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VARIABLE VOLUME WOBBLE PLATE PUMP

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Fig. 1

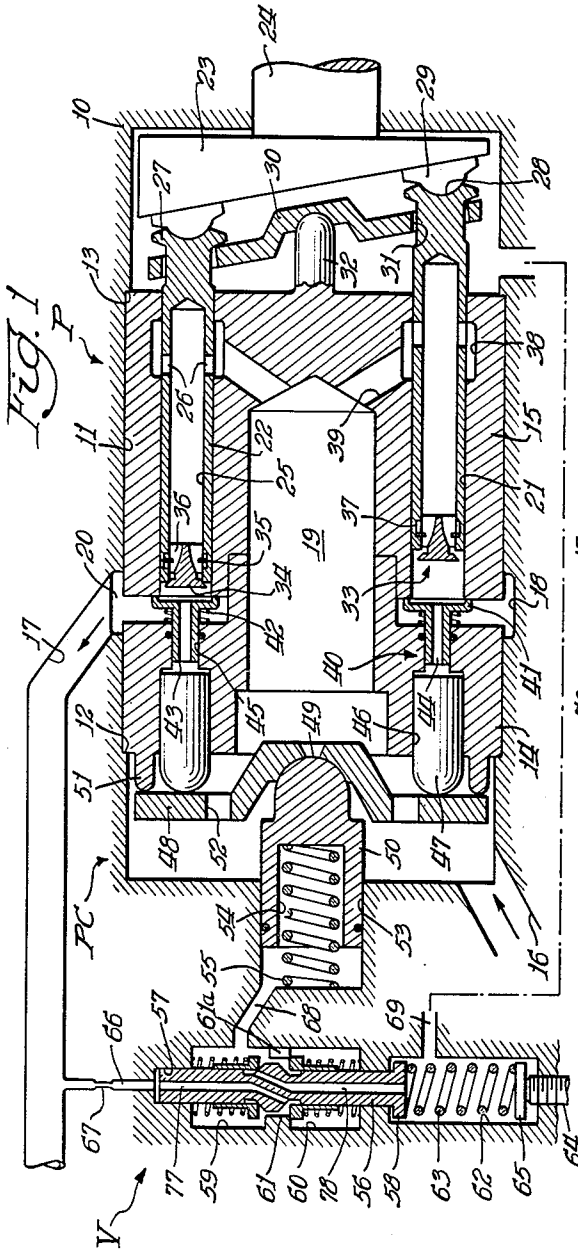
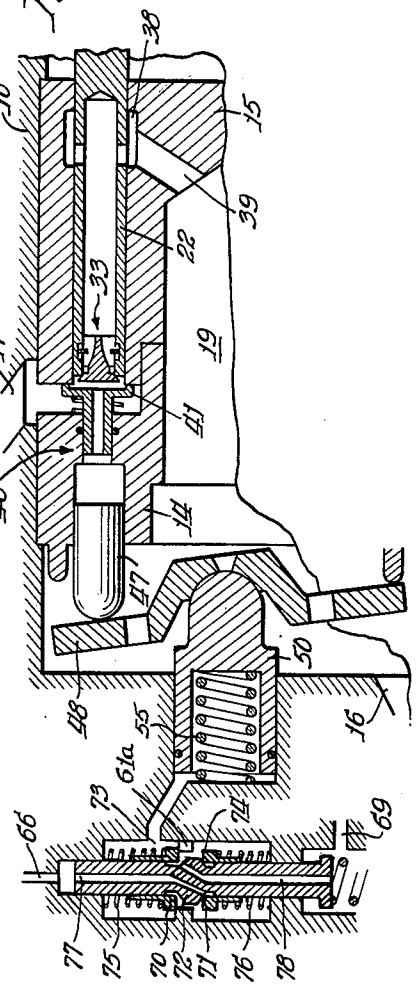


Fig. 2



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VARIABLE VOLUME WOBBLE PLATE PUMP

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6 Claims. (Cl. 103—37)

This invention relates to pumps and pump assemblies in which a plurality of pump cylinders are arranged in circular series parallel to each other and to the axis of the drive shaft, each of the cylinders having disposed therein a piston or plunger actuated by a cam or swash plate fixed on the shaft.

The pump assembly forming the subject matter of my invention is provided with means to vary the displacement thereof, such means including means responsive to the discharge pressure of the pump assembly, and is further provided with means to select the maximum discharge pressure. Such means are desirable in pump assemblies which are constantly rotating, as for example, those used in aircraft installations and where the displacement requirements vary from a maximum to a zero value.

In particular, the aforementioned means to vary the displacement of the pump assembly includes a control or bypass pump means mounted in tandem with a main fixed displacement pump, and a control valve means, the control pump means being operated by the discharge pressure from the main pump cylinders and under the control of the control valve means, which selects a relatively high fluid pressure or a relatively low fluid pressure for application to a means associated with the control pump means. The application of the fluid pressures will cause variance of the discharge pressure from the pump assembly between a maximum and zero value.

Therefore, the principal object of my invention is the provision of an improved variable displacement pump assembly.

Another object of my invention is the provision of an improved variable displacement pump assembly of the type having a plurality of circularly arranged cylinders and pistons, and means responsive to discharge pressure to vary the displacement thereof.

A still further object of this invention is the provision of an improved variable displacement pump assembly of the type described having means responsive to discharge pressure to vary the displacement thereof, which means includes a control pump means.

Still another and further object of this invention is the provision of an improved variable displacement pump assembly of the type described having means responsive to discharge pressure to vary the displacement thereof, which means includes a control valve means.

Still another object of this invention is the provision of an improved variable displacement pump assembly of the type described having means responsive to discharge pressure for varying the displacement thereof, which means includes a control pump means and a control valve means.

Another object of this invention is the provision of an improved variable displacement piston pump assembly having means associated therewith and responsive to discharge pressure for varying the displacement thereof which includes a control pump means and a control valve means for controlling the operation of the control pump means.

Another and still further object of my invention is the provision of a pump assembly including a fixed displacement pump and means to vary the displacement of the assembly.

Still another object of my invention is the provision of a pump assembly including a fixed displacement swash plate pump in which a plurality of cylinders are arranged in circular series parallel to each other and to the axis of a drive shaft having a control or bypass pump associated therewith, so as to vary the displacement of the assembly.

Still further an object of my invention is the provision of a pump assembly comprising a fixed displacement swash plate pump together with a variable bypass pump and a control valve operating to vary the displacement of the assembly.

These and other features and objects of my invention will become apparent from the following description when taken with the accompanying drawing in which:

Figure 1 is a cross-sectional illustration of a variable displacement pump assembly of a main pump, a control or variable bypass pump means and an associated control valve means, showing the pump assembly in its full displacement operation; and

Figure 2 is a partial cross-sectional illustration, similar to Figure 1, but showing the pump assembly in its zero displacement operation.

Detailed description

Referring now to the drawing, there is illustrated a main, fixed displacement pump P, a control or bypass pump means PC and an associated control valve means V. The two pumps and the valve are disposed within a common housing **10** constructed of a plurality of parts (not shown) in a well-known manner. The housing **10** is provided with a cylindrical cavity **11** having a pair of spaced shoulders **12** and **13**, and receives complementary shaped, interlocking cylinder blocks **14** and **15** between the shoulders **12** and **13**.

The housing **10** is provided with an inlet passage **16** and an outlet passage **17**, the inlet passage communicating with the cavity **11** and the outlet passage **17** communicating with an annular groove **18** formed within the cavity **11**.

The cylinder block **14** is substantially annular in shape, and the cylinder block **15** is centrally bored to define, with a central opening in the block **14**, an inlet cavity or chamber **19**. The blocks **14** and **15** also define a discharge cavity or chamber **20** adjacent the groove **18**, as illustrated.

The cylinder block **15** is provided with a plurality of longitudinal bores or cylinders **21** therethrough (two shown, but usually nine are provided) each of which slidably receives a hollow piston or plunger **22**. The pistons **22** are reciprocated within their respective cylinders by means of a cam or swash plate **23** received within the housing cavity **11**. The cam or swash plate **23** is rotatably driven by means of a shaft **24** passing through an opening in the housing **10** and being suitably journalled therein by well-known bearings and journal means.

Each piston **22** comprises an elongated cylindrical member having open-ended cylindrical bore or cavity **25** and being provided transverse openings **26** joining the outer periphery and the bore **25**. Each piston **22** is also provided with an enlarged terminal end **27** having a substantially semi-spherical indentation **28** therein for receiving a complementary shaped portion of a bearing shoe **29** which is slidable on the face of the cam or swash plate **23**. Cooperating with the enlarged terminal portion **27** of each piston **22** is a piston return element **30**

having forked portions 31 fitting over each piston and being rockably supported at its center by means of a protuberance 32, rearwardly extending from and integral with the cylinder block 15. The function of return member should be obvious.

A floating valve means 33 is carried by each of the pistons 22 so as to close the open end thereof during its pressure or discharge stroke and comprises a valve member 34 adapted to seat on the open end of the piston and being retained within the bore 25 by means of a snap ring 35 carried by fins 36 on the valve member 34 and slidable within a groove 37 formed in the walls of the bore 25.

An annular groove 38 is formed within the wall of each cylinder 21 and communicates with the inlet cavity or chamber 19 by means of a passage 39 for the flow of inlet fluid to the bore 25 of the piston 22 by means of the transverse openings 26.

Each cylinder 21 is provided with a discharge valve 40 located in the discharge chamber 20, and which comprises a valve member 41 resiliently urged toward seating engagement with a face of the block member 15 by means of a coil spring 42. Each valve member 41 is provided with a cylindrical stem portion 43 having an elongated opening 44 therethrough.

Each valve stem 43 is slidably received within a complementary shaped bore 45 formed in the block 14, which bore communicates with an enlarged, concentric bore 46. Each bore 46 slidably receives a cylindrical piston or plunger 47 having a semispherical terminal end engageable by means of a plate-like member 48. The member 48 is provided with a hub rockably supported on a hemispherical portion 49 of a piston element 50 and is retained spaced from the block 14 by means of protuberances 51 extending from and integral with the block 14. The plate like member 48 is received within the housing cavity 11 and is provided with a plurality of spaced openings 52 for the passage of fluid from the inlet 16 to the inlet cavity or chamber 19.

The piston like member 50 has a cylindrical portion slidably received within a bore 53 formed in the housing 10 communicating at one end with the cavity 11. The member 50 is provided with an open ended bore 54 to receive a coil spring 55 therein, the other end of which reacts against the terminal end of the bore 53 to resiliently urge the member 50 to the position illustrated in Figure 1, which corresponds to full displacement of the pump assembly.

The control valve means V comprises a shuttle member 56 slidable between certain limits within spaced portions of a bore 57 formed within the housing 10, and having an enlarged terminal portion 58. Between the spaced portions of the bore 57, the housing 10 is provided with enlarged communicating, concentric, cylindrical cavities 59 and 60, spaced by means of a communicating, concentric bore 61, the purpose of which will be later described. The enlarged shuttle portion 58 is received within a communicating, concentric, bore 62 having a diameter greater than the bore 57 and which also receives a coil control spring 63 urging the shuttle upwardly, as illustrated in Figure 1. The loading of the coil spring 63 may be varied by means of a slotted screw 64 acting through a spring retainer 65 received within the bore 62. The limits of movement of the shuttle 56 are determined, at one end by the end of the bore 57, and at the other end by the control spring 63.

The upper-most portion of the bore 57 communicates with the discharge passage 17 by means of a conduit 66 having a restriction 67 therein; the cavity 59 communicates with the cavity 53 by means of a passage 68; and the bore 62 communicates with the housing cavity 11 behind the cylinder block 15 by means of a passage 69.

The shuttle 56 is provided with spaced grooves 70, 71, separated by means of an enlarged cylindrical portion 72 defined at opposite ends by conical surfaces. The enlarged portion 72 is generally disposed within the bore 61.

Slidably disposed about the shuttle and contained within the cavities 59 and 60 are floating valve seats 73, 74, which are resiliently urged toward their seated positions by means of coil compression spring 75, 76, respectively. The shuttle 56 is provided with bores 77 and 78, the bore 77 communicating with the bore 57 at one end of the shuttle and with the grooves 71 closely adjacent the enlarged central portion 72 thereof, and the groove 78 communicating with the bore 62 at the opposite end of the shuttle and with the groove 70 closely adjacent the enlarged central portion 72 thereof. It will be noted that the portions of the bores 77 and 78 within the central enlarged portion 72 of the shuttle are angularly disposed and parallel to one another, but do not intersect.

The floating valve seats 73 and 74 are adapted to seat on the conical surfaces of the shuttle, previously described, but are limited in their resiliently urged movement by means of the walls joining the cavities 59 and 60 and the bore 61, these walls acting as stops for the valve seats. Passage means 61*a* is provided in the control valve means V for fluidly interconnecting cavities 59 and 60 so that the cavities 59 and 60 remain in fluid communication regardless of whether either of the valve seats 73 and 74 are disposed in engagement with the wall defined by the junctures of the bore 61 and the cavities 59 and 60.

Detailed operation

The following description sets forth the operation of the pump assembly and this operation will be described with reference, whenever possible, to one of the pair of the plurality of piston pairs, it being understood that the operation of all pistons in each of the two pumps is the same. In following the description, it must be remembered that displacement of the pump assembly will be varied by means associated therewith under the control of pump assembly discharge pressure.

Assuming the shaft 24 to be rotating, the cam or swash plate 23 joined thereto will also be rotating and cause the pistons 22 to be reciprocated within their respective cylinder bores 21 between their suction position (see the lower piston Figure 1) and their pressure or discharge position (see the upper piston Figure 1).

Inlet fluid will flow through the inlet passage 16, into the left end of the housing cavity 11, through the openings 52 and into the inlet cavity 19 fluid will flow through the passages 39, into the grooves 38, through the openings 26, and to the bores 25 in the pistons 22. With the fluid flowing into the piston bore 25, the valve 34 associated with the piston will be unseated, as shown in the lower portion of Figure 1, and fluid will flow therearound to fill the portion of the cylinder 21 unoccupied by the piston 22. Upon the pressure or discharge stroke of the piston, the trapped fluid within the unoccupied position of the cylinder 21 will be placed under pressure, thereby causing the valve member 34 to seat on the open end of the piston bore 25, and closing the communication between the cylinder and the inlet through the bore 25. When the fluid reaches a pressure sufficient to overbalance the spring 42, the discharge valve 41 will be unseated and allow the fluid under pressure to be discharged to the discharge cavity 20 and into the discharge passage 17.

It must be noted that some of the fluid will pass through the central bore 44 of the discharge valve and react against the piston 47, tending to move the piston 47 to a position, such as shown in Figure 2. However, the force of the spring 55 acting against the member 50 provides an initial loading force to retain the member 48 in its Figure 1 position, so that initially the piston 47 will be retained in its Figure 1 position and allow the discharge pressure to start building up.

With discharge pressure flowing through the discharge

passage 17 to a point of utilization, a portion thereof will flow through the passage 66 and through its restriction 67, thereby providing a pressure equal to or related to discharge to flow within the bore 57, through the shuttle passage 77 and into the shuttle groove 71. Until the discharge pressure reaches the predetermined maximum value as selected by the screw means, the shuttle 56 will be held in the position illustrated in Figure 1 wherein the floating valve seat 73 is in its seated position isolating the groove 70. The floating valve seat 74 is prevented from being seated by means of the wall joining the bore 61 and the cavity 60. Therefore, fluid flowing into the groove 71 will flow between the floating valve seat 74 and the conical surface of the shuttle 56, into the cavity 59, through the passage 68 and into the cavity 53, thereby reinforcing the force exerted on the member 50 by the spring 55 to retain the member 48 in its Figure 1 position, so as to provide the maximum displacement from the pump assembly.

Upon the discharge pressure reaching a value higher than that selected, the pressure within the bore 57 will act through the shuttle 56 and overbalance the spring 63, thereby causing the shuttle to move downwardly, so that the lower conical surface of the shuttle picks up the floating valve seat 74 and moves it from its stopped position. This action will allow the valve seat 74 to seat and effectively isolate the pocket 71. The valve seat 73 then will be resiliently urged to a stopped position spaced from its seat to allow communication between the cavity 59 and the groove 70.

The fluid pressure in the cavity 53 will then flow through the passage 68, into the cavity 59, into the groove 70, through the shuttle passage 78 and into the bore 62, from which it will flow through the passage 69 to the right-hand portion of the cavity 11 in the housing 10. Fluid escaping from the cavity 53 in this manner allows the piston member 50 to move back compressing the spring 55 as shown in Figure 2.

The only fluid pressure existing in the last-named portion of the cavity 11 is that due to fluid leaking past the pistons 22 which pressure has a value of much less than discharge. The fluid in this portion of the cavity 11 or case pressure provides fluid for the lubrication of the rotating parts of the pump.

Under these conditions, the fluid being placed under pressure in the cylinders 21 will then flow through the discharge valve bores 44 and into the cylinders 46, acting against the pistons 47 and moving them to a position such as illustrated in Figure 2. The member 48 will rock about its pivot, and cause the pistons 47 to be reciprocated within their respective cylinder bores 46. This operation effectively reduces the displacement of the pump assembly since each piston 47 will force fluid back into its associated cylinder 21 upon the suction stroke of the piston 22 therein.

As the demands on the pump assembly vary from maximum to zero, the pump and its controls will perform the cyclic operation just described, and it is to be noted that as the pressure applied to the shuttle 56 varies, oil flow will be entering, leaving or trapped in the bore 53, thereby moving the piston 50 forward, backward, or holding it in some intermediate position. The position of the piston 50 determines the degree of rocking of the member 48. With this changing condition, the extent of the strokes of the pistons 47 will vary, so as to provide a variable displacement flow from the pump.

The main pump P will always discharge a constant amount of fluid, but with the combined operation of the main pump and the variable displacement bypass pump, a variable displacement flow will be provided.

While I have described my invention in connection with one specific embodiment thereof, it is to be understood that this is by way of illustration and not by way of limitation and the scope of my invention is defined solely by the appended claims which should be construed as broadly as the prior art will permit.

I claim:

1. In a pump assembly, the combination of a housing having an inlet and an outlet; a first pump means in said housing adapted to pump fluid from said inlet through said housing and out said outlet comprising a cylinder bore, an open-ended piston means received in said bore for movement between a suction position and discharge position, cam means to move said piston means between said positions, valve means operatively associated with said piston means and adapted to close the open end thereof upon movement of said piston means to its discharge position whereby to trap a quantity of fluid within said bore and to discharge the fluid under pressure; a control pump in said housing and adapted to receive and discharge fluid from said first pump means so as to vary the displacement of said pump assembly, said control pump comprising a cylinder bore in alignment with the cylinder bore of said first pump means, a piston member received in the last-named cylinder bore and adapted to be moved between an assembly zero displacement position and assembly maximum displacement position; and means to control and determine the position of said piston member including a control element and a control valve means, said control element being movable and operatively associated with said piston member and having a pressure receiving chamber, said control valve means being fluidly connected to said outlet and being so constructed and arranged to selectively apply and disapply pump assembly discharge pressure to said chamber to move said control element and thereby said piston member to a position of higher pump displacement and allow said control element and thereby said piston member to move to a position of lower pump displacement to thereby vary the displacement of said pump assembly.

2. In a variable displacement pump assembly, the combination of a housing having an inlet and an outlet, a pair of cylinder blocks received in said housing and defining a discharge chamber in communication with said outlet, an aligned bore in each block, piston means in each bore, cam means for reciprocating said piston means in one of said bores to thereby pressurize fluid from said inlet, resiliently urged valve means in said chamber, passage means in said valve means fluidly communicating said bores, said passage means allowing a flow of fluid under pressure from said one bore to the other bore, and means to vary the position of said piston means in the said other bore to determine the amount of fluid that can flow into the said other bore to thereby determine the amount of fluid that can flow past said valve means into said discharge chamber and to said outlet.

3. In a pump assembly, the combination of a housing having an inlet and an outlet, means defining a discharge chamber in communication with said outlet, at least a pair of aligned bores in said housing, piston means in each bore, cam means for reciprocating said piston means in one of said bores to thereby pressurize fluid from said inlet, resiliently urged valve means in said chamber, passage means in said valve means fluidly communicating said bores, said passage means allowing a flow of fluid under pressure from said one bore to the other bore, means to vary the position of the piston means in the said other bore to determine the amount of fluid that can flow into the said other bore to thereby determine the amount of fluid that can flow past said valve means into said discharge chamber and to said outlet, said piston varying means including a control valve means fluidly connected to said outlet and being so constructed and arranged to cause movement of the piston means in the said other bore toward said resiliently urged valve means to raise the displacement of the pump assembly and to allow movement of the piston means in the said other bore away from said resiliently urged valve means to lower the displacement of the pump assembly.

4. In a pump assembly, the combination of a housing having an inlet and an outlet; a first pump means in said housing adapted to pump fluid from said inlet through said housing and out said outlet comprising a plurality of circularly arranged parallel cylinder bores, open-ended piston means received in each of said bores for movement between a suction position and a discharge position, cam means to move said piston means between said positions, valve means operatively associated with each of said piston means and adapted to close the open ends thereof upon movement of said piston means to their discharge position whereby to trap a quantity of fluid within each of said bores and to discharge the fluid under pressure therefrom; a control pump in said housing and adapted to receive and discharge fluid from said first pump means so as to vary the displacement of said pump assembly, said control pump comprising a plurality of cylinder bores in alignment with the cylinder bores of said first pump means, a piston member received in each of the last-named cylinder bores and adapted to be moved between an assembly zero displacement position and assembly maximum displacement position; and means to control and determine the positions of said piston members including a control element and a control valve means, said control element being movable and operatively associated with said piston members and having a pressure receiving chamber, said control valve means being fluidly connected to said outlet and being so constructed and arranged to selectively apply and disapply pump assembly discharge pressure to said chamber to move said control element and thereby said piston members to a position of higher pump displacement and allow said control element and thereby said piston members to move to a position of lower pump displacement to thereby vary the displacement of said pump assembly.

5. In a pump assembly, the combination of a housing having an inlet and an outlet, a pair of cylinder blocks received in said housing and defining a discharge chamber in communication with said outlet, a plurality of aligned bores in each block, piston means received in each bore, cam means for reciprocating the piston means in said bores in one of said blocks to pressurize fluid from said inlet, resiliently urged valve means for each bore in said one block received in said chamber, passage means in each of said valve means fluidly communicating said respective aligned bores, said passage means allowing a flow of fluid under pressure from the one aligned bore in said one block to the aligned bore in the other block, means to vary the positions of the piston means in the bores in the said other block, said piston varying means including a control element operatively associated with said piston means in the said other block and a control valve means fluidly connected to said outlet, said control element having a pressure receiving chamber therein, and said control valve means being so constructed and arranged to selectively apply and disapply outlet pressure to said pressure receiving chamber for changing the positions of the piston members in said other bores to thereby determine and control the amount of fluid that can flow into the said other bores and to determine and control the amount of fluid that can flow past each of said resiliently urged valve means into said discharge chamber and to said outlet whereby to vary the displacement of said pump assembly.

6. In a pump assembly, the combination of a housing having an inlet and an outlet, a pair of cylinder blocks received in said housing and defining a discharge chamber in communication with said outlet, a plurality of aligned bores in each block, piston means received in each bore, cam means for reciprocating the piston means in said bores in one of said blocks to pressurize fluid from said inlet, resiliently urged valve means for each bore in said one block received in said chamber, passage means in each of said valve means fluidly communicating said respective aligned bores, said passage means allowing a flow of fluid under pressure from the one aligned bore in said one block to the aligned bore in the other block, means to vary the positions of the piston means in the bores in the said other block, said piston varying means including a control element operatively associated with said piston means in the said other block and a control valve means fluidly connected to said outlet, said control element having a pressure receiving chamber therein, and said control valve means being outlet pressure responsive and being so constructed and arranged to selectively apply and disapply outlet pressure to said pressure receiving chamber for changing the positions of the piston members in said other bores to thereby determine and control the amount of fluid that can flow into the said other bores and to determine and control the amount of fluid that can flow past each of said resiliently urged valve means into said discharge chamber and to said outlet whereby to vary the displacement of said pump assembly.

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