Aug. 4, 1959 R. ROY, JR 2,897,761

NUTATING PROPELLER PUMP

Filed Dec. 30, 1955

Fig. 1.

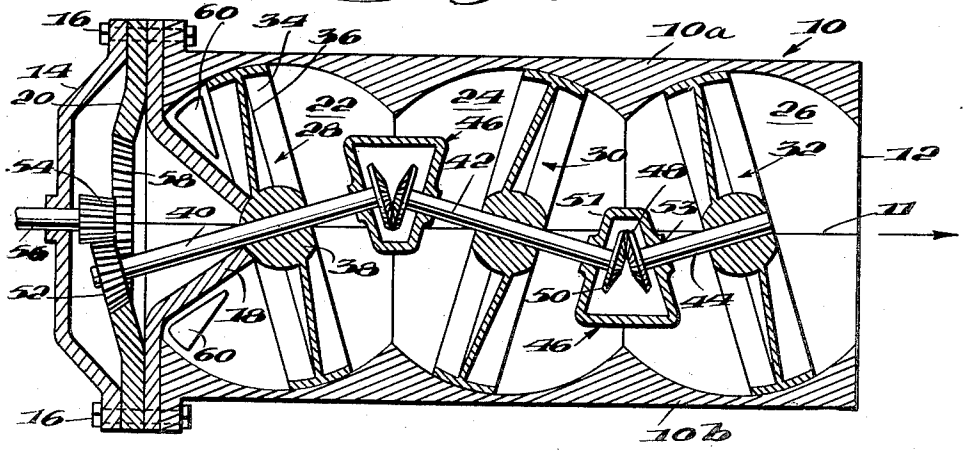


Fig. 2.

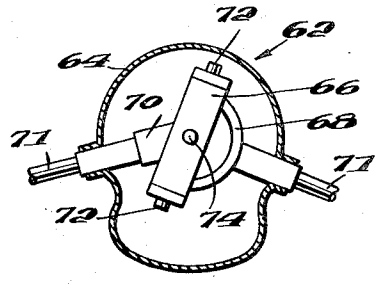


Fig. 3.

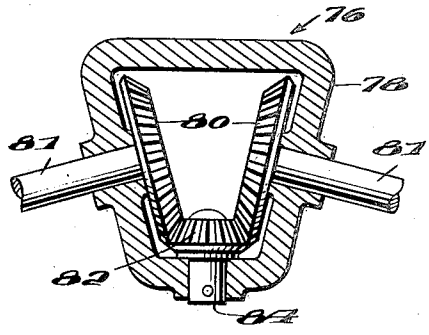


Fig. 5.

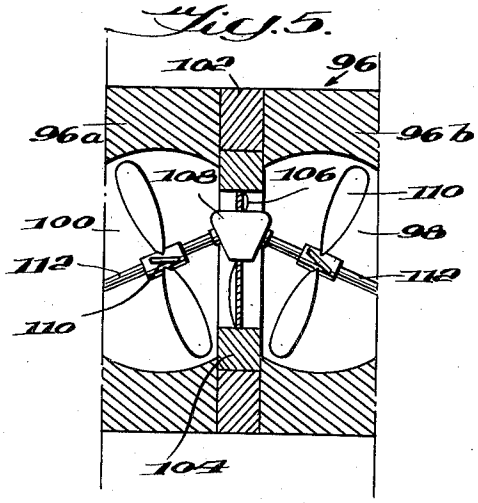
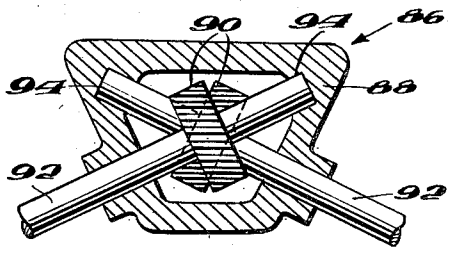


Fig. 4.



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United States Patent Office

2,897,761

Patented Aug. 4, 1959

2,897,761

NUTATING PROPELLER PUMP

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Application December 30, 1955, Serial No. 556,529

19 Claims. (Cl. 103—5)

This invention relates to fluid displacement devices and more particularly to fluid displacement pumps employing nutating propellers.

Typical nutating pumps of the prior art employ a nutating piston in the form of a disc which is fitted closely within a spherical chamber and which may be formed with a slot to receive a vane which reciprocates therein. Such pumps rely upon positive fluid displacement action, are limited to small inlet and outlet openings, and require critical fluid seals to ensure their proper operation. The present invention is directed to a pump which does not rely upon positive fluid displacement action and which, therefore, does not require complicated seal arrangements. The pump of the present invention is intended primarily for the displacement of non-compressible fluids, such as heavy drilling mud. Its operation is based upon the action of a propeller which nutates and rotates, and upon the cooperative action of a plurality of such propellers.

Accordingly, it is an object of the present invention to provide a novel fluid displacement device.

Another object of the invention is to provide a unique pump which does not rely upon positive fluid displacement for its pumping action.

A further object of the invention is to provide a fluid displacement device having a novel feeding and throwing action that aids in preventing settling out of suspended matter.

An additional object of the invention is to provide a pump having unique propeller means.

Still another object of the invention is to provide a unique system for operatively associating propeller means in groups.

A still further object of the invention is to provide a pump or fluid displacement device having a plurality of sections and in which the action of the individual sections may differ from other sections.

A further object of the invention is to provide a pump which does not require complicated seals.

Briefly, a fluid displacement device constructed in accordance with the teachings of the present invention may include a propeller mounted for nutation or wabbling motion in a chamber having an inlet side and an outlet side. The propeller may assume divergent forms and may be supported by contact of the extremities thereof with the enclosing chamber, or alternatively may receive its support from a shaft which in turn is peculiarly mounted in the chamber. According to the invention a fluid displacement device may be built up in units of similar construction, successive units being arranged so that they may be driven from preceding units. The propellers are preferably formed so that the fluid displacement results from nutation or wabbling in combination with axial rotation.

The foregoing and additional objects of the invention will become more apparent from the following detailed description of the invention in conjunction with the accompanying drawing wherein:

Figure 1 is a longitudinal section illustrating a fluid displacement device comprising plural propeller units arranged in sequence;

Figure 2 is an enlarged partly sectional view of an alternative means for coupling successive units operatively;

Figure 3 is an enlarged partly sectional view of a modified form of the coupling means illustrated in Figure 1 for use when it is desired that successive propeller units rotate oppositely;

Figure 4 is an enlarged partly sectional view of still another modification of the coupling means; and

Figure 5 is a truncated longitudinal section of an alternative form of the invention illustrating a different type of propeller and a different propeller mounting means.

Referring now to Figure 1, 10 designates generally the outer housing or casing of the fluid displacement device, which, in a preferred form may be constituted by a metal casting divided longitudinally as indicated by line 11 so as to form a pair of housing sections 10*a* and 10*b*. The housing portions may be joined through the use of bolts passing through suitable housing flanges (not shown) which may be provided in a manner well known. A suitable gasket, or other conventional joining means (not shown) is preferably clamped between the housing halves. Alternatively, in a multi-unit construction of the type illustrated, the housing for each adjacent pair of half units may be formed as a unitary body, and successive housings may be joined by flanges in the manner indicated previously. The particular manner of housing construction is not in itself a primary feature of the invention. Suffice it to say that the housing is formed in a conventional manner which will allow easy assembly of the housing and internal parts.

In the form shown, housing 10 has a discharge end 12 which is open or connected to a discharge conduit (not shown) and an inlet end which is covered by a cap 14. The cap and inlet end may be suitably flanged as indicated to receive a plurality of bolts 16 which secure the cap to the housing and at the same time hold in position a conical end member 18 and a circular ring gear member 20.

Housing 10 may be provided with a plurality of internal chambers 22, 24, 26 along the axis of the housing. The number of chambers is, of course, a matter of choice depending upon the desired use of the pump and it is in fact possible to employ chambers having different transverse dimensions. In the form shown the chambers are of generally spherical configuration with the ends of the chambers being truncated in planes perpendicular to the longitudinal axis of housing 10 so that the chambers may readily communicate with one another.

Each chamber may be provided with a propeller 28, 30, 32, respectively, which in the form illustrated in Figure 1, comprises a ring 34 having an outer contour which is slidably fitted to and complements the spherical surface of the enclosing chamber, and thus supports the propeller for motion in the chamber, and a helical vane 36 which joins the ring to a central hub 38. In practice, the parts of the propeller may be constituted by a single casting.

In the form shown in Figure 1, the helical vane comprises a single turn which progresses along the axis of rotation of the propeller. The outer extremity of the vane contacts the ring 28 throughout its length. The hub 38 of the first propeller may be smoothly spherical on one side of the propeller so as to slide in and complement a spherical seat formed by the inner edges of the conical end member 18.

Each propeller may be keyed or splined on and extend radially from a drive shaft 40, 42, 44, respectively, which is held at an angle to the axis of the associated chamber

as described below. Adjacent ends of the drive shafts are preferably operatively coupled by coupling units **46**. In the form illustrated in Figure 1, the coupling units comprise a pair of bevel gears **48**, **50** keyed or splined on the opposed ends of the drive shafts, respectively, and meshed in a housing **51** which is provided with suitable bores **53** to constitute journals for the drive shafts rotatively mounted therein. The coupling units may be filled with a suitable lubricant for the gears and may be formed in sections to allow the insertion of the gears and the removal thereof for repairs, if necessary. It will be noted that in the embodiment of Figure 1, the housing **51** of the coupling units **46** is actually supported by the drive shafts, rather than vice versa.

The last drive shaft, **44**, may be shorter than the preceding shafts, for there is no necessity for driving a succeeding unit, and the drive shaft extension is not required for the support of its propeller. In the form shown in Figure 1, the propellers are actually supported by the inner spherical housing surface which engages the complementary surface of the rings **34** of the propellers.

The first drive shaft, **40**, is provided with means for causing the first shaft and consequently the remaining shafts to rotate on their axes. In the form shown, this drive means comprises planetary gearing including a planet gear **52** keyed or splined on the end of shaft **40**, a sun gear **54** keyed or splined on the end of an exterior drive shaft **56**, which is journalled in cap **14**, and a ring or internal gear **58** formed on member **20**. The teeth of gears **52** and **58** are bevelled, as shown, so that planet gear **52** may ride around ring gear **58** with the drive shaft **40** at an angle. The orbital motion of planet gear **52** results from rotation of shaft **56** and gear **54**, which engages the planet gear. The space between the end cap **14** and the conical end member **18** may contain a suitable lubricant for the gear train, and suitable seals or gaskets may be provided between the members clamped by bolts **16** to prevent the escape of the lubricant.

The first chamber **22** may be provided with a plurality of annularly arranged inlet ports **60** adjacent the conical end member **18**. The arrangement of the ports is not critical, and the number, size, configuration, and location of the ports may be varied as will be apparent to those skilled in the art. The outlet port may be constituted by the open end **12** of the casing **10**.

In the embodiment of Figure 1 it will be observed that the angle of the drive shafts of the individual propellers with respect to the longitudinal axis of housing **10** is fixed prior to the assembly of the pump. The drive shafts cannot move longitudinally within the housing **10**, because the contact of the spherical surface of the chambers **22**, **24**, and **26** with the complementary spherical surface of the rings **34**, prevents such motion. The angle of inclination of the first drive shaft **40** is held constant by the planetary gearing unit, and the angle of inclination of the succeeding shafts is held constant by the coupling units **46**, the journals therein having a predetermined inclination. While the inclination of the drive shafts with respect to the longitudinal axis of the housing **10** is fixed once the unit is constructed, it will be apparent that any desired inclination may be chosen, and that successive units may have different inclinations. As indicated previously, the radial size of the individual propellers and their enclosing chambers may differ from unit to unit. Moreover, the construction of the individual propellers may differ, so that one propeller may have a single helical turn, while other propellers may have more than one helical turn. In fact, some of the propellers may not be helical at all, but may comprise individual paddle or turbine blades, for example.

In the operation of the apparatus illustrated in Figure 1, the drive shaft **56** may be rotated in a predetermined direction by a source of motive power (not shown). The resulting orbital motion of planet gear **52** causes drive shaft **40** and propeller **28** to rotate about the axis of drive shaft **40**. At the same time drive shaft **40** and propeller **28** are caused to nutate or wabble about a center located at the intersection of the longitudinal axis of housing **10** and the axis of drive shaft **40**. The drive shaft **40** will thereby describe a pair of cones having their apices opposed at this center of nutation and their longitudinal axes along the axis of housing **10**.

In its nutation, drive shaft **40** carries with it the coupling unit **46** which joins shafts **40** and **42**. This coupling unit thus describes a circle at the junction plane of chambers **22** and **24**, thereby causing drive shaft **42** and propeller **30** to nutate about a center located at the intersection of the longitudinal axis of housing **10** and the axis of drive shaft **42**. The rotation of drive shaft **40** about its axis is imparted to drive shaft **42** through the gears within the associated coupling unit **46**, and this causes propeller **30** to rotate about the axis of drive shaft **42** as well as to wabble or nutate. It will be apparent from the action just described that propeller **32** is caused to rotate and nutate in a similar manner through the cooperation of drive shafts **42** and **44** and the coupling unit **46** associated therewith. As few or as many propeller units as desired may be included in the driven chain.

The wabbling action of the propellers is transmitted to a fluid within housing **10** entering through inlet port **60**. This wabbling action together with the rotary motion imparted by the helical vanes **36** agitates or churns the fluid and urges it toward the outlet port at end **12** of the housing if the drive shaft **56** is rotated in the proper sense. It will be apparent that the violent churning action which can result through the operation of the pump of the present invention is particularly beneficial in the pumping of any fluid which may contain solid particles suspended therein. The action prevents the particles from settling out in the pumping mechanism and clogging the same.

Figure 2 illustrates a modification of the coupling unit of Figure 1, and in this embodiment the coupling unit generally designated **62** comprises a flexible boot or housing **64** enclosing a conventional universal joint, which may include a ring member **66**, and half ring members **68** and **70** fixed respectively, to drive shafts **71**. Member **68** may be rotatively coupled to member **66** by opposite bearings **72**, while member **70** may be rotatively coupled to ring member **66** by opposite bearings **74**. The axes of the respective pairs of bearings are orthogonally related to allow universal motion in a well known manner.

Figure 3 illustrates another modification of the coupling unit. In this embodiment coupling unit **76** includes a casing **78**, a pair of bevel gears **80** keyed or splined to the associated propeller drive shafts **81**, and an intermediate reversing or idler gear **82** which meshes with gears **80** and is keyed or splined on a stub shaft **84** journalled in housing **76** in the same manner as shafts **81**. In this embodiment the respective shafts **81** will rotate in opposite directions. These shafts may be provided with propellers of the type illustrated in Figure 1, but threaded in opposite directions.

In the embodiment of Figure 4 an alternative coupling unit **86** is illustrated. This unit comprises a housing **88** which encloses a pair of spur gears **90** having appropriately angulated teeth. These gears are mounted, respectively, on associated propeller drive shafts **92**. The ends of the drive shafts may pass through the gears and be journalled separately in the housing **88** as indicated at **94**. The gear train is designed in accordance with conventional practice so that rotation of either drive shaft about its axis will cause rotation of the remaining drive shaft in the opposite direction.

Figure 5 illustrates a modification of the invention in which a different type of propeller and a different type of propeller mounting means are employed. In this embodiment, housing **96** includes a pair of chambers **98** and **100** which are formed in housing portions **96***a* and **96***b*, respectively. Between the housing portions may be

clamped an annular journal block **102**. The journal block and the housing portions may be joined by bolts inserted in appropriate flanges (not shown) in a well known manner, and suitable gaskets may be provided between the respective parts. A ring **104** may be mounted for rotation within journal block **102** about the longitudinal axis of housing **96**. The ring may be held against longitudinal motion with respect to housing **96** by the end surfaces of housing portions **96***a* and **96***b*. It will be apparent that suitable ball or roller bearings may be provided between the surfaces of ring **104** and the associated stationary parts.

Ring **104** may form the rim of a wheel having spokes **106** and an eccentric hub formed by a coupling unit **108**. Coupling unit **108** may assume any of the forms illustrated in the previous figures or any other suitable conventional form. Spokes **106** may be flat or round or may assume a helical or paddle-shaped configuration.

The propellers in Figure 5 have been illustrated as constituted by a plurality of fan blades **110** which extend radially from a drive shaft **112**. These blades need not contact the inner surface of the associated chambers, for in this embodiment the propellers are supported by propeller shafts **112**, which in turn are supported at an angle to the axis of housing **96** by coupling unit **108**. Additional propeller units may be added in the same manner as Figure 1, and the first unit may be driven by a suitable planetary gearing unit as in that figure. It is also possible to combine units of the type illustrated in Figures 1 and 5 so that some of the propeller units are supported by the propellers themselves, while other units are supported by the propeller shafts, which in turn are supported by the coupling units.

The mechanical motion produced by the operation of the device of Figure 5 is substantially the same as that of Figure 1. If the left-hand drive shaft is caused to rotate and nutate as drive shaft **40** in Figure 1, the same motion will be imparted to the right-hand drive shaft and its propeller through coupling unit **108**. If this unit is the type illustrated in Figure 1, the shafts will rotate in the same sense. Nutation of the drive shafts will cause ring **104** to revolve in journal block **102**. The consequent rotation of spokes **106** will aid the fluid displacement.

The apparatus of the present invention is subject to numerous variations. For example, other drive means and other propeller mounting means may be employed. The speed of successive units may be made to differ, for example, by utilizing gear reduction units in place of the 1 to 1 coupling units illustrated. Moreover, in some instances it may be desirable to use merely a single propeller unit. The invention is not limited to a mud pump but may be employed for other purposes. While there have been described herein what are at present considered preferred embodiments of the invention, it will be obvious to those skilled in the art that other modifications and changes may be made therein without departing from the essence of the invention. It is, therefore, to be understood that the exemplary embodiments are illustrative and not restrictive of the invention, the scope of which is defined in the appended claims, and that all modifications that come within the meaning and range of equivalency of the claims are intended to be included therein.

I claim:

1. In a device of the type described, a housing having a longitudinal axis and a pair of communicating chambers arranged successively along said axis, a propeller in each of said chambers, a drive shaft for each propeller, the propellers extending radially from their respective drive shafts, said drive shafts extending into the respective chambers at an angle to said axis, and adjacent ends of said shafts being coupled rotatively, and means coupled to one of said shafts for rotating it about its axis and simultaneously nutating said shaft about a point in said chamber.

2. In a device of the type described, a chamber having an axis, a propeller, means supporting said propeller in said chamber with its axis tilted with respect to said chamber axis, and means coupled to said propeller for causing it to rotate on its axis and for causing its axis to nutate about a point in said chamber.

3. In the device of claim 2, said means supporting said propeller in said chamber comprising the outer extremity of said propeller and the chamber wall.

4. In the device of claim 3, said propeller extremity and said wall being spherical.

5. In the device of claim 2, said means supporting said propeller in said chamber comprising a drive shaft along the axis of said propeller and fixed to the latter, and means supporting at least one end of said shaft for orbital motion.

6. In a device of the type described, a housing having an axis and a pair of communicating chambers along said axis, a pair of propellers, means movably mounting one of said propellers in each of said chambers, respectively, each said propellers extending radially in its chamber, a drive shaft for each propeller fixed thereto centrally thereof, means coupling said shafts for axial rotation at a pair of adjacent ends thereof with the axes of said shafts intersecting at a fixed angle, and means coupled to one of said shafts for imparting nutation and axial rotation to it, whereby both said propellers are rotated and wabbled.

7. In the device of claim 6, at least one of said propellers comprising a helical vane.

8. In the device of claim 6, at least one of said propellers comprising a plurality of blades.

9. In the device of claim 6, said propeller mounting means comprising the extremities of said propellers and the walls of said chambers.

10. In the device of claim 6, said propeller mounting means comprising means supporting said coupling means rotatively.

11. In the device of claim 6, said coupling means comprising a casing having a pair of journals for receiving the coupled ends of said shafts, and gears in said casing respectively coupled to said shafts.

12. In the device of claim 6, said coupling means comprising a casing having a pair of journals for receiving the coupled ends of said shafts and a universal joint in said casing connecting said shafts.

13. In the device of claim 6, the last-mentioned means comprising a planetary gear train with a planet gear fixed to said one shaft.

14. In a device of the type described, a housing having a pair of shafts therein, the axes of said shafts intersecting at a predetermined angle, a propeller mounted on each shaft, mounting means for supporting said shafts for nutation in said housing and coupling means coupling said shafts for axial rotation.

15. In the device of claim 14, said mounting means comprising a ring journalled in said housing, said coupling means being supported eccentrically in said ring by another propeller.

16. In the device of claim 14, said coupling means comprising a gear train connecting said shafts for opposite rotation.

17. In a device of the type described, a housing having a spherical chamber therein, said chamber having an axis and an inlet and an outlet spaced along said axis, a shaft in said chamber at an angle to said axis, a propeller fixed on said shaft between said inlet and said outlet and extending radially therefrom, said propeller having a spherical extremity which slides on and complements the surface of said chamber, and drive means coupled to one end of said shaft for causing said shaft to rotate on its axis and nutate in said chamber.

18. In the device of claim 17, said housing having a second chamber therein, said second chamber having an

axis and an inlet and an outlet spaced along its axis, the inlet of the second chamber being connected to the outlet of the first chamber, a shaft in said second chamber at an angle to the second chamber axis, a propeller fixed on said second shaft and extending radially therefrom, the last-mentioned propeller having a spherical extremity which slides on and complements the surface of the second chamber, and means coupling a pair of adjacent ends of said shafts for axial rotation and nutation.

19. In the device of claim 18, each said propellers comprising a helical vane which progresses along the associated shaft.

References Cited in the file of this patent

UNITED STATES PATENTS

812,361	Pickles et al.	Feb. 13, 1906
1,073,386	Bassett	Sept. 16, 1913
1,378,118	Jacobsen et al.	May 17, 1921
2,015,826	Vincent	Oct. 1, 1935
2,083,070	Krueger	June 8, 1937
2,253,306	Probst	Aug. 19, 1941
2,273,718	Morgan	Feb. 17, 1942
2,305,505	Wagner	Dec. 15, 1942
2,654,322	Olsen	Oct. 6, 1953