

[54] **DIAPHRAGM PUMP**

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[51] Int. Cl. ... **F04b 43/00, F04b 45/00, F15b 15/24**  
[58] Field of Search ..... **417/413, 470, 471; 92/13.8**

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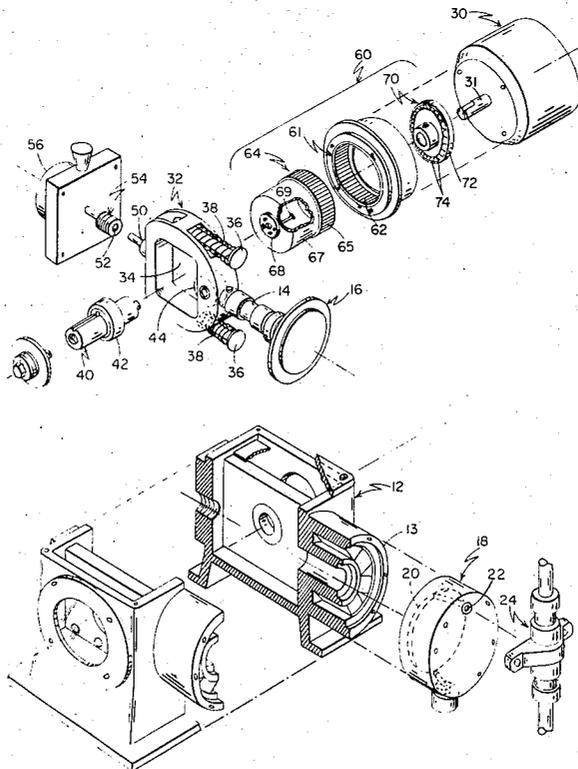
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Primary Examiner—William L. Freeh  
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[57] **ABSTRACT**

A diaphragm pump having a housing, an operating rod projecting within the housing and mounted therein for reciprocating translational movement, a rotatable camshaft mounted in the housing for reciprocating the operating rod, an electric motor for driving the camshaft and strain wave speed reducing gearing interposed between the motor and camshaft for rotating the camshaft at slow speed from the relatively high speed motor. Such gearing includes an external ring gear having internal teeth fixed to the housing, a deformable internal strain gear having external teeth in cooperative engagement with the ring gear, the strain gear being drivingly connected to the camshaft, and a strain inducer mounted internally of the strain gear in cooperative engagement therewith, the strain inducer being drivingly connected to the motor. The pump also includes a yoke fixed to the operating rod within the housing, cam and follower means interposed between the camshaft and yoke for driving the yoke in one direction, spring means interposed between the yoke and the housing for moving the yoke in an opposite direction and adjustable stop means for limiting movement of the yoke in the opposite direction to establish an adjustably predetermined stroke of the pump.

**1 Claim, 9 Drawing Figures**





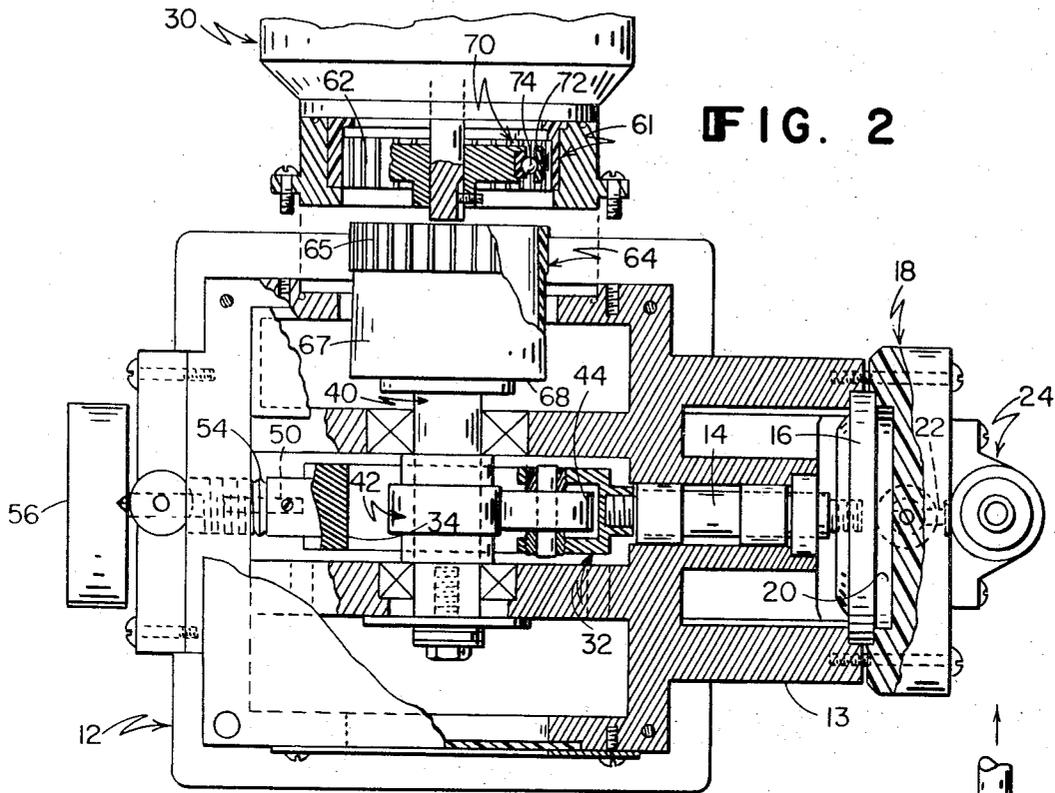


FIG. 2

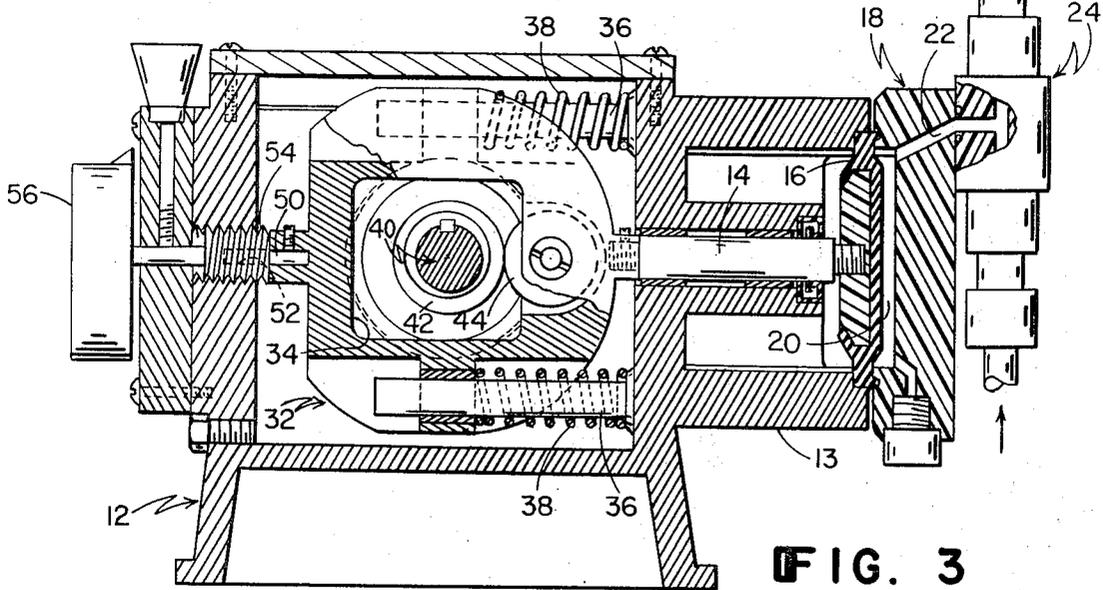


FIG. 3

FIG. 4

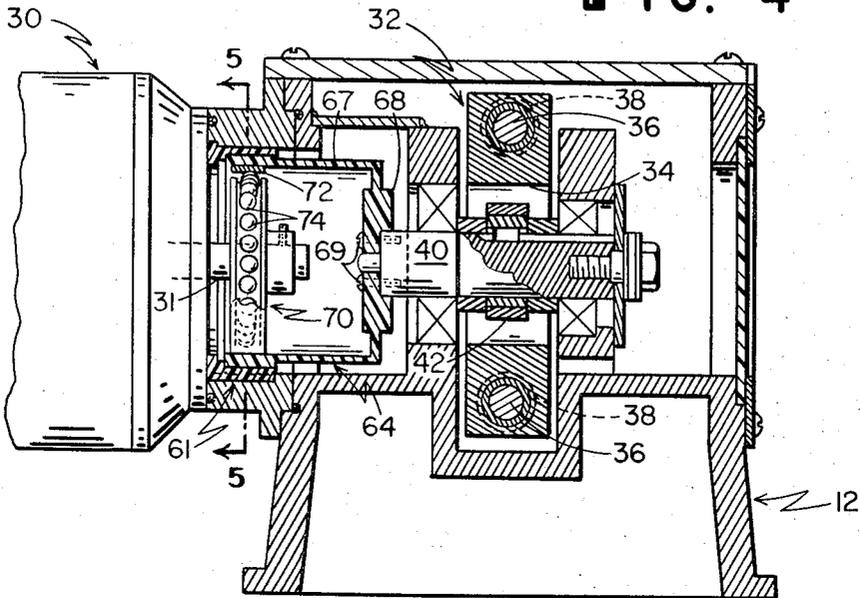


FIG. 6



FIG. 7

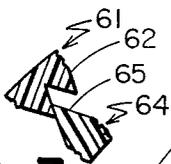


FIG. 8

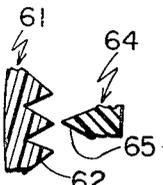


FIG. 9

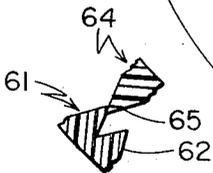
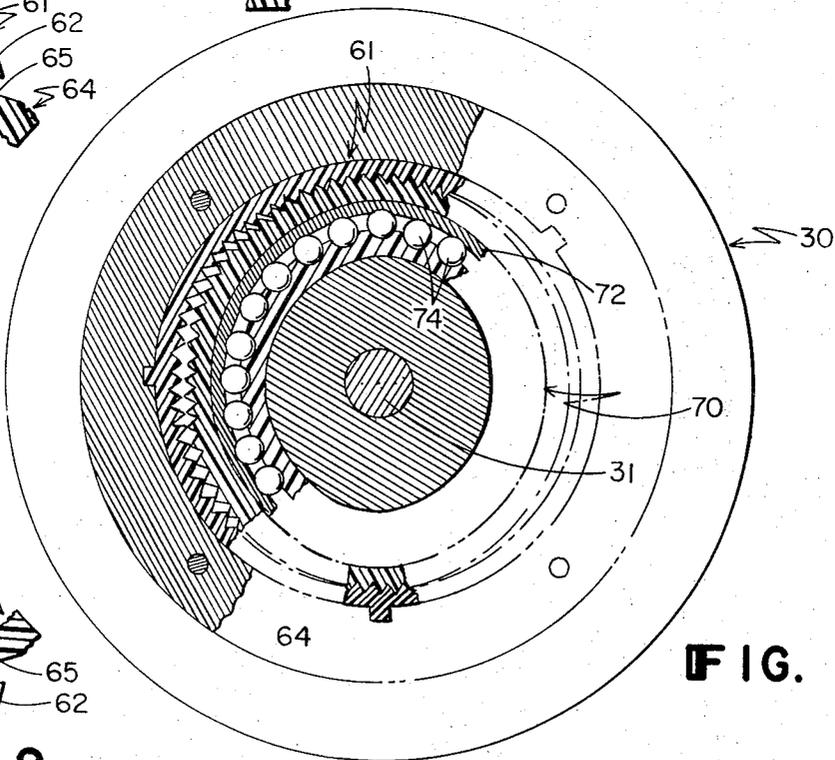


FIG. 5



## DIAPHRAGM PUMP

This invention relates to diaphragm pumps for chemical metering and the like and more particularly to a novel drive mechanism for such pumps.

It is a major object of the present invention to provide a much improved diaphragm pump having smaller and lighter operating mechanisms than those heretofore in use.

Accordingly, the present invention provides, in a diaphragm pump having a housing, an operating rod projecting within the housing and mounted therein for reciprocating translational movement, a rotatable camshaft mounted in the housing for reciprocating the operating rod and an electric motor for driving the camshaft, strain wave speed reducing gearing interposed between the motor and camshaft for rotating the camshaft at slow speed from the relatively high speed motor. Such gearing includes an external ring gear having internal teeth fixed to the housing, a deformable internal strain gear having external teeth in cooperative engagement with the ring gear, the strain gear being drivably connected to the camshaft, and a strain inducer mounted internally of the strain gear in cooperative engagement therewith, the strain inducer being drivably connected to the motor. The pump of the invention may also include a yoke fixed to the operating rod within the housing, said yoke having a central opening with its axis perpendicular to the operating rod with the camshaft extending through it, cam and follower means interposed between the camshaft and yoke for driving the yoke in one direction, spring means interposed between the yoke and the housing for moving the yoke in an opposite direction and adjustable stop means for limiting movement of the yoke in the opposite direction to establish an adjustably predetermined stroke of the pump.

For the purpose of more fully explaining still further objects and features of the invention, reference is now made to the following detailed description of a preferred embodiment thereof, together with the accompanying drawings, wherein:

FIG. 1 is an exploded isometric view, partly in section, of a diaphragm pump according to the invention;

FIGS. 2, 3 and 4 are, respectively, top, side and end sectional views of the pump of FIG. 1;

FIG. 5 is a cross-sectional view of a portion of the pump of FIGS. 1 through 4, taken on line 5-5 of FIG. 4; and

FIGS. 6 through 9 are cross-sectional detail views showing successive steps in the operation of the portion of FIG. 5.

In the drawings is shown a diaphragm pump of the type having a housing 12 with a diaphragm operating rod 14 projecting within said housing and mounted therein for reciprocating translational movement. On its outer free end, operating rod 14 carries a flexible diaphragm 16 which is the operating element of a diaphragm pump, such as is shown in U.S. Pat. No. 2,741,187, for example. Thus, housing 12 has a circular boss 13 on one of its outer walls to which is secured the outer margin of diaphragm 16 by clamping it between said boss and the rim of a cup shaped pump base member 18, forming an enclosed sealed pumping compartment 20 of which diaphragm 16 is a reciprocating wall. The pumping compartment 20 is connected through

passageway 22 to an arrangement of one way valves (not shown) in a valve housing 24 to accomplish the pumping function in a well-known manner.

According to the present invention, a novel drive mechanism is provided for reciprocating diaphragm operating rod 14 from a relatively high speed electric driving motor 30. In general, such mechanism includes a yoke 32, having a central opening 34, fixed to operating rod 14 within housing 12, a camshaft 40 mounted in said housing and extending through said yoke central opening, cam and follower means interposed between camshaft 40 and yoke 32 and strain wave speed reducing gearing, generally designated 60, interposed between motor 30 and camshaft 40 for rotating said camshaft at slow speed.

More specifically, yoke 32 is generally planar and is rigidly mounted on the end of operating rod 14 generally parallel to the axis thereof within housing 12. It is provided on the same side as operating rod 14 with upper and lower slide rods 36 slidably mounted therein, which rods bear against the wall of housing 12. Compression springs 38 are interposed between the remote ends of slide rods 36 in contact with housing 12 and yoke 32, normally to urge yoke 32 in a direction away from the wall of housing 12 upon which said rods bear. On its opposite side from operating rod 14, yoke 32 is provided with an adjustable stop mechanism for limiting movement of yoke 32 in the direction in which it is urged by springs 38. To this end, a stop mechanism slide rod 50 is centrally mounted on yoke 32, said rod being slidably received within a bore 52 on screw threaded adjusting member 54 which is threadably mounted in housing 12 and has its end within said housing adapted for contact with yoke 32. A knob 56 is provided on the end of member 54 outside of the housing for adjusting its axial position to establish an adjustably predetermined stroke of diaphragm operating rod 14.

For driving yoke 32 in the direction opposite to that in which it is urged by springs 38, camshaft 40 is rotatably mounted in housing 12 and extends through central opening 34 of said yoke in a direction perpendicular thereto and is provided thereat with an eccentric cam element 42 which contacts a circular cam follower 44 rotatably mounted on yoke 32 on the same side as operating rod 14 with its operating surface exposed within yoke central opening 34.

Camshaft 40 itself is driven at slow speed from motor 30 through strain wave speed reducing gearing 60, such gearing being disclosed in U.S. Pat. No. 2,906,143 for example. In the preferred embodiment of the diaphragm pump herein disclosed such gearing 60 has a ratio of 48:1 and includes an external ring gear 61 having axially extending internal teeth 62 fixed to housing 12, a deformable internal strain gear 64 having axially extending external teeth 65, at the same diametral pitch but of a slightly smaller pitch diameter, in number two less than those of ring gear 61, in cooperative engagement with the teeth 62 of ring gear 61 and a strain inducer mounted internally of strain gear 64 in cooperative engagement therewith. The difference in pitch diameter is caused by the fact that the number of teeth in this case on the strain gear is less than the number of teeth on the ring gear. The difference in the number of teeth between the two gears, or the tooth differential, is equal to or a multiple of the number of places at which the strain gear is deflected to cause tooth en-

gagement with the ring gear. This differential is desirably two, using a strain inducer having an elliptical contour with two lobes. The strain gear is made of a material which is elastic under the conditions of operation, and in the case of a steel strain gear, is made of relatively thin cross section so that it can be deflected easily in a radial direction. The strain inducer includes, mounted on the shaft 31 of motor 30, an elliptical strain inducer member 70 having on its outer surface a ball bearing race 72 carrying bearing balls 74 which rotatably support the deformable strain gear 64. The latter is drivingly connected to camshaft 40 by a cup-shaped driving element having a deformable cylindrical wall 67 and an end wall 68 to which an end of camshaft 40 is attached centrally thereof as by screws 69. The elliptical contour of strain inducer member 70 including bearing balls 74 has a major axis larger than the inside diameter of deformable internal strain gear 64 by an amount approximately equal to the difference in pitch diameter of the ring gear and the strain gear. The minor axis is smaller than the inside diameter of the strain gear by approximately the same amount. When the strain inducer is inserted into a position inside the strain gear, it causes the strain gear to be distorted into elliptical form, with the distance from the gear axis to the pitch line of the teeth at the major axis equal to the pitch diameter of the ring gear. At the major axis the pitch circles of the two gears are coincident. At the minor axis the distance of the pitch line of the strain gear teeth from the gear axis is less than the pitch diameter of the ring gear, and if a full tooth height is used, the teeth will just clear one another. At intermediate points, the teeth will have varying degrees of engagement. This condition prevails where the tooth differential is equal to the number of lobes on the strain inducer which in this case is two. FIGS. 5 through 9 are illustrative of the above.

In operation, motor shaft 31 rotates elliptical strain inducer 70 at a speed of 3450 r.p.m., which in turn drives strain gear 64 within fixed ring gear at a speed of 72 r.p.m. to rotate camshaft 40. The rotation of eccentric cam element 42 with camshaft 40 moves yoke 32 in opposition to springs 38 to provide the forward

stroke of operating rod 14 and its diaphragm 16. The return stroke is provided by springs 38 upon the further rotation of eccentric cam element 42, as adjusted by the rotative position of knob 56.

What is claimed is:

1. A diaphragm pump comprising
  - a housing
  - an operating rod projecting within said housing and mounted therein for reciprocating translational movement
  - a yoke fixed to said operating rod within said housing, said yoke having a central opening with its axis perpendicular to said operating rod
  - a camshaft mounted in said housing and extending through said yoke central opening
  - cam and follower means interposed between said camshaft and said yoke for driving said yoke in one direction
  - at least one spring loaded plunger mounted on said yoke for moving said yoke in an opposite direction between said yoke and said housing
  - adjustable stop means for limiting movement of said yoke in said opposite direction to establish an adjustably predetermined stroke of said operating rod

said adjustable stop means including screw threaded means threadably mounted in said housing and having an end within said housing for contacting said yoke

an electric motor for driving said camshaft, and strain wave speed reducing gearing interposed between said motor and said camshaft for rotating said camshaft at slow speed, including an external ring gear having internal teeth fixed to said housing

a deformable internal strain gear having external teeth in cooperative engagement with said ring gear, said strain gear being drivingly connected to said camshaft and

a strain inducer mounted internally of said strain gear in cooperative engagement therewith, said strain inducer being drivingly connected to said motor.

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