Aug. 21, 1956 J. H. HOLSTEIN 2,759,427

CENTRIFUGAL PUMP

Filed March 6, 1953 4 Sheets-Sheet 1

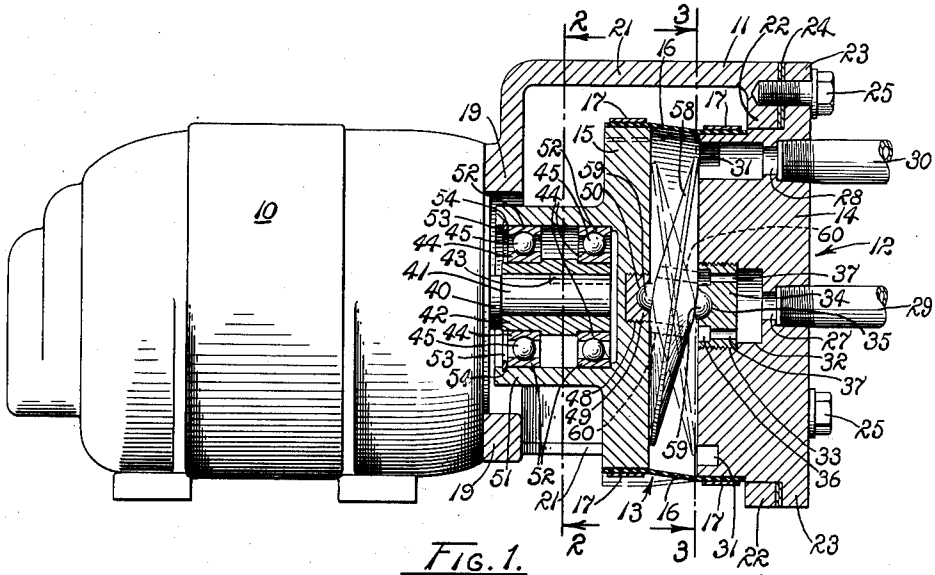


FIG. 1.

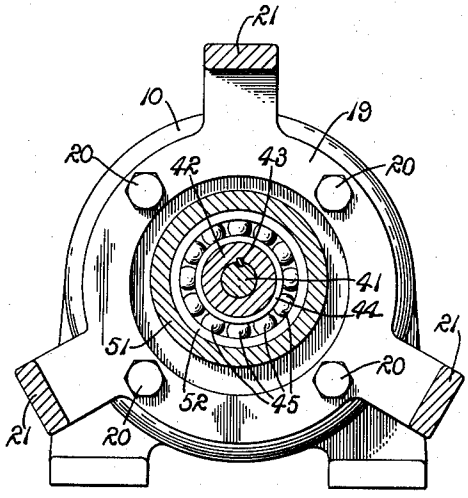


FIG. 2.

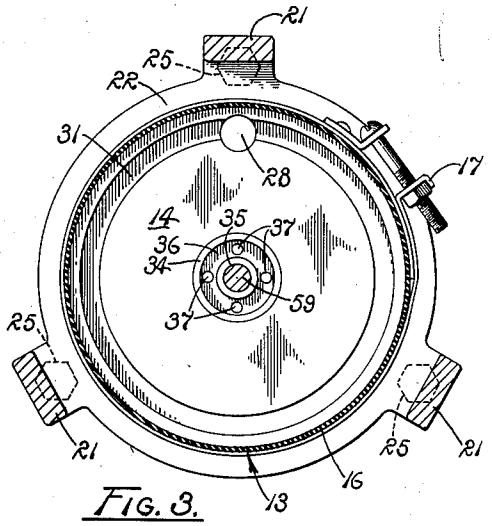


FIG. 3.

JOHN H. HOLSTEIN
INVENTOR
HUEBNER, BEEHLER,
WORREL & HERZIG
ATTORNEYS
BY
Richard M. Worrel

Aug. 21, 1956 J. H. HOLSTEIN 2,759,427

CENTRIFUGAL PUMP

Filed March 6, 1953. 4 Sheets-Sheet 2

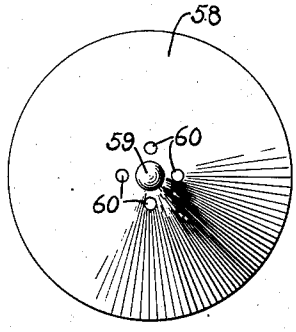


FIG. 4.

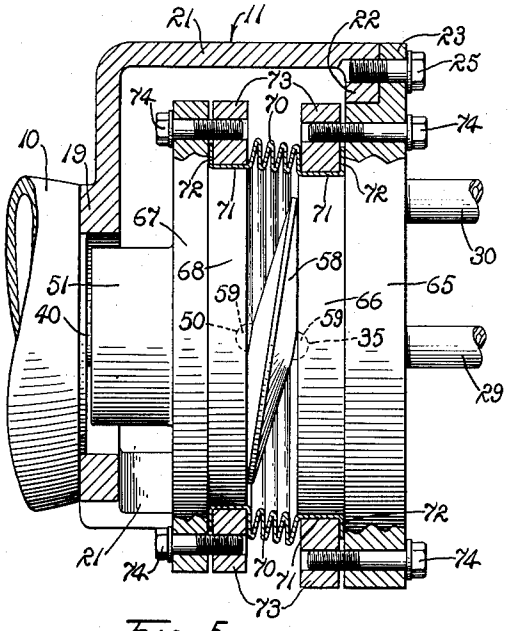


FIG. 5.

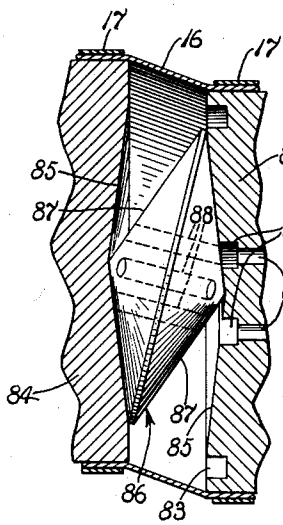


FIG. 6.

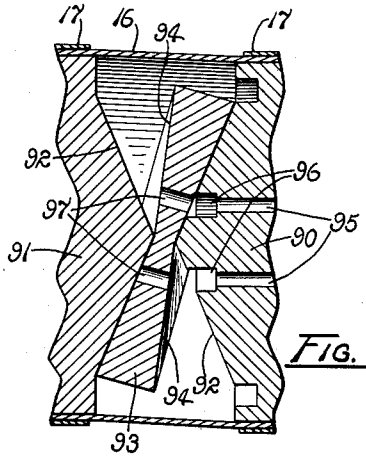


FIG. 7.

JOHN H. HOLSTEIN
INVENTOR
HUEBNER, BEEHLER,
WORREL & HERZIG
ATTORNEYS
BY Richard M. Worrel

Aug. 21, 1956 J. H. HOLSTEIN 2,759,427

CENTRIFUGAL PUMP

Filed March 6, 1953 4 Sheets-Sheet 3

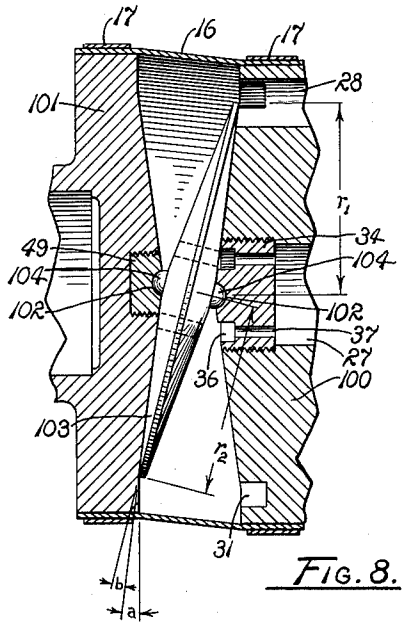


FIG. 8.

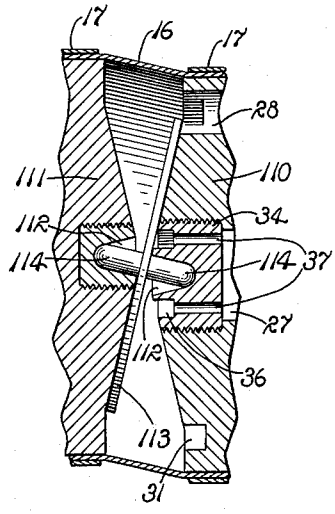


FIG. 9.

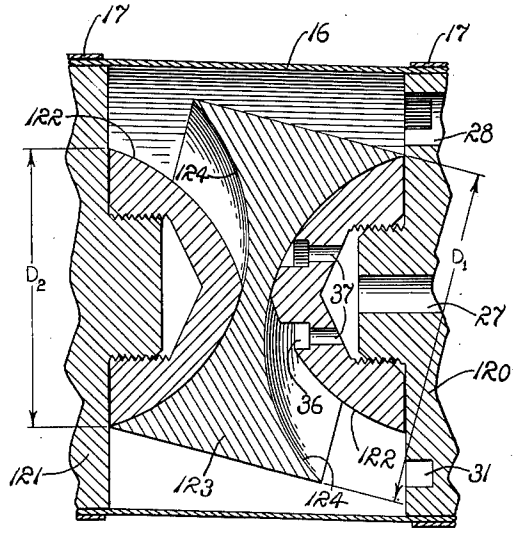


FIG. 10.

JOHN H. HOLSTEIN
INVENTOR
HUEBNER, BEEHLER,
WORREL & HERZIG
ATTORNEYS
BY Richard M. Worrel

Aug. 21, 1956 J. H. HOLSTEIN 2,759,427

CENTRIFUGAL PUMP

Filed March 6, 1953 4 Sheets-Sheet 4

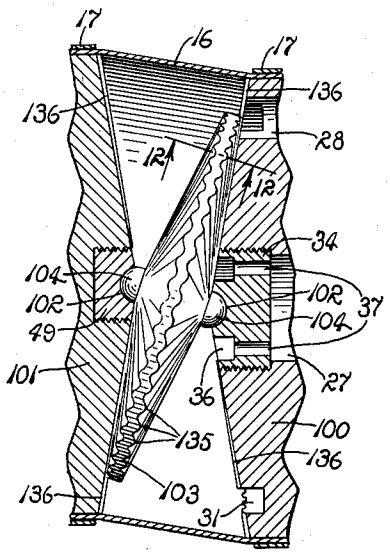


FIG. 11.

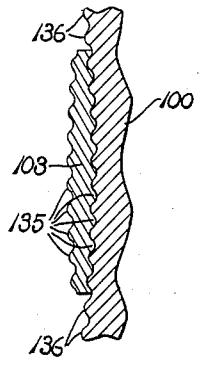


FIG. 12.

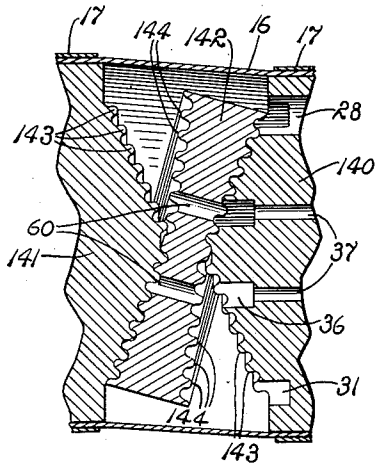


FIG. 13.

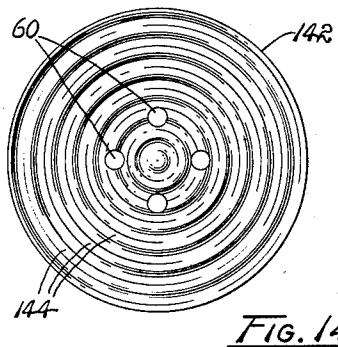


FIG. 14.

JOHN H. HOLSTEIN
INVENTOR
HUEBNER, BEEHLER,
WORREL & HERZIG
ATTORNEYS
BY
Richard M. Worrel

United States Patent Office 2,759,427 Patented Aug. 21, 1956

2,759,427

CENTRIFUGAL PUMP

John H. Holstein, Fresno, Calif.

Application March 6, 1953, Serial No. 340,711

13 Claims. (Cl. 103—83)

The present invention relates to centrifugal pumps and more particularly to an improved centrifugal pump having a fluid chamber in which pumping action is produced by external manipulation of the chamber and the conventional extension of driving means into the chamber obviated with the concomitant avoidance of the need for packing, leakage incident to packing failure, and the usual care and attention required by conventional centrifugal pumps.

The leakage of conventional pumps is of such general experience that it is usually regarded as an unavoidable nuisance that must be tolerated during pump operation. Such leakage is wasteful, frequently creates unsanitary conditions, and is productive of hazardous situations in which workmen, attendants, and property are endangered. The leakage of water from electrically operated pumps increases the likelihood of short circuits and the difficulties incident thereto. The leakage of gasoline or other inflammable fluids creates fire hazards. The loss or exposure of fluid explosives during pumping action is virtually intolerable but has been allowed to occur in many instances because of the difficulties encountered in precluding leakage and the requisite constant attention required.

Most pumps of the centrifugal and other types require the utilization of a pumping chamber which contains an impeller motivated by a shaft rotatably or reciprocally extended into the chamber. The provision of effective packing about such shafts has been virtually impossible and eventual leakage is almost always encountered. In addition to the hazards referred to, the attention required by such packing, its frequent replacement, and the maintenance expenses involved are objectionable.

Although there have been pumps intended to be leak proof, they have been subject to inefficiencies and other difficulties precluding optimum effectiveness and general acceptance which the present invention is believed to overcome. For descriptive convenience, the pump shown in the patent to Hunter No. 2,033,577 is referred to as being the closest prior art to which the applicant is aware. The Hunter patent utilizes an enclosed pump casing having an axial inlet opening and a radial outlet. A wobbler element is centrally mounted therein for limited universal tipping movement. The wobbler is of magnetically attractive material and a portion of the casing of a material through which a magnetic field is effective. A magnetic impeller is rotatably driven externally adjacent to the casing with the intent that the wobbler be rotated in a "rapid whirling motion sufficient to cause it" centrifugally to expel fluid from the casing. Although the Hunter pump avoids the utilization of packing and may possess real advantages, it is not positively driven, and is subject to other difficulties which it will subsequently become apparent are obviated by the present invention.

The broad essence of the present invention resides in the discovery that an effective pumping action can be attained by revolutionary movement, as distinguished from rotary movement, in a device providing a hollow

housing having spaced opposite end walls and a flexible side wall interconnecting the end walls, means mounting the end walls in predetermined spaced relation for revolutionary movement of one end wall relative to the other in a circular orbit, and an impeller positioned between the end walls of the housing axially swivelly engaged with said end walls and which is motivated in progressively tilted circular progression by relative revolutionary movement of the end walls of the housing. The motion of the impeller is one of nutation imparted thereto by planetary movement of an end wall swivelly connected to the impeller.

An object of the present invention is to provide an improved centrifugal pump.

Another object is to provide a pump having a fluid chamber in which pumping action is produced by external manipulation of the chamber.

Another object is to provide a pump which cannot leak unless there is structural or material failure.

Another object is to provide a pump avoiding the use of packing between relatively movable parts and the adjustment, replacement, care, and expenses incident to convenitional pump packing.

Another object is to provide a pump which can be operated for protracted periods with no appreciable wear.

Another object is to provide a positively driven centrifugal pump which is virtually leak-proof.

Another object is to provide improved elements and arrangements thereof in a revolutionary or revolvable device of the character described that is operable as a fluid pump, fluid motor, meter or the like.

Further objects and advantages will become apparent in the subsequent description in the specification.

Referring to the drawings:

Fig. 1 illustrates a pump embodying the principles of the present invention having driving connection to an electric motor, the motor being shown in side elevation and the pump in vertical section.

Fig. 2 is a section through the device of the present invention taken on a plane represented between line **2—2** in Fig. 1.

Fig. 3 is a section through the device of the present invention taken on a plane represented by the line **3—3** in Fig. 1.

Fig. 4 is a face view of a discoidal impeller employed in the pump shown in Figs. 1, 2 and 3.

Fig. 5 is a fragmentary portion of a pump embodying the principles of the present invention demonstrating the utilization of a pump housing of modified form. It will be observed that Figs. 1 and 5 both show the utilization of a discoidal impeller of the same form universally connected concentrically to substantially parallel circular end walls of a pump housing.

Figs. 6, 7, 8, 9, 10, 11 and 13 are vertical sections of various cooperative forms of the impeller and the housing of the present invention demonstrating the wide range of permissible variations in the cooperative configurations of conjugate faces of the impeller and end walls of the housing within the scope of the present invention.

Fig. 12 is a section taken on line **12—12** of Fig. 11.

Fig. 14 is a face view of the impeller shown in Fig. 13.

Referring in greater detail to the drawings:

In Figs. 1, 2 and 5 a prime mover, such as an electric motor, is indicated generally at **10** having a frame **11** rigidly extended therefrom. The first form of the pump of the present invention is shown at **12**.

The pump **12** consists of an obliquely cylindrical housing **13** having a pair of substantially circular end walls **14** and **15** interconnected in parallel spaced relation by a flexible sleeve or side wall **16**. The side wall is conveniently formed of rubber, flexible plastic, flexible metal tubing, such as stainless steel, bronze, copper or the like,

or any other suitable material providing the desired flexibility and resistance to fatigue. The side wall or sleeve 16 is fitted to the peripheries of the end walls and clamped in fluid tight engagement therewith by circumscribing clamps 17 or otherwise secured thereto.

The frame 11 may take any suitable form but conveniently consists of a collar 19 rigidly mounted on the prime mover 10, as by means of bolts 20, and has spaced arms 21 extended from the collar away from the motor and mounting an annular yoke 22 in parallel spaced relation to the collar 19. The end wall 14 of the housing 13 is slidably fitted into the yoke 22 and provides a circumscribing flange 23 fitted against the yoke 22 oppositely from the arms 21. For purposes soon to become apparent, the positioning of the end wall in the yoke 22 is preferably adjustable relative to the motor, as by means of shims 24 insertable between the flanges 23 and yoke 22. The end wall 14 fitted to the yoke 22 is dependably mounted therein by means of headed bolts 25 extended through the flange 23 and shims 24 and screw-threadedly mounted in the yoke.

The end wall 14 mounted in the yoke 22 provides an inlet 27 concentrically therein and an outlet 28 radially spaced from the inlet. An intake conduit 29, or suction pipe, is screw-threadedly mounted in the inlet 27 and an outlet conduit 30, or discharge conduit, is screw-threadedly mounted in the outlet 28. An annular groove 31 is provided concentrically in the inner face of the end wall 14 in registry with the outlet 28 and serves as a discharge manifold, or port, for flow of fluid therethrough to the outlet conduit.

As shown in Fig. 1, the end wall 14 rigidly mounted in the frame 11 has a substantially flat inner face disposed toward the motor 10. A counterbore is provided in the inner face concentrically of the inlet 27 and a second counterbore 33 concentrically thereof. As a production expedient, a plug-like bearing 34 is screw-threadedly mounted in the second counterbore 33 so as to define an inner manifold in the counterbore 32. The bearing provides a socket 35 concentrically of the inner face of the end wall 14 which is preferably circumscribed by an annular groove 36, constituting an intake port, connected in fluid communication with the counterbore 32 by a plurality of bores 37 formed therebetween. The plug bearing 34 provides a face flush with the inner face of its respective end wall.

The motor 10 provides a rotated drive shaft 40 axially aligned concentrically with the rigidly mounted end wall 14 and its plug bearing 34. An eccentric shaft 41 is rigidly mounted on the drive shaft 40 and extended therefrom in parallel spaced relation to the aligned axis of the drive shaft and the end wall 14. A bearing sleeve 42 is mounted on the eccentric shaft 41 as by means of a key 43, in the well known manner. The sleeve has opposite ends of reduced diameter to which the inner races 44 of a pair of bearings 45 are fitted concentrically of the eccentric shaft.

The inner end wall 15 has a substantially flat face disposed toward the end wall 14 and has a bore 48 concentrically therein. A plug like bearing 49 is screw-threadedly mounted in the bore 48 and provides a socket 50 concentrically of the face of its end wall. The end wall 15 also has a cylindrical bearing cage 51 integral therewith extended concentrically therefrom in fitted engagement with outer races 52 of the bearings 45. The cage is conveniently held in assembled relation on the bearings 45 by a snap ring 53 releasably engaged in an inwardly disposed annular groove 54 in the cage.

A discoidal impeller 58 is provided between the end walls 14 and 15 and has oppositely extended axial bosses 59 engaged in the sockets 35 and 50 for universal swivel movement. The proper selection of the shims 24 conveniently provides the spacing of the end walls and their sockets for the nesting of the bosses therein. Opposite faces of the impeller 58 are of conical form. The eccentricity of the shaft 41 relative to the socket 35 and the concentricity of the drive shaft 40 relative to the end wall

14 and its socket assures that the axis of the impeller is continuously and uniformly angularly related to the aligned axes of the shaft 40 and the end wall 14 during rotary motion of the shaft. The angularity of the axis of the impeller relative to the axis of the drive shaft 40 is approximately one-half the angular relation of the conical surfaces of the impeller to planes normal to the axis of the impeller. A plurality of bores 60 are provided through the impeller in registry with the annular groove 54.

Operation

The operation and utility of the present invention are believed to be clearly apparent and are briefly summarized at this point. When the motor 10 is energized, the drive shaft 40 is rotated and the eccentric shaft 41 carried in a circular orbit concentric to the drive shaft. The end wall 15 is mounted concentrically on the eccentric shaft 41 and is revolved, but not rotated, in a circular orbit concentric to the drive shaft and to the end wal 14 and the socket 35. The flexibility of the side wall 16 permits the rapid revolving of the end wall 15 while the end wall 14 is maintained in fixed position.

The revolutionary planetary movement of the end wall 15 relative to the end wall 14 causes the axis of the impeller 58 to be motivated in a conical path of nutational movement. The opposite sides of the impeller and the opposite end walls 14 and 15 have adjacent conjugate faces. The orbit of revolution of the end wall 15 is preferably of such diameter that the adjacent conjugate faces are in rolling engagement along radial lines of contact. It will be apparent that such radial lines of contact on opposite sides of the impeller are diametrically related as the impeller is tipped in continuous circumferential progression incident to rotary motion of the drive shaft 40.

Fluid to be pumped is supplied to the housing 13 through the intake conduit 29, inlet 27, counterbore 32, bores 37, and annular groove 36. As the impeller 58 is whirled in its progressively tilted circumferential progression in rolling engagement with the end walls 14 and 15, fluid in the housing is rapidly whirled and thrown outwardly toward the side wall 16. This provides an area of reduced pressure centrally of the impeller and housing and an area of substantially greater pressure adjacent to the side wall 16. The bores 60 permit passage of fluid through the impeller so that the adjacent conjugate faces on opposite sides of the impeller are thoroughly effective. The increased pressure peripherally of the impeller causes an effective pumping action outwardly of the discharge conduit 30.

It will be observed that no moving parts are extended through the walls of the housing and thus no packing is required and no leakage is possible in the absence of structural or material failure. The amount of flexing required of the side wall 16 is such that there are many materials of the character suggested that last indefinitely when utilized for the purpose. Although the forms of the conjugate faces of the impeller and the end walls in Fig. 1 are such that the impeller creeps in a slow rotary movement incident to the tilted progression of the impeller, the wear incident to such movement and to the universal pivoting of the bosses 59 in the sockets 35 and 50 is negligible.

Not only is the described pump thoroughly effective in pumping fluids but is capable of effectively motivating fluid borne solid materials. This is particularly true when the spacing of the end walls is slightly increased so that the impeller in its progression does not actually engage both end walls along the described radial lines of contact but is spaced therefrom so that said radial lines are lines of proximity rather than contact.

Modified housing

It will be apparent that the described flexibilty re-

quired of the side wall **16** can be achieved by a circumferentially corrugated or accordian pleated side wall of any suitable material. Such modification is shown in Fig. 5 in which the motor **10** and frame **11** are given the same numerals, as before. An end wall **65** is rigidly mounted in the frame by means of the bolts **25** in the manner described for the end wall **14**. The end wall **65**, however, provides an inwardly disposed cylindrical extension **66** terminating in an inwardly disposed face similar to that of the end wall **14**. An end wall **67** is mounted on the drive shaft **40** of the motor in the manner described for the end wall **15** and provides an inwardly disposed cylindrical extension **66**. The impeller **58** is mounted between the end walls **65** and **67** in the manner previously described.

A substantially cylindrical corrugated side wall **70** of metal or other suitable material has opposite ends **71** fitted to the cylindrical extensions **66** and **68** of the end walls and radially outwardly turned flanges **72**. Annular collars **73** are fitted over the ends **71** of the side wall in circumscribing relation to the respective extensions of the end walls against the collar **73**. Bolts **74** extend through the end walls and are screw-threadedly engaged in the collars and draw the collars tightly against the end walls in fluid tight clamping relation to the flanges **72**.

The pump shown in Fig. 5 operates in the identical manner to that shown in Fig. 1 except that the corrugated form of the side wall provides certain advantages for particular operational requirements and permits the use of less flexible material therefor.

Alternate impeller and end wall forms

It has been discovered that the impeller and the end walls of the subject pump may take many forms without departing from the spirit or the scope of the present invention and still provide the effective conjugate faces described. Attention is invited to Figs. 6 to 14, both inclusive, which show several exemplary forms of conjugate faces symmetrical about centers thereof. Although the various forms show the utilization of impellers having similar opposite faces operatively associated with respectively similar end wall faces, it will be apparent that different face forms may be utilized on opposite sides of an impeller so long as the conjugately associated end wall faces are of appropriate cooperative form. For example, one side of the impeller and the associated end wall face may be of the form shown in Fig. 6 while the opposite side and associated end wall face is of the form shown in Fig. 7. Other combinations will readily occur to those skilled in the art. It is to be understood that the end walls subsequently referred to can be mounted in the manner described in connection with Figs. 1 and 5 or by any other suitable means capable of achieving the described relative revolutionary movement. For purposes of simplicity, the various end walls shown in Figs. 6 to 11 and 13 are interconnected by the form of side wall **16** shown in Fig. 1 and secured in position by clamps **17**. It is to be understood that other forms of side wall may be utilized as demonstrated in Fig. 5.

In Fig. 6 a rigidly mounted end wall **80** having centrally located inlets **81** interconnected by an annular groove **82** and providing an annular outlet groove **83**, similar to the groove **31** and connected to an outlet, not shown, is illustrated. The sleeve **16** interconnects the periphery of the end wall **80** in fluid tight interconnection with the periphery of an end wall **84** mounted for revolutionary movement in a circular orbit concentric to the end wall **80**. The end walls **80** and **84** provide facing, conical, concave faces **85**.

A discoidal impeller **86** is positioned between the faces **85** which provides oppositely disposed convex conical faces **87**. Bores **88** are provided through the impeller and serve the same purpose as the bores **60**. Convex apices of the conical faces **87** of the impeller are engaged in the concave apices of the conical faces **85** and thus the necessity for the bosses **59** and sockets **35** and **50** obviated. The nested apices of the impeller and end walls provide the requisite universal swivel engagement and as the end wall **84** is revolved in its orbit, the impeller is progressively tilted in circumferential progression and pumps in the manner previously described.

Fig. 7 illustrates a form of housing and impeller of substantially opposite form to that shown in Fig. 6. A stationary end wall **90** and an orbitally revolved end wall **91** are interconnected, as before, by the side wall **16**. The end walls provide inwardly convex conical faces **92** having adjacent apices. A circular impeller **93** bridges the space between the faces **92** and provides oppositely disposed concave conical faces **94**. The thickness of the impeller at its center is such as to fit between the apices of the faces of the end walls and thus the impeller is mounted for the described tilting movement between the end walls without the necessity of bosses **59** or sockets **35** or **50**. The end wall **90** provides the usual inlets **95** and outlet groove **96** and the impeller bores **97** therethrough so that the conjugate faces on opposite sides of the impeller both perform effective pumping action.

The form of the invention shown in Fig. 7 has as an advantage in that the orbit of the end wall **91** may be quite small and vibration thus minimized. By the same token, however, the mechanical advantage of the end wall **91** in motivating the impeller is substantially less than the mechanical advantage of the end wall **84** on the impeller **86**.

In operating the forms of the pump heretofore described, the principal movement of the impellers **58**, **86** and **93** is the progressive tilting in circumferential progression described but in addition thereto, the impellers have a slight rotational movement. While there is no particular objection to such rotation in most operations, the form of the invention shown in Fig. 8 demonstrates that the conjugate faces can be so shaped as to avoid the rolling action. In Fig. 8, a fixed end wall is represented at **100** and its associated orbitally travelled end wall at **101**. The end walls have inwardly disposed, convex, conical surfaces providing concentrically therein impeller mounting sockets **102**. A discoid impeller **103** having axially extended bosses **104** is mounted between the end walls by engagement of the bosses in the sockets. The impeller has oppositely disposed convex conical faces engaged with the conical faces of the end walls along diametrically related radial contact lines. In Fig. 8 angle "*a*" is the conical angle between the surface of the end wall **101** and a plane passed through the end wall normal to the axis of revolution of said end wall. Angle "*b*" is the conical angle between a surface of the impeller **103** and a plane normal to the axis of the impeller. To avoid rotation of the impeller during pumping action, the conjugate faces of the end walls and impellers are so formed that angle "*a*" equals angle "*b*." "r_1" is the distance between the center of the swivelling action of the impeller in the end wall and the position at which the outer periphery of the impeller engages the end wall. "r_2" is the radius of the impeller.

Trigonometrically:

The periphery of a circle having a radius of $r_1=2\pi \cos a$
The periphery of a circle having a radius of $r_2=2\pi \cos b$
$<a=<b$

Therefore the periphery of the impeller is equal to the periphery of a circle on each end wall defined by impeller engagement therewith during pumping action. Inasmuch as the total distance on the end wall to be engaged by the periphery of the impeller during a complete cycle of peripheral progression is equal to the circumference of the impeller to be rolled therealong, the impeller does not rotate during its progressive tilting.

Fig. 9 shows the utilization of a fixed end wall **110** and an orbitally revolved end wall **111** operated in more

closely adjacent relation than the previously described forms of the invention. Each of the end walls provides a convex conical surface having a socket 112 concentrically therein. A flat circular impeller 113 is mounted between the end walls by engagement of axially extended bosses 114 into the socket 112.

In the preceding forms of the invention, the conjugate faces of the impellers and end walls have been surfaces of revolution generated by straight lines. In Fig. 10 is illustrated a further form of the invention in which the conjugate faces are surfaces of revolution generated by curved lines. In Fig. 10, a fixed end wall 120 has an orbitally travelled end wall 121 operatively associated therewith in the manner previously described. The end walls provide substantially hyberbolical faces 122 having rather pronounced apices or vertices. An impeller 123 is mounted in bridging relation between the end walls and provides oppositely disposed, concave fractospherical faces 124 concentrically engaged with the faces 122 of the end walls. The pump represented in Fig. 10 operates in the same manner as those previously described. The disparity between the diameters (D_1 and D_2) of the conjugate faces of the impeller and the end walls causes the impeller to rotate comparatively more rapidly between the end walls incident to its progressive tilting in circumferential progression than the other forms.

It has also been discovered that the conjugate faces of the end walls and impeller need not be precise surfaces of revolution. In Fig. 11, the structure shown in Fig. 8 is reproduced and like elements designated by like numbers. It will be recalled that the impeller 103 does not rotate when the end wall 101 is travelled in its orbit concentric to the end wall 100 to achieve the pumping action. Inasmuch as there is no relative rotation, the impeller can be provided with radially disposed corrugations 135 and the end walls with radial corrugations 136 complementary thereto. The corrugations 135 and 136 mesh, as shown in Fig. 12, during pumping action and effectively preclude impeller rotation.

The end walls 140 and 141 of Fig. 13 are somewhat similar to the end walls 90 and 91 of Fig. 7 and the impeller 142 has oppositely disposed concave faces somewhat similar to the impeller 93. The end walls and impeller of Fig. 13, however, have been provided with complementary concentric corrugations 143 and 144 respectively on their conjugate faces. Although it is found that such corrugations slightly inhibit the pumping action because of the increased surface friction thereof, they have the advantage of aiding in the dependable maintaining of the impeller in concentric relation to the walls on opposite sides thereof.

While the several forms of impellers and end walls have different individual characteristics, it will be apparent that all of the forms and innumerable others can be utilized without departing from the spirit or the scope of the present invention. No matter which of the precise forms of impellers and end walls are utilized, the pumping action is the same and dependable results attained. All of the forms of the present invention avoid the use of packing between relatively movable parts and the difficulties incident thereto, the pumping action of the impeller being motivated by manipulation of the obliquely cylindrical housing 13.

Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiments, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices and apparatus.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A centrifugal pump comprising a hollow housing having spaced opposite end walls and a flexible side wall interconnecting the end walls and therewith defining a pumping chamber, means mounting the end walls in predetermined spaced relation for revolutionary movement of one thereof relative to the other in a circular planetary path, and an impeller positioned between the end walls of the housing having an axis swivelly engaged with said end walls, the impeller and the opposite end walls of the housing having adjacent conjugate faces in rolling engagement along diametrically opposite radial lines of contact, and the housing having an intake port therein adjacent to the axis of the impeller and having an outlet port therein adjacent to the periphery of the impeller.

2. In a centrifugal pump, the combination of a substantially fluid tight housing having spaced end walls and a flexible side wall interconnecting the end walls, said housing having an inlet substantially centrally of an end wall thereof and an outlet laterally spaced therefrom; means carrying one of the end walls in a circular planetary path substantially concentric to the opposite end wall and in constant spaced relation to said opposite end wall; and a substantially circular impeller having a central portion of an axial thickness substantially equal to the spacing of the central portions of the end walls and radially thereof being of progressively relatively less thickness than the spacing of the corresponding radial portions of the end walls swivelly mounted in the opposite end walls whereby upon circular movement of one end wall relative to the opposite end wall the axis of the impeller is motivated in a conical path of nutation with diametrically opposite radial lines on opposite sides of the impeller in rolling engagement with their respectively adjacent end walls of the housing.

3. In a centrifugal pump, the combination of a substantially fluid tight housing having substantially circular spaced end walls concentric about substantially parallel axes and a flexible tubular side wall interconnecting the end walls, the housing having an inlet substantially centrally of an end wall thereof and an outlet radially spaced from the inlet; means motivating one of the end walls in a circular path concentric to the opposite end wall and in fixed spaced relation thereto, and a substantially circular impeller having an axis swivelly mounted concentrically in the end walls of the housing in equal angular relation to the axes of the end walls, the impeller and the end walls having adjacent conjugate faces in rolling engagement along diametrically opposite radial lines of contact, said conjugate faces being radially divergent at all positions other than along their radial lines of contact and being progressively of increased divergence circumferentially of the impeller on opposite sides of their line of contact to a position diametrically opposite to their line of contact where they are radially divergent at an angle substantially twice the angle between the axis of the impeller and the axes of the end walls.

4. In a pump of the character described, a housing having an unobstructed chamber defined by opposite substantially circular end walls and a flexible substantially cylindrical side wall interconnecting the end walls in substantially fluid tight relation, the housing having an inlet centrally of an end wall thereof and an outlet radially spaced therefrom, a substantially circular impeller mounted between the end walls of the housing having an axis swivelly engaged at opposite ends concentrically with the end walls of the housing, and means for non-rotatably revolving one of the end walls of the housing relative to the other end wall in a circular planetary path concentric to said other end wall whereby the impeller is progressively nutationally tilted in circumferential progression in the housing.

5. A centrifugal pump comprising a hollow obliquely cylindrical housing having substantially circular concentrically symmetrical end walls and a flexible side wall interconnecting the end walls, the housing having an inlet centrally of an end wall and an outlet radially spaced

therefrom, a substantially circular concentrically symmetrical impeller having axial portions on opposite sides thereof swivelly engaged concentrically with the end walls of the housing, the impeller and the end walls having adjacent conjugate faces, and means connected to the end walls of the housing motivating one of the end walls in a circular planetary path of revolutionary movement concentrically of the opposite end wall whereby the impeller is progressively tilted in a continuous direction of circumferential progression in the housing.

6. A centrifugal pump comprising a hollow obliquely cylindrical housing having spaced substantially circular opposite end walls and a substantially cylindrical flexible side wall interconnecting the peripheral portions of the end walls in substantially fluid tight relation, the housing having an inlet centrally of an end wall and an outlet radially spaced therefrom, a substantially circular impeller having ports therethrough positioned between the end walls of the housing having opposite sides axially engaged concentrically with the end walls for universal movement relative thereto, the impeller and the end walls having adjacent conjugate faces of complementary configuration symmetrical concentrically about their respective centers, which adjacent faces diverge radially of the impeller, and means connected to the end walls of the housing adapted to revolve one of the end walls in a circular path concentric to the other end wall of a diameter such that the impeller continuously bridges the space between the end walls and is continuously tipped in circumferential progression into opposite end wall engagement along lines radial of the conjugate faces.

7. A centrifugal pump comprising a hollow substantially fluid tight obliquely cylindrical housing having spaced apart opposite end walls peripherally interconnected by a flexible cylindrical side wall, said housing having an inlet centrally of an end wall thereof and an outlet spaced radially of the housing therefrom, a circular impeller positioned within the housing between the end walls having oppositely disposed central portions complementarily fitted to axial portions of the end walls for universal tipping movement relative thereto and providing ports centrally therethrough, the impeller and the end walls having adjacent conjugate faces of complementary configuration symmetrical about their respective centers divergently related radially of the housing, a frame rigidly mounting one of the end walls of the housing in fixed position, driving means mounted in the frame having a rotated drive shaft axially aligned concentrically of the rigidly mounted end wall of the housing, and eccentric bearing means mounted on the drive shaft mounting the end wall of the housing opposite to the rigidly mounted end wall eccentrically on said shaft a distance radially of the shaft such that the opposite faces of the impeller are engaged with the faces of their respectively adjacent end walls along diametrically related opposite radial lines.

8. A centrifugal pump comprising a pair of substantially circular end walls, a flexible substantially cylindrical sleeve peripherally interconnecting the end walls in spaced relation with the peripheral portions of the end walls in equally spaced relation, one of the end walls having an inlet centrally thereof and an outlet radially spaced from the inlet, a circular impeller having oppositely disposed axial portions engaged concentrically in the end walls for universal tipping movement relative to the end walls and having ports therethrough adjacent to said axial portions thereof, the impeller and the end walls having adjacent conjugate spaces of complementary configuration symmetrical about their respective centers, a frame rigidly mounting one of the end walls in fixed position, driving means mounted in the frame having a rotated drive shaft axially aligned concentrically of the rigidly mounted end wall, a shaft mounted eccentrically on the drive shaft and extended toward the rigidly mounted end wall in substantially parallel relation to the axis of the drive shaft,

and a bearing rotatably mounted on the eccentric shaft mounting the end wall opposite to the rigidly mounted end wall eccentrically on the shaft whereby said end wall is non-rotatably revolved concentrically of the rigid end wall and the impeller tipped in continuous circumferential progression in an orbit of nutation.

9. A centrifugal pump comprising a pair of flat circular end walls having sockets concentrically therein, one of the end walls having an inlet centrally thereof and an outlet radially spaced therefrom, a cylindrical flexible sleeve fitted to the peripheries of the end walls and interconnecting the end walls in parallel relation, means mounting opposite ends of the sleeve on the end walls in fluid tight relation thereon, a discoidal impeller having ports centrally therethrough positioned between the end walls having oppositely disposed conical surfaces of predetermined common conical angularity and axially disposed bosses concentrically thereof swivelly engaged in the sockets of the end walls, a frame rigidly mounting one of the end walls in fixed position, driving means mounted in the frame having a rotated drive shaft axially aligned concentrically of the rigidly mounted end wall, and means mounting the end wall opposite to the rigidly mounted end wall eccentrically on the shaft for free rotation of the shaft therein whereby said end wall is non-rotatably revolved in a circular orbit concentric to the shaft with the axis of the impeller in continuous angular relation to the aligned axis of the shaft substantially equal to the conical angularity of the surfaces of the impeller and a plane normal to the axis thereof.

10. A centrifugal pump comprising an obliquely cylindrical housing having a pair of end walls and a flexible substantially cylindrical sleeve interconnecting the end walls in spaced relation, the end walls having inwardly disposed conical surfaces of predetermined angularity relative to planes normal to their respective conical axes and each conical surface providing an inwardly disposed socket at its apex, a discoidal impeller having oppositely axially extended bosses swivelly mounted in the sockets of the inwardly disposed surfaces of the end walls, the impeller being of substantially the same diameter as the inwardly disposed conical surfaces of the end walls and of the same conical angularity on opposite sides thereof relative to planes normal to its axis as the conical angularity of the inwardly disposed surfaces of the end walls relative to planes normal to the axes thereof, and means mounting the end walls adapted to revolve one of the end walls relative to the other in a circular orbit in a plane normal to the axes of the conical surfaces of the end walls whereby the impeller is progressively tilted in circumferential progression in the housing in an orbit of nutation, the diameter of said orbit being such that the impeller continuously bridges the space between the inwardly disposed faces of the walls.

11. A centrifugal pump comprising means having an impeller chamber therein defined in part by spaced walls disposed in facing relation, an impeller enclosed in said chamber axially swivelly engaged at opposite sides thereof with the spaced walls, and means for imparting substantially circular planetary movement to one of said walls concentrically about the position of swivel engagement of the impeller with the opposite wall for imparting a movement of nutation to the impeller, the chamber means having an inlet port adjacent to the positions of swivel engagement of the impeller with the walls thereof and an outlet port spaced from said positions of swivel engagement.

12. A substantially fluid tight centrifugal pump comprising a closed housing having an impeller chamber therein defined by spaced facing end walls, each symmetrical about a predetermined center thereof, and a flexible side wall interconnecting the end walls in fluid tight engagement therewith; an impeller enclosed in said chamber axially swivelly connected at opposite sides thereof to the centers of the end walls; means connected

to an end wall of the housing for imparting planetary circular movement thereto concentrically about the center of the opposite end wall whereby the impeller has imparted thereto a motion of nutation; an intake conduit connected to the housing in fluid communication with the chamber adjacent to the center of an end wall thereof; and a discharge conduit connected to the housing in fluid communication with the chamber in spaced relation to the intake conduit radially of the impeller.

13. A substantially fluid tight centrifugal pump comprising a closed obliquely cylindrical housing having an impeller chamber therein defined by spaced facing end walls, each end wall being symmetrical about a predetermined center thereof, and a flexible tubular side wall interconnecting the end walls in fluid tight engagement therewith; a circular impeller enclosed in the chamber of the housing axially swivelly engaged at opposite sides thereof with the centers of the end walls; means mounting an end wall of the housing in fixed position; means connected to the end wall of the housing opposite to the

fixedly mounted end wall for imparting planetary circular movement thereto concentrically about the center of the fixedly mounted end wall, the impeller and the end walls having adjacent conjugate faces and the radius of the circular movement of the movable end wall being such that said conjugate faces are in rolling engagement along diametrically opposite radial lines of contact as the impeller is revolved in an orbit of nutation; an intake conduit connected to the housing in fluid communication with the chamber adjacent to the center of the fixedly mounted end wall; and a discharge conduit connected to the housing in fluid communication with the chamber in spaced relation radially of said fixedly mounted end wall from the intake conduit.

References Cited in the file of this patent

UNITED STATES PATENTS

2,033,577	Hunter	Mar. 10, 1936
2,107,090	Swennes	Feb. 1, 1938