

Jan. 6, 1959

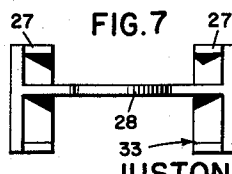
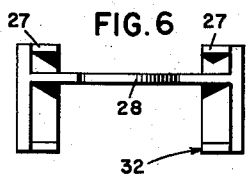
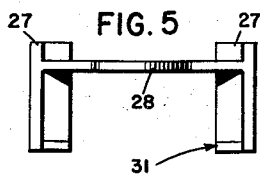
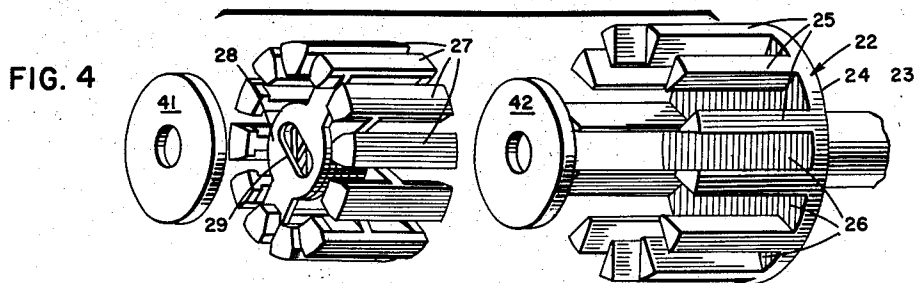
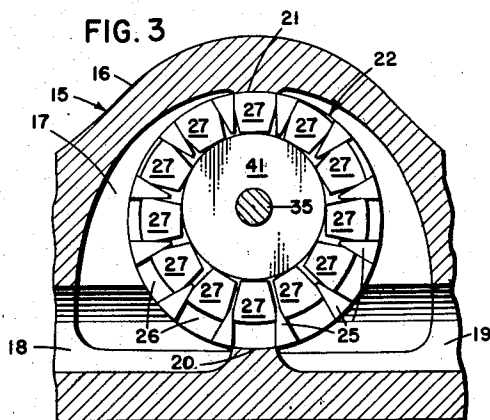
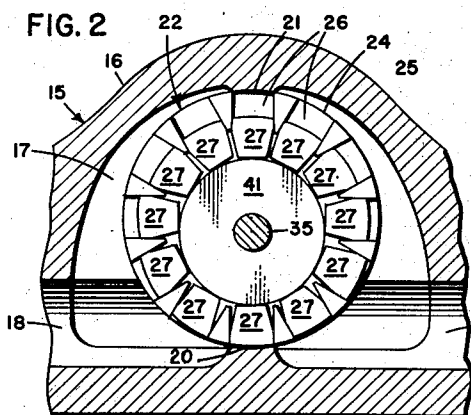
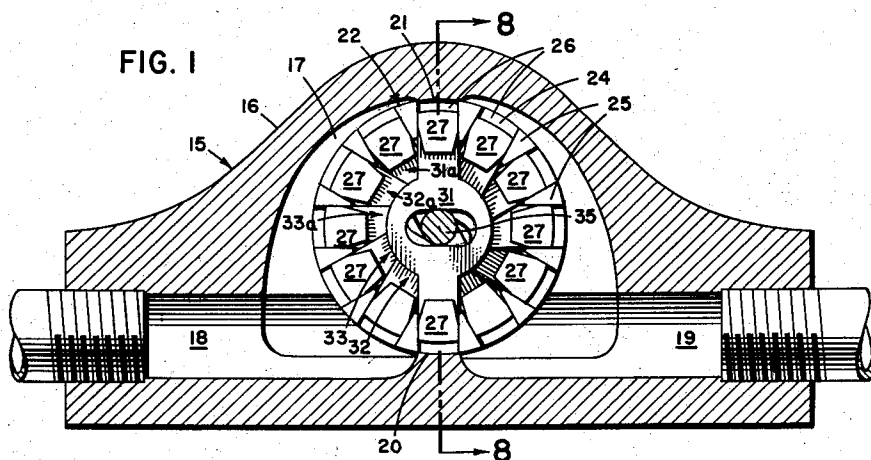
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2,867,175

VARIABLE CAPACITY HYDRAULIC PUMP

Filed April 2, 1953

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 8

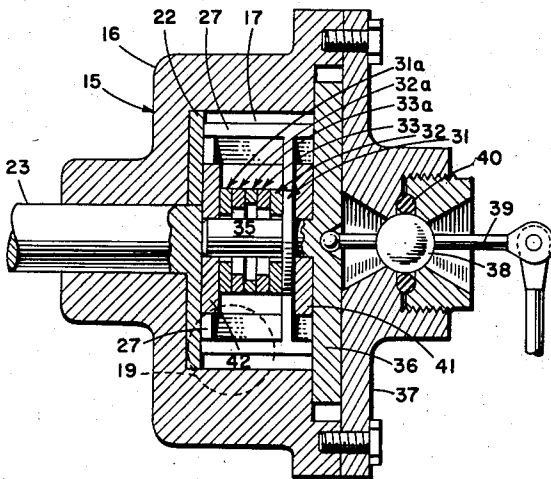


FIG. 9

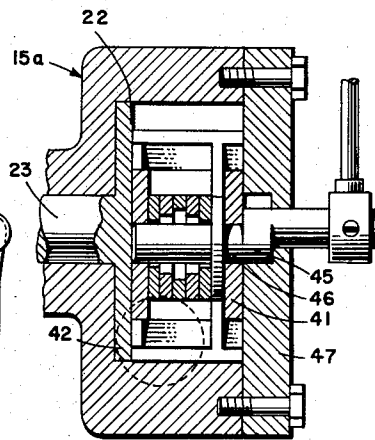


FIG. 10

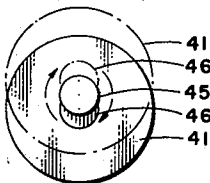


FIG. 11

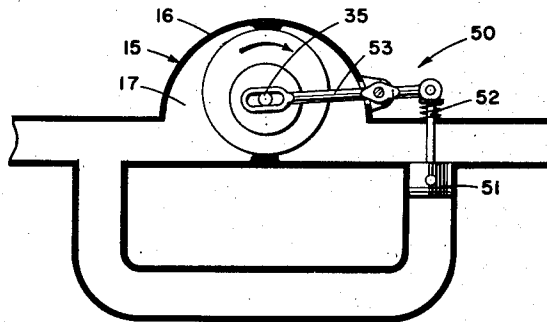
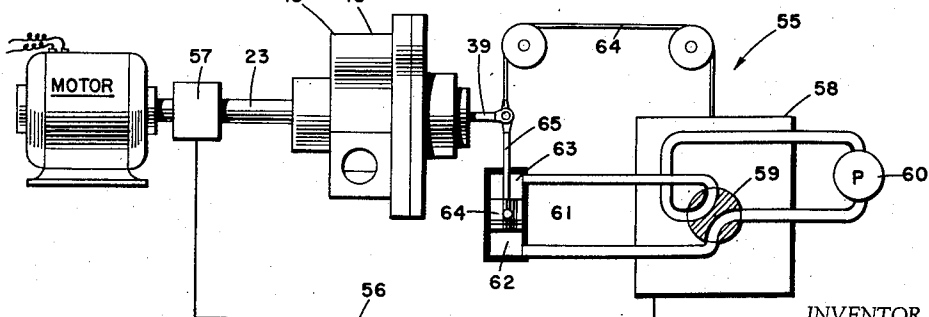


FIG. 12



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VARIABLE CAPACITY HYDRAULIC PUMP

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6 Claims. (Cl. 103—161)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The invention relates to improvements in hydraulic pumping equipment suitable for use in servo systems and more particularly to an improved variable capacity hydraulic pump.

An important object of the invention is to provide a variable capacity hydraulic pump having rotary eccentrically mounted dynamically balanced parts capable of operation at high speeds of the order of 4000 R. P. M.

Another important object of the invention is the provision of a variable capacity hydraulic pump with a balanced volume adjustment which is externally adjustable while the pump is running, and which requires little force to adjust and none to hold in position.

A further object is to provide a variable capacity hydraulic pump which is adjustable to supply fluids at any volume-pressure ratio from high volume at low pressure to low volume at high pressure.

A still further object is the provision of a variable capacity hydraulic pump which is automatically adjustable to deliver high pressure against high resistance to flow and high volume under low resistance to flow, balanced against power available in the drive.

Another object is to provide a pump of the character described which is adjustable to reverse the flow while the pump is being driven in one direction by passing the adjustment through a zero pumping stage.

Another important object is the provision of a pump as described which imposes no load on the driving motor when the volume adjustment is in its neutral setting for zero flow.

The invention also aims to provide pumping equipment which cannot be stalled by flow resistance and which utilizes the available power to pump a commensurate volume over the output pressure.

The invention additionally aims to provide a self-lubricating pump adjustable for gradual variation of flow.

A still further object of the invention is the provision of a pump as described which is so designed as to minimize frictional wear and impose no side or torque stress on reciprocating parts.

Yet another object is to provide, in connection with a servo unit, a pump capable of fine adjustment to produce a very small flow for effecting minute control movements more accurately than by other means.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a central longitudinal sectional view of the improved pump, the rotary parts being shown in elevation and the outer circular cam being removed to show the pistons in their neutral nonpumping positions;

Figs. 2 and 3 are fragmentary views similar to Fig. 1

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but with the outer circular cam in place and showing the pistons in their diametrically oppositely displaced lower and upper eccentric positions respectively;

Fig. 4 is an exploded perspective view of the rotary parts of the pump;

Figs. 5-7 are plan views of the three variations of paired piston units required by the twelve chamber pump illustrated in Figs. 1-4;

Fig. 8 is a central vertical transverse sectional view substantially on the line 8-8 of Fig. 1 and illustrating a preferred diametrical type of piston displacement adjustment mechanism;

Fig. 9 is a view similar to Fig. 8 but showing a modified semicircular type of piston displacement adjustment mechanism;

Fig. 10 is a front elevational view of the eccentric shaft and outer circular cam utilized in the modified form of invention shown in Fig. 9;

Fig. 11 is a diagrammatic view illustrating a system of automatic differential pressure control of the pump illustrated in Figs. 1-8; and

Fig. 12 is a diagrammatic view illustrating a system of automatic control of the pump illustrated in Figs. 1-8 utilizing a signal derived from the pump driveshaft.

In the drawings which for the purpose of illustration show preferred and modified forms of the invention, and wherein similar reference characters denote corresponding parts throughout the several views, the numeral 15 generally designates the improved variable capacity pump shown in Figs. 1-8, 11 and 12. This pump 15 includes a housing 16 providing a compartment 17 having inlet and discharge portions 18, 19, opposite sides of the compartment being shaped to provide lands 20, 21 between the inlet and discharge portions. Mounted for rotation in the compartment 17 between the opposite lands 20, 21 is an impeller wheel 22 fastened on a driveshaft 23 and including a circular disc 24 having a concentric annular series of circumferentially spaced transverse elongate vanes 25 integrally projecting from the inner margin of its rim and defining pairs of diametrically opposed piston chambers 26. Radially slidable in these chambers are diametrically opposed transversely elongate pistons 27 arranged in pairs each integrally connected by a flat rigid link 28 having a medial transverse slot 29. In Figs. 5-7 are shown three dual piston units 31-33 which are similar except for the position of the flat rigid links 28 between pistons 27. In the twelve-piston pump 15 shown in Figs. 1-3 and 8, six dual piston units are employed. Unit 31 shown in Fig. 5 and a similar interchangeable unit 31a are used in reversed positions, at opposite outer sides of the six-unit assemblage shown in Figs. 4 and 8. Unit 33 shown in Fig. 7 and a similar interchangeable unit 33a are used in adjacent but reversed positions centrally of the six-unit assemblage. Unit 32 shown in Fig. 6 and a similar interchangeable unit 32a are used in reversed positions intermediate the units 31, 33 and the units 31a, 33a respectively. The arrangement of dual piston units is such that the six flat rigid links 28 are disposed in adjacent parallel relation as shown in Fig. 8.

Extending through the transverse slots 29 in links 28 in a piston displacement adjustment shaft 35 integrally connected normal to a plate 36 mounted for vertical sliding movement transversely of the housing. The housing 16 is equipped with a removably secured cap 37 provided with a central socket 38 pivotally supporting a lever 39 swingable to rectilinearly move the plate 36 and shaft 35 transversely of the housing. Any suitable packing 40 may be used to prevent loss of hydraulic fluid from the housing. Rotatable concentrically on opposite ends of the shaft 35 are circular cams 41, 42 adjacent the flat links 28 of the outer piston units 31, 31a and internally engaging the opposite ends of

all pistons simultaneously so as to position and hold the pistons against lost motion in an annular relationship concentric to the piston displacement adjustment shaft 35.

When the shaft 35 is concentric with the impeller wheel 22, as shown in Fig. 1, the pistons are held against radial sliding movement relative to the impeller wheel by the circular cams 41, 42 and no pumping action occurs upon rotation of the driveshaft 23 in either direction. As the shaft 35 is adjusted downwardly or upwardly toward positions of maximum eccentricity relative to the impeller wheel 22, as shown in Figs. 2 and 3, the circular cams impart radial oscillatory sliding movement to the pistons of amplitudes gradually increasing toward maximum, and a gradually increasing pumping action takes place in a direction depending on the direction of eccentricity of the piston displacement adjustment shaft 35 and the direction of rotation of the impeller driveshaft 23. From an inspection of Fig. 4 it is clear that the symmetric relationship of impeller wheel parts to the driveshaft 23 is such as to make possible accurate static and dynamic balancing of the impeller wheel 22. Inasmuch as the symmetrically arranged dual pistons 31—33, 31a—33a are always concentrically supported for rotation about the piston displacement adjustment shaft 35, it is evident that accurate static and dynamic balancing of the piston assemblage is possible. It is therefore possible to provide a variable capacity hydraulic pump capable of operation at high speeds of the order of 4000 R. P. M. even though the piston assemblage is rotating about any selected one of a plurality of axes eccentric to the axis of rotation of the impeller wheel. Because of its ability to operate at such high speeds the pump has a high ratio of output capacity to weight, and coupled with this feature to make the pump particularly suitable for aircraft servo use, the balanced volume adjustment shaft 35 requires little energy to set and none to hold in position.

The pump 15a shown in Figs. 9 and 10 is similar to that of Figs. 1-8 except that a rotary eccentric crankshaft 45 is used instead of the previously described rectilinearly movable plate 36 and stub shaft 35 as the capacity and direction-of-flow adjusting means. The same circular cams 41, 42 previously described in connection with Figs. 1-8 are concentrically mounted for rotation on the crankpin 46 of the shaft 45. In the form of invention shown in Figs. 1-8, the cams 41, 42 are constrained to rectilinear movement diametrically of the impeller wheel, and this movement effects a variation in volume of fluid pumped by producing a corresponding variation in the piston stroke. Referring again to Figs. 9 and 10, the crankshaft 45 is mounted for rotation in the cover plate 47 about an axis aligning with that of the impeller wheel, and the crankpin 46 is offset one half piston stroke. By giving the crankshaft 45 a half turn, the cams 41, 42 are moved through a 180° arc concentric with the impeller wheel and, in contradistinction to the action of the pump 15 of Figs. 1 and 8, the volume and direction of flow are thus varied without changing the length of the piston stroke.

Fig. 11 diagrammatically illustrates a system 50 incorporating automatic stall prevention mechanism in the pump 15. Inasmuch as the difference in inlet and outlet pressures is what tends to stall the pump, the differential pressure is used to bring the volume adjustment toward neutral. Assuming that the displacement adjustment shaft 35 is set below the impeller wheel center, and that the direction of rotation of the impeller wheel driveshaft is clockwise as viewed in Fig. 11, the direction of fluid flow is from left to right, and the resultant differential pressure will lower the piston 51 against the resistance of spring 52, causing lever 53 to swing and thus move the adjustment shaft 35 upwardly toward neutral position. The system 50 just described thus prevents stalling of the pump drive motor in case the outlet pressure builds up due, for instance, to increase in

work load, by automatically adjusting the outlet capacity-pressure ratio through a reduction in output volume and an increase in output pressure. The system 50 constitutes one of many possible applications of the pump 15 specially adapted for aircraft servo use. The automatic selection of fast control displacement of an aircraft control surface when resistance to displacement is low, as with low air speed, and slow displacement under opposite conditions is very desirable. The safety feature of not stalling the motor eliminates excess horsepower requirement and power waste.

Fig. 12 diagrammatically illustrates a system 55 for automatically controlling operation of the pump 15 responsive to a running characteristic of the pump driveshaft 23, such as angular velocity or strain. Over a conductor 56 a signal derived from a governor or strain gage 57 on the driveshaft 23 and indicative of driveshaft speed or torque is impressed on a signal controlled device 58 arranged to set a reversing valve 59 controlling the direction of hydraulic flow in a circuit including a pump 60 and a servomotor 61. The valve controlled circuit is so arranged that the pump 60 may introduce hydraulic fluid into any given end 62 of the servomotor cylinder and permit outflow from the opposite end 63 and return to the pump, the position of the reversing valve 59 being controlled by the device 58 consonant with the signal received from the pickup 57 on the driveshaft. This servomotor 61 has its piston 64 connected, as by a shaft 65, to the pump capacity adjustment lever 39. An indication of the set position of the lever is continuously supplied to the device 58 by a follow-up connection 64 acting in the usual manner to gradually reduce and then eliminate the control exerted by the device 58 as the lever 39 approaches and then reaches a position of adjustment commensurate with the signal derived from the driveshaft pickup unit 57.

The pumps described herein are recommended for military and naval aircraft and ordnance use, for instance, in hydraulic equipment for the retraction of wheels and floats, especially where working pressures vary throughout the operating cycle, for elevators where the loads are variable and precision necessary, and for gun and turret training.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a variable displacement hydraulic pump, a housing providing a compartment having inlet and discharge portions and walls including opposite lands between said inlet and discharge portions, an impeller wheel mounted for rotation in the compartment between said lands including an annular series of circumferentially spaced transverse vanes defining pairs of diametrically opposed piston chambers therebetween, said housing also having first and second walls longitudinally spaced relative to the impeller wheel axis of rotation, an annular series of diametrically opposed pistons arranged in pairs and radially slidable in said chambers, rigid links each integrally connecting one of said pairs of diametrically opposed pistons in fixed relationship to form a plurality of pistons and link assemblies, half of said piston and link assemblies being duplicates of the remaining piston and link assemblies and reversed in their disposition relative to the remaining piston and link assemblies to thereby effect a progressively increasing predetermined distance of the link connecting points on each piston and link assembly from the inner end of the pistons individual thereto, a piston displacement adjustment shaft, means mounting said shaft for rectilinear movement between diametrically opposed eccentric positions within said annular series of impeller wheel vanes into and out of a concentric position relative to said impeller wheel, cir-

cular cam means centered on said shaft in radial engagement with said pistons so as to maintain a set eccentric or concentric relationship of said annular series of pistons to said annular series of vanes, and means connecting said adjustable shaft to said housing for adjustably moving said shaft relative to said housing.

2. In a variable displacement hydraulic pump, a housing providing a compartment having inlet and discharge portions and walls including opposite lands between said inlet and discharge portions, an impeller wheel mounted for rotation in the compartment between said lands including an annular series of circumferentially spaced transverse vanes defining pairs of diametrically opposed piston chambers therebetween, said housing also having first and second walls longitudinally spaced relative to the impeller wheel axis of rotation, an annular series of diametrically opposed pistons arranged in pairs and radially slidable in said chambers, rigid links each integrally connecting one of said pairs of diametrically opposed pistons in fixed relationship, said links being stacked in engagement with one another from the link nearest the first wall to the link nearest the second wall of the housing, each link being connected to the pistons individual thereto at a predetermined distance from the end of its pistons nearest the first wall to form a plurality of piston and link assemblies, said predetermined distance being substantially equal to the cumulative thickness of the successively stacked links interposed between the link nearest the first wall and said each link plus a predetermined spacing distance between the link nearest the first wall and the first wall, half of said piston and link assemblies being duplicates of the remaining piston and link assemblies and reversed in their disposition relative to the remaining piston and link assemblies to thereby effect said predetermined distance of the link connecting points from the first wall end of the pistons individual thereto, a piston displacement adjustment shaft, means mounting said shaft for movement along a semicircular path between diametrically opposed eccentric positions within said annular series of impeller wheel vanes, circular cam means centered on said shaft in radial engagement with said pistons so as to maintain a set eccentric or concentric relationship of said annular series of pistons to said annular series of vanes, and means connecting said adjustable shaft to said housing for adjustably moving said shaft relative to said housing.

3. In a hydraulic pumping system, a variable displacement hydraulic pump having an intake portion, a discharge portion, and a pump displacement adjustment member movable to vary the volume of hydraulic fluid transferred from said intake portion to said discharge portion, a pump bypass conduit, and pressure responsive means disposed for movement partially within the discharge portion of the pump and partially within the bypass conduit and acting on said pump displacement adjustment member to vary the output of the pump inversely of changes in the differential pressure of hydrau-

lic fluid in said intake portion and said discharge portion.

4. In a hydraulic pumping system, a motor, a variable displacement hydraulic pump including a pump displacement adjustment member movable to vary the volume of hydraulic fluid transferred from said intake portion to said discharge portion, a driveshaft connecting the motor and pump, means on the drive shaft for indicating running characteristics of the drive shaft, such as torque or angular velocity, and means responsive to variation in a running characteristic of said shaft, such as torque or angular velocity, operatively connected to said indicating means on the drive shaft and acting to adjust said pump displacement adjustment member.

5. In a variable capacity fluid pump having a housing with a compartment defined therein and intake and discharge passages communicating with said compartment, the combination of an impeller rotatable within said compartment, a drive shaft integral with said impeller to rotate the latter, said impeller including a circular disc and a plurality of circumferentially spaced transverse elongate vanes integral with and extending from said disc to define a plurality of transverse elongate diametrically opposed piston chambers therebetween, a plurality of elongate diametrically opposed pistons radially slidable within said chambers arranged in pairs and rotatable with said impeller, a plurality of rigid flat slotted links integrally connecting opposite pairs of said pistons, a piston displacement adjustment shaft oppositely disposed to said drive shaft mounted for incremental movement between diametrically opposed eccentric positions and passing through the slots of each link so that said links are arranged along said adjustment shaft in adjacent relationship to each other, a pair of circular disc cams disposed upon said adjustment shaft one on each side of said links, the periphery of said cams radially engaging said pistons to maintain their positions around said adjustment shaft and means connecting said adjustable shaft to said housing for adjustably moving said adjustment shaft relative to said housing.

6. The device of claim 5 further defined in that said adjustment shaft is mounted for incremental movement along a linear path.

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