June 29, 1965 O. E. SZEKELY 3,191,544

PUMP

Filed May 10, 1962 3 Sheets-Sheet 1

FIG. 1

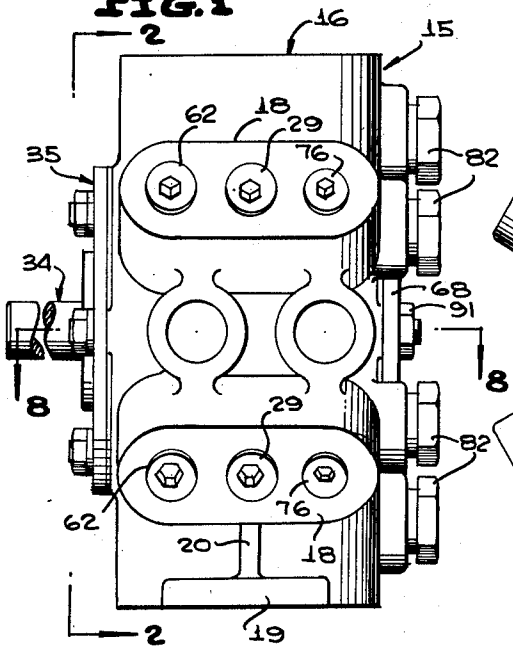


FIG. 2

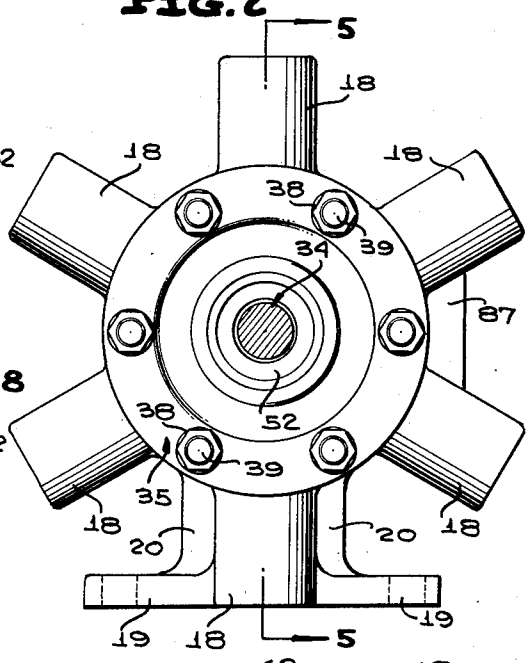


FIG. 3

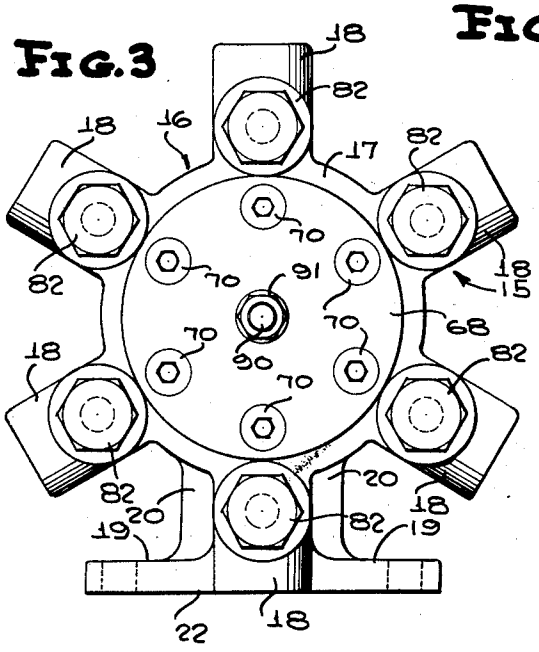
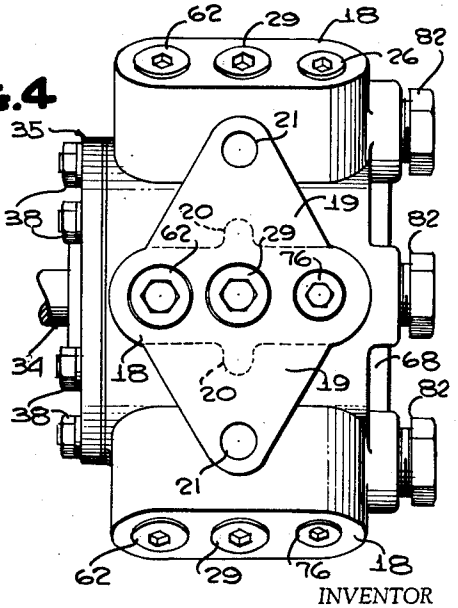


FIG. 4



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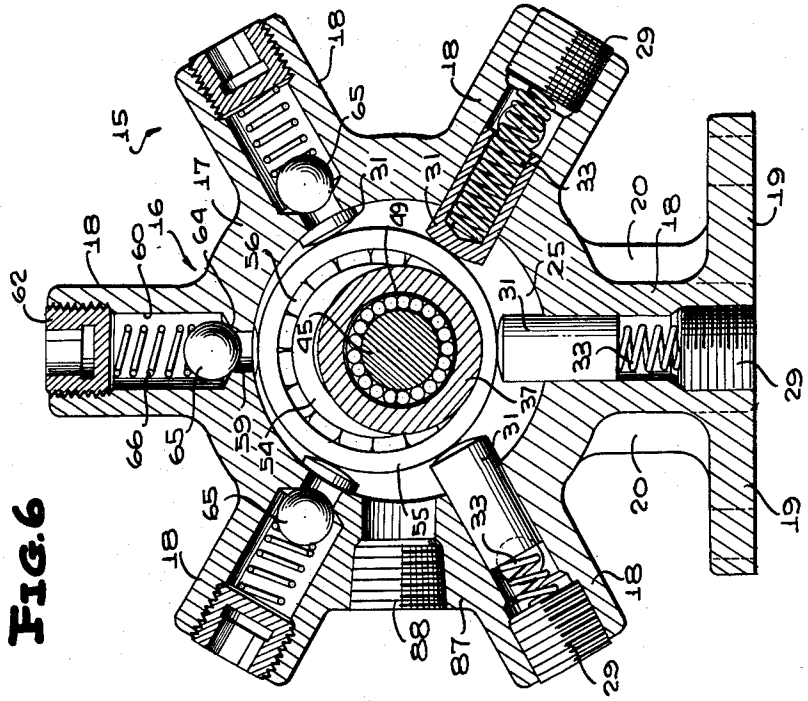


FIG. 6

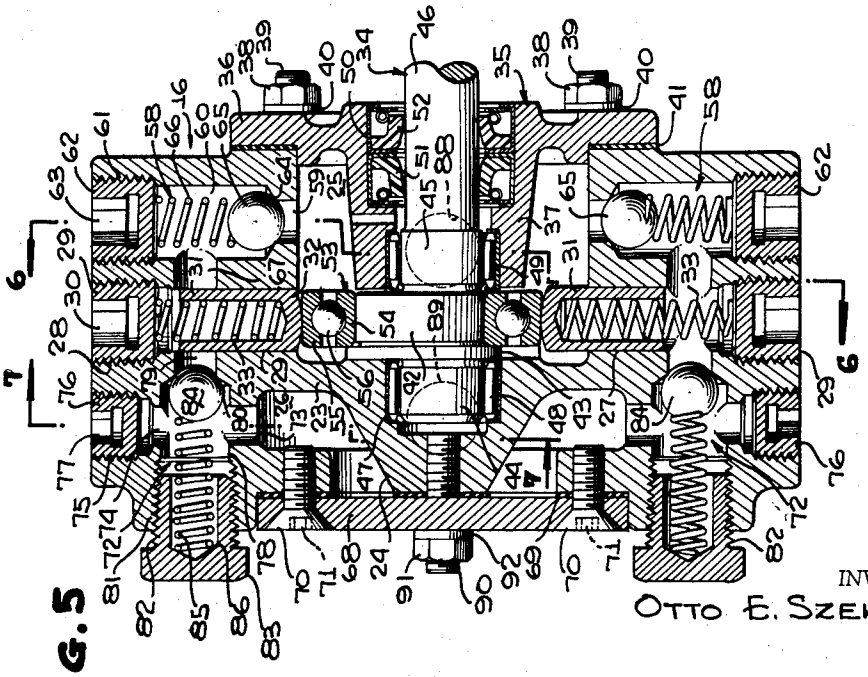


FIG. 5

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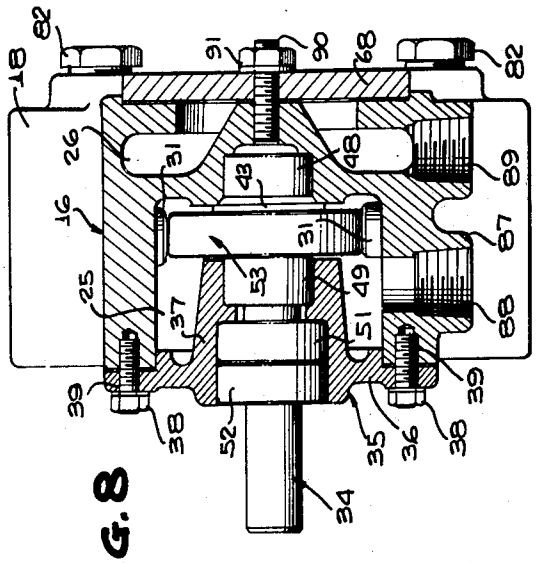


Fig. 8

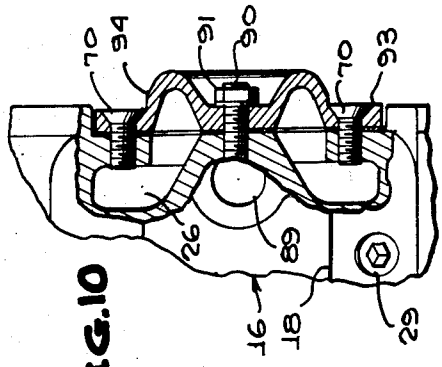


Fig. 10

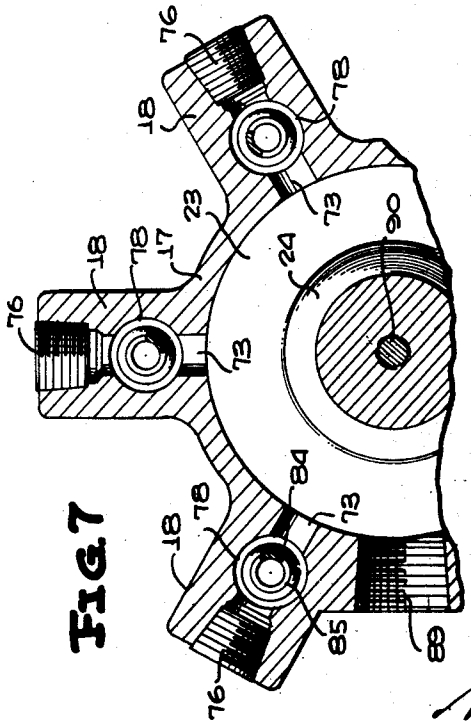


Fig. 7

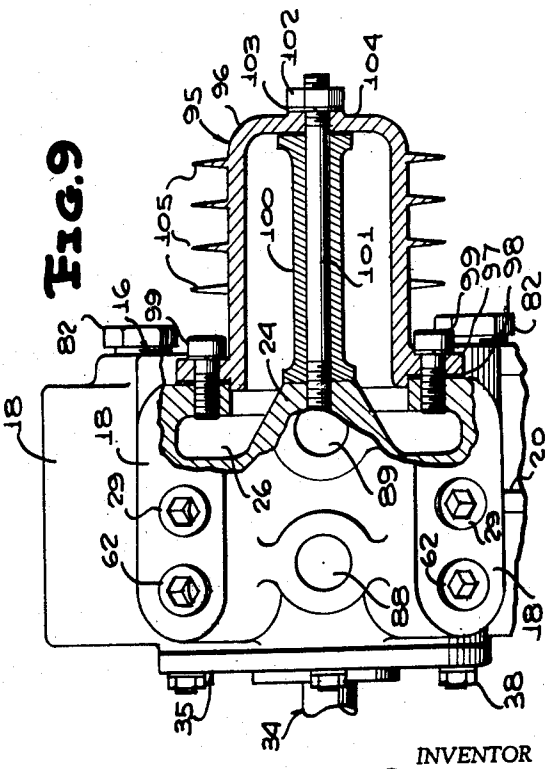


Fig. 9

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3,191,544

PUMP

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Filed May 10, 1962, Ser. No. 193,695
6 Claims. (Cl. 103—174)

This invention relates in general to new and useful improvements in pump construction, and more specifically relates to a novel pump of the multiple piston type.

A primary object of this invention is to provide a novel piston type pump wherein pistons are driven from a cam member in a manner so as to reduce friction to a minimum and thus provide for a marked increase in efficiency.

Another object of this invention is to provide a novel piston type pump for pumping liquids wherein the individual components of the pump are individually removable while the pump is in place so that repair of the pump can be accomplished within a minimum amount of time.

Another object of this invention is to provide a novel piston type pump construction wherein the entire drive mechanism of the pump, including the shaft and bearings of the pump, may be removed by removing a single support fitting.

Another object of this invention is to provide a novel piston type pump wherein the pump will operate at relatively high speeds and under high pressures with a minimum of vibration.

Still another object of this invention is to provide a novel multiple piston pump wherein the pump is driven from an eccentric on the drive shaft thereof, the drive shaft being provided with a bearing of the type including an inner race and an outer race, the inner race being secured to a shaft eccentric and the outer race being engaged with the inner ends of pistons and being held by the pistons against rotation, there being a minimum of movement between the pistons and the outer race so that the friction of the drive connection between the drive shaft and the pistons is reduced to substantially the friction of the bearing.

Another object of this invention is to provide a novel pump construction wherein the pistons are disposed centrally of a housing, and opposite ends of the housing are provided with annular manifolds, one of the manifolds being an inlet manifold and the other of the manifolds being an outlet manifold, and the manifolds having fittings which provided with annular manifolds, one of the manifolds be-readily coupled into existing systems.

A further object of this invention is to provide a novel piston type pump wherein the outlet manifold is formed within one end of the housing of the pump and is in part defined by a cover plate on the end of the pump housing, the cover plate being replaceable so as to vary the capacity of the outlet manifold in accordance with the requirements of the particular liquid being pumped.

A still further object of this invention is to provide a novel piston type pump construction wherein each piston is provided with an inlet valve and an outlet valve, and the piston housing being of a construction wherein each piston may be individually replaced and each of the valves may be individually replaced.

Yet a further object of this invention is to provide a small high pressure pump construction which is suitable for use in aircraft and missiles and which pump has all of the working components thereof readily accessible whereby practically all repairs to the pump may be accomplished while the pump is in place and without the removal of parts other than those which are actually being replaced or repaired.

Another advantage of the pump is that it may be driven in either direction of rotation without affecting the operation thereof.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more clearly understood by reference to the following detailed description, the appended claims and the several views illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is a side elevational view of the pump which is the subject of this invention and shows generally the details thereof.

FIGURE 2 is a vertical sectional view taken along the line 2—2 of FIGURE 1, and shows the details of the drive shaft end of the pump.

FIGURE 3 is an elevational view of the end of the pump opposite from that of FIGURE 2 and shows the details of the pump remote from the drive shaft end.

FIGURE 4 is a bottom view of the pump and shows the general details of the base of the pump.

FIGURE 5 is a longitudinal vertical sectional view taken along the line 5—5 of FIGURE 2, and shows the specific internal construction of the pump.

FIGURE 6 is an enlarged transverse vertical sectional view taken along the line 6—6 of FIGURE 5, and shows further the details of construction of the pump.

FIGURE 7 is an enlarged fragmentary vertical sectional view transversely of the pump along the line 7—7 of FIGURE 5, and shows other features of the pump.

FIGURE 8 is an enlarged horizontal sectional view taken along the line 8—8 of FIGURE 1 and shows the arrangement of the manifolds of the pump and the connections for fluid flow into and out of the manifolds.

FIGURE 9 is a fragmentary elevational view with parts broken away and shown in section of the pump with a modified form of cover plate wherein the outlet manifold capacity is increased.

FIGURE 10 is a view similar to FIGURE 9 and shows another form of cover plate for varying the capacity of the outlet manifold.

Referring now to the drawings in detail, it will be seen that there is illustrated the pump, which is the subject of this invention, the pump being generally referred to by the numeral 15. The pump 15 includes a housing, which is generally referred to by the numeral 16.

Referring now to FIGURE 6 in particular, it will be seen that the housing 16 includes a central portion 17 which is of a generally circular cross-section and which has a plurality of what may be considered cylinder blocks 18 radiating therefrom. As is best shown in FIGURE 4, the lowermost cylinder block 18 has a pair of mounting flanges 19 projecting therefrom, with the mounting flanges being reinforced by ribs 20 which extend vertically along the opposite sides of the cylinder block. The mounting flanges 19 are generally triangular in outline and the remote portions thereof are provided with openings 21 for receiving hold-down bolts (not shown) used in the mounting of the pump. The mounting flanges 19, together with the bottom surface of the lowermost cylinder block 18, defines a supporting base 22 for the pump.

The cylindrical construction of the pump housing 16 does not extend the full axial length thereof, as is shown in FIGURE 5. A web 23 extends across the pump housing 16 to the left of the longitudinal center thereof, and this web 23 is provided with a frusto-conical extension 24 which extends substantially to the left end of the pump housing 16. The web 23 divides the interior of the pump housing 16 into a right hand chamber 25 and a left hand chamber 26, with the right hand chamber 25 being of a greater length than the left hand chamber 26, but with the left hand chamber 26 being of a greater diameter than the right hand chamber 25. The chamber 25, as will be

described hereinafter, is an inlet chamber and the chamber 26 is an outlet chamber.

As is clearly shown in FIGURES 5 and 6, along generally the axial center of the pump housing 16, a plurality of radiating cylinders 27 are formed, each cylinder 27 being aligned with the respective cylinder block 18. At this time, it is pointed out that although the pump 15 is illustrated as having six cylinders arranged in a single row, it is feasible that the number of cylinders will vary, and the number of rows of cyinders could vary. However, the description of the pump herein will be restricted to a pump wherein all of the cylinders lie in a single plane disposed substantially centrally of the longitudinal axis of the pump.

Each of the cylinders 27 terminates at its outer end in an enlarged internally threaded bore 28 in which there is disposed a plug 29. The plug 29, for simplicity, may be in the form of a conventional pipe plug having a tool receiving socket 30 in the outer end thereof to facilitate the removal thereof.

In each of the cylinders 27 there is an elongated piston 31. The piston 31 is of a tubular construction having a closed inner end 32. A spring 33 is telescoped within each piston 31 and has the outer end thereof bearing against the plug 29. The pistons 31 are of a tubular construction solely for the purpose of conserving space.

The pistons 31 are reciprocated within the cylinders 27 by means of a drive shaft 34 which extends out through one end only of the pump housing 16, as is shown in FIGURE 5. The shaft 34 will be driven in any desired manner. The drive shaft 34 is primarily supported by means of a drive shaft support fitting, generally referred to by the numeral 35. The fitting 35 includes a plate 36 and an inwardly projecting hub 37. The plate 36 is removably secured to the right end of the pump housing 16, as viewed in FIGURE 5, by means of nuts 38 threadedly engaged on studs 39 projecting from the central portion 17 of the pump housing 16, as is shown in FIGURE 8, there also being provided lock washers 40 to prevent accidental loosening of the nuts 38. A gasket 41 provides a seal for the connection between the plate portion 36 and the pump housing 16. It is to be noted that the plate portion 36 closes the outer end of the inlet manifold 25.

The drive shaft 34 includes an eccentric 42 adjacent the left end thereof, as viewed in FIGURE 5. A flange 43 extends around the shaft to the left of the eccentric 42 for a purpose to be described in detail hereinafter. To the left of the flange 43, the shaft is provided with a journal 44. A similar journal 45 is disposed to the right of the eccentric 42. A shaft portion 46 extends from the journal 45 to the right and out of the drive shaft support fitting 35.

The right right face of the web 23 is recessed, as at 47, and a suitable bearing 48, preferably a needle bearing, is positioned within the web 23 and receives the journal 44 to aid in the supporting of the drive shaft 34 for rotation. The inner end of the hub 37 is recessed for receiving another bearing 49 which is identical with the bearing 43 and which engages the journal 45. The right end of the drive shaft support fitting 35 is recessed, as at 50, and receives a pair of shaft seals 51 and 52 which engage the shaft portion 46 and prevent the escape of fluid from within the pump housing 16 along the drive shaft 34.

In lieu of the normal pump construction wherein the pistons directly engage the eccentric, the pump 15 incorporates an antifriction bearing 53 carried by the eccentric 42 and engaging the inner end of the pistons 31. The antifriction bearing 53 includes an inner race 54 and an outer race 55 with antifriction rolling members 56 disposed therebetween. The inner race 54 is positioned by abutment against the flange 43. The rolling members 56 are illustrated in the form of balls, although they may equally as well be rollers.

The fluid to be pumped by the pump 15 is delivered

from the inlet manifold 25 to the cylinders 27 by means of inlet valves, each being generally referred to by the numeral 58. The inlet valves 58 are disposed partially in the central portion 17 and partially in the cylinder heads 18 of the pump housing 16. Each inlet valve 58 is placed in communication with the inlet manifold 25 by means of a radiating inlet passage 59.

Each inlet valve 58 includes a radiating passage 60 which is aligned with and forms an enlarged extension of the associated inlet passage 59. Each radiating passage 60 opens through the end of the associated cylinder block 18 with the outer portion of each of the radiating passages 60 being enlarged and internally threaded at 61. A removable plug 62 is normally threaded into the enlarged portion 61 and is provided with a tool receiving socket 63 in the end thereof to facilitate the quick removal of the plug 62.

Due to the differences in diameters of the inlet passage 59 and the radiating passage 60, at the intersection of each inlet passage 59 and radiating passage 60 there is formed an outwardly facing valve seat 64 with which there is engaged a ball valve member 65. A spring 66 is engaged with each valve member 65 to hold the same on its associated seat 64 and the opposite end of the spring 66 bears against the plug 62.

Each of the inlet valves 58 also includes an axial passage 67 which extends from a central portion of the associated radiating passage 60 to the outer end portion of the associated cylinder 27.

It is to be noted that the chamber which defines the outlet manifold 26 opens to the left end of the valve housing 16. In order to close the outlet chamber 26, there is provided a replaceable cover 68. The replaceable cover plate 68 is sealed relative to the pump housing 16 by means of a gasket 69 and is removably secured to the pump housing by a plurality of screws 70. The screws 70 have tool receiving sockets 71 to facilitate the quick removal thereof. Other details of the cover plate 68 will be described hereinafter.

Each of the cylinders 27 has associated therewith an outlet valve, generally referred to by the numeral 72. Each outlet valve 72 is placed in communication with the outlet manifold 26 by means of a radially disposed outlet passage 73. In the forming of the outlet passage 73, a bore 74 is formed in each of the cylinder blocks 18 to the left of the associated cylinder 27, as viewed in FIGURE 5. The bore extends down into the outlet manifold 26. The outer portion of each of the bores 74 is enlarged and internally threaded, as at 75, and a removable plug 76 is threaded thereinto. The plug 76 is provided with a tool receiving socket 77 to facilitate the removal thereof.

Each of the outlet valves 72 includes an axial bore 78 which has a reduced right end portion 79 opening into the outer end of the respective cylinders 27 in opposition to the axial passage 67. The reduction of the right end of the axial passage 78 results in the forming of a valve seat 80. The left end of the axial bore or passage 78 opens through the left end of the valve housing 16 and is both enlarged and internally threaded, as at 81. A plug 82 is threaded into the threaded portion 81 of the axial passage 78 and closes the same. The plug 82 is provided with an outer head portion 83 to facilitate the removal thereof.

It is to be noted that the valve seat 80 is disposed intermediate the intersection of the axial passage 78 with the outlet passage 73 and the associated cylinder 27. Thus, a ball valve member 84 engaged with the valve seat 80 prevents the inward flow of fluid from the outlet manifold 26 into the associated cylinders 27. The valve member 84 is urged towards a seated position on the valve seat 80 by means of a coil spring 85 which bears against the valve member 84 and has the left end thereof telescoped within the interior of the plug 82, the inner end portion of the plug 82 being tubular to provide a bore 86 in which the left portion of the spring 85 is received.

Referring now to FIGURE 6 in particular, it will be seen that the pump housing **16** has a thickened web **87** extending between two adjacent ones of the cylinder blocks **18**. The web **87** is provided with an inlet connecting passage **88**, which is in communication with the inlet manifold **25**, and an outlet connecting passage **89**, which is in communication with the outlet manifold **26**, as is shown in FIGURE 8. It is to be noted that the axes of the connecting passages **88** and **89** are horizontally disposed and are in parallel relation for receiving fittings of parallel inlet and outlet pipes (not shown).

Operation

In the operation of the pump **15**, the drive shaft **34** is rotated in either of the two possible directions. As eccentric **42** rotates, the inner race **54** of the bearing **53** rotates therewith, thereby imparting a generally eccentric motion to the outer race **55**. However, the outer race **55** remains stationary through its engagement with the pistons **31** and the eccentric movement of the eccentric **42** is transmitted to the pistons **31** to effect a reciprocation thereof, the pistons **31** being always urged inwardly against the outer race **55** by means of the springs **33**. At this time, it is pointed out that due to the fact that the outer race **55**, for all practical purposes does not move, there is only a very slight rocking movement between the inner ends of the pistons **31** and the outer race **55**. Thus, the friction of the connection between the drive shaft **34** and the pistons **31** is substantially reduced to the internal friction of the bearing **53** which is very small.

As each of the pistons **31** moves inwardly due to the urging of the associated spring **33**, fluid must be drawn into the outer end of the respective cylinder **27**. Since the valve members **84** prevent the inflow of fluid from the outlet manifold **26** through the outlet valves **72**, fluid flow into the cylinders **27** can be only through the inlet valves **58**. The fluid demand on each of the inlet valves **58** results in the unseating of the associated valve member **65**, and fluid flow from the inlet manifold **25** through the respective inlet valve **58** and into the cylinder **27**. As the piston **31** is urged outwardly by the action of the eccentric **42**, the fluid, that is the liquid being pumped, is urged out of the cylinder **27** by the outward movement of the piston **31**. The liquid being pumped being relatively incompressible, it cannot go into the passages of the inlet valve **58** and therefore moves into the passages of the outlet valve **72** by unseating the valve member **84** from the valve seat **80**. The pumped liquid then passes into the outlet manifold **26** through which it is delivered to the outlet connecting passage **89** and into any outlet pipe connected thereto.

The pump **58** is a high pressure pump and may be considered a metering pump due to the positive displacement of the pistons **31**. However, it is more desirable to maintain a constant pressure than a constant output. In accordance with this purpose, the outlet manifold **26** is made of sufficient size to accommodate the liquid being pumped so that there is no pulsation or variation in the pressure of the liquid being delivered by the pump **15**. An experimental model of the pump has been constructed on a scale conforming generally to the scale of the actual patent drawings in FIGURES 1 through 4, and this pump has operated under pressures of 3,000 p.s.i. without bursting. In order that the cover plate **68** may be light weight and still withstand this tremendous pressure, a stud **90** is threaded into the end of the frusto-conical portion **24** and is passed through the central portion of the cover plate **68** to anchor the same. A nut **91** and a washer **92** serve to clamp the central portion of the cover plate **68** against the frusto-conical portion through the gasket **69**. It is to be understood, however, that when the liquid being pumped is slightly thicker than normal, a slight bulging of the cover plate **68** is permissible so as to momentarily increase the size of the outlet manifold **26** and thus compensate for any variations in pressure in the liquid being pumped.

It is to be noted that the inlet chamber **25** is completely separate from the outlet chamber **26** by the web **23** and that the only passages for fluid between the inlet chamber **25** and the outlet chamber **26** extends through the outer ends of the cylinders **27** and are controlled by the valve members **65** and **84**. Any pressure built up within the outlet chamber **26** normally serves to close all of the valve members **84** except those which have been unseated by liquid being pumped through the respective passages **79**, However, should there be any instantaneous primary pressure that could escape back past the valve members **84**, this primary pressure would not be directed into the inlet chamber **25** since any reverse pressure would immediately result in the closing of the intake valve member **65** and prevent the undesired reverse flow of liquid. Therefore, unlike other pump constructions, the pump **15** is provided with an inlet chamber and an outlet chamber which are separate under all operating conditions of the pump. The high volumetric efficiency of the pump is in part attributable to this construction.

The extremely smooth operation of the pump without vibration is due to the combination of the eccentric weight of the eccentric **42** and the counteracting forces caused by the pumping of the liquid by the pistons. It will be readily apparent that as the eccentric moves about the axis of the shaft **34**, the eccentric weight results in a continuous outwardly moving force which would normally cause vibration. However, this outward moving force of the eccentric is counteracted by the resistance to outward movement of the pistons by the fluid in the outer ends of the cylinders so that the eccentric force of the eccentric is balanced by the eccentric force exerted by the pistons. The discharge of liquid from the cylinders is always opposite to the eccentric weight of the eccentric. Accordingly, there is substantially no unbalance of force, either due to that of the eccentric, or that of the pumping actions of the pistons on one side of the pump as compared to the intake action of the pistons on the opposite side of the pump so that the pump operates extremely smooth and with continuity of discharge.

It is to be understood that the capacity of the outlet manifold **26** may have to be increased, depending upon the particular liquid being pumped. Accordingly, in FIGURE 10, there is illustrated a modified form of cover plate which is referred to by the numeral **93**. The cover plate **93** differs from the cover plate **68** only in that it is provided with an annular bulge **94** surrounding the center thereof. The cover plate **93** is retained in place by means of the screws **70** and the stud **90** and nut **91**.

Referring now to FIGURE 9 in particular, it will be seen that there is illustrated still another form of cover plate, generally referred to by the numeral **95**. The cover plate **95** is in the form of a generally cup-shaped member **96** having a mounting flange **97**. The mounting flange **97** is sealed relative to the pump housing **16** by means of a gasket **98** and is retained in place thereon by means of cap screws **99** in lieu of the screws **70**. In addition, the cup portion **96** is reinforced by a tubular spacer **100** which surrounds an elongated stud **101**, as compared to the stud **90**, so that when a nut **102** is threaded on the stud **101** and tightened down against a lock washer **103** which, in turn, bears against an end wall **104** of the cup portion **96**, in ward deflection of the end wall **104** will be resisted by the spacer **100**. The inner end of the spacer **100** bears against the outer end of the frustoconical portion **24** of the web **23**.

In some instances, it may be desired to slightly cool the liquid passing through the outlet manifold **26**. To this end, the cup portion **96** may be provided with suitable cooling fins **105** to facilitate the transfer of heat therefrom.

It has been experimentally found that different liquids may be pumped at a maximum efficiency by varying the capacity of the outlet manifold **26** in the manner described above. It has also been found through experimentation

that efficiencies as high as 92% are possible with the pump construction and for commercially mass produced pumps, an efficiency on the order of 80 to 85% is expected, as compared to the normal efficiency in the vicinity of 65% for piston type pumps. In addition, in the experimental pumps, no appreciable wear was found and due to the fact that the pressure of the pumped liquid remains substantially constant, as well as the resultant reduction of friction, the operation of the pump is almost vibrationless.

Repair and replacement of pump parts

The pump 15 is intended primarily for use in missiles and aircraft and is constructed so as to be repairable in place with a minimum of effort.

When it is desired to repair or replace the drive shaft 34 or any portion thereof, the drive shaft support fitting 35 is removed by first removing the nuts 38 and the lock washers 40. Then the drive shaft support fitting 35 and the drive shaft 34 are pulled as a unit out of the end of the pump housing 16 without disturbing any of the other components of the pump. The bearing 48 remains within the web 23, but can be removed through the opening in the housing 16. One the other hand, all the other components carried by the drive shaft 34 and the drive shaft support fitting 35 may be readily inspected and replaced, as necessary. On the other hand, in the event quick repairs to a missile or the like are required, an entire new drice shaft and drive shaft support fitting assembly could be placed in the housing 16 with a minimum of effort.

When any one of the pistons 31 or the return spring 33 thereof requires replacement or repairs, this can be accomplished by removing the plug 29 of the particular cylinder 27 which then makes the piston and its associated spring readily accessible.

When any one of the inlet valves 58 is not functioning properly, the plug 62 related to the particular inlet valve is removed, after which the spring 66 and the valve member 65 may be readily removed. The valve seat 64 can be readily inspected with the plug 62 removed and replaced if necessary while the pump 15 remains in place.

With respect to the outlet valves 72, any one of the outlet valves 72 may be readily replaced or repaired by merely removing the associated plug 82. Once the plug 82 has been removed, the spring 85 and the valve member 84 can be removed and replaced, as necessary. Further, inspection of the valve seat 80 becomes possible and, if necessary, the valve seat 80 can be refaced.

The only time it is necessary to remove the pump 15 to repair any part thereof is when there is trouble with the lowermost piston 31 and its associated inlet valve 58 and outlet valve 72. Since the plugs 29, 62 and 76 of the lowermost cylinder block 18 normally will bear against a supporting plate, removal of these plugs will be prevented. However, if the pump 15 is so mounted on the supporting plate wherein the plugs can be removed through the supporting plate, it is not necessary to remove the pump 15 for any repairs thereto.

At this time attention is directed to the fact that all of the operating parts of the pump are disposed on the inlet side of the web 23 with the result that the operating parts are in communication with the inlet chamber 25. Such an arrangement has definite advantages.

It is to be noted that the cylinders 27 open directly into the inlet chamber 25. Thus, during the operation of the pump 15, any of the liquid being pumped which flows past the pistons 21 will return to the inlet chamber. Thus, there is no possibility of loss of the fluid being pumped. Further, in this manner the fluid being pumped can be utilized in lubricating the walls of the cylinders 27.

A further advantage of the operating mechanism being mounted within the inlet chamber 25 is that the eccentric 42, together with the bearing 53 carried thereby, functions as a rotor within the inlet chamber 25 to effect a slight pumping action. This, coupled with the radial arrangement of the inlet passages 59, permits a forced

flow of the liquid being pumped from the inlet chamber 25 through the inlet passage 59 in timed relation to the demand of liquid by the cylinders 27. It has been found that the eccentric 42 provides suitable pumping action to the liquid within the inlet chamber 25 so that free delivery of liquid through the pump 15 is possible when the pistons 31 are removed and replaced by plugs and the outlet valve members 84 are removed. This forced flow of liquid from the inlet chamber 25 through the inlet passages 59 greatly enhances the flow of the liquid to the individual cylinders 27 upon demand.

Although a preferred embodiment of the invention has been illustrated and described herein, it is to be understood that other minor modifications may be made in the pump structure within the spirit and scope of the invention, as defined in the appended claims.

I claim:

1. A high pressure pump comprising a housing having an axial center, a plurality of cylinders formed integral with said housing and slightly projecting therefrom as parts of radiating cylinder blocks, said cylinders being disposed in a single plane and radiating from the axial center of said housing, a piston disposed in each cylinder, an inlet valve and an outlet valve for each cylinder in each cylinder block, a centrally located drive shaft having cam means engaging said pistons for reciprocating said pistons in response to rotation of said shaft, an annular inlet manifold in said housing around said axial center on one side of the plane of said pistons, radially radiating inlet passages in said housing and opening outwardly through said cylinder blocks into said inlet valves; each of said inlet valves including a radial passage extending from and in alignment with a respective one of said inlet passages through the respective one of said cylinder blocks to the exterior thereof, an axial passage opening into an outer portion of a respective cylinder and into an intermediate part of said radial passage, a valve seat at the intersection of said radial passage and the respective inlet passage, a valve member, a spring engaging said valve member to normally hold said valve member on said valve seat, and a removable plug closing the outer end of said radial passage and restraining said spring against outward movement, said plug providing access to said valve seat, said valve member and said spring for replacement and repair, an annular outlet manifold in said housing around said axial center on one side of the plane of said pistons, radiating outlet passages in said housing and opening outwardly through said cylinder blocks into said outlet valves, each of said outlet valves including an axial passage extending from a respective cylinder through an adjacent end of the respective one of said cylinder blocks to the exterior thereof, said first mentioned and second mentioned axial passages being in axial alignment, a respective outlet passage opening into said outlet valve axial passage intermediate the ends thereof, a valve seat around said outlet valve axial passage intermediate the respective outlet passage and cylinder, an outlet valve member engaged with said outlet valve seat, a spring urging said outlet valve member to a seated position, and a removable exposed plug in the end of the respective cylinder block and closing said outlet valve axial passage and bearing on the spring therein, said outlet valve plug providing access to said outlet valve seat, said outlet valve member and said outlet valve spring for replacement and repair, each of said cylinders opening out through the exterior of the respective cylinder block, a removable plug closing the outer end of each cylinder, a spring bearing against each cylinder plug and each piston to hold said pistons in engagement with said cam means, said cylinder plugs providing access to each piston and its associated piston spring for individual replacement, each piston having at least one closed end preventing fluid flow through its associated cylinder, and closure plates partially defining said annular inlet and outlet manifolds

in non-interfering relationship with each of said exposed plugs.

2. A high pressure pump comprising a housing having an axial center, a plurality of cylinders formed integral with said housing and slightly projecting therefrom as parts of radiating cylinder blocks, said cylinders being disposed in a single plane and radiating from the axial center of said housing, a piston disposed in each cylinder, an inlet valve and an outlet valve for each cylinder in each cylinder block, a centrally located drive shaft having cam means engaging said pistons for reciprocating said pistons in response to rotation of said shaft, an annular inlet manifold in said housing around said axial center on one side of the plane of said pistons, radially radiating inlet passages in said housing and opening outwardly through said cylinder blocks into said inlet valves; each of said inlet valves including a radial passage extending from and in alignment with a respective one of said inlet passages through the respective one of said cylinder blocks to the exterior thereof, an axial passage opening into an outer portion of a respective cylinder and into an intermediate part of said radial passage, a valve seat at the intersection of said radial passage and the respective inlet passage, a valve member, a spring engaging said valve member to normally hold said valve member on said valve seat, and a removable plug closing the outer end of said radial passage and restraining said spring against outward movement, said plug providing access to said valve seat, said valve member and said spring for replacement and repair, an annnular outlet manifold in said housing around said axial center on one side of the plane of said pistons, radiating outlet passages in said housing and opening outwardly through said cylinder blocks into said outlet valves; each of said outlet valves including an axial passage extending from a respective cylinder through an adjacent end of the respective one of said cylinder blocks to the exterior thereof, said first mentioned and second mentioned axial passages being in axial alignment, a respective outlet passage opening into said outlet valve axial passage intermediate the ends thereof, a valve seat around said outlet valve axial passage intermediate the respective outlet passage and cylinder, an outlet valve member engaged with said outlet valve seat, a spring urging said outlet valve member to a seated position, and a removable exposed plug in the end of the respective cylinder block and closing said outlet valve axial passage and bearing on the spring therein, said outlet valve plug providing access to said outlet valve seat, said outlet valve member and said outlet valve spring for replacement and repair, each of said cylinders opening out through the exterior of the respective cylinder block, a removable plug closing the outer end of each cylinder, a spring bearing against each cylinder plug and each piston to hold said pistons in engagement with said cam means, said cylinder plugs providing access to each piston and its associated piston spring for individual replacement, each piston having at least one closed end preventing fluid flow through its associated cylinder, closure plates partially defining said annular inlet and outlet manifolds in non-interfering relationship with each of said plugs, said drive shaft opening through one side only of said housing through one of said closure plates and a drive shaft support fitting removably carried by said housing primarily supporting said drive shaft in said housing with said drive shaft being removable from said housing after removal of only said drive shaft support fitting.

3. A high pressure pump comprising a housing having an axial center, a plurality of cylinders formed in said housing, said cylinders being disposed in a single plane and radiating from the axial center of said housing, a piston disposed in each cylindwer, an inlet valve and an outlet valve for each cylinder, a centrally located drive shaft having cam means engaging said pistons for reciprocating said pistons in response to rotation of said shaft, an annular outlet manifold in said housing around said axial center and at one side of the plane of said pistons, outlet passages placing said outlet valves in communication with said outlet manifold, and an interchangeable cover plate on one end of said housing defining a wall of said outlet manifold whereby the volume of said outlet manifold may be selectively varied in accordance with the properties of the fluid being pumped.

4. The high pressure pump as defined in claim 3 wherein said housing has a transverse web dividing said housing into two and forming separate inlet and outlet chambers, said web having an axial extension forming an inner wall of said outlet chamber, a removable cover plate secured to said web extension and forming one end wall of said outlet chamber, communication between said inlet chamber and said outlet chamber being only through said cylinders and said inlet valves and said outlet valves thereof, and said inlet valves always preventing return pressure impulses from being directed into said inlet chamber whereby maximum volumetric efficiency is obtained.

5. The pump of claim 1 wherein due to the positioning of the cylinders along the axial centers of said housing and said drive shaft, said drive shaft may be rotated in either direction with equal pumping results.

6. The high pressure pump as defined in claim 1 wherein said cam means includes an eccentric on said drive shaft, a bearing carried by said eccentric and engaging said pistons, said bearing being of the anti-friction type and including an inner race and outer race, and rolling bearing elements disposed between said races, said inner race being fixed to said eccentric for movement therewith, and said outer race being engaged by said pistons and held substantially motionless thereby with a minimum of relative movement between said outer race and said pistons whereby the force of the eccentric weight of said eccentric is balanced by the resistive forces of said pistons during the pumping strokes thereof whereby the operation of said pump is smooth and without vibration.

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