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[54] **UNITARY PUMP-MOTOR ASSEMBLY**

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[51] **Int. Cl.** **F04b 39/06**
[58] **Field of Search** ... 417/368, 369, 370, 371, 410, 417/366; 418/197, 203

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[57] **ABSTRACT**

A housing enclosing a motor and a pump having a common drive shaft. The pump is composed of helical driving and idler elements and the motor is cooled by a secondary flow of liquid forced through the motor by helical passages, or similar arrangements, to thereafter sweep the heat generating surfaces of the motor.

13 Claims, 4 Drawing Figures

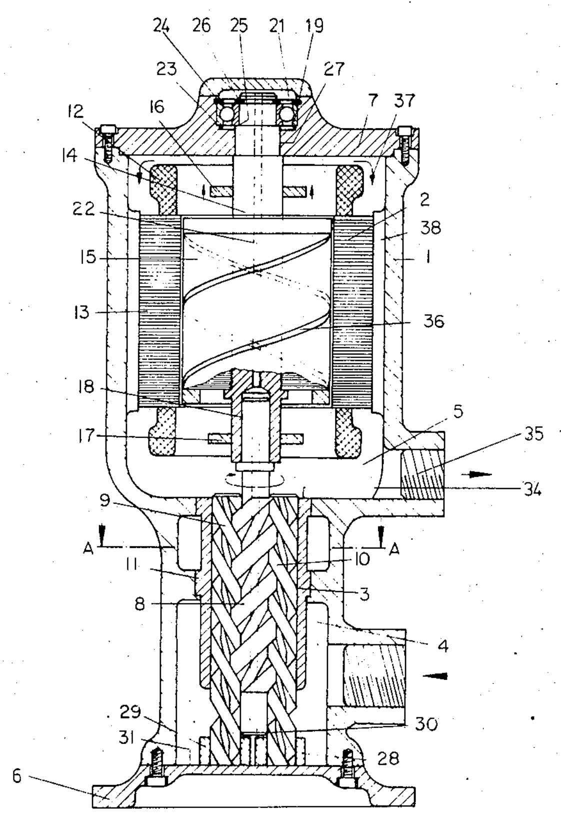

Fig. 1

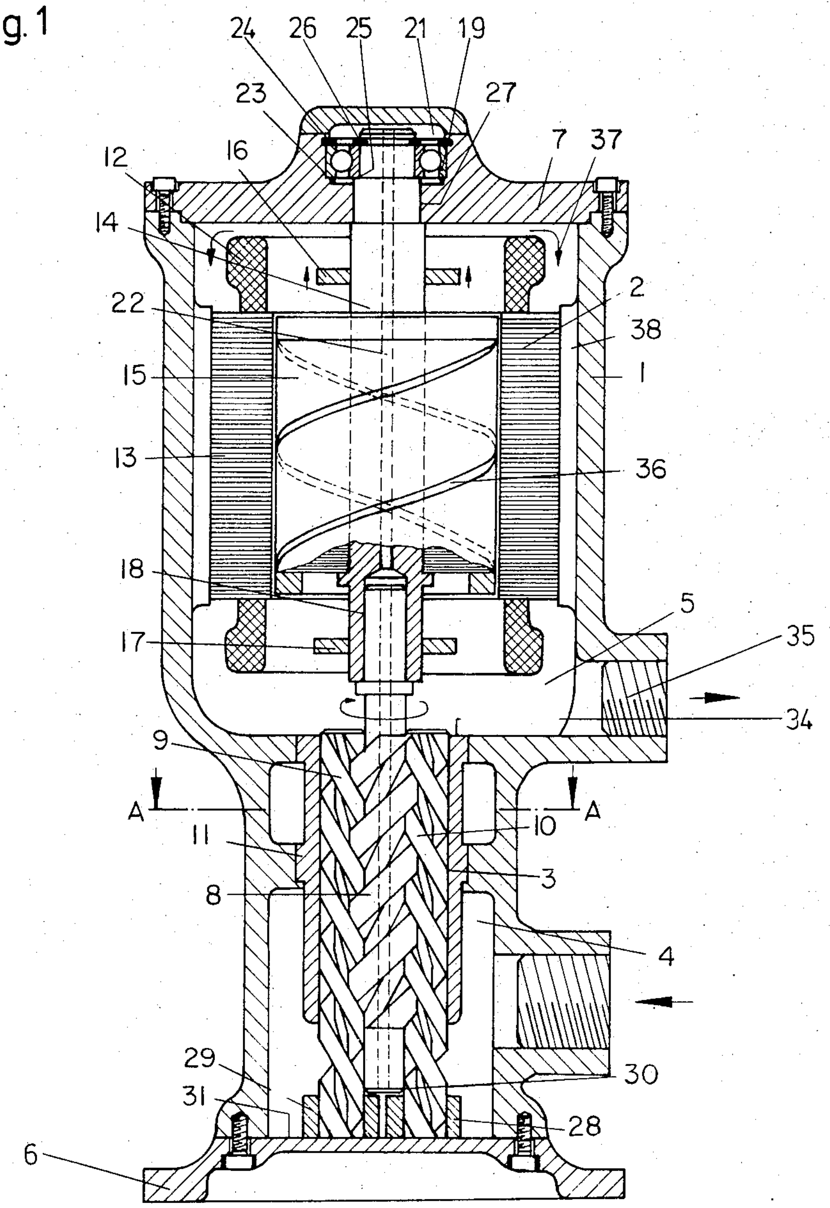

Fig. 2

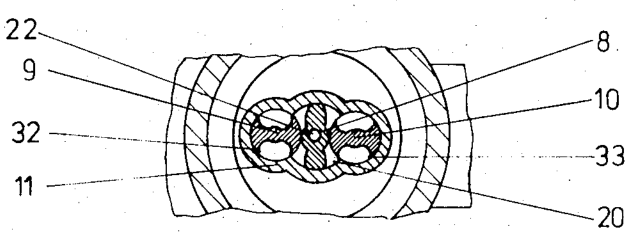

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Fig. 3

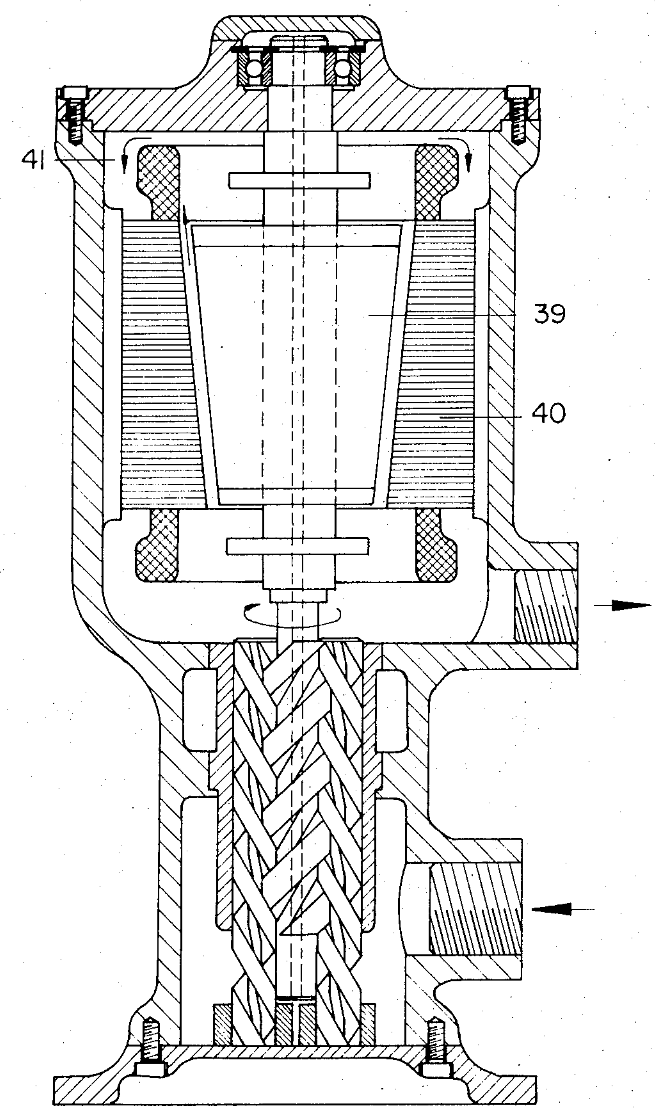

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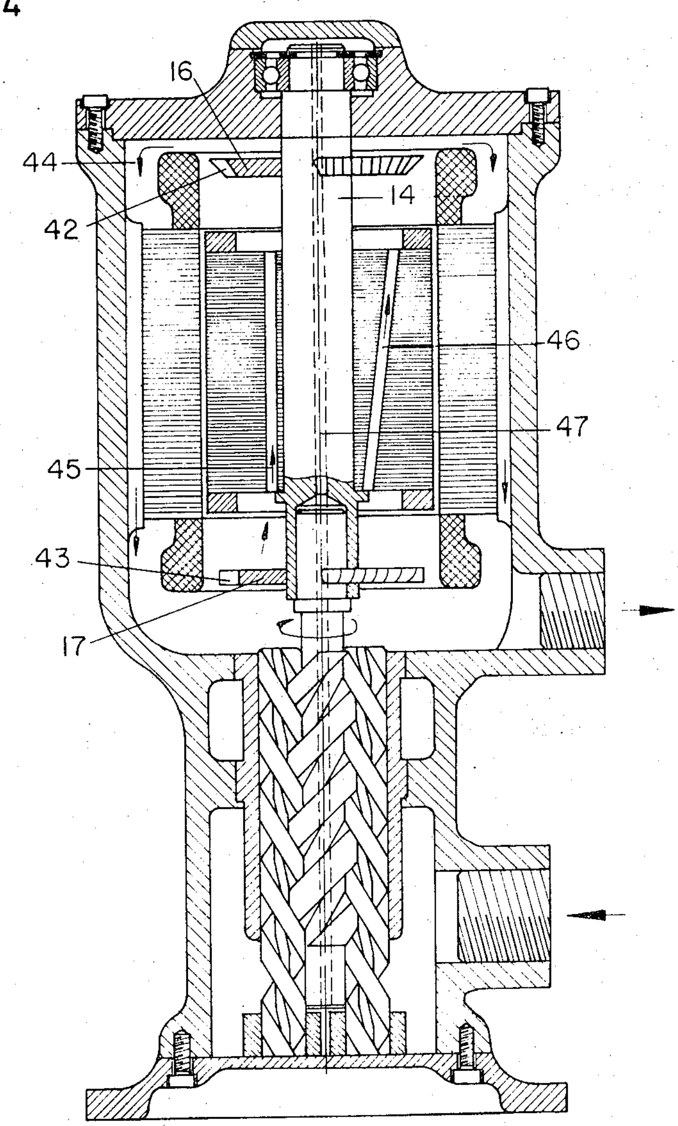
Fig. 4



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UNITARY PUMP-MOTOR ASSEMBLY

This invention relates generally to a seal-free pump and electric motor assembly, with the motor arranged in the suction or pressure chamber of the device and completely immersed in the fluid flow.

In conventional pumps of this kind, particularly those used in hydraulic installations or for delivering oil, the electric motor is arranged in the flow of the liquid fluid, with the total volume of liquid delivered by the pump being passed through the electric motor in order to dissipate the heat generated in the stator windings and in the rotor of the motor. This mode of construction has the disadvantage that the insulation on the stator windings is subject to heavy erosion. Moreover, it causes a considerable loss in pressure as the entire volume of liquid passes through the motor and, in order to intensify the cooling, the cross section of the fluid flow area must be kept relatively small, so that there are no areas that are not affected by the fluid flow.

In other known pumps of this type, the motor is located out of the direct path of the flow of liquid. The stator windings are cooled by means of a secondary flow obtained by providing a plurality of choke passages connecting the pressure chamber with the suction chamber. This secondary flow obtained by choking causes a reduction in the efficiency of the pump which is particularly significant when the output of the motor is high, as in this case a large secondary flow is required to dissipate the heat.

Pumps of the type provided with helical displacement elements can also have the motor separated from the pump. The pump and the motor are structurally adapted for each other and form technically a functional unit, although there is a structural separation between the pump and the motor. The pump is designed as an independent part, having a special pressure chamber connected to the motor by an aperture; and the helical shafts are mounted in the pump housing independent of the motor mounting and are provided with means for equalizing axial thrust. The motor shaft is secured to the pump shaft. The motor shaft is journalled in one pump bearing at one end and, at the other, is supported by a bearing arranged in the motor cover plate.

The disadvantage of this type of pump resides in that it is of highly complex construction; the arrangement of the pump and the motor in series makes it a relatively long unit; the separate mounting of the pump and the insertion of the motor shaft produces a statically indeterminate mounting which can be extremely noisy if the manufacturing tolerances turn out to be somewhat out of the ordinary.

It is therefore the primary object of the present invention to provide a motor-pump assembly in which the motor is adequately cooled, while the foregoing disadvantages of known pump units are eliminated.

An aspect of the present invention resides in a motor-pump assembly in which a secondary flow of liquid is caused to flow through the motor by an auxiliary fluid flow arrangement, with the fluid being taken from and returned to the pressure or the suection chamber of the pump.

This approach avoids the necessity of passing the whole flow through the motor; moreover, the flooding of the motor chamber with a choked flow, which causes such high energy losses, is eliminated.

The auxiliary arrangement is provided in such a manner that the secondary flow of liquid is just sufficient to dissipate the heat produced by the motor. The device requires little power, since it has to overcome only the internal resistance of the motor, which is much less than when the whole flow is passed through the motor.

In accordance with another aspect of the present invention, the auxiliary arrangement can be of one or more configurations.

In one such configuration, the arrangement consists of one or more helical grooves formed in the rotor or in the internal surface of the stator. An arrangement of this kind is particularly suitable when the liquids passing through the pump are of high viscosity. The helical grooves act as a simple helical pump producing a secondary flow through the motor according to the direction of rotation and the direction of the pitch.

In another configuration, the auxiliary fluid flow arrangement consists of at least one conduit arranged in the rotor, the distance between the conduit and the rotor increasing along the length of the rotor. In this case, the conduit acts as a sling wheel with the liquid emerging from that side of the rotor where the distance between the conduit and the axis is the greatest.

In still another modification, the auxiliary fluid arrangement consists of a rotor and stator, both of conical configuration. The fluid flow is produced by the liquid moving from the smaller to the larger diameter under centrifugal force. In order to improve the delivery action, one or more helical grooves may be arranged in the conical rotor of the conical stator.

However, the provision for the auxiliary fluid flow may also consist of axial or radial pump impellers fitted to the motor shaft. This is particularly suitable when the pump unit is used for low-viscosity liquids. Since large motors usually carry balancing discs on their shafts, the invention also provides for the impellers to be formed on these discs.

As still another aspect of the invention, there is provided for pumps using a helical displacement element, to arrange the pump and the motor in a common housing. The motor being located in the pressure chamber, and the drive and impeller shafts leading directly into the pressure chamber. The motor shaft and the drive shaft comprising a rigid shaft, one end of which is mounted in the drive-shaft bore in the pump housing and the other end in the motor cover plate.

This arrangement produces a simplified and economical construction, since the pump bearing at the motor end is eliminated. The design also has the advantage that the mounting is statically determinate, which results in a very smooth operation. The latter is particularly significant as these pump units are frequently used to operate hydraulic elevators in residential buildings. Additionally, the units can be made considerably shorter, as the absence of a bearing at the motor end does away with the need for a pump cover at the motor end.

Furthermore, when the bearing in the cover plate at the motor end is in the form of a fixed bearing arranged in an area separate from the pressure chamber and not under pressure, and when the passage of the shaft from the pressure chamber to the chamber not under pressure is such that the axial forces acting upon the shaft are equalized, the pump itself requires no means for equalizing the axial thrust or for locating the drive shaft.

In accordance with the invention, the cover plate at the motor end is a relatively simple part, so that the production costs can be minimized.

The pump itself is of a generally conventional construction with idler shafts mounted radially in the pump-housing and provided with collars on the suction side. The collars bear on the one hand against the suction-side housing cover and, on the other hand, against the suction-side end of the drive shaft. The idler shafts in the pressure chamber are approximately in line with the end-face of the pump housing. This eliminates the pressure-side mounting and axial location of the impeller shafts normally required in helical pumps, so that the electric motor may be brought closely adjacent to the pump. Moreover, the need for axial thrust equalization for the impeller shafts is obviated, since the shaft collars increase the bearing surface on the suction side, which absorbs the axial hydraulic thrust.

In view of the foregoing and in summary, it will be appreciated that it is the primary aspect of the present invention to provide an apparatus for pumping a fluid which comprises a housing provided with a pressure and a suction chamber and in which a fluid inlet in the housing has a passageway to the suction chamber. A fluid outlet is located in the housing with a passageway extending to the pressure chamber. A pump is located within the suction chamber of the housing for transferring the fluid from the inlet to the outlet. A motor is provided having a stator and rotor within the housing at a location essentially out of the path of the fluid passing from the fluid inlet to the fluid outlet. The pump and the motor are speced relative to each other and the outlet passageway is located, generally, therebetween. This is to say that the outlet passageway originates in the pressure chamber of the housing as compared to the pre-pumping area or suction chamber. Between the stator and between the motor of the housing there is provided a passageway for passing cooling fluids therethrough with the passageways encompassing most of the outside surfaces of the motor. Finally, the apparatus includes auxiliary flow producing means disposed within the pressure chamber to the axial end of the motor which is closest to the fluid outlet with the flow producing means being effective to force and divert a comparatively small portion of the fluid which has passed the pump and is within the pressure chamber into the cooling passageways and thereafter into the passageway of the outlet without returning the fluid to the pump or the suction chamber.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the drawings:

FIG. 1 is a longitudinal section through a pump-motor unit in accordance with the invention;

FIG. 2 is a cross sectional view through the pump-motor unit, shown in FIG. 1, taken along the line A—A thereof; and

FIGS. 3 and 4 show modifications of the pump-motor unit shown in FIG. 1.

Referring now to FIGS. 1 and 2, there is shown a housing **1** enclosing an electric motor **2** and a pump **3**. The housing **1** is formed as one unitary member and contains a suction chamber **4** and a pressure chamber **5**, and is closed on the suction end by a housing cover **6** and at the motor end by a cover **7**. The pump **3** comprises a helical drive shaft **8** and parallel arranged helical idler shafts **9,10**, in meshing engagement with shaft **8**. The shafts **8,9** and **10** are coaxially surrounded by a pump housing sleeve **11** fitted to the housing **1**.

The motor **2** comprises a stator **13** with windings **12** and a rotor **15** fitted to a motor shaft **14** extending centrally through housing **1**. Also arranged on the motor shaft, at opposite ends of the motor windings **12** are balancing discs **16,17**. The drive shaft **8** and the motor shaft **14** are formed into one rigid shaft by a shrink-fit connection **18**, one end of the shaft being journalled in a ball bearing **19** in cover **7** while the other end is mounted in opening **20** in pump housing sleeve **11** for drive shaft **8**. The ball bearing **19** is secured in a space **21** provided in cover **7**. This space is separated from the pressure chamber **5**, but is connected through a passage **22**, shown in dotted lines in the drawing and passes through motor shaft **14** and drive shaft **8**, to suction chamber **4** and is thus relieved of the fluid pressure from the pump unit. The ball bearing **19** is attached by a shoulder **23** and locking ring **24** to cover **7**, and by a shoulder **25** and locking ring **26** to motor shaft **14**, and is therefore a fixed bearing. An extension **27** of the shaft **14** from pressure chamber **5** to depressurized space **21** is dimensioned so that axial forces acting upon the shaft are equalized.

The pump idler shafts **9,10** are provided on the suction side with cylindrical shaft collars **28,29** which axially bear against inner face **31** of housing cover **6** and, at the opposite end face, provide a supporting surface for the suction end **30** of shaft **8**. This absorbs the axial hydraulic forces acting from pressure chamber **5** to suction chamber **4**, and the axial forces produced by the helical teeth and acting from suction chamber **4** to pressure chamber **5**. The shafts **9,10** are mounted radially in bores **32,33** in pump housing **11**, see FIG. **2**. In pressure chamber **5**, the end faces of the shafts are in approximate alignment with end-face **34** of pump housing **11**, and therefore take up no room in pressure chamber **5**. The latter has a fluid outlet opening **35** located between the motor and the pump. Thus the liquid flowing out of the pump does not pass through the motor.

For the purpose of cooling the motor, the rotor is provided with an auxiliary fluid flow arrangement comprising a plurality of helical grooves **36**, producing a secondary flow in the direction of arrows **37**. To enable the secondary current to flow around stator **13**, the said stator is held in housing **1** by means of narrow, axially extending, ribs **38**.

The pump housing **11** can be formed integral with housing **1**, and conversely the housing **1** can be composed of a plurality of individual parts.

The pump-motor assembly shown in FIG. **3** corresponds substantially to the device shown in FIG. **1**, except for a modified auxiliary fluid flow arrangement. A rotor **39** is of conical construction and is surrounded by a complementary conical stator **40**. Due to the variation in the peripheral velocities of the rotor, when the latter rotates, a secondary fluid flow is produced which flows around the motor as indicated by arrows **41**.

In the pump-motor assembly shown in FIG. **4**, which also is basically of the same construction as the assembly shown in FIG. **1**, two other arrangements of the auxiliary fluid flow are illustrated. In one embodiment, the approach comprises wheels **42,43** secured to motor shaft **14** by means of balancing discs **16,17.** The circumference of the wheels is provided with little buckets or propeller-like parts which in the case of wheel **43** causes the liquid to be conveyed axially from the pump side to the motor side, as indicated by the appropriate arrow **44.** The buckets of the wheel **42,** formed on the circumference of disc **16** are formed as radially extending straight ribs. The ribs cause the movement of the liquid to accelerate in a radial direction and thus is caused to flow around stator **2.**

In order to improve the flow through the motor, passages **45** are arranged in the rotor, but have no delivery function.

The pump wheels **42,43,** may be omitted if, as is shown in one half of the rotor, at least one duct **46** is provided in the rotor, the distance between the duct **46** and rotor axis **47** increasing along the length of the rotor, thereby producing a flow through the motor.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is aimed, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. Apparatus for pumping a fluid comprising:

a housing having a pressure and a suction chamber;

a fluid inlet in said housing having a passageway to said suction chamber;

a fluid outlet in said housing having a passageway to said pressure chamber;

a pump within the suction chamber of said housing for transferring the fluid from the fluid inlet to the fluid outlet;

a motor having a stator and rotor within said housing at a location essentially out of the path of the fluid passing from said inlet to said outlet;

said pump and motor being spaced relative to each other and the outlet passageway being located generally therebetween;

fluid cooling passageways between said stator and rotor and between the motor and the housing encompassing most of the outside surfaces of the motor;

auxiliary flow producing means disposed within said pressure chamber adjacent to the axial end of said motor closest to said fluid outlet, said auxiliary flow producing means being effective to force and divert a comparatively small portion of the fluid which has passed the pump and is within the pressure chamber into said cooling passageways and thereafter into the passageway of the outlet without returning the fluid to the suction chamber.

2. A pump-motor assembly according to claim **1,** wherein said motor comprises a rotor having at least one helical liquid flow passage extending along the axis of said rotor.

3. A pump-motor assembly according to claim **1,** wherein said motor comprises a stator having at least one helical liquid flow passage extending along the axis of said stator on the internal face thereof.

4. A pump-motor assembly according to claim **1,** wherein said motor includes a drive shaft and said fluid flow means comprises a radial or axial pump wheel arranged on said drive shaft.

5. A pump-motor assembly according to claim **4,** and a balancing disc interposed between said drive shaft and said pump wheel.

6. A pump-motor assembly according to claim **1,** wherein said fluid flow means comprises a longitudinally extending passage in said motor whose distance from the motor axis increases in one axial direction.

7. A pump-motor assembly according to claim **1,** wherein said motor comprises a rotor and a stator of conical configuration.

8. A pump-motor assembly according to claim **1,** wherein said pump comprises helical fluid displacement elements, and said motor is located in or proximate to said pressure chamber; and a common drive shaft for said pump and motor.

9. A pump-motor assembly according to claim **8,** wherein said displacement elements terminate into said pressure chamber; and part of said common drive shaft constitutes an integral part of one of said displacement elements.

10. A pump-motor assembly according to claim **9,** wherein said drive shaft is supported in the housing only at its axial ends.

11. A pump-motor assembly according to claim **10,** and a bearing for supporting said common drive shaft arranged spaced from said pressure chamber in a housing location effective to equalize the axial forces acting upon the motor shaft and the pump shaft portions.

12. A pump-motor assembly according to claim **11,** wherein said pump comprises idler elements and a drive element, and cylindrical collars on the axial ends of said idler element bearing against said housing and the opposite end thereof providing a supporting end surface for said drive element.

13. A pump-motor assembly according to claim **12,** wherein the axial ends of said idler elements terminate proximate to said pressure chamber.

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