit constructed and arranged to prevent manual operation of the motor in at least one direction while the pump is idle.

It is an object of the present invention to provide a power unit comprising a self-contained reversible pump, a hydraulic motor such as a piston and cylinder device, fluid passage connecting the pump and motor, and one or more check valves disposed in the form of passages designed to prevent reverse flow of fluid under forces applied directly to the motor while the pump is idle.

More specifically, it is an object of the present invention to provide a hydraulic motor and a fluid supply system therefor, including a check valve preventing operation of the motor in at least one direction by forces applied directly to the motor while the pump is idle, in combination with means responsive to pressures developed in the system for holding the check valve open during operation of the pump.

It is a further object of the present invention to provide a power unit including a piston and cylinder device requiring a differential flow of fluid to and from the device in combination with a reservoir for accommodating excess fluid discharged from the cylinder during operation in one direction, and supplying the fluid to the system upon operation of the device in the other direction, in combination with means establishing a hydraulic lock to prevent manual movement of the piston in at least one direction while the motor is idle.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a longitudinal vertical section through the power unit.

Figure 2 is a bottom plan view of the unit shown in Figure 1.

Figure 3 is a more or less diagrammatic sectional view showing the essential fluid passages and valves for the unit shown in Figure 1.

Figure 4 is a longitudinal section through a pressure relief valve, permitting escape of fluid under excessive pressure from the cylinder.

Figure 5 is a vertical longitudinal section through a modified form of the unit.

Figure 6 is a bottom plan view of the unit shown in Figure 5.

Figure 7 is a more or less diagrammatic sec-

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tional view showing the essential fluid passages and valves for the unit shown in Figure 5.

Referring now to Figures 1-3 the power unit comprises a base or body 10 in the form of a casting, having a motor seat recess 12, a pump chamber 14, a cylinder seat 16, and a cavity 18. The cavity 18 is adapted to be closed by a cover 20 which is herein illustrated as of inverted cup shape, the cavity 18 and the cover 20 together constituting a fluid reservoir 22. Mounting ears 23 are provided on the body in alignment with the axis of the cylinder seat 16.

Located within the pump chamber 14 is a reversible rotary pump 24 of any suitable type. Conveniently, the pump may be of the type comprising a small externally toothed pinion 26 and an internally toothed gear 28 having one more tooth than is provided on the pinion 26. Pumps of this type are well known and accordingly, the pump is not illustrated in detail. However, preferably, sufficient clearance is provided between the rotating elements of the pump and the removable end closure plate 29 so that a restricted but substantial bypass flow of fluid may take place through the pump when the pump is idle. The pinion 26 is operatively connected to the shaft 30 of a reversible electric motor 32.

Mounted in overlying relation with respect to the cylinder seat 16 is a cylinder 34 having a piston 36 slidable therein. The lower end of the cylinder 34 is closed by the cylinder seat 16 and at its upper end it is provided with an end closure 38 having an opening therethrough for receiving the piston rod 40.

Inasmuch as the piston rod 40 occupies only the portion of the cylinder at one side of the piston 36, movement of the piston 36 in the cylinder results in a differential flow of fluid. Thus, when the piston is moved upwardly from the position shown in Figure 1, less fluid will be expelled from the upper end of the cylinder than is introduced into its lower end. Conversely, with the piston moving downwardly, more fluid is expelled from the lower end of the cylinder than is introduced into the upper end thereof.

The body 10, as best seen in Figure 2, is provided with a pair of arcuate pump ports 42 and 44 which will operate as inlet and outlet ports dependent upon direction of rotation of the pump 24. The port 42 is connected to a longitudinal drilled fluid passage 46 which is closed at its end by a removable plug 48. In position beneath the cylinder 34, the passage 46 is provided with a transverse connecting passage 50 which extends into an enlarged chamber 52 in which is located

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a check valve 54 biased toward a valve seat 56 by a light compression spring 58. The outer end of the chamber 52 is closed by a removable plug 60. The chamber 52 connects to a vertically extending drilled passage 62 (Figure 1) which communicates directly with the interior of the cylinder 34. A pressure relief valve indicated generally at 66, is provided which affords controlled communication between the interior of the cylinder 34 and the passage 46. The pressure relief valve is shown in detail in Figure 4.

As seen in this figure, the pressure relief valve is constituted by a passage 67 communicating with the passage 46 connected to an enlarged chamber 68 formed in the body 10 to receive a screw 72 having a longitudinal passage 74 therethrough. The bottom of the passage 74 is tapered to provide a valve seat 76 and associated with the valve seat 76 is a valve 78 preferably in the form of a ball, biased toward closed position by a relatively strong compression spring 80. The purpose of the pressure relief valve is to permit escape of fluid trapped in the cylinder by the operation of the locking means presently to be described, in the event of thermal expansion of the fluid. Accordingly, the spring 80 is selected to prevent opening of the valve 78 until undesirably high pressures are built up in the cylinder.

The port 44 is in communication with a longitudinally extending drilled passage 82 which at its outer end is connected to a fitting 84 carrying a metal conduit 86 having a second fitting 88 at its upper end communicating with the interior of the cylinder 34 through the end closure 38.

A transverse passage, indicated generally at 90 (see Fig. 3), is provided across the body 10 intersecting the passages 82 and 46 and in alignment with the passage 50 and enlarged chamber 52. The transverse passage 90 includes an enlarged threaded portion 92 receiving a threaded member 94 provided with transverse openings 96 therethrough. The member 94 is provided with a longitudinally extending passage 98 which communicates with the openings 96 and at its inner end is provided with a tapered valve seat 100. Inwardly of the threaded portion 92 thereof, the passage 90 includes an elongated chamber 102 of cylindrical cross-section in which is movably mounted a ball valve 104 which operates as a control valve for the check valve 54. The ball valve 104 is dimensioned to have a very close fit with the inner wall of the chamber 102 and has a piston-like longitudinal movement in the chamber, in response to reversal of pressure upon opposite sides of the ball valve. Beyond the ball valve the chamber 102 is reduced to provide a conical valve seat 106 and is provided with a passage 108 in which is received a pin 110 adapted to engage control valve 104 and check valve 54. The pin 110 is of such cross-section as to permit flow of fluid from the passage 46 to the chamber 102 so that the adjacent end of the control valve 104 is at all times subjected to the fluid pressure prevailing in passage 46.

Another transverse passage, indicated generally at 112, is provided, this passage having a reduced intermediate portion 114 communicating with a passage 116 leading to the interior of the reservoir 22. Outwardly of its intermediate reduced portion 114, the transverse passage 112 has longitudinally extending enlarged chambers 118 and 120 which communicate with the passages 46 and 82 respectively. The junctions between the enlarged chambers 118 and 120 and the reduced intermediate portion 114 are tapered to

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provide conical valve seats 122 and 124 respectively. Located in the chambers 118 and 120 are ball valves 126 and 128 respectively. Intermediate the ball valves is a rigid pin preferably of triangular cross-section and of such length that it prevents simultaneous seating of the valves 126 and 128.

With the structure thus far described the operation may be considered under four different operating conditions.

For the first condition it is assumed that the motor 32 is operating in such direction that the passage 46 is the supply passage, so that fluid under pressure is discharged into the passage 46. Establishment of pressure in the passage 46 operates on the valve 126 and forces it down against the valve seat 122. Movement of the valve 126 is transmitted to the pin 130 with the result that the valve 128 is maintained off its seat 124. Fluid under pressure in the passage 46 flows to the check valve 54. The valve 54 is retained on its seat only by the very light compression spring 58 and the pressure built up in the pump is sufficient to force check valve 54 off its seat permitting flow of fluid past the valve and upwardly through the passage 62 into the bottom of the cylinder. This results in upward movement of the piston and fluid is accordingly discharged from the upper end of the cylinder through the conduit 86 and thence returned to the passage 82. Return of this fluid past the threaded member 94 is permitted by the transverse openings 96 therein. However, the quantity of fluid discharged from the upper end of the cylinder and returned to the passage 82 is less than the quantity of fluid flowing into the bottom of the cylinder through the passage 46. Accordingly, excess fluid must be supplied to the circulating system and this is the purpose of the reservoir 22. Fluid from the reservoir 22 flows out of the transverse passage 112 past the valve 128 and supplies the excess fluid required by the pump during this phase of the operation. During this operation pressure in the passage 46 operates against the upper side of the ball valve 104 (as seen in Figure 3) with the result that the ball valve 104 is forced against the valve seat 100, thus preventing bypass of fluid through the transverse passage 90.

For the second condition, it is assumed that the motor is operating in such a direction that the passage 82 is the supply passage and accordingly, fluid under pressure is forced into the passage 82. Fluid under pressure in the passage 82 operates on the ball valve 128 and forces it inwardly against its seat 124 thus preventing flow of fluid into the reservoir. Fluid in the passage 82 passes through openings or ports 96 in the threaded member 94 and thence through the fitting 84, conduit 86, and fitting 88 into the upper end of the cylinder 34. Downward movement of the piston in the cylinder tends to force fluid down through the passage 62. At this time if the check valve 54 were permitted to close, operation of the unit would be prevented. However, fluid under pressure in the passage 82 operates on the underside (as seen in Figure 3) of the control valve 104, thereby forcing the valve upwardly against the pin 110 and positively maintaining the valve 54 in open position. Moreover, due to the elongated nature of the chamber 102 and the piston-like movement of the control valve 104 therein, substantial movement may be imparted so that the check valve 54 is retained in wide open position. Fluid therefore flows out

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of the lower end of the cylinder 34 past the check valve 54 and through the passage 46 to the pump. However, a larger quantity of fluid is discharged from the lower end of the cylinder than is admitted to the upper end thereof. Accordingly, provision must be made for removing this excess fluid from the circulating system and again, this is accomplished by the reservoir 22. Inasmuch as the ball valve 128 is retained on its seat 124 by the operating pressure of the pump, the valve 126 is mechanically retained off its seat 122 by the rigid pin 130. Accordingly, the excess fluid developed in the system due to the differential displacement in the cylinder, flows past the valve 126 and into the reservoir 22 through the passage 116.

For the third operating condition it is assumed that a mechanical force is applied to the piston 36 or the piston rod 40, in a direction tending to cause the piston rod to move upwardly. The first effect of this force will be to tend to cause fluid to flow out of the top of the cylinder and thence into the passage 32. At the same time pressure will be reduced in the passage 46. Fluid flowing under a pressure dependent upon the force exerted on the piston 36 flows into the passage 32 and through the transverse openings 96 in the threaded member 94. The pressure established in the passage 32 will normally close valve 128. However, as before noted, a restricted bypass flow of fluid through the pump is permitted when the pump is idle. Accordingly, a restricted flow of fluid will take place through the pump from the passage 32 to the passage 46. Since the ball valve 128 is retained closed by the pressure in the passage 32, the ball valve 126 is necessarily open. Since upward movement of the piston 36 discharges less fluid from the upper end of the cylinder than is drawn into the lower end of the cylinder, upward movement of the piston under the circumstances under consideration will withdraw excess fluid from the reservoir 22. The pressure of the spring 58 is negligible and fluid is drawn into the lower end of the cylinder by upward movement of the piston therein. Accordingly, a slow upward manual movement of the piston 36 is permitted.

For the fourth condition it is assumed that a force is applied to the piston 36 tending to move the same downwardly in the cylinder 34. Under these conditions downward movement of the piston is positively prevented by the check valve 54 which is normally retained on its seat 56 by the light compression spring 58. Accordingly, the piston cannot be moved downwardly in the cylinder by forces applied directly thereto, while the pump 24 is idle.

It was previously pointed out that control ball valve 104 is of larger diameter than check ball valve 54. This is for the purpose of insuring positive opening of the check valve 54 when fluid is admitted under pressure into passage 32 to move the piston downwardly. The system is characterized by the fact that it is completely filled with fluid at all times and it is therefore possible upon completion of upward movement of the cylinder under power to trap the operating pressure in the cylinder so that the fluid between the piston and the check valve 54 is under operating pressure, which may be 150 pounds for example. Therefore, in order to unseat the check valve 54 by pressure applied to the control valve 104, a force sufficient to overcome this trapped operating pressure must be applied. This is accomplished by making the valve 104 substan-

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tially larger than the valve 54. It will be observed that since the valve 104 is designed for piston-like movement in the cylindrical chamber 102, operating pressure in passage 32 is effective over an area equal to the cross-sectional area of the ball valve 104. In practice, it is improbable that full operating pressure can be trapped in the cylinder between the piston and the check valve 54. However, substantial pressure will normally be trapped in this part of the system and this pressure in many cases will be increased by thermal expansion of the fluid due to changes in ambient temperature. Thus, the problem is a serious one and the provision of a relatively large control ball valve 104 is necessary.

In practice, the control ball valve 104 is proportioned relative to the check valve 54 so that it can overcome trapped pressures built up between the piston and check valve up to the setting of the pressure relief valve 78. Thus, in the event that thermal expansion of the fluid takes place to a degree which opens the pressure relief valve 78, a maximum pressure is present in the space between the piston and the check valve, and the control valve 104 is of such size that when the pump is rotated in a reverse direction to move the piston 36 downwardly, the force available on the control valve 104 will be sufficient to open the check valve 54.

From the foregoing it will be observed that the power unit may be operated freely to move the piston up or down in the cylinder by reverse rotation of the motor 32. Moreover, with the motor and pump idle, the piston may be moved upwardly in the cylinder at a slow controlled rate dependent upon the capacity of the bypass through the pump. However, a positive fluid lock prevents downward movement of the piston by forces applied directly thereto when the pump is idle until pressure is developed sufficient to open relief valve 66. It will be appreciated that this arrangement is highly useful where the piston is connected to a window of a motor vehicle for example. In such case the window may be raised or lowered by power as desired. However, the window may not be opened by forces applied directly thereto, the positive fluid lock described preventing such motion. On the other hand, if the window is open and it is desired to close the same, this may be accomplished manually so that the window may be closed even though power failure or other cause prevents mechanical operation.

For other applications of the power unit, it may be desirable to prevent movement of the piston in either direction by the application of direct mechanical forces thereto while the pump is idle. By way of example, such an application would be in the use of the power unit as means for shifting an adjustable front seat of a motor vehicle back and forth. Operation of the power unit in the usual manner will move the seat forwardly or reversely under the control of the operator. However, when the pump is idle the piston is positively locked in its adjusted position and forces applied thereto under normal driving conditions will not result in movement of the seat from its desired adjusted position. Structure to accomplish this last result is illustrated in Figures 5-7.

Referring now to these last mentioned figures, the unit is substantially the same as that previously described with the exception of the provision of an additional set of check, control, and relief valves which necessitate a slight change in the shape of the casting.

The structure comprises a base or body 150 provided with a cylindrical recessed motor seat 152 and a cylindrical pump recess 154 adapted to be closed to provide a cylindrical pump chamber by a removable cover plate 156. A rotary pump 158 is provided which is connected to the drive shaft 160 of the motor 162. At the opposite end of the body 150 is a cylindrical cylinder seat 164 on which the power cylinder 166 is mounted. The cylinder seat 164 and the adjacent portion of the body 150 constitute a bottom end closure for the cylinder 166. The upper end of the cylinder is closed by a cap 168.

Located within the body 150 is a cavity 170 closed by an inverted cup-like closure 172, the cavity 170 and the closure 172 together providing a fluid reservoir 174.

At the opposite side of the body 150 from the cylinder seat 154 and in axial alignment therewith are a pair of mounting ears 175 by means of which the entire unit is adapted to be mounted for rocking movement during use.

In communication with one side of the pump recess 154 is a port 176 which communicates with an elongated passage 178 provided at its outer end with a closure plug 180. Beneath the cylinder 166 the passage 178 is provided with a pressure relief valve 181 which may be in all respects identical with the pressure relief valve 69 illustrated in detail in Figure 4. Extending transversely from the passage 178 is a second passage 182 which communicates with an enlarged chamber 184 in which a check valve 186 is provided. The outer end of the chamber 184 is closed by a removable cap 188 which is recessed at its inner end to receive a light compression spring 190. A valve seat 192 is provided at the junction between the passage 182 and the chamber 184 on which the check valve 186 seats and against which it is retained by light spring pressure in the absence of fluid pressure in the system. A vertical passage 194 (best seen in Figure 5) connects the chamber 184 with the interior of the cylinder 166.

In alignment with the transverse passage 182 and chamber 184 is a transverse passage indicated generally at 196 which includes a threaded portion 198 adapted to receive a plug or threaded member 200 having transverse through passages 202 and a longitudinal bore 204 opening into the inner end of the member 200. The inner end of the member 200 is beveled as indicated at 206 to provide a seat for a control ball valve 208 located in an elongated cylindrical chamber 210. The ball valve 208 has very slight clearance with respect to the cylindrical chamber 210 and is movable therein in piston-like fashion. Opposite the valve seat 206, the chamber 210 is reduced to provide a conical valve seat 212 and beyond the valve seat 212 the transverse passage 196 is further reduced as indicated at 214. Located within the portion 214 of the passage is a rigid pin 216 which preferably has its body portion of triangular or square cross-section to permit flow of fluid through the portion 214 of the transverse passage. Accordingly, fluid under the pressure existing in the passage 178 is available against the upper side (as seen in Figure 7) of the ball valve 208.

From the structure thus far described it will be apparent that when the pump is operating in a direction to supply fluid under pressure to the passage 178, this fluid moves control valve 208 onto its valve seat 206 and the fluid flows past check valve 186 and through the passage 194 into the underside of the cylinder.

The body 150 is also provided with a second port 220 communicating with a second longitudinally extending passage 222, the outer end of which is closed by a removable plug 224. Communicating with the passage 222 adjacent the end thereof closed by the plug 224, is a transverse passage 226 connected with an enlarged valve chamber 228 so as to provide a conical valve seat 230. The outer end of the chamber 228 is closed by a removable plug 232 recessed as indicated at 234 to provide a seat for a light compression spring 236. Located within the chamber 228 is a check valve 238 normally retained against the valve seat 230 by the spring 236.

In alignment with the passage 226 and chamber 228 is another transverse passage indicated generally by the numeral 240 which includes an enlarged threaded portion 242 adapted to be closed by a removable plug 244 identical with the plug 200 previously described and provided with transverse passages 246 and an axial passage 248 opening into the inner end of the plug. The end of the plug 244 is tapered to provide a conical valve seat 250. Inwardly of the threaded portion 242, the transverse passage 240 includes an elongated cylindrical chamber 252 terminating at the end thereof opposite to the plug 244 in a conical valve seat 254. Beyond the valve seat 254 the transverse passage 240 includes a reduced portion 256.

Located within the cylindrical chamber 252 is a control ball valve 258 adapted to seat against valve seats 250 or 254 depending upon the differential pressure existing in passages 178 and 222. Located intermediate the control valve 258 and the check valve 238 is a rigid element herein disclosed as a pin 260, the portion of the pin occupying the reduced portion 256 of the transverse passage being of triangular or non-circular cross-section to permit free flow of fluid through the portion 256 of the passage. As a result of this construction the underside of the control ball valve 258 (as seen in Figure 7) is subjected at all times to the fluid pressure existing in the passage 222.

Extending upwardly from the chamber 228 in which the check valve 238 is located, is a passage 262 which communicates with a fitting 264 connected to a metal conduit 266 carrying at its upper end a second fitting 268 extending through the closure 168 and affording communication with the interior of the cylinder 166 above the piston 270 therein. The piston 270 is connected to a piston rod 271 which extends from one side only thereof and through an appropriate sealed opening in the closure 168.

Extending outwardly from the chamber 228 is a passage 272 which communicates with an enlarged check valve chamber 274 provided with a valve seat 276. Located within the chamber 274 is a check valve 278, normally retained on the valve seat 276 by the light pressure of the compression spring 280. The chamber 274 is closed by a removable cap 282 recessed at its inner end to provide a spring seat for the spring 280.

Another transverse passage 284 is provided which extends through the chamber 274 and connects the chamber with the extreme end of the passage 222. The outer end of the passage 284 is closed by a removable plug 286.

Means are provided for selectively connecting the reservoir 174 to the passages 178 and 222 and this means comprises a transverse passage 290 having a vertically extending connecting

passage 292 which is shown in Figure 5 as connected to a short pipe or conduit 294 having its upper open end located generally midway between the top and bottom of the reservoir 174. The passage 290 adjacent its ends is laterally enlarged to provide valve chambers 296 and 298 including valve seats 300 and 302 at their inner ends. Ball valves 304 and 306 are located respectively in the chambers 296 and 298. Intermediate the ball valves 304 and 306 is a rigid pin 308 of such length as to prevent simultaneous closure of both valves 304 and 306. The outer ends of transverse passage 290 are closed by removable caps 310 and 312 which also constitute abutments limiting movement of the valves 304 and 306 respectively away from their valve seats.

The operation of the unit just described will be considered under four different operating conditions:

First condition

Assume that the pump 158 is rotated in such direction as to feed fluid under pressure into the passage 178. This fluid acts on the ball valve 304 and forces it against its seat 300. The fluid continues to flow to the check valve 186, forcing the check valve off its seat with the result that fluid flows past the check valve and upwardly through passage 194 into the cylinder 166 below the piston 270 thereof. The fluid under pressure in the passage 178 acts against the control valve 258 and forces it against valve seat 254, thereby preventing a bypass flow of fluid around the cylinder. In addition, fluid under pressure in the passage 178 flows through the openings 246 in the plug 244 and operates against the control valve 258 forcing it against valve seat 254.

Accordingly, all fluid discharged from the pump is forced into the underside of the cylinder 166. Moreover, it will be observed that movement of the control valve 258 against its valve seat 254 forces check valve 238 away from its seat 230. Accordingly, fluid discharged from the upper end of the cylinder 166 flows through the external conduit 266, the passage 262, into the chamber 228, and thence past the check valve 238 into passage 222 and thence back to the intake side of the pump.

Due to the fact that the piston rod 271 is located in the cylinder 166 at one side only of the piston 270, it is apparent that a differential flow of fluid from and to the cylinder results as the piston 270 is moved. Under the conditions assumed, in which the piston is moving upwardly, more fluid flows through the passage 178 into the bottom of the cylinder 166 than flows out of the top of the cylinder. This differential flow is permitted by the reservoir 174. Since the valve 304 is retained on its seat 300 by operating pressure in the passage 178, ball valve 306 is retained off its seat 302 by the pin 308. Accordingly, the passage 222 is in communication with the reservoir 174 via passages 290 and 292, and the excess fluid required by the pump to force the piston 270 upwardly is withdrawn from the reservoir.

Second condition

Assume that the pump 158 is rotated in a direction to discharge fluid under pressure into the conduit 222. At this time the fluid under pressure initially closes valve 306 against its valve seat 302 and at the same time movement of the valve 306 operates through the pin 308 to open the valve 304.

Fluid under pressure in the passage 222 flows through the transverse opening 202 in the plug 200 and also through the passage 204 in the plug to operate against the control ball valve 208, moving the valve upwardly (as seen in Figure 7) against its seat 212, thus opening check valve 186 against the action of the light spring 190.

The fluid under pressure in the passage 222 flows to the transverse passage 226 and lifts check valve 238 from its seat 230, thus permitting flow of fluid into the chamber 228 and thence through the passage 262 and conduit 266 into the upper end of the cylinder 166. At the same time the fluid under pressure passes through the passage 256 and operates against control valve 258 moving it against its seat 250. Fluid under operating pressure also acts through passage 272 against relief valve 278 but this valve is retained closed by the strong relief spring 280 so that flow of fluid through this passage is prevented. Accordingly, all fluid delivered by the pump is prevented by the several valves mentioned from bypassing the cylinder and the entire flow of fluid is thus directed into the upper end of the cylinder 166.

The resulting downward movement of the piston 270 displaces a greater quantity of fluid from beneath the piston than flows into the upper end thereof. This flow of fluid from the cylinder flows around check valve 186 which is retained open at this time by operating pressure applied to control valve 208. However, the flow of fluid into the passage 178 is more than can be accommodated by the pump. The excess flow of fluid into the passage 178 flows into the reservoir 174 past the valve 304 which is retained off its seat at this time by the closure of valve 306 under operating pressure in passage 222.

Third condition

Assume that pressure is applied directly to the piston 270 or piston rod 271 in a direction tending to move the piston downwardly in the cylinder 166, while pump 158 is idle. This results in establishing increased pressure below the piston and fluid tends to escape past check valve 186. The check valve 186 however, is retained on its seat by the relatively light compression spring 190 and accordingly, escape of fluid from the cylinder is positively prevented. This provides a rigid hydraulic lock which prevents movement of the piston in the cylinder by the application of external force thereto while the pump is inoperative.

Fourth condition

Assume that pressure is applied to the piston 270 or piston rod 271 in a direction tending to raise the piston in the cylinder 166, while the pump is idle. Under these conditions pressure is established in the fluid above the piston and causes the fluid to tend to escape through fitting 268, conduit 266, fitting 264, passage 262, to the chamber 228. However, return of fluid from the chamber directly to passage 222 is prevented by check valve 238 which is retained on its seat 230 by the action of compression spring 236. At the same time, pressure relief valve 278 is retained in closed position by the relatively strong relief spring 280. As a result, upward movement of the piston is positively blocked by a hydraulic lock.

As in the previously described power unit, the control valves 208 and 258 are of substantially larger size than check valves 186 and 238 respectively. This is for the purpose of insuring that upon reversal of direction of operation of

the piston under power sufficient force will be available to lift the check valves 186 and 238 from their respective seats. This is necessary due to the fact that termination of an operation may result in trapping fluid at either side of the piston and between the piston and the associated check valve under full operating pressure. Moreover, even though the pressure existing in the cylinder may be substantially less than operating pressure when movement of the piston under power is terminated, nevertheless the fluid will be trapped and pressures may increase very substantially due to thermal expansion or the like.

The pressure relief valves 278 and 181 prevent building up of dangerous pressures within the cylinder by expansion of trapped fluid. Normally, the relief valves will be set to operate at such a pressure that forces developed by operating pressure on the control valves 298 or 258 will be sufficient to lift check valves 186 and 238 from their seats against the maximum pressure permitted by the setting of the relief valves.

In both of the power units illustrated and described it will be noted that the control valves are constantly subjected at opposite sides thereto to pressures existing in the fluid passages connected to opposite sides of the pump. Accordingly, the control valves are responsive to pressure differentials existing in such passages and in general, at all times operate to keep the check valve controlling flow of fluid from the cylinder to the return passage to the pump in open position whenever the pump is being driven.

While all of the valves, and particularly the operating valves in the power unit, are illustrated as being in the form of balls, it will of course be appreciated that the valves may be of different shapes so long as their functions are preserved. In the case of operating valves which have the dual functions of preventing a flow of fluid which would bypass the cylinder and also to control the position of the check valves, it would be possible to substitute means quite different from the ball valves shown. Thus, for example, valves in the form of pistons of cylindrical shape could be employed. Alternatively, a movable diaphragm or a collapsible bellows could be employed which would itself constitute a seal to prevent the bypass flow and which would have sufficient movement to retain the corresponding check valve open under appropriate conditions.

While springs are shown as associated with each check valve, these may be omitted, particularly where the unit is to be used with the transverse passages horizontal. Similarly, balanced springs may be provided urging reservoir valves 126, 128, and 304, 306 into their respective valve seats.

The drawings and the foregoing specification constitute a description of the improved power unit in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What I claim as my invention is:

1. A self-contained fluid power actuator comprising a driving motor, a pump disposed coaxially with said driving motor, and a reversible hydraulic motor, all mounted on a common body, said body having a pair of spaced passages therein for connection to opposite sides of the hydraulic motor, a transverse passage extending from a first one of said passages through and beyond the second of said passages, the portion of said transverse passage beyond said second

passage being enlarged to form a check valve chamber, a fluid connection beyond said check valve for connection to one end of the motor, an elongated enlargement in said transverse passage intermediate said pair of passages, a ball valve in said enlargement having piston-like movement therein in response to differences in pressures in said pair of passages, and a rigid element connecting said ball valve and said check valve.

2. Structure as defined in claim 1 in which said enlargement has a valve seat at each end thereof for receiving said ball valve.

3. Structure as defined in claim 2 in which said ball valve has an area exposed to fluid pressure substantially greater than the exposed area of said check valve.

4. A unitary hydraulic system comprising a driving motor, a reversible pump, and a reversible fluid motor mounted on a common base member, said base member having a pair of fluid passages connecting opposite sides of said pump to opposite sides of said motor, means establishing a restricted by-pass connecting said passages, a check valve disposed when in closed position to prevent flow of fluid from said motor to one of said passages, and means responsive to pump pressure in the other of said passages to hold said check valve open, whereby said pump may drive said motor in either direction, said check valve prevents movement of said motor in one direction by externally applied forces, and said motor may be moved in the opposite direction at a rate determined by by-pass flow of fluid by externally applied forces.

5. A system as defined in claim 4 in which said fluid motor comprises a cylinder having a piston therein and a piston rod extending from said piston through one end only of said cylinder, and a reservoir to compensate for unequal flow of fluid into and out of said cylinder, said reservoir being connected between said pair of passages, and check valves between each of said passages and said reservoir arranged to prevent flow of fluid from the passage receiving the output of said pump to said reservoir.

6. A hydraulic system comprising a reversible pump constructed and arranged to have a leakage flow therethrough which is substantially less than the capacity of the pump, a reversible motor, a pair of fluid passages connecting opposite sides of said pump to opposite sides of said motor, a check valve disposed when in closed position to prevent flow of fluid from said motor to one of said passages, and means responsive to pump pressure in the other of said passages to hold said check valve open, whereby said pump may drive said motor in either direction, said check valve prevents movement of said motor in one direction by externally applied forces, and said motor may be moved in the opposite direction at a rate determined by by-pass flow of fluid by externally applied forces.

7. A hydraulic system comprising a power cylinder, a piston in said power cylinder, a piston rod connected to said piston and extending through one end only of said power cylinder whereby movement of said piston results in unequal flow of fluid into and out of said power cylinder, a reversible pump constructed and arranged to provide for a restricted flow of fluid therethrough when idle which flow is substantially less than the capacity of the pump, a first passage connecting one side of the pump to the end of said power cylinder through which said piston rod extends, a second passage connecting

the other side of said pump to the other end of said power cylinder, a check valve in said second passage arranged to prevent flow of fluid from said power cylinder to said second passage, a check valve actuator comprising a control cylinder 5 connected to said first passage, a piston in said control cylinder, and means operated by movement of said last recited piston in response to pump pressure in said first passage to hold 10 said check valve open to permit flow of fluid from said power cylinder, a reservoir to compensate for unequal flow of fluid to and from said power cylinder and connected between said first and second passages, connected check valves between 15 said reservoir and said first and second passages arranged to operate in response to excess pressure in one of said first and second passages to prevent flow of fluid from the passage under higher pressure to said reservoir and to provide for flow of fluid from said reservoir to the one of said passages under lower pressure, whereby said power 20 piston may be moved in either direction by said pump, said power piston is locked against movement in one direction when said pump is idle, and said power piston may be moved in the other 25 direction by externally applied force when said

pump is idle at a rate determined by the restricted flow of fluid through said pump when said pump is idle.

8. A system as defined in claim 7 in which said control cylinder is formed by an enlargement in a transverse passage connecting said first and second passages, said enlargement having valve seats at either end, and the piston in said control cylinder is a ball valve arranged to seat against one or the other of said valve seats in accordance with pressure difference between fluid in said first and second passages.

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