

Sept. 1, 1964

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SCREW PUMP UNIT

3,146,723

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2 Sheets-Sheet 1

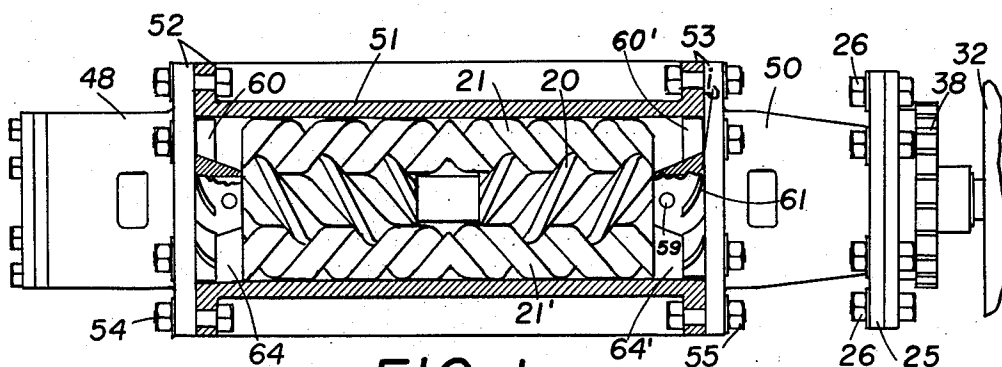


FIG. 1

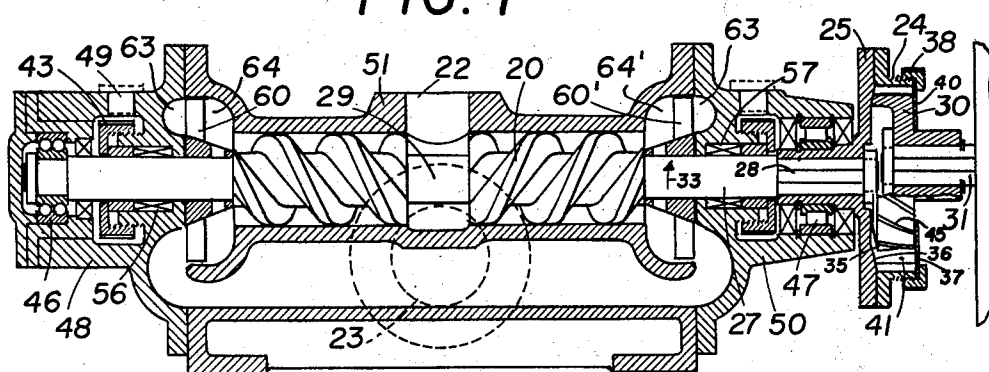


FIG. 2

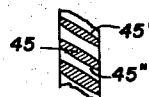


FIG. 2a

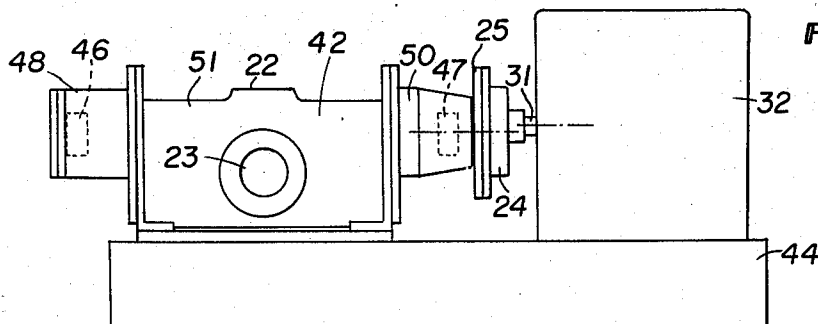


FIG. 3

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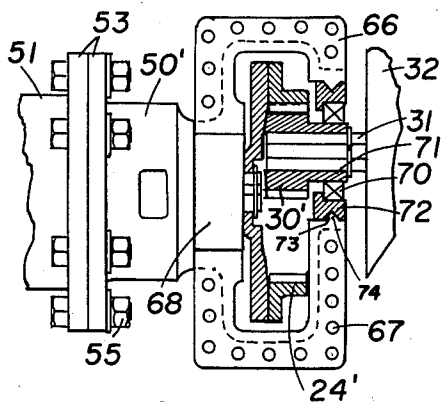


FIG. 6

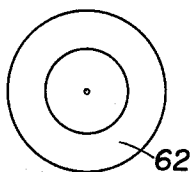


FIG. 5

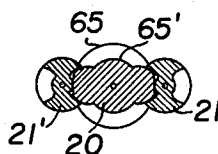


FIG. 4

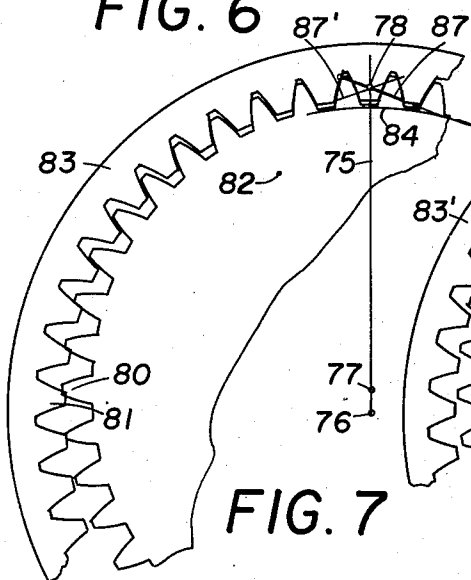


FIG. 7

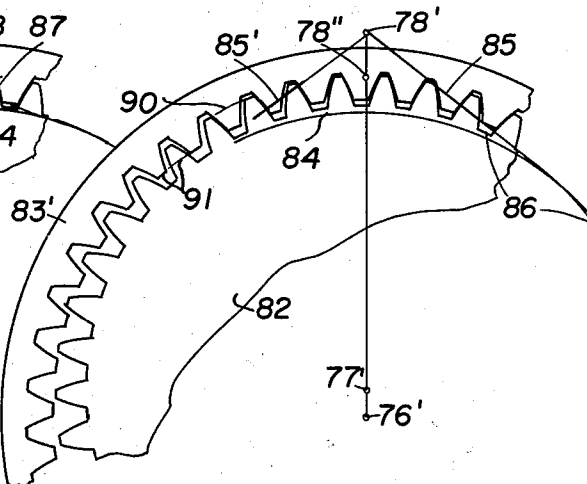


FIG. 8

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5 Claims. (Cl. 103—118)

The present invention relates to screw pumps comprising at least a pair of interengaging screws rotatable on parallel axes and adapted to displace fluid in the direction of said axes.

A line of screw pumps must include provision for displacing a great many different volumes per minute. This is ordinarily accomplished with a great many different screw diameters, that require a great many different cutters for producing them.

One object of the present invention is to save cost by using a comparatively small number of screw diameters and attaining the many required displacement volumes by running the pumps of each diameter at many different speeds. A further object is to provide pump units of given screw diameters and lead driven from a constant speed motor through gear pairs, and to avoid using flexible couplings by crowning at least one member of the gear pair.

A still other object is to provide a pump unit driven by a crowned external gear meshing with an internal gear; and a pump unit where the drive can be disconnected without displacing either the motor or the pump on their base.

A further aim is to provide a screw pump unit having a high-speed motor of low weight and moderate cost and a gear reduction with external and internal gear to attain a suitable pump speed, and to do so without adding to the number of bearings.

Another object is to devise a screw pump unit that can be run at relatively high speed without danger of cavitation, where the fluid has a larger axial intake velocity than attainable by suction, and where a propeller is added to the positive displacement screws to impart initial pressure on the fluid, to enable it to attain the high intake velocity at the screws.

Other objects will appear in the course of the specification and in the recital of the appended claims.

In the drawings:

FIG. 1 is a plan view of a screw pump unit constructed according to the present invention, the screw-carrying portion being shown in axial section, and the motor being indicated fragmentarily.

FIG. 2 is an axial section corresponding to FIG. 1 and taken at right angles thereto.

FIG. 2a is a fragmentary section of one member of the reduction gear pair shown in FIG. 2, illustrating crowning, the section being taken along a mean cylindrical surface laid through the teeth coaxial with said one member, and developed into a plane.

FIG. 3 is a diagrammatic side view of the screw pump unit of FIGS. 1 and 2, at a smaller scale.

FIG. 4 is a cross section of the interengaging screws shown in FIGS. 1 and 2.

FIG. 5 is a diagram showing the intake area of the propeller shown in FIGS. 1 and 2.

FIG. 6 is a fragmentary view and axial section showing a modified gear reduction in a unit otherwise corresponding to FIGS. 1 and 2.

FIG. 7 is a fragmentary end view of a gear pair with external and internal gear of small tooth number difference, illustrating a difficulty existing with the conventional design.

FIG. 8 is a similar end view of the gear pair modified in accordance with the invention to overcome said difficulty, so that it can be used in the present screw pump unit.

In the embodiments illustrated a central power screw

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20 engages a pair of screws 21, 21', all rotatable on parallel axes. To achieve thrust balance, each screw contains a right hand half and a left hand half. The shape of the screws themselves is known, and any known combination and screw number may be used. On rotation the screws may displace fluid from the outer ends towards the center, to be discharged through opening 22 (FIG. 2). The intake is through an opening 23 and thence to the ends of the screws.

In establishing a line of screw pumps it is important to provide only a small number of different screw diameters, and to have only one lead for a screw of given diameter. In this way only a small number of the expensive tools are required to produce the screw shapes, and a small number of stock parts. Also a small number of different machine set-ups are sufficient.

Yet it is mandatory to offer a great many delivery volumes per minute while preferably retaining a constant motor speed.

In accordance with the invention a motor of preferably high speed is provided, to save in weight and cost, and a number of different gear reductions are used with each pump diameter to provide the great number of delivery volumes.

The invention provides a gear reduction that has the double purpose of changing the speed and of giving flexibility of assembly. Such flexibility is now commonly attained with flexible couplings, that usually comprise external gear members with crowned teeth meshing with concentric internal gear members with straight teeth, the tooth numbers being the same on the external and internal members.

In accordance with the invention crowned teeth are provided on one member of the reduction gear pair, whereby the desired flexibility is achieved without a flexible coupling.

In the embodiment illustrated the reduction gear comprises an internal gear 24 removably secured to a flange member 25 by screws 26. Member 25 is rigidly secured to the shaft 27 of the pump screw 20, as by splines 28. Internal gear 24 meshes with an external pinion 30 rigidly secured to the motor shaft 31, that projects from motor 32 and that is journaled in bearings within the motor housing.

To displace fluid from the ends towards the center 29 of the screws, the drive of screw 20 should be in the direction of arrow 33 with the hand of thread shown. Pinion 30 preferably contains helical teeth 45 of a hand opposite to the hand of screw 20, so that when driving in the direction of arrow 33 it draws the gear 24 and flange member 25 towards the pinion.

On its left side face the pinion 30 has a slightly conical contact surface 35 adapted to contact a conical contact surface 36 provided on flange member 25. In operation the contact surfaces 35, 36 roll and somewhat slide on each other and completely balance the end thrust of the gear teeth.

A disk 37 is tightly secured to the right end face of gear 24 by a nut 38 threading onto the gear. It contacts the plane end face 40 of the pinion 30. Disk 37 may be thin and elastic and shaped to exert pressure on end face 40. It forms a lubricant pocket at the lower end 41 of internal gear 24. If desired further sealing means may be provided. With the described arrangement the pinion 40 is preferably placed vertically above the gear center.

It should be noted that the internal gear 24 is out in the open and is readily accessible. It can be detached from the flange member 25 by removing the screws 26, and without displacing either motor 32 or pump 43 on their common base 44, FIG. 3.

In mounting the motor 32 and pump 42 on base 44, the two have to be aligned with each other so that their

axes are as nearly parallel as readily feasible. Involute gears are known to be insensitive to changes in center distance. The gears are thus entirely insensitive to small horizontal or vertical displacements. Displacement in the plane of the axes changes the backlash, of which there is enough for small mounting displacements. Small displacements at right angles to said plane do not even affect the backlash.

One of the two members of the gear pair 24, 30 is provided with crowned teeth. Crowning is preferably applied to the pinion. The sides 45', 45'' of the teeth 45 (FIG. 2a) are longitudinally convex in development instead of being straight. This is known to enable them to mesh properly even if their axes are not exactly parallel.

Accordingly a crowned gear pair fulfills the double purpose of providing a gear reduction and of giving some flexibility as to parallelism. A flexible coupling is dispensed with as the invention also provides ready disconnection, and a saving in cost is made.

Shaft 27 of pump screw 20 is rotatably mounted in bearings 46, 47 held by parts 48, 50 rigidly secured to the central pump body 51 by flanges 52, 53 and screws 54, 55. The shaft passes through seals 56, 57 before reaching the bearings 46, 47, all seals being pointed out by diagonal lines. Each seal 56, 57 can be tightened by turning a nut 43, accessible from the outside through an opening 49.

Another aspect of the invention will now be described. In general the invention tends to use increased rotational speeds of the screws. The fluid then moves axially of the screws at a faster rate. As this speed exists already on the entering side of the screws it has to be provided by suction. There is however a definite known limit as to what suction can do.

The invention achieves increased velocities on the entering side of the screws by putting the fluid under some initial pressure. While the screw pump provides a positive fluid displacement, a non-positive bladed rotary part is used to act on the fluid before it enters the screws, so that the entering velocity is not caused by suction alone. The said part is in the nature of a propeller 60 or 60' (FIGS. 1 and 2) rigidly secured to shaft 27 as for instance by radial pins 59. There is one propeller for each end of the double screw 20. The two propellers 60, 60' are symmetrical to one another. They are alike except for hand.

Each contains twisted blades 61 of low angle of incidence i (FIG. 1), at least at the entering or intake side. Angle i at any radius within the sweep of the blades is smaller than, ordinarily less than one half of the lead angle at this radius that corresponds to the lead of screw 20 connected with the propeller. Also a comparatively large area 62 (FIG. 5) is swept at the entering side, so that the fluid can enter at a relatively slow velocity that can be safely attained by suction. Area 62 is larger than the total area of the thread spaces of said screws (21, 20, 21'). The thread spaces are the areas between the threads, bounded by the outside circles and root circles. These circles are indicated at 65, 65' for screw 20.

The blades 61 are shown curved for strength, but do not necessarily have to be curved. They may be made truly helical if desired.

The fluid is guided from the intake opening 23 towards the outer ends of screw 20 and to a ring-shaped guide channel 63 adjacent the respective propellers 60, 60', on the far side of screw 20. Thence it passes through the propellers 60, 60' to a space 64 or 64' immediately ahead of the screws, and to the screws 20, 21, 21' themselves. It moves axially along the screws to center 29 and to discharge opening 22.

In spite of the gear reduction provided no bearings are added. There are the bearings 46, 47 for rotatably mounting screw 20; and there are the bearings (not shown) within the motor housing for mounting the motor

rotor and motor shaft 31. This contributes to easy assembly and disassembly.

Larger Reduction Ratios

When the gearing provides a substantially larger reduction than shown in FIG. 2, it is preferably enclosed, as shown in FIG. 6. This embodiment uses the same central part 51 and end part 48, as described, and may use the same pump screws 20, 21, 21'. The driving pinion 30' is here however at a smaller proportion to the internal gear 24'.

A split housing 66 encloses the gear pair 24', 30'. It is preferably split on a horizontal level into a lower and an upper half. The two halves are highly secured together by screws passing through the holes 67.

The end part 50' of the screw pump is modified from the described part 50 on the outside to receive housing 66. The housing holds lubricant and is tightly around the cylindrical surface 68 of end part 50'. A seal diagrammatically indicated at 70 is provided at the hub 71 of pinion 30' and held by a ring 72. Ring 72 contains a peripheral V-shaped groove 73 that is matched by a projection 74 of housing 66, to tightly hold said ring. If desired the housing 66 may rest on the base 44 of the unit, preferably on a somewhat yielding plate secured to said base.

In this embodiment also no bearings have been added, and some mounting flexibility is attained by crowning the teeth of the pinion 30', so that the reduction gear of this unit also has the function of a flexible coupling.

Limitation of Internal Gear Drive

The internal gear drive is known to have a limitation when the tooth number of the pinion is only slightly smaller than that of the internal gear. FIG. 7 illustrates the difficulty with a conventional design of involute gears. Radial line 75 contains the gear center 76 and pinion center 77, and also the pitch point 78, or instantaneous center of relative motion. The pitch point can be considered the contact point of the pitch circles (not shown) that move with the gear and pinion and roll on each other without sliding.

Conventionally the pitch point 78 is placed either midway of the working depth of the teeth, as shown in FIG. 7 or closer to the tooth bottom of the pinion. In either case interference occurs with the shown tooth numbers of 45 and 42. Pinion tooth 80 interferes with gear tooth 81 and adjacent gear and pinion teeth interfere with each other so that the tooth numbers shown in FIG. 7 are not actually feasible with the conventional design.

FIG. 8 illustrates a way of avoiding interference in accordance with the invention while retaining the involute tooth form best suited for accurate manufacture and insensitive to changes in center distance. Pinion 82 is identical with pinion 82 of FIG. 7. The gear 83' has the same tooth number and the same base circle 84 as the gear 83 of FIG. 7. But the center distance 76'—76'' is slightly increased so that the pitch point is shifted to a position 78' shown with exaggeration. As well known the straight line of action 85 passes through the pitch point and is tangent to the base circles 84, 86 of the gear and pinion. Circle 86 happens to coincide with the root circle of the pinion by coincidence. 85, 85' are the lines of action for opposite tooth sides. They compare with lines of action 87, 87' in FIG. 7.

By shifting the pitch point, or instantaneous center of relative motion, towards the outside as compared with FIG. 7, tooth interference is eliminated. Pitch point 78' lies outside of the outside circle 90 of the pinion. Actually it does not take as much shift as shown, to clear. A pitch point in position 78'' is sufficient in many cases. In either case the outside circle 90 of the pinion is closer to the pitch point 78', 78'' than the inside circle 91 of the internal gear.

In this way it is possible to come close to a one to one ratio.

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It should be understood that the invention is capable of various further modifications and uses, and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains, and as may be applied to the essential features hereinbefore set forth, and as fall within the scope of the invention or the limits of the appended claims.

I claim:

1. A screw pump unit containing a base, a screw pump and motor rigidly mounted on said base, said pump comprising at least a pair of interengaging screws rotatable on parallel axes for displacing fluid axially of said screws from an inlet side to a discharge side, an internal gear removably secured to one of said screws, disconnectable means for connecting said internal gear with said one screw and permitting disconnection of said internal gear from said one screw without displacing said pump and motor on their base, said motor having a shaft parallel to the axes of said screws, a pinion rigidly secured to the shaft of said motor, said pinion meshing with said internal gear and forming a reduction pair of other than one to one and of less than two to one ratio therewith, the teeth of at least one member of said pair being crowned longitudinally to permit moderate misalignment between the directions of the axes of said one screw and of said pinion without a flexible coupling connection.

2. A screw pump unit according to claim 1, wherein said pinion has a tooth number at least three quarters of the tooth number of the internal gear, and wherein said internal gear is out in the open without enclosure, for direct access.

3. A screw pump unit according to claim 1, wherein said pinion has a tooth number larger than three quarters of the tooth number of the internal gear, wherein said gears contain involute teeth, and wherein internal tooth interference is avoided by placing the pitch point closer to the outside circle of the pinion than to the inside circle of the internal gear.

4. A screw pump unit according to claim 1, wherein the fluid inlet side is disposed adjacent said internal gear, wherein thrust surfaces are provided on said pinion and on a part rigid with said internal gear for engagement with each other, and wherein said pinion and internal gear contain helical teeth of a hand opposite to the hand of

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the adjacent portion of the pump screw to which said internal gear is connected, so that the driving pressure keeps said thrust surfaces in engagement.

5. A system of screw pump units using the same standard motor speed and comprising a limited number of sizes for delivering a volume per minute selected from a much larger number of choices than the number of sizes, said units comprising gear means with crowned teeth for transmitting power from the motor to the pump without need of a flexible coupling, said gear means comprising an internal gear and a mating externally toothed gear of less than two to one ratio, disconnectable means for connecting said gear means with said pump, and permitting disconnection of said gear means from said pump, the gear ratio of said gear means being selected to effect the desired delivery volume with said standard motor speed.

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