

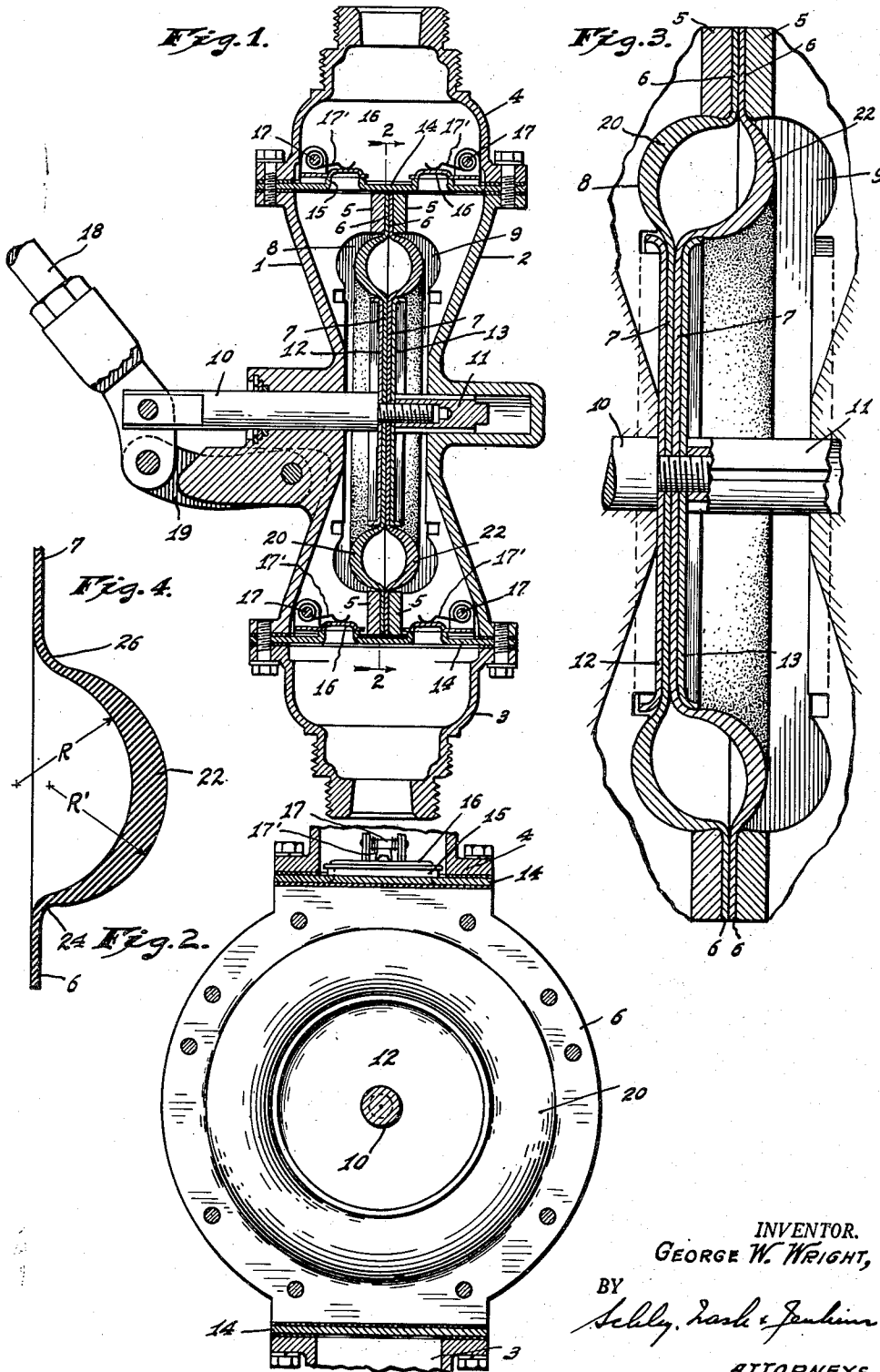
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SELF-SUSTAINING ARCHED DIAPHRAGM STRUCTURE

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SELF-SUSTAINING ARCHED DIAPHRAGM
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This invention relates to a diaphragm structure, for example a diaphragm pump structure, and a diaphragm therefor which is self-sustaining against the alternating forces imposed thereon.

It is the object of my invention to provide a diaphragm device of high efficiency, in which a high displacement ratio may be obtained, and in which the diaphragm may be operated through a stroke of considerable length and is also effective with high efficiency when operated through short strokes over any portion in the total stroke range. It is an object of the invention to provide a diaphragm structure which avoids diaphragm buckling and lost motion during operation. It is an object of the invention to provide a diaphragm which has high flexibility for ease of operation and which is at the same time self-sustaining against the forces imposed thereon.

In accordance with my invention, I provide a diaphragm having a working annulus of flexible material supported between relatively reciprocable inner and outer peripheral supports. The working annulus may have either a single diaphragm element or two such elements arranged oppositely, and each has a configuration which in section is in the form of a deep and desirably semi-circular arch springing from the peripheral supports. The walls of the arch are of varying thickness so that in section the arch resembles a crescent, with the top or apex wall portion of the arch of substantial thickness and rigidity and with the adjoining walls becoming relatively thinner and more flexible toward the base of the arch, where they are joined by relatively thin and flexible walls to the peripheral supports. Preferably the relatively thin and flexible walls extend through reverse curves from the arch and merge into radial webs which are clamped in the supporting structure. In a single-acting diaphragm device one such diaphragm element may be used; while in a double acting diaphragm device two such diaphragm elements are preferably used, with the arches of their working annuluses disposed oppositely and outwardly convex.

The accompanying drawing illustrates my invention. In such drawing, Fig. 1 is a vertical axial section through a double acting diaphragm pump embodying my invention; Fig. 2 is a vertical radial section taken on the line 2-2 of Fig. 1 and showing the diaphragm in elevation; Fig. 3 is a fragmental section on an enlarged scale showing the diaphragm structure at the limit of its movement to the left; and Fig. 4 is a diagrammatic section showing the preferred

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form of the working annulus of the diaphragm.

The pump shown in Fig. 1 comprises a front casing 1, a rear casing 2 symmetric with the front casing, a bottom intake fitting 3, and a top discharge fitting 4. The casings 1 and 2 have continuous annular flanges 5, between which the outer peripheral rims 6 of the diaphragm elements are clamped, and the casings form a front displacement space 8 and a rear displacement space 9 on opposite sides of the diaphragm. The diaphragm has a central disk-shaped circular web 7 which is supported on opposite sides by suitable circular plates 12 and 13 clamped together and against a shoulder on the operating shaft 10 by means of the nut 11 screwed onto the reduced end of the shaft 10. The shaft 10 is connected to an operating lever 18 fulcrumed on a link 19 carried by the front casing 1.

The intake and discharge valves are of identical construction, and comprise a plate 14 clamped against each end of the casing assembly, between it and the respective end fittings 3 and 4. Each valve plate 14 is punched and flanged upwardly to form a pair of valve openings bounded by upstanding rims 15, on opposite sides of the assembled flanges 5, and the rims 15 are dressed to form planar valve seats. Flap valves 16 seating on the valve seats of the rims 15 are loosely pivoted by upstanding ears on eccentric pivots 17 mounted between lugs secured to the plate 14, and the valves are urged to closed position by pressure applied adjacent their centers by the down-turned ends of springs 17' coiled about the pivots 17. Conveniently, the valve openings are of generally oval cross-sectional shape, and the section of Fig. 1 may be considered as taken on their minor axes.

With the intake fitting 3 connected to a source of liquid, reciprocation of the operating shaft 10 through strokes in opposite directions produces a double-acting pumping effect. As the shaft 10 moves to the left, it carries the web of the diaphragm bodily to the left and flexes the working annulus of the diaphragm. This increases the volume of the rear displacement space 9, to draw liquid into that space through the (lower right) valve between the intake fitting 3 and the rear displacement space 9. Simultaneously, the front displacement space is reduced in volume, to discharge liquid therein through the (upper left) valve between that displacement space 8 and the discharge fitting 4. A corresponding action occurs upon the opposite stroke of the shaft 10, to draw liquid into the displacement space 8 through its associated intake valve, and to dis-

charge liquid from the displacement space 9 through its associated discharge valve.

The diaphragm shown comprises two symmetrical diaphragm elements, having working annuluses 20 and 22. The diaphragm elements are molded of rubber or rubber-like material and may contain a layer of reinforcing fabric or cord. Each diaphragm element has a central web 7 joined to the inner periphery of its working annulus of the diaphragm, and an outer annular web or rim 6 joined to the outer peripheral edge of its working annulus of the diaphragm. The two diaphragm elements are mounted face to face with their arched working annuluses disposed oppositely and outwardly convex. The webs 7 of the two elements are clamped together between the circular plates 12 and 13 on the operating shaft 10, and the two rims 6 are clamped together between the flanges 5 of the pump casings.

The working annulus of each diaphragm element is in the form of a deep arch supported at its base by the peripheral webs 6 and 7. Preferably, the arch is a substantially semicircular arch, pre-formed to a normal shape like that shown in Figs. 1 and 4. The top or apex portion of the arch wall is relatively thick and of substantial body and rigidity, and from this relatively thick wall portion at the apex of the arch, the walls of the arch become progressively thinner and more flexible toward the base of the arch, so that the arch section is substantially crescent shaped. This crescent shape is preferably obtained by forming the inner surface of the arch on a radius R about a center offset on the opposite side of the plane of the inner face of the diaphragm element, and by forming the upper surface of the arch on a radius R' , desirably somewhat longer than the radius R , about a center offset on the near side of the plane of the face of the diaphragm element. As is seen in Fig. 4, the outer peripheral end of the arch is joined by a reversely curving wall portion 24 to the outer peripheral web or rim 6, and the inner peripheral end of the arch wall is joined by a reversely curving wall portion 25 to the central web 7; and the reversely curved wall portion 26, which is subjected to greater flexing during operation, is desirably curved about a radius somewhat greater than that of the wall portion 24.

By reason of the arched form of the working annulus of the diaphragm element, and of the material distribution therein, with a relatively thick and rigid wall portion at the top or center of the arch and with progressively thinner and more flexible wall portions toward the ends of the arch, the working annulus is substantially self-sustaining against force imposed against its upper surface and strongly resists buckling under such force. The upper surface, on the radius R' in Fig. 4, is thus the working surface which receives the pressure of the fluid being pumped, and such working surface is supported by the underlying structure provided, as illustrated in the drawing, by the thick arched body of the wall. As the inner periphery of the working annulus is moved toward the end of a stroke, the arch of the annulus will be widened and its walls stressed. In view of the progressive narrowing of the arched wall toward its ends, the stress will be distributed over the entire length of the preformed wall, and the stress reaction therein will tend to maintain the arched form of the wall and to oppose its collapse or buckling.

As the central web of the diaphragm is moved

toward the end of a stroke, the self-sustaining arched working annulus moves toward the inner face of the diaphragm chamber. Since it will be maintained in its outwardly convex form, as noted above, it can be made to approach the chamber wall quite closely, and indeed to press itself into contact with that chamber wall; and the clearance space between the diaphragm and the chamber wall can be reduced to a minimum to obtain a high displacement ratio. Moreover, during reciprocation of the diaphragm through partial strokes, over any portion of the total stroke range, the self sustaining character of the working annulus will minimize flabbiness in the diaphragm element and lost motion in its operation.

The operational characteristics of the working annulus as described above result from the self-sustaining construction of the diaphragm element, and will occur whether the diaphragm element is used singly in a single-acting diaphragm device or used in a pair in a double-acting diaphragm device as shown in the drawing.

In the double diaphragm arrangement shown in Figs. 1 to 3, the two diaphragm elements are tightly clamped together and the two outwardly arched working annuluses 20 and 22 enclose a space of generally toroidal shape and of somewhat oval cross section. This space may be made to contain gas under elevated pressure, but will ordinarily contain air at atmospheric pressure. As the diaphragm moves through its stroke, however, the shape of the space enclosed between the two working annuluses will be changed and its volume somewhat reduced. Any such reduction in volume will tend to increase the pressure within the space, and the reaction of such pressure increase will tend to give additional support to the outwardly arched walls of the working annuluses.

I claim as my invention:

1. A diaphragm, comprising a working annulus having a normal configuration of deeply-arched crescent-shaped section with its wall relatively thick and rigid at the apex of the arch and becoming progressively thinner and more flexible toward the base thereof, inner and outer peripheral attachment means for said annulus, and relatively flexible wall portions joining said crescent-shaped wall to said attachment means.
2. A diaphragm, comprising a working annulus and radial attachment webs at the inner and outer peripheries thereof, said annulus having a normal section in the form of a deep crescent-shaped arch with its apex wall relatively thick and rigid and its adjoining wall portions progressively thinner and less rigid, and relatively thin and flexible wall portions extending in reverse curves from said arch to said webs.
3. A diaphragm, comprising a working annulus and attachment means at its inner and outer peripheries, said working annulus being pre-formed of flexible material to a normal section in the form of a substantially semi-circular arch, the wall thereof being relatively thick and rigid at the apex thereof and progressively thinner and more flexible toward the base thereof, and relatively thin and flexible walls joining said arch portion to said attachment means.
4. A diaphragm, comprising a working annulus pre-formed of flexible material to a normal section in the form of an arch, the inner and outer surfaces thereof being curved about spaced centers, the wall thickness and rigidity being substantially greatest at the apex of the arch and progressively thinner and more flexible

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toward the base thereof, and attachment means at the peripheries of said annulus flexibly joined to said arch portion.

5. A diaphragm as defined in claim 4, in which the spaced centers are on opposite sides of the plane from which the arch springs.

6. A diaphragm structure, comprising an outer diaphragm support, a relatively reciprocable disk-shaped inner diaphragm support concentrically spaced from said outer support, a diaphragm working annulus spanning the space between said supports, said annulus comprising a central deeply arched portion of progressively decreasing thickness and rigidity from the center thereof toward said supports, and flexible walls extending from said arched portion into supporting engagement with said supports.

7. A double-acting diaphragm structure, comprising an outer diaphragm support, a relatively reciprocable disk shaped inner diaphragm support concentrically spaced from said outer support, a pair of oppositely disposed diaphragm elements spanning the annular space between said supports, each of said elements comprising a deeply arched wall of substantial thickness and rigidity at its central portion and of progressively increasing flexibility toward said supports and flexible walls extending from said arched portion into supporting engagement with said supports.

8. A double-acting diaphragm structure, comprising an outer diaphragm support, a relatively reciprocable inner diaphragm support concentrically spaced from said outer support, a pair of oppositely disposed arched walls spanning the annular space between said supports, with the convex sides of the walls facing axially away from each other, each of said walls including structural reinforcing means and being self-sustaining in arch form against collapse and introversion under substantial working pressure against its convex face.

9. In a double-acting diaphragm structure, a working annulus comprising a pair of oppositely disposed arched walls with their convex sides facing axially away from each other, said arched walls being of substantial thickness and rigidity at their central portions and of progressively decreasing thickness and increasing flexibility toward their inner and outer peripheries.

10. A diaphragm pump to work against a positive pressure, 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 and arched toward the pressure side thereof, relatively flexible means connecting said annulus to said supports, said working annulus including convex working face and underlying structural means arched between said supports, said arched structural means being relatively rigid and sustaining said working annulus against collapse and introversion under substantial working pressure against its convex face.

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11. A diaphragm pressure pump as defined in claim 10 in which said structural means comprises an elastic body integral with said working face and formed to normally arched configuration said body being of greatest rigidity at its central portion and of greatest flexibility toward the peripheries thereof.

12. A diaphragm, comprising a working annulus and attachment means at its inner and outer peripheries, said working annulus being preformed to a normal section in the form of a substantially semi-circular arch, the wall thereof being relatively rigid at the apex thereof and more flexible toward the base thereof.

13. A diaphragm structure, comprising an outer diaphragm support, a relatively reciprocable disk-shaped inner diaphragm support concentrically spaced from said outer support, a diaphragm working annulus spanning the space between said supports, said annulus comprising a central deeply arched portion of decreasing rigidity from the center thereof toward said supports, and flexible walls extending from said arched portion into supporting engagement with said supports.

14. In a diaphragm structure, a working annulus comprising an annular wall extending from an inner peripheral portion to an outer peripheral portion which lies radially outward from and generally concentric with the inner peripheral portion, said wall being deeply arched between said peripheral portions and being of substantial thickness and rigidity at its portion lying centrally between said peripheral portions and of progressively decreasing thickness and increasing flexibility toward said peripheral portions.

15. In a diaphragm structure, a working annulus comprising an annular wall extending from an inner peripheral portion to an outer peripheral portion which lies radially outward from and generally concentric with the inner peripheral portion, said wall being deeply arched between said peripheral portions and being of substantial rigidity at its portion lying centrally between said peripheral portions and of increasing flexibility toward said peripheral portions.

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