May 14, 1935. P. v. VÁGÓ ET AL 2,001,336

HYDRAULIC DEVICE

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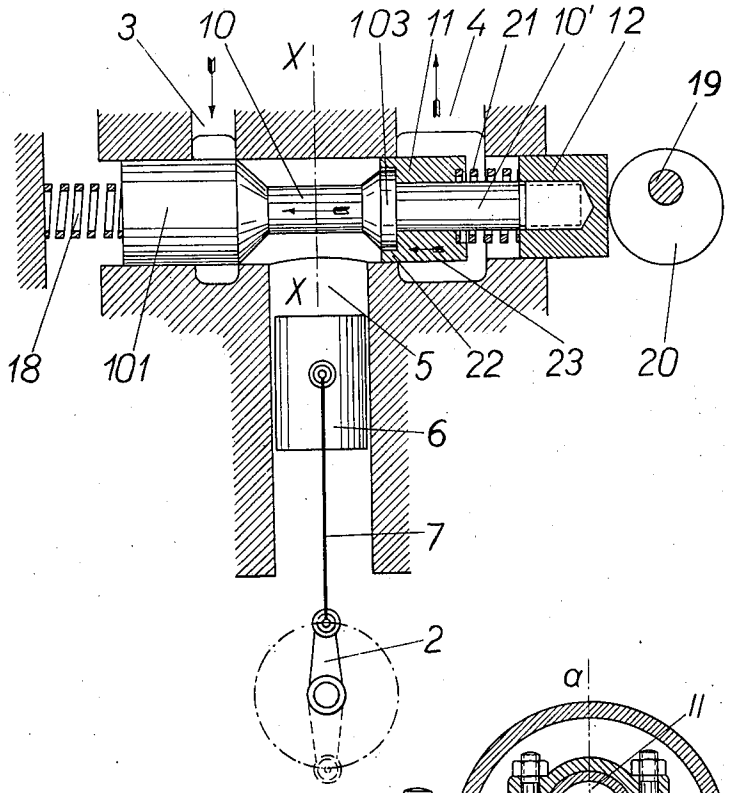


Fig. 1.

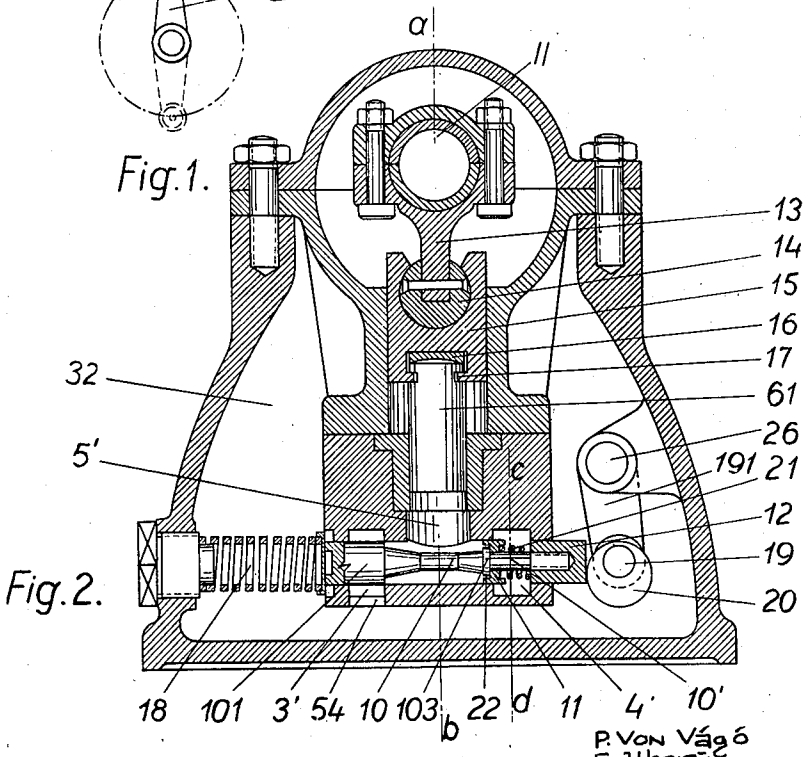


Fig. 2.

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Fig. 4.

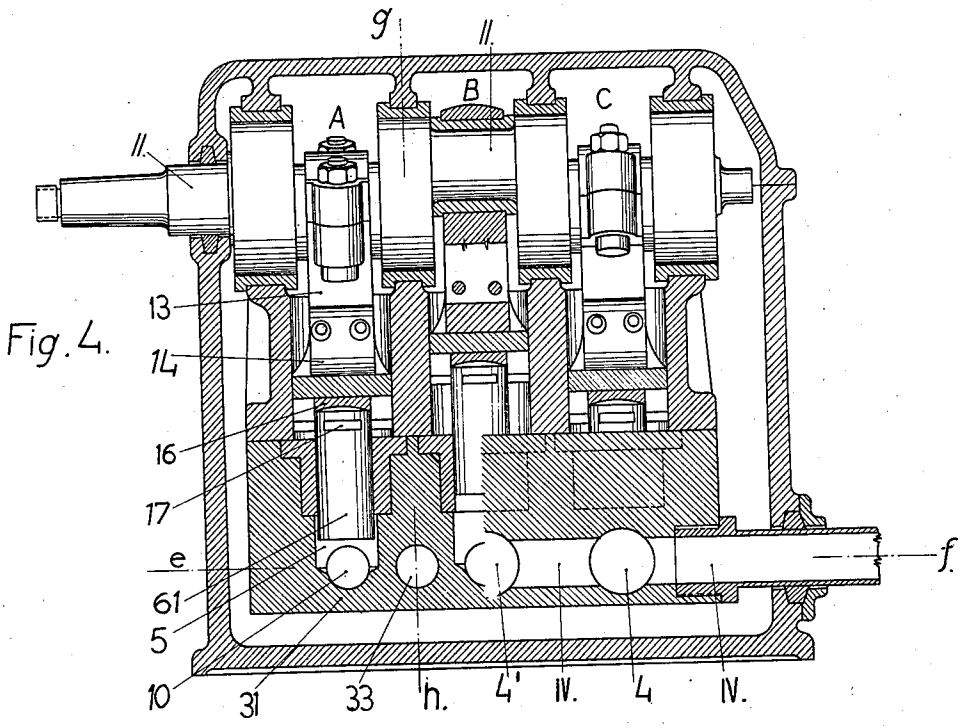
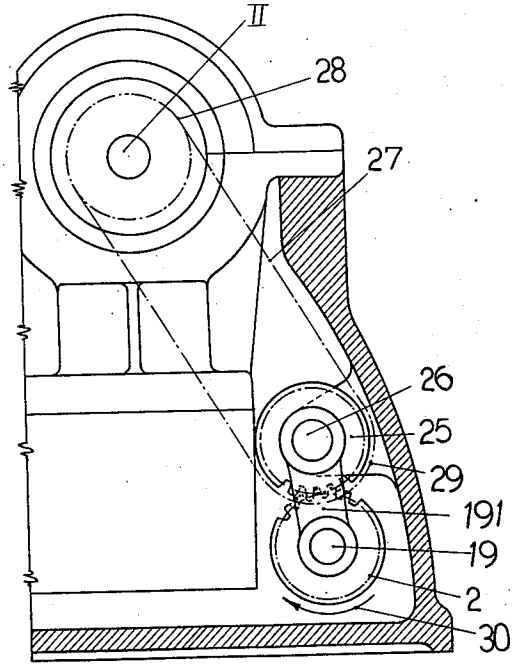


Fig. 3.



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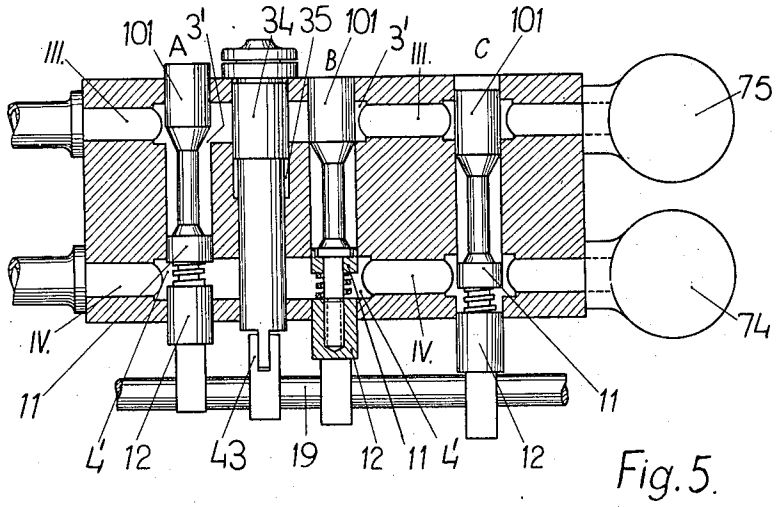


Fig. 5.

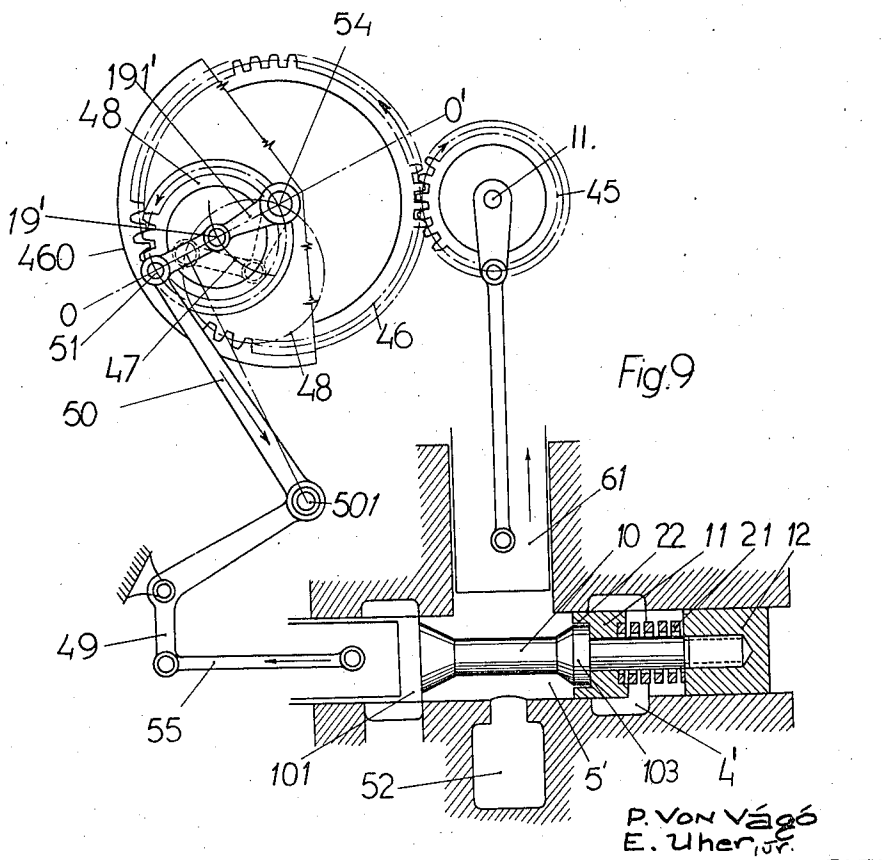


Fig. 9

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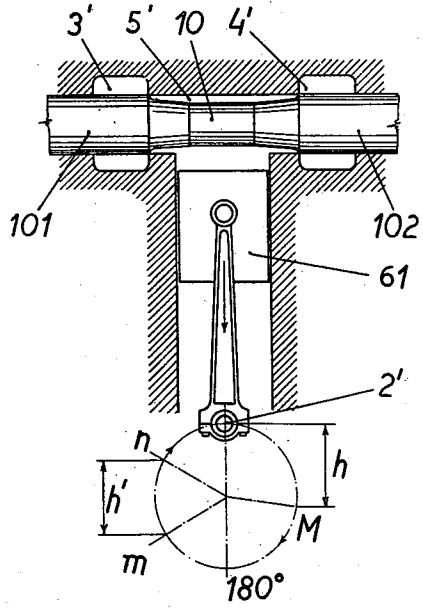


Fig 6.

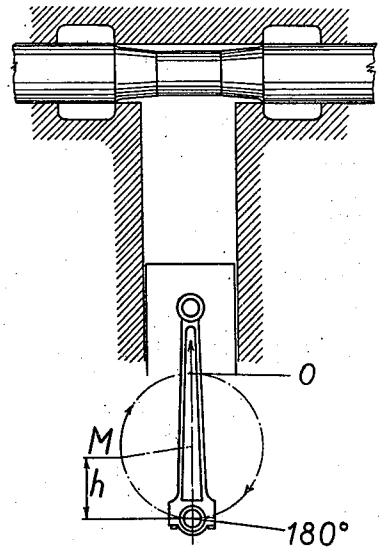


Fig. 7.

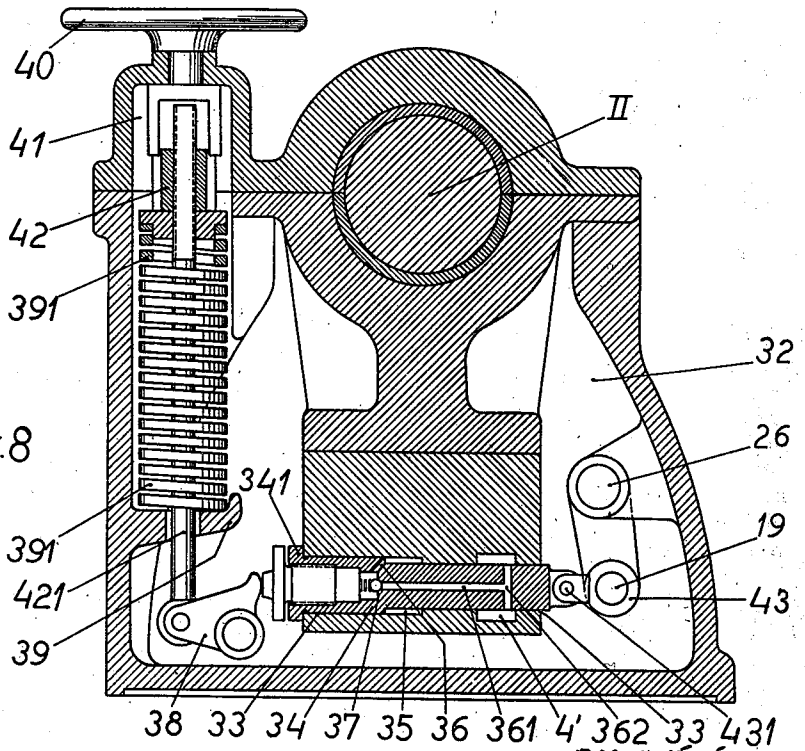


Fig. 8

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Patented May 14, 1935

2,001,336

UNITED STATES PATENT OFFICE

2,001,336

HYDRAULIC DEVICE

Paul v. Vágó and Edmond Uher, Budapest, Hungary; said Uher assignor to said von Vago

Application May 31, 1930, Serial No. 458,734
In Germany June 14, 1929

12 Claims. (Cl. 103—40)

The invention relates to hydro-dynamic device which can be used either as a pump or as a hydraulic motor and which is substantially more simple than similar devices known up to the present, operates with high efficiency, and is capable of being controlled between wide limits. In addition hereto the new device owing to its design is also suitable for being used as a hydraulic transmission gear, for which purpose two of these devices are employed in mutual connection, one of the devices according to the invention operating as a pump whilst the other operates as a hydraulic motor, the whole set being capable of being controlled at will either on the pump-side or on the hydraulic side, or on both sides.

Referring to the drawings:

Figure 1 shows a longitudinal section through the control valve and associated parts of a hydraulic machine according to the invention;

Figure 2 shows a longitudinal section of the machine as a whole, on a smaller scale;

In Figure 3, parts of the device according to the invention are shown, partly in outside view and partly in section, in order to illustrate the method of driving the control shaft;

The left hand part of Fig. 4 illustrates a cross section of the device, the section being taken along line *a—b* of Fig. 2;

The right-hand part of Fig. 4 illustrates a longitudinal section of the device, the section being taken along line *a—c—d* of Fig. 2;

Fig. 5 is a diagrammatic horizontal section of the device, the section being taken along plane *e—f* of Fig. 4;

Figs. 6 and 7 serve to illustrate various methods of control;

Fig. 8 is a section of the mechanism employed for the purpose of ensuring automatic control of the pressure; and

Fig. 9 is a section of a part of the device, shown in order to illustrate the method of operation of the control mechanism.

In Figure 1, 6 denotes the piston of a hydraulic machine, which is driven from a crank 2 through a connecting rod 7, and reciprocates in a cylinder 5. Perpendicular to the longitudinal axis of the cylinder 5 is a bore for a slide valve, which therefore moves perpendicularly to the pump piston 6, and controls a suction passage 3 and a delivery passage 4.

The slide valve consists of two valve pistons, of which the valve piston 101 controls the suction passage and the valve piston 11 controls the delivery passage. The slide valve piston 101 is secured to or is integral with a shank member 10. The valve piston 11 controlling the delivery passage 4 is slidably mounted on the shank 10. At the end of the shank 10 is provided a packing or sealing piston 12, and between this piston 12 and the valve piston 11 there is a spring 21, which presses the movable valve piston 11 against an annular bead or collar 103 on the shank 10. The valve piston 11 can therefore move in an axial direction on the part 10′ of the shank 10. It carries at the left-hand end an annular edge 22, in which the collar 103 on the shank 10 lodges in the position of the valve piston 11 shown. The collar 103 and the annular edge 22 form a cataract shock-absorber or dashpot, as the liquid can only escape slowly from the space between the collar 103 and the piston 11 under the pressure of the spring 21. The slide valve consisting of the parts 101, 10, 11 and 12 is subject to the action of an eccentric 20, which, as hereinafter explained, revolves with the shaft 19, and displaces the valve against the spring 18. In Figure 1 the pump piston 6 is in its upper dead-centre position and the valve body in its mid position. The latter slides to and fro to left and right of the line X—X when the eccentric 20 revolves. In the mid position illustrated the suction passage 3 is exactly covered, so that the latter is opened immediately when the slide valve moves to the left. The slide valve piston 11, however, has positive lap, so that the delivery passage is only opened when the valve has moved to the right a distance equal to the lap. This arrangement of the valve controlling the delivery passage has the advantage that no shocks can occur in the machine, which therefore runs smoothly even at very high liquid pressures, and the further advantages that the centre line X—X about which the controlling valve oscillates can be displaced relatively to the passages 3 and 4, and therefore shifted to the left or right out of the position shown in Figure 1, as hereinafter described, and in this way the quantity of liquid delivered by the pump can be regulated from zero to a maximum. This method of operation of the pump is explained with reference to Figures 2, 3 and 4.

A practical embodiment of the invention is illustrated in the drawings. The shaft II of the device operates three pumps A, B, C, these pumps being of entirely similar design but keyed on at different angles Fig. 4; one of these pumps is shown in Fig. 2 in longitudinal section, the section being taken in a plane perpendicular to the plane of Fig. 4. With the cranked shaft II there cooperate the connecting rod 13 and the crosshead pin 14, connected to the same. The said

cross-head pin is riveted to the connecting rod, whilst its outside surface is turned on a lathe to the exact shape required. The piston 61 of the pump joins on to the cross-head 15 by means of a spherical pad 16 capable of sliding displacement in the lateral direction. The piston is secured in the cross-head 15 against the action of any force pulling it in the axial direction by means of the dovetail connection 17. Communication between the pump chamber 5' and the suction conduit 3' or the delivery conduit 4' is controlled by slide-valves 101 and 11, which latter are connected with one another by means of the member 10. The slide-valve part controlling the opening and closing of the delivery conduit 4' is shaped so as to enable the pump to work with positive lap.

The control shaft 19 is driven by means of the gear wheel 24 shown in Fig. 3. This gear wheel engages with the gear wheel 25, revolving loosely on the fixed shaft 26, and is driven by means of chain 27 by the chain sprocket 28 keyed on the main shaft II. The control shaft 19 is supported in bearings arranged in the cranks 191 which latter are capable of being pivoted in the direction of arrow 30 around the fixed pivot 26.

The three pumps A, B, C are connected in parallel. For this purpose the delivery conduits 4' of the individual pumps are connected with one another by means of the common bore-hole IV also shown in Fig. 5. In order to effect the damping of the pulsations of the volume of liquid delivered as far as possible, a tank 74 of suitable size, filled, of course, with liquid, should preferably be inserted into the conduit IV which tank acts like a "capacity" and by its elastic changes of volume balances the rapid variations of pressure of the column of liquid contained in conduit IV. The suction conduits 3' of the pumps A, B, C may likewise be connected with one another by means of the longitudinal channel III. If the pump rotates at a high speed, so that there is a possibility of the column of liquid drawn in being interrupted, it is advisable to insert a tank 75 of suitable shape and capacity into the suction conduit III as well; the supply of the liquid into this last named tank may for instance be effected by means of a separate small pump. Another possible method is to connect the suction chambers 3' of the pumps A, B, C with the interior of the liquid tank 32 by means of very short bore-holes 54, Fig. 2. In this case tank 32 may preferably, as shown on the drawings, be arranged so as to form the casing of the pump.

As is evident from Figs. 2 and 4, the piston bores of the pumps, the bore-holes in which the control slide-valves run, and, finally, the bore-holes connecting the suction chambers with one another, and those connecting the delivery chambers of the individual pumps with one another form groups of parallel bore-holes, each group being either parallel or perpendicular to each of the other groups. Owing to this circumstance, all these bore-holes may be very efficiently provided by drilling them simultaneously in a forged block 31. The compactness and standard character of the design resulting in this way renders it particularly suitable for high pressure pumps and hydraulic motors.

The method of operation of the device described above is the following:

If the main shaft II is rotated, Figs. 2, 3, and 4, the cranks, keyed on the shaft at angular distances of 120°, will effect the alternating motion of the pistons 61, and the eccentrics 20, keyed at angular distances of 120° likewise, on the control shaft 19—which latter is driven by means of chain 27 and gear wheels 25, 24,—will likewise effect the alternating motion of the slide-valves 101 and 11, the said movements of the pistons and of the slide-valves being synchronous. If the relative positions of the pistons 61 and of the corresponding slide-valves 101 and 11 are such that in the dead centre position of the piston the slide valves are in their middle position, the slide-valves will perform symmetrical oscillations around the middle position, that is to say the pump will draw in liquid during the whole time of the suction stroke of the piston 61 and deliver liquid during the whole time of the delivery stroke of the piston 61.

The quantity of liquid supplied by the pump can be controlled by shifting the slide-valve body 101, 10, 11 from the middle position so that the centre line of oscillation of the slide-valve will come to be situated to the left of the symmetrical position diagrammatically shown in Fig. 2. In this case the pump chamber 5' will remain connected with the suction conduit 3' during a longer time than corresponds to a complete stroke of the piston 61. On the other hand, the time during which the chamber 5' of the pump will remain in communication with the delivery conduit 4' will be correspondingly shorter and accordingly the pump will deliver a correspondingly smaller quantity of liquid into the delivery conduit. Notably the supply of liquid into the delivery conduit 4' will start only when the slide-valve body 101, 10, 11 has already performed such part of its oscillation towards the right hand side as to close the suction conduit 3'. If therefore the slide-valve body 101, 10, 11 is displaced towards the left in a measure corresponding to half the stroke of the slide-valve no liquid at all will be supplied by the pump as the delivery conduit 4' will not be opened at all. This method of control is made possible by the device already described. Notably, during those periods of the delivery stroke when the slide-valve body 101, 10, 11 has already shut-off the pump chamber 5' from the suction conduit 3', the liquid displaced by piston 61 tends to displace the piston 22, which serves to prevent leakage, in the direction opposite to the arrow 23 until the pump chamber 5' communicates with the delivery conduit 4'. During this time it is not possible for the pressure in the pump chamber 5' to increase in a detrimental extent.

The control described is effected by hand by means of the device illustrated in Figs. 2 and 4 or automatically by that illustrated in Fig. 8. The slide-valve body 101, 10, 11 in Fig. 2 is capable of being shifted from the symmetrical middle position by shifting the control shaft 19 towards the left, for which purpose the control shaft 19 is supported in bearings so as to be capable of being pivoted around pivot 26 in the manner described. For the purpose of control, accordingly, the crank support arrangement 191 is deflected towards the left in the sense of arrow 30 in Fig. 3. During this time the engagement between the gear wheels 24, 25 remains unchanged.

This deflection of shaft 19 may be effected in an automatic manner so as to be functionally dependent upon the pressure of the fluid delivered. The automatic control gear employed for the purpose of the latter alternative is shown in Fig. 8. By employing this device instead of the manual control it is possible to ensure that the pump will maintain a constant pressure regardless of the variation of the quantity of liquid required, whilst

on the other hand it enables the employment of a safety valve to be dispensed with. The essential element of the automatic control device is the differential piston **34** running in the bore-hole **33** provided in the plane *g—h* Fig. 4 of the forged pump block described above. The cylinder space **35** of the differential piston communicates by means of the bore-holes **36, 361**, and **362** provided in the piston body and through the non-return ball valve **37** with the delivery conduit **4'** of the pump. Both ends of the piston body **34** project from the bore-hole **33** running through the whole length of the block. On the left hand end of the piston **34** one lever arm of the bell crank lever **38** is supported, whilst the other lever arm of this bell crank lever is connected by means of a swivel-joint with the bottom end of rod **421** supported in the manner of a bolt in nut **42**. Nut **42** is capable of being rotated by means of hand-wheel **40** and its bottom surface reposes on the spring **391** resting against shoulder **39**, which arrangement enables the preliminary tension of the spring to be adjusted by means of the hand wheel **40**. The other, i. e. right-hand end of the differential piston **34** is connected with the control shaft **19** by means of the swivel-joint **43** and the bearing **431**.

If liquid pressure of inadmissibly large magnitude is set up in the delivery conduit **4'** of the pump, this pressure will be propagated through the bore-holes **362, 361**, and **36** to the cylinder space **35** and will displace the piston **34** towards the left against the action of spring **391**. During this time the piston **34** will carry shaft **19** along with itself by means of swivel-joint **43** and bearing **431**, owing to which the oscillation centre line of the slide valve **10** will likewise be shifted in the manner already described above. If the pressure in the delivery conduit **4'** is subsequently diminished again, the spring **391** will again return the differential piston **34** into the extreme position shown in Fig. 8. In order to prevent the described movements of the differential piston becoming too rapid and causing the occurrence of knocks, the path of flow of the liquid is throttled. For this purpose an imperfectly closing ball valve is employed. This valve permits the liquid only to flow back slowly when the piston **34** is being returned.

The control diagram of the method of control described is shown in Fig. 6. If the oscillation centre line of the slide valve body **101, 102, 10** is shifted towards the left from the symmetrical middle position, the pump chamber **5'** will communicate with the delivery conduit **4'** only during the time in which the crank **2'** is moving from position "*m*" to position "*n*". During this time the piston **61** will perform the stroke *h'*. In all other crank positions the pump chamber **5'** communicates with the suction conduit **3'**. The change over points "*m*" and "*n*" of the slide valve body **101, 102, 10** are situated in symmetrical positions relatively to the middle position of piston **61** and with the diminution of the delivery period will be shifted more and more towards the point at which the quantity of liquid delivered is reduced to zero. During this time, however, the piston speeds at which the points of changing-over "*m*" and "*n*" are reached will be continually increasing. On the other hand, the larger the piston speed, the larger will be the accelerating force acting on piston **11**. In order to prevent detrimental shocks which might arise from this it is possible to supplement the capacity of the pump chamber by the addition of space **52** shown in Fig. 9, the quantity of cushioning liquid between the piston **6'** or **61** and the piston **11** which serves to prevent leakage being thus increased.

It is however also possible to control the slide valves **101, 102** in such a manner as to keep the angle of advance opening of the slide-valves constant, or in other words to keep the position in which the slide-valves present the conditions shown in Fig. 9 constant, whilst at the same time varying the degree of admission of the pump at will. For this purpose the control gear shown in Fig. 9 is employed.

Piston **61** is driven from the main shaft II. The gear wheel **45** keyed on the main shaft II engages with the gear wheel **46** and drives shaft **54** at a speed corresponding to a transmission ratio of 1:2. In the lever arm **191'** capable of revolving around the shaft **54** as about a pivot, the pin **19'** is supported so as to be capable of being likewise deflected. This pin **19'** serves as a shaft for the gear whcel **48** meshing with the internal toothing of the gear wheel **46**, the gear ratio between these two gear wheels being 2:1, so that the number of revolutions per minute of the gear wheel **48** is equal to the number of revolutions per minute of the gear wheel **45**. The crank pin **51** arranged in the gear wheel **48**, the radius of which crank pin is equal to the radius of the pitch circle of gear wheel **48**, moves the slide valve body **101, 102, 10** by means of the connecting rod **50**, the bell crank lever **49** and the coupling rod **55**. If this control shaft **19'** is deflected in the direction of arrow **47** the gear wheel **48** will run round the internal teeth of the gear wheel **46** and owing to the diameter ratio of 1:2 stated, the pin **51** will move along the diagonal in the straight line O—O'. If the connecting rod **50** is made of sufficient length, the slide valves **101** and **102** will be displaced during the shifting of pin **51** to an extent so slight as to be practically negligible, but in proportion to the shifting of the centre line of shaft **19'** the centre line of oscillation of the slide-valves will be displaced towards the left without the angle of advance opening of the slide-valve being altered.

The diagram of control in the case of the device being used as a pump, is shown in Fig. 7. The control device shown in Fig. 9 is preferably adjusted so as to make the changing-over corresponding to an advance opening of a permanent degree, take place at the 180° position of the crank, whilst the changing-back, corresponding to varying degrees of admission, should take place in the position "*m*" between the 180° and the 0° position, the pump having been drawing in liquid during the time of the stroke *h'*. The sense of rotation is indicated by the arrow.

On the other hand if it is desired to use the device described as a hydraulic motor, it will be preferable to effect control in the manner shown on the right-hand side of the diagram in Fig. 6, i. e. the control gear will be adjusted so as to make the changing-over remain permanently in the dead-centre position marked 0 and cause changing-back to be effected between the 0° and 180° positions, for instance in position "M". In this case the hydraulic motor has obtained high-pressure liquid during the time of the stroke "*h*", and has performed the corresponding amount of work. The sense of rotation is indicated by the arrow.

What we claim is:

1. A pump comprising a cylinder, a suction passage, a delivery passage, a piston reciprocating in the cylinder, a valve passage extending

transversely to the direction of movement of the piston and communicating near one end with the suction passage and near the other end with the delivery passage, the central portion of the valve passage being in communication with the interior of the cylinder, a control valve reciprocating in the valve passage, the said control valve comprising two parts, one of which controls the suction passage and the other the delivery passage, the part controlling the delivery passage being displaceable in relation to the part controlling the suction passage, and means for shifting the mean position about which the control valve reciprocates relatively to the suction and delivery passages.

2. A pump comprising a cylinder, a suction passage, a delivery passage, a piston reciprocating in the cylinder, a valve passage extending transversely to the direction of movement of the piston and communicating near one end with the suction passage and near the other end with the delivery passage, the central portion of the valve passage being in communication with the interior of the cylinder, a control valve reciprocating in the valve passage, the said control valve comprising two parts, one of which controls the suction passage and the other the delivery passage, the part controlling the delivery passage being longitudinally displaceable in relation to the part controlling the suction passage, and resilient supporting means for the said displaceable part of the control valve.

3. A pump comprising a cylinder, a suction passage, a delivery passage, a piston reciprocating in the cylinder, a valve passage extending transversely to the direction of movement of the piston and communicating near one end with the suction passage and near the other end with the delivery passage, the central portion of the valve passage being in communication with the interior of the cylinder, a control valve reciprocating in the valve passage, the said control valve comprising two parts, one of which controls the suction passage and the other the delivery passage, and the said valve further comprising a shank common to the two said parts, the part controlling the suction passage being fixed to the said shank and the part controlling the delivery passage being displaceably mounted thereon, a shoulder on the shank adapted to limit the movement of the displaceable valve part, and a spring tending to press the displaceable valve part in the direction of the shoulder against the fluid pressure in the cylinder and the central portion of the valve passage.

4. A pump comprising a cylinder, a suction passage, a delivery passage, a piston reciprocating in the cylinder, a valve passage extending transversely to the direction of movement of the piston and communicating near one end with the suction passage and near the other end with the delivery passage, the central portion of the valve passage being in communication with the interior of the cylinder, and a control valve reciprocating in the valve passage, the said control valve comprising a shank, a part which controls the suction passage mounted fast on the shank, a part which controls the delivery passage mounted displaceably on the shank, a shoulder on the shank adapted to limit the movement of the displaceable valve part, resilient means tending to press the displaceable valve part against the shoulder, and a flange on the displaceable valve part surrounding the shoulder and forming with the shoulder a shock-absorbing dash-pot.

5. A pump comprising a cylinder, a suction passage, a delivery passage, a piston reciprocating in the cylinder, a valve passage extending transversely to the direction of movement of the piston and communicating near one end with the suction passage and near the other end with the delivery passage, the central portion of the valve passage being in communication with the interior of the cylinder, a control valve reciprocating in the valve passage, the said control valve comprising a shank, a part which controls the suction passage mounted fast on the shank, a part which controls the delivery passage mounted displaceably on the shank, a shoulder on the shank adapted to limit the movement of the displaceable valve part, resilient means tending to keep the displaceable valve part pressed against the shoulder, and means for shifting the mean position about which the shank of the control valve reciprocates relatively to the suction and delivery passages.

6. A pump comprising a main shaft, a reciprocating piston, a driving connection between the reciprocating piston and the main shaft, a control valve capable of moving transversely to the line of movement of the piston and adapted to control the admission and discharge of liquid operated upon by the piston, the said valve consisting of a shank and two valve bodies so mounted on the shank as to be displaceable relatively to one another, a pair of rockably mounted swing levers, a valve control shaft journaled in the swing levers, means for driving the valve control shaft from the main shaft, and means actuated by the valve control shaft for imparting reciprocating motion to the valve, the mean position about which the valve reciprocates being variable according to the position of the swing levers.

7. A pump comprising a reciprocating piston, a two-part valve capable of moving transversely to the line of movement of the piston and adapted to control the admission and discharge of liquid operated upon by the piston, means for imparting reciprocating motion to the valve, a valve control member capable of shifting the mean position about which the valve reciprocates, and means controlled by the pressure liquid for adjusting the valve control member.

8. A pump comprising a reciprocating piston, a two-part valve capable of moving transversely to the line of movement of the piston and adapted to control the admission and discharge of liquid operated upon by the piston, a pair of rockably mounted swing levers, a valve control shaft journaled in the swing levers, means actuated by the valve control shaft for imparting reciprocating motion to the valve, a valve control piston acted upon in one direction by the pressure liquid and adapted when actuated to move the valve control lever in such a way as to shift the mean position about which the valve reciprocates, at the same time rocking the swing levers, and a spring tending to force the valve control piston in the direction opposite to that in which the pressure liquid tends to drive it.

9. A pump comprising a main shaft, a reciprocating piston, a driving connection between the reciprocating piston and the main shaft, a two-part valve capable of moving transversely to the line of movement of the piston and adapted to control the admission and discharge of liquid operated upon by the piston, a revolving crank driven from the main shaft, the axis of rotation of the crank being adjustable transversely to its axial direction, and means for converting the

rotation of the crank into a reciprocating motion of the valve.

10. A pump comprising a main shaft, a reciprocating piston, a driving connection between the reciprocating piston and the main shaft, a control valve capable of moving transversely to the line of movement of the piston and adapted to control the admission and discharge of liquid operated upon by the piston, the said valve consisting of a shank and two valve bodies so mounted on the shank as to be displaceable relatively to one another, an internally toothed wheel driven from the main shaft, an externally toothed wheel of half the pitch diameter of the internally toothed wheel meshing with the latter, a crank pin mounted at the periphery of the externally toothed wheel, and rodding connected with the crank pin and adapted to convert the rotary motion of the crank pin into reciprocating motion of the valve.

11. A pump comprising an undivided cylinder block, a cylinder, a suction passage and a delivery passage all formed in the cylinder block, a piston reciprocating in the cylinder, a control valve capable of moving transversely to the line of movement of the piston and adapted to control the admission and discharge of liquid to and from the cylinder, the said valve consisting of a shank and two valve bodies so mounted on the shank as to be displaceable relatively to one another, means for imparting reciprocating motion to the valve, and means for shifting the mean position about which the control valve reciprocates.

12. In a variable delivery pump the combination of a plurality of cylinders and coacting plungers, driving means for effecting relative reciprocation between each of said plungers and cylinders, to effect a suction stroke and a pressure stroke, an intake passage, a discharge passage, valve mechanism operated in timed relation with said driving means for effecting communication between said cylinders and said intake passage throughout each suction stroke and between said cylinders and said discharge passage during a portion of each pressure stroke, and means for regulating said valve mechanism to vary the period of communication between said cylinders and said discharge passage to thereby vary pump delivery.

PAUL v. VÁGÓ.
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