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VACUUM OPERATED PUMP

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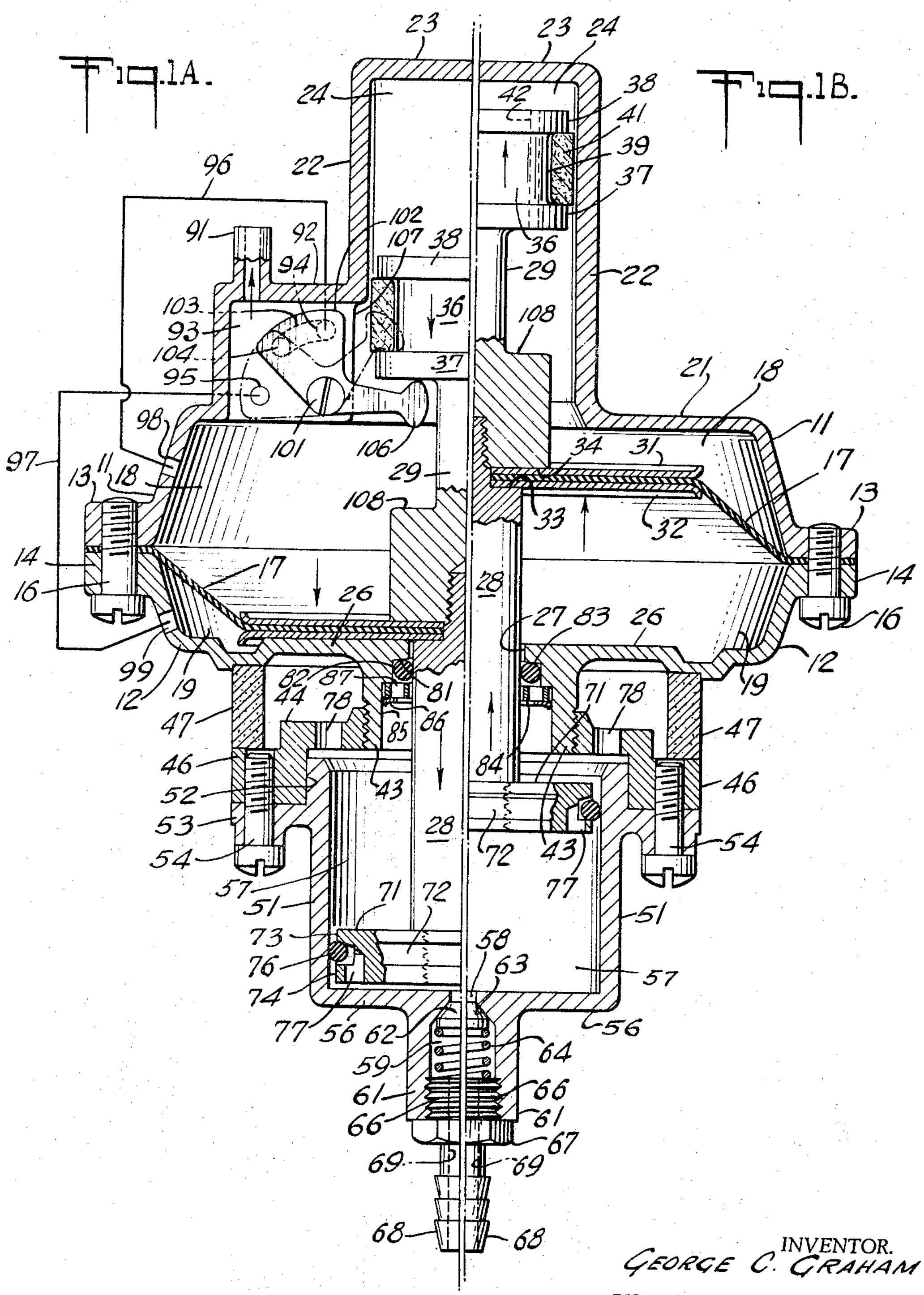

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VACUUM OPERATED PUMP

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This invention relates to a novel vacuum operated pump or compressor for use in connection with motor vehicle and stationary engines or other vacuum sources for establishing and maintaining fluid pressure in systems such as shock absorbers, tire inflating devices, or other systems requiring compressed air and other fluids under pressure.

It is a purpose of the present invention to overcome the disadvantages and deficiencies of prior devices which are manufactured with close tolerances and where high frictional engagement occurs between the reciprocating parts and their mating surfaces, thereby reducing efficiency and increasing wear, thus involving repair and replacement costs.

According to the present invention, the pump or compressor herein is designed for low cost manufacture, low friction operation, and minimum wear with little, if any, lubrication being required after original assembly of the device while, at the same time, efficient functioning of the operating parts is ensured.

A salient feature of the invention is the provision of a piston in the subject pump which is mounted without close tolerances within its pumping cylinder while other piston assembly components and mountings have ample clearances to permit free movement thereof without reducing the pumping or compression efficiency of the device.

Another important feature of the invention is the isolation of the pumping cylinder from the vacuum chamber of the device whereby high pumping efficiency is realized and a lesser quantity of negative air pressure is required to operate the device as compared with previous conventional apparatus.

By virtue of this isolation of the pumping or pressure cylinder from the vacuum chamber, it is possible to change the size of the pressure or power piston and its cylinder without changing the vacuum diaphragm components. Whatever the size the substituted pressure pistons and cylinders may be, within broad limits, the full thrust of the vacuum diaphragm is effective in operating the pressure pistons. The vacuum or negative air pressure power unit always has the same maximum thrust which is not appreciably decreased, if at all, by increased size of the compression piston and its cylinder. Accordingly, the same vacuum or negative air pressure unit can serve as a source of power for a wide range of pressure pistons and cylinders of different sizes for air compression units with only minor changes being required in substituting the pressure piston and cylinder components thereof.

Since the reciprocating pump assembly comprises a flexible diaphragm to the opposite sides of which two separate pistons are mounted, it is difficult to obtain precision alignment of a common axis between said pistons, while at the same time the flexibility of the diaphragm introduces the possibilities of deviation of reciprocating movement of the piston assembly from a true rectilinear axis. The achievement of a desirable straight line axis for the two piston rods and of the diaphragm assembly in a true rectilinear axis would ordinarily involve high cost precision manufacturing and assembly techniques which

are prohibitive for general purpose low cost vaccum pumps.

Accordingly, the structure of the present invention provides a pivoting axis for the piston-diaphragm assembly in the region of the partition between the vacuum chamber and the pressure cylinder where a ring seal and retainer ring are located so that deviations of movement from a true axis are compensated for even though the component parts are made according to low or moderate cost normal manufacturing tolerances. Therefore, even though each of the component parts of the piston-diaphragm assembly do not move in a constant straight line axis, the partition seal and the pressure piston rod seal will nevertheless effectively maintain the integrity of their sealing functions. Although the various parts of the piston-diaphragm apparatus may be assembled out of true axial alignment because of normal manufacturing tolerances and notwithstanding the existence of a pivoting axis for said piston-diaphragm assembly, nevertheless effective seals are maintained during reciprocating action by the pressure piston and the piston rod seal.

Still other objects and advantages of the invention will be apparent from the specification.

The features of novelty which are believed to be characteristic of the invention are set forth herein and will best be understood, both as to their fundamental principles and as to their particular embodiment, by reference to the specification and accompanying drawings, in which—

FIGURE 1A is a vertical central section of the pump of the present invention showing the movable pumping elements located at the end of the pressure stroke; and

FIGURE 1B is comparable to 1A showing a vertical central section of the pump showing the pumping elements located at the end of the suction stroke.

The two figures of the drawing each show one-half of the complete device as a semi-circular section, wherein like numbers refer to some of the same parts although they are shown in different operational locations. Except for the control valve mechanisms, each part of the device may be assumed to be substantially circular in cross-section. Some parts of the drawing are shown in elevation and other parts are indicated diagrammatically.

Referring now to the drawing in detail, the body of the device comprises a pair of bell sections **11** and **12**, each having annular mating flanges **13** and **14**, respectively, which are secured together by means of a plurality of spaced apart bolts **16**. Clamped fast between flanges **13** and **14** is the peripheral edge portion of a flexible diaphragm **17** which is movable within space enclosed by bell sections **11** and **12** and which divides and separates said space into two chambers **18** and **19** which vary inversely in volume according as said diaphragm moves in one direction or the other.

Formed integrally with the end wall **21** of bell section **11** is a dome **22** of circular cross-section enclosed by an integrally formed end wall **23**. Dome **22** surrounds a dummy piston chamber **24**.

Bell section **12** has an end wall or partition **26** having a central axial aperture **27** through which a piston rod **28** moves reciprocably, there being a slight clearance between said rod and said aperture. Movable reciprocably within piston chamber **24** is a dummy piston rod **29**, the inner end of said rod being threadably secured to the inner reduced end portion of piston rod **28**. Mounted on opposite sides of the central portion of diaphragm **17** are circular clamp plates **31** and **32**, said clamp plates being urged toward each other by virtue of opposing shoulders 33 and 34 of rods 28 and 29, respectively, bearing upon said plates when said rods are threadably secured together, a central portion of rod 28 extending through axially aligned central apertures in said clamp plates and said diaphragm. Thus, the reciprocating motion of diaphragm 17 will impart an equal reciprocating motion to rods 28 and 29.

Integrally formed or otherwise mounted at the outer end of rod 29 is a dummy piston head 36 which has a pair of spaced apart annular flanges 37 and 38 whose peripheries are spaced apart from and move with clearance relative to the interior surface of dummy cylinder 24. Formed between flanges 37 and 38 of dummy piston head 36 is an annular recess 39 which optionally accommodates a lubricated or unlubricated felt or plastic cut ring 41 which ensures that flanges 37 and 38 do not cause serious scoring between the metal parts. In some embodiments, ring 41 may be loose enough to permit air to bypass said ring when piston head 36 moves reciprocably within said cylinder. Otherwise, dummy piston head 36 may have a longitudinal aperture 42, off-center axially, that serves as an air vent or hole in order to ensure free flow of air when a thicker ring 41 is used or provided.

Integrally formed on the outer surface of end wall 26 of bell section 12 is a circular outwardly extending collar 43 that is located coaxially relative to aperture 27 in said end wall, and has a somewhat greater diameter than said aperture. Threadably connected to the outer end of collar 43 is a circular adapter ring 44 having an integrally formed, outwardly extending, L-shaped annular flange 46. Secured between end wall 26 of bell section 12 and flange 46 is a circular porous filter ring 47 made of helically wound cellulose ribbons or suitable material.

The pumping or compression component of the device comprises a circular compression cylinder 51, the inner end of which fits at least partially into a mating circular recess 52 formed within the confines of flange 46 of ring 44. Intermediate the ends of compression cylinder 51 and formed integrally on the surface thereof is an outwardly extending annular flange 53, a lateral surface of which mates with an opposing lateral surface of flange 46 and is secured thereto by a plurality of spaced apart bolts 54 circularly arrayed in said flanges. The outer end of cylinder 51 terminates in an integrally formed end wall 56 to enclose a pumping or compression chamber 57.

Located centrally in end wall 56 is an outlet port 58 which communicates with valve chamber 59 within valve housing 61 formed integrally with an extending outwardly from said end wall. Positioned within valve chamber 59 is a check valve 62 that is urged against valve seat 63 by one end of a valve spring 64, the other end of which bears against a plug 66 threadably inserted into the end of valve housing 61. Plug 66 is threadably tightened by means of a nut 67 integrally formed with said plug, the latter having an integrally formed, outwardly extending connection tube 68. Plug 66, nut 67 and tube 68 have a common central aperture 69. Connection tube 68 may be provided with sawtooth ridges for accommodating flexible connecting tubing or the like.

Threadably or otherwise mounted on the outer end of piston rod 28 is a piston 71 of enlarged diameter whose periphery is somewhat spaced apart from the interior wall of cylinder 51. Piston 71 has an annular recess 72 bounded by spaced apart flanges 73 and 74, said recess loosely accommodating an elastic, flexible O-ring 76. During the pressure stroke of piston 71, as shown in FIGURE 1A, O-ring 76 is urged outwardly and against flange 73 to act as an air-tight seal between piston 71 and the interior wall of cylinder 51 whereby pressure is produced within said cylinder to cause fluid or air to move through port 58 and to urge check valve 62 away from valve seat 63 against the action of spring 64, whereby compressed air passes outwardly through pipe 68. During the return stroke of piston 71 as shown in FIGURE 1B, O-ring 76 is urged against flange 74 whereby air bypasses said O-ring through recess 72 and through one or more spaced apart apertures 77 in flange 74 as well as between periphery of piston 71 and interior wall of cylinder 51. Equalizing atmospheric air is provided for cylinder 51 by means of one or a plurality of spaced apart apertures 78 arrayed in a circle in adapter ring 44, said atmospheric air reaching said apertures by passing through porous filter ring 47. In the region of aperture 27, end wall 26 has an annular coaxially aligned recess of somewhat enlarged diameter formed by the juncture between an annular sloping wall 81 and an annular perpendicular wall 82. Nested in said recess is a somewhat loosely fitting resilient O-ring 83 which is retained therein by means of a washer 84 made of a suitable low friction plastic material such as Delrin, nylon, Teflon, or of a material which is substantially self-lubricating or compatible relative to piston rod 28.

Alternatively, washer 84 may be made of a suitable material which, when initially lubricated at the time of assembly of the apparatus, requires no lubrication thereafter. Washer 84 is retained against an annular shoulder 85 in the interior of collar 43 by means of a spider ring 86 frictionally engaging an annular longitudinal wall 87 in the interior of said collar. The inside diameter of washer 84 is slightly larger than the outside diameter of piston rod 28. In order to facilitate air passage relative to washer 84, the latter may be provided with one or a plurality of spaced apart apertures 87 arrayed circularly in said washer.

The material of washer 84 is selected to have the characteristics of low friction relative to the material of piston rod 28 in order to prevent any scoring or damage of said rod. The relative diameters of aperture 27 and rod 28 are selected whereby a loose bearing fit exists between those two elements.

It is understood that the assembly of pressure cylinder 51 and adapter ring 47 may be threadably removed from collar 43 and replaced by a cylinder-adapter assembly of a different size, while piston 71 may also be removed from piston rod 28 and replaced by a piston that cooperates dimensionally with the substituted cylinder.

Motivating action for the pressure and retraction strokes of piston 71 is provided by the movement of diaphragm 17 reciprocably within the space defined by bell sections 11 and 12. The movement of diaphragm 17 is produced by alternating negative pressure conditions induced in chambers 18 and 19 on opposite sides of said diaphragm by means of a connection to the intake manifold, not shown, of the engine of a motor vehicle or the like. The intake manifold of the motor vehicle engine is attachable to a pipe 91 connected to an outwardly extending hollow boss 92 of cylinder 22, said boss being represented diagrammatically on FIGURE 1A. Boss 92 encloses a control valve chamber 93 which has a pair of spaced apart ports 94 and 95 which communicate by respective pipe lines 96 and 97, with ports 98 and 99 in respective bell sections 11 and 12. Pipe lines 96 and 97 are illustrated diagrammatically. Ports 98 and 99 each communicate with respective chambers 18 and 19 on opposite sides of diaphragm 17.

Mounted pivotally on shaft 101 in valve chamber 93 is an oscillating valve 102 which has an arcuate slot 103 on one flat side which is positionable in either of two locations whereby port 104 communicating with pipe 91 is operatively connected alternatively with either port 94 or port 95. When valve 102 is in the position shown in solid lines in FIGURE 1A establishing communication between ports 94 and 104, negative air pressure induced by way of pipe 91 through port 104 is transmitted by slot 103 to port 94 whereby negative pressure is induced in chamber 18. When valve 102 is in the position shown in dotted lines in FIGURE 1A, slot 103 establishes communication between ports 104 and 95 whereby negative pressure is induced in chamber 19. When valve 102 is spaced apart from either one of ports 94 or 95, the latter communicates with atmospheric air whereby such air can enter into one of the corresponding chambers **18** and **19** when the other is subjected to negative pressure.

The foregoing valve and porting mechanisms and functions are well known in the art which accounts for their being represented diagrammatically herein.

Connected to valve **102** is a rocker control lever **106** which is movable equi-angularly with said valve. Lever **106** extends movably through a suitable isolation barrier **107**, illustrated diagrammatically, which separates valve chamber **93** from the interior of cylinder **22** and chamber **18** where negative pressure is intermittently induced. The structural and functional means for setting up such an isolation barrier are well known in the art.

The outer end of rocker control level **106** extends into the space substantially at the juncture between cylinder **22** and bell section **21**. When dummy piston **36** moves downwardly with piston rod **29**, as shown in FIGURE 1A, the bottom surface of said piston engages the head of rocker control lever **106** and urges it downwardly to a position where control valve **102** establishes communication between port **94** and port **104**.

Upon the upward movement of piston rod **29** and of dummy piston **36**, the head of rocker control lever **106** is engaged by the upper surface of an outwardly extending boss **108** formed on piston rod **29** causing said rocker control lever to move pivotally into a position as shown in dotted outline in FIGURE 1A whereby communication is established between ports **95** and **104**.

Accordingly as control valve **102** is in either of the two alternate positions shown in FIGURE 1A, negative pressure is established alternately in chamber **18** and **19** on opposite sides of diaphragm **17** whereby said diaphragm is caused to move reciprocably within the space formed between bell sections **11** and **12**, thereby causing piston rod **28** and piston **71** to move reciprocably within the chamber of pumping or compressing cylinder **51**.

In operation, work piston **71** is moved reciprocably by the action of diaphragm **17** moving alternately within the space defined by bell sections **11** and **12** by means of alternately induced negative pressures in chambers **18** and **19**. When negative pressure is induced in chamber **18**, for example, as when control valve **102** is in the solid line position as shown in FIGURE 1A, chamber **19** is opened to atmospheric pressure since port **95** communicates with atmospheric pressure in valve chamber **93** by means well known in the art. Conversely, when control valve **102** is in a position where it provides communication between port **104** and port **95**, negative pressure is induced in chamber **19** to cause the diaphragm to move downwardly to produce the pressure stroke of piston **71**. In this circumstance, port **94** is open to atmospheric pressure which, in turn, provides atmospheric pressure for chamber **18**.

Referring to FIGURE 1B, piston rod **28** has just completed its upward travel thereby retracting piston **71** during which time chamber **19** has been exposed to atmospheric air. Hence, O-ring **83** which reposes loosely within its recess has not been required to produce any sealing action. Due to some friction of O-ring **83** against the surface of piston rod **28**, said O-ring is probably urged upwardly into the position as shown in FIGURE 1B without performing any sealing action. During this upward retraction stroke of piston rod **28**, atmospheric pressure also exists on the underside of O-ring **83** in view of atmospheric air having been drawn into cylinder **51** through filter ring **47** and through apertures **78**. It will be noted that the atmospheric air intake for the chamber of power cylinder **51** is separate and independent from the air intakes for vacuum chambers **18** and **19**, as a result of which the action of piston **71** is rendered more efficient than if a single atmospheric air intake were provided for all of said chambers.

As soon as piston rod **28** has completed its upward retraction stroke, the upper surface of boss **108** has pivotally moved control lever **106** upwardly into the position shown in dotted outline in FIGURE 1A, thereby automatically inducing negative pressure in chamber **19** while exposing chamber **18** to atmospheric pressure. The induction of negative pressure in chamber **19** substantially immediately causes O-ring **83** to be urged upwardly and into sealing contact with the surface of piston rod **28**, wall **81** and wall **82** under the action of atmospheric pressure always existing within the area bounded by annular filter **47**, with communication through aperture **78**, between washer **84** and rod **28** and through aperture **87** if the latter is provided. While piston rod **28** now moves downwardly under the action of diaphragm **17** to cause piston **71** to produce a pressure stroke, the negative pressure in chamber **19** continues to maintain O-ring **83** in a sealing position notwithstanding the friction of said O-ring against the surface of piston rod **28**. The material of O-ring seal is selected in relation to the material of piston rod **28** whereby a low friction relationship exists therebetween so that the negative pressure in chamber **19** is effective in causing said O-ring to maintain its sealing effect during the pressure stroke of piston **71**. Hence, O-ring **83** acts as a one-way, one-purpose seal. Whatever frictional engagement there may be between O-ring **83** and the surface of piston rod **28** tending initially to move in the same direction, it is immediately superseded by the far superior influence of the negative pressure in chamber **19** to produce the necessary sealing function in the opposite direction. Washer **84** acts as a retainer for O-ring **83** in its recess while also serving as a loose bearing for piston rod **28**.

A pump having a reciprocating assembly as shown and described herein, would normally have four potential spaced apart points or areas of contact between moving and stationary parts. They comprise the dummy piston **36** relative to cylinder **22**, the area where diaphragm **17** is secured by clamp plates **31** and **32**, the seal provided by O-ring **83**, and the O-ring **76** providing the pressure seal for work piston **71**.

Whereas in other pumping devices of this type it would be necessary to provide precision tolerances for each of these components, involving difficulty of fabrication and excessive cost in manufacture, the present invention permits the use of wide manufacturing tolerances in respect of dummy piston **36**, work piston **71**, the clamping means for diaphragm **17**, and the O-ring seal for work piston **71**, thereby realizing low manufacturing costs.

In actual production, it would be extremely difficult to produce perfect alignment of piston rods **28** and **29** when the latter are threadably engaged to urge clamp plates **31** and **32** into position on diaphragm **17**. Even if the component parts of the reciprocating assembly are not absolutely perfectly axially aligned, nevertheless the assembly performs satisfactorily and efficiently. This is due to the fact that a wide tolerance is permitted between dummy piston **36** and the interior wall of cylinder **22** and between the periphery of work piston **71** and the interior wall of cylinder **51**. If there is any skew from perfect axial motion of the reciprocating assembly, said skew is accommodated by the slight, yieldably, pivoting motion that takes place in the area of O-ring seal **83** and retainer washer **84** while both work piston **71** and dummy piston **36** will still perform their required functions. For example, it is quite possible that the reciprocating assembly can be slightly skewed off true axial motion by the engagement of either or both dummy piston **36** and boss **108** with control lever **106**. Notwithstanding any slight departure from true axial movement, the work of compression taking place in cylinder **51** and the work of operating the switch action of valve **102** will continue to be performed efficiently without diminution.

It is also to be noted that while dummy piston **36** does not perform any fluid pumping action, nevertheless it does operate in conjunction with cylinder **22** as a dashpot to prevent excessive speed of travel on the upward or retraction stroke of work piston **71**. The number or the diameter size of air vents **42** in the dummy piston **36** may be determined by the dash-pot effect that is necessary or desired in conjunction with the other operating parts of the pump.

By virtue of the structure of the present invention of a single-acting pump, work piston **71** and the compression chamber in cylinder **51** are isolated during the pressure stroke from the vacuum chamber of the apparatus. By virtue of this separation or isolation, it is possible to provide a comparatively large work piston **71** to produce efficiently a large volume, low pressure, air output from the compression chamber within cylinder **51**.

For example, assuming the same size vacuum diaphragm unit under the same vacuum or negative air pressure conditions with output pressures of from 20 lbs. p.s.i. to 60 lbs. p.s.i., the device of the present invention produces pressures of from about 150% to 25%, respectively, greater than those units where the vacuum chamber is not isolated from the pressure chamber. At the same time, the quantity of negative air pressure as represented by cubic inches of space on the work side of diaphragm **17** in chamber **19** where the power producing action takes place, is between about 68% to 25% less in the apparatus of the present invention than in other devices where there is no isolation between the vacuum chamber and the work piston chamber. Accordingly, the present invention requires a considerably lesser quantity of vacuum or negative air pressure that is to be drawn from the internal combustion engine which is the source of the negative air pressure. One reason for obtaining a high efficiency in the pump of the present invention by isolating the work piston from the vacuum chamber is that vacuum chamber **19** is greatly reduced in volume whereby the negative pressure induced therein is more effectively operative upon diaphragm **17**.

Although the present invention has been illustrated and described in operation as a single-acting pump, it is understood that with suitable modifications known in the art, the structure of the apparatus can operate as a double-acting pump.

Various other modifications and varied applications of the novel features of the apparatus in the detailed description above will occur to those skilled in the art and, consequently, this invention should be construed broadly in accordance with its full spirit and scope.

What is claimed is:

1. A pump comprising a housing, a flexible diaphragm mounted in said housing and dividing the interior of the latter into first and second vacuum chambers, means for subjecting said first and second vacuum chambers alternately to negative pressure and atmospheric pressure for moving said diaphragm reciprocably within said housing, a pressure cylinder on said housing, a partition between said pressure cylinder and said first vacuum chamber, a piston rod connected to one side of said diaphragm, an aperture in said partition through which said rod moves reciprocably, a portion of said rod extending into said pressure cylinder, a piston mounted on said rod and movable reciprocably within said pressure cylinder, and one-way sealing means mounted between said rod and said partition effectively isolating said first vacuum chamber from said pressure cylinder during the time when said first vacuum chamber is under negative pressure to cause said diaphragm to perform the pressure stroke for said rod and said piston, said one-way sealing means being exposed to and being activated by atmospheric pressure to produce its sealing function.

2. A pump according to claim **1** wherein said pressure cylinder is replaceably removable from said housing and said piston is replaceably removable from said rod.

3. A pump according to claim **1** and further comprising a retainer ring in said partition slightly spaced apart from said sealing means.

4. A pump according to claim **1** wherein an ample clearance exists between said piston rod and said aperture.

5. A pump according to claim **1** and further comprising means for joining said pump to a source of negative air pressure, and means for connecting said joining means alternately to said first and second vacuum chambers.

6. A pump according to claim **5** and further comprising first and second spaced apart actuating means connected to the other side of said diaphragm and movable therewith in said second vacuum chamber, said first and second actuating means alternately operating said connecting alternating means as said diaphragm moves reciprocably.

7. A pump according to claim **6** and further comprising a dummy cylinder communicating with said second vacuum chamber and wherein said means for operating said alternating means comprises a dummy piston within said dummy cylinder, said dummy piston being connected to and movable with said diaphragm.

8. A pump according to claim **7** wherein the motion of said dummy piston into said dummy cylinder operates as a dash-pot.

9. A pump comprising a housing, a flexible diaphragm mounted in said housing and dividing the interior of the latter into first and second vacuum chambers, said diaphragm being movable reciprocably within said housing, a pressure cylinder on said housing, a partition between said pressure cylinder and said first vacuum chamber, a piston rod connected to one side of said diaphragm and movable therewith, an aperture in said partition through which said piston rod moves reciprocably, a portion of said piston rod extending into said pressure cylinder, a piston on said piston rod movable reciprocably within said pressure cylinder, and a one-way first seal between said piston rod and said partition, a second seal between said piston and the interior wall of said pressure cylinder, the axis of said piston rod being yieldably pivotable in the region of said first seal to accommodate the deviation of reciprocating movement of the piston rod-diaphragm assembly from a true axis, said second seal maintaining the seal between said piston and interior wall of said pressure cylinder despite such deviation during the pressure stroke of said piston, said one-way first seal being exposed to and being activated by atmospheric pressure to produce its sealing function.

10. A pump according to claim **9** and further comprising a retainer ring in said partition slightly spaced apart from said sealing means.

11. A pump according to claim **9** wherein an ample clearance exists between said piston rod and said aperture.

12. A pump according to claim **9** and further comprising means for connecting said first and second vacuum chambers alternately to a source of negative air pressure and atmospheric pressure.

13. A pump according to claim **9** and further comprising means for joining said pump to a source of negative air pressure, and means for connecting said joining means alternately to said first and second vacuum chambers.

14. A pump according to claim **13** and further comprising a second rod connected to the other side of said diaphragm and movable therewith in said second vacuum chamber, said second rod automatically operating said connecting alternating means.

15. A pump according to claim **13** and further comprising first and second spaced apart actuating means connected to the other side of said diaphragm and movable therewith in said second vacuum chamber, said first and second actuating means alternately operating said connecting alternating means as said diaphragm moves reciprocably.

16. A pump according to claim **13** and further comprising a second rod connected to the other side of said diaphragm, a second cylinder in said housing communicating with said second vacuum chamber, said second piston on said second rod being movable reciprocably within said second cylinder, a boss on said second rod spaced apart from said second piston, said boss and said piston alternately operating said connecting alternating means as said second rod moves reciprocably with said diaphragm.

17. A pump according to claim 9 and further comprising a separate air intake for said pressure cylinder.

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