Aug. 25, 1953 G. H. HUFFERD ET AL 2,649,739

CONSTANT PRESSURE VARIABLE DISPLACEMENT PUMP

Filed June 4, 1948 4 Sheets-Sheet 1

Fig. 1

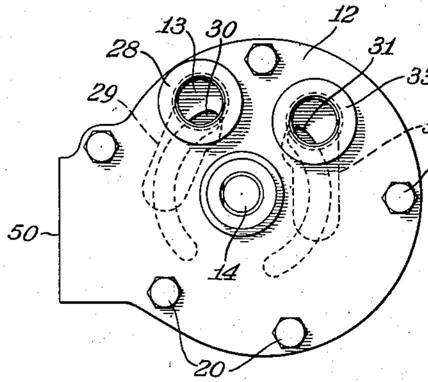

Fig. 2

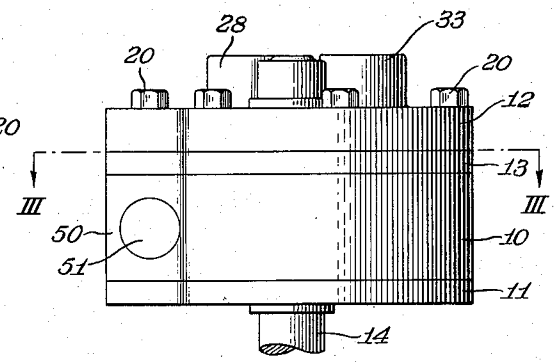

Fig. 3

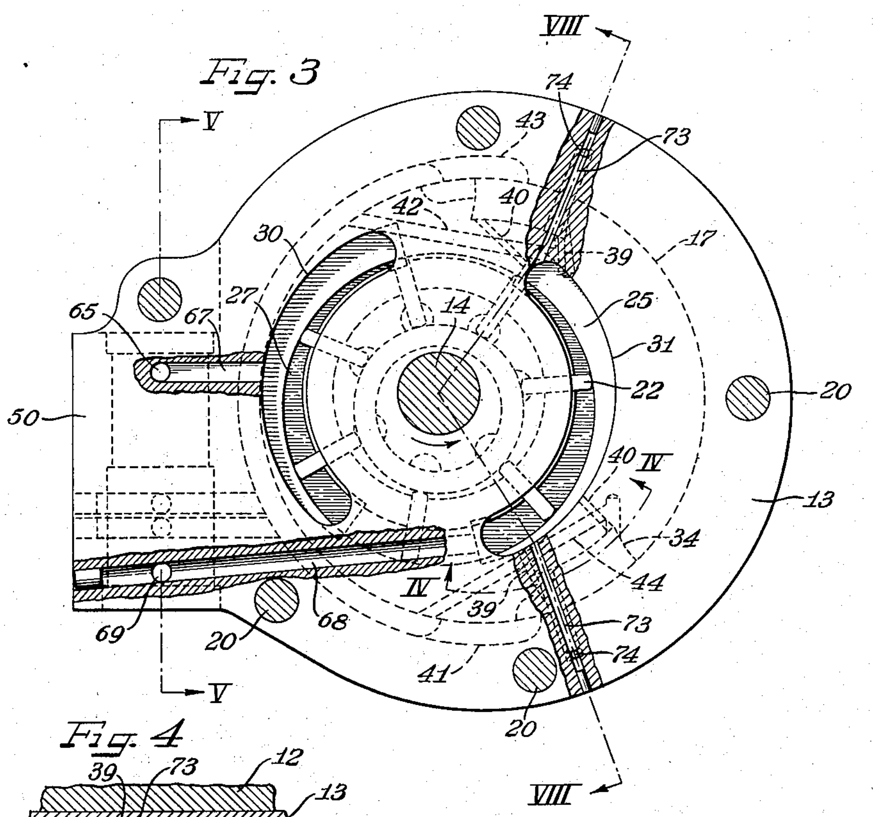

Fig. 4

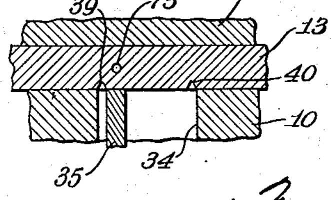

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Fig. 5

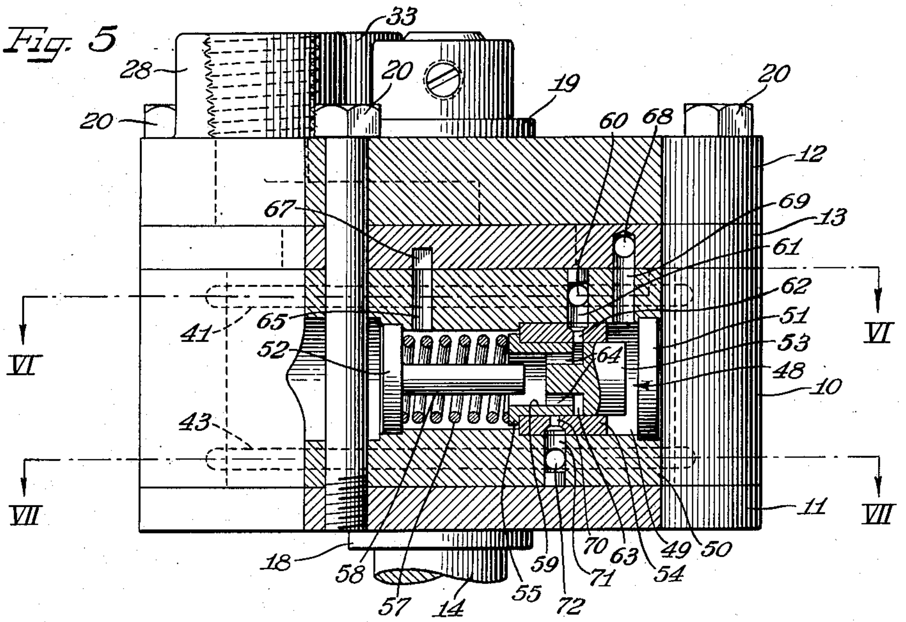
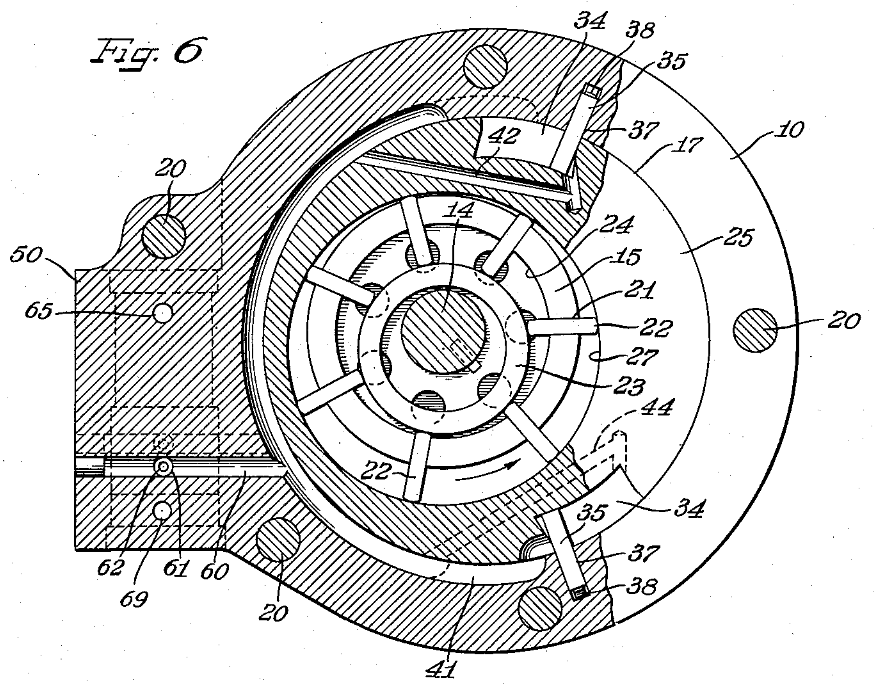


Fig. 6



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CONSTANT PRESSURE VARIABLE DISPLACEMENT PUMP

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Fig. 7

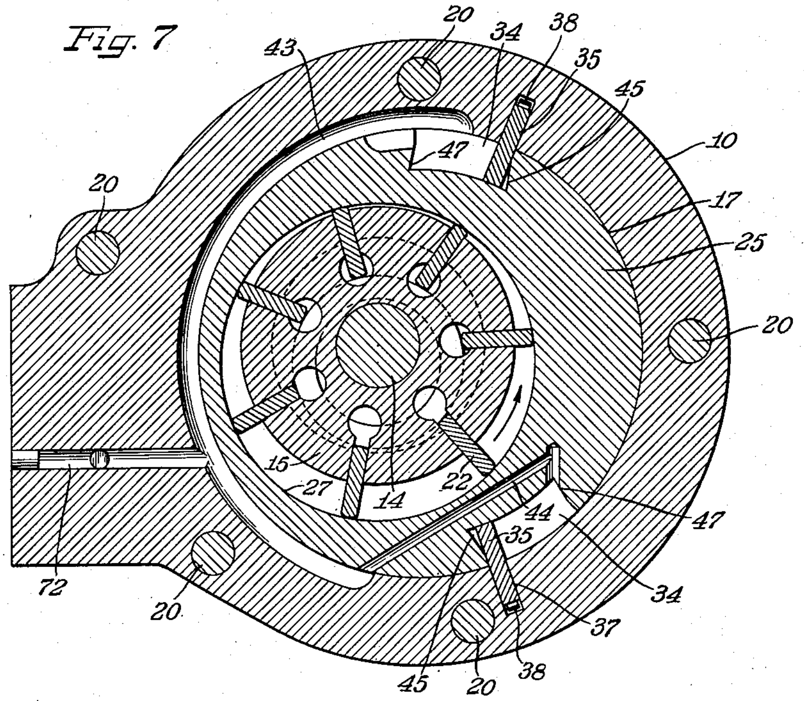

Fig. 8

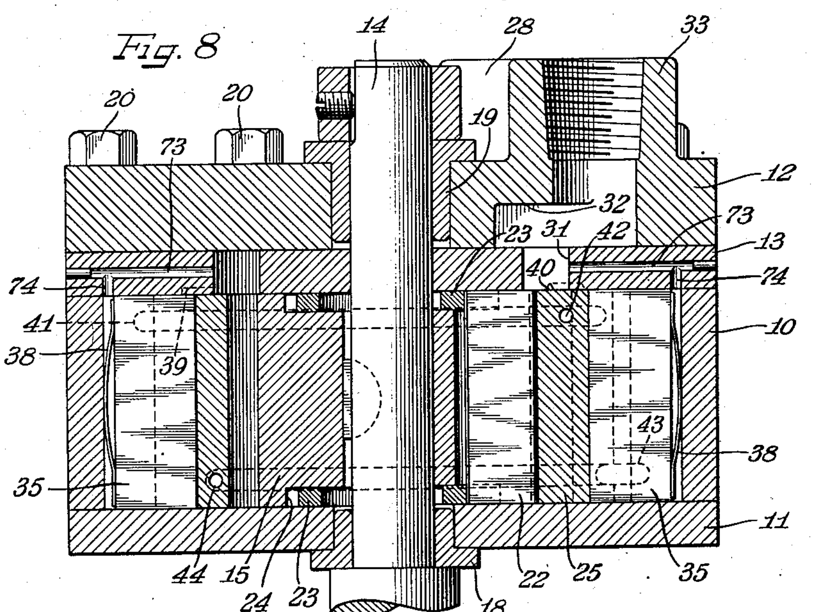

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Fig. 9

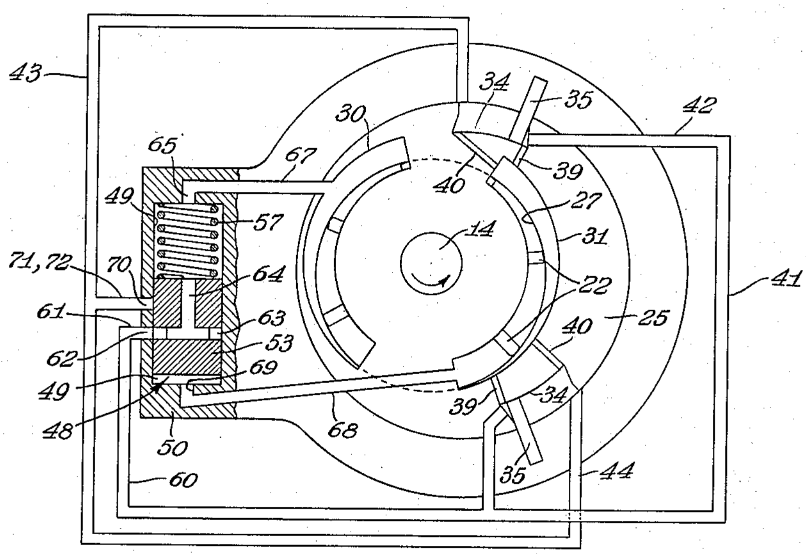
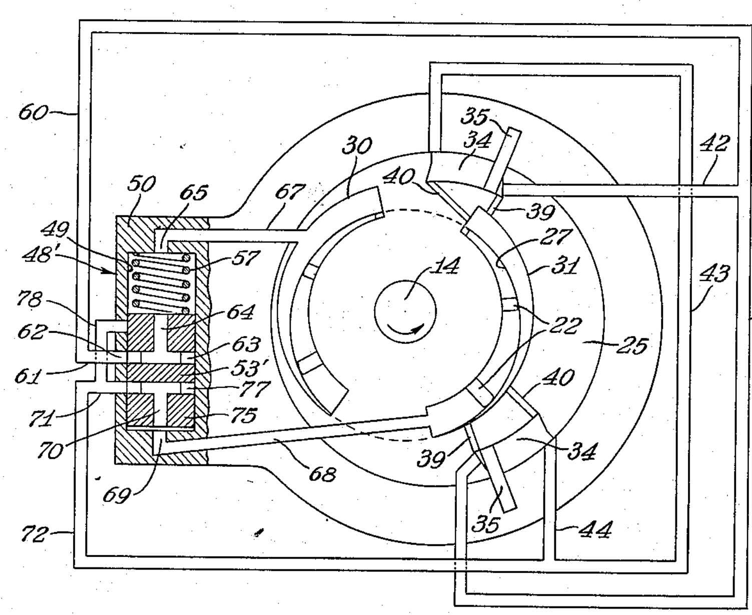


Fig. 10



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UNITED STATES PATENT OFFICE

2,649,739

CONSTANT PRESSURE VARIABLE DISPLACEMENT PUMP

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Application June 4, 1948, Serial No. 31,118

12 Claims. (Cl. 103—120)

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The present invention relates to improvements in constant pressure variable displacement pumps and more particularly concerns pumps of this character which are automatically self-adjustable in response to operating conditions and requirements.

Where a rotary, radially reciprocable vane type of hydraulic pump of variable displacement is to be used under operating conditions demanding a constant pressure output under substantially variable range of requirements as to volume, possibly the most vexing problem has been to provide for proper control of the pump displacement to meet the instant requirements during operation.

An important object of the present invention is to provide a constant pressure variable displacement pump construction of the rotary, reciprocable vane type having improved means for controlling displacement through the medium of a rotary modulator.

Another object of the invention is to provide improved means for automatically controlling a rotary modulator ring in a constant pressure variable displacement pump structure responsive to the hydraulic pressures created in the pump itself.

A further object of the invention is to provide a constant pressure variable displacement pump structure of the rotary, reciprocable vane type wherein a rotary modulator ring is automatically rotatably adjusted by pressures created by the pump itself acting upon control surfaces located at the periphery of the modulator ring.

Still another object of the invention is to provide in a constant pressure variable displacement pump structure an improved servo-motor control system for the modulator ring.

Other objects, features and advantages of the present invention will be readily apparent from the following detailed description of certain preferred embodiments thereof taken in conjunction with the accompanying four sheets of drawings, in which:

Figure 1 is an elevational view of one face of a pump unit embodying features of the invention;

Figure 2 is an edge elevational view of the pump unit;

Figure 3 is a sectional view through the pump unit taken substantially on the line III—III of Figure 2 and on an enlarged scale;

Figure 4 is a fragmentary sectional detail view taken substantially on the line IV—IV of Figure 3;

Figure 5 is a sectional view taken substantially on the line V—V of Figure 3;

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Figure 6 is a sectional view taken substantially on the line VI—VI of Figure 5;

Figure 7 is a sectional view taken substantially on the line VII—VII of Figure 5;

Figure 8 is a developed sectional view taken substantially on the angular section line VIII—VIII of Figure 3;

Figure 9 is a schematic view showing the hydraulic, servo-motor control arrangement for the pump unit; and

Figure 10 is a schematic view of a modified hydraulic, servo-motor control arrangement for the pump unit.

A pump unit embodying the features of the present invention may be constructed as a compact, generally circular flattened assembly comprising a casing including a body block **10**, opposite outer face plates **11** and **12** and an intermediate plate **13** between the outer face plate **12** and the body block **10**. The plates **11**, **12** and **13** are concentrically apertured to accommodate the drive shaft **14** to which is keyed a rotor **15** accommodated within a chamber **17** within the body block **10**. Bearings **18** and **19** are carried by the plates **11** and **12**, respectively, for the shaft **14**. In assembly the components of the casing are held together in appropriate stacked relation by appropriate means such as bolts **20**.

The rotor **15** may be of any preferred reciprocable vane type. In a preferred form it includes radial slots **21** in which are reciprocably slidably operable respective radial vanes **22**. The inner edges of the vanes are in engagement with identical control rings **23** located in appropriate end recesses **24** in the rotor (Figures 6 and 8).

As is well known, fluid displacement in a rotary, reciprocable vane type of pump is accomplished by rotation of the rotor in an eccentrically related displacement chamber so that fluid is sucked in at one side of the rotor chamber and expelled at the other side in the rotation of the rotor within the chamber. Furthermore, variations in displacement can be effected by altering the eccentricity of the rotor chamber. In the present instance, these ends are accomplished by having the circular chamber **17** within the housing or casing body **10** of substantially larger diameter than the maximum sweep of the rotor vanes **22** to accommodate a modulator ring **25** which is provided with a pump chamber **27** of circular form and of a diameter substantially equivalent to the diameter of full sweep of the impeller vanes **22** as controlled by the control rings **23**. By having the pump chamber **27** eccentrically related to the axis of the shaft **14**, a fluid displacement relationship is provided relative to the rotor 15 so that as the rotor turns in the chamber 27, the vanes 22 will operate successively in each full rotation in the direction indicated by directional arrows in Figures 3, 6, 7, 9 and 10 to suck or draw in fluid at the left side of the pump, as viewed in these figures, and to expel the fluid under pressure at the right side of the pump chamber, the left side of the chamber being therefore a low pressure side and the right side being the high pressure side.

Having reference to Figures 1, 2, 3, 5 and 8, appropriate hydraulic fluid is supplied from any suitable source through a hollow boss 28 projecting from the face plate 12 and passes by way of an undercut 29 at the inner face of the plate 12 to a semi-circular or kidney-shaped inlet port 30 in the intermediate plate 13 through which the fluid passes to the low pressure side of the pump chamber 27.

From the high pressure side of the pump chamber 27 the fluid is driven by the rotary impeller vanes 22 through a kidney-shaped high pressure or discharge port 31, substantially counterpart to the low pressure port 30, and thence goes by way of an undercut 32 in the face plate 12 out through a hollow high pressure discharge boss 33. The bosses 28 and 33 may be appropriately internally threaded to receive connecting nipples for fluid ducts or conduits.

Where it is desired to maintain a constant output pressure from the pump, several variable conditions must be taken into account such as variations in the driven speed of the pump shaft 14, variations in fluid demand, variations in the fluid supply, temperature variation, etc. All of these several factors can be compensated for by varying the pump displacement.

According to the present invention, a substantially constant pressure is maintained during operation of the pump by varying the displacement of the pump automatically and self-induced by any tendency to deviate from a predetermined mean pressure at the high pressure side of the pump. To this end, the circular chamber 17 in the casing body member 10 within which the modulator ring 25 is slidably bearinged is disposed eccentric not only to the shaft 14 but also to the pump chamber 27 complementary to the eccentricity of the periphery of the modulator ring 25 to the shaft and the pump chamber. This eccentricity of the chamber 17 and the modulator ring 25 is so related to the shaft 14 and the pump chamber 27 that by rotation of the modulator ring 25 in respective opposite directions displacement of the high pressure side of the pump chamber 27 can be modified by smooth curve increments as demanded to maintain constant pressure output from the pump in the presence of various factors tending to cause deviation of the pressure from a predetermined mean pressure.

Means for effecting rotary adjustment of the modulator ring 25 automatically in response to tendency toward pressure variation at the high pressure side of the pump is effective herein by direct communication of the high pressure side of the pump with one or more, herein shown as a pair of modulator position controlling pressure pockets 34 located in the periphery of the modulator ring 25. Each of the pressure pockets 34 is divided into a pair of pressure chambers by means projecting radially inwardly from the casing body 10 into the pressure pockets. Herein the dividing means comprises in each instance a vane 35 (Figures 6, 7 and 8) slidably mounted in a slot 37 opening radially from the wall of the chamber 17 and with a bowed leaf spring urging the vane radially inwardly into slidable bearing fluid sealing relation to the inner or base wall defining the pressure pocket 34 within the modulator ring. The location of the respective divider vanes 35 is such with respect to the width and location of the pressure pockets 34 that when the modulator ring 25 has been rotated to one limit as defined by engagement of the end walls defining the pressure pockets 34 with the respective divider vanes the maximum desired eccentricity and thus displacement relation of the pump chamber 27 relative to the rotor 15 is attained. This condition is shown in Figures 6 and 7. On the other hand, rotation of the modulator ring 25 in the opposite direction until the opposite walls defining the pressure pockets 34 abut the divider vanes 35 attains the minimum displacement condition of the pump chamber 27. It will thus be observed that a substantial range of minutely, smooth curve incremental displacement adjustment of the pump chamber 27 can be accomplished by counter-rotational movements of the modulator 25 within the limits defined by the divider vanes 35 serving also as rotation limiting abutments.

Direct pressure from the pump under servomotor control adjusts the pump displacement. To this end, a pair of high pressure ducts 39 and 40 lead from the high pressure port 31 to the respective opposite ends of each of the pressure pockets 34 directly from the high pressure side of the pump (Figures 3, 4, 8 and 9). In a convenient form, the high pressure ducts 39 and 40 may comprise grooves, in the present instance shown as V-grooves in the inner face of the intermediate casing plate 13. The ducts 39 and 40 are of limited cross-sectional flow area so that they may be considered as high pressure metering ducts. That is, these ducts are not free flow ducts but at a given pressure will transmit pressure fluid at a relatively restricted rate. Inasmuch as the pressure ducts 39 and 40 are of equal cross-sectional flow area and communicate with the respective pressure pockets 34 on opposite sides of the divider vanes 35, it will be apparent that equal pressure will be maintained thereby in both chambers of the pockets, in the absence of any bleed-off from either of the chambers of the pockets. Hence, the normal tendency of the metering ducts 39 and 40 is to maintain the pressure pockets 34 in a balanced pressure condition in both chambers thereof. This tends to maintain the modulator ring 25 steady, chatter-free and against centrifugal or other tendencies to undesired rotation.

By selectively bleeding-off pressure from either chamber of the pressure pockets 34, pressure unbalance is effected causing the modulator ring 25 to rotate in the opposite direction from the bleed-off by compensatory pressure fluid displacement into the opposite chambers of the pressure pockets. Bleed-off from the pressure chambers of the pockets 34 fed by the pressure ducts 39 leading from the outlet port 31 is accomplished by way of a semi-circular bleed-off groove 41 in the wall of the casing body member 10 defining the chamber 17 and located adjacent to one end of the pockets (Figure 6). One end of the groove 41 is in direct communication with appropriate chamber of one of the pressure pockets 34 while the opposite end communicates with the appropriate chamber by way of an angular duct 42 extending through the modulator ring 25. Bleed-off communication with the remaining chambers of the pressure pockets 34 is accomplished in similar fashion by way of a similar bleed-off groove 43 located in the chamber wall of the body member 10 adjacent to the opposite ends of the pockets 34. One end of the groove 43 communicates directly with the appropriate chamber of one of the pockets 34, in this instance the opposite pocket 34 from that with which the groove 41 communicates directly, while the remaining end of the groove 43 communicates with the appropriate chamber of the remaining pocket 34 by way of an angular duct 44 provided in the body of the modulator ring 25 (Figure 7).

In order to limit contact of the pressure faces defining the opposite sides of the pressure pockets 34 and also to avoid complete blocking off of the respective pressure chambers in the pockets at the extreme limits of oscillation adjustment of the modulator ring 25, the respective pressure walls to which the pressure ducts 39 lead are undercut, as indicated at 45, while the opposite respective pressure walls to which the pressure ducts 49 lead are undercut, as indicated at 47. This relationship is also advantageous in maintaining constant communication between the pressure ducts 39 and 40 and the respective bleed-off grooves 41 and 43 by way of the pressure chambers in the pockets 34 whereby to afford continuous, efficient, highly sensitive modulator adjustment sensitivity in the system.

The bleed-off grooves 41 and 43 form part of a servo-motor system including an automatic control valve assembly 48 (Figure 5). For convenience, the control valve assembly 48 is housed in a transverse bore 49 in a lateral boss 50 on the pump casing and more particularly on the body block 10. Opposite ends of the bore 49 are enclosed by plugs 51 and 52, respectively.

As the principal component of the servo-motor valve assembly 48, a reciprocable cylindrical plug valve 53 is concentrically bearinged in the bore 49 by a bushing 54 located adjacent to but spaced from that end of the bore 49 adjacent to the closure plug 51. The end of the valve plug 53 opposite the closure plug 51 is formed with a lateral flange 54 serving as a limit flange engageable with the adjacent end of the bearing bushing 54 serving as a stop to limit movement of the valve plug to what may be termed its extreme forward position wherein the forward tip of the valve plug is in spaced relation to the closure plug 51, the space at and about the forward tip comprising a pressure chamber. Means are provided for normally biasing the valve member 53 to its forward limit, in the present instance comprising a helical compression spring 57 bearing against the valve flange 55 at one end and against the closure plug 52 at the other end. A rearward reciprocal limit for the valve member 53 is defined by a stop pin 58 which may conveniently be formed as a coaxial extension of the plug member 52 extending coaxially through the spring 57 and having the tip thereof in predetermined spaced relation to the base of the valve member within a counterbore 59.

The construction and arrangement of the servo-valve assembly 48 is such that a bleed-off passage is normally open from the pressure pockets 34 by way of the groove 41 through the valve assembly to the low pressure side of the pump. This is the condition of the unit shown in Figures 3, 5, 6, 7 and 9. To this end, a duct 60 leads from the bleed-off groove 41 through the boss 50 and communicates with a branch duct 61 which registers with a port 62 through the bushing 54. The bleed-off passage is continued through the valve member 53 by way of an annular groove 63 in the periphery thereof communicating with a series of longitudinally extending free passage apertures 64 opening into the counterbore 59 and thereby communicating with the relatively substantial chamber behind the valve member 53 and within the valve bore 49 and intervening between the valve member and the closure plug 52. From adjacent to the rear end of this bleed-off chamber leads a duct 65 passing through the boss 50 and communicating with a channel groove 67 in the opposing face of the intermediate port plate 13 and leading from the inlet port 30. Thus, at the start of operation of the pump one of the pressure chambers in each of the pressure pockets 34, namely, the pressure chambers to which the pressure ducts 39 lead from the high pressure port 31, are bled off to the low pressure side of the pump, and irrespective of where the modulator ring 25 may have come to rest at the cessation of previous operation of the pump, the modulator ring will promptly assume the position of maximum pumping displacement eccentricity as the pump builds up pressure and the pressure fluid metered through the metering ducts 40 exerts fluid pressure in the remaining pressure chambers in the pressure pockets 34, the latter pressure chambers being blocked against frictional bleed-off at this time.

By having the biasing spring 57 appropriately conditioned to exert a force, in the fully extended position of the valve member 53, just short of the mean pressure for which the pump is intended to be rated, while yet exposing the forward end of the valve member to the dynamic pressure fluid at the high pressure side of the pump, the pump will attain to the mean pressure at its output or pressure side before any change in displacement can occur. Direct communication between the pressure chamber at the head of the valve member 53 and the high pressure side of the pump is attained by way of a duct 68 leading from the high pressure port 31 through the port plate 13 to the boss 50 where it communicates with a branch duct 69 leading therefrom through the plate 13 and the boss 50 to the pressure chamber at the head of the valve member 53. Thus, when the pressure at the high pressure side of the pump attains to the mean pressure for which the pump is rated, such pressure will be directly reflected on the head of the valve member 53 and exert force in opposition to the spring 57. By having the spring 57 in its maximum extended condition exert a force slightly less than the mean pressure desired at the discharge side of the pump, there will, of course, be a certain amount of movement of the valve member 53 in opposition to the spring as a result of the mean desired pressure to which the head of the pump is exposed. The amount of valve movement thus permitted is just enough to shift the head portion of the valve member 53 into blocking relation to the bleed-off port 62. Thereupon, compression of the spring 57 loads the same sufficiently to cause it to exert a force which is equal to the mean pressure developed in the pressure fluid by the pump and the valve will at the mean pressure of the fluid remain in the balanced condition blocking the bleed-off port 62. Hence, the high pressure fluid metered through the high pressure ducts 39 will become effective in the pressure chambers in the pressure pockets 34 on the opposite side from the chambers fed by the pressure ducts 40 and the pressure conditions within the pockets 34 will remain balanced and the modulator 25 will be held against any appreciable movement, quietly and free from hunting.

When the fluid pressure increases beyond the mean rated pressure, the increased pressure is exerted against the head of the valve member 53 and the valve member 53 moves against the spring 57 further to compress the latter, until the bleed-off groove 63 in the valve member registers with a bleed-off port 70 which leads through the bushing 54 to a branch duct 71 in the boss 50 communicating with a bleed-off duct 72 leading from the bleed-off groove 43. This places the chambers in the pressure pockets 34 that are fed by the metering ducts 40 under bleed-off or suction communication with the low pressure side of the pump and promptly results in turning of the modulator ring 25 to decreased displacement eccentricity relative to the rotor 15. This cuts down the volume of fluid displaced by the pump and accordingly reduces the output pressure to the desired mean pressure and the valve member 53 slides back to blocking relation to the bleed-off port 70. By having the bleed-off ports 62 and 72 spaced axially of the valve member 53 a distance slightly greater than the diameter of the bleed-off groove 63 in the valve member minor fluctuations are accommodated without disturbing the pump displacement while major fluctuations will result in bleed-off unbalance of the appropriate pressure chambers in the pressure pockets 34 to effect rotary displacement adjustment of the modulator ring 25.

When the valve member 53 is subjected to pressure so far in excess of the mean pressure that the bleed-off groove 63 is placed in full registration with the bleed-off port 70, the stop pin 58 is engaged by the base of the valve member and this assures movement of the modulator ring 25 to its minimum displacement position so as to cut down the pressure quickly to the mean output pressure.

In order to assure that even under relatively high pressure the stationary divider blades or vanes 35 will maintain proper fluid sealing relation at their inner edges against the base walls of the pressure pockets 34 on the modulator ring 25, means are preferably provided for directing high pressure fluid behind the vanes within the slots 37. To this end, respective pressure ducts 73 preferably lead from the high pressure outlet port 31 in the port plate 13 to branch ducts 74 opening into the limited spaces or chambers behind the vanes 35 and in which the vane biasing springs 38 are located. This assures that the divider blades or vanes 35 will at all times during operation of the pump be positively urged radially inwardly into effective sealing relation against the modulator ring 25 within the respective pressure pockets 34.

A sliding fluid tight relation between the ends of the several impeller vanes 22, the rotor 15 and the modulator ring 25 and the divider vanes or blades 35, and the face plate 11 and the port plate 13 is afforded by accurate machining of the parts so that there is a minimum of pressure leakage between the working parts. However, any leakage that may occur is not objectionable since the pump comprises a closed system.

In the servo-control system for the pump as described up to this point and schematized in Figure 9, control is attained only by selective bleed-off to the low pressure side of the pump.

However, a more positive and more quickly responsive control is accomplished by combination of high and low pressure selection as schematically shown in Figure 10. Modification for this purpose requires but few and simple changes. Accordingly, all that need be done is to change the servo-control system to provide a slightly modified servo-valve assembly 48' including a slidable plug valve 53' having a port 75 through the head end thereof communicating with an annular distributor groove 77 in the periphery of the valve member and which in the forward limit position of the valve member 53' is arranged to register with the port 70 leading by way of the passage 71, 72 to the groove 43 or its equivalent providing a passage to or from the pressure chambers within the pressure pockets 34 fed by the high pressure metering ducts 40. Hence, during the initial phases of operation of the motor, pressure fluid is delivered to the pressure pockets 34 not only by the metering ducts 40 but also by way of the passage 43. As the pump pressure increases and attains to the rated mean output pressure, the valve member 53 is moved by the pump pressure similarly as the valve member 53 previously described to block the port 70 and the port 62 to maintain the control system in balance until the mean output pressure of the pump deviates materially and thus requires readjustment in displacement.

Should the pump pressure increase materially, the valve member 53' is shifted until the high pressure groove 77 thereof registers with the port 62 whereby the pressure chambers in the pockets 34 fed by the metering ducts 39 are quickly supplied with high pressure fluid to build up pressure therein and cause the modulator ring 25 to shift rotatably toward decreased pump displacement. At the same time bleed-off relief of the remaining pressure chambers in the pressure pockets 34 is attained by registration of the bleed-off groove 63 with a branch duct 78 leading from the duct 71 forming part of the passage 43. Thus, there is attained simultaneous high and low pressure responsiveness in the servo-control system as required to maintain the preferred mean output pressure for the pump.

It will, of course, be understood that various details of construction may be varied through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

We claim as our invention:

1. A constant pressure variable displacement pump including a casing, a vane type rotor, a rotary modulator member cooperating with the rotor to provide a variable displacement pump chamber eccentric to the axis of rotation of the modulator member, a casing providing bearing surfaces for and rotatably supporting said modulator member in face-to-face relation, means on said modulator member and said casing at the interfaces thereof providing opposed cooperatively related pairs of pressure surfaces facing in the respective opposite directions of rotary movement of the modulator member, one surface of each pair of surfaces being on the modulator member and the other of each pair of surfaces being on the casing and the pairs of surfaces being separable upon rotation of the modulator member and means for selectively subjecting certain of the surfaces to dynamic fluid pressure of the rotor while effecting communication with the

low pressure side of the pump for the remaining surfaces in order to adjust the rotary position of the member and thereby vary the displacement of the pump chamber relative to the rotor.

2. In combination in a constant pressure variable displacement pump, a casing, a reciprocable vane type rotary impeller, a rotary modulator block rotatable between predetermined limits in said casing and defining a pump chamber eccentric to the axis of rotation of the modulator member and disposed about said impeller affording displacement area for the impeller by eccentric relation of the chamber to the axis of the impeller, the modulator having a recess in its periphery providing opposing pressure surfaces facing in the direction of rotation of the modulator and means projecting from said casing into said recess to provide pressure surfaces opposing the pressure surfaces in said recess means for normally continuously subjecting said surfaces of said modulator to the high pressure side of the pump for normally maintaining the modulator member in dynamic balance, and means automatically responsive to dynamic pressure variations in the pump for unbalancing the pressure between certain of the opposing surfaces for adjusting the modulator member rotatably as required to vary the displacement of the pump and maintain a substantially mean pump pressure.

3. In a constant pressure variable displacement pump assembly, a casing, a rotary modulator slidably bearing within said casing and having a circular pump chamber therein eccentric to the axis of rotation of the modulator, said casing and said modulator having means at the interfaces thereof providing opposing separable pressure-responsive surfaces respectively facing in the opposite directions of rotation of the modulator a reciprocable vane rotary impeller rotatable on a fixed axis in said casing eccentric to the axis of the pump chamber and with the vanes in fluid impelling cooperation with the pump chamber wall, said modulator being rotatable for varying the relative eccentricity of said pump chamber and impeller and thus the pump displacement, and passageway means maintaining dynamic pressure fluid communication from the high pressure side of the pump chamber to said pressure responsive surfaces to effect a substantially pressure balanced relation against displacement of the modulator.

4. In a constant pressure variable displacement pump assembly, a casing, a rotary modulator slidably bearing within said casing and having a circular pump chamber therein eccentric to the axis of rotation of the modulator, said casing and said modulator having means at the interfaces thereof providing opposing separable pressure-responsive surfaces respectively facing in the opposite directions of rotation of the modulator a reciprocable vane rotary impeller rotatable on a fixed axis in said casing eccentric to the axis of the pump chamber and with the vanes in fluid impelling cooperation with the pump chamber wall, said modulator being rotatable for varying the relative eccentricity of said pump chamber and impeller and thus the pump displacement, passageway means maintaining dynamic pressure fluid communication from the high pressure side of the pump chamber to said pressure responsive surfaces to effect a substantially pressure balanced relation against displacement of the modulator, and means for selectively opening communication between said surfaces and the low pressure side of the pump for effecting dynamic unbalance and rotation of the modulator for varying displacement relation of the pump chamber relative to the impeller.

5. In a constant pressure variable displacement pump assembly, a casing, a rotary modulator within said casing and having a circular pump chamber therein eccentric to the axis of rotation of the modulator, a reciprocable vane rotary impeller rotatable on a fixed axis in said casing eccentric to the axis of the pump chamber and with the vanes in fluid impelling cooperation with the pump chamber wall, said modulator being rotatable for varying the relative eccentricity of said pump chamber and impeller and thus the pump displacement, separate pressure responsive surfaces on said modulator facing in respectively opposite directions of rotation of the modulator and opposing respectively oppositely facing fixed surfaces on the casing, passageway means maintaining dynamic pressure fluid communication from the high pressure side of the pump chamber to said pressure responsive surfaces to effect a substantially pressure balanced relation against displacement of the modulator, and means for selectively opening communication between the opposing surfaces of the modulator and fixed surfaces on the casing and the low pressure side of the pump for effecting dynamic unbalance and rotation of the modulator for varying displacement relation of the pump chamber relative to the impeller, said last mentioned means including a valve member automatically responsive to variations in pressure at the high pressure side of the pump.

6. In combination in a constant pressure variable displacement rotary pump, a reciprocable vane rotary impeller, a rotary ring modulator having a circular pump chamber therein disposed eccentrically to the axis of rotation of the modulator and cooperating eccentrically with the rotor, the modulator ring being oscillatable for varying the eccentricity of the pump chamber relative to the rotor for varying pump displacement, a casing bearingly enclosing the modulator and rotor, the casing and modulator ring having means at their interfaces providing pressure-responsive opposing surfaces directed respectively in the directions of rotation of the modulator and defining therebetween pressure chamber areas subject to dynamic fluid pressure from the pump for controlling the oscillation position of the modulator, and a system of fluid passageways and servomotor means in said casing affording controlled communication between the pump chamber and said areas for automatically adjusting the modulator to vary the pump displacement and maintain a substantially constant pressure at the output side of the pump.

7. In combination in a pump structure of the character described, a reciprocable vane rotary impeller, a rotary modulator ring having therein a chamber disposed eccentric to the axis of rotation of the modulator ring and within which the impeller is operable, a slidable bearing for the modulator ring, a pressure pocket in the surface of the modulator ring exteriorly of said pump chamber, a vane projecting from the bearing into said pocket, and means for subjecting said pressure pocket and vane to the effects of pressure fluid for rotatably shifting the modulator ring to vary the pump chamber displacement relative to the rotor.

8. In combination in a constant pressure variable displacement pump of the character described, a reciprocable vane rotary impeller, a

modulator ring having an eccentric pump chamber therein within which the impeller is operable, the periphery of the modulator ring being disposed eccentrically relative to the pump chamber, said periphery having a pressure pocket therein affording opposite pressure surfaces, an encircling guide surface about the periphery of the modulator ring, said encircling surface having a divider vane extending therefrom into said pressure pocket to divide the pressure pocket into a pair of pressure chambers, means affording an inlet port and an outlet port for said pump chamber, metering ducts leading from said outlet port to the respective pressure chambers in said pocket, and means for selectively communicating said pressure chambers with the inlet port.

9. In combination in a constant pressure variable displacement pump of the character described, a reciprocable vane rotary impeller, a modulator ring having an eccentric pump chamber therein within which the impeller is operable, the periphery of the modulator ring being disposed eccentrically relative to the pump chamber, said periphery having a pressure pocket therein affording opposite pressure surfaces, an encircling guide surface about the periphery of the modulator ring, said encircling surface having a divider vane extending therefrom into said pressure pocket to divide the pressure pocket into a pair of pressure chambers, means affording an inlet port and an outlet port for said pump chamber, metering ducts leading from said outlet port to the respective pressure chambers in said pocket, and means for selectively communicating said pressure chambers with the inlet port, said last mentioned means being constructed and arranged also to effect communication between the high pressure side of the pump chamber selectively with said pressure chambers supplemental to the metering ducts.

10. In combination in a pump of the character described, a rotary impeller, a rotary modulator having therein a variable displacement pump chamber for the impeller eccentric to the axis of rotation of the modulator, means for guiding the modulator ring rotatably, said modulator ring having a pressure pocket therein, said guiding means having a divider vane extending adjustably into said pocket, means for effecting communication between the pump chamber and the respective chambers into which said pocket is divided by said vane, and means for subjecting the back of the vane to high pressure from said pump chamber to drive the vane into fluid sealing bearing relation within said pocket.

11. In combination in a pump assembly of the character described, a rotary modulator ring, means for rotatably guiding the modulator ring, said modulator ring having a pressure pocket in the periphery thereof, said guide means having a vane extending into said pressure pocket and dividing the latter into a plurality of pressure chambers, and means behind said vane for positively urging the same into the pressure pocket.

12. In combination in a self-controlled constant pressure variable displacement pump, means defining a housing, said housing having circular bearing means therein, a circular modulator ring rotatably supported by said bearing means, said modulator ring having therein a pump chamber with its axis eccentrically related to the axis of rotation of the modulator ring, a pump rotor mounted with respect to said housing with its axis eccentric to the axis of said pump chamber and having variable displacement means operative about the periphery of the rotor against the wall defining the perimeter of said pump chamber, said housing providing inlet and outlet passages communicating with respectively low pressure and high pressure sides of the pump chamber so that in the rotation of the rotor hydraulic fluid is drawn into the pump chamber through the inlet passage and driven from the outlet passage, means at the outer periphery of the modulator ring comprising opposed substantially spaced surfaces rigid with the modulator ring and angular to the modulator ring perimeter and means in fixed relation to said bearing means and affording oppositely directed surfaces also angularly related to the perimeter of the modulator ring and disposed in direct opposition respectively to said oppositely facing surfaces rigid with the modulator ring, whereby to define respective pressure chambers between the cooperative opposing surfaces, a system of fluid passageways connecting said high pressure passage with said pressure chambers, means for relieving said pressure chambers of pressure, and means operative responsive to internal pressure conditions in said pump chamber for automatically controlling flow through said passageways and said pressure relieving means, whereby to adjust the rotary position of the modulator ring in accordance with internal pressure conditions in the pump chamber.

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