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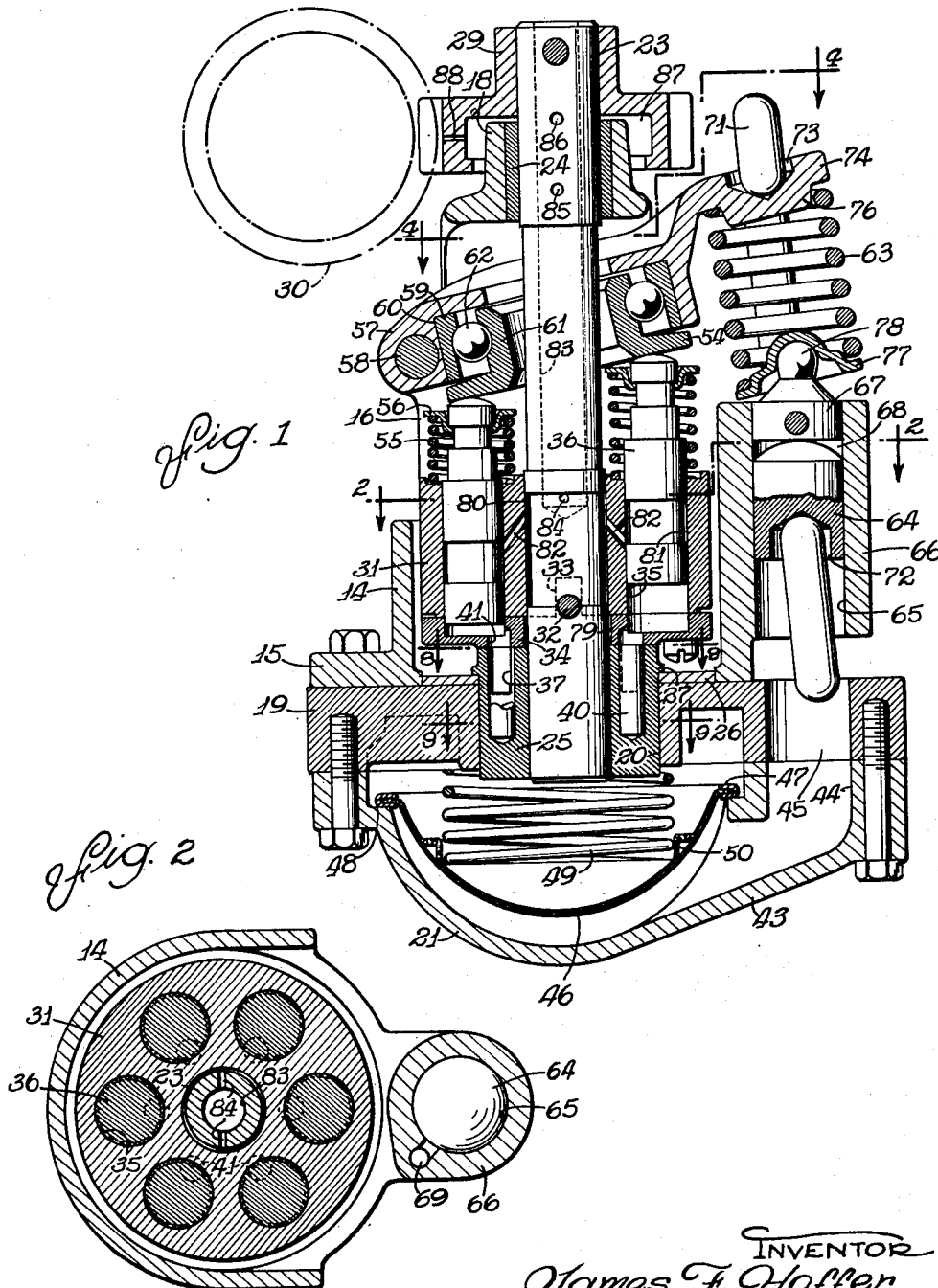
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Filed May 3, 1937

4 Sheets-Sheet 1



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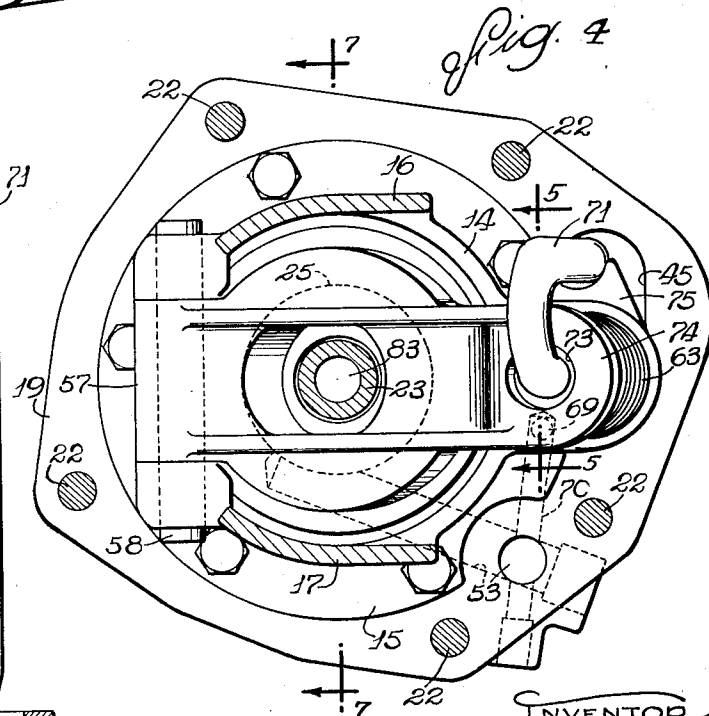
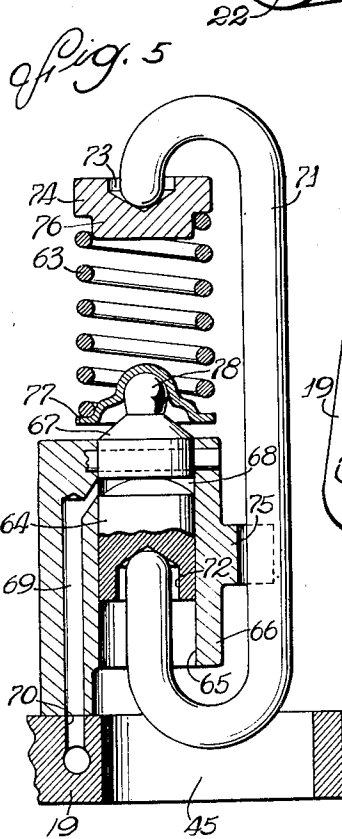
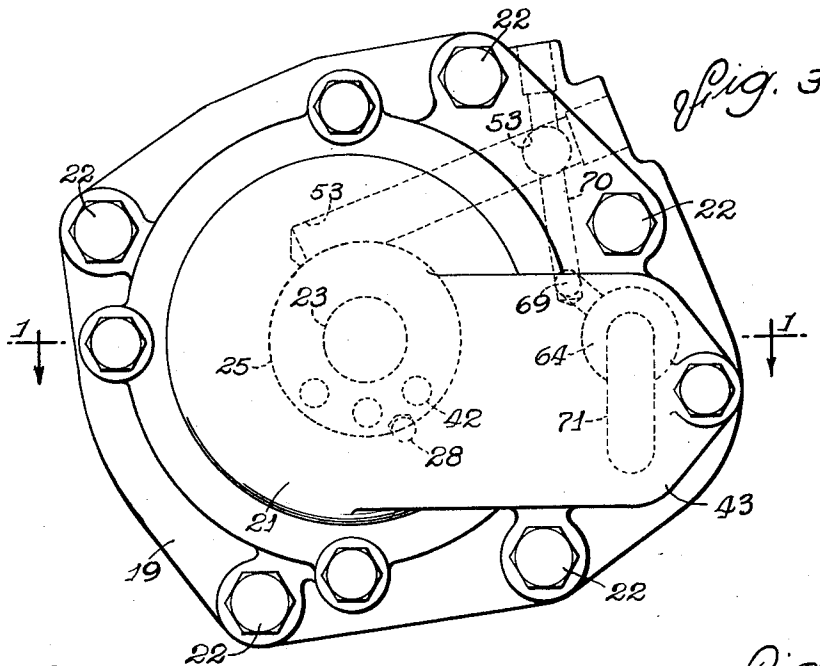
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4 Sheets-Sheet 2




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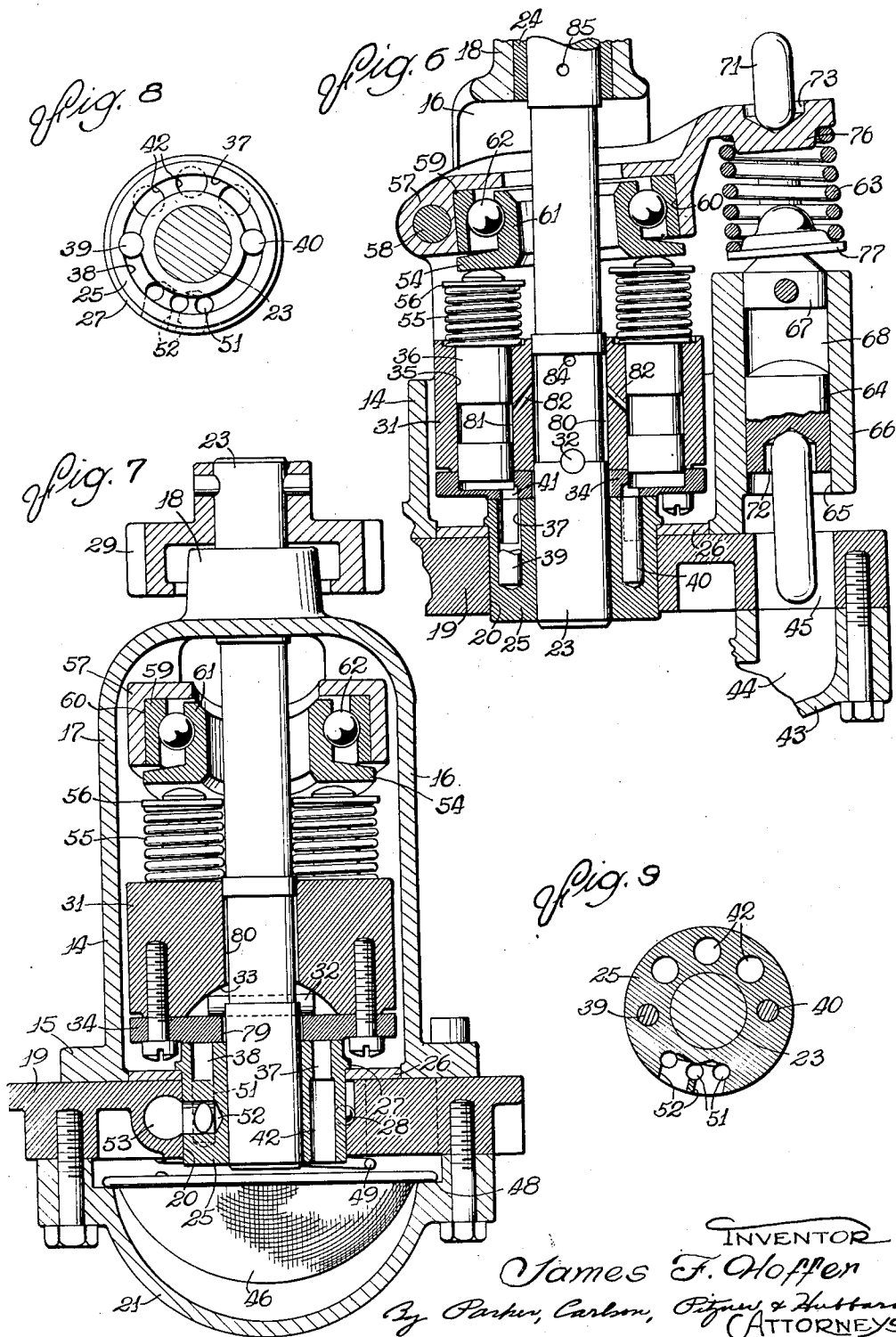
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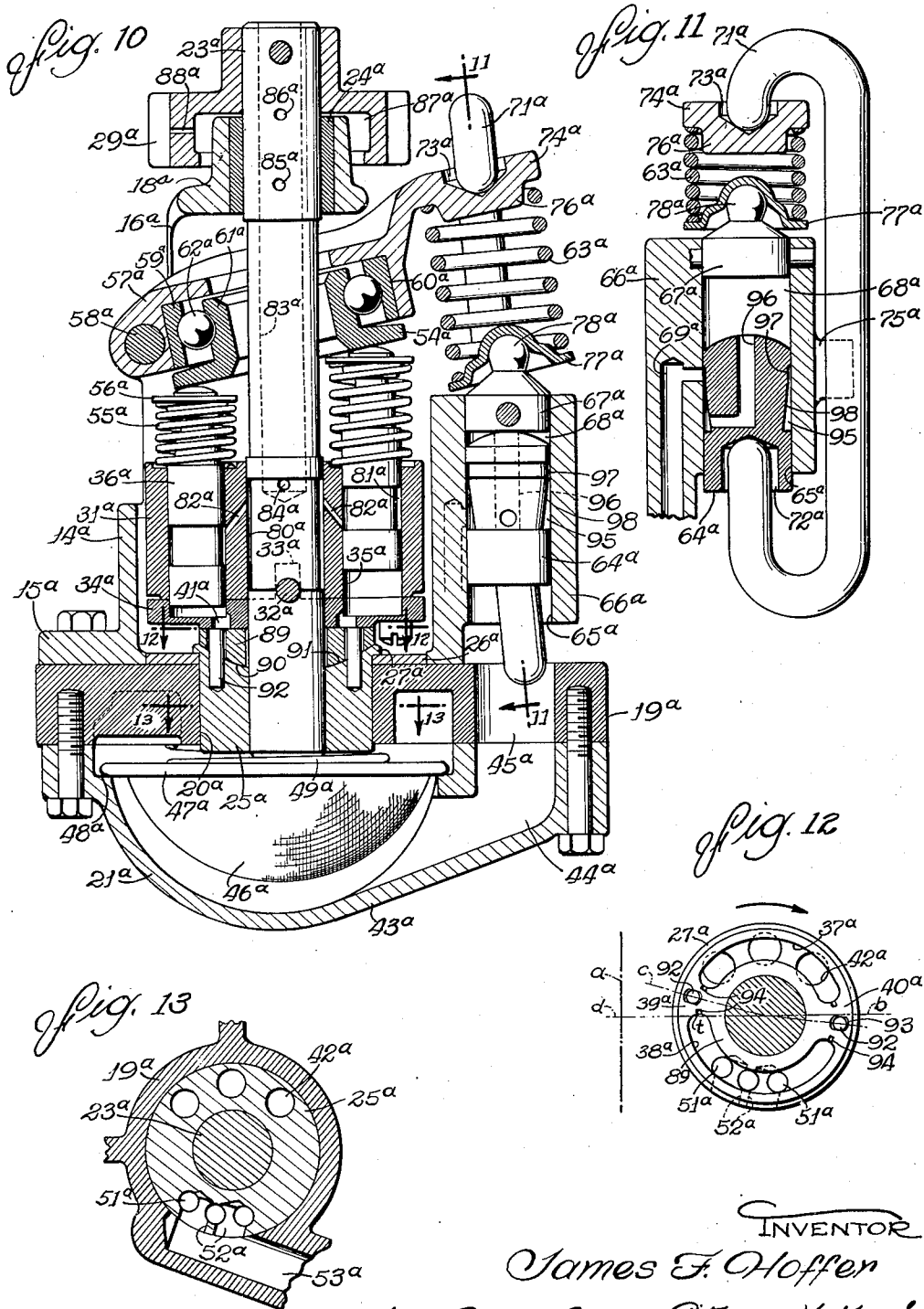
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,299,233

PUMP

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Application May 3, 1937, Serial No. 140,305

16 Claims. (Cl. 103—162)

The present invention relates generally to improvements in fluid handling pumps, and has particular reference to a variable delivery pump having a plurality of annularly arranged cylinder and piston units operable in uniformly timed sequence by an angularly adjustable cam or swash plate.

One of the objects of the present invention is to provide a novel pump of the foregoing character in which the swash plate is automatically adjustable in response to variations in the delivery pressure so as to decrease the volume of delivery as the delivery pressure rises, whereby the power required is reduced to a minimum and at maximum pressure and zero delivery need only be sufficient to drive the parts without doing any work, and whereby unnecessary wear on the moving parts is avoided.

Another object is to provide a novel swash plate pivoted for angular adjustment eccentrically of the pump shaft and operatively connected at the free end to a control means responsive to the delivery pressure of the pump so as to substantially eliminate fluttering of the swash plate and pulsations in the fluid delivery.

Still another object resides in the provision of a novel control valve having relatively small contacting faces to reduce friction and the possibility of inaccuracy in manufacture, and located closely to the pump shaft so as to facilitate the removal of air from the pump cylinders.

A further object is to provide a new and improved pump automatically adjustable to vary the fluid delivery and operable upon a sudden drop in the delivery pressure to make available immediately a relatively large volume of fluid under pressure.

Further objects and advantages will become apparent as the description proceeds.

In the accompanying drawings,

Figure 1 is a longitudinal sectional view substantially along line 1—1 of Fig. 3 of a pump embodying the features of my invention and adjusted for maximum delivery.

Fig. 2 is a transverse sectional view taken substantially along line 2—2 of Fig. 1.

Fig. 3 is a bottom end view of the pump.

Fig. 4 is a transverse sectional view taken substantially along line 4—4 of Fig. 1.

Fig. 5 is a fragmentary detail sectional view taken substantially along line 5—5 of Fig. 4.

Fig. 6 is a fragmentary view similar to Fig. 1, but illustrating the pump adjusted for low delivery.

Fig. 7 is a longitudinal sectional view taken substantially along line 7—7 of Fig. 4.

Fig. 8 is a plan view of the stationary member of the pump valve taken substantially along line 8—8 of Fig. 1.

Fig. 9 is a transverse sectional view taken substantially along line 9—9 of Fig. 1.

Fig. 10 is a view similar to Fig. 1, but of a modified form of the pump.

Fig. 11 is a fragmentary sectional view taken substantially along line 11—11 of Fig. 10.

Fig. 12 is a plan view of the non-rotatable member of the pump valve taken substantially along line 12—12 of Fig. 10.

Fig. 13 is a fragmentary transverse sectional view taken substantially along line 13—13 of Fig. 10.

Referring more particularly to the drawings, the pump, constituting the exemplary embodiment of the invention, comprises a main body casing or housing 14 which is generally cylindrical in form and provided at one end with a peripheral flange 15, and which is formed at the other end with longitudinally extending diametrically opposed arms 16 and 17 integral with an axially disposed bearing sleeve 18. A base plate 19 is removably bolted to the flange 15 and is formed with a central bore 20 in axial alignment with the bearing sleeve 18. Bolted to the bottom of the plate 19 is a dome-shaped or hollow semi-spherical cover 21.

The assembled pump body may be mounted on any suitable support depending on the purpose and location of the pump. Although not limited thereto, the pump is especially suited for use in the oil system of an automotive vehicle engine, and when so used is adapted to be mounted in an upright portion with the base plate 19 secured by means of bolts 22 to a wall of the transmission case (not shown). The lower end of the pump, including the base plate 19, is immersed in the oil in the transmission case which constitutes a source of oil supply.

The pump is adapted to be driven by a shaft 23 extending longitudinally through the casing 14 and journaled at opposite ends respectively in a bushing 24 in the bearing sleeve 18 and a combination bushing and valve stator 25 fixed in the bore 20. A flat annular ring 26 is positioned against the inner face of the base plate 19 between the flange 15 and the valve stator 25, and serves as a spacer to effect proper bearing alignment. The valve stator 25 has a peripheral rib 27 engaging over the inner edge of the spacer ring 26 to resist outward axial thrust, and is held

in a fixed angular position by a ball key spline 28. It will be understood that the shaft 23 may be driven by any suitable means. In the present instance, a spiral gear 29 is fixed on the outer end of the shaft 23, and meshes with a spiral gear 30 adapted to be connected to the source of power, such for example as the crank shaft of an engine.

The pump comprises a rotatable cylinder body 31 secured to the shaft 23 within the casing 14. In the present instance, the connection is effected by means of a transverse pin 32 extending snugly through the shaft 23, and at opposite ends into a diametrical slot 33 in the lower or outer end of the body 31. A valve plate 34 is bolted to one end of the body 31, and serves to confine the pin 32 within the slot 33. A plurality of parallel bores 35 open through the body 31 to the valve plate 34, and define pump cylinders annularly arranged in uniformly spaced relation about the shaft 23. In the present instance, six cylinders 35 are provided. A plurality of pump plungers or pistons 36 are reciprocally disposed respectively in the open ends of the cylinders 35, and are operable in uniformly timed sequence with a variable stroke as hereinafter described.

The valve stator 25 and plate 34 are in face bearing engagement, and constitute a rotary end face valve for controlling the admission and discharge of fluid respectively to and from the pump units. The valve stator 25 (see Fig. 8) is provided with two arcuate suction and delivery ports 37 and 38 separated by diametrically spaced land areas 39 and 40 and arranged in concentric relation to the shaft 23. To produce the ports 37 and 38, a continuous circular groove may be formed in the valve face of the stator 25. Then, two pins, the ends of which define the land areas 39 and 40, may be pressed into suitably located holes drilled into the groove to separate the latter into equal arcuate segments defining the ports 37 and 38. Formed in the valve face of the plate 34 are a plurality of ports 41 which open respectively to the closed ends of the pump cylinders 35, and which are annularly arranged in a circle of the same curvature as the ports 37 and 38 for movement successively across the latter upon rotation of the cylinder body 31. The contacting annular valve faces of the stator 25 and plate 34 are made small in relation to the cylinder body 31 and are located closely to the axis of rotation, thereby reducing the valve friction area and lessening the likelihood of manufacturing errors or irregularities and consequently the chance of valve leakage. To facilitate the removal of air, the ports 41 are located between the axes of the cylinders 35 and the axis of the shaft 23, and preferably at the innermost side areas of the cylinders. This is made possible by the reduced size of the contacting valve faces. Since the liquid being pumped will be thrown radially outwardly by centrifugal force, any air in the cylinders 35 will collect in the region of the ports 41, and will pass readily there-through with the pump discharge, so that the cylinders will be automatically scavenged of air.

The suction port 37 is adapted to receive fluid from the interior of the cover 21 through a plurality of longitudinal bores or passages 42 in the valve stator 25. A duct or enlargement 43 integral with the bottom of the cover 21 defines an inlet passage 44 which registers with a slot or opening 45 in the base plate 19. The opening may be connected to any suitable source of liquid

supply, and in the present instance is adapted for direct communication with the engine transmission case (not shown).

A filter 46 is interposed in the path of the incoming fluid within the cover 21. In the present instance, the filter 46 consists of a cup-shaped or hollow semi-spherical multi-ply screen having a peripheral clip 47 resting on an upwardly facing annular seat 48 formed in the top portion of the cover 21. The filter 46 is concave upwardly, and projects downwardly through the seat 48 into the lower portion of the cover 21. A coiled compression spring 49 engages the underside of the base plate 19, and acts to hold the filter 46 yieldably against the seat 48. Preferably, the upper screen ply is buckled to provide an annular centering rib or projection 50 for the engaging end of the spring 49. It will be evident that if the filter 46 should become clogged, it will be lifted from the seat 48 by the suction of the pump to permit the passage of fluid.

The discharge port 38 is in communication, through a plurality of closely spaced vertical bores 51 and intersecting cross bores 52 in the valve stator 25, with an outlet passage 53 formed in and opening to the top of the base plate 19 for connection to a suitable discharge line (not shown) leading to the point of use of the pressure fluid.

The means for actuating the pistons 36 comprises a cam or swash plate 54 which is angularly adjustable relatively to the plane of rotation of the cylinder body 31 to vary the piston stroke from zero to maximum. The swash plate 54 freely encircles the shaft 23, and is engaged by the outer end of the pistons 36 which are urged upwardly by individual compression springs 55. In the present form, each spring 55 seats at one end against the cylinder body 31 and at the other end against a key washer 56 on the outer end of the associated piston 36.

The swash plate 54 is rotatably supported in a swivel plate 57 mounted at one end on a pivot pin 58 for angular or swinging adjustment about an axis perpendicular to and spaced laterally from the axis of the shaft 23. The swivel axis is also substantially perpendicular to the axial plane of the land areas 39 and 40. To provide an anti-friction mounting for the plate 54, a bearing sleeve 59 is fitted tightly in a circular recess 60 in the lower face of the swivel plate 57, and defines an outer raceway. An annular flange or sleeve 61 on the plate 54 extends concentrically into the sleeve 59 and defines an inner raceway. Suitable roller elements 62 are interposed between the sleeves 59 and 61 to complete the bearing relationship.

It will be evident that when the swash plate 54 is angularly disposed, rotation of the cylinder body 31 will cause the pistons 36 to be reciprocated in timed sequence and with a simple harmonic motion, and that each piston will be moving through its suction and pressure strokes while the associated cylinder 35 is in communication respectively with the inlet and discharge ports 37 and 38. As the pistons 36 of each set of diametrically opposed pistons reach top and bottom dead centers respectively, the associated cylinders 35 will be closed momentarily by the land areas 39 and 40, and at these times only two cylinders will be open to either of the valve ports 37 and 38. At all other times, three cylinders 35 will be open to each of the valve ports 37 and 38. Consequently, the pump will discharge continuously, and the rate of discharge will be sub-

stantially constant for any given setting of the swash plate 54. If the angular position of the swash plate 54 is changed, the length of the piston stroke will be adjusted to adjust the rate and volume of pump delivery. When the plate 54 is adjusted into a plane perpendicular to the shaft 23, no reciprocation will be imparted to the pistons 36.

Provision is made for automatically controlling the angular position of the swivel plate 57 to vary the pump delivery in accordance with the load requirements. Thus, the plate 57 is automatically adjusted to reduce the pump delivery upon an increase in delivery pressure, and to increase the delivery upon a decrease in pressure. The means for this purpose comprises generally a coiled compression spring 63 acting against the swivel plate 57 in one direction to increase fluid delivery, and a control plunger 64 movable in response to the pump delivery pressure and operatively connected to act against the plate in the opposite direction to decrease fluid delivery.

The control plunger 64 is slidably mounted in a vertical bore 65 opening through a tubular enlargement 66 on one side of the casing 14 directly over and spaced from the opening 45 in the base plate 19. The bore 65 is open at the lower end to atmospheric pressure, and is closed at the upper end by a plug 67 to define a pressure chamber 68 communicating with the pump discharge passage 53 through connected bores or passages 69 and 70. An open link 71 engages at opposite ends in a socket 72 in the lower end of the plunger 64, and a socket 73 in the top of an arm 74 on the swivel plate 57, and is loosely guided for generally vertical movement in a notched lug 75 on the side of the enlargement 66. The link 71 serves to connect the plunger 64 and the arm 74 for joint movement, and hence to move the latter in a direction to decrease pump delivery in response to a pressure increase in the chamber 68. The compression spring 63 is seated at one end against the lower side of the arm 74 about a centering projection 76, and at the other end against a retainer 77 in universal bearing engagement with a ball-ended projection 78 on the plug 67.

Prior pumps of the present type are subject to delivery pressure pulsations at certain critical points when operating under varying conditions of delivery pressure, speed, and volume of delivery. These pulsations when present are caused by fluttering of the cam or swash plate due to shifting of the hydraulic forces reacting through the pistons 36 as the cylinder ports 41 move successively along the pressure valve port 38. One of the important features of the present invention resides in the elimination of these pulsations so as to obtain a substantially constant delivery pressure for any given volume of delivery. This is accomplished by minimizing the variations in the reaction forces relative to the control forces acting on the swash plate 54. More particularly, the swivel plate 57 is pivoted at one side of the shaft 23, and is elongated, by the provision of the arm 74, to extend substantially beyond the other side of the shaft for operative association with the spring 63 and the plunger 64 setting up the opposing control forces. Since the pistons 36 are located much closer to the pin 58 than the spring 63, the reaction forces set up by the pistons under pressure have a small moment arm compared to that of the control forces. Consequently, the effect of the variation in the location of the pistons in entering, crossing, and

leaving the pressure zone defined by the port 38 is negligible.

The construction, although not sacrificing compactness, places no mechanical limitations on the size or strength of the spring 63 or the control plunger 64. The pressure of the spring 63 can be materially increased without interference with the proper design and proportions of the pump, and this increased spring pressure in itself, apart from its relatively increased moment arm, tends to reduce fluttering of the swash plate 54. The pressure area of the plunger 64 can be correspondingly increased. The pump therefore has no critical period during which pressure pulsations are likely to occur.

The control means, being readily accessible and not subject to close structural limitations, also permits ready and convenient selective alterations in the operating characteristics of the pump, as for example, by the substitution of springs 63 of different pressures, and in some instances originally by varying the pressure area of the plunger 64. It is possible therefore to provide a pump that will deliver fluid at different predetermined minimum and maximum pressures.

Fluid under pressure in the pump is utilized for lubricating the bearings for the shaft 23 and the gearing 29, 30. To this end, the valve plate 34 loosely encircles the shaft 23 to provide an annular space 79 adapted to receive any fluid seeping or leaking inwardly past the valve faces. This fluid is under pressure, and penetrates downwardly into the lower bearing 25 for the shaft 23. The fluid is also forced upwardly through the notch 33 into an annular space 80 defined by an undercut section of the shaft 23. The supply of lubricating fluid under pressure may be supplemented by that permitted to seep or leak upwardly along one or more of the pistons 36. Each of these pistons 36 is formed intermediate its ends with an undercut portion defining an annular space 81 opening in all positions of reciprocation through an upwardly inclined port 82 to the space 80. The amount of fluid supplied from each of the spaces 81 will depend on the size of the sliding clearance between the piston 36 and the cylinder 35. The shaft 23 is formed with an axial bore 83 which opens at its lower end through a port 84 to the space 80, and at its upper end through a port 85 to the interior of the bushing 24 and through a port 86 to a central chamber 87 in the gear 29. Fluid collecting inside the gear 29 is delivered by centrifugal force through a port 88 to the gear tooth zone.

A modified form of pump is illustrated in Figs. 10 to 14, and the parts thereof corresponding to similar parts of the first form are identified by the same reference characters plus the letter *a*. The two forms are closely alike, and hence only the differences will be described.

In the modified form, a valve stator 89 is provided separate of the bushing 25^a, and has a universal or floating mounting so that it will adjust itself with respect to the rotating valve member 34^a, and hence compensate for machining irregularities or run-out of the valve faces. The swivel stator is of particular advantage when the pump drive shaft is mounted in anti-friction or ball bearings which are subject to shaft run-out or eccentricity. More particularly, the valve stator 89 has a spherical base surface 90 seated in a complementary recess 91 in the top of the bushing 25^a. Two diametrically opposite pins 92 fixed in the bushing 25^a project upwardly through radial slots 93 in the valve stator 89

to locate the latter in the proper angular position about the shaft 23^a. The stator 89 is formed with two arcuate valve ports 37^a and 38^a which are separated by land areas 39^a and 40^a, and which open to the suction and outlet passages 42^a and 51^a in the bushings 25^a. It will be understood that the slots 93 are located in the land areas 39^a and 40^a.

An important feature resides in advancing the location of the ports 37^a and 38^a relative to the top and bottom dead center positions *t* and *b* of the pistons 36^a so as to effect a pressure equalization in each cylinder 35 just before the start of both the pressure and suction strokes. Referring to Fig. 12, *a* represents the axis of the pivot pin 58^a and *d* represents the perpendicular dividing plane between the suction and pressure phases of the piston movements. The center line *c* of the land areas 39^a and 40^a is inclined to the line *d*. Assuming that the pump shaft 23^a is rotating in the direction of the arrow, each cylinder 35^a will receive fluid from the port 37^a during the suction stroke. The piston 36^a will start on the pressure stroke at the point *b*, but the cylinder 35 will not open to the port 38^a until a short time later. Hence, the pressure in the cylinder 35^a will build up approximately to the pump discharge pressure before the cylinder is connected to the port 38^a. Similarly, the cylinder 35^a will be closed by the land area 39^a during the initial part of the suction stroke so that the pressure will be expanded approximately to that of the atmosphere before communication with the port 37^a. Consequently, no noticeable pressure fluctuations or pulsations are produced in the pump delivery as a result of movement of the cylinders into communication with either the deliver side of the suction side of the pump.

If desired, short bleed grooves 94 opening to the ends of the ports 37^a and 38^a may be formed in the land areas. These grooves are so graduated that the cylinder ports 41^a will not open abruptly to the ports 37^a and 38^a, thereby avoiding sudden shock even if the cylinder pressure is not equalized with that of the stationary port with which it is about to communicate.

In the modified form, the control plunger 64^a is formed to smoothen out any impulses in the delivery pressure of the pump so as to prevent them from influencing the position of the swivel plate 57^a. More particularly, the plunger 64^a is formed intermediate its ends with a peripheral groove or undercut 95 controlling the passage 69^a. An axial bore 96 in the plunger 64^a opens from the groove 95 to the pressure chamber 68^a. The bottom of the groove 95 is formed with a slightly tapered area 97 adapted to restrict the opening to the passage 69^a, and a contiguous steeply tapered area 98 adapted to establish relatively unrestricted communication with the passage 69^a. When the delivery pressure is low, the plunger 64^a will occupy its uppermost position calling for maximum delivery, and the area 98 will permit a free flow between the passage 69^a and the chamber 68^a. As the pressure rises, the plunger 64^a will move downwardly, thereby gradually restricting the opening to the passage 69^a. In the high pressure range, the area 97 will throttle the communication with the passage 69^a so as to damp any impulses that may tend to be present.

In operation, the shaft 23 rotates the cylinder body 31 constantly, with the valve plate 34 and the stationary valve member 25 in bearing en-

gagement. If there is a demand for fluid, the delivery pressure will be low, and hence the swivel plate 57 will be inclined to reciprocate the pistons 36. Fluid will enter from the opening 45 through the passages 44 and 42 and the inlet port 37 to the cylinders 35 on the suction side of the pump, and will be delivered under pressure from the cylinders on the pressure side through the delivery port 38, and the passage 51, 52, and 53.

The delivery pressure is transmitted from the passages 53 through the passages 70 and 69 to the chamber 68, and acts against the plunger 64 in opposition to the spring 63 and the hydraulic reaction of the pistons 36 on the pressure stroke to balance the swivel plate 57 in a predetermined position for a required delivery. Since the forces set up by the spring 63 and the plunger 64 are relatively large and have a long moment arm about the pivot 58, the effect of the slight variation in the reaction of the pistons 36 on the swash plate 54 is inconsequential, and hence fluttering of the swivel plate 57, with attendant fluctuations in the delivery pressure, is avoided.

At minimum pressure, the swivel plate 97 occupies a position of maximum inclination as determined by engagement of the plunger 64 with the plug 67. As the volume requirements fall and approach zero, the delivery pressure will increase, and will effect adjustment of the swivel plate 57 to reduce the stroke of the pistons 36. At maximum pressure, the plate 57 will level off to stop reciprocation of the pistons 36. Consequently, at zero delivery, the power inlet is only that required to rotate the cylinder body 31, and needless friction and wear are avoided. Should there be a sudden demand for fluid, an increased delivery is immediately available.

Since the cylinder ports 41^a are located at the sides adjacent the shaft 23, any air or gas that may be present will pass out with the liquid discharge so that the pump is being constantly scavenged. The valve faces are located closely about the shaft 23, and hence are relatively small and subject only to a relatively low linear speed, so that friction is reduced and objectionable run-out is avoided. Liquid leaking or seeping past the valve faces and along the pistons 36 is utilized for lubricating the pump shaft bearings and drive.

In the modified form, the swivel valve stator 89 insures accurate valve seating, and the advance of the inlet and delivery ports relatively to the suction and pressure phases of the pistons 36^a avoids sudden pressure changes and impulses. The control plunger 64^a throttles the pressure connection to the chamber 68^a at high pressures to smoothen out still more the control of the swivel plate 57^a.

In both forms of the invention, the valve is hydraulically balanced so as to maintain the proper oil film thickness and prevent undue leakage. The contact area of the annular valve faces, including the valve ports, is no greater, and preferably is approximately equal to, the aggregate area of the pump cylinders. Hence, referring to Fig. 1, the outward hydraulic thrust in the pump cylinders 35 under pressure against the rotary valve plate 34 is offset by the pressure between the contacting valve faces.

I claim as my invention:

1. A pump comprising, in combination, a pump casing having fluid inlet passage means and pressure delivery passage means, a pump body

having a plurality of parallel annularly arranged cylinders, a plurality of pistons reciprocable in said cylinders, valve means for connecting said cylinders alternately and successively to said inlet and delivery passage means, a swash plate pivotally mounted on an axis extending transversely of said cylinders at one side of said body for angular adjustment and coacting with the outer ends of said pistons, drive means for effecting relative rotation between said pistons and said swash plate and for operating said valve means in timed relation to the piston reciprocation, spring means acting on said swash plate at the other side of said body in a direction to increase the angularity of said swash plate, and means automatically responsive to the delivery pressure of said pump opposing said spring means to decrease said angularity upon an increase in said pressure.

2. A pump comprising, in combination, a pump casing having fluid inlet passage means and pressure delivery passage means, a drive shaft journaled in said casing, a rotary body mounted on said drive shaft and formed with a plurality of parallel cylinders annularly arranged about said shaft, a plurality of pistons reciprocable in said cylinders, a swash plate mounted at one end in said casing on an axis located at one side of and perpendicular to said shaft for angular adjustment and coacting with the outer ends of said pistons, spring means for holding said pistons in engagement with said swash plate, valve means operable in timed relation to the reciprocation of said pistons for connecting said cylinders alternately and successively to said inlet passage means and said pressure passage means respectively during the suction and pressure strokes of said pistons, spring means engaging the other end of said swash plate at the opposite side of said shaft and tending to adjust said swash plate in a direction to increase the volume of delivery, and hydraulic means operable in response to the discharge pressure of said pump and connected to said other end of said swash plate to adjust said swash plate in a direction to decrease the volume of delivery.

3. A pump comprising, in combination, a pump casing having a fluid inlet passage and a pressure delivery passage, a shaft journaled in said casing, a cylinder body secured to said shaft for rotation in said casing and having a plurality of parallel pump cylinders annularly arranged about said shaft, a plurality of pistons reciprocable in said cylinders, valve means operable in timed relation to the reciprocation of said pistons for connecting the cylinders alternately and successively to said inlet passage and said delivery passage respectively during the suction and pressure strokes of said pistons, a swivel plate loosely encircling said shaft and pivotally mounted at one end on an axis perpendicular to said shaft and located at one side of said cylinder body, a swash plate journaled in said swivel plate and coacting with the outer ends of said pistons, spring means tending to retract said pistons from said cylinders into engagement with said swash plate, a control cylinder rigid with the other side of said body and extending generally parallel to said first mentioned cylinders, a plunger reciprocable in said control cylinder and movable in response to an increase in the pump delivery pressure to decrease the inclination of said swivel plate, and compression spring means tending to increase the inclination of said swivel plate.

4. A pump comprising, in combination, a pump casing having a fluid inlet passage and a pres-

sure delivery passage, a shaft journaled in said casing, a cylinder body secured to said shaft for rotation in said casing and having a plurality of parallel pump cylinders annularly arranged about said shaft, a plurality of pistons reciprocable in said cylinders, valve means operable in timed relation to the reciprocation of said pistons for connecting the cylinders alternately and successively to said inlet passage and said delivery passage respectively during the suction and pressure strokes of said pistons, a swash plate loosely encircling said shaft and pivotally mounted on an axis perpendicular to said shaft and located at one side of said cylinder body, spring means tending to retract said pistons into engagement with said swash plate, a control cylinder rigid with one side of said body and extending parallel to said first mentioned cylinders and having a flow connection with said delivery passage, a plunger reciprocable in said control cylinder, a link connecting said plunger to said swash plate for joint movement, and spring means tending to adjust said swash plate against the pressure in said control cylinder.

5. A pump comprising, in combination, a casing having an inlet passage and a discharge passage, axially spaced bearings in said casing, a drive shaft journaled in said bearings, a drive gear fixed on said shaft adjacent one of said bearings, a stationary end face valve member on the other of said bearings, and having arcuate inlet and delivery ports about said shaft and in communication respectively with said passages, a rotary body secured to said shaft and having a plurality of parallel cylinders annularly arranged about said shaft, pistons reciprocable in said cylinders, an end face rotary valve member on one end of said body coacting with said stationary valve member and having a plurality of ports opening respectively from said cylinders for movement across said arcuate ports, said rotary valve member being concentrically spaced from said shaft to define an annular space adapted to receive fluid from between said valve members and to lubricate said last mentioned bearing, an undercut annular space in said shaft open to said first mentioned space, an undercut peripheral space in certain of said pistons, passages in said body connecting the piston spaces to the shaft space, an axial bore in said shaft and having an inlet port opening from said shaft space and outlet ports opening to said first mentioned bearing and said gear, and a port opening from the interior of said gear to the tooth zone.

6. A pump comprising, in combination, a casing having an inlet passage and a discharge passage, axially spaced bearings in said casing, a drive shaft journaled in said bearings, a stationary end face valve member on one of said bearings, and having arcuate inlet and delivery ports about said shaft and in communication respectively with said passages, a rotary body secured to said shaft and having a plurality of parallel cylinders annularly arranged about said shaft, pistons reciprocable in said cylinders, an end face rotary valve member on one end of said body coacting with said stationary valve member and having a plurality of ports opening respectively from said cylinders for movement across said arcuate ports, said rotary valve member being concentrically spaced from said shaft to define an annular space adapted to receive fluid from said valve members and to lubricate said one bearing, an undercut annular space in said shaft open to said first mentioned space, an undercut

peripheral space in certain of said pistons, passages in said body connecting the piston spaces to the shaft space, and an axial bore in said shaft and having an inlet port opening from said shaft space and an outlet port opening to the other of said bearings.

7. A pump comprising, in combination, a casing having an inlet passage and a discharge passage, axially spaced bearings in said casing, a drive shaft journaled in said bearings, a stationary end face valve member on one of said bearings, and having arcuate inlet and delivery ports about said shaft and in communication respectively with said passages, a rotary body secured to said shaft and having a plurality of parallel cylinders annularly arranged about said shaft, pistons reciprocable in said cylinders, an end face rotary valve member on one end of said body coacting with said stationary valve member and having a plurality of ports opening respectively from said cylinders for movement across said arcuate ports, an annular space about said shaft, an annular space about certain of said pistons, passages in said body connecting the piston spaces to the shaft space, and an axial bore in said shaft and having an inlet port opening from said shaft space and an outlet port opening to the other of said bearings.

8. A pump comprising, in combination, a pump casing having a fluid inlet passage and a pressure delivery passage, a shaft journaled in said casing, a cylinder body secured to said shaft for rotation in said casing and having a plurality of parallel pump cylinders annularly arranged about said shaft a plurality of pistons reciprocable in said cylinders, valve means operable in timed relation to the reciprocation of said pistons for connecting the cylinders alternately and successively to said inlet passage and said delivery passage respectively during the suction and pressure strokes of said pistons, a swash plate loosely encircling said shaft and pivotally mounted on an axis at one side of and perpendicular to said shaft, an arm rigid with said plate and extending to the other side of said shaft, spring means tending to retract said pistons into engagement with said swash plate between said axis and said arm, a control cylinder on one side of said body and extending parallel to said first mentioned cylinders and having a flow connection with said delivery passage, a plunger reciprocable in said control cylinder and having a valve area controlling said flow passage, means connecting said arm and said plunger for joint movement, and spring means tending to adjust the inclination of said swash plate in opposition to the pressure in said control cylinder.

9. In a variable flow piston and cylinder pump having a pressure outlet, in combination, a pivotal swash plate for controlling the piston reciprocation, a control cylinder closed at one end and having a passage opening from one side to said outlet, a plunger reciprocable in said cylinder and having a peripheral groove opening to the closed end of said cylinder, said groove registering with said passage and having a tapered surface for gradually restricting said passage as said plunger moves outwardly, means connecting said plunger and said plate for joint movement in response to an increase in pressure in said cylinder, and spring means acting to resist outward movement of said plunger, whereby said plate will be angularly adjusted to vary the pump delivery inversely in accordance with changes in the delivery pressure.

10. In a variable flow pump, in combination, a drive shaft, a plurality of parallel piston and cylinder units annularly arranged about said shaft and having a common inlet and a common outlet, a swivel plate pivotally mounted on an axis extending transversely and at one side of said shaft for angular adjustment, means coacting with said swivel plate at the other side of said shaft for automatically determining the position of adjustment in accordance with the delivery pressure of the pump, and an annular swash plate encircling said shaft for operative engagement with said pump units and having an anti-friction mounting in said swivel plate.

11. In a variable delivery pump, a control valve comprising, in combination, an end face valve member formed with an annular groove, two pins inserted in said member at diametrically opposed points to define lands dividing said groove into an arcuate inlet passage and an arcuate discharge passage, and a coacting valve face member having a plurality of ports relatively movable in succession across said lands and arcuate ports.

12. In a variable delivery pump, a control valve comprising, in combination, a supporting plate having an opening therein, a block rigidly seated in said opening and having in one face a partial spherical valve seat, a circular stationary valve member having a flat valve face and having a partial spherical base surface complementary to and bearing in said seat and formed in said face with two peripherally spaced arcuate valve slots separated by lands, spline means connecting said valve member to said support, said spline means constraining said valve member against rotation in the plane of said face while permitting a limited rocking movement of said valve member in said seat, said spline means including upstanding pins rigid with said block and extending into radial slots in said valve member at said lands, and a rotary valve member having a flat face coacting with said first mentioned face.

13. In a pump, in combination, a casing having an inlet passage and a discharge passage, a drive shaft journaled in said casing, a rotary body secured to said shaft and having a cylinder parallel to said shaft, a piston reciprocable in said cylinder, valve means for connecting said piston alternately to said passages in the rotation of said body, means for reciprocating said piston in timed relation to the rotation of said body, an annular space about said shaft, an annular space about an intermediate portion of said piston within said cylinder, a passage in said body interconnecting said spaces, and passage means formed in said shaft for conducting away fluid leaking from said cylinder past said piston into said last mentioned space and passing therefrom to said first mentioned space.

14. A pump comprising, in combination, a pump casing having fluid inlet passage means and pressure delivery passage means, a pump body having a plurality of parallel annularly arranged cylinders, a plurality of pistons reciprocable in said cylinders, valve means for connecting said cylinders alternately and successively to said inlet and delivery passage means, a swash plate pivotally mounted on an axis extending transversely of said cylinders at one side of said body for angular adjustment and coacting with the outer ends of said pistons, drive means for effecting relative rotation between said pistons and said swash plate and for operating said valve means in timed relation to the piston reciprocation, spring means acting on said swash plate at the

other side of said body in a direction to increase the angularity of said swash plate, and hydraulic means operable in response to the discharge pressure of said pump and acting on said swash plate at said other side of said body in opposition to said spring means to decrease the angularity of said swash plate upon an increase in said pressure, said hydraulic means including a restricted valve for controlling the transmission of said pressure and defining a graduated flow area of increasing size as said hydraulic means operates in response to a progressive decrease in said pressure.

15. A pump comprising, in combination, a pump casing having fluid inlet passage means and pressure delivery passage means, a pump body having a plurality of parallel annularly arranged cylinders, a plurality of pistons reciprocable in said cylinders, valve means for connecting said cylinders alternately and successively to said inlet and delivery passage means, a swash plate pivotally mounted on an axis extending transversely of said cylinders at one side of said body for angular adjustment and coacting with the outer ends of said pistons, drive means for effecting relative rotation between said pistons and said swash plate and for operating said valve means in timed relation to the piston reciprocation, a control cylinder closed at one end and having a control passage opening from one side to said delivery passage means, a plunger reciprocable in said control cylinder and having a peripheral groove opening to the closed end of said control cylinder, said groove registering with said control passage and having a tapered sur-

face for gradually restricting the flow area of said control passage as said plunger moves outwardly, means connecting said plunger and said swash plate at the side of said body opposite to said axis for joint movement in response to an increase in pressure in said control cylinder, and spring means acting to resist outward movement of said plunger, whereby said plate will be angularly adjusted to vary the pump delivery inversely in accordance with changes in the delivery pressure.

16. In a variable flow piston and cylinder pump having a pressure outlet, in combination, a pivotal swash plate for controlling the piston reciprocation, a control cylinder closed at one end and having a passage opening from one side to said outlet, a plunger reciprocable in said cylinder and having a recess in the side thereof opening to the closed end of said cylinder, said recess registering with said passage and having a root surface for controlling the effective flow area through said passage, said root surface being tapered initially at a slight angle and then at a relatively steep angle in a direction progressively effective to increase said flow area as said plunger moves inwardly in said cylinder in response to a decrease in pressure, means for connecting said plunger and said plate for joint movement, and spring means acting to resist outward movement of said plunger, whereby said plate will be angularly adjusted to vary the pump delivery inversely in accordance with changes in the delivery pressure.

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