Feb. 16, 1971 P. SADLER 3,563,678

PUMPS

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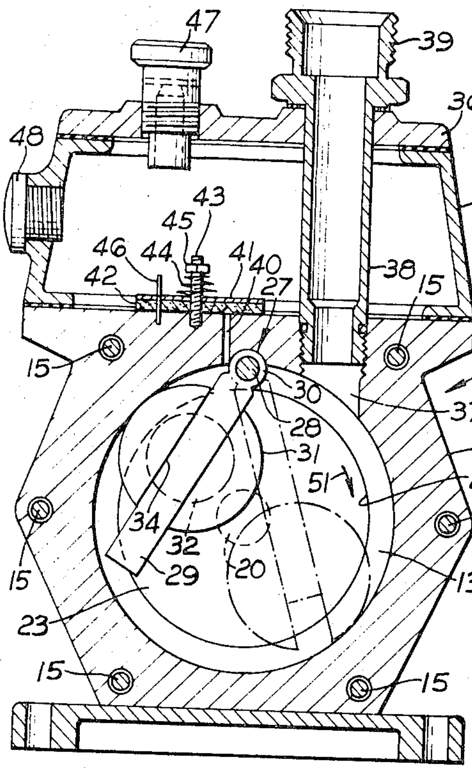

Fig. 1.

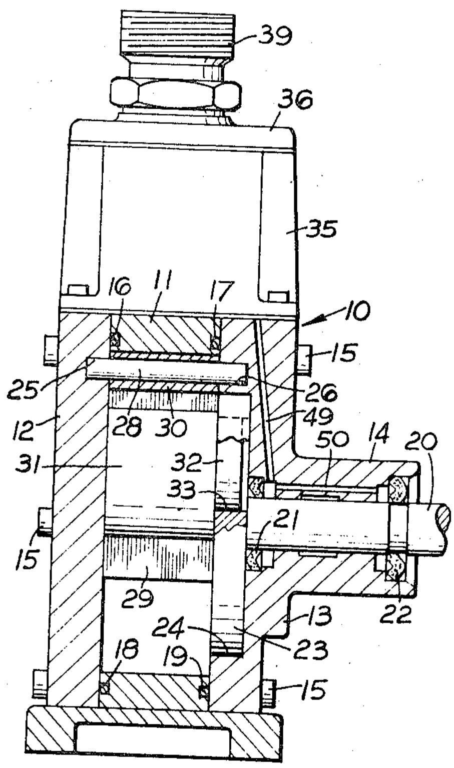

Fig. 2.

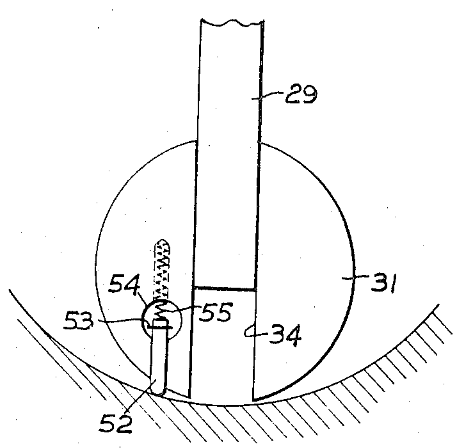

Fig. 4.

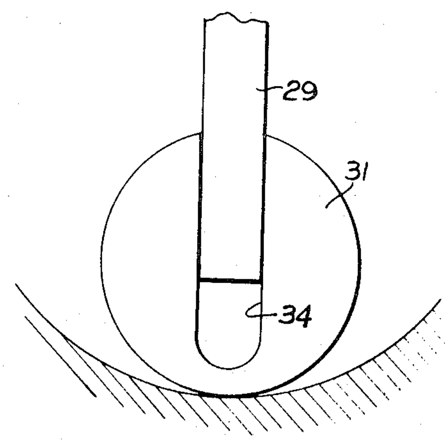

Fig. 3.

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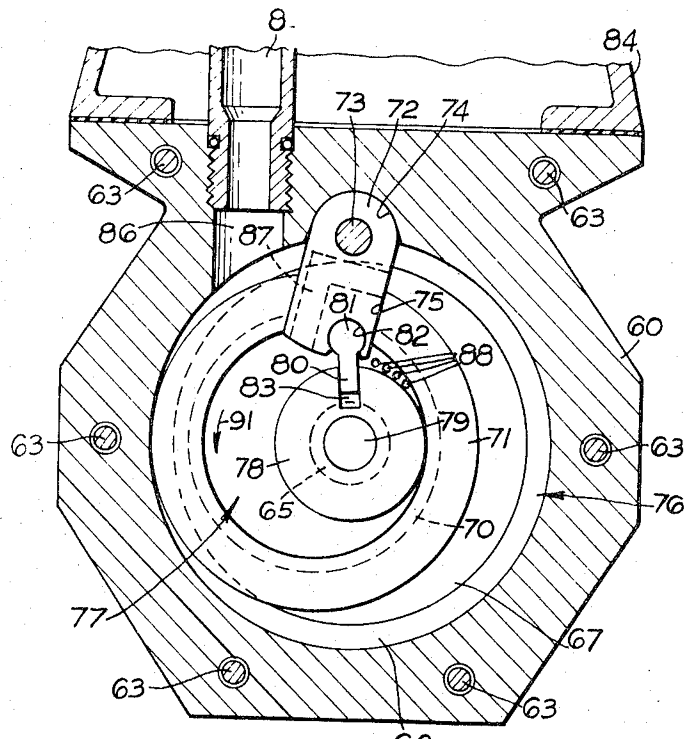

Fig. 5.

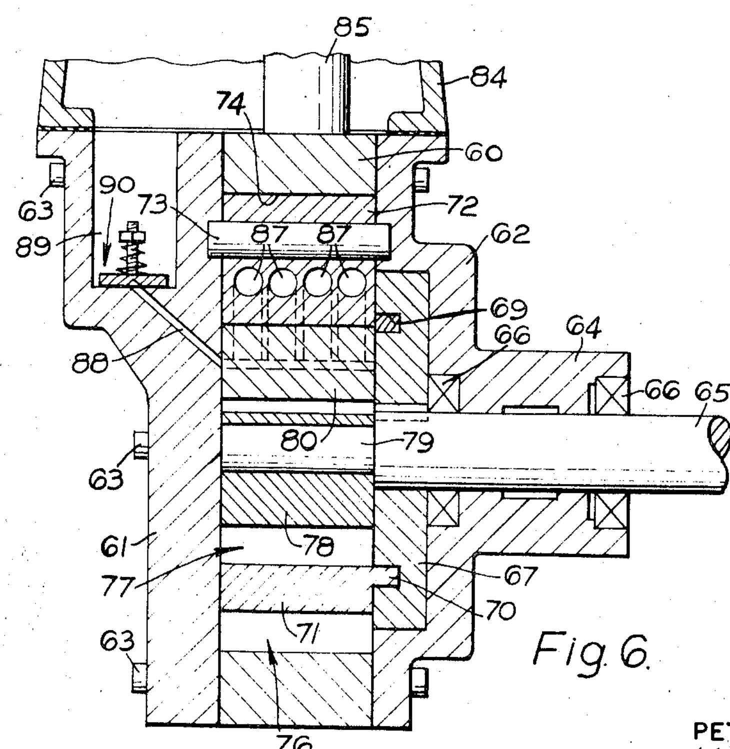

Fig. 6.

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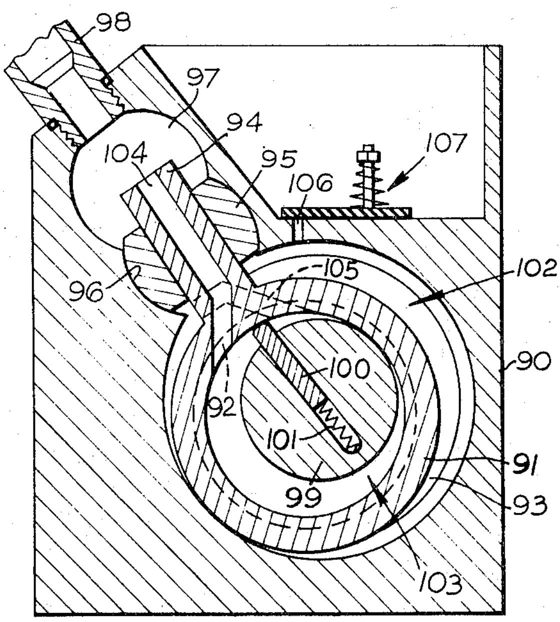

Fig. 7

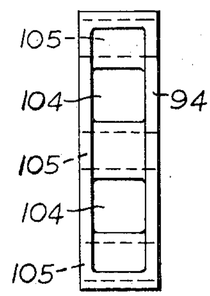

Fig. 8.

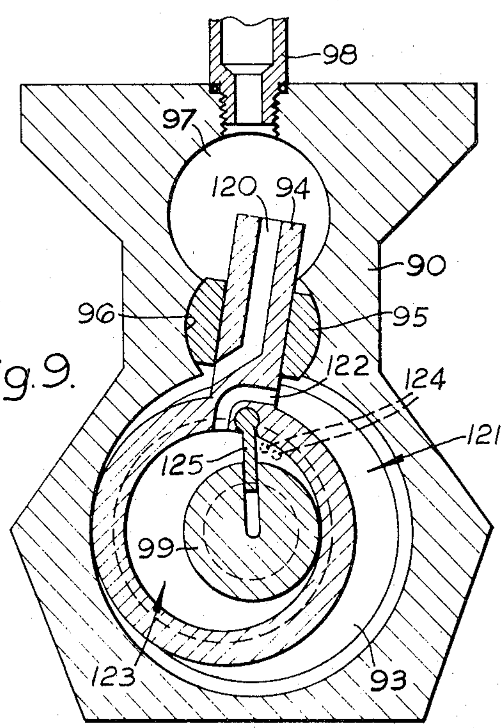

Fig. 9.

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PUMPS

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U.S. Cl. 418—6 2 Claims

ABSTRACT OF THE DISCLOSURE

A rotary piston pump, wherein a circular piston moves orbitally within a cylindrical pumping chamber within a stator with inlet and outlet ports being provided, one to each side of a pivoting vane cooperating with both the stator and the piston to form a partition in the pumping chamber, characterized in that the rotary piston is carried by a rotary end disc rotated by a main spindle and defining an end wall or part of an end wall of the pumping chamber.

This invention concerns pumps and has for its object to provide a construction of rotary piston pump, intended primarily as a vacuum pump, which is improved as compared with prior known constructions in that it can be so constructed as to provide for a considerably increased volumetric displacement in comparison with comparable known pump constructions having a substantially identical stator-enclosed volume.

In the prior known rotary piston pumps, the dimensions of the piston or rotor (which moves orbitally within a cylinder or stator) are dictated by the fact that it has been customary to mount the piston or rotor eccentrically directly onto a driving shaft of the pump. Accordingly, the minimum diameter of the piston must, in the prior proposals, always approximate to the radius of the interior space of the cylinder or stator, in order that it may both be connected to the shaft and lie with part of its curved surface close to the inner wall of the cylinder or stator. The displacement of the known pumps is, accordingly, restricted.

According to the present invention, there is provided a rotary piston pump comprising a stator enclosing a cylindrical pumping chamber, a piston, which is circular in cross-section and smaller in diameter than the pumping chamber, arranged in the pumping chamber with its axis parallel to the chamber's axis, means, in the form of a rotary end disc defining an end wall, or part of an end wall, of the pumping chamber, for causing the piston to move orbitally within the pumping chamber so as always to be close to the curved wall thereof, a vane co-operating with the stator and the piston to form a partition in the pumping chamber, and an inlet port and an outlet port communicating with the pumping chamber, one to each side of the vane.

The pump of the invention accordingly does not have its piston connected directly to the shaft, but is connected thereto in such a way as not to impose the above-discussed restriction on the size of the piston or rotor, so that improved displacement can be obtained with appropriate dimensioning of the piston.

In order that the invention may be fully understood, it will be described further, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a cross-sectional front view illustrating a first embodiment of the pump of the invention;

FIG. 2 is part-sectional end view of the pump of FIG. 1;

FIG. 3 is an enlarged fragmentary detail showing an alternative form which the piston of the pump of FIGS. 1 and 2 may take;

FIG. 4 is a view similar to FIG. 3 but showing yet another alternative form for the piston;

FIG. 5 is a cross-sectional fragmentary front view of a second embodiment of the pump of the invention;

FIG. 6 is a cross-sectional end view of the pump of FIG. 5;

FIG. 7 is a view similar to FIGS. 1 and 5 but showing a third embodiment of the pump of the invention;

FIG. 8 is a detached top view of the vane of the pump of FIG. 7; and

FIG. 9 is a view similar to FIGS. 1, 5 and 7 but showing a fourth embodiment of the pump of the invention.

Referring firstly to FIGS. 1 and 2, these figures illustrate a first embodiment of pump **10** conforming to the invention, which is a single stage pump.

The pump **10** comprises a stator or casing composed of an intermediate body **11** machined internally to provide a cylindrical pumping chamber of short axial length, a blank cover plate **12** closing off one end of the body **11** and a bearing cover plate **13**, formed integrally with a central bearing sleeve **14**, closing off the other end of the body **11**. Bolts **15**, through the cover plates **12** and **13** and the body **11**, clamp together these latter parts which are sealed relative to one another by O-rings **16** and **17** provided in respective grooves **18**, **19** in the faces of the body **11**. A main spindle **20** extends through the bearing sleeve **14** and is sealed relative thereto by packings **21**, **22** accommodated in respective recesses in the sleeve **14** which carries, on its end facing the interior space of the body **11**, a rotary end disc **23** which is set into a recess **24** in the bearing cover plate **13** and is an accurate clearance fit in such recess **24**. The rotary end disc **23** defines most of one end wall of the cylindrical pumping chamber within the casing, the other end wall of which is provided by the blank cover plate **12**.

Machined into the cover plates **12**, **13** so as to be aligned parallel to the axis of the cylindrical pumping chamber are circular pivot apertures **25**, **26** (FIG. 2), a groove **27** in the body **11** opening into the pumping chamber and extending between the confronting ends of the apertures **25**, **26**. A pivot **28** locates by its ends in the apertures **25**, **26** and serves for the mounting in the body **11** of the casing of a vane **29** which is of width substantially equal to the axial length of the cylindrical pumping chamber, and has, on one end, a generally circular-sectioned pivot head **30** through which the pivot **28** extends. The vane **29** is of overall length approximately equal to three-quarters of the diameter of the pumping chamber, and projects into the pumping chamber so as to be swingable therein about the axis of the pivot **28**.

Also disposed in the pumping chamber is a rotary piston **31**, this being effectively in the form of a circular disc of axial thickness substantially equal to the axial length of the pumping chamber. This piston **31** is of diameter less than half of the diameter of the pumping chamber and is formed integrally with an axial stub spindle **32** which projects into an eccentric aperture **33** in the rotary end disc **23**, so that rotation of the end disc **23** by means of the main spindle **20** causes orbital movement of the rotary piston **31** within the pumping chamber. The arrangement is such that in whatever position the piston **31** may be there is always only a minimal clearance between the outer peripheral curved surface of the piston **31** and the curved surface defining the pumping chamber, as will be evident from FIG. 1.

The rotary piston **31** has a slot **34** extending diametrically thereacross, and the pivoted vane **29** extends into this slot, being a close sliding fit therein.

Bolted onto the top of the stator or casing is an oil reservoir **35** which has a top closure plate **36** and is open at its bottom. An inlet port **37**, extending through the body 11 and communicating with the pumping chamber close to the pivot 28, to one side of the vane 29, has an inlet tube 38 screwed therein. This inlet tube 38 extends through the reservoir 35 and the top closure plate 36 and terminates in a union or coupling 39.

A very narrow outlet port or passage 40, also through the body 11, communicates with the pumping chamber close to the pivot 28 but to the other side of the vane 29 as compared with the inlet port 37. This outlet port 40 opens to the top surface of the stator or casing in register with a non-return valve comprising a valve disc 41, having a resilient facing 42, resting on the top surface of the stator or casing. A stud 43, secured into the stator or casing, projects upwards through a central clearance hole in the disc 41 and a spring 44, located on this stud 43 by a nut 45, resiliently presses the disc 41 down to close the outlet port 40. An offset peg 46, extending through the valve disc 41 and locating in the body 11, prevents the valve disc 41 from rotating.

An outlet plug 47 having a very restricted outlet orifice, to prevent unintentional entry of foreign matter into the reservoir 35, is provided in the top closure plate 36, and a filling plug 48 is provided in one end of the reservoir 35.

The reservoir 35 will, in use, be filled to about half its height with a suitable vacuum oil, and it will be seen that lubricating ducts 49, 50 extend through the bearing cover plate 13 and sleeve 14 to enable the oil flow to the packages 21, 22. Naturally, also, vacuum oil will be provided in the pumping chamber to ensure that a film thereof is produced between all of the closely-adjacent rleatively moving surfaces.

It will be appreciated from the foregoing description that the pivot head 30, of the vane 29, being a close fit in the groove 27, may be regarded as sealing the corresponding end of the vane 29 relative to the stator of the pump, whilst the rotary piston 31, being a close fit to the inner curved wall of the pumping chamber and having the vane 29 a close sliding fit through the slot 34 thereof, may be regarded as also sealing the vane 29 relative to the stator at a position (which varies according to the orbital position of the rotary piston 31) spaced away from the pivot head 30. The vane 29 and piston 31 accordingly together effectively constitute a movable partition in the pumping chamber of the stator.

For consideration of the operation of the pump, it is convenient to assume the rotary end disc 23 to be in an initial position corresponding to the rotary piston 31 being as close as possible to the pivot head 30 of the vane 29. In this position, the contact of the rotary piston 31 with the wall of the stator is, effectively, between the pivot port 37 and the outlet port 40 both of which are open to the pumping chamber of the pump. As the rotary end disc 23 is now rotated, in the direction indicated by the arrow 51 in FIG. 1, it moves the rotary piston 31 orbitally so that after a very short angular movement of the end disc 23, the piston moves past the inlet port 37 and the vane 29 also swings towards such inlet port 37 which is now open only to a confined space, which may be regarded as a suction space, defined between the piston 31, and the adjacent part of the vane 29 between the piston 31 and the pivot head 30 of the vane 29. The remainder of the space within the pumping chamber, which is still open to the outlet port 40, may be regarded as a compression space.

As the end disc 23 continues to rotate, moving the rotary piston 31 peripherally around the circular wall of the pumping space, the suction space open to the inlet port 37 increases progressively in volume to suck in through the inlet port 37 and tube 38, whilst the compression space open to the outlet port 40 correspondingly decreases in volume and the contents thereof are forced out through the outlet port 40, past the non-return valve, through the oil in the reservoir 35, and to atmosphere through the outlet plug 47. These actions continue throughout a single entire rotation of the end disc 23 and corresponding orbital movement of the rotary piston 31, until such time as the piston 31 passes the outlet port 40. At this stage, the suction space is constituted by the entire interior space of the stator, and the compression space has effectively reduced to nothing. As the rotation of the end disc 23 continues to move past the inlet port 37 again, the space which was previously the suction space now becomes the compression space with the contents thereof being forced out through the outlet port 40, and a fresh suction space is developed in communication with the inlet port 37, and the above described operations are repeated for the second and each successive rotation of the end disc 23.

It will be appreciated from the foregoing that the operation of the pump is continuous, each rotation of the end disc 23 serving to cause simultaneous suction into the pumping chamber through the inlet port 37 and compression in and ejection from the pumping chamber through the outlet port 40.

This embodiment of the pump of the invention (which can, of course, be employed for pumping liquids as well as gases if desired) has the advantage that the rotary piston may be dimensioned so as to occupy only a small proportion of the swept volume of the pump, as compared with prior known rotary-piston-type pumps wherein the piston occupies a very large or major proportion of the interior space of the rotor. Accordingly the effective volumetric displacement of the described pump of the invention is substantially greater than prior known rotary pumps of comparable dimensions.

In the embodiment of the pump of FIGS. 1 and 2, the sealing of the piston 31, as it passes through the bottom dead centre position, transfers between the two opposite edges of walls of the slot 34, and this transfer may detract from the efficiency of the pump. To eliminate this transfer of the seal between the piston and the wall of the pumping chamber, the alternative arrangements of FIGS. 3 and 4 may be employed. In FIG. 3, the slot 34 does not extend all the way across the piston 31, and the vane 29 is of a length such that it does not need to project right through the piston 31, which continues to contact the inner wall of the pumping chamber at a single sealing location as it passes through the bottom dead centre position.

Similar considerations apply in the construction of FIG. 4, wherein a sealing strip 52 is retained in a sealing slot disposed close to one side of and substantially parallel to the slot 34 by pins 53 accommodated in a bore 54 at the inner end of such sealing slot. Springs 55 load the strip 52 resiliently out of the sealing slot to engage with and seal with the wall of the pumping chamber as the piston 31 passes through the bottom dead centre position.

The embodiment of the pump shown in FIGS. 5 and 6 is a two-stage or compound pump, and comprises a casing composed of body 60 internally machined to provide a cylindrical chamber closed at one end by a blank cover plate 61 and a bearing cover plate 62, which plates 61, 62 are bolted onto the body 60 by bolts 63. Bearing sleeve 64 is integral with the bearing cover plate 62 and accommodates a main spindle 65 which is sealed by packings 66 and carries on its inner end a rotary end disc 67 let into a recess 68 in the cover plate 62.

An eccentric slot 69 is formed in that face of the rotary end disc 67 which faces inwards of the body 60, and this accommodates a bearing ring 70 formed integrally with a first rotary piston 71 which, in contrast to the disc-like piston 31 of the previous embodiment, is in the form of an annulus or ring. A first vane 72, mounted on a pivot 73 engaging by its ends in the cover plates 61, 62, locates snugly by one end in a groove 74 in the body 60 and projects into a radial slot 75 in the piston 71. The external space outside the first piston 71 and between the latter and the body 60 constitutes a first pumping chamber, indicated generally by the reference number **76**, of the pump.

The interior surface of the first piston **71** is cylindrical and defines a second pumping chamber **77** of the pump, this accommodating a second disc-like piston **78** which is mounted coaxially on an extension **79** of the main spindle **65**. A second vane **80** is pivotally located by an enlarged head **81** in a groove **82** in the free end of the first vane **72**, and this second vane **80** projects into a radial slot **83** in the second piston **78**.

As with the preceding embodiment, an oil reservoir **84** is secured to the top of the housing of the pump, and an inlet tube **85** extending therethrough is screwed into an inlet port **86** which opens into the first pumping chamber **76** closely adjacent the first vane **72**, to one side thereof. Transfer ports **87**, through the first vane **72**, connect the first pumping chamber **76** from the side of the vane **72** remote from the inlet port **86** to the interior of the second pumping chamber **77** at the inlet port side of the second vane **80**.

A number of small outlet ports **88** in the blank cover plate **61** connect the second pumping chamber **77** with a recess **89**, in the cover plate **61**, which is open to the oil reservoir **84** and accommodates a non-return valve **90** similar to the corresponding component in the embodiment of FIGS. 1 and 2.

For consideration of the operation of this embodiment, it is convenient to assume the rotary end disc **67** (which rotates in the direction of the arrow **91** of FIG. 5) to be in a disposition wherein the first piston **71** is at its uppermost position in the first pumping chamber **76**, the second piston **78** is in its lowermost position in the second pumping chamber, and the two vanes **72** and **80** are substantially vertical.

As the end disc **67** is now rotated, by a suitable drive (not shown) applied to the main shaft **65**, the point of contact of the first piston **71** with the inner cylindrical surface of the body **60** initially moves past the inlet port **86**, approaching the position illustrated in FIG. 5. The space now occurring, in the first pumping chamber **76**, between the first vane **72** and the point of contact of the first piston **71** with the inner wall of the body **60**, and in communication with the inlet port **86**, constitutes a suction space, whilst the remainder of the pumping chamber **76** constitutes a compression space. As the end disc **67** rotates, the suction space increases in volume, drawing in fluid by way of the inlet tube **85** and inlet port **86**, whilst the compression space reduces in volume so that its contents are displaced through the transfer ports **87** into the second pumping chamber **77**.

When the end disc **67** has completed a complete revolution, the suction space has reached its maximum volume, and the compression space has reached minimum volume, substantially equal to zero, whereafter the point of contact of the first vane **71** with the inner surface of the body **60** again passes the inlet port **86** at which time the space which was the suction space now becomes the compression space, and a fresh suction space develops in the same manner as above discussed. Thus, in the next revolution of the end disc **67** the fluid drawn into the first pumping chamber **76** during the preceding revolution is compressed through the transfer ports **87** into the second pumping space **77**.

Considering now the fluid entering the second pumping chamber **77**, it will be appreciated that the pumping effect occurring therein is comparable with that in the pump of FIGS. 1 and 2. When the second piston **78** is in its uppermost position in the second pumping chamber **76** (that is to say when the end disc **67** has been rotated to bring the first piston **71** to its lowermost positon) the transfer ports **87** are in communication with a suction space in the second pumping chamber **67** which suction chamber increases in volume during completion of a revolution of the first piston **71** and then becomes a compression space the contents of which are expelled through the outlet ports **88**, past the non-return valve **90**, and through the oil reservoir **84**.

This compound, or two-stage embodiment of the pump of the invention, as above described, is, of course, somewhat more efficient than the single stage embodiment of FIGS. 1 and 2.

Turning now to FIGS. 7 and 8, the pump here illustrated is also a two-stage pump, comprising a stator **90** housing an annular or ring-like first rotary piston **91** engaging into an eccentric slot **92** in a rotary end disc **93** set into a recess in the stator in the same way as in the embodiment of FIGS. 5 and 6. Instead of having a first vane which is slidable relative to the first rotary piston as in the preceding embodiment, this pump has a first vane **94** formed integrally with the first piston **91** and projecting radially therefrom through a part-cylindrical swivel gland **95** housed in a bearing recess **96** machined into the stator so as to be in communication with the interior of the stator. This recess **96** connects, in turn, with an inlet port **97** fitted with an inlet tube **98**.

A second rotary or orbital piston **99** is secured to that end of the stator **90** which has been cut away to give the section shown in FIG. 7, so as to project into the interior of the first piston **91** substantially coaxially with the rotary end disc **93** and to lie with one point on its outer curved surface close to the inner curved surface of the first piston **91**. A second vane **100**, accommodated in a substantially diametrically disposed slot in the second piston **99** is loaded, by springs **101** to protrude from the second piston **99** and engage the inner curved surface of the first piston **91**.

The space **102** outside the first piston **91** constitutes a second stage pumping chamber of the pump and the space **103** within the first piston **91** and outside the second piston **99** constitutes a first stage pumping chamber of the pump.

The inlet port **97** communicates with the first stage pumping chamber **103** to one side of the second vane **100** by way of inlet passages **104** (see also FIG. 8) extending through the first vane **94** and the first piston **91**. The first stage pumping chamber **103**, in turn, communicates with the second stage pumping chamber **102** from the other side of the second vane **100** by way of transfer ports **105** in the first piston and vane **91**, **94** (which transfer ports **105** also constitute, effectively, inlet ports for the second stage pumping chamber **102**) to one side of the first vane **94**, whilst an outlet port **106** from the second stage pumping chamber **102**, at the other side of the first vane **94**, opens to an oil reservoir **107** formed in the stator **90** at a non-return valve **108**.

Operation of this pump will be evident from the previous description of the embodiment of FIGS. 5 and 6. Upon rotation of the annular piston **91** air is drawn into the first stage pumping chamber **103** (which is divided by the piston **99** and vane **100** into a suction space and a compression space) and forced through the transfer ports **105** into the second stage pumping chamber **102** being sucked into the latter and expelled through the outlet port **106** by the first piston **91**.

The pump illustrated in FIG. 9 is very similar in its operation to that of FIGS. 7 and 8, and parts which are substantially similar to those already described have been allocated similar reference numerals. This embodiment differs from the FIGS. 7 and 8 embodiment, however, in that inlet passages **120** through the vane **94** open into pumping chamber **121** outside the first rotary piston **91** so that the chamber **121** is the primary stage pumping chamber, and transfer ports **122** through the first vane **94** and rotary piston **91** connect the primary stage pumping chamber with the interior space **123** of the first rotary piston whch constitutes the secondary stage pumping chamber. Outlet ports **124** to atmosphere, by way of a non-return valve (not shown) are provided through that end of the stator **90** which has been cut away to provide the sectional view of FIG. 9. In this case, the second vane

125 is pivotally carried by the first piston **91** in a manner comparable with the vane **80** in FIG. 5.

The invention is not confined to the precise details of the above-described examples and variations may be made thereto. As already mentioned, the invention can be applied to pumps for liquids as well as gases. Obviously it is not restricted to pumps of short axial length, the dimensions of the pump being limited, of course, by practical considerations.

I claim:

1. A rotary piston pump comprising:
a stator enclosing a cylindrical pumping chamber,
a cover plate sealed to the stator and closing off one end of the pumping chamber,
a recessed bearing cover plate sealed to the stator and closing off the other end of the pumping chamber and having a central aperture therethrough,
a main spindle journalled in the aperture of the bearing cover plate,
a rotary end disc nested in the recess of the bearing cover plate and mounted on the main spindle and having an eccentrically disposed piston aperture,
a vane pivotally mounted for swinging within the pumping chamber and being of a width substantially equal to the axial length of the pumping chamber,
a circular rotary piston being of a thickness substantially equal to the axial length of the pumping chamber and having an axial stub spindle receivable in the eccentric piston aperture of the rotary end disc for imparting an orbital movement of the rotary piston according to the rotation of the main spindle and rotary end disc,
the rotary piston having a diametrically-disposed slot extending thereinto from one side of the periphery thereof,
the vane having a sliding fit in the slot of the rotary piston,
the vane and rotary piston unisonly constituting a movable partition in the pumping chamber,
an inlet port extending through the stator and communicating with the pumping chamber at one side of the vane,
an outlet port extending through the stator and communicating with the pumping chamber at the other side of the vane.

2. A single stage piston pump comprising:
a casing in the form of a stator enclosing a cylindrical pumping chamber, inlet and outlet ports and a bearing recess extending through the stator and intercommunicating with the pumping chamber,
an apertured swivel gland housed in the bearing recess,
a first cover plate sealed to the stator and defining an end wall of the stator,
a recessed second cover plate sealed to the stator and defining the other end wall of the stator and having a central aperture therethrough,
a driven spindle journalled in the aperture of the second cover plate,
a rotary end disc nested in the recess of the second cover plate and mounted on the spindle and having an eccentrically disposed piston aperture therein,
an annular rotary piston disposed within the pumping chamber and being of a thickness substantially equal to the axial length of the first stage pumping chamber and of a diameter less than the diameter of the pumping chamber and having a stub spindle receivable in the eccentric piston aperture of the rotary end disc for imparting an orbital movement to the piston responsively to the rotation of the spindle and rotary end disc,
a vane integral with the piston and extendable radially therefrom through the aperture in the swivel gland.

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