Aug. 19, 1969 L. E. RUSSELL 3,462,073

AIR COMPRESSOR

Filed Dec. 15, 1966 2 Sheets-Sheet 1

FIG-1

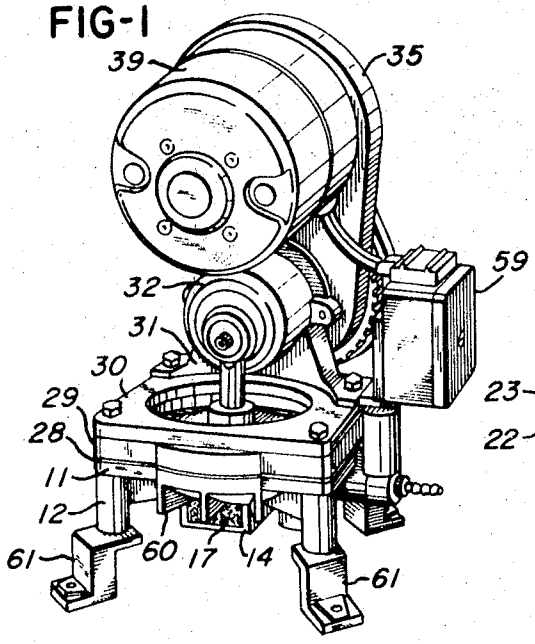
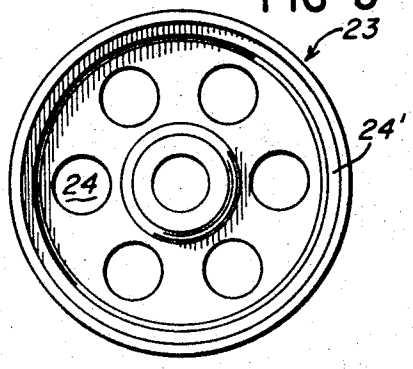


FIG-5



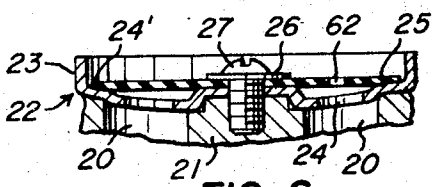


FIG-6

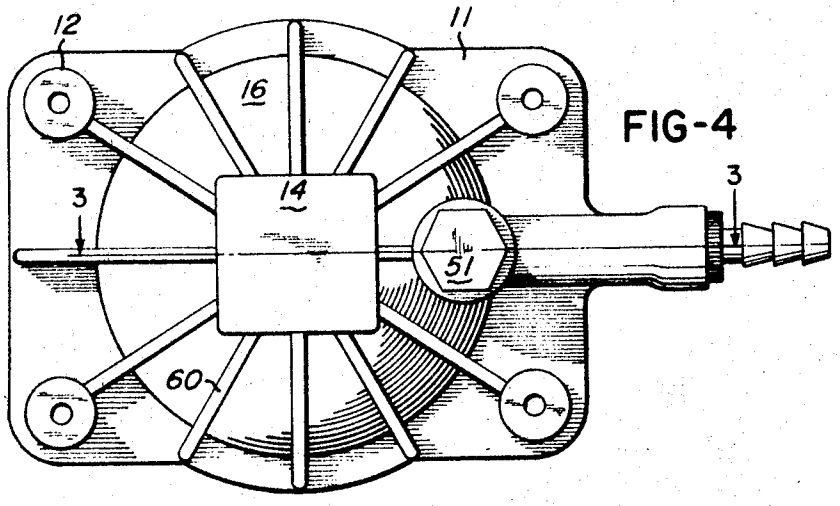


FIG-4

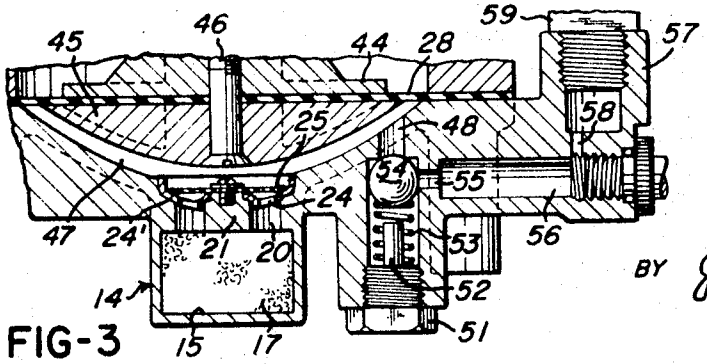


FIG-3

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Aug. 19, 1969 L. E. RUSSELL 3,462,073

AIR COMPRESSOR

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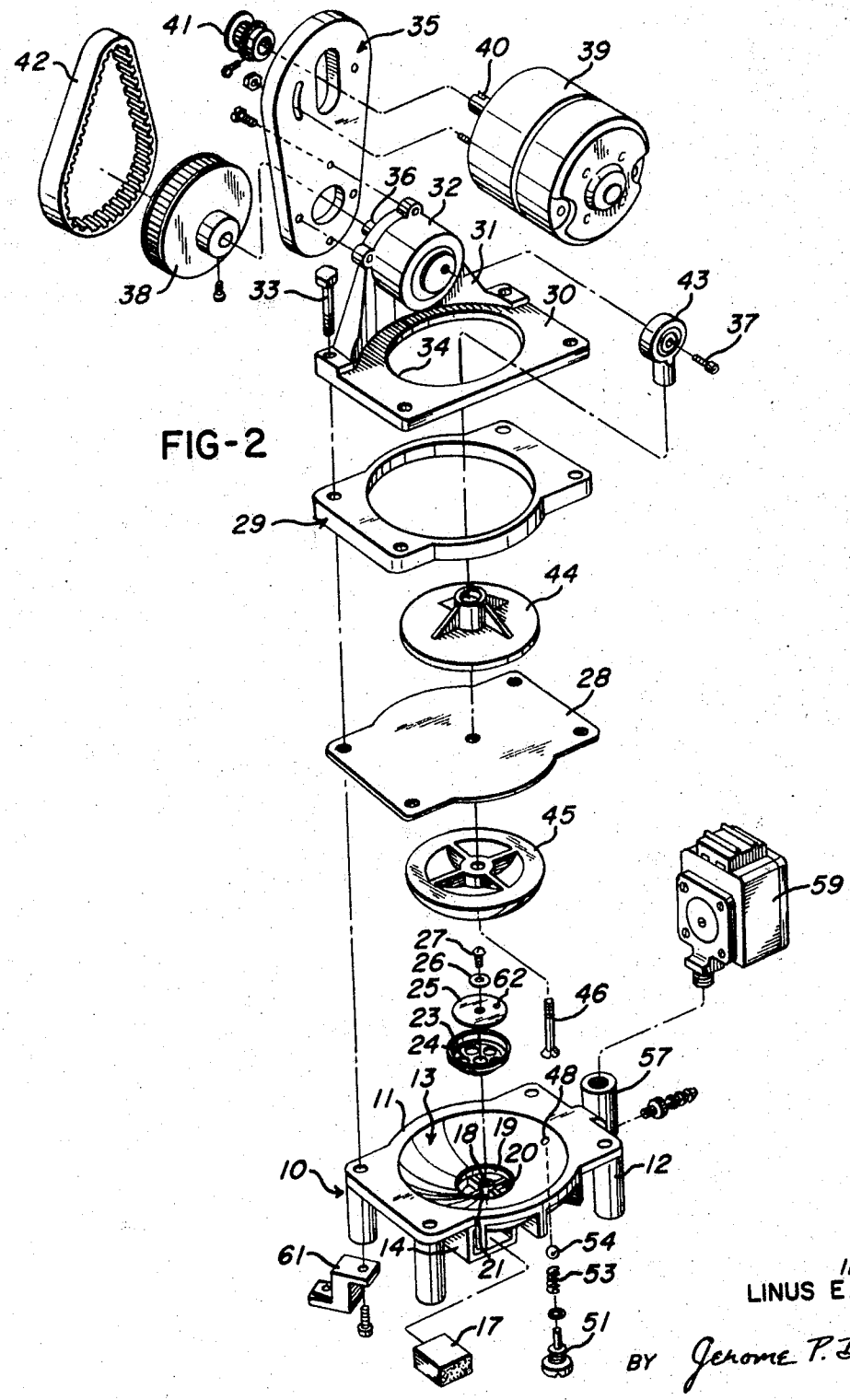


FIG-2

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3,462,073

AIR COMPRESSOR

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U.S. Cl. 230—170 14 Claims

ABSTRACT OF THE DISCLOSURE

An air compressor or like device employing a reciprocable diaphragm having means therewith forming a shell-like pumping chamber. The pumping stroke rocks fluid in the line of flow between radially displaced intake and outlet valves, the orientation of the rocking means effecting an optimal drive of fluid. A generally new intake valve unit provides for full flow therethrough on suction strokes and a positive seal on compression strokes. The valve further includes means to obviate the existence of a pressure head in the pumping chamber on starting up.

The present invention, though not so limited, has particular application to air compressors and like structures.

Invention embodiments feature fluid handling apparatus which affords an improved flow pattern and achieves a high working efficiency. They are particularly effective in the form of fractional horsepower compressors which are capable of an unusually high output for their component size. Their component design is such to provide therein an air space of shell-like configuration which is utilized to its fullest extent and serviced by a unique intake valve. The latter has novel detail per se, enabling air compressors and like fluid handling devices to start up against a substantially zero pressure head.

A primary object of the invention is to provide a fluid handling device such as an air compressor or like structure which may be economically fabricated, more efficient and satisfactory in use, adaptable to a wide variety of applications and unlikely to malfunction.

A further object of the invention is to provide an air compressor or like structure having an optimal output for its component size.

Another object of the invention is to provide an air compressor or like structure with means automatically providing therein a zero pressure head on shutdown, facilitating thereby a rapid and effective starting operation.

A further object of the invention is to provide an improved intake valve having particular advantage for use in air compressors and like structures.

An additional object of the invention is to provide fluid handling devices such as air compressors and like structures with means to define therein an improved flow pattern.

A further object of the invention is to provide in an air compressor or like structure a fluid chamber having a shell-like configuration and optimally defined intake and discharge openings enabling a maximal use of the chamber space.

Another object of the invention is to provide contoured pumping elements so uniquely incorporated in an air compressor or like structure as to afford an extremely smooth pumping action which avoids locking, binding and marring of parts and reduces the normal requirement for maintenance.

An additional object of the invention is to provide a fluid handling device such as an air compressor or like structure possessing the advantageous structural features, the inherent meritorious characteristics and the means and mode of operation here described.

With the above and other incidental objects in view as will more fully appear in the specification, the invention intended to be protected by Letters Patent consists of the features of construction, the parts and combinations thereof, and the mode of operation as hereinafter described or illustrated in the accompanying drawings, or their equivalents.

Referring to the accompanying drawing wherein is shown one but obviously not necessarily the only form of embodiment of the invention,

FIG. 1 is a perspective view of an air compressor embodying various features of the present invention;

FIG. 2 is an exploded view of the compressor structure illustrated in FIG. 1;

FIG. 3 is a cross-sectional view taken on line 3—3 of FIG. 4;

FIG. 4 is a bottom view of the compressor base;

FIG. 5 is a view of the cup-like base of the unique intake valve employed in the compressor structure of FIG. 1; and

FIG. 6 is a view which illustrates the assembly of the aforementioned intake valve.

Like parts are indicated by similar characters of reference throughout the several views.

Referring to the drawings the air compressor there shown includes a base **10** comprising a generally rectangular plate **11** supported at each of its corners by a short cylindrical leg **12**. The central portion **13** of the plate **11** is dished to assume the characteristic form of a segment of a generally spherical shell. This shell form produces a convexity on the plate bottom which depends intermediately of and in centered relation to the legs **12**.

A box-like enclosure **14** forming a chamber **15** is centered on and dependent from the apex of the convex surface **16** of the dished portion **13**. One side of the enclosure **14** provides an inlet opening, which opening is bridged by an air filter **17**.

A recessed shoulder **19** rims a central aperture **18** in the bowl-like surface produced by the plate portion **13**. The aperture **18** provides an outlet from the chamber **15**. The wall of aperture **18** is bridged by four integrally connected radial ribs **20** which are spaced at 90° intervals and joined at the center of the aperture by a hub **21**. The latter has a threaded bore and projects slightly above the upper surface of the ribs **20** and the shoulder **19**.

The shoulder **19** seats a valve unit **22**. The valve **22** consists of a cup **23** nesting a flexible flapper element **25**. Both valve elements are centrally apertured to accommodate the projection therethrough of the hub **21**. Centered intermediate the radial limits of its dished base the cup **23** has formed therein an annular depression including six circularly arranged, equidistantly spaced apertures **24**. The relatively elevated portions of the cup base which rim the apertures **24** are offset to form radially spaced seats **24'** for the peripheral skirt portion of the flexible flapper **25**. The flapper **25** substantially fills the cup **23** and together therewith normally seals the aperture **18**. The flapper **25** is centrally contained in a fixed relation to the base of cup **23** by means of a washer **26**, which washer overlies the upper end of the hub **21** and is secured thereto by a screw **27** engaged in the threaded bore of the hub. Note that the free skirt of the flapper **25** has a uniformly balanced seat on the elevated base portions **24'**. In thus bridging the relatively depressed apertures **24**, one accomplishes an optimal seal thereof, avoiding leakage thereby.

The upper surface of the plate **11** is coextensively covered by a flexible diaphragm **28** which bridges the bowl-like cavity formed by its dished portion **13**. A centrally apertured spacer plate **29** is further superposed to overlie the peripheral portions of the diaphragm **28** which seat to the plate **11**. Stacked on the plate **29** is a

plate 30 having a central elliptical aperture 34. The major axis of the aperture 34 coincides, in a vertically spaced sense, with the transverse axis of the dished portion 13 of plate 11 and is equidistantly spaced from the front and rear edges of the plate 30. Formed integral with and rising vertically from the rear edge of plate 30 is a vertically disposed support plate 31. A bearing 32 having one end connected to form the uppermost extremity of the support 31 projects at right angles thereto and in a sense forwardly therefrom, in a vertically spaced alignment with the minor axis of the aperture 34. The cross-sectional area of the aperture 34 is smaller than that of the circular aperture in the plate 29 and the opening defined by the central depression in the plate 11.

The superposed parts 30, 29, 28 and 11 have aligned apertures in their respective corners which accommodate the projection therethrough of screws 33 which threadedly engage in the underlying leg supports 12.

Fixed to the rear of the bearing 32 and the rearmost face of the vertical support plate 31 is a vertically oriented motor mounting plate 35. The plate 35 has an opening which accommodates the projection therethrough of a drive shaft 36 housed in and projected through the bearing 32. The foremost extremity of the drive shaft 36 has connected thereto a projected, eccentrically disposed drive pin 37 which overlies a central portion of the aperture 34 in vertically spaced relation thereto. The opposite end of the shaft 36 mounts a large drive pulley 38 having a gear-like periphery.

A drive motor 39 is mounted to project perpendicular to the plate 35 above and in vertically spaced relation to the bearing 32. The motor drive shaft 40 projects through an aperture in the mounting plate 35 and has fixed thereto, at its outer end, a small drive pulley 41. The pulley 41 also has a gear-like periphery. The pulleys 41 and 38 are positively interconnected by a continuous drive belt 42, the inner engaging surface of which has gear-like formations complementary to those on the pulleys.

Accordingly, on energizing the motor 39, there is a drive of the shaft 36 by way of the motor drive shaft 40, pulley 41, belt 42 and pulley 38. This produces, of course, a corresponding circular movement of the eccentric drive pin 37.

The pin 37 projects through a bearing in the upper end of a connecting rod 43 which depends through the aperture 34 in the plate 30 to fixedly nest in the vertically projected tubular hub of a disc-shaped backing plate 44. The plate 44 depends within the aperture of the spacer plate 29 and has a through bore which aligns with a small central aperture in the diaphragm 28 as the base of the plate 44 seats to the center of the diaphragm. Fixed in relatively opposed relation to the plate 44, to the underside of the diaphragm 28, is a retainer element 45. The retainer 45 has its face most remote from the diaphragm 28 formed generally as the segment of a sphere which depends within the bowl-like cavity defined by the dished portion 13 of the plate 11. A screw 46 is projected through a central aperture in the retainer 45 to extend upwardly through the central aperture in the diaphragm 28 and the through bore of the backing plate 44 to threadedly engage in the lower end of the connecting rod 43.

Thus, there is a fixed assembly of the diaphragm 28 to the connecting rod 43 by way of the backing plate 44 and the retainer element 45. The rod 43 is so connected to and eccentrically driven by the drive pin 37 to operate in the plane of the major axis of the elliptical opening 34. The drive of the rod 43 produces thereby an eccentric flexing of the diaphragm, in the same sense.

Observing the drawings, it will be noted that the diaphragm 28 seals the top of the bowl-like cavity produced by the dished configuration of the portion 13 of the plate 11. Moreover, it will be seen that the configuration of the retainer 45 establishes between the retainer and diaphragm and the base of the cavity a thin generally spherically contoured shell-like space 47. The space 47 provides a fluid chamber coextensive with the base surface of the cavity. In this instance, the aperture 18 provides an inlet to said cavity by way of the normally closed valve 22. A relatively small outlet 48 from the chamber 47 is defined in the base surface of the cavity on a line which generally defines with the major axis of the elliptical aperture 34 a vertical plane including the central point of the inlet aperture 18. The outlet 48 is positioned to one side of the cavity base, on the upper wall portion thereof adjacent its peripheral limit.

Structure forming an integral appendage to the plate 11 provides below the outlet 48 a communicating chamber 49. The chamber 49 is defined by a tubular dependent portion 50 the lower end of which is closed by a screw plug 51. The plug 51 includes central vertically projected stud 52 which is surrounded by a coil spring 53. One end of the spring 53 abuts the body of the plug 51 and the other end biases a ball valve 54 into a normal sealing relation to the outlet 48 in the plate 11.

The uppermost extremity of the tube 50, adjacent the outlet 48, has a lateral aperture 55 which opens to a horizontally defined discharge passage 56. Formed integral with the plate 11, to one side thereof, is a cup-like projection 57 the base of which has a small opening 58 which communicates with the outermost end of the discharge passage 56. The cup 57 is adapted to threadedly receive the adapter of a pressure switch 59 the purpose of which shall be further described.

It is to be noted that the convex surface to the bottom of the plate 11 has integrally formed radially projected ribs 60. The ribs 60 not only provide rigidity to the base 10 as such but they also function to rapidly dissipate developed heat as will be further described. Moreover, in positioning the pump in any suitable location the legs 12 may be secured to a reference surface through the medium of right-angled vibration pads 61 which are illustrated in FIG. 2 of the drawings. The pads 61 may be of any suitable vibration dampening material.

Further, in respect to the flapper portion 25 of the valve 22, it should be noted that there is a very small bleed hole 62 adjacent and spaced inwardly of its outer peripheral edge.

In the unit illustrated, it is provided that the apertures 24 of the valve unit 22 afford a cross-sectional flow area which is considerably greater than that of the discharge outlet 48. In the preferred compressor here illustrated, the optimal ratio of these areas is about 8 to 1.

Further, it has been found, in the application here described, that the diameter of the bleed hole in the valve flapper 25 has an important optimal dimension of about .015 inch. For a proper operation of this bleed hole, in any event, its diameter should be between .010 and .020 inch.

Note further, viewing FIG. 3 of the drawings, the operating surface of the retainer 45 is formed on a lesser radius than the base surface of the related cavity.

In the use of the described device as an air compressor, as has been noted previously, the motor 39 is energized to drive the shaft 36 and thereby the connecting rod 43 through the medium of the eccentric pin 37. Resultingly, the connecting rod 43 will be eccentrically reciprocated in the plane of the major axis of the aperture 34 and the transverse axis of the plate 11. As here prescribed, the vertical extent of the recprocation will be within vertical limits governed by the thickness of the spacer plate 29. As the diaphragm 28 and the retainer 45 is correspondingly eccentrically rocked, the upward travel thereof produces an insuction uniformly lifting the skirt of flapper 25 from the base seats 24' rimming the apertures 24. This causes air to be pulled through the air inlet to the chamber 15 and through the aperture 18 to the chamber 47 by way of the apertures 24. The spherical contour of the retainer 45 and the form of the chamber 47 is such that on rocking thereof the retainer 45 will

pressure substantially the total air in advance thereof from the side portion of the shell-like chamber remote from the outlet 48 to move in a progressive smoothly developed fashion across to the outlet 48, to displace the ball check valve 54 and escape through the opening 55 and the discharge passage 56.

It is to be noted that the stud 52 on the adjustable screw plug 51 affords a limit for the displacement of the ball check valve 54 against the bias of spring 53. By providing controlled travel of the ball 54 in this manner one may obtain an optimal operating efficiency. The pressure switch 59 may be appropriately set and arranged to cut off the motor 39 at a predetermined pressure level, in an obvious conventional manner.

It will thus be seen that there is a relatively large amount of air drawn to the chamber 47 by way of the intake valve 22 which air is efficiently and effectively compressed in discharge thereof through limited outlet 48 by means of the particularly formed retainer 45. The fact that the base of the valve unit 22 is so formed to essentially cup the flapper 25 and the flapper 25 is retained thereto only through the medium of an attachment at its center, there is a most effective and generally uniform lift of the flapper skirt to provide inflow to the chamber 47. Moreover, in the compression stroke the raised perimeters of the inlet apertures 24 facilitate an optimal seating of the flapper which inhibits loss of compression thereby. Again, the direct pressured movement of the air, in compression thereof, from one side to the other of the thin shell-like space affording the chamber 47 insures optimal compression effect on each stroke of the rod 43. The ribs 60 provide for rapid dissipation of the heat developed in the high compression process. Their disposition at the base of the compressor facilitates a safe and effective transfer of this heat.

Referring to the flapper 25, the bleed hole 62 has been found to offer a uniquely effective medium for insuring, in the starting of the air compressors, a substantially zero pressure head in the chamber 47. It has been found, in the critical dimensioning of the bleed hole that with a shutdown of the compressor, for any reason, there is a relatively quick unloading of the air in the chamber 47. The air, under the existing pressure, is dumped through the bleed hole and back into the chamber 15. This leaves a pressure condition in the chamber 47 which is receptive to an immediate startup of the compressor without any back pressure to affect the operating efficiency. Thus, the air compressor provided by the present invention can reach a required operating pressure in a minimal interval of time.

It may be further seen that there is provided, in the invention structure, a uniquely improved valve unit which enhances the functional operation of the described structure as a compressor. The valve unit will, of course, have similar advantages in other fluid handling devices.

It has been further found in the case of an air compressor as above described that one can very economically obtain approximately double the operating volume achieved in conventional units having approximately the same range of cost. It should be noted in this respect that losses are minimal due also to the contouring of the cooperating surfaces of the pumping elements and the thin shell-like, generally spherically contoured character of the chamber which is defined therebetween. By the rocking of the one spherical component on the other practically all the space in the chamber 47 is fully utilized. One obviates thereby the prevalent problem of locking and binding of parts and the resulting damage thereto in the operation of a normal air compressor. Of course, the operation of the invention embodiments is enhanced by the nature of the inflow and outlet structure.

It is also important to note that the form of the intake valve utilized in this invention is such to avoid undue or uneven lift of the flapper 25 and the consequent slapping thereby of the base 23 on seating thereto. This is a factor in providing for a quieter and smoother operating air compressor as obtained by the present invention.

While the invention has been described in reference to an air compressor, it should be readily obvious that with appropriate dimensioning a similarly constituted embodiment may be utilized to differently operate on other types of fluids. It should be further obvious that the described compressor may be used as a vacuum-type pump with excellent results. Of course, it should be obvious that in a vacuum application there would be no bleed hole in the flapper 25.

The invention has nevertheless been described in reference to the air compressor embodiment because of the particularly unique results which obtain in such use.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statute the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprises but one of several modes of putting the invention into effect.

Having thus described my invention, I claim:

1. A fluid handling device such as a compressor or like structure comprising a base having an arcuately contoured bowl-like cavity, a resilient diaphragm, means fixing said diaphragm in a bridging relation to said cavity and a sealed engagement with the base about said cavity, arcuately contoured means fixed to said diaphragm to nest interiorly of said cavity and to normally define with the surface thereof a shell-like space, means defining an inlet to and an outlet from said space, at least said outlet being in a side area of the surface defining said cavity, adjacent its peripheral limit and in a plane passing through the center of said cavity, and there being means connected to rock in said plane and in so rocking to eccentrically flex said diaphragm and to rock said arcuately contoured means progressively toward and away from said outlet to draw fluid inwardly of said space by way of said inlet and to pressure said fluid laterally to move from a side area of said cavity remote from said outlet to and through said outlet.

2. A device as in claim 1 wherein said base is characterized by a plate a central portion of which is inset to produce thereby a convex surface, which defines said cavity and heat dissipating ribs connected to project outwardly from said convex surface.

3. A device as in claim 2 characterized by means defining an inflow chamber centered at the bottom of said convex surface having a lateral opening, said inflow chamber being in communication with said cavity by way of said inlet to provide thereby for a smooth and unobstructed flow of fluid to said cavity from an entrance to the bottom of said base.

4. A device as in claim 1 characterized by said base including an elevated plate having a through passage forming said inlet substantially at the apex of said cavity and said inlet being bridged by an intake valve comprising a cup-like base which has a plurality of apertures and an overlaid flapper means having a central connection to said cup-like base and positioning the relatively free peripheral skirt thereof in a normally overlying relation to seal said apertures, said apertures occupying relatively depressed portions of said cup-like base and being relatively surrounded by relatively elevated portions of the bottom of said cup-like base which seats the skirt of said flapper means to insure thereby a normally effective seal of said apertures.

5. Apparatus as in claim 4 characterized by a small bleed aperture in a peripheral portion of the skirt of said flapper

means, said bleed aperture being formed and positioned to automatically effect a zero pressure head in said shell-like space in response to a shut down of said fluid handling device.

6. A device as set forth in claim 1 characterized by said inlet and said outlet being spaced at least a major portion of a radial length of said cavity in said plane and said arcuately contoured means being arranged to operate in a substantially straight line path between said inlet and said outlet to produce thereby an optimal drive of fluid from said inlet to and through said outlet.

7. A device as in claim 1 characterized by said contoured means fixed to said diaphragm having the form of a segment of a sphere complementary to the form of the surface which defines said cavity and said segment being formed to substantially bridge said cavity in defining said shell-like space.

8. A device according to claim 1, wherein said inlet and outlet are spaced radially of one another, characterized in that said means to flex said diaphragm includes drive means eccentrically rotatable substantially in the radial plane in which said inlet and outlet are located.

9. A fluid handling device such as a compressor or like structure comprising a base having an arcuately contoured bowl-like cavity, a resilient diaphragm, means fixing said diaphragm in a bridging relation to said cavity and a sealed engagement with the base about said cavity, arcuately contoured means fixed to said diaphragm to nest interiorly of said cavity and to normally define with the surface thereof a shell-like space, means defining an inlet to and an outlet from said space, at least said outlet being in a side area of the surface defining said cavity, means connected to eccentrically flex said diaphragm and to rock said arcuately contoured means progressively toward and away from said outlet to draw fluid inwardly of said space by way of said inlet and to pressure said fluid laterally to move from a side area of said cavity remote from said outlet to and through said outlet and a power head mounting plate superposed on said diaphragm fixing means and having an elliptical aperture through which said flexing means extends to connect to said diaphragm, said inlet and outlet being in a radial line approximately coinciding with the major axis of said elliptical aperture, and means eccentrically rotatable substantially in the major axis of said elliptical aperture connected to actuate said flexing means.

10. A device according to claim 9, characterized in that said flexing means includes a connecting rod connected at an inner end to said diaphragm and projecting through said diaphragm fixing means and through said elliptical aperture in said mounting plate, drive means supported on said mounting plate terminating in said eccentrically rotatable means connected to an outer end of said rod.

11. A fluid handling device such as a compressor or like structure comprising a base having an arcuately contoured bowl-like cavity, a resilient diaphragm, means fixing said diaphragm in a bridging relation to said cavity and a sealed engagement with the base about said cavity, arcuately contoured means fixed to said diaphragm to nest interiorly of said cavity and to normally define with the surface thereof a shell-like space, means defining an inlet to and an outlet from said space, at least said outlet being in a side area of the surface defining said cavity, means connected to eccentrically flex said diaphragm and to rock said arcuately contoured means progressively toward and away from said outlet to draw fluid inwardly of said space by way of said inlet and to pressure said fluid laterally to move from a side area of said cavity remote from said outlet to and through said outlet, said base including an elevated plate having a through passage forming said inlet, said inlet being bridged by an intake valve comprising a cup-like base which has a plurality of apertures and an overlaid flapper means having a central connection to said cup-like base and positioning the relatively free peripheral skirt thereof in a normally overlying relation to seal said apertures, said apertures occupying relatively depressed portions of said cup-like base and being relatively surrounded by relatively elevated portions of the bottom of said cup-like base which seats the skirt of said flapper means to insure thereby a normally effective seal of said apertures, a small bleed aperture in a peripheral portion of said flapper means, said bleed aperture being formed and positioned to automatically effect a zero pressure head in said shell-like space in response to a shut down of said fluid handling device, said bleed aperture having a diameter not greater than about .020 inch and not less than about .010 inch.

12. A device as set forth in claim 11 characterized by said bleed aperture having a diameter of approximately .015 inch.

13. An air compressor, including a base having on one surface dependent feet achieving a relatively elevated position of the base and in the opposite surface an upwardly facing bowl-like cavity, valve controlled inlet and outlet openings in said base communicating at their one ends with said cavity and opening at their opposite ends through the said one surface of said base, diaphragm means seating on said opposite surface of said base in closing relation to said cavity including a diaphragm having to one side a central backing plate means and to its opposite side an arcuately contoured retainer defining in said cavity a shell-like space, further plate means superimposing on and clamping said diaphragm to said base, said further plate means having a central opening aligning with said cavity and accommodating said backing plate means therein for freedom of rocking motion, mounting plate means superimposing on said further plate means and having an opening of elliptical shape through which access may be had to said backing plate means, said mounting plate means having vertically extending support means in offset parallel relation to the major axis of said elliptical opening, a rotary shaft means extending perpendicularly from said support means across said elliptical opening, and an eccentric drive from said shaft to said diaphragm means including a connecting rod passing vertically through said further and mounting plate means and attaching at a lower end to said backing plate means, said rod rocking in a plane coincident with the major axis of said elliptical opening and in a plane including said outlet opening, a motor on said vertical support means in overhead parallel relation to said shaft, and a driving connection between said motor and said shaft means.

14. An air compressor according to claim 13, wherein said inlet and outlet openings are in a common plane which is the same as the plane in which said connecting rod rocks.

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U.S. Cl. X.R.

103—228