Feb. 2, 1960 L. L. ASPELIN 2,923,245

PUMP

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Fig. 1

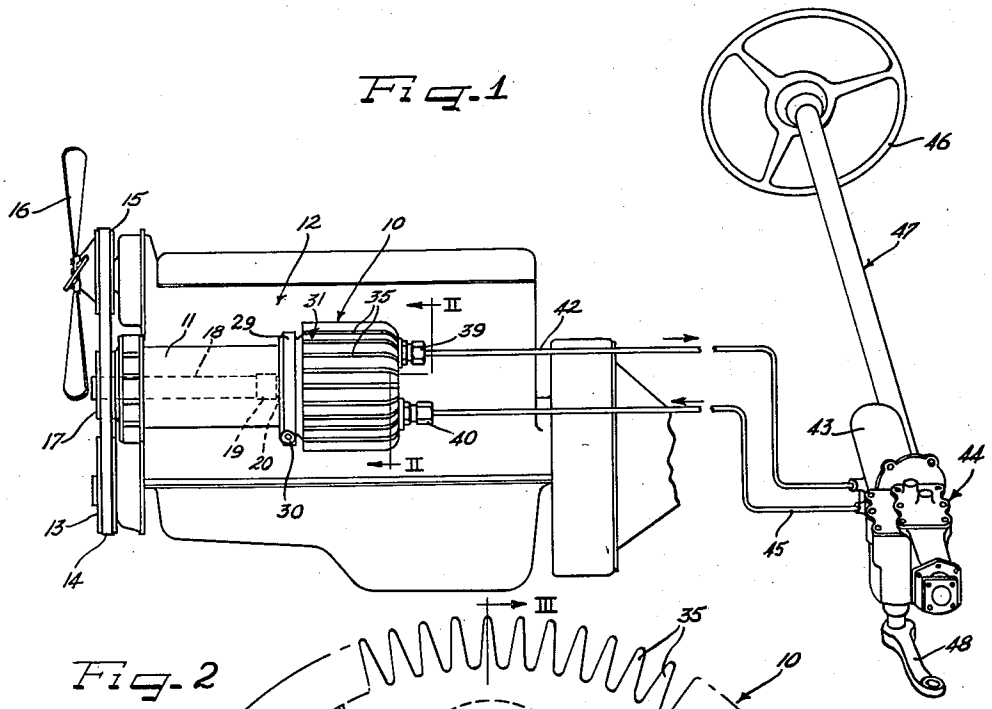
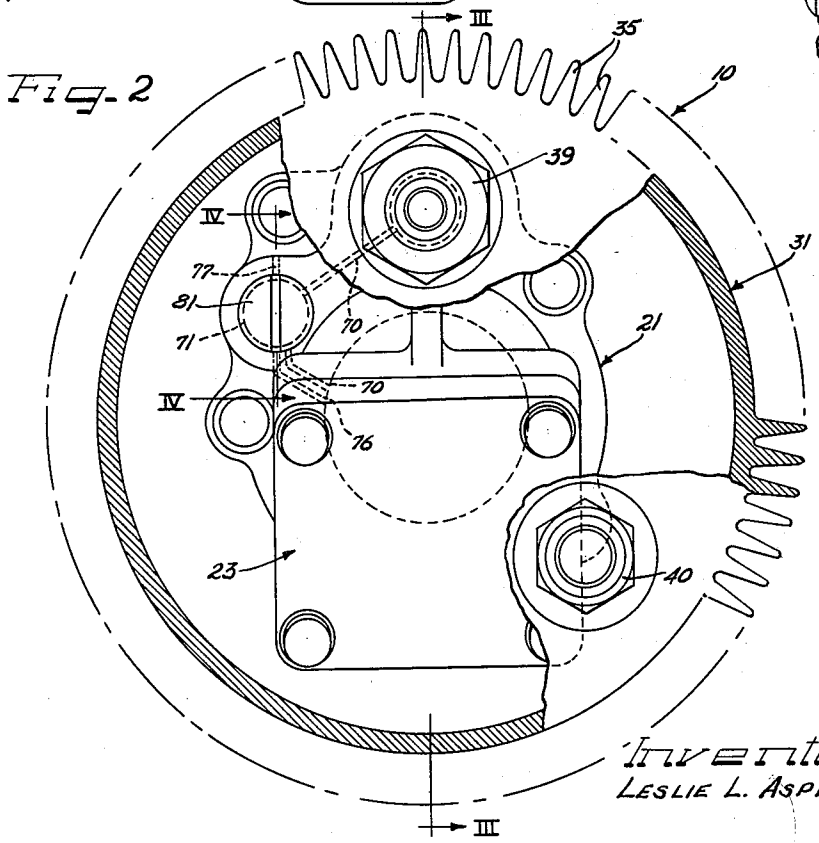


Fig. 2



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Fig. 3

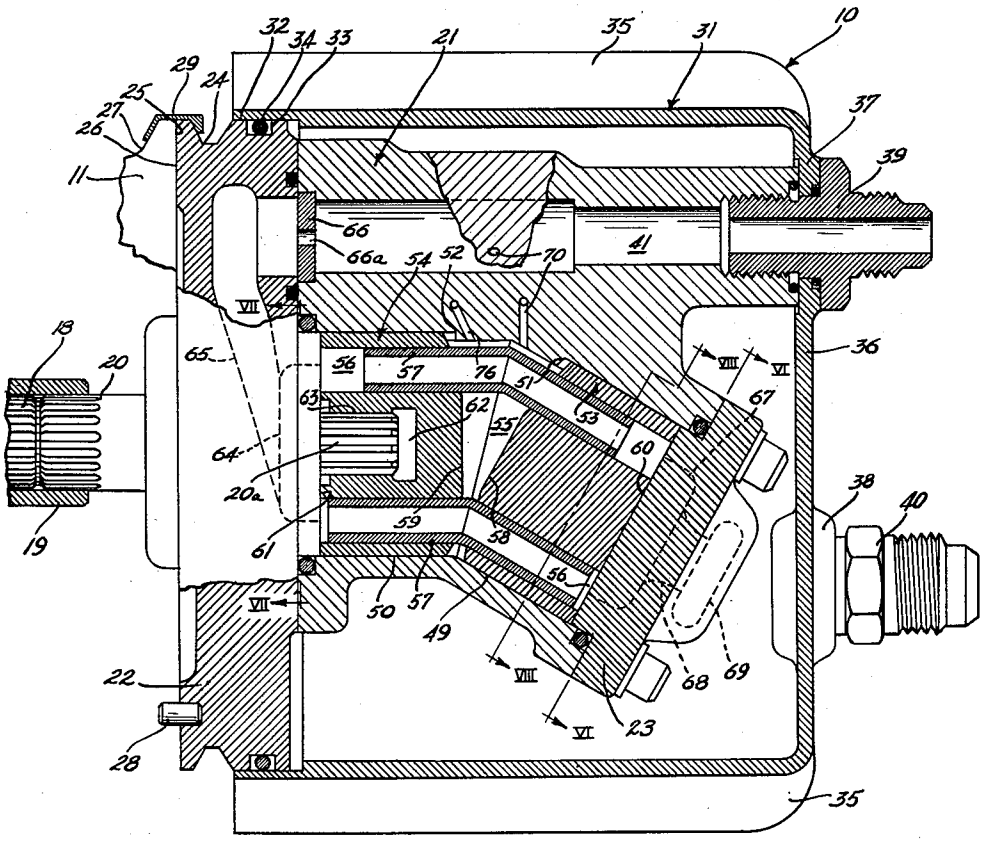
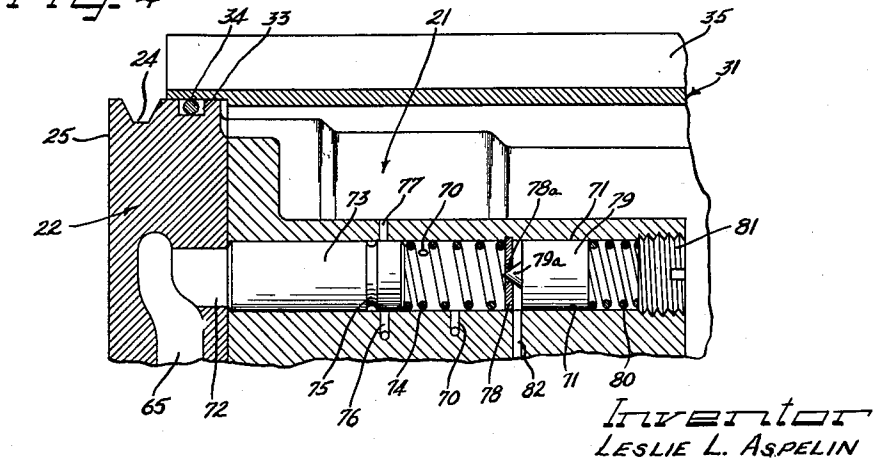


Fig. 4



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Fig. 5

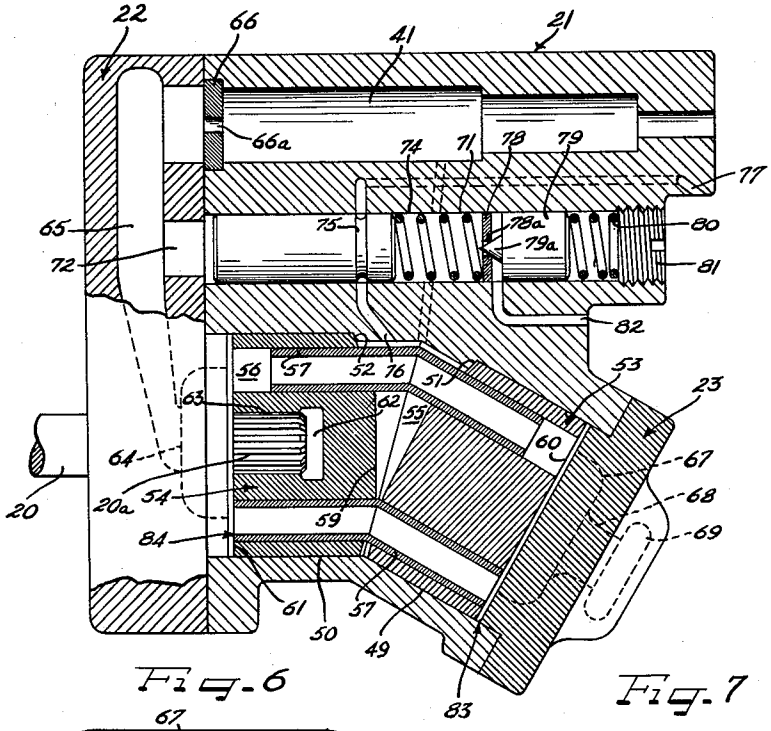


Fig. 6

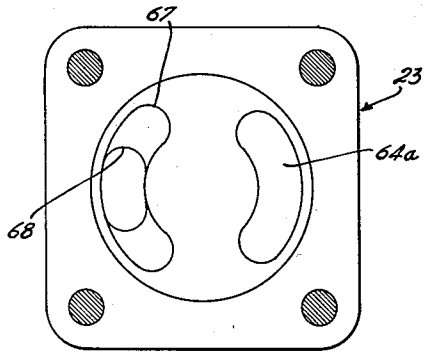


Fig. 7

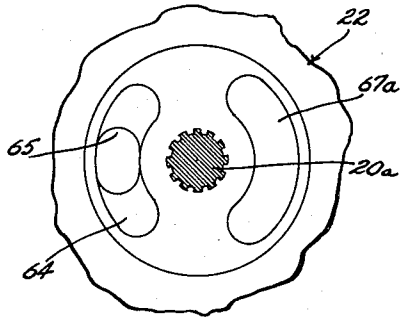
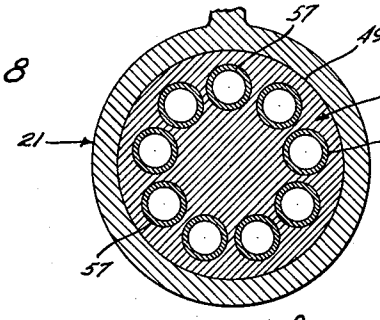


Fig. 8



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Fig. 9

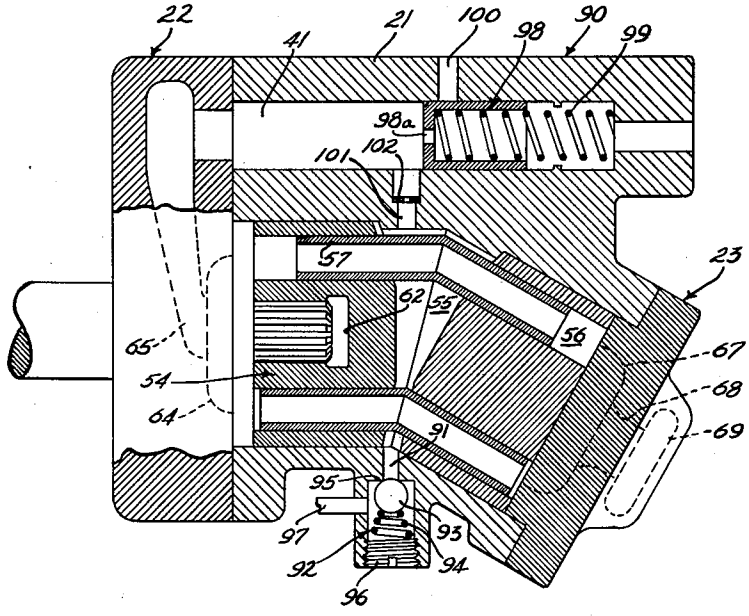


Fig. 10

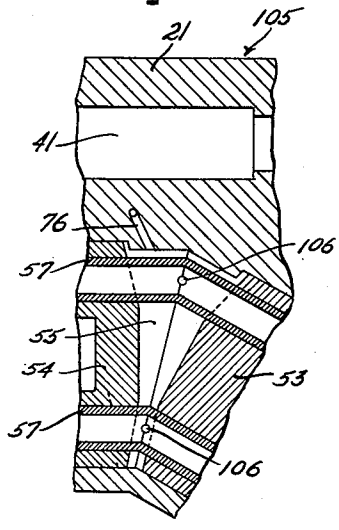
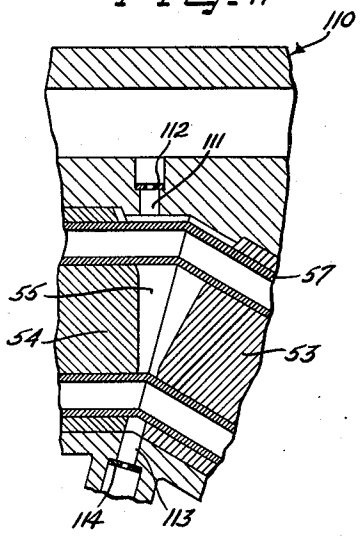


Fig. 11



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United States Patent Office 2,923,245 Patented Feb. 2, 1960

2,923,245

PUMP

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Application March 17, 1954, Serial No. 416,903

11 Claims. (Cl. 103—42)

This invention relates to a pump especially adapted for power steering to deliver the desired flow of hydraulic fluid while being driven by the vehicle engine throughout a wide range of speeds. Specifically, this invention deals with an angular piston and cylinder type pump adapted to be mounted on an automobile generator and encased in a pond of hydraulic fluid to supply this fluid at a substantially constant flow rate to an actuator for power steering or the like, without unduly working the fluid or consuming excess power when driven at speeds in excess of those required for maintaining the desired flow rate.

Rotary pumps of the type in which a series of angular plungers or pistons are reciprocated in holes or bores of rotatably driven cylinder blocks in angular relation to each other are known in the art. Such pumps generally have the cylinder blocks riding on end faces of the pump casing and have thereby been subject to excessive wear and have presented difficult sealing problems. It has, therefore, been proposed to balance the thrust loads of the cylinder blocks on the end faces of the pump casing as a function of pressure developed by the pump by bleeding fluid under pressure into the space between the cylinders and by regulating the relative areas of the inner and outer faces of the cylinders. This technique has satisfactorily maintained a sealing film of fluid between the outer end faces of the cylinder blocks and the end walls of the casing when the inner and outer face areas of the cylinder blocks are carefully and accurately sized but manufacturing tolerance requirements make it difficult to mass-produce such pumps and to change pump sizes and the number of angular pistons or plungers without a redesign of the relative area sizes.

The present invention now provides for the balancing of the cylinders to deliberately control their axial positions relative to the end faces of the pump casing without regard to the relative area sizes of the inner and outer faces of the cylinder block. The control of this invention is accomplished by direct connecting of the space between the angularly disposed cylinder blocks to the discharge line of the pump and the controlled release of pressure in the space between the cylinders so that the pressure in the space between the cylinders will always be a controlled amount less than the pressure developed by the pump. Since portions of the outer end faces of these cylinders are exposed to the pump inlet pressures, the pressure in the space between the cylinders will always develop a thrust force that is greater than the opposed thrust force delevoped on the outer faces of the cylinder blocks by the discharge pressure of the pump. The automatic balancing of the thrust load on the inner and outer faces of the cylinder blocks will be accomplished regardless of variations in relative sides of the inner and outer faces of the blocks or variations in total areas of these faces.

This arrangement will eliminate heretofore encountered pump noise due to the excessive thrust loads of the cylinders against the end faces of the pump casing such

as would ordinarily develop on high speed operation of the pump. These excessive thrust loads will squeeze out the oil film between the cylinder blocks and the casing walls creating excessive wear and unwanted noises.

An important additional feature of this invention resides in the automatic unloading of the pump whenever pressures in excess of a predetermined maximum are developed. For this purpose, a spring biased relief or topping valve automatically vents the space between the cylinder blocks to pump inlet pressure thereby permitting the pump discharge pressure on the outside faces of the cylinder blocks to axially shift the blocks toward each other and off of the end walls of the casing. This unseating of the cylinder blocks joins the inlet and outlet ports of the pump. As a result, the flow rate and discharge pressure of the pump is automatically maintained below a predetermined maximum regardless of the speed of operation of the pump. At the same time, the excess fluid is not being worked and the load on the pump is relieved so that cool operation can be maintained.

It is then an object of this invention to provide a pump especially adapted for operation throughout a wide range of speeds to deliver a substantially constant rate of flow under a predetermined maximum pressure without working the fluid whenever the operating speeds of the pump are such to delvelop excessive flow rates or pressures.

A further object of this invention is to provide an automatic unloading control for pumps to directly join the pump inlet and outlet ports whenever the pump tends to deliver fluid in excess of a predetermined maximum rate.

A further object of this invention is to provide a control for pumps of the angular piston and rotary cylinder block types which will regulate the thrust loads of the cylinder blocks on the end faces of the pump casing regardless of the areas of the end faces of the cylinder blocks so as to eliminate noise and excessive thrust loads.

A still further object of the invention is to provide an automatic control for an angular piston and rotary cylinder type pump which maintains the space between the cylinder blocks of the pump at pressures lower than the pressures developed by the pump and which automatically unloads the pressure between the cylinders whenever excessive pressures are developed by the pump.

A still further object of this invention is to provide a pump adapted to be attached to the generator of an automobile engine for co-rotation therewith and adapted to be cooled by the hydraulic fluid which it pumps.

A still further object of this invention is to provide a submerged generator-driven pump for vehicular power steering.

A specific object of this invention is to provide a pump of the angular piston and rotary cylinder type having axially shiftable cylinder blocks controlled by pump discharge pressure downstream from a fixed orifice and automatically unloaded to directly join its inlet and outlet ports and to decrease its working stroke whenever excessive discharge pressures are developed.

Other and further objects of this invention will be apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of preferred embodiment, illustrate several modifications of the invention.

On the drawings:

Figure 1 is a somewhat diagrammatic eelvational view of a pump of this invention mounted on the generator of an automobile engine for supplying hydraulic fluid to a power steering apparatus on the vehicle driven by the engine;

Figure 2 is an enlarged cross-sectional view with parts

in end elevation, taken substantially along the line II—II of Figure 1;

Figure 3 is a longitudinal cross-sectional view, with parts in elevation, taken along the line III—III of Figure 2;

Figure 4 is a fragmentary longitudinal elevational view, with parts in elevation, taken along the line IV—IV of Figure 2;

Figure 5 is a somewhat diagrammatic longitudinal cross-sectional view, with parts in elevation, illustrating the operation of the pump of Figures 1 to 4;

Figure 6 is a transverse cross-sectional view, with parts in elevation, taken along the line VI—VI of Figure 3;

Figure 7 is a transverse cross-sectional view, with parts in elevation, taken along the line VII—VII of Figure 3;

Figure 8 is a transverse cross-sectional view, with parts in elevation, taken along the line VIII—VIII of Figure 3;

Figure 9 is a somewhat diagrammatic longitudinal cross-sectional view similar to Figure 5 and illustrating the modified control arrangement for the pump;

Figure 10 is a fragmentary longitudinal cross-sectional view of the central portion of the pump of Figs. 1 to 8 showing another manner of venting the space between the pistons to pump discharge pressure; and

Figure 11 is a view similar to Figure 10 but illustrating a further modified control arrangement for the pump.

As shown on the drawings:

The pump **10** is illustrated in Figure 1, as mounted on a generator **11** of an automobile engine **12**. This engine **12**, as is conventional, has a crankshaft-driven pulley **13** driving a fan belt **14** which belt, in turn, drives the fan pulley **15** for rotating the cooling fan **16** of the engine. A pulley **17** on the generator **11** engages the fan belt **14** to be driven thereby. The generator shaft **18** is joined by a coupling **19** to the pump shaft **20**.

The pump casing **21** has, as best shown in Figure 3, a large end head **22** at one end thereof and a smaller end head **23** at the other end thereof. The end head **22** has an external V-groove **24** adjacent the outer end face **25** thereof and this end face abuts the end face **26** of the casing of the generator **11**. The generator casing also has a V-groove **27** similar to the groove **24** adjacent the end face **26**. A pin **28** seated in recesses respectively provided in the end faces **25** and **26**, controls the radial alignment of the pump casing on the generator and a clamping ring **29** extending around the grooves **24** and **27** releasably connects the pump on the generator casing with the end face **25** of the pump head **22** abutting the end head **26** of the generator casing.

A drawbolt or the like **30** (Figure 1) is provided to tighten the ring **29**.

The entire pump casing **21** is enclosed in an outer housing **31** of substantially cup-shape with an open end **32** receiving the end head **22** of the pump. A groove **33** in this head **22** carries the seal ring **34** for engaging the inner face of the housing **31** adjacent the open end **32** thereof. Longitudinal fins **35** radiate from the casing **31** around the periphery thereof.

The closed end wall **36** of the casing **31** has bosses **37** and **38** thereon carrying fittings **39** and **40** respectively. The fitting **39** registers with the discharge passage **41** of the pump casing **21** and is located adjacent the top of the housing **31**. The fitting **40** communicates with the interior of the housing **31** near the bottom thereof.

As shown in Figure 1, a feed line **42** extends from the fitting **39** to the actuator **43** of a power steering apparatus **44** of any suitable design. Return fluid from the actuator **43** is fed to the fitting **40** through a tube **45**. As is conventional, the steering wheel **46** of the vehicle mounted on the steering column **47** controls a valve (not shown) in the power steering apparatus **44** for regulating the admission of fluid to the actuator **43** thereby driving the steering pitman arm **48**.

Hydraulic fluid is maintained in the housing **31** at a level near the top thereof so that the pump casing **21** will be substantially submerged in the fluid to be cooled thereby. Heat from the fluid is radiated from the casing **31** by the fins **35**.

As best shown in Figure 3, the pump casing **21** has a pair of cylindrical bores **49** and **50** extending inwardly from the end heads **22** and **23** in angular relationship. The angle between the bores **49** and **50** is less than 180° and more than 90°, preferably about 150°. Shoulders **51** and **52** are provided at the inner ends of the bores. Cylinder blocks **53** and **54** ride in the bores and are of less axial length than the bores so as to be axially shiftable toward and away from the shoulders **51** and **52** toward and away from each other. A space **55** is thereby provided between the cylinder blocks.

The cylinder blocks can be composed of metal, plastic, or the like material, and are capable of having good bearing relationship with the metal of the casing defining the bores in which they ride.

The cylinders each have longitudinal holes **56** extending therethrough in spaced parallel relation around the axial centers thereof. These holes **56** receive angled hollow pistons or plungers **57**, the angled end portions of which are freely slidable in the holes. The piston knees are disposed in the space **55** between the cylinders.

The shoulders **51** and **52** are adapted to be abutted by the inner end faces **53** and **59** respectively of the cylinders **53** and **54** so that these faces will always be held in spaced apart relationship with their entire areas thereof exposed to the space **55**.

The outer end face **60** of the cylinder **53** rides on the end head **23** of the casing while the outer end face **61** of the cylinder **54** rides on the end head **22** of the casing.

The outer end face **61** of the cylinder **54** is recessed at **62** and the side walls of the recess are splined at **63** to receive the splined end **20***a* of the drive shaft **20**. The end face of the head **22** on which the cylinder **54** rides is provided with a discharge port **64** registering with the pumping spaces of the holes **56** when the pistons **57** are adjacent the outer end faces **60** and **61** of the cylinder blocks to receive fluid therefrom. A passageway **65** in the end head **22** connects the port **64** with the upstream face of an orifice plate **66** seated in the discharge passageway **41** of the casing **21**. This plate **66** has an orifice **66***a* restricting the flow of pump fluid for maintaining a pressure differential between the passageway **65** and the outlet passage **41**. A blind inlet port **67***a* is also provided in the end face of the end head to form the pumping spaces of the holes **56** when the pistons are retracted from the outer end faces of the cylinder blocks.

The end head **23** has a main inlet port **67** opposite the blind port **67***a* registering with the pumping spaces of the holes **56** in those areas where the pistons are retracted from the end faces **60** and **61** of the cylinder blocks. This end head **23** also has a blind outlet port **64***a* opposite the live port **64**. The blind ports **64***a* and **67***a* coact with the main ports **64** and **67** respectively so that both ends of the pumping spaces will be simultaneously joined as the holes **56** pass over the port areas.

The inlet port **67** is connected through a passageway **68** in the end head **23** with an inlet opening **69** adjacent the bottom portions of the housing **31** so as to receive hydraulic fluid direct from the housing.

In accordance with this invention, a bleeder passageway **70** directly connects the space **55** between the cylinder blocks **53** and **54** with the discharge passageway **41** downstream from the orifice **66***a* to feed fluid being discharged by the pump directly to the space **55**. This fluid under pressure in the space **55** acts on the faces **58** and **59** of the cylinder blocks **53** and **54** to urge the same outwardly and force the outer faces **60** and **61** thereof against the end heads **23** and **22** respectively.

As best shown in Figures 2, 4 and 5, the pump casing **21** has a bore **71** parallel with the discharge passageway **41** and intersecting the bleeder passageway **70**. This

bore 71 communicates through a passage 72 in the end head 22 with the passage 65 upstream from the orifice plate 66. A solid cylindrical plunger valve 73 slides in the bore 71 at the end thereof adjacent the passage 72 to be acted on by pressure developed by the pump in the passage 65. This valve 73 is urged by a spring 74 in the bore 71 against the end head 22 and when so bottomed on the end head, has the circumferential groove 75 thereof out of registration with a bleeder passageway 76 that joins the space 55 between the cylinder blocks with an outlet passage 77 communicating with the interior of the housing 31. The spring 74 is bottomed on a fixed orifice plate 78 locked in the bore 71 and having an orifice 78*a* closed by a topping valve or relief valve 79. A spring 80 acts on the valve 79 to seat the nose 79*a* of the valve in the orifice 78*a* for closing the orifice. The spring 80 is bottomed by a screwplug 81 closing the end of the bore 70. A bleeder passage 82 vents the downstream side of the orifice plate 78 with the interior of the housing 31.

It will be noted that the bleeder passage 70 communicates with the upstream side of the orifice plate 78 and with the front face of the valve 73 so that both the valve 73 and the valve 79 are always subjected to the discharge pressure downstream from the orifice plate 66 which pressure tends to assist the spring 74 in holding the valve 73 against the end head 72 with its groove 75 out of registration with the passageway 76 while simultaneously attempting to unseat the relief or topping valve 79 from the orifice 78. This action of the spring 74 and the discharging pressure on the valve 73, however, is opposed by the higher discharge pressure of the pump upstream from the orifice plate 66 and existing in the passageway 65. This latter higher pressure tends to shift the valve 73 against the spring bias 74 for registering the groove 75 with the bleeder passageway 76 and thereby venting the space 55 to the interior of the casing 31 through the passages 76 and 77. This venting of the space 55 to inlet pressure in the housing 31 will lessen the load on the inner faces 58 and 59 of the cylinder blocks whereupon pump discharge pressure acting on the outer faces 60 and 61 of the cylinder blocks, will shift the blocks axially toward the shoulders 51 and 52 of the bores and off of the end faces of the end heads. As shown in Figure 5, passages 83 and 84 are thereby opened up between the end heads and the outer end walls of the cylinder blocks. These passages are effective to conect the outlet port 64 with the inlet port 67 through the holes 56 and the interiors of the pistons 57.

The orifice 66*a* in the plate 66 is sized for maintaining a predetermined pressure differential on the upstream and downstream sides of the plate and when the pump is speeded up to deliver excessive amounts of fluid to the downstream side of the plate, the valve 73 will be shifted by the increased upstream pressure for venting the space 55 to inlet pressure. This bleeding of the space 55 through the passageways 76 and 77 will be sufficient to partially unload the cylinder blocks so as to eliminate heretofore encountered pump noises caused by excessive loading of the blocks against the end heads. In the event, however, the pump speed is such as to develop excessive back pressures even at low flow rates in the passage 41, then the topping valve 79 will be unseated due to the pressure in the bore 71 exerted through the bleeder passageway 70 on the orifice plate 78. The valve 79 will thereby be opened to directly vent the space 55 and the discharge passage 41 with the interior of the housing 31. In such event, the pump pressure will be relieved and the cylinder blocks 53 and 54 can shift even closer together to increase the passages 83 and 84.

From the above description, it will be understood that the pump of this invention will deliver a substantially constant flow of fluid at less than a predetermined maximum pressure even when the pump is speeded up by the engine 12 to deliver excessive volumes of fluid or to develop excessive pressures. The shifting of the cylinder blocks 53 and 54 not only eliminates heretofore encountered pump noises developed at high speeds in the angular piston type of pump, but also joins the inlet and outlet ports of the pump so that hydraulic fluid is not worked when not needed. At the same time, the pump is adapted to develop the desired flow rate at the desired pressure even when it is driven at very low speeds because in such event, the full pumping capacity will be utilized. Since the excess fluid is not worked the fluid does not become unduly heated and the pump is not consuming excessive power when the power steering actuator 43 does not call for fluid. At the same time, the fluid is instantly available at the desired pressure when the steering wheel 46 is manipulated to admit fluid to the actuator.

Since the control of the pump is a function of flow and pressure developed by the pump, wide tolerances can be accommodated and widely variable pump sizes can be made without changes in the basic pump design. Accurate relative sizing of the inner and outer faces of the cylinder blocks is not necessary as long as the inner faces, when subjected to the throttled discharge pressure downstream from the orifice 66*a*, develop more thrust than the outer faces of the blocks which are partially vented to inlet pressure.

In the modification diagrammatically illustrated in Figure 9, parts identical with parts described hereinabove, have been marked with the same reference numerals.

In the pump 90 of Figure 9, the space 55 between the cylinder blocks 53 and 54 is vented through a passage 91 with a spring loaded ball check relief valve or topping valve 92 having a ball 93 spring loaded by a spring 94 against a seat 95. The spring is adjustably loaded by a plug 96. The ball 93 selectively vents the passage 91 with an outlet passage 97 communicating with the pump inlet.

The outlet passage 41 of the pump slidably receives a thimble-type flow valve 98 which is spring biased by a spring 99 to cover a vent 100 communicating with the pump inlet. The valve 98 has a fixed orifice 98*a* in the head end thereof and is adapted to maintain a pressure differential between the upstream and downstream sides of the valve. When this pressure differential increases the valve will be shifted against the spring bias to open the vent 100 whereupon the excess pressure will be relieved.

The outlet passage 65 of the pump is also connected through a passage 101 with the space 55 between the cylinder blocks. This passage 101 contains a fixed orifice plate 102 for maintaining a predetermined differential on opposite sides of the plate.

In operation, the pump 90 will develop the desired flow rate at the desired pressure at relatively low speeds. When the flow rate increases to increase the pressure differential across the valve 98, the valve will be shifted to relieve the excess flow. When an excessive pressure is developed by the pump in the passageway 41 so as to increase the pressure differential across the fixed orifice plate 102, pressure in the space 55 will be increased eventually to a point where the ball 93 will be unseated to vent the space 55 and permit the cylinders 53 and 54 to move toward each other thereby relieving the thrust load on the cylinders and connecting the inlet and outlet ports of the pump.

The arrangement of Figure 9 is such that the topping valve 93 will automatically open to decrease the pressure developed by the pump whenever the pressure exceeds a predetermined amount while the flow valve 98 will maintain a constant flow delivery rate for the pump by selectively connecting the pump outlet with the pump inlet through the vent 100.

In the pump 105 of Figure 10 the space 55 between the cylinder blocks 53 and 54 is connected to the interiors of the pistons 57 by holes 106 in the knees of the pistons. The pressure in the space will therefore be about one

half the discharge pressures developed by the pump since some of the pistons will be vented to the inlet port and others will be at the same time connected to the outlet port. This pressure in the space **55** will be controlled as in the pump **10**, through the passage **76** to the valve **73** (shown in Figs. 4 and 5) and the valve will operate to relieve excess pressures for permitting the cylinder blocks to ride off of their end face seats.

In the simplified pump **110** of Figure 11, the pressure in the space **55** between the cylinder blocks **53** and **54**, is developed by connecting the space to the pump discharge pressure through a passage **111** containing a fixed orifice plate **112**. This space **55** is also vented to pump inlet pressure through a passageway **113** containing a fixed orifice plate **114**. The sizes of the orifices in plates **112** and **114** are selected to maintain a predetermined pressure in the space **55** relative to the outlet pressure of the pump and thereby balance the axial thrust loads on the cylinder blocks. These orifice plates **112** and **114** will always maintain a pressure in the space **55** which is less than the pump discharge pressure but which will increase as pump discharge pressure increases thereby holding the cylinder blocks against the end faces of the end heads **22** and **23** with a variable thrust designed to prevent substantial leakage without excessively loading the blocks at low pump pressures. If desired, of course, the space **55** can also be vented by means of a topping valve or relief valve as in the embodiment shown in Figure 9. The orifice plates **112** and **114** provide a simple expedient for balancing the pump so as to maintain a desired thrust on the cylinder blocks which will eliminate noise even at high speed operation.

It will be understood that many variations of the illustrated methods of balancing the cylinder blocks in accordance with the flow rate developed by the pump are possible and are within the scope of this invention. This balancing eliminates heretofore encountered pump noises and excessive wear on the pump cylinder blocks. The feature of deliberately leaking the pump fluid across the end sealing faces of the pump to join the inlet and outlet ports of the pump for silencing the pump and for preventing useless working of fluid that is not required for operation, is a very important one and makes possible maintenance of cool actuating fluid for power steering apparatus, refrigerators, air conditioners, and the like, while continuously operating the pump throughout a wide range of speeds and pressures.

It will be understood that variations and modifications may be effected without departing from the scope of the novel concepts of this invention.

I claim as my invention:

1. In an angular piston pump of the type having cylinder blocks rotatably mounted and axially shiftable in angularly displaced adjacent bores and hollow angled pistons slidably mounted in holes of the cylinder blocks and connecting said blocks for co-rotation, the improvement of holes extending through the walls of said hollow pistons communicating between the interiors of the pistons and the space between the cylinder blocks whereby said space will be subjected to the mean pressure of the piston interiors for urging the cylinder blocks outwardly in their bores.

2. A pump adapted for variable speed driving to deliver a substantially constant flow at a predetermined pressure which comprises a pump casing having a pair of bores in angular relation with a common space therebetween, end heads for said casing closing said bores, cylinder blocks rotatable and axially shiftable in said bores, said cylinder blocks having longitudinally extending holes therethrough, angled hollow pistons having the legs thereof slidably mounted in the holes of both cylinder blocks and extending across the space between the blocks, an inlet port in one end head communicating with the holes in the cylinder blocks to admit fluid thereto, an outlet port in the other end head communicating with the holes in the cylinder blocks to release pumped fluid therefrom; said pump casing having a fixed orifice throttling flow from the outlet port, a passageway connecting the discharge from the orifice to the space between the cylinder blocks, an outlet passage in said pump casing communicating with said space between the cylinder blocks, and means controllably releasing pressure from said space through said outlet passage.

3. In a pump of the angular piston and rotary cylinder type having a pump housing rotatably journaling a pair of spaced cylinder blocks defining a pressure responsive space therebetween, said cylinder blocks riding against end faces of the pump housing to seal the inlet and outlet ports of the pump, the improvements of orifice means throttling flow from the pump, a passageway connecting the downstream side of said orifice means with the space between the cylinder blocks, a relief passageway connected to vent said space between the cylinder blocks to a low pressure area in said pump, and valve means in said relief passageway to control the venting flow therethrough.

4. A pump which comprises a casing, an end head on one end of the casing, a cup-shaped housing surrounding said casing and receiving the end head in the open mouth end thereof, said casing defining a pair of bores in angular relation, one of said bores being closed by said end head, an end head in the housing closing the other of said bores, opposed cylinder blocks rotatably and slidably mounted in said bores and riding against said end heads, said blocks having spaced axially extending holes therethrough, hollow angular pistons having the end legs thereof slidably mounted in holes of both blocks, the end head in said housing having an inlet for supplying fluid from the housing to the holes and pistons, the end head in the mouth of the housing having an outlet port receiving fluid from said holes, a fixed orifice plate in the casing receiving fluid from the outlet port to create a pressure differential on the upstream and downstream sides thereof, means in said casing connecting the space between the cylinder blocks to pump outlet pressure downstream from the orifice plate to urge the cylinder blocks outwardly against the end head by fluid pressure, a relief passage leading from said space, and spring loaded pressure responsive valve means in said relief passage connected to the downstream side of said orifice plate and venting the space between the cylinder blocks to the interior of the housing at a predetermined maximum downstream pressure, whereby pressure in the space between the cylinder blocks will be controlled as a function of pump discharge pressure downstream from the orifice and excess pressure in said space will be relieved to control the loads of the blocks on the end heads and pump discharge will be reduced with reduction of pressure in said space.

5. In a pump of the angular piston and rotary cylinder block type having the cylinder blocks thereof urged into sealing engagement with end faces of the pump casing by fluid in the space between the cylinder blocks, the improvements which comprise throttling means in the pump outlet reducing the pressure of flow from the pump, a passageway joining the pump outlet downstream from the throttling means with the space between the cylinder blocks, passage means connected to selectively vent the space between the cylinder blocks, and pressure responsive valve means in said passage means connected across said throttling means for opening the passage at a predetermined pressure differential for controlling the pressure in said space as a function of the discharge flow rate of the pump.

6. In a pump of the angular piston and rotary cylinder block type having a pair of axially shiftable cylinder blocks seatable against end walls of the pump casing under the influence of pressure in the space between the cylinder blocks and having an intake conduit and a discharge conduit, the improvement which comprises a bleeder passageway connected to said space and to said

discharge conduit to develop thrust forces on the inner faces of the cylinder blocks for urging the blocks apart and against the end walls, passage means connected to said space for relieving fluid from said space, and a pressure responsive flow control valve means in said passage means connected to the discharge conduit and responsive to said pump discharge pressure and opening said passage means in response to a predetermined pump discharge pressure for relieving the pressure in said space and controlling pump output as a function of pump discharge pressure.

7. In a pump of the angular piston and rotary cylinder block type wherein the cylinder blocks are urged against end heads by pressurized fluid between the blocks for separating the pump inlet and outlet, the improvement of orifice means throttling the outlet flow from said pump, a control plunger having opposed ends slidably mounted in a bore in said pump and respectively connected to pressures on the upstream and downstream sides of said orifice means, a fluid pressure source connected to the space between the cylinder blocks for pressurizing said space, a relief passageway connected to the space between the cylinder blocks, and valve means interposed in said relief passageway and controlled by the position of said control plunger for controlling flow through said passageway whereby pressure in said space will be relieved whenever the pressure differential on opposite sides of the orifice exceeds a predetermined differential.

8. In combination, an angular piston pump having cylinder blocks rotatably mounted in angular relation and axially shiftable toward and away from each other with a pressure space therebetween, hollow angular pistons connecting the blocks and slidable in holes in the blocks, means defining bores in angular relation containing the cylinder blocks, means defining a plurality of inlet and outlet ports in the ends of the bores whereby movement of the blocks away from the ends of the bores will permit leakage across the ends of the blocks to reduce the pump output, a discharge conduit leading from the pump, a fluid pressure source connected to said pressure space for directing fluid pressure into said space, a pressure relief passage leading from said space, valve means interposed in said relief passage, and valve control means operatively connected to said valve means and to said discharge conduit and responsive to flow rate through said discharge conduit to operate said valve means and relieve pressure in said space at a predetermined maximum flow rate whereby a uniform pump output flow rate is maintained.

9. In combination, an angular piston pump having cylinder blocks rotatably mounted in angular relation and axially shiftable toward and away from each other with a pressure space therebetween, hollow angular pistons connecting the blocks and slidable in holes in the blocks, means defining bores in angular relation containing the cylinder blocks, means defining a plurality of inlet and outlet ports in the ends of the bores, whereby movement of the blocks away from the ends of the bores will permit leakage across the ends of the blocks to reduce the pump output, a discharge conduit leading from the pump, a fluid pressure source connected to said pressure space for directing a fluid pressure into said space, a pressure relief passage leading from said space, valve means interposed in said relief passage controlling flow through said relief passage, and valve control means connected to said discharge conduit and responsive to discharge rate and pressure and operatively connected to said valve means opening said valve means at a predetermined maximum pressure and a predetermined minimum flow rate to control pump discharge.

10. In an angular piston pump of the type having cylinder blocks rotatably mounted in angular relation and axially shiftable toward and away from each other together with hollow pistons connecting the blocks and slidable in holes of the blocks, and having an inlet conduit and a discharge conduit, the improvement of a first flow restricting passageway connected to the pump discharge conduit and communicating with the space between the cylinder blocks, and a second flow restricting passageway communicating with the space between the cylinder blocks for venting said space, said flow restricting passageways having sizes to maintain a pressure in said space between the cylinder blocks less than the pressure in said pump discharge conduit and a function of said discharge pressure.

11. In combination, an angular piston pump having cylinder blocks rotatably mounted in angular relation and axially shiftable toward and away from each other with a pressure space therebetween, hollow angular pistons connecting the blocks and slidable in holes in the blocks, means defining bores in angular relation containing the cylinder blocks, means defining a plurality of inlet and outlet ports in the ends of the bores whereby movement of the blocks away from the ends of the bores will permit leakage across the ends of the blocks to reduce the pump output, a discharge conduit leading from the pump, an orifice in said discharge conduit, a pressurizing conduit connecting said pressure space with said discharge conduit, a pressure relief conduit leading from said pressure space, a pressure relief valve plunger, a chamber slidably housing said pressure relief valve plunger and having a head end and a rear end with said valve plunger moving toward said head end to a closed position and moving toward said rear end to an open position, flow ports connected to said pressure relief conduit and positioned to be open to relieve said conduit in said open position of said pressure relief plunger, passage means connecting the head end of said chamber upstream of said orifice and connecting said rear end of said chamber downstream of said orifice, spring means urging the plunger toward the head end of said chamber so that said spring means will be overcome at high pump speeds and increased pump discharge pressure upstream of said orifice to partially unload said pressure space and said blocks, and a spring loaded pressure responsive topping valve connected to the discharge conduit downstream of said orifice and responsive to discharge conduit pressure and connected to said pressure space to open at a predetermined maximum pressure in said discharge conduit and vent said pressure space.

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