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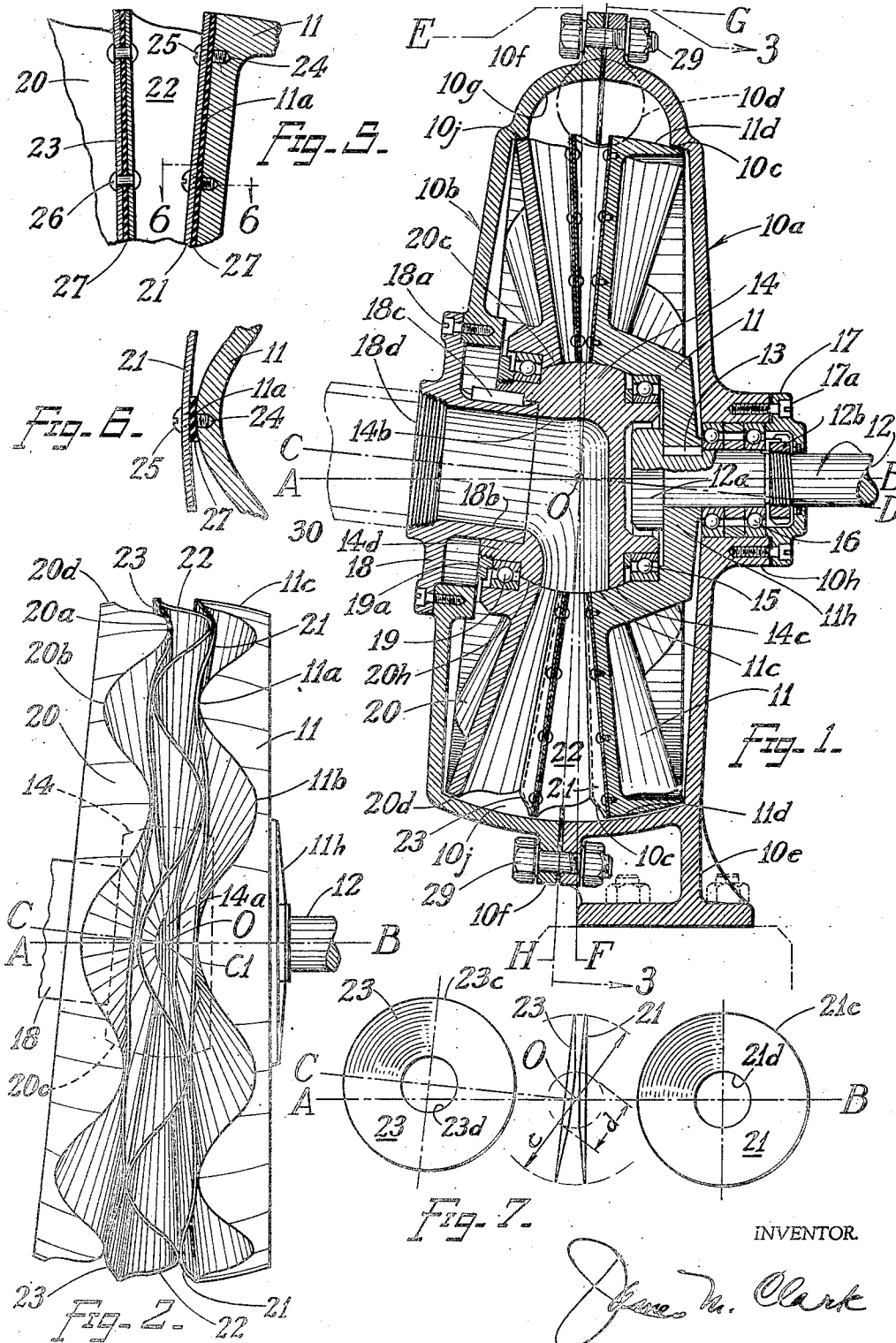
J. M. CLARK

2,582,413

EXPANSIBLE CHAMBER ROTARY FLUID DISPLACEMENT DEVICE

Filed July 20, 1945

2 SHEETS—SHEET 1



INVENTOR.

J. M. Clark

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2 SHEETS—SHEET 2

INVENTOR.

James M. Clark

UNITED STATES PATENT OFFICE

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EXPANSIBLE CHAMBER ROTARY FLUID
DISPLACEMENT DEVICE

James M. Clark, New York, N. Y.

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The present invention relates to fluid displacement devices and is particularly adapted to that type of rotary blower, pump, motor and the like which depends for the variation in the capacity or volume of its compartments upon the rotation of its elements about oblique axes.

Many devices have been proposed which operate upon the principle of two or more elements rotating upon oblique or intersecting axes such that the working faces progressively approach and recede from each other to vary the volume of their compartments during the rotative cycle. These rotary devices have had the inherent advantage over devices of the reciprocating type in that they do not involve sudden changes in direction with their accompanying inertia effects and the resulting objectionable pulsating flow as well as the necessity of suitable valve means. Very few of these prior rotary devices have, however, met with general and efficient use, due primarily to a plurality of reasons such as the development of relatively great friction, excessive stresses upon the rotating elements due to centrifugal forces at elevated speeds, and the necessity for sealing between fixed and moving parts. Other difficulties have resulted from the lack of simplicity of design due to the inherent irregularity of the working chambers and the necessity of providing universal or other power transmitting means between the obliquely disposed or wobbling elements of many of such devices.

These and other difficulties and objections have been largely overcome, and eliminated altogether, by the rotary type fluid displacement device comprising the present invention. This device consists essentially, in its simplest form, of two rigid elements journaled upon oblique axes for rotation within a fixed casing, the working faces of the rotating elements having radially extending projections or corrugations to which are attached a flexible diaphragm by means of which one rigid element transmits rotation to the other and which cooperates to form variable capacity compartments between the projections into and from which the fluid is successively drawn and expelled.

In its simplest preferred form the fluid enters axially into a fixed part-spherical element having its center at the intersection of the oblique axes and from which it passes outwardly in a radial direction into the compartments as their working faces are receding and is discharged in the same outwardly radial direction from the opposite ends of the compartments as their working faces approach at the opposite side of the

rotational cycle. The displacement is both positive due to the reduction in compartment volume and the suction and discharge is materially augmented by the centrifugal forces developed by the rotation of the fluid masses which are discharged tangentially from the device.

The improved design is such that the interior of the casing is also part-spherical, being concentric with the central element, whereby the radial dimensions of the rotating elements remain fixed and maintain relatively close clearances between the outer face of the central element and the inner faces of the casing, which also cooperate to provide working faces for the rotating compartments. The central element is suitably apertured to provide an inlet opening and the casing is suitably formed to provide a tangential discharge opening. The flexible diaphragm attached to the conic elements forms therewith a universal joint or flexible coupling and the degree of flexing is of such relatively small proportions that the fatigue requirements of the diaphragm material is greatly reduced. The radial projections on each rigid element are preferably staggered or complementary with respect to the projections on the opposed element and are disposed at sufficient intervals as measured rotationally as to provide a plurality of radially extending compartments.

The present rotary displacement devices are also such that they require a minimum of accurately finished surfaces in contact with the rotating parts and the clearances between the fixed and rotating parts remain uniform and constant during its operation. The relatively low pressure differential between adjacent compartments as compared to the overall pressure difference between the suction and discharge compartments reduces the sealing problem and leakage losses to a minimum.

The present invention is not limited to the above described form but is advantageously adapted to duplex or multiple devices arranged either in parallel for increased volume or in series for higher pressures. It has also been found advantageous in this connection to provide a single unit comprising two rigid journaled elements with one or more floating corrugated rigid elements having intermediate flexible units.

It is accordingly a major object of the present invention to provide a relatively simple rotary displacement device in which positive compression is augmented by centrifugal effects to attain a relatively high degree of efficiency. It is a further object to provide in a device of this type a

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flexible bellows or diaphragm which serves in the dual capacity of a piston to vary the compartment volume and as a flexible coupling to transmit rotation from one rotary element to another thereby saving the weight and expense of additional moving parts such as a universal joint or other torque transmitting means.

It is a further object to provide a rotary displacement device which is of relatively simple construction and operation and is readily adapted for access for repair and servicing. A further object resides in producing such a rotary device which is free from inertia effects and provides a steady and continuous flow simultaneously discharged from a plurality of successive and adjacent compartments. It is a further object to provide such a rotary device which obviates the necessity of valves and in which the sealing problem is materially reduced since the compartments are relatively long and require sealing only at their ends at which the clearances are uniformly and continuously maintained.

A further object resides in a novel bellows compartment construction as a result of the bending action, and fatigue conditions to which the bellows elements are subjected are reduced to a minimum and any blow-back or leakage between the ends of adjacent compartments is also kept within reasonable limits due to the relatively low pressure differential prevailing from one compartment to the next.

It is a still further object to provide such a rotary device in which the rotating elements are relatively lightly stressed, are comparatively light in weight and the friction between the fixed and rotating elements is relatively small. A further object resides in a unique bellows compartment shape having a relatively high ratio of its area to its volume which readily lends itself to the dissipation of the heat of compression which may be developed at higher pressures.

Other objects and advantages of the present invention will become apparent to those skilled in the art to which it pertains after reading and understanding the present specification and the attached drawings, forming a part hereof, in which:

Fig. 1 is an axial cross-sectional view of a preferred embodiment of my improved rotary displacement device;

Fig. 2 is a side elevational view of the rotating elements of Fig. 1;

Fig. 3 is a transverse view of the device as taken along the plane indicated by the lines 3—3 of Fig. 1;

Fig. 4 is a side view of the central rotating element;

Fig. 5 is a detailed view of an attachment of the flexible diaphragm to the adjacent rotating elements adjacent their tips;

Fig. 6 is a cross-sectional view of the attachment taken along the lines 6—6 of Fig. 5; and

Fig. 7 is a developed diagrammatic view of the flexible diaphragm elements prior to their attachment to the adjacent rigid elements.

Referring now to the cross-section in Fig. 1, taken together with the side view of the rotating elements in Fig. 2, it will be seen that the casing 10 is split or divided transversely into the main casing half 10a and the secondary or suction half 10b. A rigid driving rotor 11 is rotatably disposed within the casing half 10a, its hub portion being keyed at 13, or otherwise suitably fixed, to the drive shaft 12 which is journaled for rotation, from a suitable power source, upon

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the horizontal axis A—B. The rotor 11, which will hereinafter be more fully described, has a part-spherical concave face 11c which rotates about or around a similar but convex part-spherical outer face 14c of a central inlet element 14 which is fixed to the casing half 10b. This central element 14 may be fully supported in a cantilever fashion from the casing half 10b, by the inlet hub element 13 and its outer end may be additionally supported in an anti-friction bearing 15 having its outer race carried by the hub of the rotor 11, as shown in Fig. 1.

The casing half 10a is provided with a hub portion 10h within which a main anti-friction thrust bearing 16 is carried for the journalling of the drive shaft 12. The latter is provided with an integral head portion 12a which rotates within a recessed end portion of the central element 14, and against the hub 11h of the rotor 11. The inner races of the thrust bearing 16 are retained against the rotor hub 11h by means of the threaded locking ring 12b on the shaft 12. The outer races of the bearing 16 are retained and positioned by the bearing cap 17 fastened to the casing hub 10h by the attachment screws 17a, the cap fitting preferably being provided with a suitable gasket or lubricant seal.

The central inlet fitting 14 is rigidly supported from the casing half 10b by the inlet hub fitting 13 which has a cylindrical portion 13b projecting into a corresponding female hub portion 14d of the central fitting to which it is fixed by the key 13c. The fitting 13 is attached to the casing half 10b by means of suitable attachment screws 13a and is preferably provided with a tapped or threaded inlet hub 13d to receive a suction pipe 30, or other fitting as desired. The inlet bore 13b of the fitting 13, as well as the adjacent bore 14b are preferably co-axial and continuous internally, having a common axis C—D. This axis is obliquely disposed with respect to the horizontal axis A—B and intersects the latter at the point O, which will preferably be referred to as the geometrical center of the device and the point from which the basic part-spherical surfaces and radial lines preferably originate, as will hereinafter be more fully explained.

The central fitting 14 has a part-spherical outer surface 14c, the center of which is the geometrical center point O and is internally bored such that it serves as an elbow to smoothly direct the axial flow entering its bore 14b into a transverse and radially downward flow to the inlet opening or port 14a through its part-spherical outer surface 14c. The outer surface of the hub portion 14b of the fitting 14 is suitably shaped to receive the anti-friction bearing 19 against a shoulder formed adjacent its part-spherical portion 14c and is threaded to receive the bearing retainer ring 18a. The bearing 19 is disposed in a co-axial and normal relationship with respect to the oblique axis C—O—D. This bearing forms the rotatable support for the rigid driven rotor 20 which is rotatable about the oblique axis C—O and within a transverse plane normal thereto. Except for its hub portion 20h, the rigid rotor 20 is identical with and oppositely disposed with respect to the driving rotor 11. Like its counterpart it has a part-spherical concave inner face 23c which rotates about the similar but convex part-spherical outer face 14c of the central element 14, the major difference residing in its having a larger internal opening to engage the larger diameter bearing 19 and permit of the fluid inlet 14b—13b,

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whereas the driving rotor has an inwardly extending hub portion to engage and be driven by the drive shaft 12.

The driving rotor 11 is preferably formed such that it presents a radially corrugated or sinusoidal-shaped working face toward the similar shaped driven rotor 20. The ridges or male projecting portions of the corrugations are defined by the radial lines 11a which, extended inwardly, each pass through the center O and define a relatively flat cone of revolution having its apex at the center O. The valleys or female indentations of the corrugations are defined by the radial lines 11b which, extended inwardly, each also pass through the center O and define a somewhat steeper cone of revolution, also having its apex at the center O. The corrugated working face of the driving rotor 11 terminates outwardly at a convex part-spherical outer surface 11d which forms an outer flange backing up the corrugations and rotates closely contiguous to a concave part-spherical portion 10c formed within the casing portion 10a. In machines designed for higher pressures suitable sealing means may be provided at these contiguous surfaces to prevent blow-back of fluid from the discharge portion, around and behind the rotors 11 and 20, to the suction portion of the casing. The corrugations similarly extend inwardly where they terminate at the inner concave part-spherical surface 11c, contiguous to the outer convex surface 14c of the central element 14.

The driven rotor 20 is similarly formed such that it presents a radially corrugated working face having corresponding ridges 20a and valleys 20b terminating in a convex part-spherical outer surface 20d which forms an outer flange backing up the corrugations and rotates closely contiguous to the concave part-spherical portion 10j formed within the casing portion 10b. For illustrative purposes rotors 11 and 20 have been shown as having eight complete corrugations in each of their working faces, although efficient devices may be designed having lesser or greater numbers of corrugations. These rotors should, however, each have a like number of corrugations and the corrugations of one should be staggered or offset with respect to those of the opposite rotor; that is, the ridges 11a of rotor 11 are opposite to the valleys 20b of rotor 20, and the ridges 20a of the latter rotor are in turn opposite the valleys 11b of rotor 11, as may be clearly seen in Fig. 2.

In the modification which has been illustrated in the drawings an intermediate or third rigid element 22 is provided between the driving and driven rotors 11 and 20. This intermediate rotor need not necessarily be perfectly rigid but may preferably be formed from a disc of metal or other material of a thickness which permits of a slight degree of flexing. It preferably is formed into a symmetrically conic element with a like number of similar radial corrugations as provided in the rotors 11 and 20. This intermediate corrugated rotor 22, which may preferably be termed a floating rotor, is shown in detail in Fig. 4, and in its assembled relationship in the device in Figs. 1 and 2.

This rotor 22 may be made from an annular disc of flat sheet material of such inner and outer diameters that when given its serrated or corrugated form the inner periphery 22c of the corrugations forms a spherical inside diameter of sinusoidal configuration which permits it to be rotated contiguous to and with a relatively small clearance with respect to the spherical diameter

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of the outer working face 14c of the fixed central inlet element 14. Similarly its outer periphery 22d forms a virtual outside diameter which permits it to be rotated with a relatively small clearance with respect to the inner working faces 10c and 10j of the fixed casing elements 10a and 10b. This floating disc 22 is preferably formed with corrugations of like pitch, depth and configuration as those of the rigid driving and driven discs or rotors 11 and 20 and each of its medians or radial lines 22a should pass closely through its center of development O, which is also the geometrical center of each of the spherical or part-spherical surfaces previously referred to. It will be obvious, of course, that where the disc 22 is made from a sheet of uniform thickness, as shown in the drawings, the radial lines 22a when projected inwardly will pass the point O to within approximately one-half this thickness.

Between the driving rotor 11 and the floating disc 22 there is disposed a relatively flat flexible diaphragm 21, and a like flexible diaphragm 23 is disposed between the floating disc 22 and the driven rotor 20. These flexible diaphragms are preferably made of rubber or synthetic rubber, such as neoprene, Thiokol, rubberized fabric, or similar compositions, or they may be of steel or other metal, or other flexible material having suitable flexing, fatigue, corrosion-resistant and other characteristics as may be required by the specific fluid to be handled and the rotational speed, volume, pressure and other operating conditions for which the particular device is designed.

Each flexible diaphragm 21 and 23 is formed into an annular disc of frusto-conical shape as shown in Fig. 7. They may be made of a single continuous piece or formed with a suitable joint. The inside diameter 21d is preferably of the same order as the inside diameter as measured through the center O, of the part-spherical surfaces 11c and 20c of the rigid rotors 11 and 20, and that of the inner surfaces 22c of the floating disc 22, being of such inside diameter that it may be rotated and flexed contiguous to and with a relatively small clearance with respect to the outer working face 14c of the central element 14. Similarly the outside diameter c, 21c and 23c of the flexible elements 21 and 23 is preferably of the same order as the corresponding diameters of the spherical outer surfaces 11d, 20d and 22d of the driving, driven and floating rotors, respectively.

Referring now to the assembly in Fig. 1, the driving rotor 10 is journaled for rotation about the horizontal axis A—O—B and the driven rotor is journaled for rotation about the inclined or oblique axis C—O—D. The vertical line E—O—F is drawn normal to the horizontal axis A—O—B through the center O at which the horizontal and inclined axes also intersect. The line G—O—H represents a transverse plane, passing through the center O, which plane is intermediate and equidistant from the horizontal plane passing through C—D. The angle E—O—G, as measured in the vertical plane of the section in Fig. 1, is accordingly one half the angle C—O—A; and angle C—O—G is equal to angle G—O—B. Similarly the angle C—O—H is equal to the angle B—O—H. Since the angle C—O—B as measured over the top of the device in Fig. 1 is appreciably less than the angle C—O—B as measured under the center O, the rotors 11 and 20 have approached each other at the top forming a region of maximum compression, and have

receded from each other at the bottom to form a region of maximum extension and suction.

The ridges 11a, as shown in Figs. 5 and 6 are provided with a plurality of radially aligned tapped holes 24 which match similarly disposed holes in the flexible diaphragm 21, and the latter is attached along their adjacent radial lines to the ridges 11a by means of the screws 25. Where the flexible diaphragm 21 is of metal or similar hard surfaced material, there is preferably provided an intermediate sealing strip 27 of rubber or suitable gasket material. Similarly disposed holes are provided in both the diaphragm 21, radially arranged intermediate the first said rows of holes, matching like holes in the floating disc 22, through which the latter, a sealing strip 27 and the adjacent flexible diaphragm 21 are attached as by the rivets 28, or by bolts, or other removable attachment means. Where the flexible diaphragms 21 and 23 are made of rubber or like material the sealing strips 27 may be dispensed with, and washers or radially extending strips may be used under the heads of the fastening bolts or rivets on the exposed side of each diaphragm.

Returning now to Figs. 1 and 3 both casing halves 10a and 10b are formed at their upper portions into a gradually increasing tangential discharge 10g preferably terminating in a threaded outlet 10d into which may be fitted a discharge pipe 31. Each casing half is also provided with a peripheral flange 10f extending outwardly parallel to the transverse plane defined by the intermediate line G—O—H. The flanges 10f are interrupted above and below the discharge 10g and are apertured circumferentially as at 23 to receive the flange bolts 29 by which the halves are bolted together preferably about an intermediate annular gasket to prevent passage of fluid therebetween, due either to suction or pressure created within the device. The casing portion 10a is also preferably formed with a base or pedestal portion 10e suitably apertured for bolting or fastening to a foundation or other supporting structure.

The operation of the device is as follows:

A suitable rotative source of power is preferably coupled to the drive shaft 12 to impart rotation thereto in the direction of the arrows in Figs. 1 and 3, or in a clockwise direction as viewed in Fig. 3. The casing halves 10a and 10b, as well as the central inlet element 14 and hub fitting 18 attached to 10b, all remain fixed. The rotating drive shaft 12 imparts like rotation to the driving rotor 11 through the key 13, and the rotor drives the flexible diaphragm 21, the floating rotor 22, the flexible diaphragm 23 and the driven rotor 20 each of which are connected by the screws 25 and/or the rivets 28. The driving rotor 11 is caused to rotate about the axis A—O—B, the axis of the shaft 12, and the driven rotor is caused to rotate at the same rotational speed about the inclined axis C—O—D to which it is confined by the bearing 19. It will accordingly be seen that the floating disc 22, and the flexible diaphragms 21 and 23 at each side of it, serve as a flexible joint or universal coupling which transmits rotative torque from the driving rotor 11 to the driven rotor 20 at substantially the same angular velocity. This is a distinct advantage in a device of this type inasmuch as it not only dispenses with the necessity for a universal joint or coupling, thereby simplifying the device by serving a dual purpose, but also causes the rotating parts to rotate

uniformly at the same angular velocity and is of a novel construction which permits the displaced fluid to flow radially outwardly through the coupling means, as will hereinafter be explained.

Let us now consider the compartment C1, as indicated in Figs. 3 and 4, which straddles the horizontal lateral axis K—O—L. This compartment C1, being intermediate the points of maximum approach of the rotors 11 at 20 at the top and of maximum divergence of these rotors at the bottom, is of average or mean capacity. The fluid is confined within this compartment by the relatively flattened flexible diaphragm 21 on the one side and the single pitch of the corrugated floating disc 22 on the other side. The leading and trailing joints formed by the strips 27 at the radial lines of contact of the diaphragm 21 and the disc 22 prevent leakage into the adjacent compartments. The outside of the compartment C1 is formed by the inner part-spherical surfaces 10c and 10j of the casing halves 10a and 10b against which the peripheral edges of the elements 21 and 22 rotate with a minimum clearance. The inner end of the compartment C1 has just passed the point of inlet I as indicated in Fig. 3 and defined by the point 14e and is open to the inlet port 14a in the fitting 14 and the inlet conduit 34.

As the chamber or compartment C1 is rotated, clockwise in Fig. 3, through substantially 90 degrees into the position indicated at C2 its volume has been materially increased. This increase is due to the flexible diaphragm 21 being withdrawn away from the opposed disc 22 by virtue of its attachment to the diverging rotor 21 by means of the screws 25. This increase in volume of the space or compartment is accomplished by outward flexing of the element 21 which may be of such resilient material to stretch sufficiently to permit slight circumferential elongation between the lines of attachment to the floating disc 22 which is preferably rigid or semi-rigid but of such material as to permit slight bowing by virtue of its corrugated shape to contract slightly in the circumferential direction to assist in the outward bulging or deflection of the element 21. At this point it is fitting to note that the flexing and/or bowing of the elements 21 and 22 does not in any manner disturb their radial dimension or that of the defined compartment, this radial dimension remaining at all times equal to

$$\frac{c-d}{2}$$

as indicated in Fig. 7. This feature, which holds throughout the rotative cycle, derives the distinct advantage of maintaining the designed clearance between the inner and outer edges of the elements 21 and 22 and the part-spherical surfaces 10c and 10j—10j against which they rotate. Inasmuch as the volume of the compartment between C1 and C2 increases materially it is filled by fluid drawn thereinto outwardly radially from the inlet port 14a as the compartment passes from the inlet point 14e to the point of cut-off 14f. This portion of its rotation, in passing through approximately 90 degrees, may accordingly be referred to as the inlet or suction stage of the rotative cycle.

As rotation is continued and the compartment moves from the position C2 through another 90 degrees to the position C3 the volume of the compartment is correspondingly reduced by a reverse

flexing and bowing of the elements 21 and 22 until at C3 it is restored to its intermediate or mean volume substantially equivalent to that at C1. Inasmuch as the compartment in rotating from C2 to C3 is now confined by the spherical outer surface 14c of the fitting 14 at its inner end the reduced volume is accompanied by a material increase in pressure of the fluid confined therein.

At a point M in the rotative cycle which may be beyond the position C3 the spherical inner surfaces 10c and 10f of the casing halves are preferably merged into the discharge portion 10g. This point has been indicated as the beginning of the discharge in Fig. 3 as approximately 22½ degrees beyond the position C3 straddling the lateral axis K—O—L but may be appreciably more or less depending upon the nature of the fluid, gas or liquid to be handled by the device. As rotation of the compartment continues to the upper position C4 the element 21 is flexed into the position of maximum reversal, opposite its form at C2, due to the maximum approach of the rotors 11 and 20 with respect to the floating disc 22 which throughout the rotative cycle assumes a floatingly centralized position therebetween due to its attachment to each through the resilient diaphragms 21 and 23. Accordingly as the compartment is rotated from the point at which the casing discharge 10g diverges outwardly from and slightly beyond the position C4 the further reduction in volume is accompanied by increased pressure and outward tangential discharge of the fluid through the discharge 10g, the outlet 10d and the conduit 31.

It will be noted that apart from the positive compression of the gas or liquid due to the variation in volume or capacity of the several compartments that the fluid in entering axially and being rotated and discharged outwardly has its compression appreciably augmented by the centrifugal forces which are thus developed. The present device is accordingly a combined rotary and centrifugal type compressor or pump and its centrifugal effect assists materially in feeding the fluid into the inner ends of the compartments and discharging the same from their outer ends. For purposes of explanation the rotors 11 and 20 have been shown as provided with eight projections and recesses apiece, or eight complete corrugations or sine curve face portions, and three intermediate diaphragms or compartment forming discs have also been shown.

It will be appreciated that successful devices utilizing the present invention may be made with rotors having a greater or lesser number of projections, having face portions of other shapes and with one or more compartment forming discs. In the form of device illustrated there are accordingly formed sixteen pairs of laterally disposed compartments or a total of thirty-two compartments, each of which has substantially the same volume at a given point in the rotative cycle. Each lateral pair will suck and discharge fluid simultaneously and at the same instant the leading and following pair of compartments will be completing and starting their corresponding functions respectively due to the overlapping of these compartments in the circumferential direction. This insures a relatively smooth discharge flow free from the pulsations and surges common to many prior rotary devices. Accordingly there will be no tendency of blowback or leakage between each laterally disposed pair and a relatively small tendency toward leakage between leading and trailing compartments, or vice

versa, due to the pressure differential therebetween being but a small fraction of the pressure difference between the suction and discharge ports. This small pressure differential also minimizes any tendency of the pressure within a given compartment affecting the shape of the adjacent leading and trailing compartments.

It will also be noted that a very important feature of the present device is the dual function of the elements 21, 22 and 23 in both defining the compartments of compression and in serving as both a flexible and universal coupling to transmit rotative torque from the driving rotor 11 to the driven rotor 20. This is not only accomplished in a flexible manner with the torque distributed uniformly along each projection of the driven rotor but the rotors are driven uniformly at precisely the same rotative speeds throughout the rotative cycle without the whip or speed variations incidental to many universal joints or couplings as they rotate past their dead-center positions.

The embodiment shown is adapted for use as a blower, supercharger or air compressor for the development of low or moderate pressures when rotated at moderate speeds. It will be obvious to those skilled in the art that greater delivery and somewhat higher pressures may be obtained from the illustrated device by rotation at higher speeds and a corresponding increase in input power. Higher pressures may be obtained by designing the device with a greater obliquity of the rotor axes A—B and C—D, or an increase in the angle C—O—A. The latter angle may also be decreased for lower pressures and when the angle C—O—A is made to equal zero, or when the two rotor axes are aligned and the inlet port made open for a full 360 degrees the device has been found to operate successfully as a centrifugal type blower without positive action of the compartments. A further modification of the invention contemplates control means for varying the angle of obliquity C—O—A to provide a variable capacity and pressure rotary displacement device. It will also be obvious to those skilled in the art that the described device may be advantageously utilized as a pump for the displacement of water or other fluids in which event it may be desirable to increase the angular extent of either or both the inlet and discharge portions of the cycle to compensate for the lesser compressibility of the fluid and to otherwise modify the arrangement and relationship of the component parts to most efficiently handle the specific fluid for which the device is intended.

The present device is accordingly adapted to successful application in other forms than has been shown and described and such other forms which vary either in general arrangement or the details of the respective elements are all intended to come within the embrace of this invention as more particularly defined in the appended claims.

I claim:

1. A rotary displacement device comprising a driving rotor, an opposed driven rotor adapted for rotation on an axis inclined to the axis of the said driving rotor, radial projections on the opposed faces of said rotors in a staggered relationship with respect to each other, a flexible radially corrugated disc attached to the staggered projections of each said rotor defining radially extending compartments between said rotors and means to conduct fluid into and from the ends of said compartments.

2. A fluid displacement device comprising a circumferentially corrugated driving rotor, a circumferentially corrugated driven rotor having the ridges of its corrugations oppositely and complementarily disposed with respect to those of said driving rotor, casing means for rotatively supporting said rotors on inclined axes, fluid inlet and outlet means formed by said casing means and flexible corrugated compartment forming means disposed between and attached to said ridges for rotatively coupling the said rotors whereby said rotation causes reversible flexing of said compartment forming means and displacement of the fluid.

3. A fluid displacement device comprising a corrugated driving rotor, a corrugated driven rotor, the ridges of the said corrugations of both said rotors oppositely disposed in a staggered relationship with respect to each other, casing means for rotatively supporting said rotors on intersecting axes, fluid inlet and outlet means formed by said casing means, flexible corrugated means attached to the ridges of said corrugations of each said rotor, said flexible means arranged to both rotatively couple said rotors by attachment to said ridges and to provide variable capacity compartments therebetween by the flexing of said corrugated means.

4. A fluid displacement device comprising a driving rotor having radial projections, a driven rotor having radial projections oppositely disposed in an offset relationship with respect to the projections of the first said driving rotor, flexible sinusoidal bellows means attached to the projections of each said rotor adapted to define a plurality of fluid chambers therebetween, a member adapted to rotationally support said rotors on intersecting axes, inlet and outlet means formed by said member and means to rotate said driving rotor arranged to cause said chambers to be varied in capacity by the reversible flexing of said bellows means for the displacement of fluid from said inlet through said outlet means.

5. A rotary displacement device comprising a conic driving rotor, a conic driven rotor, said rotors formed with radially disposed projections circumferentially offset with respect to each other, casing means for rotatively journaling said rotors on separate axes, fluid inlet and outlet means formed by said casing means, a plurality of flexible annularly shaped circumferentially deformed elements attached to each other and to the projections of each said rotor adapted to define a plurality of radially extending fluid compression chambers therebetween and means to rotate said rotors for the reversible deformation of said elements and outward radial displacement of said fluid.

6. A fluid compression device comprising a first rotor having radially disposed projections, a second rotor having radially disposed projections oppositely facing the projections of said first rotor in a circumferentially staggered relationship therewith, a casing having journals for the rotational support of said rotors on oblique axes, fluid inlet and outlet means formed by said casing, a plurality of circumferentially deformed flexible elements having radially disposed projecting portions attached to each other and to the projections of said rotors arranged to define radially extending fluid chambers therebetween and means to drive said rotors in such manner that fluid is compressed within said fluid chambers by the reverse flexing of said flexible ele-

ments by the approaching and receding movements of the respective rotor projections.

7. A rotary fluid displacement device comprising a pair of frusto-conical rotors having radially disposed projections thereon, a housing member adapted to rotationally support said rotors for rotation about intersecting axes with the frusto-conical surfaces and radial projections of said rotors extending through the intersection of said axes, a hollow part-spherical inlet member disposed about said axes intersection arranged to supply fluid axially toward said intersection and radially outwardly therefrom into the region between said rotors, fluid outlet means formed by said housing member, the said radial projections of one rotor staggered with respect to the other rotor, and circumferentially continuous corrugated diaphragm means of flexible material fixedly attached to the projections of said rotors arranged to define radially extending variable capacity compartments therebetween intermittently in communication at their inner ends with said fluid inlet as said rotors are convergingly and divergingly rotated about said intersecting axes for displacement of the fluid from the outer ends of said compartments.

8. A rotary displacement device comprising a pair of conic rotors having radially disposed projections, a housing having journals within which journals said rotors are adapted for rotation on intersecting axes, fluid inlet and outlet means formed by said housing, the said projections of said rotors radially arranged to extend through the intersection of said axes and a flexible circumferentially corrugated diaphragm having radial projections on its opposite sides alternately attached to the projections of said rotors arranged to define radially extending fluid spaces between said rotors and within said housing.

9. A rotary displacement device comprising a housing, a pair of frusto-conical circumferentially corrugated rotors journaled for rotation within said housing on intersecting axes, an inlet centrally disposed about the said axes intersection carried by said housing arranged to supply fluid axially inward into said housing and radially outward between said rotors, an outlet within said housing tangentially disposed with respect to the outer peripheries of said rotors carried by said housing, circumferentially corrugated flexible means disposed between and connected to the corrugations of said rotors defining radially extending fluid spaces successively open to the corrugations of said inlet and outlet and means to drive said rotors and said flexible means for the outward displacement of fluid from said housing.

10. In a rotary displacement device including a housing, a pair of circumferentially deformed frusto-conical rotors journaled for rotation within said housing on intersecting axes, said housing defining an axial inlet and a peripheral outlet, and a floating circumferentially deformed disc disposed intermediate said rotors, flexible diaphragms attached between said floating disc and each said rotor in such manner that they are circumferentially deformed to define a plurality of variable capacity fluid compartments between said rotors in communication at their inner ends with said inlet and at their outer ends with said outlet.

11. The combination with a rotary displacement device comprising a fixed housing, a pair of circumferentially corrugated conic rotors, and journals carried by said housing arranged for the

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rotation of said rotors on separate but intersecting axes, of flexible corrugated means disposed between and interconnecting said rotors to form displacement compartments in cooperation with said rotors.

12. The combination with a rotary fluid displacement device comprising a fixed housing, and a pair of frusto-conical circumferentially corrugated rotors adapted for rotation within said housing upon separate intersecting axes, of circumferentially continuous torque transmitting means of flexible material connecting said rotors arranged to define therewith and with said housing circumferentially corrugated compartments having reversely bowing sides for the displacement of fluid.

13. The combination with a rotary fluid displacement device comprising circumferentially deformed conic rotors arranged to rotate upon oblique intersecting axes, the said rotor deformations being oppositely disposed in a circumferentially staggered relationship, and a continuous flexible circumferentially deformed fluid space defining means of flexible material rotatively coupling said rotors and reversingly bowed by the rotation of said rotors for the displacement of fluid therefrom.

14. A rotary fluid displacement device comprising a casing member defining a part-spherical chamber, a pair of circumferentially deformed conic rotors journaled within said casing member on separate intersecting axes, inlet and outlet means formed by said casing member, the said rotor deformations being oppositely disposed in a circumferentially staggered relationship, continuous circumferentially deformed diaphragm means of flexible material rotatively coupling said rotors, said rotors and said diaphragm means having part-spherical peripheries adapted to be rotated contiguous to said part-spherical chamber, and means to rotate said rotors and said diaphragm means for the reversible flexing of said means and the displacement of fluid from within said casing.

15. A fluid displacement device including a fixed casing having an internal chamber, a pair of rotors journaled in said casing for rotation on separate oblique axes, fluid inlet and outlet means carried by said casing said rotors having circumferentially deformed working faces, circumferentially deformed rigid diaphragm means disposed between said rotors and flexible diaphragm means connecting the working faces of said rotors with said rigid diaphragm means adapted to define fluid compartments within said chamber and means to rotate said rotors for the variable deformation of said compartments and the displacement of fluid from said chamber.

16. A fluid displacement device including a fixed casing having an internal chamber, a pair of circumferentially deformed rotors journaled in said casing for rotation within said casing on intersecting axes, said casing having a tangential discharge portion, a fixed member centrally disposed about said intersecting axes having a radial inlet portion, circumferentially deformed means coupling said rotors defining radially extending fluid compartments successively opening at their inner ends to said inlet portion, said coupling means formed from an initially annular disc of flexible material and means to rotate one of said rotors to deform said compartments for the displacement of fluid radially outward there-through from said inlet to said discharge portion.

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17. In a rotary displacement device comprising a radially ridged conic driving rotor and a radially ridged conic driven rotor rotatable on an axis intersecting that of said first rotor the said radial ridges being oppositely disposed on the work faces of said rotors in a circumferentially staggered relationship, a flexible circumferentially and continuously bowed diaphragm intermediately connecting the ridges of said rotors defining compartments therebetween, means to drive the first of said rotors whereby said diaphragm is reversingly bowed toward and away from the work face of one of said rotors as it is rotated and means to conduct fluid into and from said compartments.

18. In a rotary displacement device comprising a corrugated faced driving rotor and a corrugated faced driven rotor adapted to rotate upon an axis oblique to the axis of said driving rotor, a compression space defining flexible element of corrugated form interconnecting said rotors and means to rotate said driving rotor whereby said flexible element is reversingly flexed by said rotors for the displacement of an entrained fluid.

19. In rotary fluid displacement devices the combination of a fixed housing, a pair of circumferentially corrugated conic rotors, journals carried by said housing arranged for the rotation of said rotors on separate but intersecting axes, and flexible corrugated means disposed between and interconnecting said rotors to form displacement compartments in cooperation with said rotors.

20. In a rotary fluid displacement device comprising a fixed housing, a pair of circumferentially corrugated conic rotors and journals carried by said housing arranged for the rotation of said rotors on separate but intersecting axes, the improvement comprising flexible corrugated means disposed between and interconnecting said rotors arranged to form displacement compartments in cooperation with said rotors.

21. A rotary displacement device comprising a driving rotor, a driven rotor adapted to rotate upon an axis oblique to the axis of said driving rotor, compression space defining means of circumferentially corrugated flexible material interconnecting said rotors and means to rotate said driving rotor whereby said compression space defining means is reversingly flexed for displacement of an entrained fluid.

22. A rotary displacement device comprising a driving rotor, a driven rotor arranged for rotation upon an axis oblique to the axis of said driving rotor, a relatively thin rigid circumferentially corrugated element spaced from and disposed intermediate said rotors and chamber defining means interconnecting said intermediate element and each said rotor arranged to form radially extending expansible chambers upon rotation of said driving rotors.

23. A rotary displacement device comprising a driving rotor, an opposed driven rotor adapted for rotation on an axis inclined to the axis of the said driving rotor, radially extending projections on the opposed work faces of said rotors in a staggered relationship with respect to each other, an annular disc spaced from and disposed between the work faces of said rotors, said disc formed with circumferential corrugations providing radially extending projections centrally disposed between the adjacent radially extending projections on said rotor working faces and flexible means disposed between and connected

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to each said rotor and said centrally disposed disc defining radially extending expandable chambers between said rotors.

JAMES M. CLARK.

Number
1,347,512
1,678,049
2,324,168

6

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

10

Number	Name	Date
32,372	Jones et al.	May 21, 1861

16

Name	Date
Kirby	July 27, 1920
Kearney	July 24, 1928
Montelius	July 13, 1943

FOREIGN PATENTS

Country	Date
Great Britain	1910
Great Britain	Jan. 30, 1919
Germany	Jan. 20, 1940