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JP 600206997 A **US 4543049 A**
US 1245691 A

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INT CL **F04C**
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(54) Abstract Title: **Vacuum pump with endplate location**

(57) A vacuum pump comprises a stator 30 which may be of tubular material located between an intake plate 20 and a back plate 40 which both may have a raised, mating portion 22 for engaging a cavity wall of the stator to relatively locate the stator and plates. The stator may include two internal pump chambers separated by a divider plate 66 to form a multi-stage pump. Communication between the pump chambers may be by a passage in the divider plate or via passages in the stator wall and a cross-over chamber in external cap 70. A rotor 50, 60 in each chamber and fixed to a shaft 12 may have vanes 52, 62 and may be offset from the centre of the chamber. The inlet plate may have a ballast opening and an inlet 26 opening directly to the first chamber or into an inlet chamber in the cap.

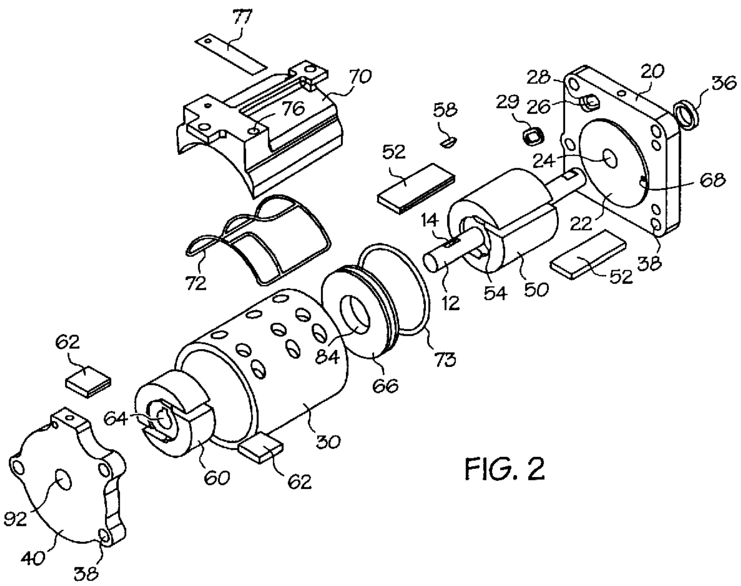

FIG. 2

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This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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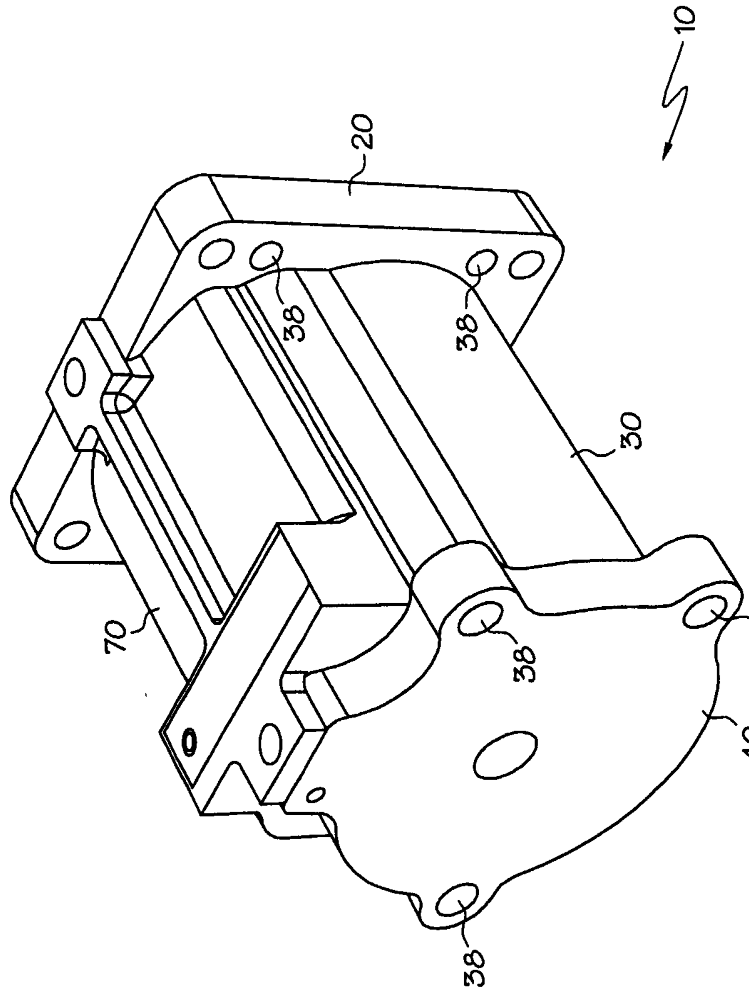

FIG.1

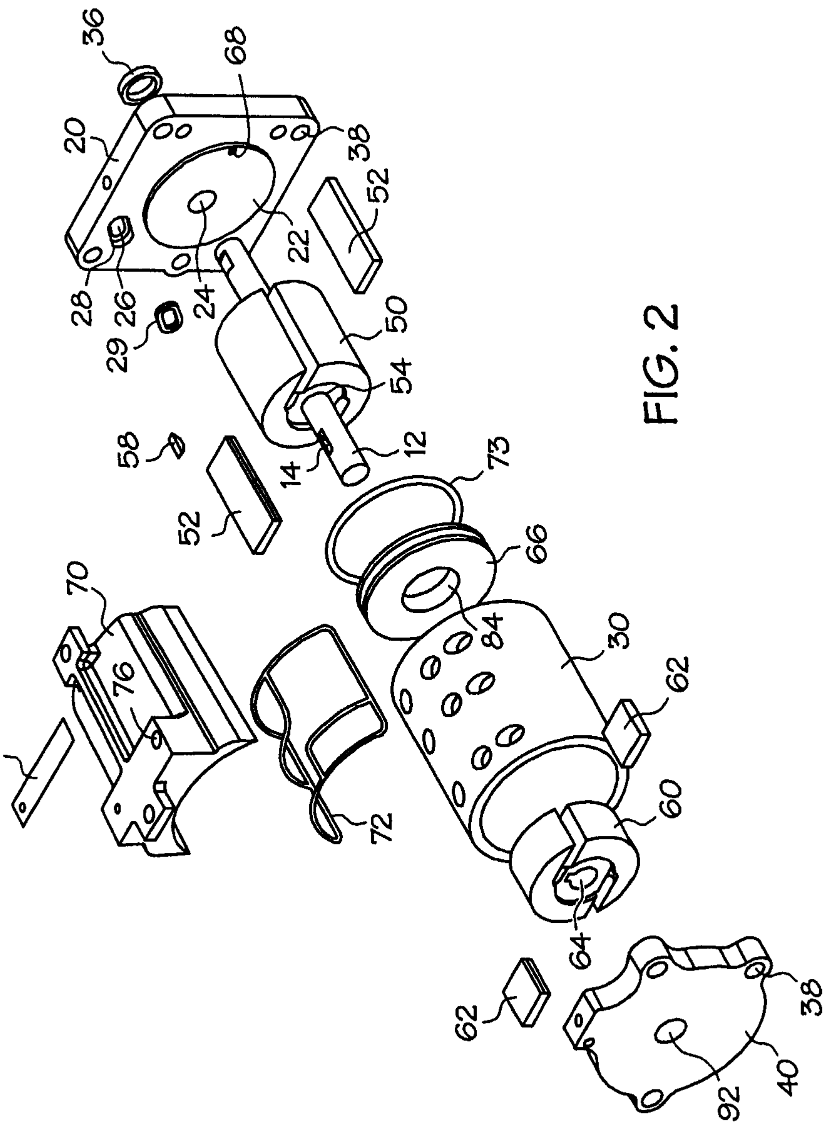
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FIG. 2

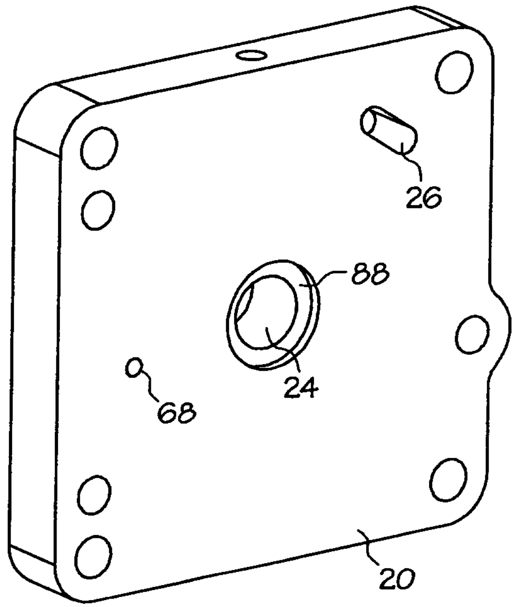

FIG. 3

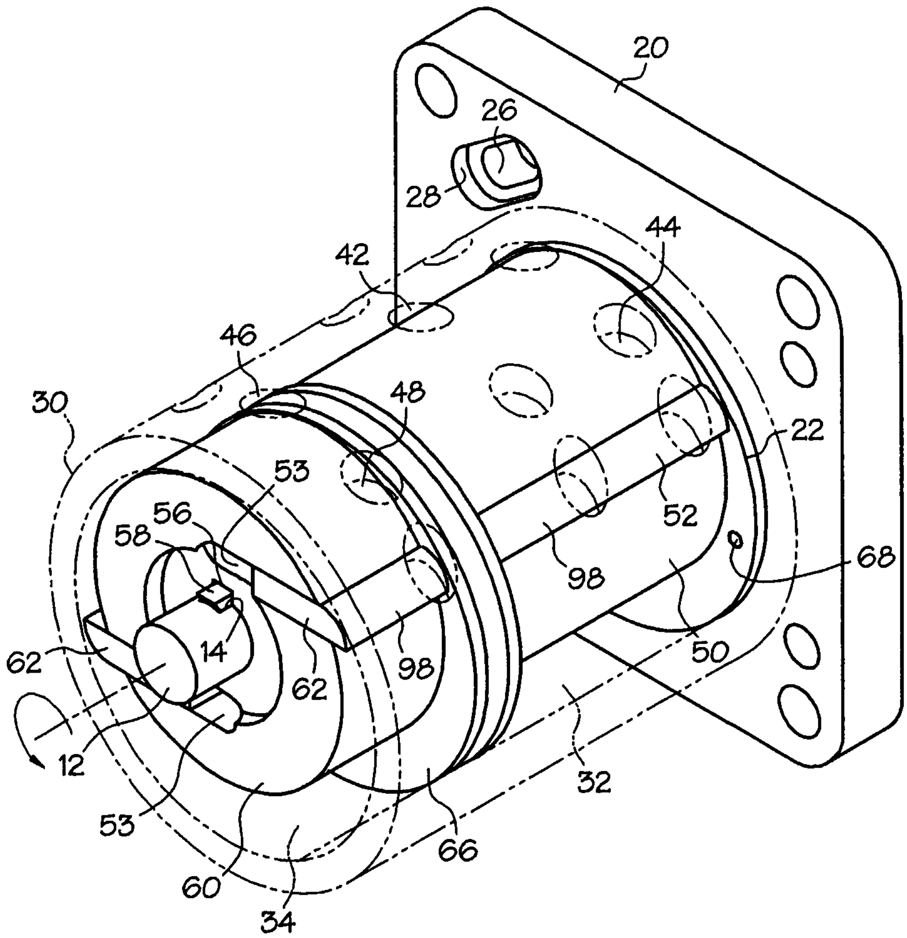
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FIG. 4

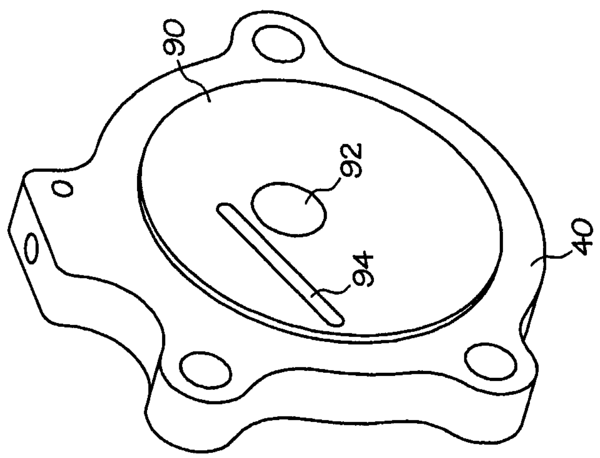

FIG. 5

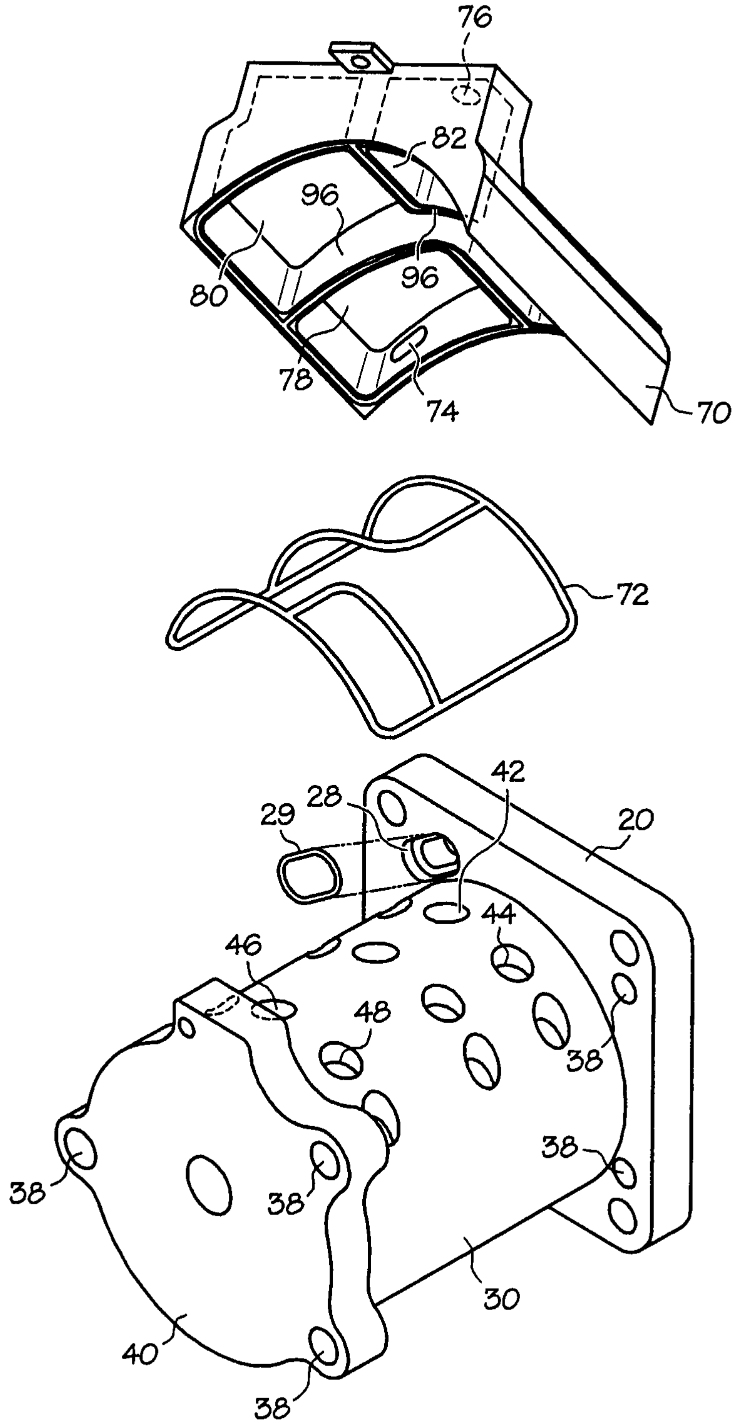

FIG. 6

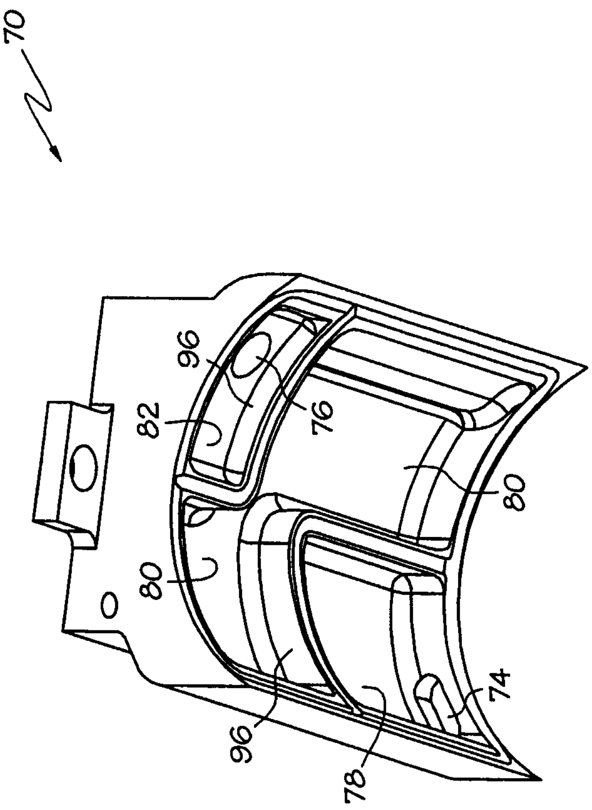

FIG. 7

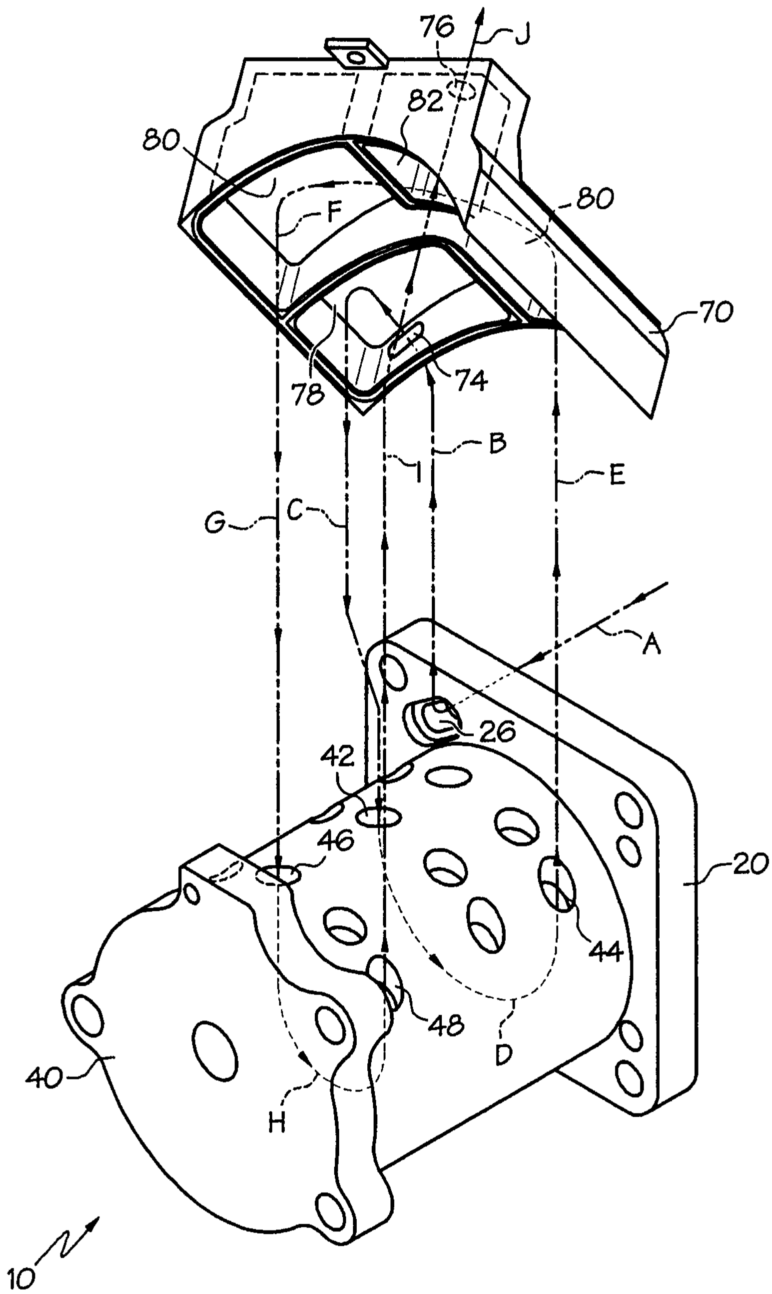

FIG. 8

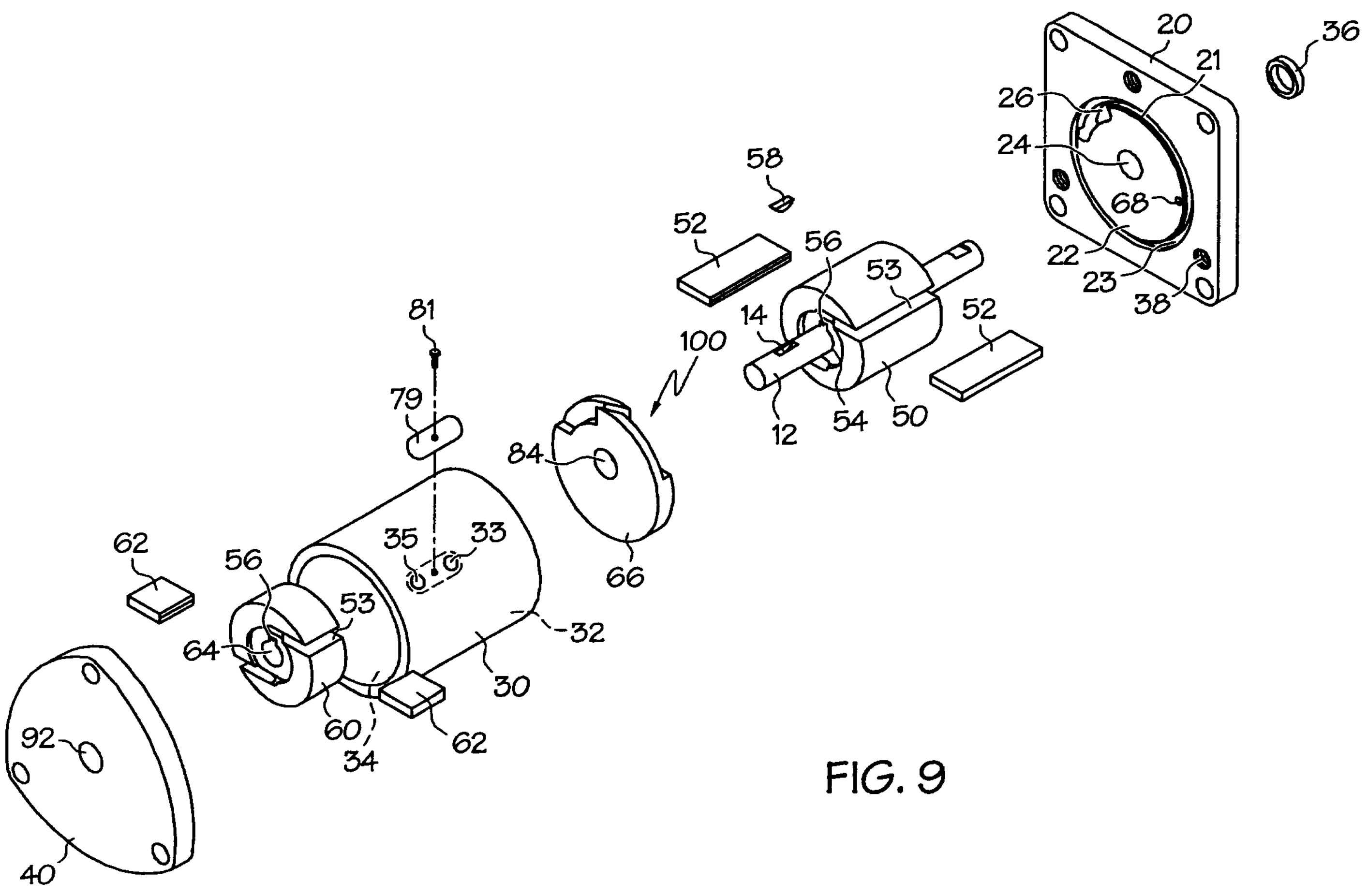
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FIG. 9

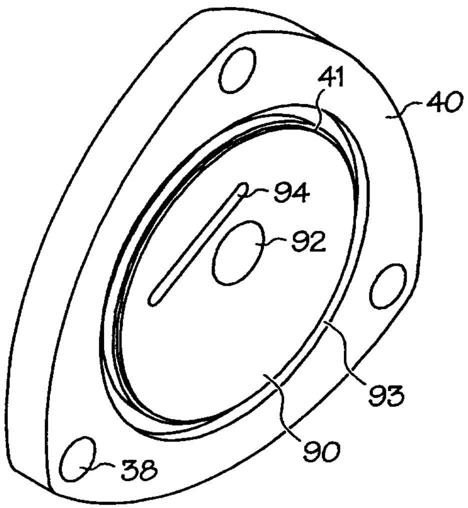

FIG. 11

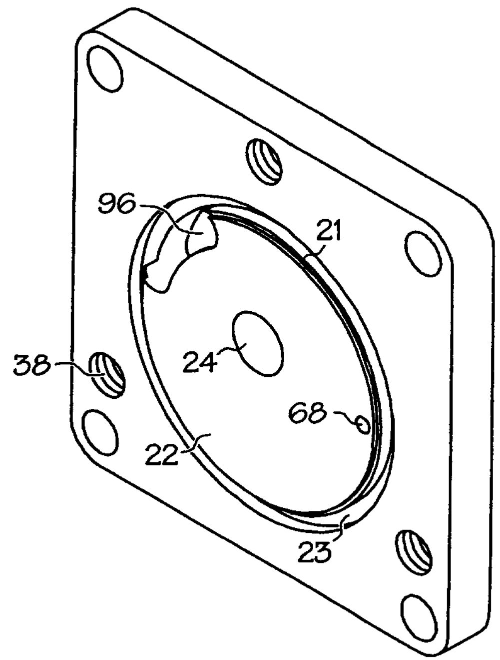

FIG. 10

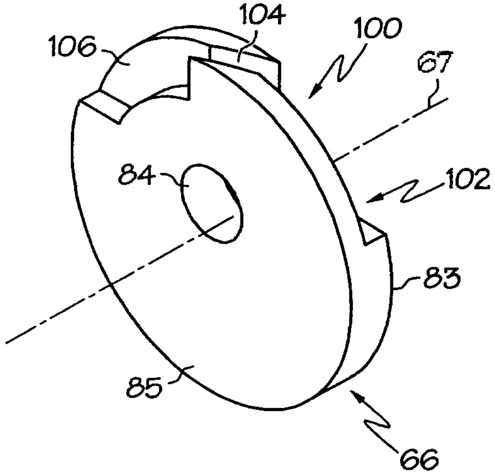

FIG. 12

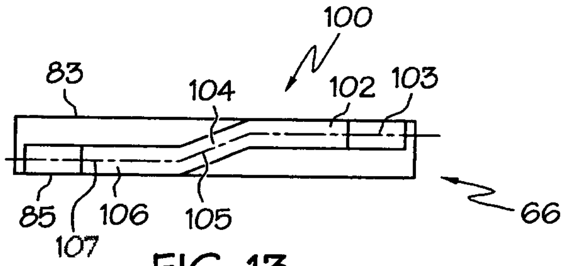

FIG. 13

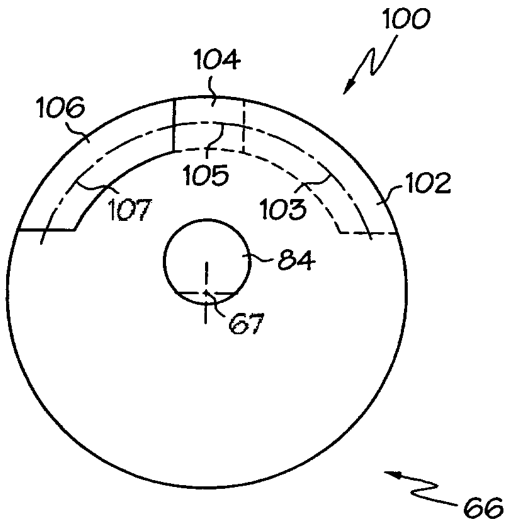

FIG. 14

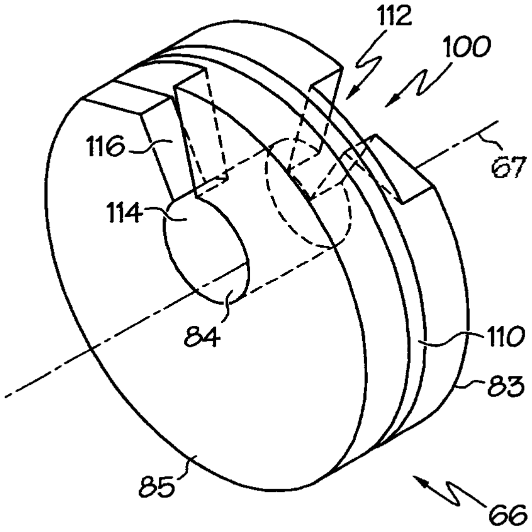

FIG. 15

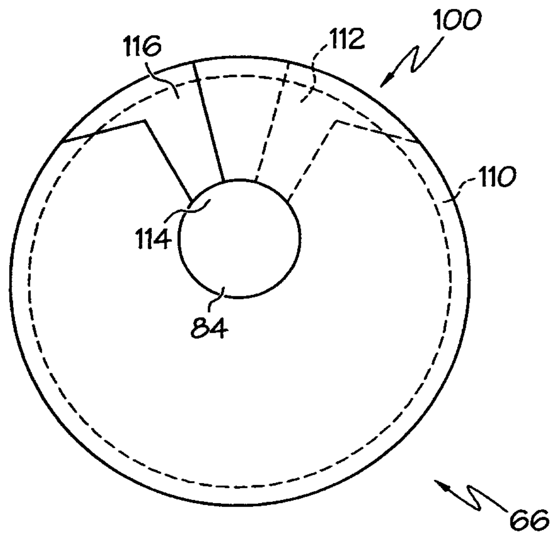

FIG. 16

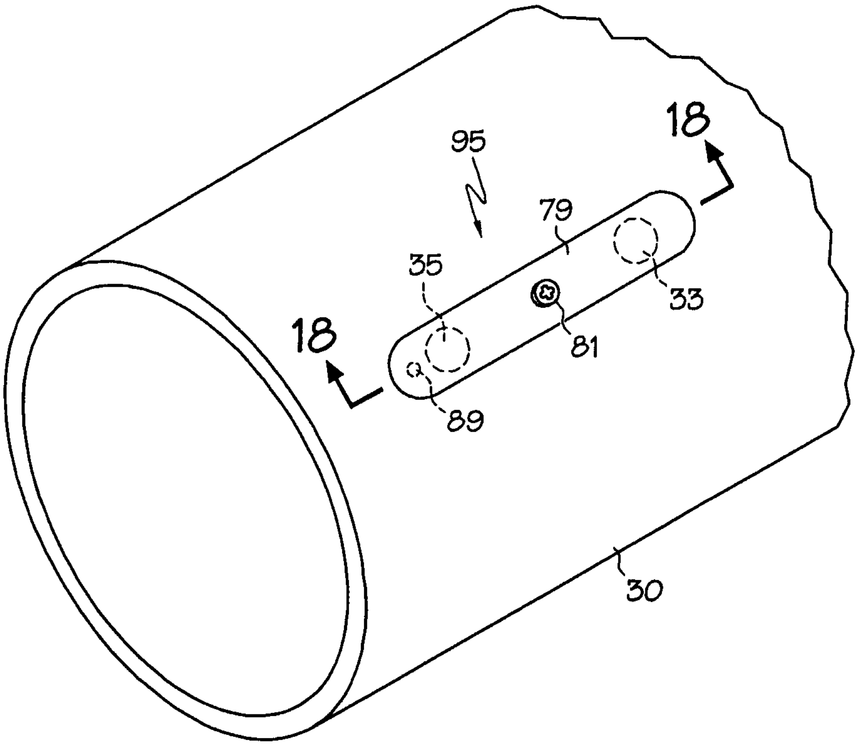

FIG. 17

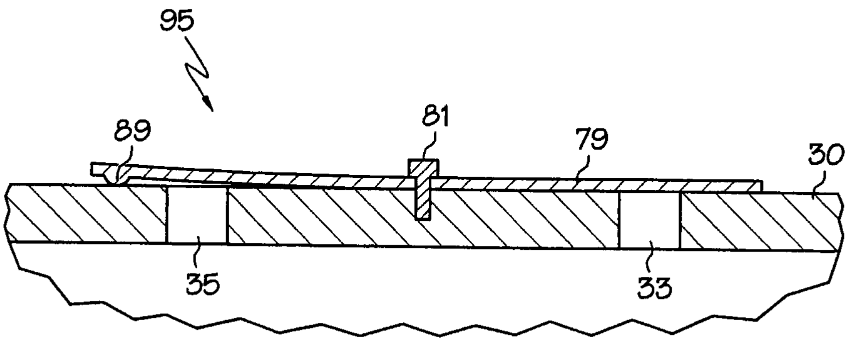

FIG. 18

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VACUUM PUMP

BACKGROUND OF THE INVENTION

Vacuum pumps may be used for a wide variety of industrial processes, such as dehydration, decontamination, degassing, and the forming, lifting and holding of fluids U.S. Patent No. 4,523,897 to Lower et al. and U.S. Patent No. 3, 837, 764 to Fritch et al. disclose examples of vacuum pumps.

The manufacturing process of a typical vacuum pump generally requires a skilled assembly technician to establish the correct clearances between parts of the pump. This often includes expensive grinding and lapping operations. Clearances are then maintained by compressive loads applied by screws or dowel pins.

It would be desirable for a pump to have a design wherein the correct clearances between internal parts may be substantially fixed as a function of the machining processes during manufacture, wherein expensive grinding and lapping operations are not required.

It would be desirable for a pump to be manufactured from relatively inexpensive parts.

It would be desirable for a pump to have a design which inherently resists the undesirable shifting of internal parts.

All US patents and applications and all other published documents mentioned anywhere in this application are incorporated herein by reference in their entireties.

Without limiting the scope of the invention a general description of some of the claimed embodiments of the invention is set forth below. Additional details of the disclosed embodiments of the invention and/or additional embodiments of the invention may be found in the Detailed Description of the Invention below.

A brief abstract of the technical disclosure in the specification is provided as well, only for the purposes of complying with 37 C.F.R. 1.72. The abstract is not intended to be used for interpreting the scope of the claims.

BRIEF SUMMARY OF THE INVENTION

An advantage of the present invention is to provide a vacuum pump wherein the correct clearances between internal parts may be achieved as a function of machining processes during the manufacturing of the pump using standard machining centers such as lathes and mills. Therefore, grinding and lapping operations generally performed by a skilled technician are not required.

Another advantage of the present invention is to provide a vacuum pump design which inherently resists the undesirable shifting of internal parts.

Another advantage of the present invention is to provide a vacuum pump having a stator that may be manufactured from an inexpensive tube of material. In some embodiments the stator may be cylindrical.

Another advantage of several embodiments of the present invention are to provide a vacuum pump having a tubular stator and a novel chamber dividing plate. Some embodiments may further include an integrated cap having an exhaust valve.

Another advantage of several embodiments of the present invention is to provide a vacuum pump wherein the clearance between the stator and the rotors may be fixed by providing end plates having a shaft journal aperture precisely located relative to a flange that may be used to locate the stator.

Another advantage of several embodiments of the present invention is to provide a divider plate located within an internal cavity of the stator.

Another advantage of several embodiments of the present invention is to provide a divider plate having a fluid passageway therethrough. The fluid passageway may be oriented within the area swept by the pump rotor vanes.

In one embodiment, the present invention may comprise a vacuum pump having a stator having an internal cavity. An intake plate and a back plate may be positioned on opposite sides of the stator. A rotatable shaft may be positioned such that at least a portion of the rotatable shaft is oriented within the internal cavity of said stator. A divider plate may be located within the internal cavity of the stator and may divide at least a portion of the internal cavity of the stator into a first pump chamber and a second pump chamber. A first rotor may be oriented within the first pump chamber and a second rotor may be oriented within the second pump chamber. Both rotors may be arranged to rotate with the shaft. A cap having an external crossover chamber may be placed adjacent to the stator. The cap may have a first cap chamber, a second cap chamber and a third cap chamber external to the stator. Fluid being pumped may pass through an intake aperture in the intake plate and an inlet aperture in the cap, thereby entering the first cap chamber. The first chamber of the stator may include a first inlet aperture providing communication between the first cap chamber and the first pump chamber. The first chamber of the stator may also include a first outlet aperture allowing communication between the first pump chamber and the second cap chamber external to the stator. A second inlet aperture may be provided in the second pump chamber to allow communication between the second cap chamber and the second pump chamber. Thus, the second cap chamber may comprise a crossover chamber which receives fluid from the first pump chamber and directs flow to the second pump chamber. The second pump chamber may include a second outlet aperture providing communication between the second pump chamber and the third cap chamber. The third cap chamber may provide an exhaust outlet.

In another embodiment, the present invention is directed to a method of forming a vacuum pump by providing a first plate, a second plate, a shaft, a first rotor, a second rotor, a tubular stator having an internal cavity, a divider plate and a cap external to the stator having a chamber. The divider plate may be arranged within the internal cavity of the stator to form a first pump chamber and a second pump chamber. The first rotor may be placed within the first pump chamber and the second rotor may be placed within the second pump chamber. The shaft may be arranged to rotate the first rotor and the second rotor. The first plate and second plate may be arranged on opposite sides of the tubular stator, and the external cap may be positioned so the chamber of the cap provides communication between the first pump chamber and the second pump chamber external to the stator.

These and other embodiments which characterize the invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages and objectives obtained by its use, reference should be made to the drawing which forms a further part hereof and the accompanying descriptive matter, in which various embodiments of the invention are described.

BRIEF DESCRIPTION OF THE DRAWINGS

A detailed description of the invention is hereafter described with specific reference being made to the drawings.

Figure 1 shows an embodiment of an inventive vacuum pump.

Figure 2 shows an exploded view of an embodiment of an inventive vacuum pump.

Figure 3 shows a first or intake plate.

Figure 4 shows an embodiment of an inventive vacuum pump partially assembled.

Figure 5 shows a second or back plate.

Figure 6 shows an embodiment of an inventive vacuum pump partially assembled.

Figure 7 shows an underside view of the external cap having a crossover chamber.

Figure 8 shows an example path of fluid flow through the device.

Figure 9 shows an exploded view of another embodiment of an inventive vacuum pump.

Figure 10 shows an embodiment of an intake plate.

Figure 11 shows an embodiment of a back plate.

Figure 12 shows an isometric view of an embodiment of a divider plate.

Figure 13 shows a top view of an embodiment of a divider plate.

Figure 14 shows a side view of an embodiment of a divider plate.

Figure 15 shows an isometric view of an embodiment of a divider plate.

Figure 16 shows a side view of an embodiment of a divider plate.

Figure 17 shows an embodiment of a flutter valve.

Figure 18 shows a partial sectional view of the stator and flutter valve.

DETAILED DESCRIPTION OF THE INVENTION

While this invention may be embodied in many different forms, there are described in detail herein specific preferred embodiments. This description is an exemplification of the principles of the invention and is not intended to limit the invention to the particular embodiments described.

For the purposes of this disclosure, like reference numerals in the Figures shall refer to like features unless otherwise indicated.

Figures 1 and 2 show an embodiment of an inventive vacuum pump 10, which may include a first or intake plate 20, a stator 30 having an internal cavity, a second or back plate 40, a shaft 12, a first rotor 50, a second rotor 60, a divider plate 66 and a cap 70. Each rotor 50, 60 may include at least one and desirably a plurality of vanes 52, 62. Each rotor 50, 60 may further include a longitudinal aperture 54, 64 for receiving the shaft 12. The longitudinal aperture 54, 64 of each rotor 50, 60 may be oriented along the central longitudinal axis of the rotor 50, 60.

The divider plate 66 may include an aperture 84 sized for receiving the shaft 12. The center of the aperture 84 may be offset from the center of the divider plate 66. The divider plate 66 may be positioned between the rotors 50, 60 and each rotor 50, 60 may be coupled to the shaft 12. When the rotors 50, 60, divider plate 66 and shaft 12 are placed within the stator 30, the divider plate 66 may divide the internal cavity of the stator 30 into a first pump chamber and a second pump chamber, and the first rotor 50 may be oriented within the first pump chamber and the second rotor 60 may be oriented within the second pump chamber.

The stator 30 may be any suitable shape and preferably has a circular cross-section. The stator 30 may be manufactured from relatively inexpensive tubular material. The stator 30 may be fixed between the intake plate 20 and the back plate 40. The intake plate 20 and back plate 40 may include bolt apertures 38, and bolts, ties or the like may be used to secure the intake plate 20, stator 30 and back plate 40 together. Apertures through the wall of the stator 30 may provide for the intake and exhaust of each pump chamber as discussed in detail below.

An external cap 70 having a crossover chamber may be suitably shaped to overlay and seal against a portion of the stator 30. The cap 70 may be positioned to overlay the apertures through the wall of the stator 30, and may thus provide fluid to, and receive fluid from the pump chambers. A cap seal 72 may be provided between the cap 70 and the stator 30, and the cap 70 may be secured to both the intake plate 20 and the back plate 40.

The inside surface of the intake plate 20 may include a raised portion or flange 22, which may be shaped to locate and receive the stator 30. For example, a flange 22 may have a circular shape to match an inner circular diameter of the stator 30. A shaft journal aperture 24 may be provided through the intake plate 20 and may pass through the flange 22. The center of the shaft journal aperture 24 may be offset from the center of the flange 22. The shaft 12 may extend through the intake plate 20 and may thus be connected to a rotary drive for pump operation. The intake plate 20 may further include a gas ballast inlet 68, an intake aperture 26 and an associated seal recess 28 for use with a seal 29, such as a sealing ring.

Figure 3 shows the back side of the intake plate 20. The gas ballast inlet 68, intake aperture 26 and shaft journal aperture 24 are visible, as well as an alignment recess 88. The alignment recess 88 may be used in conjunction with a locating device 36 (see Figure 2), such as a locating ring, to lock the pump 10 against radial movement with respect to another object. For example, a first portion of a locating device 36 may be oriented within the alignment recess 88 of the intake plate 20, while a second portion of the locating device 36 may be oriented within a recess of a body piece or casing, thus locking the pump 10 against moving radially with respect to the body piece or casing.

Figure 4 shows an intake plate 20, a first rotor 50 and vanes 52, a second rotor 60 and vanes 62, a shaft 12 and a divider plate 66 of an embodiment of an inventive vacuum pump 10 partially assembled. A stator 30 is also shown in phantom lines. The shaft 12 may pass through the shaft journal aperture 24 of the intake plate 20, the longitudinal aperture 54 of the first rotor 50, the aperture 84 of the divider plate 66 and the longitudinal aperture 64 of the second rotor 60.

Each rotor 50, 60 is preferably arranged to rotate with the shaft 12. Thus, a coupling may be provided between each rotor 50, 60 and the shaft 12. For example, the longitudinal apertures 54, 64 of the rotors 50, 60 may be dimensioned to provide a press fit about the shaft 12 and transmit forces via friction. Alternatively, portions of the shaft 12 may have a cross-sectional shape, and the longitudinal apertures 54, 64 of the rotors 50, 60 may have a similar and mating cross-sectional shape. Alternatively, as shown in Figure 4, the shaft may be provided with one or more grooved portion(s) 14, and each rotor 50, 60 may include a slot 56, which may extend radially from the longitudinal aperture 54, 64. A key 58 may be oriented with a first portion extending into a grooved portion 14 of the shaft 12 and a second portion extending into a slot 56 of a rotor 50, 60. Thus, a key 58 may transmit forces between the shaft 12 and one or more rotors 50, 60 to effect rotation of the rotors 50, 60 upon rotation of the shaft 12.

A stator 30 may be tubular in shape and may include an internal cavity. The stator 30 may be positioned such that the rotors 50, 60, divider plate 66 and a portion of the shaft 12 are located within the internal cavity, as shown in Figure 4. The flange 22 of the intake plate 20 may be used to properly position the stator 30. For example, at least a portion of the flange 22 may be located within the internal cavity of the stator 30 when the stator 30 is properly positioned. The flange 22 may be shaped to mate with the stator 30. Thus, the flange 22 may be shaped similarly to an inner surface or cross-section of the stator 30. The outer dimensions of the flange 22 may be approximately equal to the inner dimensions of the stator 30.

The divider plate 66 may also be shaped similarly to an inner surface or cross-section of the stator 30. The outer dimensions of the divider plate 66 may be approximately equal to the inner dimensions of the stator 30.

The divider plate 66 may divide the internal cavity of the stator 30 into a first pump chamber 32 and a second pump chamber 34. The divider plate 66 may include a groove 86 for receiving a seal, such as an o-ring, for sealing against the interior of the stator 30 to prevent fluid transfer between the first pump chamber 32 and the second pump chamber 34.

Each rotor 50, 60 may have smaller outer dimensions than the inner dimensions of the stator 30, and may be positioned with the axis of rotation offset from the central axis of the stator 30. Thus, each rotor 50, 60 may be offset from the center of the respective pump chamber 32, 34 in which it is located. The amount of clearance at the closest point between each rotor 50, 60 and the stator 30 is preferably 0.0005" to 0.0020".

A rotor 50, 60 may include any number of vanes 52, 62. Each rotor 50, 60 may include a vane slot 53 for each vane 52, 62. A vane 52, 62 may be slidable within a vane slot 53. Vane slots 53 may radiate from the center of the rotor 50, 60 or may be offset from the center, as shown in Figure 4, allowing the vane 52, 62 to extend farther and provide a greater volumetric displacement per revolution of the rotor 50, 60.

Desirably, each vane 52, 62 maintains contact with the inner surface of the stator 30 as the rotors 50, 60 rotate. It should be noted that an oil film may exist between all moving/contacting parts of the vacuum pump 10. A vane 52, 62 may include a shaped or radiused edge portion 98 to provide an improved seal between the vane 52, 62 and the stator 30 wall throughout all portions of rotational travel and thus optimize fluid compression and reduce gas re-expansion while the pump operates. Contact between a vane 52, 62 and the stator 30 may be provided and maintained by a spring arranged to bias the vane 52, 62 outwardly, or may be accomplished by centrifugal force generated during rotation of the rotors 50, 60 and vanes 52, 62. The vanes 52, 62 are preferably dimensioned to allow a small amount of clearance in the axial direction of the pump 10 between the edge of the vane 52, 62 and an adjacent plate (i.e. the intake plate 20, divider plate 66 or back plate 40).

The stator 30 may include at least one first inlet aperture 42 in communication with the first pump chamber 32, at least one first outlet aperture 44 in communication with the first pump chamber 32, at least one second inlet aperture 46 in communication with the second pump chamber 34 and at least one second outlet aperture 48 in communication with the second pump chamber 34. Inlet apertures 42, 46 and outlet apertures 44, 48 allow fluid being pumped by the vacuum pump 10 to enter and exit the respective pump chambers 32, 34 through the wall of the stator 30. Various embodiments of a stator 30 may include a plurality of first inlet apertures 42, a plurality of first outlet apertures 44, a plurality of second inlet apertures 46 and a plurality of second outlet apertures 48.

Each inlet aperture 42, 46 and outlet aperture 44, 48 may have a central longitudinal axis and may have any suitable shape and orientation. For example, the longitudinal axis of each inlet and outlet aperture of the stator 30 may be oriented in the radial direction of the stator 30. Each inlet and/or outlet aperture may have a circular or oval shape. In some embodiments, the longitudinal axis of an inlet or outlet aperture of the stator 30 may parallel to the longitudinal axis of another inlet or outlet aperture. As shown in Figure 4, the longitudinal axis of each inlet and outlet aperture of the stator 30 may be parallel to the longitudinal axis of all of the other inlet and outlet apertures of the stator 30. The longitudinal axis of each inlet and outlet aperture of the stator 30 may be oriented in a vertical direction, which may provide improved flow characteristics in and out of the pump chambers 32, 34.

Figure 5 shows the internal chamber side of a back plate 40. A back plate 40 may include a raised portion or flange 90, which may be shaped to locate and receive the stator 30 as described with respect to the flange 22 of the intake plate 20. A back plate 40 may also include a degassing groove 94 and a shaft journal aperture 92 for receiving the shaft 12.

Figure 6 shows an embodiment of an inventive vacuum pump 10 partially assembled. An intake plate 20, stator 30 and back plate 40 are assembled and an external cap 70 having crossover chamber is positioned for assembly.

Figure 7 shows another view of an external cap 70 having crossover chamber.

Referring to Figures 6 and 7, a cap 70 may include a first chamber 78, a second chamber 80 and a third chamber 82. The chambers 78, 80, 82 may be divided by wall portions 96. The first chamber 78 may include an inlet aperture 74. The third chamber 82 may include an exhaust aperture 76.

A cap seal 72 may be provided to better seal the cap 70 against the exterior of the stator 30 and to better prevent fluid leakage between the chambers 78, 80, 82. The shape of the cap seal 72 may be similar to the wall portions 96 of the cap 70.

A seal ring 29 may also be provided between the cap 70 and the intake plate 20. The seal ring 29 may sit within a seal recess in the intake plate 20.

When the cap 70 is properly positioned with respect to the intake plate 20 and the stator 30, the cap inlet aperture 74 may be in communication with the intake aperture 26 of the intake plate 20, and the cap first chamber 78 may be in communication with a first inlet aperture 42 of the stator. The cap second chamber 80 may be in communication with both a first outlet aperture 44 and a second inlet aperture 46 of the stator 30. A cap third chamber 82 may be in communication with a second outlet aperture 48 of the stator 30.

The cap second chamber 80 may comprise an external crossover chamber allowing fluid communication between the first pump chamber 32 and the second pump chamber 34 (see Figure 4) outside or to the exterior of the stator 30. Fluid communication to the exterior of the stator 30 eliminates the necessity for the divider plate 66 to include communication apertures to provide fluid communication between the first pump chamber 32 and the second pump chamber 34. As known in the past, communication between the pump chambers through the divider plate reduces efficiency of the operation of the pump.

When the intake plate 20, stator 30, back plate 40 and cap 70 are properly assembled, the cap 70 may be attached to both the intake plate 20 and the back plate 40, such as by screws, bolts or the like. Further, the intake plate 20 and back plate 40 may be secured with respect to one another, such as by using tie rods or bolts. The intake plate 20 and back plate 40 may include corresponding bolt apertures 38 for receiving tie rods, bolts or the like.

The inventive pump 10 may be operated by applying a rotational force to the shaft 12, thereby rotating the first rotor 50 within the first pump chamber 32 and rotating the second rotor 60 within the second pump chamber 34. For example, a rotary drive, such as a motor or pulley may be used. When the pump 10 is arranged to operate as a two-stage vacuum pump, fluid being pumped may be directed through the first pump chamber 32 and then through the second pump chamber 34.

As the shaft 12 and rotors 50, 60 rotate as indicated in Figure 4, fluid may be drawn through the intake aperture 26 of the intake plate 20.

Figure 8 shows an example path of fluid flow through the pump 10. Fluid flow path lines are labeled with reference characters A – J. Fluid may be external to the pump 10 and be drawn into the intake aperture 26 of the intake plate 20 (path A). The intake aperture 26 may be in communication with the cap inlet aperture 74 (path B), and the fluid may enter the cap first chamber 78. The fluid may then be drawn (path C) through a first inlet aperture 42 of the stator 30 into the first pump chamber 32. As a vane 52 of the first rotor 50 sweeps through a rotation (path D), fluid from the first pump chamber 32 may be exhausted out of the chamber through a first outlet aperture 44 of the stator 30 and into the cap second chamber 80 (path E). The fluid may travel through the cap second chamber 80 or crossover chamber (path F) and be drawn through a second inlet aperture 46 of the stator 30 (path G). The fluid may be pumped through the second pump chamber 34 (path H) and pass through a second outlet aperture 48 into the cap third chamber 82 (path I). The fluid may be exhausted from the cap third chamber 82 through the exhaust aperture 76 (path J).

Additionally, an exhaust valve 77 may be provided in communication with the exhaust aperture 76 (see Figure 2). An exhaust valve 77 may comprise a reed valve, a ball valve, a spring-loaded plug or plate, or the like. In some embodiments, a second exhaust valve may be provided in the cap 70 in communication with the second chamber 80 to provide relief for the first pumping stage.

During a pumping operation, a gas ballast inlet 68 in the intake plate 20 (see Figure 4) may be in communication with the first pump chamber 32. The gas ballast inlet 68 may introduce a controlled amount of atmosphere into the pump 10 to prevent pumped gasses from condensing inside the pump 10 prior to being exhausted. A gas ballast inlet 68 may be removed or may alternatively be provided in the stator 30 and/or back plate 40, and may be in communication with the first pump chamber 32 and/or the second pump chamber 34. Further, a gas ballast inlet 68 may be provided in the cap 70 and may be in communication with the any of the chambers 78, 80, 82 of the cap 70.

A cover for the vacuum pump 10 may be provided and may comprise a reservoir containing vacuum pump oil. The vacuum pump 10 may be immersed in the vacuum pump oil. The oil bath may provide improved sealing and lubrication, and may allow the pump 10 to achieve a lower ultimate pressure.

When used as an oil-sealed pump, a controlled amount of oil may be introduced into the pump 10. For example, oil may be introduced through the intake aperture 26 and may follow the general path of the fluids being pumped. Additional oil may be introduced into the pump 10 through clearances between the shaft 12 and the shaft journal aperture 24 of the intake plate 20 and/or between the shaft 12 and the shaft journal aperture 92 of the back plate 40. If desired, the various components of the pump 10 may be provided with additional apertures in communication with the pump chambers 32, 34 and/or the cap chambers 78, 80, 82 to allow additional oil introduction. Further, a positive displacement pump may be used to pump oil into the inventive vacuum pump 10.

During a pumping operation, a degassing groove 94 in the back plate 40 (see Figure 5) may be in communication with the second chamber 34 to allow any gas entrained in pump lubricating oil to be exhausted. A degassing groove 94 may help to reduce the ultimate pressure of the pump. A degassing groove 94 may be omitted from the design, or may alternatively be located in the stator 30 or in any other suitable location.

To improve the ultimate pressure or vacuum generated by an inventive vacuum pump 10, grinding and lapping operations may be performed to achieve tighter tolerances between the individual parts of the pump.

Figure 9 shows another embodiment of an inventive vacuum pump 10, which may include a first or intake plate 20, a stator 30 having an internal cavity, a second or back plate 40, a shaft 12, a first rotor 50, a second rotor 60 and a divider plate 66. Each rotor 50, 60 may include at least one and desirably a plurality of vanes 52, 62. Each rotor 50, 60 may further include a longitudinal aperture 54, 64 for receiving the shaft 12. The longitudinal aperture 54, 64 of each rotor 50, 60 may be oriented along the central longitudinal axis of the rotor 50, 60.

The divider plate 66 may include an aperture 84 sized for receiving the shaft 12. The center of the aperture 84 may be offset from the center of the divider plate 66. The divider plate 66 may be positioned between the rotors 50, 60 and each rotor 50, 60 may be coupled to the shaft 12. When the rotors 50, 60, divider plate 66 and shaft 12 are placed within the stator 30, the divider plate 66 may divide the internal cavity of the stator 30 into a first pump chamber 32 and a second pump chamber 34. The first rotor 50 may be oriented within the first pump chamber 32 and the second rotor 60 may be oriented within the second pump chamber 34.

The divider plate 66 may include a fluid passageway 100 which may extend from the first side 83 of the divider plate 66 to the second side 85. The fluid passageway 100 preferably allows fluid communication between the first pump chamber and the second pump chamber.

As the rotors 50, 60 rotate, they may define a swept area or an area through which a portion of the rotor 50, 60 passes. The swept area may be measured in a direction orthogonal to the longitudinal axis of the shaft 12. When a rotor 50, 60 includes vanes 52, 62, the swept area preferably includes the area swept by the vanes 52, 62. In some embodiments, the vanes 52, 62 may contact the outer periphery of the internal cavity of the stator 30 as the rotors 50, 60 rotate. Thus, the swept area may be equal to an area defined by the outer periphery of the inner cavity of the stator 30, as oriented orthogonally to the longitudinal axis of the stator 30. The swept area may also be equal to an area defined by the outer periphery of the divider plate 66. In some embodiments, the entire fluid passageway 100 of the divider plate 66 may be located within the bounds of the swept area when the swept area is projected onto the divider plate 66. Thus, the entire fluid passageway 100 may be oriented within the radial bounds of the area swept by the rotor vanes 52, 62.

In some embodiments, the swept area may comprise a circular shape having a center point and a radius. When the swept area is projected onto the divider plate 66 with the center point of the swept area at the center of the divider plate 66, the entire fluid passageway 100 may be within the radius of the swept area. The distance between the center of the divider plate 66 and an outermost point of the fluid passageway 100 may be less than or equal to the radius of the swept area.

The stator 30 may be any suitable shape and preferably has a circular cross-section. The stator 30 may be manufactured from relatively inexpensive tubular material. The stator 30 may be fixed between the intake plate 20 and the back plate 40. The intake plate 20 and back plate 40 may include bolt apertures 38, and bolts, ties or the like may be used to secure the intake plate 20, stator 30 and back plate 40 together.

Referring to Figures 9 and 10, the inside surface of the intake plate 20 may include a mating portion 21, such a raised portion or flange 22, which may be shaped to locate and receive the stator 30. For example, a flange 22 may have a circular shape to match an inner circular diameter of the stator 30. In some embodiments, a mating portion 21 may comprise a raised annular shape dimensioned to surround the outer edge of the stator 30. In some embodiments, a mating portion 21 may comprise a plurality of pins or raised protrusions that are spaced to engage the stator 30 and properly position the stator 30 with respect to the intake plate 20. For example, a mating portion 21 may comprise at least one elongate or a plurality of raised protrusions, each protrusion may be oriented to engage the outer circumference of the stator 30, and each protrusion may be spaced equally about the outer circumference of the stator 30.

The inside surface of the intake plate 20 may also include a groove 23. An O-ring may be inserted into the groove 23 to provide a better seal between the intake plate 20 and the stator 30. Preferably the groove 23 is shaped similarly to the cross-sectional shape of the stator 30 and arranged such that an O-ring placed within the groove 23 will abut an edge of the stator 30. A shaft journal aperture 24 may be provided through the intake plate 20 and may pass through the flange 22. The center of the shaft journal aperture 24 may be offset from the center of the flange 22. The shaft 12 may extend through the intake plate 20 and may thus be connected to a rotary drive for pump operation. The intake plate 20 may further include a gas ballast inlet 68 and an intake aperture 26 which allow for fluid communication with an internal cavity of the stator 30.

The outer side of the intake plate 20 may include an alignment recess 88, for example as shown in Figure 3. The alignment recess 88 may be used in conjunction with a locating device 36 (see Figure 9), such as a locating ring, to lock the pump 10 against radial movement with respect to another object. For example, a first portion of a locating device 36 may be oriented within the alignment recess 88 of the intake plate 20, while a second portion of the locating device 36 may be oriented within a recess of a body piece or casing, thus locking the pump 10 against moving radially with respect to the body piece or casing.

When assembled, the shaft 12 may pass through the shaft journal aperture 24 of the intake plate 20, the longitudinal aperture 54 of the first rotor 50, the aperture 84 of the divider plate 66 and the longitudinal aperture 64 of the second rotor 60.

Each rotor 50, 60 is preferably arranged to rotate with the shaft 12. Thus, a coupling may be provided between each rotor 50, 60 and the shaft 12. For example, the longitudinal apertures 54, 64 of the rotors 50, 60 may be dimensioned to provide a press fit about the shaft 12 and transmit forces via friction. Alternatively, portions of the shaft 12 may have a cross-sectional shape, and the longitudinal apertures 54, 64 of the rotors 50, 60 may have a similar and mating cross-sectional shape. Alternatively, as shown in Figure 9, the shaft may be provided with one or more grooved portion(s) 14, and each rotor 50, 60 may include a slot 56, which may extend radially from the longitudinal aperture 54, 64. A key 58 may be oriented with a first portion extending into a grooved portion 14 of the shaft 12 and a second portion extending into a slot 56 of a rotor 50, 60. Thus, a key 58 may transmit forces between the shaft 12 and one or more rotors 50, 60 to effect rotation of the rotors 50, 60 upon rotation of the shaft 12.

In some embodiments, a stator 30 may be tubular in shape and may include an internal cavity. The stator 30 may be positioned such that the rotors 50, 60, divider plate 66 and a portion of the shaft 12 are located within the internal cavity. The mating portion 21 of the intake plate 20 may be used to properly position the stator 30.

For example, at least a portion of a flange 22 may extend into a portion of the internal cavity of the stator 30 when the stator 30 is properly positioned. The flange 22 may be shaped to mate with the stator 30. Thus, the flange 22 may be shaped similarly to an inner surface or cross-section of the stator 30. The outer dimensions of the flange 22 may be approximately equal to the inner dimensions of the stator 30. The mating portion 21 preferably engages the stator 30 and prevents the intake plate 20 from moving orthogonally with respect to the longitudinal axis of the stator 30.

The divider plate 66 may also be shaped similarly to an inner surface or cross-section of the stator 30. The outer dimensions of the divider plate 66 may be approximately equal to the inner dimensions of the stator 30. The divider plate 66 may divide the internal cavity of the stator 30 into a first pump chamber 32 and a second pump chamber 34 (see Figure 4). In some embodiments, the divider plate 66 may be dimensioned such that the outer periphery of the divider plate 66 abuts the inner periphery of the stator 30.

As shown in Figure 9, the stator 30 may include a first exhaust aperture 33 and a second exhaust aperture 35. The first exhaust aperture 33 may be located on one side of the divider plate 66 when the vacuum pump is assembled, and may be in fluid communication with the first pump chamber 32. The second exhaust aperture 35 may be located on the other side of the divider plate 66 when the vacuum pump is assembled, and may be in fluid communication with the second pump chamber 34. In some embodiments, a valve may be associated with each exhaust aperture 33, 35. In some embodiments, a valve may comprise a reed valve. As shown in Figure 9, a single strip of material 79 or reed may be placed over the exhaust apertures 33, 35 and may have a first portion that may comprise a valve for the first exhaust aperture 33 and a second portion that may comprise a valve for the second exhaust aperture 35. The strip of material 79 may be fastened to the stator 30 using a fastener 81, such as a screw.

Each rotor 50, 60 may have smaller outer dimensions than the inner dimensions of the stator 30, and may be positioned with its axis of rotation offset from the central axis of the stator 30. Thus, each rotor 50, 60 may be offset from the center of the respective pump chamber 32, 34 in which it is located. The amount of clearance at the closest point between each rotor 50, 60 and the stator 30 is preferably 0.0005" to 0.0020".

A rotor 50, 60 may include any number of vanes 52, 62. Each rotor 50, 60 may include a vane slot 53 for each vane 52, 62. A vane 52, 62 may be slidable within a vane slot 53. Vane slots 53 may radiate from the center of the rotor 50, 60 or may be offset from the center, as shown in Figure 9, to allow for a greater length of vane 52, 62 travel per revolution of the rotor 50, 60.

Desirably, each vane 52, 62 maintains contact or approximate contact with the inner surface of the stator 30 as the rotors 50, 60 rotate. A vane 52, 62 may include a shaped or radiused edge portion 98 to provide an improved seal between the vane 52, 62 and the stator 30 wall throughout all portions of rotational travel, and thus optimize fluid compression and reduce gas re-expansion while the pump operates. Contact between a vane 52, 62 and the stator 30 may be provided and maintained by a spring arranged to bias the vane 52, 62 outwardly, or may be accomplished by centrifugal force generated during rotation of the rotors 50, 60 and vanes 52, 62. The vanes 52, 62 are preferably dimensioned to allow a small amount of clearance in the axial direction of the pump 10 between the edge of the vane 52, 62 and an adjacent plate (i.e. the intake plate 20, divider plate 66 or back plate 40).

Figure 11 shows an embodiment of a back plate 40 where the internal chamber side is visible. A back plate 40 may include a mating portion 41 which may be shaped to locate and receive the stator 30 as described with respect to the mating portion 21 of the intake plate 20. In some embodiments, a mating portion 41 of the back plate may comprise a raised portion or flange 90, and may be shaped similarly to the cross-sectional shape of the stator 30. In some embodiments, the mating portion 41 may extend into the internal cavity of the stator 30. The inside surface of the back plate 40 may also include a groove 93. An O-ring may be inserted into the groove 93 to provide a better seal between the back plate 40 and the stator 30. Preferably the groove 93 is shaped similarly to the cross-sectional shape of the stator 30 and arranged such that a seal, such as an O-ring, placed within the groove 93 will abut an edge of the stator 30. A back plate 40 may also include a degassing groove 94 and a shaft journal aperture 92 for receiving the shaft 12.

During assembly, the mating portion 21 of the intake plate 20 and the mating portion 41 of the back plate 40 may be used to locate and fixedly position the stator 30 relative to the intake plate 20 and the back plate 40. Preferably, the mating portions 21, 41 may engage the stator 30 to properly position the stator 30 within standard tolerances for a vacuum pump. The intake plate 20, back plate 40 and stator 30 may be secured together using any suitable device(s), for example a plurality of bolts, tie rods or a clamping device such as a band clamp, hose clamp, or the like may be used.

The location of the shaft aperture 24 in the intake plate 20 and the shaft aperture 92 in the back plate 40 may determine placement of the rotatable shaft 12 and thus placement of the rotors 50, 60. Thus, the use of a tubular stator 30 and intake and back plates 20, 40 having mating portions 21, 41 and shaft apertures 24, 92 allow all parts of the vacuum pump to be properly positioned relative to one another without expensive techniques, such as lapping and grinding, and/or skilled assembly technicians, that are often utilized in prior art designs to achieve desirable tolerances.

Figures 12-14 show an embodiment of a divider plate 66 having a fluid passageway 100 extending therethrough. The fluid passageway 100 may extend from a first side 83 of the divider plate 66 to a second side 85 of the divider plate, and may allow fluid communication between the first pump chamber and the second pump chamber. The fluid passageway 100 may comprise a plurality of portions, including a first cutaway portion 102, a second or transition portion 104 and a third cutaway portion 106.

The first portion 102 may comprise a volume of space that extends from the first side 83 of the divider plate 66 approximately halfway through the thickness of the divider plate 66. A longitudinal axis 103 of the first portion 102 may extend in a circumferential direction. The first portion 102 may comprise a shaped opening in the surface of the first side 83.

Similarly, the third portion 106 may comprise a volume of space that extends from the second side 85 of the divider plate 66 approximately halfway through the thickness of the divider plate 66. A longitudinal axis107 of the third portion 106 may extend in a circumferential direction. The third portion 106 may comprise a shaped opening in the surface of the second side 85. The shaped opening in the surface of the first side 83 may be shaped similarly to the shaped opening in the surface of the second side 83. The shaped opening in the surface of the first side 83 may be circumferentially offset from the shaped opening in the surface of the second side 83.

The second portion 104 may connect the first portion 102 and the third portion 106 creating a chute or channel passageway. A longitudinal axis 105 of the second portion 104 may be oriented at an angle to the longitudinal axes of the first portion 102 and the third portion 106. A longitudinal axis 105 of the second portion 104 may be oriented at a non-zero angle to a central axis 67 of the divider plate 66 and to the longitudinal axis of the stator 30. While the length of the second portion 104 may be relatively short, in some embodiments, if the longitudinal axis 105 of the second portion 104 were projected past either side 83, 85 of the divider plate 66, the longitudinal axis 105 of the second portion 104 may spiral helically about the central axis 67 of the divider plate 66. The second portion 104 may therefore be relatively straight or curved as dependent upon the relative positioning of the first portion 102 as compared to the third portion 106.

The longitudinal axis 103, 105, 107 of any portion 102, 104, 106 of the fluid passageway 100 may be nonparallel to the longitudinal axis of the rotatable shaft 12. The divider plate 66 may also include an aperture 84 extending in an axial direction. The aperture 84 may be offset from the center of the divider plate 66. When the vacuum pump is assembled, the shaft 12 may pass through the aperture 84.

Figures 15 and 16 show another embodiment of a divider plate 66 having a fluid passageway 100 extending therethrough. The fluid passageway 100 may comprise a first portion 112, a second portion 114 and a third portion 116. The second portion 114 may comprise a shaft aperture 84 and may thus comprise a cylindrical bore. The rotatable shaft 12 may pass through the second portion 114. The longitudinal axis of the second portion 114 may be parallel to the longitudinal axis of the stator 30. The second portion 114 is preferably sized to allow a proper amount of fluid to pass through the fluid passageway 100 during operation of the vacuum pump when the shaft 12 is in position.

The first portion 112 may comprise a shaped volume of space extending from a first side 83 of the divider plate 66 through a predetermined thickness of the divider plate 66. In some embodiments, the first portion 112 may extend less than halfway through the thickness of the divider plate 66. In some embodiments, the first portion 112 may extend halfway or more than halfway through the thickness of the divider plate 66. The first portion 112 may act as a funnel and direct fluid into the second portion 114 of the fluid passageway 100.

The third portion 116 may be shaped according to a mirror image of the first portion 112. The third portion 116 may comprise a shaped volume of space extending from a second side 85 of the divider plate 66 through a predetermined thickness of the divider plate 66. The third portion 116 may deliver fluid from the second portion 114 to the second pump chamber. In some embodiments, the first portion 112 may be aligned with the third portion 116 across the thickness of the divider plate 66. In some embodiments, the first portion 112 may be circumferentially offset from the third portion 116.

The divider plate 66 may include a groove 110 for receiving a seal, such as an o-ring, for sealing against the stator 30 to prevent fluid transfer between the first pump chamber 32 and the second pump chamber 34 via gaps between the stator 30 and the divider plate 66.

During operation, the shaft 12 may be rotated by an external rotary drive, causing the rotors 50, 60 to rotate. A fluid may be drawn through the intake aperture 26 of the intake plate 20 and into the first pump chamber 32. In some embodiments, fluid may leave the first pump chamber 32 by way of the first exhaust aperture 33 in the stator 30. However, due to suction generated by the second rotor 60, fluid will generally be drawn through the fluid passageway 100 of the divider plate 66 and into the second pump chamber 34. Preferably, the flutter valve 79 of the first exhaust aperture 33 will prevent anything from entering the first pump chamber 32 through the first exhaust aperture 33. Fluid in the second pump chamber 34 may exit the vacuum pump 10 through the second exhaust aperture 35.

Figure 17 shows an embodiment of a valve 95 which may be used to control flow into and/or out of the second pump chamber 34 through the second exhaust aperture 35. The valve 95 may preferably be arranged such that the valve 95 will not fully close. The valve 95 may comprise a flutter plate 79 and a fastener 81. The fastener 81 may secure the flutter plate 79 in position over the second exhaust aperture 35. The flutter plate 79 may include a shaped surface portion 89. Preferably the shaped surface portion 89 may act as a stop and prevent the flutter plate 79 from fully closing against the stator 30. A small space left between the stator 30 and flutter plate 79 allows oil to pass through the second exhaust aperture 35 into the second pump chamber 34. In some embodiments, the shaped surface portion 89 may comprise a dimple. In some embodiments, the shaped surface portion 89 may comprise a pin or other small element attached to the flutter plate 79. In some embodiments, the shaped surface portion 89 may comprise a bend or crease in the flutter plate 79. Preferably, the shaped surface portion 89 is located across the second exhaust aperture 35 from the fastener 81. In some embodiments, a similar valve may be used with the first exhaust aperture 33.

In some embodiments, a vacuum pump 10 may comprise a single stage vacuum pump having one pump chamber and one rotor. A single stage vacuum pump may include any suitable features as disclosed herein with respect to the various embodiments.

In some embodiments, a vacuum pump 10 may comprise more than two pump stages, such as three pump stages or four pump stages. Additional pump chambers may be provided by providing an additional rotor and an additional divider plate for each additional pump chamber. For example, a third rotor and a second divider plate may be positioned within the internal cavity of the stator. In some embodiments, the stator 30 may be modified to include at least one additional inlet aperture and at least one additional outlet aperture, and the cap 70 may be modified to include an additional chamber. The length of the shaft 12, stator 30 and cap 70 may be increased accordingly. A three stage pump may include a cap having four chambers, wherein two of the four chambers may be crossover chambers allowing fluid communication between the pump stages.

In another embodiment, a valve may be provided in the cap 70 to modify the orientation of the cap chambers and allow the inventive pump 10 to be switched between configurations for single stage and two stage operations. When arranged for single stage operation, the cap 70 may be designed without a crossover chamber. When arranged for single stage operation, the cap may include an intake chamber in communication with the intake aperture 26 and both pump chambers 32, 34, and an exhaust chamber in communication with both pump chambers 32, 34 and the exhaust aperture 76.

In another embodiment, a single stage pump may be provided by omitting the divider plate 66 and using a single rotor, a stator having a first inlet aperture 42 and a first outlet aperture 44, and a cap 70 having an intake chamber in communication with the intake aperture 26 of the intake plate 20 and the first inlet aperture 42 of the stator 30, and an exhaust chamber in communication with the first outlet aperture 44 of the stator 30 and the exhaust aperture 76 of the cap 70.

In another embodiment, the flange 22 of the intake plate 20 and the flange 90 of the back plate 40 may be modified. For example, instead of a raised flange that is shaped similarly to the inner shape of the stator 30, the intake plate 20 and back plate 40 may include a plurality of raised points arranged to locate the stator 30. For example, each plate may include three raised points spaced equally about the inner circumference of a tubular stator that may be used to properly locate the stator. Further, the flange portions may be eliminated, and the stator may be positioned manually.

In another embodiment, the intake plate 20 and/or the back plate 40 may include a receiving groove or recess which may be shaped to receive the stator 30. Thus, at least a portion of the wall of the stator 30 may be received within the groove or recess. A groove or recess may have functionality similar to a flange 22 in locating and receiving the stator 30 as discussed herein.

Any of the embodiments disclosed herein, and especially embodiments where a flange portion is eliminated or alternatively is not shaped similarly to an inner surface of a stator, may include gaskets to seal the stator against the intake plate or back plate.

In another embodiment, the stator 30 may have an elliptical or oval cross-section. Further, the shaft 12 may be centered at one of the focus points of the elliptical cross-section. The flange 22 of the intake plate 20 and the flange 90 of the back plate 40 may also have an elliptical or oval shape and be designed to locate and receive the stator 30.

In another embodiment, the cap 70 may be omitted, and fluid passageways, such as tubular members or conduits, may provide communication between the various inlet and outlet apertures through a wall of the stator 30. For example, a first or intake tubular member or conduit may provide communication between the intake aperture 26 and the first inlet aperture 42. A second or crossover tubular member may provide communication between the first outlet aperture 44 and the second inlet aperture 46. The second outlet aperture 48 may comprise an exhaust aperture and may be provided with an exhaust valve, or alternatively a third or exhaust tubular member may provide communication between the second outlet aperture 48 and an exhaust valve.

In other alternative embodiments, fluid may enter and exit the pump chambers 32, 34 through locations alternate to those provided in the preferred embodiment. For example, fluid may enter the first pump chamber 32 directly through an aperture provided in the intake plate 20, or alternatively, directly through an aperture provided in the stator 30 without passing through the cap 70. The divider plate 66 may be provided with an aperture to allow fluid communication between the first pump chamber 32 and the second pump chamber 34. The second pump chamber 34 may exhaust fluid through the back plate 40 or through the stator 30 without passing through the cap 70.

In an alternative embodiment, the intake plate 20 may be eliminated and an alternative surface, such as a cover, may be used to bound the first pump chamber 32. The alternative surface will preferably have sufficient hardness and durability to resist wear and galling. Similarly, in another alternative embodiment, the back plate 40 may be eliminated and an alternative surface, such as a cover, may be used to bound the second pump chamber 34. In either case, the aperture 84 of the divider plate 66 may be sized and arranged to support the shaft 12.

In another embodiment, the shaft journal aperture 92 of the back plate 40 may be eliminated and the shaft 12 may be reduced in length. Desirably the aperture 84 of the divider plate 66 may be sized and arranged to support the shaft 12.

In some embodiments, a stator 30 having inlet and outlet apertures and a cap 70 having a crossover chamber may be utilized with a divider plate 66 having a fluid passageway 100.

The present invention is also directed to methods of making an inventive vacuum pump 10. A tubular stator may be located relative to an intake plate and a back plate. Either plate may include a flange shaped to locate the stator. A divider plate may be provided to divide an internal cavity of the stator into a first pump chamber and a second pump chamber. A cap 70 may be provided to allow communication between the first pump chamber and the second pump chamber.

Any features of any embodiment described herein may be used with any features of any other embodiment described herein.

The invention may also be described according to any of the following numbered paragraphs:

1. A vacuum pump comprising:

a stator having an internal cavity;

a rotatable shaft, at least a portion of the rotatable shaft oriented within the internal cavity of said stator;

a divider plate located within the internal cavity of the stator, the divider plate dividing at least a portion of the internal cavity of the stator into a first pump chamber and a second pump chamber;

a first rotor oriented within said first pump chamber, the first rotor coupled to and rotatable with said rotatable shaft;

a second rotor oriented within said second pump chamber, the second rotor coupled to and rotatable with said rotatable shaft; and

a cap adjacent to said stator, the cap having a first cap chamber, a second cap chamber and a third cap chamber;

the stator further comprising:

a first inlet aperture providing communication between the first cap chamber and the first pump chamber;

a first outlet aperture providing communication between the first pump chamber and the second cap chamber;

a second inlet aperture providing communication between the second cap chamber and the second pump chamber; and

a second outlet aperture providing communication between the second pump chamber and the third cap chamber.

2. The vacuum pump of paragraph 1, wherein the stator is formed from a tubular piece of material.

3. The vacuum pump of paragraph 1, further comprising an intake plate and a back plate.

4. The vacuum pump of paragraph 3, wherein the intake plate includes a flange arranged to position the stator.

5. The vacuum pump of paragraph 4, wherein the flange is shaped similarly to a cross-section of the stator.

6. The vacuum pump of paragraph 4, wherein the back plate includes a flange arranged to position the stator.

7. The vacuum pump of paragraph 6, wherein the flange of the back plate is shaped similarly to a cross-section of the stator.

8. The vacuum pump of paragraph 3, wherein the intake plate and the back plate are secured to one another and arranged to place compressive forces upon the stator.

9. The vacuum pump of paragraph 3, wherein the cap is coupled to the front plate.

10. The vacuum pump of paragraph 3, wherein the cap is coupled to the back plate.

11. The vacuum pump of paragraph 3, wherein the intake plate includes an intake aperture and the cap first chamber includes an inlet aperture in communication with the intake aperture of the intake plate.

12. The vacuum pump of paragraph 1, wherein the cap third chamber includes an exhaust aperture.

13. The vacuum pump of paragraph 1, wherein the first inlet aperture, first outlet aperture, second inlet aperture and second outlet aperture of the stator each have a central longitudinal axis, and the central longitudinal axis of all of the apertures are parallel.

14. The vacuum pump of paragraph 1, further comprising a plurality of first inlet apertures and a plurality of first outlet apertures in the stator.

15. A vacuum pump comprising:

an intake plate;

a back plate;

a tubular stator having an internal cavity located between the intake plate and the back plate;

a rotatable shaft, at least a portion of the rotatable shaft oriented within the internal cavity of said stator;

a divider plate located within the internal cavity of the stator, the divider plate dividing at least a portion of the internal cavity of the stator into a first pump chamber and a second pump chamber;

a first rotor oriented within said first pump chamber, the first rotor coupled to and rotatable with said rotatable shaft; and a second rotor oriented within said second pump chamber, the second rotor coupled to and rotatable with said rotatable shaft;

the stator further comprising:

a first inlet aperture in communication with the first pump chamber;

a first outlet aperture in communication with the first pump chamber;

a second inlet aperture in communication with the second pump chamber; and

a second outlet aperture in communication with the second pump chamber.

16. The vacuum pump of paragraph 15, further comprising a cap, the cap providing communication between the first outlet aperture and the second inlet aperture of the stator.

17. The vacuum pump of paragraph 15, wherein the intake plate includes a flange shaped similarly to a cross-section of the tubular stator.

18. A vacuum pump comprising:

an intake plate;

a back plate;

a tubular stator having an internal cavity located between the intake plate and the back plate;

a rotatable shaft, at least a portion of the rotatable shaft oriented within the internal cavity of said stator;

a rotor oriented within the internal cavity of the stator, the first rotor coupled to and rotatable with said rotatable shaft; and

a cap adjacent to said stator, the cap having a first cap chamber and a second cap chamber;

the stator further comprising:

an inlet aperture providing communication between the first cap chamber and the internal cavity of the stator; and

an outlet aperture providing communication between the internal cavity of the stator and the second cap chamber.

19. A method of forming a vacuum pump comprising:

a) providing a first plate, a second plate, a shaft, a first rotor, a second rotor, a divider plate, a cap having a chamber, and a tubular stator having an internal cavity;

b) positioning the divider plate within the internal cavity of the stator to form a first pump chamber and a second pump chamber;

c) placing the first rotor within the first pump chamber and the second rotor within the second pump chamber;

d) arranging the shaft to rotate the first rotor and the second rotor;

e) locating the first plate and second plate on opposite sides of the tubular stator; and

f) fixing the cap relative to the stator so the chamber of the cap provides communication between the first pump chamber and the second pump chamber.

20. A vacuum pump comprising:

a stator having an internal cavity, the internal cavity having an outer periphery;

a rotatable shaft, at least a portion of the rotatable shaft oriented within the internal cavity of the stator;

a first rotor oriented within said internal cavity, the first rotor coupled to and rotatable with said rotatable shaft;

a second rotor oriented within said internal cavity, the second rotor coupled to and rotatable with said rotatable shaft;

a divider plate oriented between the first rotor and the second rotor, the divider plate further comprising a fluid passageway extending therethrough, wherein the entire fluid passageway of the divider plate is located within the outer periphery of the internal cavity of the stator.

21. A vacuum pump comprising:

a stator having an internal cavity and a longitudinal axis;

a rotatable shaft, at least a portion of the rotatable shaft oriented within the internal cavity of said stator;

a divider plate located within the internal cavity of the stator, the divider plate dividing at least a portion of the internal cavity of the stator into a first pump chamber and a second pump chamber;

a first rotor oriented within said first pump chamber, the first rotor coupled to and rotatable with said rotatable shaft;

a second rotor oriented within said second pump chamber, the second rotor coupled to and rotatable with said rotatable shaft;

the divider plate further comprising a fluid passageway allowing fluid communication between the first pump chamber and the second pump chamber, the fluid passageway having multiple portions, each portion having a longitudinal axis, the longitudinal axis of at least one portion being nonparallel to the longitudinal axis of the stator.

22. A vacuum pump comprising:

a stator having a wall portion and an internal cavity, the wall portion having an outlet aperture and an inlet aperture;

a rotatable shaft, at least a portion of the rotatable shaft oriented within the internal cavity of said stator;

a divider plate dividing at least a portion of the internal cavity of the stator into a first pump chamber and a second pump chamber;

a first rotor oriented within said first pump chamber, the first rotor coupled to and rotatable with said rotatable shaft;

a second rotor oriented within said second pump chamber, the second rotor coupled to and rotatable with said rotatable shaft; and

a fluid conduit providing a fluid passageway between the outlet aperture and the inlet aperture of the stator;

wherein the outlet aperture of the stator allows fluid communication between the first pump chamber and the fluid conduit, and the inlet aperture of the stator allows fluid communication between the fluid conduit and the second pump chamber.

23. The vacuum pump of paragraph 22, wherein the stator is formed from a tubular piece of material.

24. The vacuum pump of paragraph 22, further comprising an intake plate and a back plate.

25. The vacuum pump of paragraph 24, wherein the intake plate includes a flange arranged to position the stator.

26. The vacuum pump of paragraph 25, wherein the flange is shaped similarly to a cross-section of the stator.

27. The vacuum pump of paragraph 25, wherein the back plate includes a flange arranged to position the stator.

28. The vacuum pump of paragraph 27, wherein the flange of the back plate is shaped similarly to a cross-section of the stator.

29. The vacuum pump of paragraph 24, wherein the intake plate and the back plate are secured to one another and arranged to place compressive forces upon the stator.

30. The vacuum pump of paragraph 24, wherein the fluid conduit is fixed to the stator.

31. The vacuum pump of paragraph 22, further comprising an intake fluid conduit in fluid communication with the first pump chamber.

32. The vacuum pump of paragraph 22, further comprising an exhaust fluid conduit in fluid communication with the second pump chamber.

33. The vacuum pump of paragraph 22, wherein the inlet aperture and the outlet aperture of the stator each have a central longitudinal axis, and the central longitudinal axis of the inlet aperture is parallel to the central longitudinal axis of the outlet aperture.

34. The vacuum pump of paragraph 22, further comprising an auxiliary outlet aperture and an auxiliary inlet aperture in the stator, and an auxiliary fluid conduit providing a fluid passageway between the auxiliary outlet aperture and the auxiliary inlet aperture of the stator;

wherein the auxiliary outlet aperture of the stator allows fluid communication between the first pump chamber and the auxiliary fluid conduit, and the auxiliary inlet aperture of the stator allows fluid communication between the auxiliary fluid conduit and the second pump chamber.

35. The vacuum pump of paragraph 22, further comprising:

a second divider plate dividing at least a portion of the internal cavity of the stator into a third pump chamber;

a third rotor oriented within said third pump chamber, the third rotor coupled to and rotatable with said rotatable shaft; and

a second fluid conduit providing a fluid passageway between a second outlet aperture and a second inlet aperture in the stator;

wherein the second outlet aperture of the stator allows fluid communication between the second pump chamber and the second fluid conduit, and the second inlet aperture of the stator allows fluid communication between the second fluid conduit and the third pump chamber.

36. A method of forming a vacuum pump comprising:

a) providing a first plate, a second plate, a shaft, a first rotor, a second rotor, a divider plate, a fluid conduit, and a tubular stator having an internal cavity, an outlet aperture and an inlet aperture;

b) positioning the divider plate within the internal cavity of the stator to form a first pump chamber and a second pump chamber, wherein the outlet aperture is in fluid communication with the first pump chamber and the inlet aperture is in fluid communication with the second pump chamber;

c) placing the first rotor within the first pump chamber and the second rotor within the second pump chamber;

d) arranging the shaft to rotate the first rotor and the second rotor;

e) locating the first plate and second plate on opposite sides of the tubular stator; and

f) arranging the fluid conduit relative such that the fluid conduit provides a fluid passageway for fluid communication between the outlet aperture and the inlet aperture.

The above disclosure is intended to be illustrative and not exhaustive. This description will suggest many variations and alternatives to one of ordinary skill in this art. All these alternatives and variations are intended to be included within the scope of the claims where the term "comprising" means "including, but not limited to". Those familiar with the art may recognize other equivalents to the specific embodiments described herein which equivalents are also intended to be encompassed by the claims.

Further, the particular features presented in the dependent claims can be combined with each other in other manners within the scope of the invention such that the invention should be recognized as also specifically directed to other embodiments having any other possible combination of the features of the dependent claims. For instance, for purposes of claim publication, any dependent claim which follows should be taken as alternatively written in a multiple dependent form from all prior claims which possess all antecedents referenced in such dependent claim if such multiple dependent format is an accepted format within the jurisdiction (e.g. each claim depending directly from claim 1 should be alternatively taken as depending from all previous claims). In jurisdictions where multiple dependent claim formats are restricted, the following dependent claims should each be also taken as alternatively written in each singly dependent claim format which creates a dependency from a prior antecedent-possessing claim other than the specific claim listed in such dependent claim below.

This completes the description of the preferred and alternate embodiments of the invention. Those skilled in the art may recognize other equivalents to the specific embodiment described herein which equivalents are intended to be encompassed by the claims attached hereto.

CLAIMS:

1) A vacuum pump comprising:

an intake plate having a shaped mating portion;

a back plate having a shaped mating portion;

a stator having a wall portion, an internal cavity and a longitudinal axis, the stator located between the intake plate and the back plate;

a rotatable shaft, at least a portion of the rotatable shaft oriented within the internal cavity of the stator;

a first rotor oriented within said stator, the first rotor coupled to and rotatable with said rotatable shaft; and

wherein the mating portion of the intake plate contacts the stator and properly locates the stator with respect to the intake plate.

2) The vacuum pump of claim 1, wherein the mating portion of the intake plate engages the stator and prevents the intake plate from moving orthogonally with respect to the longitudinal axis of the stator.

3) The vacuum pump of claim 1, wherein the mating portion of the intake plate comprises a raised flange.

4) The vacuum pump of claim 3, wherein the raised flange of the intake plate is shaped similarly to a cross-sectional shape of the stator.

5) The vacuum pump of claim 3, wherein the intake plate further comprises a groove.

6) The vacuum pump of claim 5, wherein the groove is oriented about the periphery of the raised flange of the intake plate.

7) The vacuum pump of claim 5, further comprising a seal oriented within the groove, wherein the seal abuts an edge of the stator.

8) The vacuum pump of claim 3, wherein the raised flange comprises a circular shape.

9) The vacuum pump of claim 1, wherein the stator comprises a tubular shape.

10) The vacuum pump of claim 9, wherein the stator comprises a cylindrical shape.

11) The vacuum pump of claim 1, wherein the mating portion of the back plate contacts the stator and properly locates the stator with respect to the back plate.

12) The vacuum pump of claim 11, wherein the mating portion of the back plate engages the stator and prevents the back plate from moving orthogonally with respect to the longitudinal axis of the stator.

13) The vacuum pump of claim 11, wherein the mating portion comprises a raised flange.

14) The vacuum pump of claim 13, wherein the raised flange comprises a circular shape.

15) The vacuum pump of claim 13, wherein the back plate further comprises a groove.

16) The vacuum pump of claim 15, wherein the groove is oriented about the periphery of the raised flange of the back plate.

17) The vacuum pump of claim 16, further comprising a seal oriented within the groove, wherein the seal abuts an edge of the stator.

18) The vacuum pump of claim 1, further comprising:

a second rotor oriented within said stator, the second rotor coupled to and rotatable with said rotatable shaft; and

a divider plate located between the first rotor and the second rotor.

19) The vacuum pump of claim 18, further comprising:

a third rotor oriented within said stator, the third rotor coupled to and rotatable with said rotatable shaft; and

a second divider plate located between the second rotor and the third rotor.

20) A vacuum pump comprising:

an intake plate having a raised flange;

a back plate having a raised flange;

a stator having an internal cavity and a longitudinal axis, the stator located between the intake plate and the back plate;

a rotatable shaft, at least a portion of the rotatable shaft oriented within the internal cavity of the stator;

a divider plate located within the internal cavity of the stator, the divider plate dividing at least a portion of the internal cavity of the stator into a first pump chamber and a second pump chamber;

a first rotor oriented within said first pump chamber, the first rotor coupled to and rotatable with said rotatable shaft; and

a second rotor oriented within said second pump chamber, the second rotor coupled to and rotatable with said rotatable shaft;

wherein the raised flange of the intake plate extends into the internal cavity of the stator.

21) The vacuum pump of claim 20, wherein the raised flange of the intake plate is shaped similarly to an outer periphery of the internal cavity of the stator.

22) The vacuum pump of claim 20, wherein the raised flange of the back plate extends into the internal cavity of the stator.

23) The vacuum pump of claim 22, wherein the raised flange of the back plate is shaped similarly to an outer periphery of the internal cavity of the stator.

24) The vacuum pump of claim 20, wherein the intake plate further comprises an intake aperture in fluid communication with the first pump chamber, the intake aperture passing through the raised flange of the intake plate.

25) The vacuum pump of claim 20, wherein the stator comprises a cylindrical tube.

Application No: GB0607292.0 **Examiner:** James Paddock
Claims searched: 1 **Date of search:** 9 August 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-5,8-15, 18	US1245691 A DEYSHER See Figure 1. Twin chamber vane pump with inlet and outlet ends mated to stator via positioning lips.
X	1-6,8-10	US4543049 A DIESEL KIKI See Figure 1. Endplate orthogonally retained by axial flange engaging stator.
X	1-4, 8-14	JP60206997 A SHIMADZU See Figure 1. Central raised flange engages stator interior for end plate retention.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

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The following online and other databases have been used in the preparation of this search report

WPI EPODOC