

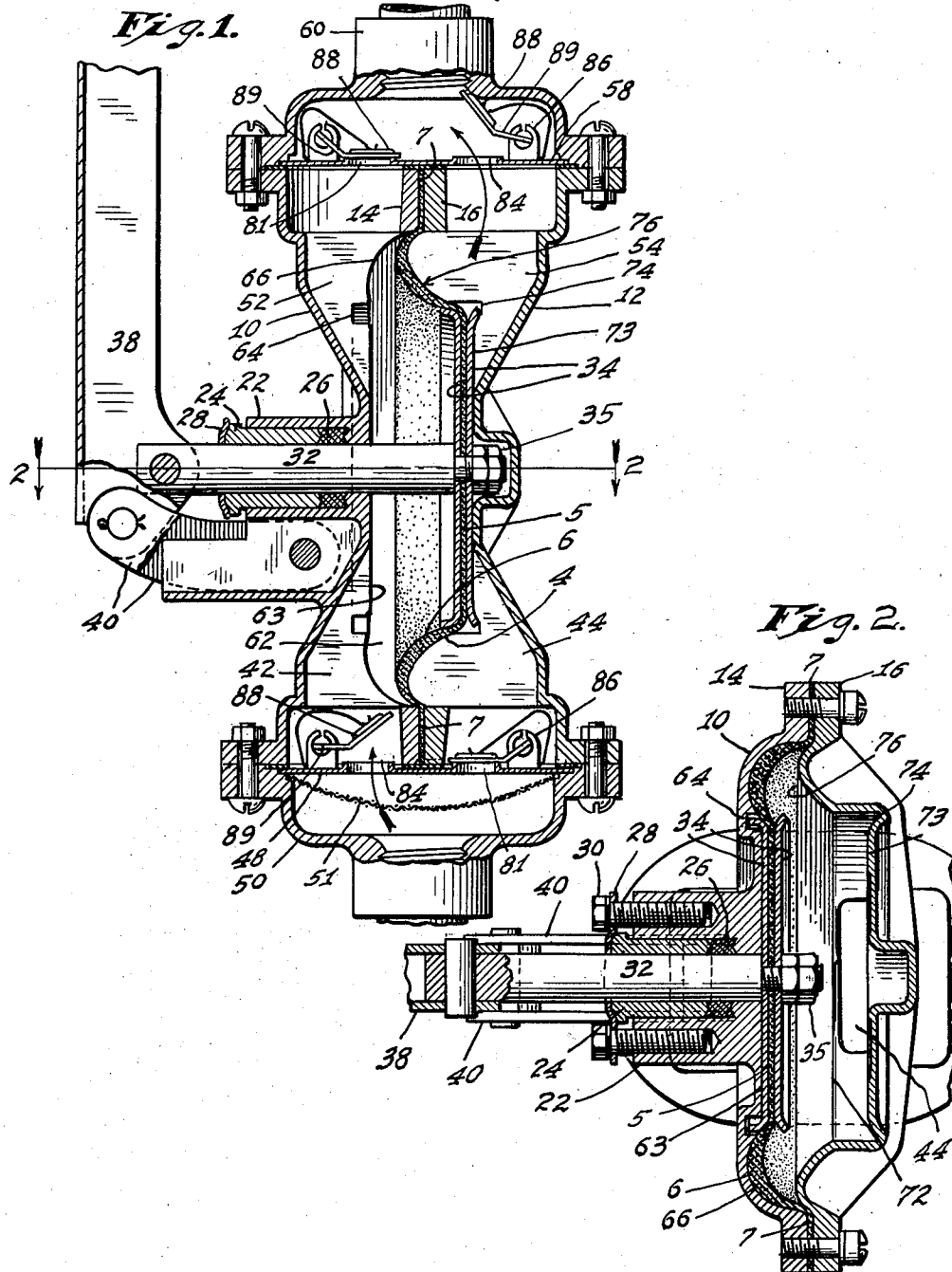
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DIAPHRAGM PUMP

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DIAPHRAGM PUMP

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5 Claims. (Cl. 103—150)

This invention relates to a diaphragm pump in which a displacement chamber is swept by a diaphragm having a permanently arched working annulus which is stressed in compression on its suction stroke and in tension on its pressure discharge stroke, and to a double-acting pump embodying a single-walled permanently arched diaphragm.

It is an object of the invention to provide a diaphragm and displacement chamber relationship which is adapted both to have a substantial suction lift and to work against a discharge head, and is adapted especially to work against a high discharge head. It is an object of the invention to improve and simplify the diaphragm pump of my co-pending application Serial No. 221,848, filed April 19, 1951, now Patent No. 2,685,304, and to provide a double-acting pump which utilizes only one of the diaphragm elements described and claimed in said co-pending application. It is an object of the invention to provide a diaphragm pump in which the diaphragm has a single-walled working annulus which is supported in arched configuration against introversion, and to combine such a diaphragm with a single displacement chamber or with opposite displacement chambers which provide minimum clearance volume at the end or ends of the stroke. It is an object of the invention to provide such a pump which will produce a high suction lift and will operate against a high discharge head, and which will operate efficiently with short partial strokes.

In my aforesaid co-pending application, two diaphragm elements having self-sustaining or permanently arched annular working portions are arranged with the convex faces of each arched portion facing the displacement chamber which it sweeps. On each suction stroke the arched wall is stressed in tension and on each pressure stroke the arched wall is stressed in compression. In accordance with one aspect of the present invention, the concave face of an arched wall faces the displacement chamber which it sweeps, and such wall is stressed in compression on its suction stroke and in tension on its pressure or discharge stroke—just the opposite of the stress relationships in the co-pending application. The displacement chamber so swept desirably has an annular convex wall which mates with the concave face of the arched working annulus of the diaphragm, to give small clearance volume at the end of the discharge stroke.

The single-walled diaphragm may lie between and sweep two opposite displacement chambers, to provide a double-acting pump. With respect to the chamber on the convex side of the arched diaphragm wall the stress reactions on that wall are in the same arrangement as in my co-pending application, while with respect to the opposite displacement chamber the stress reactions are reversed, as described above.

In a double-acting diaphragm pump embodying the invention, the working annulus of the diaphragm spans the space between a stiffened central piston and an outer diaphragm support or casing; and such working annulus is supported in arched form, without introversion, throughout the opposite reciprocating strokes of the piston. Dis-

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placement chambers are formed on opposite sides of the diaphragm, with walls which substantially mate with the piston and the arched working annulus at the ends of the stroke. On the convex side of the arched working annulus, the displacement chamber is concave, to mate with the convex face of the working annulus at the end of its stroke toward that wall. On the concave side of the arched working annulus, the displacement chamber is convex, to mate with the concave side of the arched working annulus at the end of its stroke toward that wall. The two displacement chambers are each provided with inlet and outlet valves, desirably of the construction shown in my co-pending application Serial No. 445,030, filed July 22, 1954. The piston of the diaphragm is reciprocated, as by a rod connected to a manually operable handle lever.

The accompanying drawing illustrates the invention. In such drawing:

Fig. 1 is a vertical axial section through a pump embodying the invention; and

Fig. 2 is a horizontal axial section taken on the line 2—2 of Fig. 1.

The diaphragm 4 shown in the drawing has a flat central portion 5, an annular working portion 6, and a flat rim 7. In cross-section, the working annulus 6 is arched between the central portion 5 and the rim 7, and is supported in its arched configuration with sufficient strength to sustain it against collapse or introversion under the forces imposed on it during the operation of the pump. While this support might be provided in other ways, it is preferably provided by the material of the diaphragm wall itself.

The diaphragm is preferably molded of rubber or other flexible material which is inert and impervious to the fluid on which it is to work, and for some purposes, such as for pumping gasoline under low-temperature conditions, it may be made of molded leather. Its arched working annulus is desirably molded in arched configuration, and desirably has little elasticity and may contain fabric or other reinforcing material embedded in it. The diaphragm shown is made in accordance with my prior application Serial No. 221,848. Its working annulus has a normal circular arched shape extending through an arc of about 180°, and its wall is relatively thick and rigid at the apex of the arch, and progressively thinner and more flexible toward the base of the arch, where it is flexibly connected at its peripheries to the inner and outer supports formed by the portions 5 and 7. In operation, the major part of the flexing of the diaphragm occurs at the peripheral flexible portions, and the arched portion remains in arched form, with the span of the arch increasing and decreasing as the distance between the inner and outer supports varies during reciprocation of one with respect to the other.

The pump housing shown comprises a front casing 10 and a rear casing 12, having peripheral flanges 14 and 16 between which the rim 7 of the diaphragm 4 is clamped. The casing 10 has a central hub 22 which receives a bearing sleeve 24 and provides space at the inner end thereof for a packing ring 26. The bearing sleeve 24 is held in place and pressed against the packing ring 26 by a yoke 28 secured by a pair of bolts 30. A piston rod 32 is slidably received in the bearing sleeve 24, and carries at its inner end a pair of disks 34 which are clamped against opposite faces of the central portion 5 of the diaphragm 4 by a pair of nuts 35, to form a central piston. The outer end of the piston rod 32 is connected to a handle lever 38 pivotally supported from the casing 10 by a pair of pivot links 40.

At the bottom, the two casings 10 and 12 are formed to provide inlet passages 42 and 44 on opposite sides of the diaphragm, and to present coplanar end faces. A

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valve plate 48 is clamped against such end faces by an inlet fitting 50, and provides inlet valves leading from the fitting 50 respectively to the two inlet passages 42 and 44. The inlet fitting 50 may contain a screen 51.

At the top, the two casings 10 and 12 are formed to provide outlet passages 52 and 54. An outlet valve plate 58 is clamped against coplaner top faces of the casings, by an outlet fitting 60, and provides outlet valves leading from the two passages 52 and 54 to that outlet fitting 60.

The casing 10 forms a displacement chamber 62 between itself and the diaphragm structure, in open communication with the inlet passage 42 and the outlet passage 52. The central portion 63 of the displacement chamber wall is flat, to conform to the flat face of the adjacent piston disk 34 at the end of the stroke. The piston disks 34 are desirably flanged at their edges, and the chamber wall is formed with a groove 64 to receive the flanged edge of the adjacent disk 34. Beyond that groove 64, the chamber 62 is defined by a concave annular wall 66 adapted to mate with the convex face of the arched working annulus 6 at the end of the stroke, as shown in Fig. 2.

The casing 12 forms a displacement chamber 72 between itself and the diaphragm structure. The central portion 73 of its inner wall is flat to mate with the adjacent disk 34 of the piston, and is bounded at its edges by an annular groove 74 to receive the flange of the adjacent piston disk 34. Beyond that groove 74, the inner wall of the chamber forms a convex annular face 76 to mate with the concave face of the arched working portion 6 of the diaphragm at the end of its stroke, as shown in Fig. 1.

The inlet and outlet valve assemblies or plates 48 and 58 are conveniently of identical construction. Each comprises a flat plate, which may be stamped from sheet metal, with valve ports 81 punched through it at points on opposite sides of the casing flanges 14 and 16. About each port, a collar or rim is struck up from the plate and provided with a flat top surface to form a valve seat 84. Adjacent each valve port 81, the plate carries a pair of upstanding brackets 86 provided with pivot holes to support a valve 88. Each valve 88 is a sheet-metal stamping having a flat head adapted to seat in sealing engagement on its seat 84. The valve head is integrally carried by an arm 89 which has laterally projecting ears received in the pivot holes of its supporting bracket 86. Desirably, the pivot holes connect with notches through which the valve-supporting pivot ears may be inserted edgewise, the notches being positioned at points which lie out of alignment with the ears during operation of the valves.

For operation, the pump is suitably supported and its inlet and outlet fittings are suitably connected to a source of liquid and to a discharge pipe. The pump is operated manually by reciprocation of the manual lever 38, which drives the piston rod 32 to reciprocate the central piston of the diaphragm through successive strokes in opposite directions. At the end of the rearward stroke toward the casing 12, as shown in Fig. 1, the piston is carried substantially against the flat central wall 73 of the rear displacement chamber 72, and the arched working annulus is drawn substantially tight against the mating convex annular wall 76 which defines the outer portion of the rear displacement chamber. The volume of the displacement chamber 72 is thus reduced substantially to zero, and the pump has discharged upwardly through the outlet passage 54 substantially all of the liquid contained in that displacement chamber 72.

Upon a forward stroke from the end-position shown in Fig. 1, the piston of the diaphragm travels toward the opposite flat central wall 63 of the front displacement chamber 62, and the working annulus 6 moves toward the concave wall 66. In this movement, the working annulus sustains itself in arched form, with the apex of the arch

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presented forwardly. There is no collapse or introversion of that arched wall, and as the reverse stroke starts, pumping occurs immediately, with substantially no lost motion.

At the end of the forward stroke, the piston lies substantially against the flat central wall 63 of the front displacement chamber 62, and the arched working annulus lies substantially tight against the concave annular wall 66. At this end of the stroke, the volume of the displacement chamber 62 is reduced substantially to zero, and the pump has discharged upwardly through the outlet passage 52 substantially all the fluid contained in the chamber 62.

The pump shown is double-acting, that is, as it discharges fluid from one of the chambers 62 and 72, out through its outlet passage 52 or 54, it draws fluid into the other of those chambers through its inlet passage 42 or 44. There is a complete reversal of forces on the diaphragm working annulus as the stroke directions change. On rearward strokes, the discharge head in the rear chamber 72, and the suction head in the front chamber 62, both tend to distend the working annulus forwardly, and thus stress the annulus wall in tension. Because the wall is deeply arched, the wall lies substantially in the form of a deep catenary and with a wall cross-section arc length of 180°, as preferred, the tension stress is substantially minimum.

On forward strokes, the discharge head in the front chamber 62, and the suction head in the rear chamber 72, both tend to collapse the forwardly arched working annulus, and the arched wall is stressed in compression. Because the wall is supported in a self-sustaining or permanent arch, it resists the collapsing stress, and undergoes no introversion.

At the end of each stroke, therefore, the wall is already in the proper shape and position for the next succeeding opposite stroke, and substantially no movement of the handle is necessary to take up looseness in the diaphragm. Because the clearance volumes in the displacement chambers at the ends of the stroke are small, the displacement ratio of the pump is high—that is, the ratio of swept volume to total volume is high—and a high suction lift can be drawn when the strokes of the pump are carried to their full limit. But effective pumping does not require full strokes of the pump, for since the arched working annulus sustains itself in arched configuration at all points in the stroke range, partial strokes over any portion of the stroke range will produce positive and effective pumping, and even such partial strokes involve substantially no free movement to take up looseness in the diaphragm.

While the several aspects of the invention have been illustrated as embodied in a double-acting pump, single-acting pumps may also utilize certain aspects of the invention. In a single-acting pump having only the rear displacement space 72, only the suction head will stress the arched working annulus in compression, and the discharge head will stress the wall thereof in tension, and the arch strength and the tensile strength of the wall may be made suitable to withstand the respective stresses.

I claim as my invention:

1. A diaphragm pump adapted to work against both a suction head and a discharge head, comprising relatively reciprocable inner and outer peripheral diaphragm supports for supporting the inner and outer peripheries of an annular diaphragm wall, an annular diaphragm wall connected to and extending between said inner and outer peripheral supports, said wall being deeply arched in cross section between said supports and being supported in arched form, casing means forming displacement chambers respectively at the concave side and the convex side of said arched wall, inlet and outlet valves for said chambers, and means to reciprocate one of said peripheral supports to cause said diaphragm wall to sweep said displacement chambers.

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2. A double-acting diaphragm pump, comprising an outer diaphragm-support, a relatively reciprocable piston forming an inner diaphragm-support spaced from said outer support to leave an annular space between the outer support and the piston, a working annulus flexibly connected to said supports and spanning the annular space between said supports and formed in cross section as a deep arch, casing means forming pumping chambers on opposite sides of said piston and annulus, the convex face of said arched annulus being presented to one of said chambers and the concave face to the other, and structural means supporting said arched annulus against collapse and introversion under substantial compressive forces.

3. A double-acting diaphragm as defined in claim 2 in which the two pumping chambers have central wall portions lying opposite said piston and substantially conforming respectively to the adjacent faces of the piston at the ends of its stroke, the chamber opposite the convex face of the working annulus having an annular concave wall substantially conforming to said convex face at the end of the stroke toward said concave wall, and the chamber opposite the concave face of the working annulus having an annular convex face substantially conforming to said concave face at the end of the stroke toward said convex wall.

4. A diaphragm pump adapted to work against a suction head and a substantial discharge head, comprising an outer diaphragm support, a relatively reciprocable inner diaphragm support spaced from said outer support, a working annulus spanning the annular space between said supports, the annulus cross-section having the form of a deep arch springing from said inner and outer supports, relatively flexible means connecting the arched working annulus to said inner and outer supports, casing means forming a pumping chamber at the concave side of said arched working annulus, said annulus having structural means supporting the same as a relatively rigid self-sustaining arch between said relatively flexible connecting means, said working annulus during its suction stroke away from said casing means being thereby main-

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tained as a substantially rigid arch stressed in compression and tilting bodily about said inner and outer supports, said working annulus having substantial tensile strength and its said deeply-arched cross-section being stressed in tension during its discharge stroke toward said casing means.

5. A diaphragm pump adapted to work against a suction head and a substantial discharge head, comprising an outer diaphragm support, a relatively reciprocable inner diaphragm support concentrically spaced from said outer support, a diaphragm working annulus spanning the space between said supports and having in cross-section the form of a deep arch springing from said supports, casing means on the concave side of said arched annulus defining a displacement space between itself and said annulus, said casing having an annular convex arched wall formed and positioned substantially to mate with the concave face of said arched annulus at the end of its stroke toward said wall, said arched annulus being relatively thick and rigid at the apex portion thereof and relatively thin and flexible at the edges thereof adjacent said supports and being supported from said supports by its relatively flexible edge portions, said arched annulus being self-sustaining in arched form against compressive stress on its suction stroke away from said annular casing wall, and being stressed in tension on its discharge stroke toward said annular casing wall.

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