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HYDRAULIC ARRANGEMENT INCLUDING A PISTON PUMP WITH ADJUSTABLE AND REVERSIBLE OUTPUT
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FIG.1

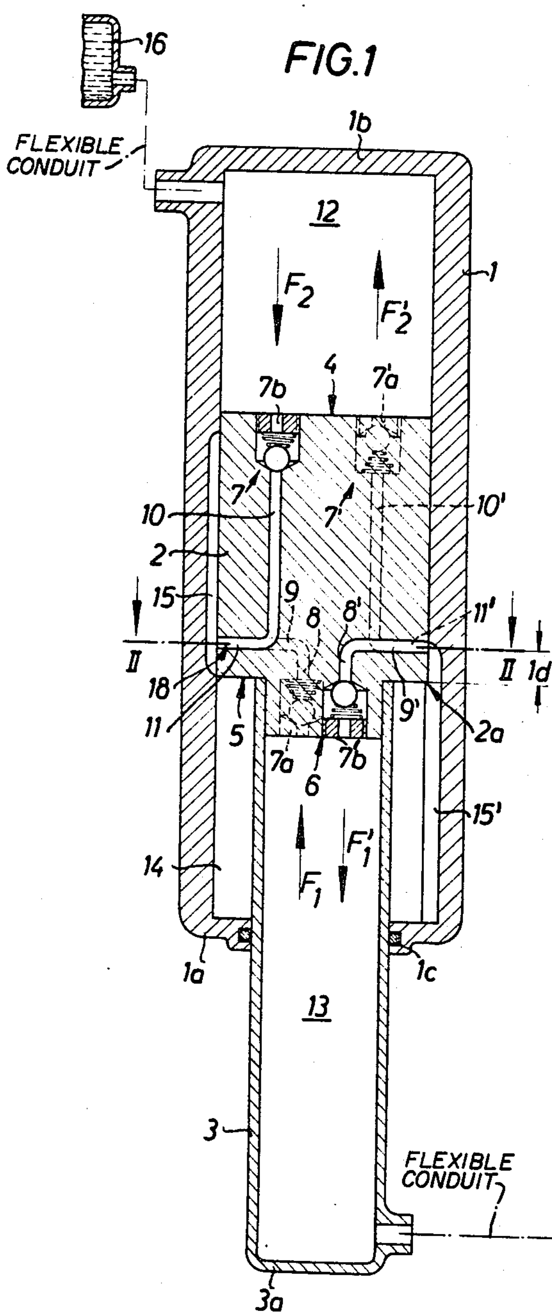

FIG. 2

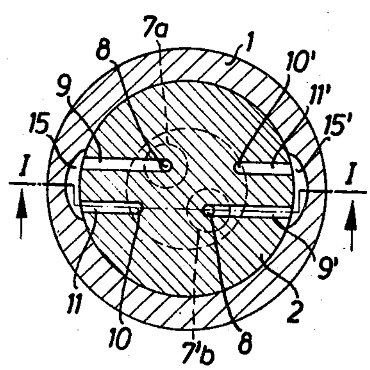

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FIG. 3

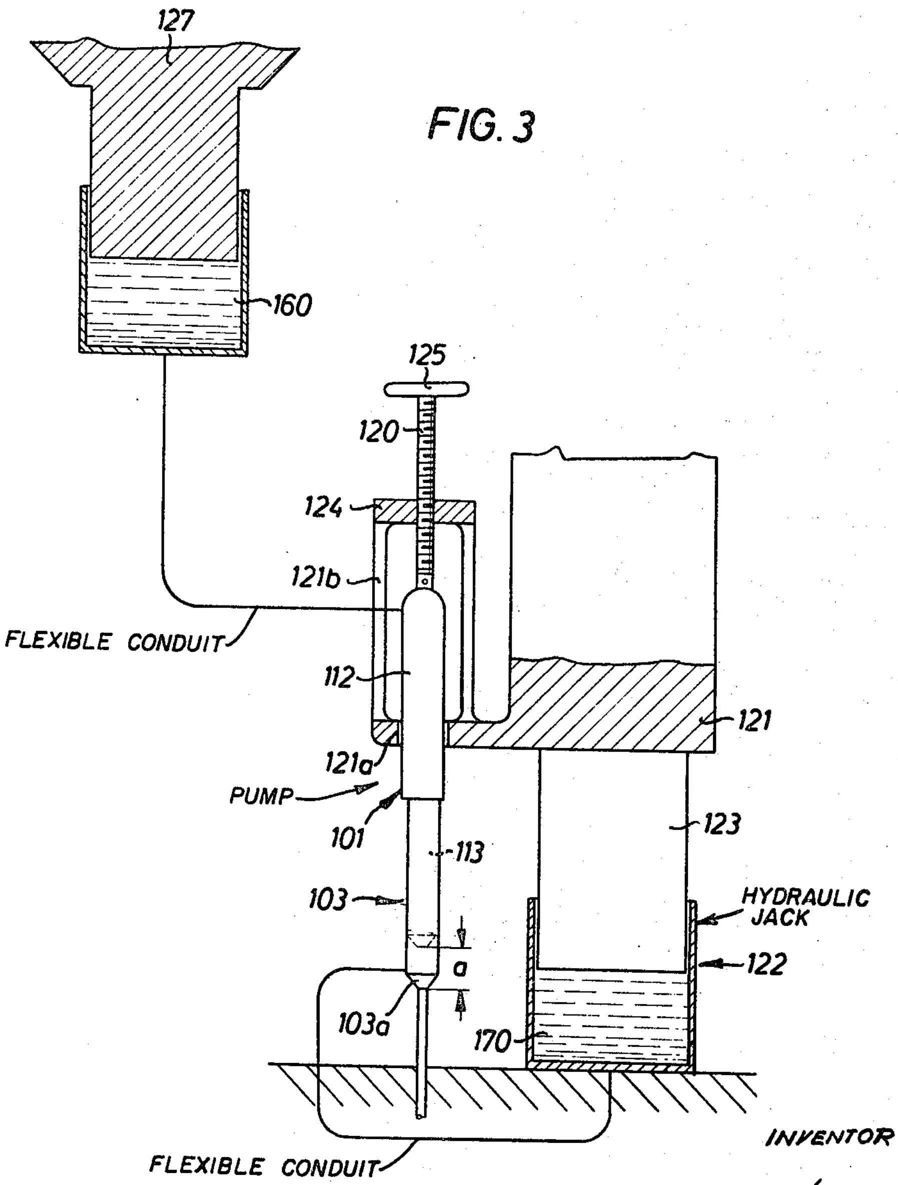

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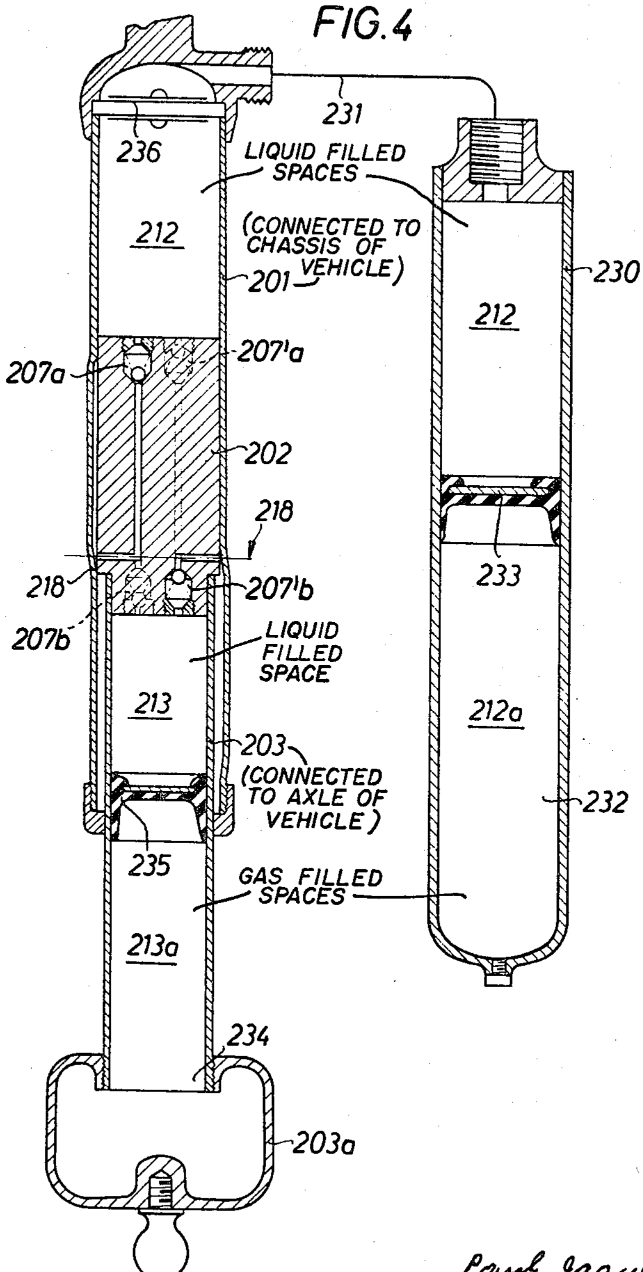
FIG. 4



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HYDRAULIC ARRANGEMENT INCLUDING A PISTON PUMP WITH ADJUSTMENT AND REVERSIBLE OUTPUT

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ABSTRACT OF THE DISCLOSURE

A pump arrangement including a cylinder member, a piston member slidably guided in the cylinder member, a hollow piston rod connected to the piston member and projecting in a sealed manner through one end of the cylinder member, and valves and passage means providing communication between the interior of the hollow piston rod and the cylinder spaces to opposite sides of the piston member, wherein the position of one of the members relative to the other is adjustable from a neutral position to an adjusted position to either side of the neutral position to change the magnitude and direction of the output of the pump during oscillation of one of the members relative to the other about the adjusted position.

The present invention relates to a hydraulic arrangement including a piston pump.

It is an object of the present invention to provide a hydraulic arrangement including a piston pump with an adjustable and reversible output.

It is a further object of the present invention to provide for such an arrangement in which adjustment and reversal of the output of the pump can be carried out in an extremely simple manner.

It is an additional object of the present invention to provide for such an arrangement in which the pump is composed of relatively few and simple parts so that the whole arrangement may be manufactured at a very reasonable cost and will stand up trouble-free under extended use.

With these and other objects in view, the arrangement according to the present invention mainly comprises a cylinder member having a peripheral wall and a pair of end walls, a piston member slidably guided in the cylinder member, a hollow piston rod projecting from one side of the piston member in a sealed manner through one end of the cylinder member and defining between its outer surface and the inner surface of the peripheral wall and between the one side of the piston member and the one end wall of the cylinder member a pumping chamber. The position of one of the members relative to the other is adapted to be adjusted from a neutral pistion to an adjusted position displaced in axial direction to either side of the neutral position and one of the members is further adapted to be oscillated about the adjusted position. The arrangement includes further two pairs of valves carried by the piston member in which one volve in each pair is a suction valve and the other a pressure valve, the suction valve of one pair communicates with the interior of the hollow piston rod and the pressure valve of this one pair communicates with the cylinder space between the piston member and the other end wall of the cylinder member, whereas the suction valve of the other pair communicates with the aforementioned space and the pressure valve of the other pair communicates with the interior of the hollow piston rod. The arrangement includes further a first pair of passage means respectively providing communication between the valves of each pair, a second pair of passage means respectively providing communication between the pumping chamber and one of the first passage means when the one member is displaced to one side of the aforementioned neutral position and providing communication between the pumping chamber and one of the second pair of passage means when the aforementioned one member is displaced to the other side of the neutral position, and a pair of containers adapted to contain a fluid under pressure respectively connected to the cylinder space and the interior of the hollow piston rod.

2

The aforementioned second passage means preferably comprise a pair of circumferentially displaced grooves extending in axial direction of the cylinder member and from the inner surface of the peripheral wall thereof into the latter. The pair of grooves are axially displaced with respect to each other so that the inner, adjacent ends of the grooves overlap each other in axial direction a given distance and so that the outer ends thereof are spaced in axial direction a distance greater than the stroke of the oscillating member. The pair of first passage means respectively communicate with the grooves.

Each of the first passage means may have a transverse portion ending at the peripheral surface of the piston member and the transverse portion of one of the pair of first passage means communicates with one of the grooves, whereas the transverse portion of the other of the pair of first passage means communicates with the other of the grooves. The transverse portions of the first passage means are preferably located substantially in one plane normal to the axis of the piston member. The axial distance of the aforementioned plane from the outer peripheral edge of the piston member at the one side thereof is substantially equal to the aforementioned given distance at which the inner ends of the grooves overlap each other.

The arrangement may be in the form of a hydraulic jack and in such an arrangement the pair of containers above mentioned communicate respectively with the cylinder space and the interior of the hollow piston rod. One of the containers includes substantially a vertically arranged cylinder having an upper open end and an elongated piston member extending with a lower portion thereof through the open end in the cylinder and having an upper portion projecting beyond the upper end of the cylinder to form a hydraulic jack with the latter. One of the members of the pump, that is either the piston member or the cylinder member thereof is in this case carried by the upper portion of the piston forming the hydraulic jack and the other member of the pump is connected to moving means to me oscillated thereby. The pump member carried by the upper portion of the piston of the hydraulic jack is adjusted in axial direction so that the relative position of cylinder member and piston member of the pump may be adjusted and so that the amount of output and direction thereof may be adjusted by adjusting the relative position of the piston member and cylinder member of the pump relative to each other while one of the members is oscillated with a fixed stroke.

The arrangement of the present invention may also be in the form of a hydro-pneumatic vehicle suspension, and in this arrangement one of the members of the pump, that is either the cylinder member or the piston member is mounted on the chassis of the vehicle, whereas the other member is mounted on the axle of a vehicle wheel. In this arrangement the containers form respectively continuation of the cylinder space and the hollow piston rod and are respectively separated therefrom by a movable piston. The containers are filled with a gas under pressure, whereas the cylinder space and the interior of the hollow piston rod are filled with a liquid so that the arrangement will act as a shock absorber or a hydropneumatic spring between chassis and axle.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a cross-section taken along the line I—I of FIG. 2 and showing the pump of the present invention and partly also the two containers associated therewith;

FIG. 2 is a transverse cross-section of the pump taken along the line II—II of FIG. 1;

FIG. 3 is a partial, partially cross-sectioned view of a hydraulic jack arrangements in which the pump according to the present invention is used; and

FIG. 4 is a cross-sectional view of an arrangement according to the present invention in which the pump is used in a hydro-pneumatic suspension arrangement for a vehicle.

Referring now to the drawings, and more specifically to FIGS. 1 and 2 of the same, it will be seen that the pump according to the present invention mainly comprises a cylinder member **1** having opposite end walls **1**a and **1**b and a peripheral cylindrical wall extending between the end walls. A piston member **2** is slidably guided in the cylinder member **1** and a hollow piston rod **3** fixedly connected to the bottom face **5** of the piston member **2** projects axially aligned with the piston member through and beyond an opening formed in the end wall **1**a of the cylinder member **1**. A sealing ring **1**c located in a groove about the opening in the end wall **1**a of the cylinder member engages the outer surface of the hollow piston rod **3** to provide a proper seal. The piston member **2** preferably projects with a central portion thereof in the upper end of the hollow piston rod **3** and this central portion has a bottom face **6** located below the upper end of the hollow piston rod **3**.

The piston member **2** carries two pairs of valves, that is the pair of valves **7**a and **7**b and the pair of valves **7'**a and **7'**b. The valves are one-way valves and the valve **7**a is a suction valve, whereas the valve **7**b is a pressure valve. Each valve comprises a valve chamber forming a valve seat, a preferably spherical valve member, and a pretensioned coil compression spring arranged in such a manner to press the valve member in the desired direction against the valve seat. The valve chamber of the valve **7**b communicates with the cylinder space **12** between the upper surface **4** of the piston member **2** and the upper end wall **1**b of the cylinder member **1**, whereas the valve **7**a communicates with the space **13** in the hollow piston rod **3**. A member having a calibrated outlet opening is arranged in the valve chamber of the valves **7**b and **7'**b downstream of the respective valve member.

The chamber of the valve **7**a is extended through the piston by an axial passage **8** which communicates with a transverse passage **9**, best shown in FIG. 2, having an outer end at the peripheral surface of the piston **2**. Likewise, the chamber of the valve **7**b is extended through the piston **2** by a longitudinal passage **10** which communicates with a transverse passage **11** substantially located in the same plane as the transverse passage **9**, but laterally displaced therefrom, as best shown in FIG. 2.

It would also be possible to connect the chambers of the valves **7**a and **7**b by means of a single longitudinally extending passage and to provide a single transverse passage communicating with the aforementioned longitudinal passage and having an outer end at the peripheral surface of the piston **2**.

The second pair of valves **7'**a and **7'**b carried by the piston are constructed in such a manner that the valve **7'**a at the upper end of the piston member **2** is a suction valve, whereas the valve **7'**b which communicates with the interior **13** of the hollow piston rod **3** is a pressure valve. A longitudinally extending passage **10'** is provided communicating with the valve chamber of the valve **7'**a and the longitudinal passage **10'** is continued by transverse passage **11'** which has an outer end at the peripheral surface of the piston member **2**, whereas the longitudinal passage **8'** which communicates with the chamber of the valve **7'**b ends in a transverse passage **9'** arranged with respect to the passage **11'**, as best shown in FIG. 2. The transverse passages **9'** and **11'** are located in the same plane as the transverse passages **9** and **11**.

A pumping chamber **14** of variable volume is defined between the annular bottom surface **5** of the piston member **2** and the inner surface of the end wall **1**a of the cylinder member **1**, and the portions of the outer surface of the hollow piston rod **3** and the inner surface of the peripheral wall of the cylinder member **1** respectively located at any instant between the aforementioned bottom surface of the piston member and the end wall **1**a of the cylinder member.

A pair of second passage means are provided in the form of a pair of longitudinally extending grooves **15** and **15'** extending from the inner peripheral surface of the cylinder member **1** into the peripheral wall of the latter. The grooves **15** and **15'** are angularly displaced from each other and preferably arranged diametrically opposite to each other, as best shown in FIG. 2, and the grooves **15** and **15'** are also axially displaced with respect to each other. The groove **15'** preferably extends for a certain distance upwardly from the end wall **1**a of the cylinder member and the groove **15** is arranged in such a manner that the lower end thereof overlaps the upper end of the groove **15'** through a distance **1**d which is preferably substantiall equal to the distance at which the plane in which the transverse passage portions **9**, **11**, **9'** and **11'** are located is spaced from the peripheral bottom edge **2**a of the piston member **2**. The axial length of the groove **15** is slightly smaller than the axial length of the piston member **2**. The grooves **15** and **15'** are arranged with respect to the outer ends of the transverse passages **9**, **11**, **9'** and **11'** in such a manner that, as clearly shown in FIG. 2, the transverse passages **9** and **11** will communicate during a certain portion of the movement of the piston member **2** with the groove **15**, whereas the transverse passages **9'** and **11'** communicate during a certain part of the piston stroke with the groove **15'**. Means may be provided, not shown in the drawing, to prevent rotation of the piston member **2** relative to the cylinder member **1**.

In the described arrangement the pumping chamber **14** will be in communication with one or the other pair of valves, that is the pumping chamber **14** will be in communication with the valves **7**a and **7**b over the groove **15** and the transverse passages **9** and **11**, or the valves **7'**a and **7'**b will be in communication with the pumping chamber **14** through the groove **15'** and the transverse passages **9'** and **11'**.

The cylinder member **1** is mounted by means not shown in FIG. 1 on a non-illustrated support in such a manner that the axial position of the cylinder member relative to the piston member **2** may be adjusted, whereas the piston member **2** is adapted to be oscillated through a given stroke in a known manner relative to the cylinder member by means not shown in the drawing and for instance connected to the lower end **3**a of the hollow piston rod. The arrangement includes further two containers **16** and **17** adapted to be filled with a fluid under pressure and respectively communicating through conduits, as schematically illustrated in FIG. 1, with the upper end of the cylinder space **12** and the lower end of the space **13** in the hollow piston rod. The conduits schematically illustrated in dash-dotted lines in FIG. 1 have to be constructed in such a manner so as to permit adjustment of the vertical position of the cylinder member as well as oscillation of the piston **2** and piston rod **3** connected thereto. The fluid pressure in the containers **16** and **17** may be substantially equal, and if the fluid pressures differ substantially from each other the springs of the various valves have to be pretensioned in such a manner so as to prevent flow of fluid from one to the other container under the difference of the fluid pressure alone.

The cylinder member **1** and the piston member **2** are shown in FIG. 1 in a relative position to each other so that when the piston member **2** moves upwardly from the position shown, communication between the pumping chamber **14** and the valves *7'a* and *7'b* will be interrupted while commmunication between the pumping chamber **14** and the valves *7a* and *7b* will be established. In this position the bottom edge *2a* of the piston member **2** coincides with the bottom edge of the groove **15** and this position may be called the neutral position of the pump indicated by the line **18**. When the piston member **2** is oscillated so that it moves through equal distances above and below the line **18**, its median position relative to the cylinder member **1** coincides with its neutral position.

The pump described above will operate as follows:

If the piston member **2** moves from the neutral position shown in FIG. 1 in downward direction, that is in direction of the arrow F'_1, the passages **9** and **11** remain separated from the pumping chamber **14**, whereas the passages **9'** and **11'** remain in communication with the pumping chamber **14** through the groove **15'**. During downward movement of the piston member **2** the volume of the pumping chamber **14** will be reduced, the pressure of the fluid therein increased, and this increasing pressure will act on the valve *7'a* to maintain the latter in closed position, whereas the valve *7'b* will be opened so that fluid from the pumping chamber **14** will be transferred to the space **13** in the interior of the hollow piston rod to pass from the latter into the container **17**.

During subsequent upward movement of the piston member **2** in the direction of the arrow F_1 to the position shown in FIG. 1, the volume of the pumping chamber **14** increases so that an underpressure or suction is created therein which will cause closing of the valve *7'b* and opening of the valve *7'a* and simultaneously flow of fluid from the container **16** into the space **12** and from the latter into the pumping chamber **14**.

Therefore, when the piston **2** oscillates between an upper position as shown in FIG. 1 and a downwardly displaced position, the pump will transfer fluid from the space **12** into the space **13** and therefore from the container **16** into the container **17**.

When the piston member **2** is moved from the position shown in FIG. 1 upwardly in the direction indicated by the arrow F'_2 fluid from the space **13** will obviously be transferred in the pumping chamber **14** whereas during subsequent downward movement of the piston member **2** in the direction of the arrow F_2 to the position shown in FIG. 1 fluid from the pumping chamber **14** will be transferred into space **12**. Therefore during such an oscillation of the piston member **2** fluid will be transferred from the space **13** into the space **12** or from the container **17** into the container **16**. In other words, the direction of output is reversed. The transfer of the fluid occurs in the latter case through the valves *7a* and *7b* which communicate in this case through the groove **15** with the pumping chamber **14** whereas the other pair of valves *7'a* and *7'b* are during the oscillation of the piston member **2** out of communication with the pumping chamber.

When the relative position of cylinder member **1** and piston member **2** is adjusted in such a manner that the piston member during its oscillation will move through equal distances about the line **18**, then the fluid transferred through one of the grooves through part of the piston stroke will be compensated by the fluid transferred through the other groove through the other part of the piston stroke so that the net transfer of fluid between the containers **16** and **17**, that is the net output of the pump will be zero, since the amount of liquid displaced upwardly by the upper surface **4** of the piston during movement of the latter in upward direction beyond the neutral position will flow again downwardly during movement of the piston in downward direction through the same distance to the other side of the neutral position, and the same holds true with regard to the amount of liquid displaced by the annular bottom face **5** of the piston.

As mentioned above, the cylinder member **1** is mounted in such a manner that the axial position thereof relative to the piston member **2** may be changed. Such an adjustment of the position of the cylinder member **1** will change the position of cylinder member **1** relative to the piston member **2** so that the median position about which the piston member **2** is oscillated relative to the adjusted position of the cylinder member **1** will change. As is evident from the description above such a change will produce a change in the amount of the output produced by the pump and by such a change also the direction of the fluid flow through the pump may be changed. The described arrangement permits therefore in an extremely simple manner to change the total output produced by the pump per cycle from a maximum amount inherent in the dimensions of the pump elements and in the stroke of the piston member to zero and to change also the direction in which the fluid is pumped, without changing the stroke at which the piston member is oscillated or without adjusting any of the valves. It is evident that, the adjustment of the relative position of cylinder member and piston member **2** to each other cannot only be accomplished by mounting the cylinder member **1** adjustable in axial direction, but the cylinder member **1** may be mounted in a fixed position and the median position about which the piston member **2** will be swung may be adjusted in axial direction relative to the cylinder member.

When the piston member **2** oscillates exclusively to one or the other side of the neutral position **18** thereof, fluid, for instance liquid, will be transferred from one to the other container. When, on the other hand, the piston oscillation passes from one to the other side of the neutral position, then not only the net liquid transfer per cycle will be changed but also another effect will take place that is, as will be explained later on, the liquid levels in the container will rise and fall. This effect, i.e. the rise and fall of the liquid levels in the containers, increases when the median piston position approaches the neutral position indicated by the line **18**, and will obtain its maximum when the piston **2** oscillates about the position **18**, that is when the net transfer of liquid will be zero.

When the piston member **2** passes downwardly below the neutral position, liquid from the chamber **14** will be transferred to the container **17** so that the liquid level in the latter rises. The transferred amount of liquid will correspond to the volume displaced by the piston member **2** from the pumping chamber **14** as the piston member **2** moves downwardly from its neutral position indicated by the line **18**. When the piston member **2** during its upward movement passes beyond the position **18** the same liquid transfer will occur through the groove **15** from the container **17** into the chamber **14** so that the level of the liquid in the container **17** will drop. The rise and fall of the liquid level in the container **17** will continue during oscillation of the piston member and will reach its maximum value when the piston member **2** oscillates through equal distance through either side of the neutral position **18**. The amount of the level change will depend on the cross-section of the container **17** and on the volume of the pumping chamber **14** swept by the piston member **2**.

The same effect but with a different intensity will be produced in the container **16**. The liquid level variations in this container will not only depend on the volume of the pumping chamber **14** swept by the piston member **2**, but also on the volume swept by the piston member **2** in the cylinder space **12**. When the piston member **2** moves from its uppermost position toward its neutral position, liquid from the pumping chamber **14** will be transferred through the groove **15** into the cylinder space **12**, but during this downward movement of the piston member **2**, the volume of the cylinder space **12** increases so that a partial vacuum will be created in the space **12** and so that liquid from the container **16** will flow into the cylinder space. The decrease of the volume of the pumping chamber **14** during the downward movement of the piston member **2** and therefore the volume of the liquid transferred from the pumping chamber **14** into the cylinder space **12** is smaller than the increase of the volume of the cylinder space **12** and flow of liquid from the contianer **16** into the cylinder space, due to the difference of the annular piston surface **5** and the upper piston surface **4**.

In other words, oscillation of the piston member **4** about the neutral position **18** will create in the containers **16** and **17** liquid level variations which will depend on the annular surface **5** of the piston and on the upper surface **4** thereof, reduced or not reduced, by the annular surface **5** of the piston.

To influence the relative extent of these level variations, the piston member **2** may be provided with an upwardly projecting central cylindrical portion of a cross-section substantially equal to the cross-section of the hollow piston rod **3** and extending in a sealed manner through an appropriate opening in the upper end wall **1*b*** of the cylinder member. Of course, this upwardly extending projection has to be constructed or the transverse spacing of the valves **7*b*** and **7′*a*** has to be arranged in such a manner that flow of fluid from the cylinder space **12** to the valves **7*b*** and **7′*a*** is not impeded.

In the illustrated arrangement in which the area of the annular end face **5** of the piston is considerably smaller than the area of the upper piston face **4**, the level variations in the container **17** will be smaller than those in the container **16**. This difference in the level variations has to be taken into account in practical applications of the above-described pump.

FIG. 3 schematically illustrates the application of the above described pump in a hydraulic jack. It is to be understood that the pump only schematically illustrated in FIG. 3 is constructed and arranged in the manner as described above in connection with FIGS. 1 and 2. The pump only schematically shown in FIG. 3 has a cylinder member **101** in which a piston member not shown in FIG. 3 is arranged in the manner as described above and from which the hollow rod **103** projects downwardly in a sealed manner through the bottom wall of the cylinder member **101**. The interior space **113** of the hollow piston rod is connected through a flexible conduit schematically illustrated in FIG. 3 to a hydraulic jack **122**. This hydraulic jack which corresponds to the container **17** illustrated in FIG. 1 comprises a cylinder **170** having an upper open end. The jack includes further a load lifting member **121** from the lower end of which a piston **123** projects in a fluid-tight member into the upper open end of the cylinder **117**. A bracket **121*b*** is arranged laterally of the member **121** and fixedly connected thereto by being for instance integrally made therewith. The bracket **121*b*** is formed in a lower part thereof with an opening **121*a*** in which the cylinder member **101** of the pump is slidably guided and an upper transverse portion **124** of the bracket is formed with an internal screw thread aligned with the axis of the cylinder member **101** into which a screw spindle **120** is threadingly engaged which is connected in any convenient manner to the upper end of the cylinder member **101** so that the screw spindle **120** may be rotated relative to the cylinder member while the latter is constrained to follow axial movements of the spindle. A handwheel **125** may be connected to the upper end of the screw spindle to rotate the latter about its axis and to move the same and the cylinder member **101** connected thereto thereby in axial direction. By the described arrangement the axial position of the cylinder member **101** may therefore be adjusted. It is apparent an adjustment of the axial position of the cylinder member **101** may also be carried out by means different from the means schematically illustrated in FIG. 3. The lower end **103*a*** of the hollow piston rod **103** is connected to a rod-shaped member which in a known manner, not illustrated in the drawing, is oscillated so that the hollow piston rod **103** will perform a vertical stroke of a length *a* indicated in FIG. 3. The cylinder space **112** of the piston member **101**, which corresponds to the space **12** shown in FIG. 1, is connected by means of a flexible conduit to a cylinder **160** filled with liquid which is held under pressure substantially equal to the pressure of the liquid in the cylinder **170** by a weight **127** which has a lower piston part extending through an upper end of the cylinder **160**.

It is understood that the pump only schematically illustrated in FIG. 3 is constructed in the same manner as described in connection with the pump illustrated in FIGS. 1 and 2.

As explained above the direction and amount of output produced by the pump may be varied by changing the relative position of the cylinder member of the pump to the piston member and the hollow piston rod thereof. This adjustment of the position of cylinder and piston member of the pump may be accomplished in the arrangement illustrated in FIG. 3 by adjusting the axial position of the cylinder member **101** by means of the screw spindle **120** and the wheel **125** connected thereto.

When the piston of the pump oscillates about the neutral position, as described before in connection with FIG. 1, the net output produced by the pump will be zero. When now the position of the cylinder member **101** is changed in downward direction by means of the handwheel **125**, the pump during operation will feed fluid from the cylinder **160** into the cylinder **170** so that the member **121** of the jack will be raised. During this upward movement of the member **121** the cylinder member **101** will likewise move in upward direction, since spindle **120** is fastened to cylinder member **101**, so that the relative position of cylinder member and piston member will be changed and during the upward movement of the piston **123** the cylinder member **101** will return to its starting or neutral position resulting in a zero net output of liquid. The speed of the movement of the member **121** of the jack will therefore gradually change from maximum to zero and the total movement will correspond to the initial adjustment of the cylinder member **101** of the pump from the neutral position. Instead of turning the screw spindle **120** by the handwheel **125**, it is also possible to operate the spindle **120** by remote control and to adjust the position of the piston member by this remote control in any desired manner during the operation of the arrangement.

In this way a plurality of jacks may be controlled in the same manner so that each jack will move with the same speed and through the same distance. If lowering of the member **121** is desired, the piston member **101** is adjusted in the manner as described before to the opposite side of the neutral position so that lowering of the jack will occur through a pumping action and not through free flow of liquid from the cylinder **170** into the cylinder **160**.

As above described, in connection with FIG. 1, the pump will produce, when adjusted so that the net output obtained from the pump is zero, liquid level variations in the containers connected thereto and such level variations will also be produced in the liquid contained in the cylinder **170** of the jack. However, such level variations can be held by appropriate dimensioning of the pump within acceptable limits and these variations will also prevent sticking of the piston **123** in the cylinder piston **170**.

FIG. 4 schematically illustrates another application of the pump according to the present invention and in this arrangement the pump is used as a hydro-pneumatic suspension arangement for a vehicle. Elements of the pump itself which correspond to the elements described above in connection with FIG. 1 are indicated in FIG. 4

with the same reference numerals to which the number **200** has been added. In view of the specific application to which the pump illustrated in FIGURES 1 and 2 is placed, the construction illustrated in FIG. 4 differs slightly from the construction above-described in connection with FIGURES 1 and 2. In order to shorten the overall length of the arrangement, the cylinder chamber **212** located above the piston member **202** is divided in two parts and the second part of the chamber **212** is located in a laterally arranged cylinder **230** which is connected to the cylinder space **212** in the cylinder member **201** by a conduit **231**. The cylinder spaces **212** in the cylinder member **201** and in the cylinder **230** are filled with liquid and a floating piston **233** is arranged in the cylinder **230** which separates the liquid filled space **212** in the cylinder **230** from the space **212***a* which is filled with a gas **232** under pressure. The space **212***a* between the floating piston **233** and the closed end of the cylinder **230** corresponds therefore to the container **16** shown in FIG. 1.

In a similar manner a floating piston **235** is arranged in the hollow piston rod **203** which separates the upper liquid filled space **213** in the interior of the hollow piston rod from the lower space **213***a* which is filled with a gas **234** under pressure. The space **213***a* has preferably at the lower end an enlarged portion **203***a*. The space **213***a* and the enlarged portion **203***a* thereof corresponds therefore to the container **17** illustrated in FIG. 1. The pump is preferably arranged so that the axis thereof extends in vertical direction and the cylinder member **201** is fixedly connected in any known manner to the chassis of a vehicle, not shown in the drawing, whereas the hollow piston rod **203** is connected in any convenient manner to the axle of a wheel of the vehicle, also not shown. In the initial position of the pump the gas **232** and **234** in the chambers **212***a* and **213***a* are preferably under equal pressure which is chosen in such a manner that the piston **202** will be in the neutral position indicated by the line **218** when the load carried by the arrangement is equal to the net weight of the vehicle and half of its service load. If the vehicle is now loaded to its full load, the cylinder **201** will move relative to the piston **202** in downward direction and the chassis will approach the surface on which the vehicle is adapted to move. The piston **202** will thereby be moved above its neutral position. During movement of the vehicle over an uneven ground, vertical oscillating movements will be transmitted to the piston **202** as will occur in any shock absorber. While these alternative movements will vary in frequence and amplitude, the piston member **202** will still be oscillated about a median position located above the neutral position thereof. Therefore, as above described, the pump will produce a pumping action which will transfer liquid from the chamber **213** into the chamber **212**. The pressure in the chamber **213** will thereby decrease and that in the chamber **212** will increase so that the cylinder member **202** and the chassis connected thereto will be raised. This raising of the cylinder member **202** and the chassis connected thereto will continue until the relative position of cylinder member and piston member is again as shown in FIG. 2, that is in which the median position of the oscillation of the piston member **202** will coincide with its neutral position. The chassis will thereby return to its normal elevation and will be maintained, therein, since further oscillation of the piston member **202** due to uneveness of the ground will not produce any net output of liquid.

The pump arrangement above described will therefore produce an automatic correction of the elevation of the chassis without requiring a separate drive for operating the pump. This automatic correction of the elevation will occur of course in both directions. If the load on the vehicle is reduced, the piston **202** will oscillate below the line **218** and will therefore provide for a correction in reversed sense.

Since in the described arrangement a liquid column and a gas cushion is interposed between the chassis and the piston or the axle connected to the latter, the pump will also act like a spring and the pumping will produce a damping of the relative movement of chassis and axle so that the arrangement forms de facto a hydro-pneumatic suspension arrangement. The damping produced can be improved by arrangement of throttling means in the flow of liquid and such throttling means are schematically illustrated at **236** in the upper end of the cylinder chamber **212** in the cylinder member **201**.

Since the automatic correction of the elevation of the chassis is produced by transfer of liquid from one to the other chamber there will be produced a pressure difference between the chambers which will temporarily be increased by the braking effect on the movement of the liquid. This pressure difference could at certain piston positions cause a short-circuit between the chambers **212** and **213**. For instance when the median position of the piston is located downwardly displaced from its neutral position, an overpressure relative to the chamber **213** may be produced in the chamber **212** so that a direct liquid flow from the chamber **212** into the chamber **213** may occur over the valves **207'***a* and **207'***b*. Such an occurrence would however be greatly undesirable and to prevent such an occurrence the springs of the valves must be pretensioned by the necessary amount.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of piston pumps with adjustable and reversible output differing from the types described above.

While the invention has been illustrated and described as embodied in a piston pump with adjustable and reversible output connected to a hydraulic jack or used as a hydro-pneumatic suspension arrangement in a vehicle, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention, and therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A pump arrangement comprising, in combination, a cylinder member having a peripheral wall and a pair of end walls; a piston member slidably guided in said cylinder member; a hollow piston rod projecting from one side of said piston member in a sealed manner through one end wall of said cylinder member and defining between its outer surface and the inner surface of the peripheral wall of the cylinder member and between said one side of said piston member and said one end wall a pumping chamber, the position of one of said members relative to the other member being adjustable from a neutral position to an adjusted position displaced in axial direction to either side of the neutral position and one of the members being adapted to be oscillated about said adjusted position; two pairs of valves carried by said piston member, one valve in each pair being a suction valve and the other in each pair being a pressure valve, the suction valve of one pair communicating with the interior of said hollow piston rod and the pressure valve of said one pair communicating with the cylinder space between said piston member and the other end wall of said cylinder member, the suction valve of the other pair communicating with said space and the pressure valve of said other pair communicating with the interior of said hollow pis-

ton rod; a first pair of passage means respectively providing communication between the valves of each pair; a second pair of passage means for respectively providing communication between said pumping chamber and one of said first pair of passage means when said one member is displaced to one side of said neutral position and providing communication between said pumping chamber and the other of said first pair of passage means when said one member is in said neutral position and when said one member is displaced to the other side of said neutral position; and a pair of containers adapted to contain a fluid under pressure respectively connected to said cylinder space and the interior of said hollow piston rod.

2. A pump arrangement as set forth in claim **1**, wherein the valves of each pair are respectively located in the region of opposite end faces of said piston member, said first passage means extending through said piston member.

3. A pump arrangement as set forth in claim **2**, wherein said second passage means comprises a pair of circumferentially spaced grooves extending in axial direction of the cylinder member from the inner surface of the peripheral wall thereof into the latter, said pair of grooves being axially displaced with respect to each other so that the inner adjacent ends of said grooves overlap each other in axial direction a given distance and so that the outer ends thereof are spaced in axial direction a distance greater than the stroke of the oscillating member, said pair of first passage means respectively communicating with said grooves.

4. A pump arrangement as set forth in claim **3**, wherein each of said first passage means has a transverse portion ending at the peripheral surface of said piston member, said transverse portion of one of the pair of first passage means adapted to communicate with one of said grooves and the transverse portion of the other of said pair of first passage means adapted to communicate with the other of said grooves.

5. A pump arrangement as set forth in claim **4**, wherein said transverse portions are located substantially in one plane normal to the axis of said piston member.

6. A pump arrangement as set forth in claim **5**, wherein the axial distance of said plane from the outer peripheral edge of said piston member at said one side thereof is substantially equal to said given distance at which the inner ends of said grooves overlap each other.

7. A pump arrangement as set forth in claim **3**, wherein each of said first passage means includes two separate axially extending portions respectively communicating at one of the ends thereof with the pair of valves coordinated with the respective passage means, and a pair of transverse portions respectively communicating at one of the ends thereof with the other ends of said axially extending portions and at the other ends thereof with the respective groove, said transverse portions being located in one plane and in said plane transversely spaced from each other.

8. A pump arrangement as set forth in claim **1**, wherein each of said valves includes a valve member, a valve seat, and prestressed spring means engaging the valve member and tending to maintain the latter in engagement with said valve seat.

9. A pump arrangement as set forth in claim **8**, wherein each of said containers contains a fluid under pressure, wherein the fluid pressure in one container is greater than that in the other container, said containers respectively communicating with said cylinder space and the interior of said hollow piston, and wherein said spring means are prestressed to such an extent as to prevent flow of fluid from said one into said other container only due to the difference in fluid pressure in the two containers.

10. A pump arrangement as set forth in claim **8**, wherein each of said pressure valves includes a member downstream of said valve member and formed with a calibrated opening therethrough through which the fluid emanating from the pressure valves passes.

11. A pump arrangement as set forth in claim **1**, and including adjustable mounting means for adjusting the relative position of pump member and piston member to each other; and moving means operatively connected to one of said members for oscillating the same in axial direction, said containers respectively communicating with said cylinder space and the interior of said hollow piston so that the arrangement acts as a pump pumping, during oscillation of said one of said members, fluid from one of the containers into the other container, whereby the direction of flow of fluid and the amount of fluid pumped during each stroke of the oscillating member will depend on the adjusted position of said one member relative to the other member.

12. A pump ararngement as set forth in claim **11**, wherein one of said containers includes a substantially vertically arranged cylinder having an upper open end, and an elongated piston extending with a lower portion thereof through said open end in the cylinder and having an upper portion projecting beyond said upper end of said cylinder to form a hydraulic jack with the latter, one of said members of said pump being carried by said upper portion of said piston, and the other member being connected to said moving means to be oscillated thereby, said adjustment means being connected to said one member and said upper portion of said piston.

13. A pump arrangement as set forth in claim **1**, wherein said cylinder member of said pump is carried by said upper portion of said piston adjustable in axial direction, and said adjustment means including screw means connected to said other end wall of said cylinder member for rotation relative thereto and movement in axial direction therewith, said screw means being threadingly connected to said upper portion of said piston.

14. A pump arrangement as set forth in claim **1**, wherein one of said members is mounted on the chassis of a vehicle and the other on the axle of a vehicle wheel, wherein one of said containers forms a continuation of said cylinder space separated therefrom by a movable piston and the other container forms a continuation of said hollow piston rod also separated therefrom by another movable piston, said containers being filled with gas under pressure and said cylinder space and the interior of said hollow piston rod being filled with a liquid so that the arrangement will act as a hydro-pneumatic suspension arrangement between chassis and axle of a vehicle.

15. A pump arrangement as set forth in claim **14**, wherein part of the liquid in said cylinder space is located in a separate container located laterally from said cylinder space and including conduit means providing communication between one end of said cylinder space and one end of said separate container, said one gas-filled container being integral with said separate container and extending in axial direction from the other end thereof and being separated therefrom by said one movable piston.

16. A pump arrangement as set forth in claim **15**, and including throttling means arranged in the path of flow of liquid between said cylinder space and said one container.

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