Feb. 14, 1967 H. D. FANSHAWE 3,303,786

HYDRAULIC PUMPS

Original Filed April 8, 1964 3 Sheets-Sheet 1

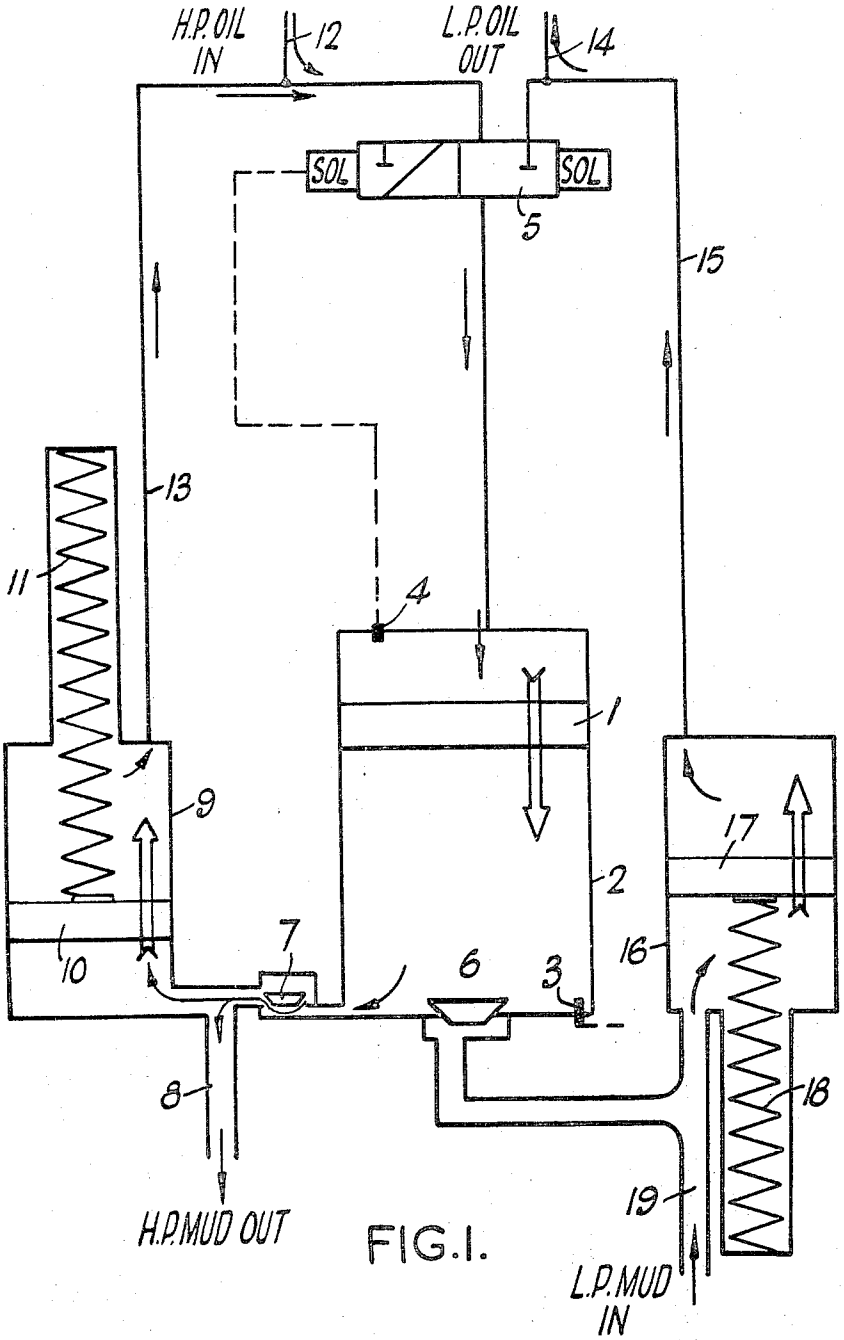


FIG. 1.

INVENTOR

H. D. FANSHAWE

BY

Cameron, Kerkam & Sutton

ATTORNEYS

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HYDRAULIC PUMPS

Original Filed April 8, 1964 3 Sheets-Sheet 2

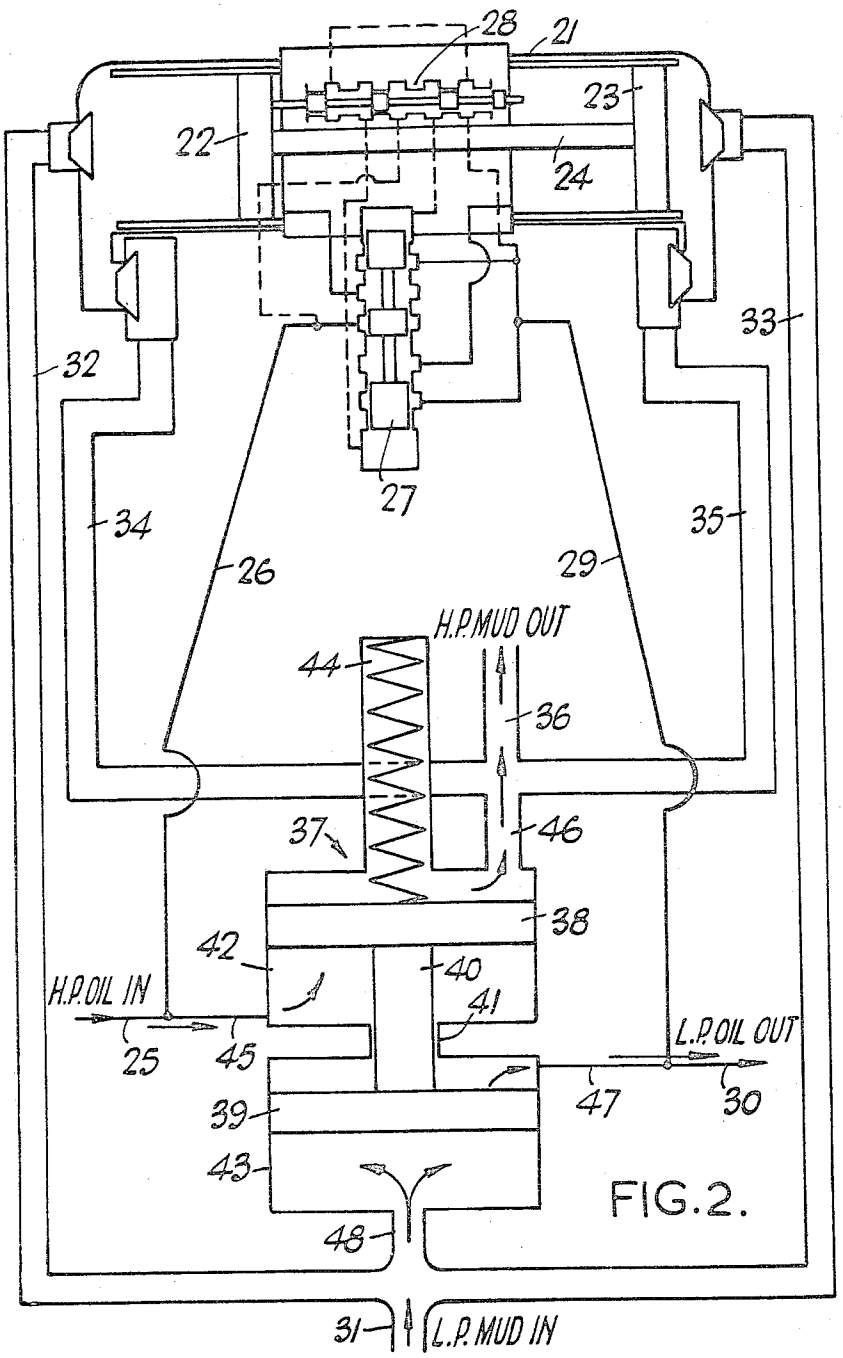


FIG. 2.

INVENTOR
H. D. FANSHAWE
BY
Cameron, Kerkam & Sutton
ATTORNEYS

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HYDRAULIC PUMPS

Original Filed April 8, 1964 3 Sheets-Sheet 3

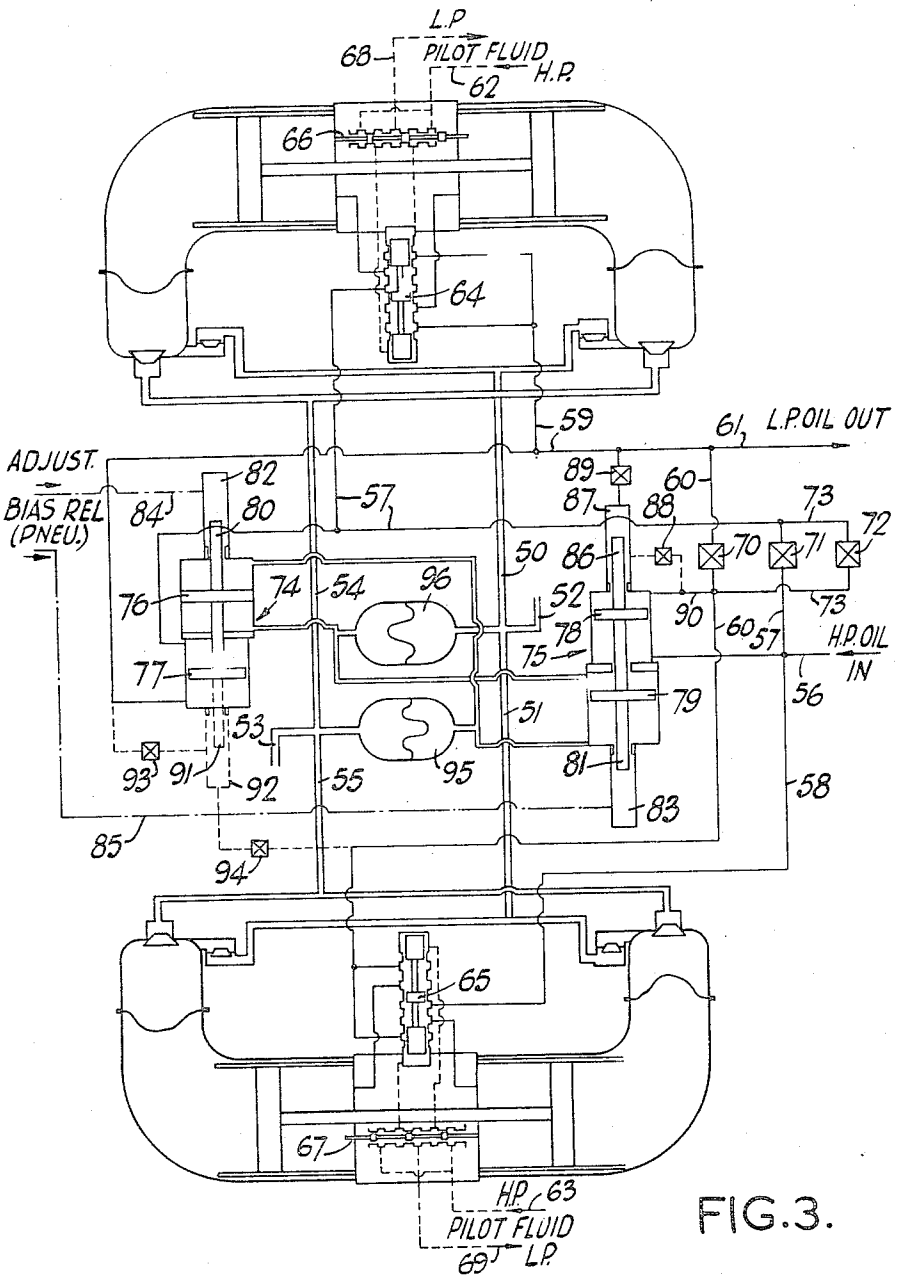


FIG. 3.

INVENTOR

H. D. FANSHAWE

BY

Cameron, Kerkam & Sutton

ATTORNEYS

United States Patent Office 3,303,786 Patented Feb. 14, 1967

3,303,786

HYDRAULIC PUMPS

Hew Dalrymple Fanshawe, North Berwick, East Lothian, Scotland, assignor to F.N.R.D. Limited, London, England, a British company

Continuation of application Ser. No. 358,216, Apr. 8, 1964. This application Apr. 22, 1966, Ser. No. 545,230
Claims priority, application Great Britain, Apr. 8, 1963, 13,958/63
12 Claims. (Cl. 103—52)

This application is a continuation of application Serial No. 358,216, filed April 8, 1964, now abandoned.

This invention relates to arrangements for pumping fluids using hydraulically-operated piston-type pumps. Since the actuating fluid for the piston of such a pump will usually not be the same as the fluid to be pumped, it will be convenient hereinafter to refer to the actuating fluid as "oil," though it need not necessarily be oil as such, and to the fluid to be pumped as "medium"; but this does not rule out arrangements in which the two fluids are in fact similar.

In the operation of a single-acting pump of this kind, there is an interruption in delivery which extends throughout the suction stroke and includes the periods, before and after the suction stroke, required for the reversal of the motion of the piston. This period can be reduced only by increasing the speed of the suction stroke and piston reversals, which results in excessive wear and the danger of cavitation.

The corresponding interruption in the demand for oil to actuate the piston may also adversely affect the operation of the oil supply means.

It is an object of the present invention to provide means for obviating these interruptions in delivery of pumped medium.

In accordance with one aspect of the invention, in a pumping arrangement, an ancillary cylinder with biased piston is provided in association with a piston-type pump on the outlet side of the delivery non-return valve, said ancillary cylinder being adapted to be connected directly to the delivery connection for the pumped medium, and the other side of the piston of the ancillary cylinder being adapted to be maintained in connection with the source of pressurised oil for actuating the pump piston, and valve means are provided for connecting the pump cylinder to means for venting pump oil for the return stroke, the bias of said ancillary piston being such as in operation to cause pumped medium during the delivery stroke to move the ancillary piston against the force of oil on the other side thereof, so that pumped medium, besides flowing to the delivery connection, also flows into said ancillary cylinder on the delivery stroke, and so that some or all of the medium which has thus been taken into the ancillary cylinder is ejected into the delivery connection by action of the force of oil on said ancillary piston as the delivery pressure from the pump decreases and during the suction stroke of the pump, whereby supply of said medium to the delivery connection may be maintained substantially continuously. It is possible that it may be better, for a number of reasons, to incorporate the ancillary gear into the main body of the pump, but it will function equally well, if nevertheless, the ancillary gear forms a separate entity with suitable connections.

It is necessary to arrange the bias on the ancillary piston so that a proportion of the pumped medium expelled from the main cylinder during its pumping stroke is drawn into the ancillary cylinder, thereby reducing the flow rate to the delivery connection.

If, as will usually be preferable, this reduced delivery rate is maintained during the whole of the period between

pumping strokes by the return flow of medium from the ancillary cylinder, then its capacity must be at least the same proportion of the capacity of the main cylinder as is the time of the interruption in the delivery from the main piston as a proportion of a complete pumping-cycle time.

If desired, a further ancillary cylinder and biased piston may be provided on the intake side of the pump for connection directly to the input supply of medium to the pump, the bias on said further piston being arranged so that during the suction stroke this second ancillary cylinder delivers medium to the pump, reducing the rate of input supply required through the inlet connection of the pump to the average for a complete pumping cycle. During the period when the intake non-return valve is closed, the same average flow through the intake connection reverses the motion of the ancillary piston and refills its cylinder with medium. If intermittent flow of medium to the intake side of the pump is permissible, the ancillary gear for that side is not required.

A more advantageous use of the invention arises in connection with pumps arranged to operate in unison out-of-phase so that medium may be pumped from one or the other pump alternately into a common delivery line. In such an arrangement the ancillary cylinder has only to take care of the interruptions to flow which otherwise occur at the ends of strokes of the main pistons. The volume of medium required to maintain flow is only a fraction of the volume of the pump cylinders and is considerably less than that required in the case of the single-acting pump. Moreover, whereas in the case of the single-acting pump, the time of these end-of-stroke interruptions is negligible compared to the interruption during the suction stroke, in the arrangement just proposed, where delivery is maintained over the alternate suction strokes of the respective pump pistons, the period of end-of-stroke interruption becomes important. It is therefore advantageous for the effect of these interruptions to be minimised. The present invention provides the means for doing so, and in this particular application it is apparent that if the pumps operate in unison with each other the ancillary cylinders for the two pumps may be combined into one and the same unit. In addition, ancillary cylinders on the intake sides of the pumps may also be combined and further, if the co-operating pumps are combined to the extent of having linked pistons so as positively to remain in unison, the pistons in the two combined intake and delivery ancillary cylinders may similarly be linked. Such an arrangement hereinafter referred to as a "linked-piston double-acting pump," is very compact since the pistons may then share a common biasing means, the volume of the ancillary cylinders need only be relatively small, and the actuating gear for the main pistons does not need to be duplicated; in addition to obviating interruptions to both delivery and suction of the pumped medium, the corresponding interruptions in the oil pressure supply and exhaust return are also eliminated.

According to another aspect of the invention, an hydraulically-operated piston-type pump which comprises a main piston or pistons, the medium and oil sides of which are adapted to be connected by valve gear to high and low pressure alternately, a biased ancillary piston, having medium and oil sides adapted to be continuously open to high pressure, and a second biased ancillary piston having medium and oil sides adapted to be continuously open to low pressure, is adapted to operate over the period when the valve means associated with it or a main piston is closed, to continue pumping by means of

the ancillary piston, the bias on these ancillary pistons being arranged to cause movement of the ancillary pistons so as to ensure that at least some of the medium supplied by the high pressure ancillary piston during the valve closure periods is returned to the ancillary cylinder associated with that piston, and that medium delivered, from the suction connection to the low pressure ancillary cylinder is returned by the piston associated therewith, during the successive strokes of the main piston or pistons.

Where the medium to be pumped is corrosive or one comprising a suspension of abrasive solids, corrosion or excessive wear of the pistons or their associated cylinders will be avoided by arranging that each piston is adapted to move the medium through the movement of a flexible diaphragm separated from the face of the piston remote from the actuating oil therefor by a substantially fixed volume of trapped actuating liquid. In arrangements according to the invention incorporating ancillary cylinders and pistons, it will be appreciated that similar arrangements may be made; where the pump comprises a plurality of pistons the same flexible diaphragm for the ancillary cylinders and pistons may be shared on the high pressure side and on the low pressure side.

It will normally be perferable to arrange that the outlet for the actuating oil for the main pistons is connected to a pressure line at, for instance 350 p.s.i.; this boost pressure precludes contamination of the oil in case of operation of the pump after possible rupture of a diaphragm, since it ensures that any leakage past the piston will be oil outwardly and not medium inwardly. It also ensures that the "fixed" volume of liquid trapped between piston and diaphragm will never decrease; any tendency for the diaphragm to over-flex due to the leakage may be contoured by means automatically operated by the diaphragm to vent this liquid. No make-up means are necessary to guard against inward bursting of the diaphragm on a suction stroke.

An additional advantage to be gained in arrangements in accordance with a feature of the invention for continued pumping during the valve closure period is that time may be allowed for gentle closure of the pumped medium non-return valves, thereby reducing acceleration forces, generally minimising wear, in particular precluding the losses which occur when a piston commences a new stroke before the associated non-return valve has had time to close after completion of the preceding stroke. This advantage may be achieved by arranging for the oil valve means associated with the piston to extend the period during which the inlet and exit elements are both closed; this period of dwell is preferably substantially independent of pumping pressures but may be adjustable to be consistent with pumping rates.

In order that the invention may be better understood, three embodiments thereof will now be described, by way of example, with reference to the accompanying diagrammatic drawings. FIGURE 1 shows a single piston pump having ancillary pistons associated with the intake and delivery sides; FIGURE 2 shows a linked-piston, double-acting pump having linked ancillary pistons operating on the intake and delivery sides, and FIGURE 3 shows an arrangement of two linked-piston, double-acting pumps with ancillary pistons on intake and delivery sides arranged to operate in parallel.

Referring to FIGURE 1 of the drawings, the main piston **1** operates in the cylinder **2** of the pump and contact means **3** and **4** are operated by the piston **1** at the ends of respective strokes to operate electrical valve reversal means **5** to cause reversal of the piston. Associated with the cylinder **2** are an intake non-return valve **6** and a delivery non-return valve **7**, the letter feeding into a delivery connection **8**.

Associated with the delivery connection is an ancillary cylinder **9** in which the piston **10** operates in conjunction with a biasing spring **11**. The pressurised oil for actuating the pump is supplied by a supply line **12** and actuating oil is fed via the valve means **5** for the delivery stroke of the pump and the pressurised supply is permanently connected to the oil side of the piston **10** through line **13**. On the suction stroke, the actuating oil is vented through the valve means **5** to the low pressure oil line **14** which is maintained in permanent connection through line **15** to the oil side of piston **17** in an ancillary cylinder **16** which is similar to cylinder **9**. Piston **17** is biased by spring **18** and is connected on its other side to the intake connection **19** and to the intake non-return valve **6** so as to remain charged with medium to be pumped.

Without the ancillary cylinder **9** the main pump would deliver a quantity equivalent to the swept volume of the cylinder **2** through the non-return valve **7** and there would be an interruption of supply to the connection **8** during the return stroke of the piston **1** while further medium were drawn into the cylinder **2** via the non-return valve **6**. In the arrangement as shown, however, part of the medium on the pumping stroke is delivered to the cylinder **9** and only part to the delivery connection **8**; then, at the end of the delivery stroke, medium which has been introduced to the cylinder **9** is caused to be ejected by action of the actuating oil in line **13** to maintain a flow of medium to the delivery connection **8** irrespective of whether the non-return valve **7** has closed. By dimensioning the cylinder **9** so that the ratio of its swept volume to the swept volume of the cylinder **2** exceeds the ratio of the time during which valve **7** is closed to the time taken to complete one cycle of the pump, this flow of medium from the cylinder **9** is maintained while the piston **1** moves through its suction stroke; and it is arranged that towards the end of the stroke of the piston **10** the biasing spring **11** will have been energised to the extent that when the piston **1** commences its delivery stroke once again, piston **10** is urged to reverse its motion and to move fast enough to refill with medium which will then be delivered through the non-return valve **7** from cylinder **2**.

Operation of the ancillary cylinder **16**, piston **17** and biasing spring **18** will be understood from the above description of the similar means of the delivery side.

Referring now to FIGURE 2 of the drawings, the pump **21** is double-acting having pistons **22** and **23** linked by a shaft **24**. The pistons are operated on their delivery strokes by pressurised oil from supply **25** through line **26** and spool valve **27**, the valve **27** being under the control of an actuating valve **28**, which is operated at the ends of alternate strokes of the piston **22** and **23** to cause reversal of the strokes, and the actuating oil is vented from behind the respective piston **22** or **23** through the line **29** to the outlet connection **30**. Medium to be pumped is provided through the intake connection **31** which is connected through feeds **32** and **33** to the intake of the respective ends of the pump and the delivery outlets from the pump are connected through feeds **34** and **35** to the delivery connection **36** for the pumped medium. Ancillary gear **37** is provided having pistons **38** and **39** linked by a shaft **40** which passes through an oil-tight seal **41** between high pressure cylinder **42** and low pressure cylinder **43**. Biasing means in the form of compressive spring means **44** are provided for the latter linked positions.

As shown, one side of ancillary piston **38** is permanently connected via line **45** to the pressurised oil supply **25** and the other side of this piston is permanently connected through connection **46** to the delivery side of the pump. Similarly one side of the ancillary piston **39** is permanently connected through line **47** to the actuating oil outlet **30** and its other side permanently connected through connection **48** to the intake side of the pump. The ratio of the annular area for oil to the full piston area for medium will be substantially the same for both main pistons and ancillary pistons.

It will be seen that, in operation, since the pistons **22** and **23** will be delivering on alternate strokes, the ancil-

lary piston 38 does not have to cope with the same situation as the piston 10 in the arrangement of FIGURE 1; there is no extended interruption during the suction strokes of the pump pistons. In this arrangement the stroke of piston 38 need be only such as to ensure continuity of supply of medium to the delivery connection 36 while the pistons 22 and 23 are at the ends of their strokes and the biasing means 44 are arranged to be energised so that the ancillary piston 38 draws in a fill of medium during each delivery stroke of piston 22 or 23; and between delivery strokes of pistons 22 and 23 this fill of medium is expelled by pressurized oil entering the ancillary cylinder through line 45, so providing this continuity of supply of medium, and also continuity of demand for pressurized oil.

The function of ancillary piston 39 will be self-evident and it will be seen that bias for this ancillary piston is provided also by means 44.

In the arrangement depicted in FIGURE 3, two linked-piston double-acting pumps are shown feeding through passages 50 and 51 to a common delivery connection 52, the supply of medium to be pumped being derived through connection 53 and supply passages 54 and 55. Pressurised oil for actuating the pumps is derived from supply 56 from which connections to the pumps are made through lines 57 and 58. The actuating oil is vented for the suction strokes through lines 59 and 60 to the outlet passage 61.

In this arrangement a separate actuating oil supply is provided through lines 62 and 63 for actuating the spool valves 64 and 65 for the respective pumps by means of the actuating valves 66 and 67, this auxiliary actuating oil being vented through lines 68 and 69.

Stop valves 70 and 71 are provided in lines 60 and 57 respectively and a further stop valve 72 is provided in line 73 linking lines 60 and 57. When valves 70 and 71 are open and valve 72 is closed the actuating oil for the two pumps is arranged to be supplied in parallel paths; but by opening valve 72 and closing the other two, the actuating oil is arranged to flow in series through two pumps.

In accordance with the invention, ancillary gears 74 and 75 are provided, each comprising linked pistons 76, 77 and 78 and 79 respectively.

The linked pistons of the ancillary gear 75 have an internal bias ram 86 which operates in cylinder 87 at a suitable pressure; stop valves 88 and 89 are provided, as indicated, to connect this cylinder to either lines 59 or line 90 respectively. Similarly, the pistons of ancillary gear 74 are linked to a bias ram 91 operated in cylinder 92, and stop valves 93 and 94 are provided for this cylinder. Additionally, bias adjusting, or relief, means for the pistons in the two ancillary gears 74 and 75 comprise rams 80 and 81 which are integral with the linked pistons of the respective arrangements and which co-operate with pneumatic cylinders 82 and 83; these latter cylinders are connected through lines 84 and 85 with a supply, or supplies, of air under adjustable pressure.

It will be seen in the drawing that the space above piston 76 and the space below piston 79 are in communication with each other, and with one side of a flexible diaphragm chamber 95. The liquid contained in these spaces is of substantially fixed volume, provision being made to vent any leakage past the pistons.

Similarly the space below piston 76, the space above piston 79 and the one side of a second flexible diaphragm chamber 96, are connected to form another fixed volume of liquid.

The other sides of the diaphragm chambers are connected with the inlet supply 53 of the medium to be pumped and with the delivery connection 52 respectively.

The space above piston 77 is connected to the supply line 57 for pressurised oil which atcautes the linked pistons of the one pump, and the space below piston 78 is connected to the supply line 58 for pressurised oil for actuating the linked pistons of the other pump. In addition, the space below piston 77 is connected to the venting line 59 of the one pump and the space above piston 78 to venting line 60 of the other pump.

The areas of bias rams 86 aand 91 and bias relief rams 80 and 81 are made such that, during strokes of the pump pistons, they apply a resultant bias, adjustable by adjustment of the pneumatic pressure in the cylinders 82 and 83, this bias tending to move the ancillary pistons in the direction to draw liquid forming part of the aforesaid fixed volume of liquid on the delivery sides of the ancillary pistons from the compartment of the diaphragm chamber 96. Thereupon the quantity of medium which has been drawn from this chamber on the preceding stroke of a pump commences to flow back, forcing medium into the delivery connection 52 until the next stroke of the piston on the other side of each pump commences, thus maintaining supply of medium to the delivery connection. It will be noted that, in the event of failure of the bias-relief adjustment source for operating the cylinders 82 and 83, the pumps themselves "fail safe" in that they continue to operate, though running roughly until the air pressure has been restored and the bias reduced to its correct magnitude.

Although not shown, the spool valves 64 and 65 have means for slowing them down over those parts of their travel when all the flow-ports and the valves are closed, thus reducing hammer of the non-return valves for medium as well as easing wear. Such means can be the provision of annular bulges around one end of a spool valve and of choke rings to retard the flow of the vented actuating oil.

Assuming that the valves 70 and 71 are open and valve 72 is closed, then the flow paths of the actuating oil for both pumps are in parallel. The pumps themselves being permanently connected for parallel suction and delivery, the ancillary means 74 and 75 are in parallel with both pumps, and operate twice in each cycle of operation of each pump. If only parallel operation is desired, one set of ancillary means may be unnecessary, but in the event that the valves 70, 71 and 72 can be operated, as above referred to, to put the flow paths of actuating oil for the two pumps in series, the two sets are required, one for each pump. This is because, in the series flow arrangement, the oil pressures are different for the two pumps. Thus, the delivery sides of the pumps being connected in parallel, the pressure rise through each pump should be the same and, in order that the actuating oil, in venting from the first pump, shall retain sufficient pressure to operate the second pump, the oil at inlet to the first pump must be under approximately twice the pressure of that at inlet to the second pump. If the actuating oil vents from the second pump to a line maintained at a boost pressure of, say 350 p.s.i., then assuming that it is required to pump the medium at 1000 p.s.i., the pressure required at inlet to the first pump will be 2350 p.s.i.; this vents at about 1350 p.s.i. into the second pump, the drop of pressure to the boost pressure providing the necessary 1000 p.s.i. in the delivery of the second pump.

The two actuating pilot valves 66 and 67 for the spool valves 64 and 65 of the pumps may be adapted to provide extended periods for reversal of the pistons so that the periods of closure of the non-return valves at the end of the delivery strokes of the piston are ample to ensure gentle operation of the valves.

In series operation, the higher pressure conditions in the actuating gear for the one pump will tend to cause greater wear of the gear of that pump than on the gear of the other pump. It is probably desirable not to permit the greater wear of one pump to proceed indefinitely, and in order to provide for more even wear of the gear as a whole, provision is made for the higher pressure to be applied alternatively at intervals to the other pump. Thus by re-connecting the valve 72 across lines 56 and 61, by changing the high pressure oil input from line 56 to the top

half of line 73, which is now broken, and venting line for low pressure oil from line 61 to the bottom half of line 73, by closing valve 89 and opening valve 88, by closing valve 93 and opening valve 94, the pumps may be interchanged for the higher pressure actuation.

If the feature of interchange is not required, then no provision need be made for re-connection of the valve 72, nor need valves 88 and 94 with their associated lines, shown dotted, be provided. In fact in this latter event the ram 91 and its associated cylinder 92, shown dotted for this reason, is not necessary and the valve 93 and its associated line, also shown dotted, will not be required. Further, valve 89 will not be required, since the line connecting cylinder 87 to line 59 will then never need to be closed.

What is claimed is:

1. A pumping arrangement for providing continuous delivery stroke is ejected into the medium delivery line one hydraulically-operated piston-type pump having a medium intake line, a medium delivery line, a line for supplying high pressure liquid and a line for discharging said liquid at low pressure, valve means associated with said high pressure and low pressure liquid lines for causing actuation of the piston of said pump, a non-return valve in the medium delivery line, an ancillary system including a biased piston means, said piston means being subject in one direction to the pressure of the medium in the delivery line on the outlet side of said non-return valve and subject in the opposite direction to the pressure of the liquid in said high pressure liquid supply line, and means for so biasing said ancillary system piston means that the pumped medium causes movement of the ancillary system piston means against the pressure of the liquid in the high pressure liquid supply line and the pumped medium flows into both the medium delivery line and the ancillary system during the delivery stroke of the pump piston, and at least some of the pumped medium taken into the ancillary system during said delivery stroke is ejected into the medium delivery line by the pressure of the liquid in the high pressure liquid supply line during the suction stroke of the pump piston, whereby the supply of pumped medium to the medium delivery line is substantially continuously maintained.

2. A pumping arrangement as claimed in claim 1 including a further ancillary system and biased piston on the intake side of the pump connected directly to the medium intake line of the pump, the means for biasing said further ancillary piston being arranged so that, during the suction stroke of the pump piston, this further ancillary system supplies medium to the pump.

3. A pumping arrangement for providing continuous delivery of a pumped fluid medium comprising two hydraulically-operated piston-type pumps and ancillary systems as claimed in claim 1, said two pumps having common medium intake and delivery lines, and being adapted to operate substantially in unison and substantially in opposite phase.

4. A pumping arrangement for providing continuous delivery of a pumped fluid medium comprising two hydraulically-operated piston-type pumps having common medium intake and delivery lines, and a common ancillary system as claimed in claim 1 connected to the two said pumps.

5. A pumping arrangement for providing continuous delivery of a pumped fluid medium comprising two hydraulically-operated piston-type pumps having common medium intake and delivery lines, and common ancillary systems as claimed in claim 2 connected to the delivery and intake sides of the two said pumps.

6. A pumping arrangement for providing continuous delivery of a pumped fluid medium comprising an hydraulically-operated piston type pump having at least one main piston, a low pressure medium intake line, a high pressure medium delivery line, a line for supplying high pressure liquid to the pump to actuate the main piston and a line for discharging low pressure liquid from the pump, one side of said main piston being subject to the pressure of the medium and the other side being subject to the pressure of the liquid, valve means for connecting the medium side of said main piston alternately to said low pressure medium intake line and to said high pressure medium delivery line, valve means for connecting the liquid side of said main piston alternately to said high pressure liquid supply line and to said low pressure liquid discharge line, a first ancillary system including a high pressure biased piston means, said piston means being continuously subject in one direction to the pressure of the medium in the high pressure delivery line and continuously subject in the other direction to the pressure of the liquid in the high pressure supply line, a second ancillary system including a low pressure biased piston means, said low pressure piston means being continuously subject in one direction to the pressure of the medium in the low pressure intake line and continuously subject in the other direction to the pressure of the liquid in the low pressure discharge line, said pumping arrangement thereby being adapted to operate over the period when the valve means associated with the medium delivery side of the main piston is closed, the pumping arrangement continuing to deliver medium to the high pressure medium delivery line by means of the piston means of said first ancillary system, and means for so biasing said ancillary system piston means that, during successive strokes of the main piston, (i) at least some of the medium supplied to the delivery line by the high pressure ancillary piston means during the period when the valve means associated with the medium delivery side of the main piston is closed is replaced in said first ancillary system from the medium delivery side of the pumping arrangement, and (ii) medium delivered from the intake line to the second ancillary system is returned to the intake by means of the piston means of said second ancillary system.

7. A pumping arrangement as claimed in claim 6 wherein the pump comprises a flexible diaphragm separated from the side of the main piston remote from that in contact with the actuating liquid by a substantially fixed volume of trapped actuating liquid.

8. A pumping arrangement as claimed in claim 6 including flexible diaphragms arranged to trap substantially fixed volumes of actuating liquid between the low and high pressure medium linees and the ancillary piston means.

9. A pumping arrangement as claimed in claim 6 wherein the pump comprises a plurality of pumping pistons, and including flexible diaphragms arranged to trap substantially fixed volumes of actuating liquid between the low and high pressure medium lines and the ancillary piston means.

10. An arrangement as claimed in claim 8 including means for maintaining the actuating liquid for the ancillary systems under pressure to preclude contamination of the actuating liquid, after rupture of any flexible diaphragm in the arrangement, by the pumped medium.

11. A pumping arrangement as claimed in claim 6 including liquid valve means associated with the pump for extending the period during which the inlet and outlet of the pump are both closed.

12. A pumping arrangement as claimed in claim 11 wherein the said liquid valve means is adjustable to be consistent with pumping rates.

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ROBERT M. WALKER, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,303,786 February 14, 1967

Hew Dalrymple Fanshawe

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 34, for "contoured" read -- countered --; line 43, after "wear," insert -- and --; line 70, for "letter" read -- latter --; column 4, lines 61 and 62, for "positions" read -- pistons --; column 5, lines 45 and 46, for "internal" read -- integral --; line 73, for "atcautes" read -- actuates --; column 6, line 5, for "aand" read -- and --; column 7, line 18, for "stroke is ejected into the medium delivery line" read -- of a pumped fluid medium comprising at least --; column 8, line 48, for "linees" read -- lines --.

Signed and sealed this 17th day of October 1967.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents