July 6, 1948. **B. N. ASHTON** **2,444,550**

HYDRAULIC POWER PACK UNIT

Filed May 20, 1944 2 Sheets-Sheet 1

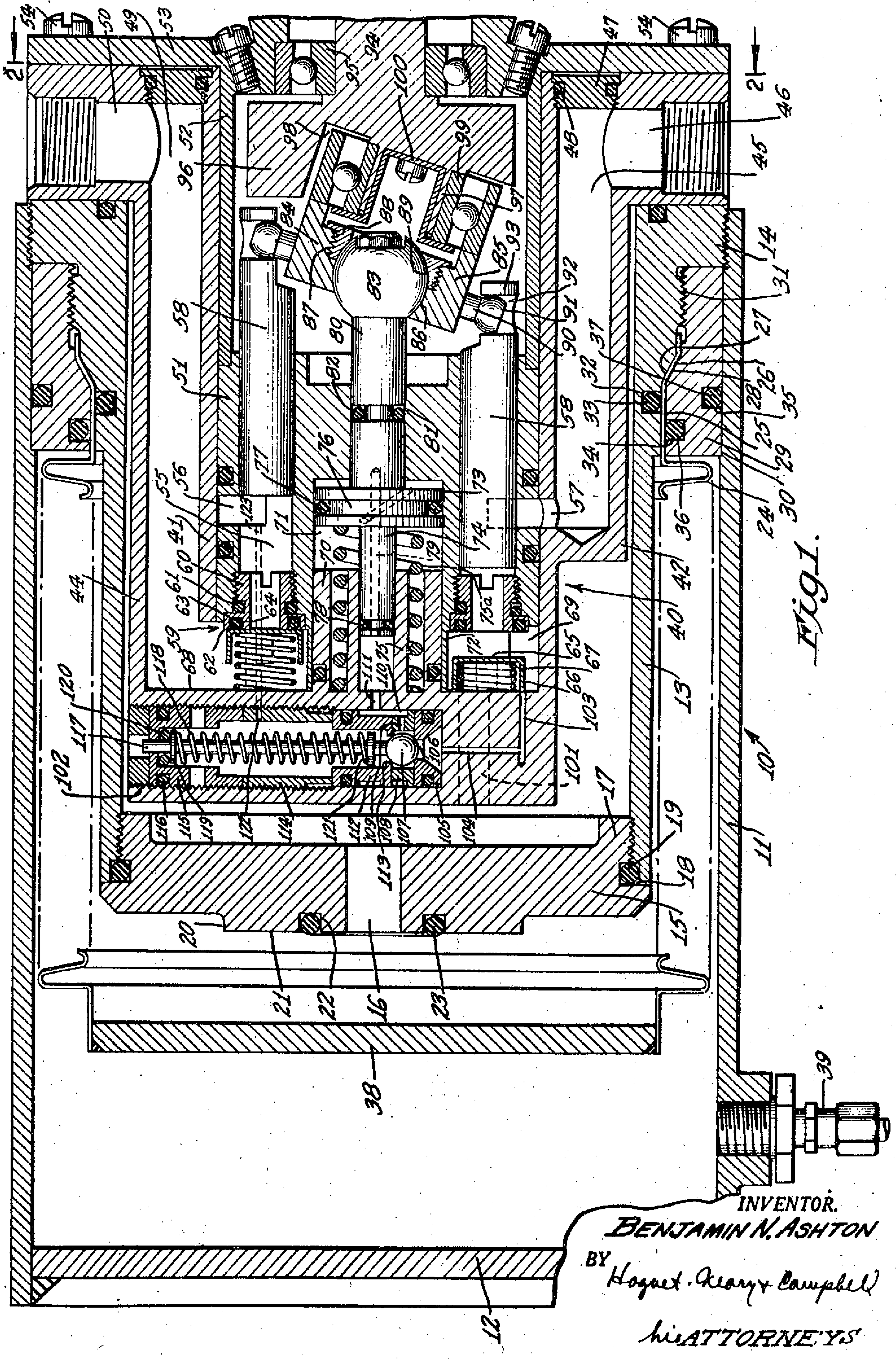

Fig. 1.

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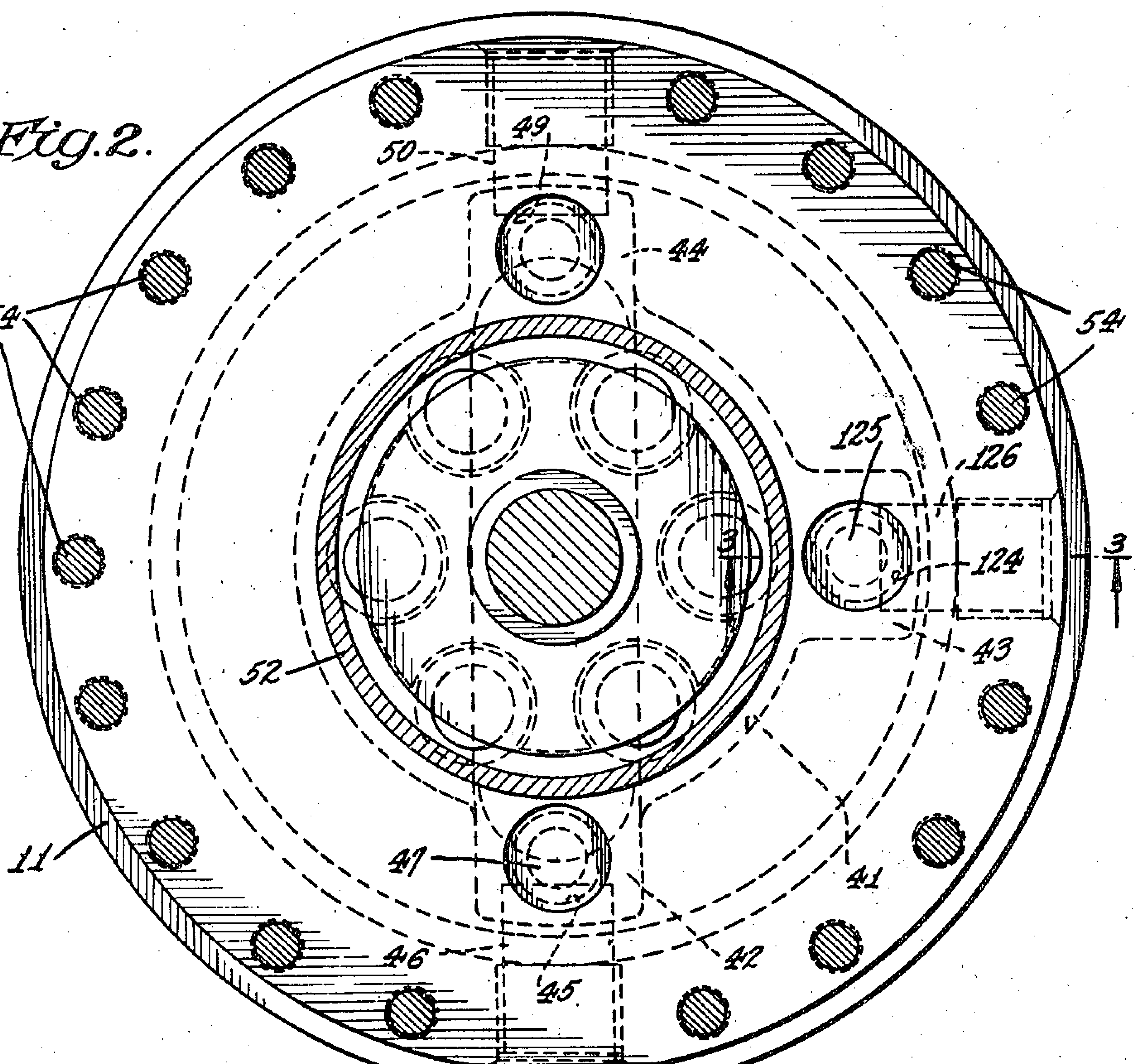
Fig. 2.



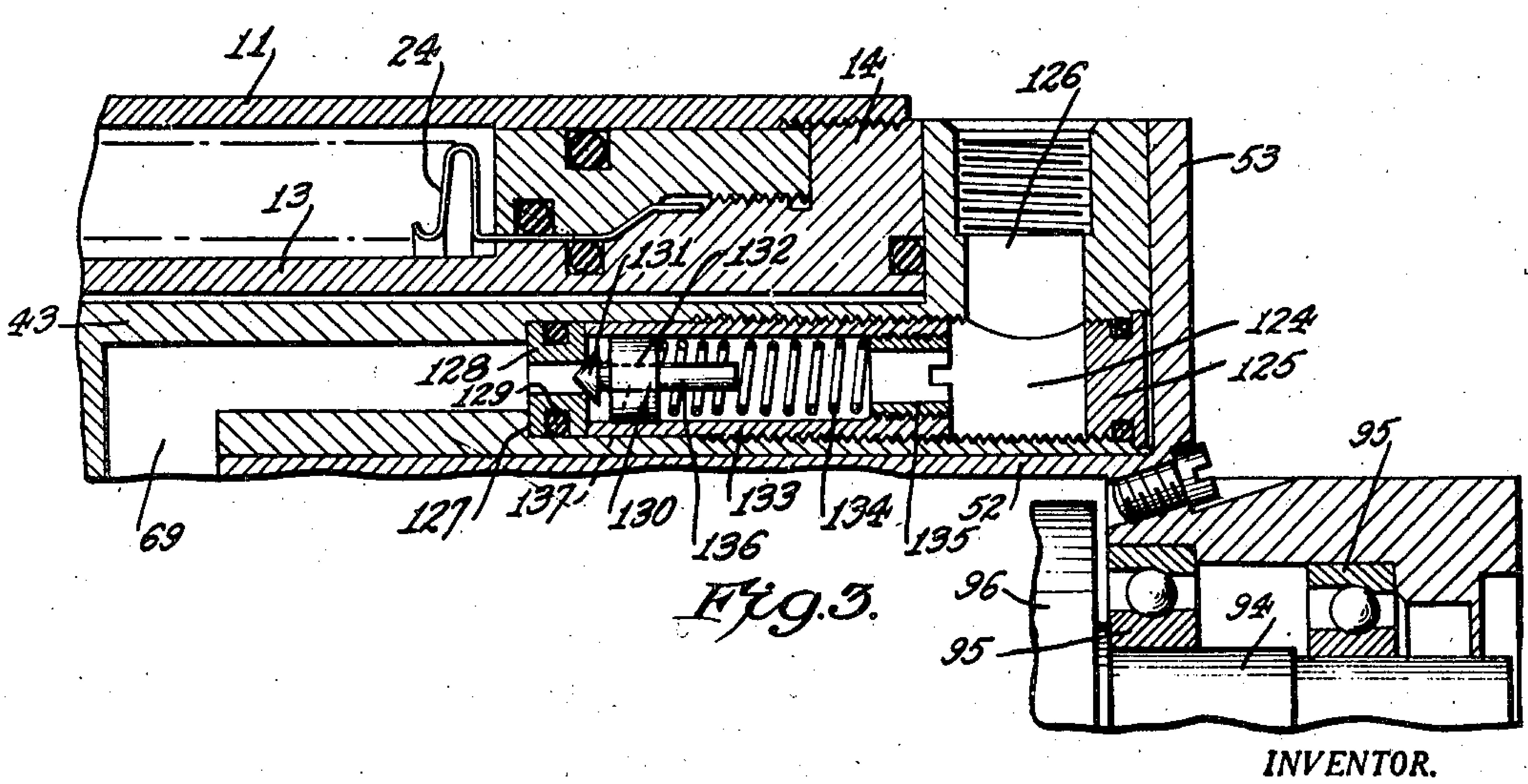


Fig. 3.

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Patented July 6, 1948

2,444,550

UNITED STATES PATENT OFFICE

2,444,550

HYDRAULIC POWER PACK UNIT

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Application May 20, 1944, Serial No. 536,492

8 Claims. (Cl. 103—223)

1

This invention relates to hydraulic power pack units and relates particularly to liquid pump and accumulator units for use in supplying liquid under pressure to hydraulic systems.

The hydraulic systems now commonly in use for actuating the landing gear, wing flaps, cowl flaps and the like of airplanes are complex constructions requiring large amounts of conduit for delivering the liquid under pressure to the hydraulic cylinders or motors that are used for actuating the flaps and landing gear. Usually, the pressure liquid is supplied by a pump connected directly to the airplane engine and this pump is connected in turn by a long conduit to an accumulator for receiving the liquid under pressure and maintaining a head of liquid in the system. The conduits lead back from the accumulator, which is usually remote from the pump, to the various selector valves in or adjacent to the cockpit and thence to the various hydraulic motors or cylinders which are likewise disposed at points remote from the cockpit of the airplane.

A great deal of weight would be saved, installation costs decreased, and danger of damage to the system by gun fire or other causes would be reduced if the pump, accumulator and other operating elements of the system were combined in a relatively compact unit.

Accordingly, an object of the present invention is to provide a small and compact power unit including a pump and an accumulator for supplying liquid under pressure within a predetermined operating range.

Another object of the invention is to provide a compact hydraulic power supply unit including a pump and an accumulator that are connected by a minimum amount of conduit to form an easily installed and replaced construction.

Other objects of the invention will become apparent from the following description of a typical form of device embodying the present invention.

In accordance with the present invention, I have provided an hydraulic power supply unit including an accumulator in which is telescopically received a pump for supplying liquid under pressure to the accumulator and also to the conduits for actuating the various hydraulic motors of an airplane.

More particularly, I have utilized an accumulator of the type disclosed in my Patent No. 2,365,994, December 26, 1944, in conjunction with a piston type pump of the type disclosed in my Patent No. 2,405,006, July 30, 1946, these elements being

2

so arranged that the motor can be disposed wholly within the accumulator, except for the drive shaft, together with relief valve and pressure regulating mechanisms whereby the power unit includes substantially all of the elements required to supply liquid to the hydraulic system.

For a better understanding of the present invention, reference may be had to the accompanying drawings in which:

Figure 1 is a view in longitudinal section of a typical form of power unit embodying the present invention;

Figure 2 is a view in cross-section taken on line 2—2 of Figure 1; and

Figure 3 is a view in cross-section taken on line 3—3 of Figure 2.

The form of power unit chosen to illustrate the present invention includes an accumulator 10 of the type disclosed in my Patent No. 2,365,994 which includes a generally cylindrical casing 11 having one end closed by a plate 12 which may be formed integrally therewith or welded to the end of the casing 11, as illustrated. Within the casing 11 is disposed a cylindrical sleeve 13 having an enlarged externally threaded end portion 14 that is screwed into the end of the casing 11 and secured thereto. The end of the sleeve 13 is provided with a disc-like closure 15 having a centrally located port 16 therein and is provided with a threaded flange 17 that is screwed into the left-hand end of the sleeve 13. Adjacent portions of the sleeve 13 and the closure member 15 are provided with opposed grooves forming a cavity 18 for receiving a rubbery sealing ring 19. The end closure member 15 is also provided with a raised portion 20 having a substantially flat surface 21 forming the seat for a valve member later to be described. The flat surface is provided with an annular groove 22 encircling the port 16 for reception of a rubbery ring 23.

Between the sleeve 13 and the casing 11 is disposed a flexible corrugated metallic bellows 24 having a cylindrical end portion 25 and a flared portion 26. The cylindrical portion 25 and the flared portion 26 are clamped between complementally shaped surface portions 27 on the sleeve member 13 and a complementally shaped portion 28 on a ring member 29 that is interposed between a portion of the sleeve 13 and the casing 11. The ring member 29 is retained against axial movement to the left by means of a shoulder 30 formed in the interior of the casing 11 and is connected to the sleeve 13 by suitable threaded portions 31. By screwing the sleeve tightly against the ring member 30, the right-hand end of the bellows is firmly retained.

In order to prevent leakage between the sleeve 13, the ring 29 and the casing 11, the sleeve 13 may be provided with a peripheral groove 32 for receiving a sealing ring 33 and the ring may be provided with an internal groove 34 and an external groove 35 for receiving sealing rings 36 and 37, respectively.

The left-hand end of the bellows 24 is provided with a rigid disc-like end plate 38 which upon contraction of the bellows 24 engages the sealing ring 23 and the valve seat 21 to trap liquid between the bellows and the sleeve 13 and thereby prevent collapse of the bellows 24 by air pressure between the bellows and the casing 11.

Air may be introduced into the casing 11 through an air check valve 39.

The internal sleeve 13 receives telescopically a piston type of pump 40 of the type disclosed generally in my Patent No. 2,405,005. The pump 40 is provided with a generally cylindrical body portion 41 (Figure 2) having three enlargements 42, 43 and 44 extending longitudinally thereof. The enlargement 42 is bored axially to form an intake conduit 45 and is provided with an intersecting laterally extending bore 46 which is internally threaded to receive a fitting on a conduit (not shown). The outer end of the bore 46 may be closed by a suitable threaded plug 47 sealed thereto by a sealing ring 48.

The bore 44 is similarly provided with a longitudinally extending bore 49 and an intersecting lateral bore 50 which is internally threaded to receive a coupling on the end of a discharge conduit (not shown). The cylindrical pump body 41 is retained in position by means of a cylindrical flange 52 on an annular base plate 53 that is secured to the pump body and to the sleeve 13 of the accumulator by means of a plurality of bolts 54 disposed around its periphery.

The cylinder block 51 is provided with a plurality of cylinders 55 extending parallel to the axis of the block and arranged in a circle around the axis of the block. The block is provided with a peripheral groove 56 which intersects the cylinders 55 at a point about midway of their length and communicates through an opening 57 with the inlet bore 45 so that liquid can be drawn into the cylinders 55 by the cylindrical pistons 58 that are slidably received in the cylinders 55.

At the inner end of each cylinder 55 is mounted a check valve 59 which includes an annular seat sleeve 60 that is threaded into the end of the cylinder and sealed thereto by means of a sealing ring 61. The end face 62 of the sleeve 60 is somewhat enlarged and is provided with an annular groove 63 for receiving a sealing ring 64 formed of rubbery material. The seat cooperates with a valve plug in the form of a plate member 65 having reversely turned flanges or lugs 66 thereon which retain and guide a coil spring 67 that bears against the end closure 68 of the cylindrical body portion 41.

As the pistons 58 are retracted in the cylinders 55, a reduced pressure is created that draws liquid into the cylinder through the port 57 and the groove 56. Upon forward movement of the piston, the liquid is forced through the valve seat sleeve 60, thereby displacing the valve plug 65 and forcing the liquid into a generally annular chamber 69 between the end member 68 of the valve housing and the cylinder block 51. This chamber 69 communicates directly with the discharge bore 49 so that the liquid pumped can be discharged directly to the hydraulic system connected with the bores 49 and 50.

The end member 68 of the pump housing 41 is provided with an annular flange 70 which fits within a cylindrical recess 71 extending axially of the cylinder block 50. The cylinder block is provided with an annular projecting flange 72 which maintains the cylinder block 51 in proper spaced relationship to the end 68 of the casing.

The flange 70 terminates short of the bottom of the recess 71, thereby leaving space for a piston 73 which has a piston rod 74 slidably received in another inner concentric flange 75 fixed to the end 68 of the casing. A spring 75a is received in the annular space between the flanges 70 and 75 and bears against the piston 73, urging it to the right. The piston is provided with a peripheral groove 76 for receiving a sealing ring 77 for cooperation with the wall of the cavity 71. The piston rod 74 is also provided with a sealing ring 78 cooperating with the inner surface of the flange 75 and is further provided with a bore 79 that opens to the recess 71 at the right-hand side of the piston 73. Another piston rod 80 is secured to the right-hand side of the piston 73 and extends through a bore 81 in the cylinder block 50. The piston rod 80 may be sealed to the bore by means of a sealing ring 82.

A ball member 83 is secured to the right-hand end of the piston rod 80 and acts as a support for a wobble plate 84 for driving the pistons. The wobble plate 84 may consist of a two-element construction, one of which is a flanged disc 85 having a semi-spherical inner surface 86 and internal threads 87 for receiving an externally threaded collar 88 having a semi-spherical inner surface 89. The wobble plate 84 is provided with radially extending pins 90 having ball-like outer ends 91 that are received in transverse bores 92 in the reduced end portions 93 of the pistons 58.

The wobble plate 84 is driven by means of a driveshaft 94 that may be connected to a motor or an airplane engine and is rotatably mounted in an anti-friction bearing 95 that is secured in the annular plate 53. The shaft 94 is provided with a disc-like counter-balancing member 96 having an inclined annular flange 97 disposed in a cut-away portion 98 of the counter-balance member 96. The flange 97 is disposed eccentrically to the axis of the shaft 94 and is so inclined that its axis intersects the center of the ball 83 in the position shown in Figure 1. The flange 97 carries a roller thrust bearing 99, the outer race of which bears against the flange on the wobble plate 84 and upon rotation causes a nutating movement of the wobble plate 84 with consequent successive reciprocation of the pistons. The bearing 99 may be retained on the flange 97 by means of a flanged, cup-shaped member 100 secured within the flange 97 and overlying the inner race of the bearing 99.

As described above, the pump 40 delivers liquid through the discharge part 50. The chamber 69 in which the pressure fluid is received from the cylinders is so connected to the interior of the sleeve 13 and the interior of the bellows 24 through the port 16 by means of a port 101.

Upon operation of the pump, pressure will be built up in the conduits of the hydraulic system and also in the accumulator bellows 24, thereby expanding it and storing liquid and liquid pressure for utilization in the system. In order to limit the pressure developed in the system, the pump is provided with a pressure unloading system now to be described. The pressure unloading device includes a transverse bore 102 in the left-hand end of the pump housing which communicates with the chamber 69 by means of the passageways 103 and 104. Adjacent the inner end of the bore 102 is mounted an annular valve seat 105 having a central passage 106 defining a seat for the ball valve 107.

Encircling the mid-portion of the ball is an annular spacer ring 108 which is provided with a transverse port 109 communicating with a peripheral groove 110 that communicates through a passage 111 with the interior of the sleeve 75. Supported on the spacer ring 108 is a sleeve 112 having a seat 113 therein for the ball 107, the seat 113 being somewhat larger in diameter than the seat in the lower member 105. The member 105 and the sleeve 112 have their peripheries sealed to the walls of the bore 102 by suitable sealing rings.

The elements 105, 108 and 112 are maintained in fixed relationship by means of a sleeve 114 threaded into the bore 102 and further engaged by an outer lock sleeve 115. The outer lock sleeve 115 is provided with a ring seal 116 and a central aperture for receiving a plunger 117 that bears against the ball 107 and forces it toward the ring 105. The upper end of a spring 118 encircling the rod 117 bears against a washer 119 that engages a sealing ring 120 and prevents leakage around the plunger. The opposite end of the spring 118 engages a flange 121 on the rod.

The sleeve 114 is provided with a port 122 which communicates with another port 123 communicating with the intake side of the cylinders at the groove 56.

The above-defined unloader construction operates in the following manner. As the pistons of the pump deliver fluid into the chamber 69 and the pressure increases, the pressure on the ball valve 107 increases correspondingly. At a predetermined maximum pressure, determined by the strength of the spring 118 and the diameter of the port 106, the ball is displaced upwardly, thereby permitting liquid to flow through the passages 103, 104 and the port 106, the passages 109, 111, through the bore 79 in the piston rod 74 to the right-hand side of the piston 73. The pressure of the liquid on the piston displaces it to the left, thereby carrying with it the wobble plate 84 and displacing all of the pistons 58 to the left. This disconnects the wobble plate 84 from the driveshaft 94 and pumping is discontinued until operation of an element connected with the pump or leakage in the system reduces the pressure to a predetermined minimum. The accumulator 10, of course, tends to maintain the pressure constant over extended periods of time and supplies additional fluid when the pump is not working.

The pressure at which the pump again goes into operation is determined by the area of the ball valve 107 in contact with seat 113. Inasmuch as the seat 113 is larger than the port 106, the pressure must drop below the maximum pressure before the spring 118 can displace the ball downwardly. When this occurs, the spring 75a urges the piston 73 to the right and the liquid flows through the bore 79 in the piston rod 74, the passage 111, the passage 109 through the now open seat 113 and out through the ports 122 and 123 to the intake side of the pump. This movement of the piston to the right re-engages the wobble plate 84 with the drive mechanism and sets the pump into operation.

In addition to the construction described above, the system may be provided with a relief valve construction, best shown in Figure 3. The relief valve is mounted in a bore 124 extending axially of the enlargement 43 and has its outer end sealed by means of a suitable sealing plug 125. The bore 124 communicates with a transverse bore 126 which is connected to a suitable relief conduit, not shown. The inner end of the bore 124 communicates with the chamber 69. The bore 124 is provided with a shoulder 127 against which bears a ring valve seat 128 sealed to the bore wall by means of a sealing ring 129. A valve plug 130 cooperates with the seat ring 128 and has a conical valve element 131 thereon and a cylindrical body portion 132 for guiding the valve in a sleeve 133 threaded into the bore 124.

The valve 130 is urged toward the seat 128 by means of a compression spring 134 that engages a sleeve 135 threaded into the outer end of the sleeve 133. The valve 130 may also be provided with a stem 136 for maintaining the spring centered thereon. If, through any failure of the elements of controlling the pressures delivered by the pump to the system and the accumulator, excessive pressure should develop, the valve plug 131 will be displaced from the seat ring 128 and allow the liquid to be discharged through suitable passages 137 in the cylindrical portion 132.

The above-described construction can be made of any size suitable for the requirements of the hydraulic system and because of its telescopic relationship can be made much more compact than prior pump and accumulator devices.

The device has many advantages, including ease of installation, compactness and reduction of the number and length of conduits in the system. Thus, the whole unit may be positioned closely adjacent to the selector valves of the hydraulic system which then need only be connected by conduits of suitable length to the hydraulic motors for actuating the elements of an aircraft.

It will be understood that the device is susceptible to considerable modification in the details of the accumulator bellows, the arrangement and type of pump used therein and, therefore, the form of the invention described above should be considered illustrative and not as limiting the scope of the following claims.

I claim:

1. A hydraulic power supply unit, comprising a pair of telescopically related cylindrical casings joined at one end and otherwise spaced apart to provide a pressure chamber, an expansible metallic bellows interposed between said casings forming with the inner casing an accumulator chamber for receiving liquid under pressure, a pump mounted within said inner casing and having an inlet and a discharge outlet for high pressure liquid, and by-pass means connecting said outlet to said accumulator chamber to supply liquid to the latter to expand said bellows and accumulate a reserve supply of liquid under pressure.

2. A hydraulic power supply unit, comprising an accumulator having an outer sealed casing, an inner hollow casing and an expansible metallic bellows interposed between said casings and dividing the space therebetween into an outer gas-receiving chamber and an inner liquid-receiving chamber, a pump mounted within said inner hollow casing and having an inlet for liquid and an outlet for supplying liquid under pressure to a hydraulic system, by-pass means for delivering liquid under pressure to said liquid-receiving chamber, and means within said inner

casing responsive to liquid pressure in said outlet for renderng said pump inoperative to supply liquid when the liquid pressure attains a predetermined maximum and for rendering said pump operative when the liquid pressure drops to a predetermined lower pressure.

3. A hydraulic power supply unit, comprising an outer cylindrical casing, a shorter hollow inner cylindrical casing telescoped within said outer casing, joined thereto at one end and otherwise spaced therefrom to form a chamber between the ends of said casings and an annular space between the sides of said casings, an expansible metallic bellows disposed in said chamber and space and enclosing said inner casing, a piston-type pump mounted inside said inner casing and having a liquid inlet, a discharge outlet, a plurality of pistons for drawing liquid through said inlet and discharging it under pressure through said outlet, disconnectible drive means for actuating said pistons, means for by-passing liquid from said pump to the interior of said bellows, and means responsive to liquid pressure at said outlet for connecting and disconnecting said drive means at predetermined minimum and maximum pressures, respectively.

4. A hydraulic power supply unit, comprising an accumulator having an outer casing, an inner casing telescoped within said outer casing, an expansible partition between said casings and forming a gas-receiving chamber between said outer casing and said partition and a liquid-receiving chamber between said partition and said inner casing, a pump mounted within said inner casing having an inlet and an outlet, disconnectible drive means for said pump, means connecting said outlet to said liquid-receiving chamber, and means responsive to liquid pressure in said outlet for connecting and disconnecting said drive means at predetermined minimum and maximum liquid pressures, respectively.

5. A hydraulic power supply unit, comprising an accumulator having an outer casing, an inner casing telescoped within said outer casing, an expansible partition between said casings and forming a gas-receiving chamber between said outer casing and said partition and a liquid-receiving chamber between said partition and sad inner casing, a pump mounted within said inner casing having an inlet and an outlet, and means connecting said outlet to said liquid-receiving chamber.

6. A hydraulic power supply unit, comprising an accumulator having an outer casing, an inner casing telescoped within said outer casing, an expansible partition between said casings and having a gas-receiving chamber between said outer casing and said partition and a liquid-receiving chamber between said partition and said inner casing, a pump mounted within said inner casing having an inlet and an outlet, disconnectible drive means for said pump, means connecting said outlet to said liquid-receiving chamber, a relief port in said pump, and valve means in said relief port for discharging liquid from said liquid-receiving chamber when the liquid pressure exceeds a predetermined maximum.

7. A hydraulic pressure supply unit, comprising a piston-type pump having a casing, inlet and discharge passages in said casing, piston-type pumping elements mounted in said casing for drawing liquid through said inlet passage and discharging it through said discharge passage, a hollow, substantially cylindrical inner casing enclosing and secured to said pump casing at one end and having a closure provided with a port at its other end, a substantially cylindrical outer casing enclosing said inner casing, sealed thereto at one end and otherwise spaced from said inner casing, the opposite end of said outer casing being closed, a cup-shaped expansible metallic bellows interposed between said outer and inner casings, enclosing the latter and sealing said inner casing from said outer casing, and bypass means connecting said outlet passage to said port to allow liquid to flow into and out of said bellows.

8. A hydraulic pressure supply unit, comprising a piston-type pump having a casing, inlet and discharge passages in said casing, pumping elements mounted in said casing for drawing liquid through said inlet passage and discharging it through said discharge passage, a hollow, substantially cylindrical inner casing enclosing and secured to said pump casing at one end and having a closure provided with a port at its other end, a substantially cylindrical outer casing enclosing said inner casing, sealed thereto at one end and otherwise spaced from said inner casing, the opposite end of said outer casing being closed, a cup-shaped expansible metallic bellows interposed between said outer and inner casings, enclosing the latter and sealing said inner casing from said outer casing, means responsive to liquid pressure in said discharge passage for maintaining the pressure therein within a predetermined pressure range, and by-pass means connecting said outlet passage to said port to allow liquid to flow into and out of said bellows.

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