FIG.1.

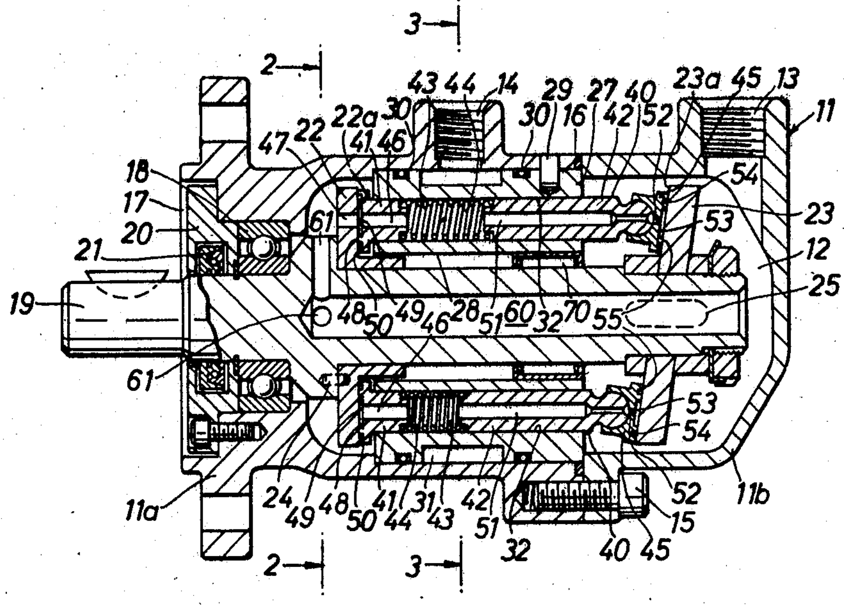

FIG.2.

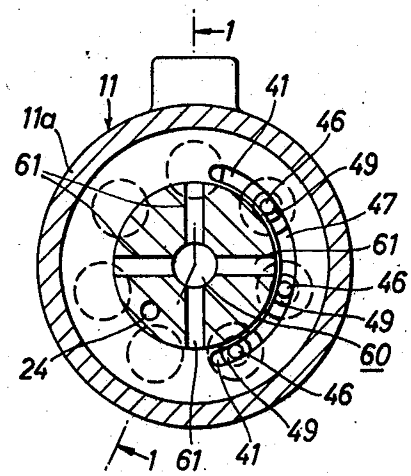

FIG.3.

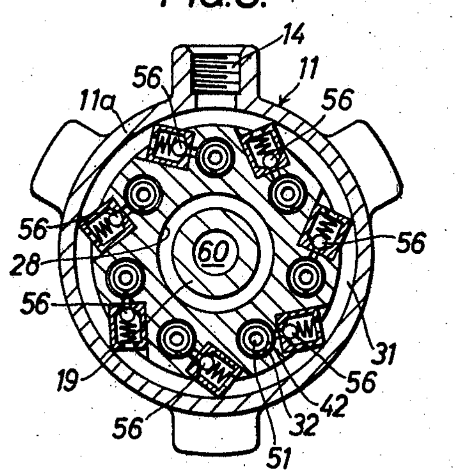

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FIG. 4.

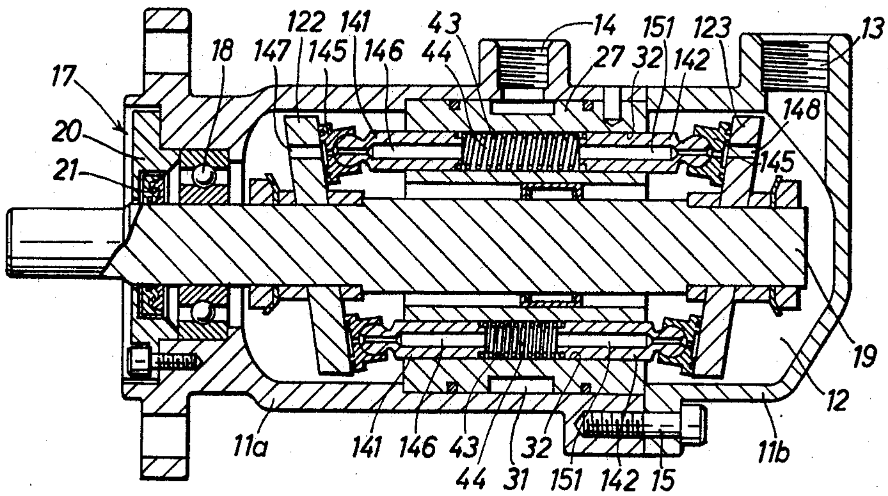
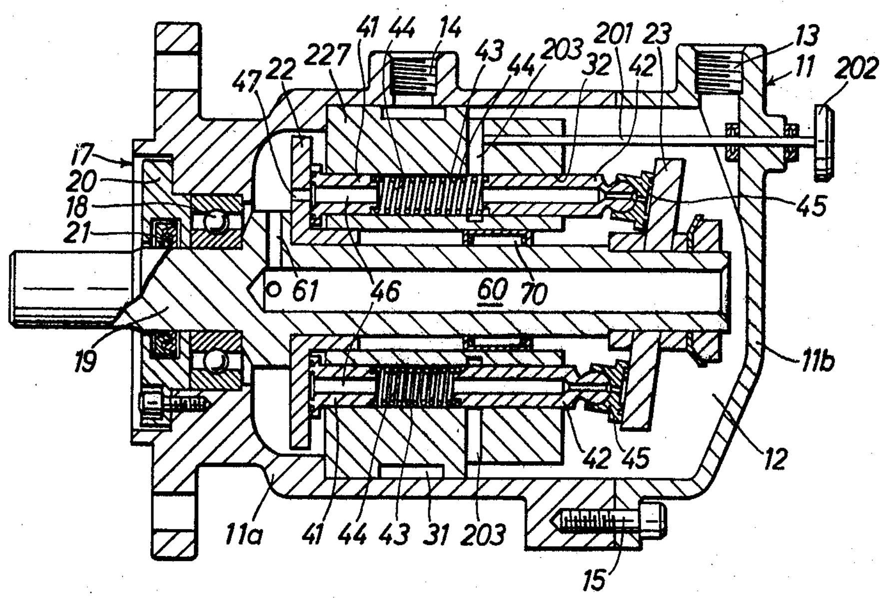


FIG. 5.



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AXIAL PLUNGER PUMP

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Int. Cl. F04b *23/04, 1/14*
U.S. Cl. 103—5 1 Claim

ABSTRACT OF THE DISCLOSURE

This invention provides improved axial plunger pumps in which containment of the thrust involved with the plunger piston operation can be achieved between a pair of disks fixed on the rotating shaft by supporting plunger pump mechanism between said disks so that no use of a thrust bearing is required for supporting the rotating shaft.

BACKGROUND OF THE INVENTION

This invention relates to improved axial plunger pumps, more particularly to axial plunger pumps which can run at a high speed and high pressure.

Axial plunger pumps are known as particularly suited for a high speed and high pressure operation and attempts have been made to provide improved axial plunger pumps for various kinds of use. Generally speaking, however, conventional axial plunger pumps are very complicated in construction and expensive. The provision of a thrust bearing which has been considered heretofore as indispensable to axial plunger pumps makes a limitation of the running speed. The speed which can be obtained with conventional axial plunger pumps is relatively high but not so extremely high. In addition, the life of thrust bearings which are used is short.

The primary object of the invention is to provide new and improved axial plunger pumps which can dispense with any thrust bearing, whereby the above mentioned disadvantages which have been inevitable with conventional axial plunger pumps can be avoided.

Another object of the invention is to provide new and improved axial plunger pumps which are simple in constructions and can be economically manufactured.

A further object of the invention is to provide a new and improved means for cotnrolling the discharge of axial plunger pumps.

SUMMARY OF THE INVENTION

The axial plunger pump of the type to which the invention is applied comprises a housing forming an enclosed chamber therein and having an inlet and an outlet. A driven shaft is rotatably supported by the housing to rotate within the enclosed chamber defined by the housing. A cylindrical barrel is mounted within the housing. This cylindrical barrel is provided with a central aperture having a diameter larger than the diameter of the driven shaft so that said driven shaft extends through the central aperture. The cylindrical barrel partitions liquid tightly in the discharge side of the chamber defined by the housing from the suction side of the chamber. The discharge side communicates with the outlet while the suction side communicates with the inlet. The cylindrical barrel is also provided with a plurality of cylindrical apertures extending in parallel to the axial direction of the shaft and satellitically arranged with respect to the central aperture.

According to the invention a pair of disks are fixed on the rotating shaft in such a spaced relationship that the distance between said pair of disks continuously varies

along the circular direction of arrangement of the above mentioned satellitic apertures. In an embodiment of the invention one disk extends in a plane normal to the axis of the rotating shaft while the other extends an inclined plane with respect to the axis of the shaft. The above mentioned relationship between the two disks can also be achieved by using two differently, for example, symmetrically inclined plates. In any case, the two disks are spaced from the opposite ends of the cylinder barrel, respectively.

According to the invention, an extensible plunger assembly is inserted in each of the satellitically arranged apertures of the cylinder barrel. The extensible plunger assembly comprises a pair of axially slidable plug members inserted in the cylindrical aperture to close the opposite end openings thereof in such a spaced relation as to form an extensible pump chamber therebetween and a spring inserted therebetween for urging them to be alienated from each other. The outer ends of the slidable plug members engaging sealingly and slidably with the two disks at their opposed surfaces, respectively.

Means are provided for communicating the pump chamber in each of the satellitically arranged apertures selectively with the suction and discharge side of the chamber defined by the housing so that the liquid to be pumped, for example, oil is introduced from the suction side to the pump chamber and then discharged from the pump chamber to discharge side during the extension and retraction operation of the plunger assembly, respectively.

In a preferred embodiment of the invention, each of the pump chambers is communicated with the discharge side of the chamber defined by the housing through a check valve and means are provided for communicating the pump chamber with the suction side of a chamber defined by the housing through an opening formed in at least one of the two disks and a passageway formed in the slidable plug member engaging the disk having said opening. The passageway of the slidable plug member is capable of communicating with said opening of said disk during the extension stroke of the plunger assembly.

In the above mentioned manner, containment of the thrust produced with the plunger piston operation can be achieved between a pair of disks fixed on the rotating shaft so that no use of a thrust bearing is required for supporting the rotating shaft. No use for any thrust bearings enables the axial plunger pump to run at a much higher speed than possible with use of a thrust bearing.

The cylinder barrel having a plurality of pump chambers may be so mounted within the housing as to be movable in the direction of the axis of the rotating shaft. In such an embodiment if a port is provided for communicating the pump chamber with the suction side of the chamber defined by the housing when the plunger assembly is in an extended position, it becomes possible to control the discharge by changing the relative position of the plunger assembly with respect to the cylinder barrel since the effective stroke of each of the plunger assemblies is changed accordingly.

Other features and advantages of the invention will become apparent from the detailed description of the preferred embodiments of the invention with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a longitudinally sectional view, taken along the line **1—1** of FIGURE 2, of an axial plunger pump showing an embodiment of the invention;

FIGURE 2 is a vertical sectional view at the line **2—2** of the FIGURE 1;

FIGURE 3 is a vertical sectional view at the line **3—3** of FIGURE 1;

FIGURE 4 is a longitudinal sectional view of an axial plunger pump similar to FIGURE 1 showing another embodiment of the invention; and

FIGURE 5 is a longitudinal sectional view of an axial plunger pump similar to FIGURE 1 showing a further embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, especially to FIGURES 1 to 3, there is illustrated an axial plunger pump including a housing or casing generally indicated as **11**. The housing **11** comprises a pair of members **11***a* and **11***b* which cooperate to form an enclosed chamber **12** having an inlet **13** and an outlet **14**. The reference numeral **15** indicates a screw connecting the cooperating members **11***a* and **11***b* to each other and the reference numeral **16** indicates packing seal means at contact surfaces of the cooperating members **11***a* and **11***b*. The member **11***a* has an end opening **17** for receiving a bearing **18** which in turn supports rotatably a driven shaft **19**. The reference numeral **20** indicates an end cover plate having oil seal means **21** for sealingly closing the opening **17** of the member **11***a*.

The driven shaft **19** which extends into the chamber **12** is connected to a drive mechanism (not shown) at the outside of the housing **11**. A pair of disks **22** and **23** are fixed on said driven shaft **19** within the enclosed chamber **12**. The disk **22** is mounted on the shaft in a normal relation to the axial direction thereof while the disk **23** is an inclined plate so that the distance between the two disks **22** and **23** continuously varies along a circular direction. The disk **22** is secured by a screw **24** to the shaft **19** and the inclined disk **23** is secured by means of a key **25** and a nut **26** to the inner end of the shaft **19**.

Within the housing **11** there is mounted a cylinder barrel **27** which is provided with a central aperture **28** having a diameter larger than the outer diameter of the shaft **19** so that the shaft **19** extends through the aperture **28**. The cylindrical barrel is secured by screws (only one of which is indicated as **29**) to the member **11***a* in a sealing engagement with use of O-rings **30** so that the outlet **14** is liquid-sealed tightly by the cylinder barrel pertitioned from the chamber **12**. The cylinder barrel **27** is provided at its outer periphery with an annular recess **31** which communicates with the outlet **14**. The cylinder barrel **27** is also provided with a plurality of elongated cylindrical apertures **32** arranged in a circle around the shaft **19**, in other words, satellitically with respect to the central apertures **28**, and extending in directions parallel to the shaft **19**.

In each of the cylindrical apertures **32** there is inserted an extensible plunger assembly generally indicated as **40**. The extensible plunger assembly **40** comprises a pair of slidable plug members **41** and **42** inserted in the cylindrical apertures **32** to close the opposite end openings thereof, respectively, so as to form a pump chamber **44** therebetween in cooperation with the cylindrical apertures **32**. A coil spring **43** is inserted between the inner ends of the slidable plug members **41** and **42** so as to urge the slidable members **41** and **42** outwardly, respectively. The outer ends of the slidable members **41** and **42** abut sealingly and slidably on the opposed surfaces **22***a* and **23***a* of the disks **22** and **23**, respectively. The outer end of the member **41** is in direct contact with the surface **22***a* while the outer end of the member **32** engages through a swivel block **45** with the surface **23***a*.

The slidable member **41** is formed with a through oil passageway **46** for introducing oil into the pump chamber **44** through a window opening **47** formed in the perpendicular disk **22**. The window opening **47** is of an elongated arc form as shown in FIGURE 2 so that the passageway **46** may communicate with the chamber **12** only for a certain rotating angle of the disk **22** which corresponds to the extension stroke of the plunger assembly **40**. The end surface **48** of the slidable member **41** which is in contact with the inner surface **22***a* of the disk **22** is provided with a central cavity **49** and an annular recess **50** so that the oil pressure which will be produced in the pump chamber **44** is supplied between the contact surfaces **48** and **22***a* so as to provide a static pressure bearing system. In order to provide static pressure bearng system between the swivel block **45** and the surface **23***a* of the disk **23** as well, the slidable member **42** is provided with an oil passageway **51** extending in its axial direction and communicating with a central port **52** which is formed in the swivel block, **45**. The swivel block **45** is provided with a central cavity **53** and an annular recess **54** at its end surface **55** which is always in contact with the surface **23***a* of the inclined disk **23**. The port **52** communicates the central cavity **53** with the oil passageway **51**.

The pump chamber **44** of each of the cylindrical apertures **32** is communicated to the annular recess **31** through a check valve means **56** which allows the pressure oil to be discharged to the annular recess **31** and then to the outlet **14**.

The driven shaft **19** is provided with an axial oil passageways **60** and a pluarlity of radial oil passageway **61**. The axial passageway **60** is opened at its one end to the chamber near the inlet **11** and communicated at its inner end with the radial passageways **61** which are in turn opened at the position near the opposite surface of the perpendicular disk **22** to the surface **22***a*. The shaft **19** is also rotatably carried by a needle bearing **70** which is in turn supported by the cylinder barrel **27** at its central aperture **28**.

The operation of the apparatus illustrated in FIGURES 1 to 3 is as follows:

When the shift **19** is driven to rotate, the two disks **22** and **23** are rotated with the outer ends of the slidable members **41** and the swivel blocks **45** engaging with the slidable members **42** sliding on the opposed surfaces **22***a* and **23***a* of the disks **22** and **23**, respectively, under pressure and sealing condition. The distance between the two disks **22** and **23** at the position of each of the plunger assemblies **40** varies continuously. While the slidable member **41** abuts against the disk **22** perpendicular to the axis of the shaft, there is no substantial movement of the member **41**, the other slidable member **42** abutting against the inclined disk is enforced to a reciprocating movement along the cylindrical aperture **32** whereby the volume of the pump chamber **44** is varied. In the extension stroke of the plunger assembly **40**, oil flowing into the chamber **12** from the inlet **13** and passing through the passageways **60** and **61** is introduced to the pump chamber **44** through the window opening **47** of the disk **22** and the passageway **46** of the member **32**, while the check valve **56** is in a closed position. This is the suction stroke. During the retraction stroke of the plunger means **40**, pressure oil is discharged through the check valve **56** to the annular recess **31** which is communicated with the outlet **14**, while the slidable member **41** travels the blind portion of the disk **22** so that the passageway **46** is kept in a closed condition.

According to the invention the thrust due to the pumping operation of plunger assemblies **40** is fully supported by the two disks **22** and **23**. The shaft **19** can, therefore, be supported by radial bearings **18** and **70** alone and dispense with any thrust bearing.

Another embodiment of the invention is illustrated in FIGURE 4, in which the same reference numerals as used in FIGURE 1 indicate the corresponding parts, respectively. In the modification shown in FIGURE 4, a pair of inclined disks **122** and **123** are fixed on the driven shaft **19**. These two disks **122** and **123** extend symmetrically inclined planes, respectively, with respect to the axis of the shaft **19** so that both the two slidable members **141** and **142** which correspond to the members **41** and **44** illustrated in FIGURE 1 are enforced to simultaneous axially reciprocating movements which cooperate to produce the expansion and contraction operation of the pump chamber **44** formed between them. The engagement of the member **141** to the inclined disk **122** is carried out in the same manner as the engagement of the member **142** to the inclined disk **123**. The latter is thus similar to the engagement of the member **42** to the inclined disk **23** illustrated in FIGURE 1. The reference numeral **145** indicates the swivel block similar to the swivel block **45** of FIGURE 1. Introduction of oil from the chamber **12** into the pump chamber **44** is carried out through both the passageways **146** and **151** which can communicate through central ports **152** with window openings **147** and **148** formed in the inclined disks **122** and **123**, respectively. Each of the window openings **147** and **148** is formed in a similar manner to the window opening **47** of the disk **47** shown in FIGURE 1. The structure and the operation of the other parts of the embodiment of FIGURE 4 are substantially identical with those of corresponding parts illustrated in FIGURES 1 to 3.

A further modified embodiment of the invention is illustrated in FIGURE 5, in which the same reference numerals as used in FIGURE 1 indicate the corresponding parts, respectively. In the embodiment shown in FIGURE 5, the cylinder barrel **227** is engaged within the housing **11** so as to be slidable in an axial direction with the sealing angagement between the outer periphery of the barrel **227** and the inner wall of the housing **11** being maintained. The reference numeral **201** indicates a screw for driving the cylinder barrel **227**. The screw **201** is operable by a handle **202** outside of the housing. In connection of the slide movement of the cylinder barrel, importance exists in the provision of a port for communicating each of the pump chambers **44** with the suction side of the chamber **12** when each of the plunger members **42** is in a retracted position with the plunger assembly **40** being in an extended state. It will be apparent that so far as the pump chamber is communicated through a port **203** with the suction side, no pumping operation can be effected. The effective discharging operation starts after the inner end of the plunger member **42** goes leftwardly over the port **203**. Accordingly, the effective stroke of the plunger member **42** can be changed by moving the barrel **227** in an axial direction to change the relative position of the port **203** to the plunger member **42**, whereby the discharge can be controlled at will. The structure and the operation of the other parts illustrated in FIGURE 5 are substantially identical with those of the corresponding parts illustrated in FIGURE 1.

What I claim is:

1. An axial plunger pump comprising:

a housing forming an enclosed chamber having an inlet and an outlet, said inlet being at one end of the housing and said outlet being intermediatelly disposed on the housing;

a driven shaft rotatably mounted axially within the enclosed chamber;

a bearing arranged in the housing at the end remote from the chamber inlet which bearing mounts the driven shaft for rotational movement;

a cylindrical barrel having an external centrally disposed annular recess, a central through aperture, a plurality of through apertures satellitically arranged with respect to the central aperture and a port extending from each of the satellitically arranged through apertures to the annular recess, said cylindrical barrel being mounted within the housing in liquid sealing relationship and located to provide alignment of the annular recess with the chamber outlet;

a first disk fixedly mounted on the driven shaft adjacent the cylindrical barrel and in proximity to the bearing mount, said first disk being disposed perpendicularly to the driven shaft;

a second disk fixedly mounted on the driven shaft adjacent the end of the cylindrical barrel remote from the first disk, the second disk being inclined with respect to the axis of the shaft;

a plurality of extensible plunger assemblies located in the satellitically arranged aperture in the cylindrical barrel, each of said plunger assemblies comprising a first and a second slidably arranged section having axial through bores and a spring located between the sections to bias the sections away from each other and into engagement with the first and second disks respectively;

a check valve in each of the ports between the satellitically arranged apertures in the cylindrical barrel and the annular recess;

means for effecting communication between the chamber inlet and the axial bores in each of the plunger assemblies, comprising an axial through bore in the driven shaft, radially extending bores in the driven shaft extending perpendicularly from the axial passageway in the driven shaft at a location adjacent to the first disk on the side thereof remote from the plunger assemblies, and a window opening in the first disk aligned with the bores in the plungers and extending for a length of at least two plunger openings; and

a needle bearing arranged in the central aperture of the cylindrical barrel of the end nearest the inlet to support the driven shaft.

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