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(54) **GEAR PUMP FOR PUMPING ABRASIVE WELL FLUID**

(75) Inventor: **Farral D. Gay**, Claremore, OK (US)

Correspondence Address:
James E. Bradley
P.O. Box 61389
Houston, TX 77208-1389 (US)

(73) Assignee: **Baker Hughes Incorporated**

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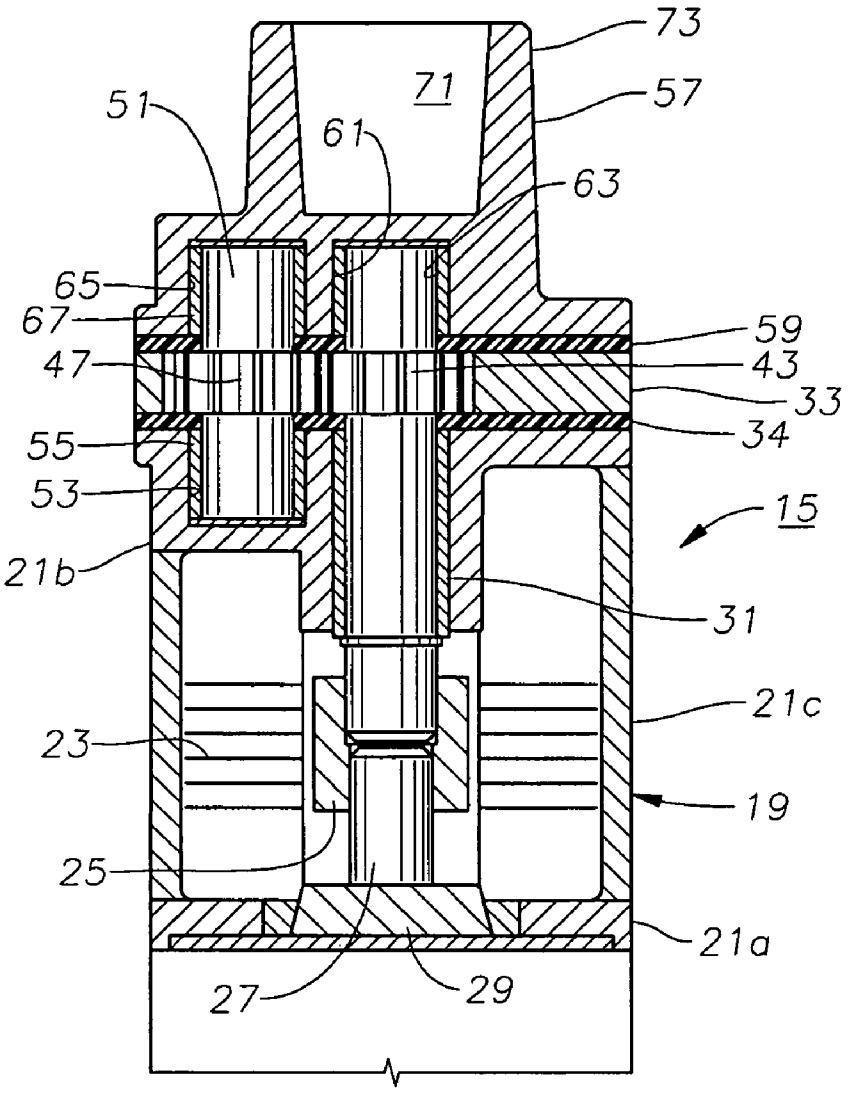
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(57) **ABSTRACT**

A gear pump is configured for pumping abrasive fluids from a well. The gear pump includes an electrical motor that is sealed within a motor housing and submersed with the pump. The gear pump has a drive shaft that rotates a drive member, which in turn rotates a driven gear. The gear pump has intake chamber leading to an intake side of the drive and driven gears and a discharge chamber extending from the discharge side. One of the gears has metal teeth while the other has elastomeric teeth.



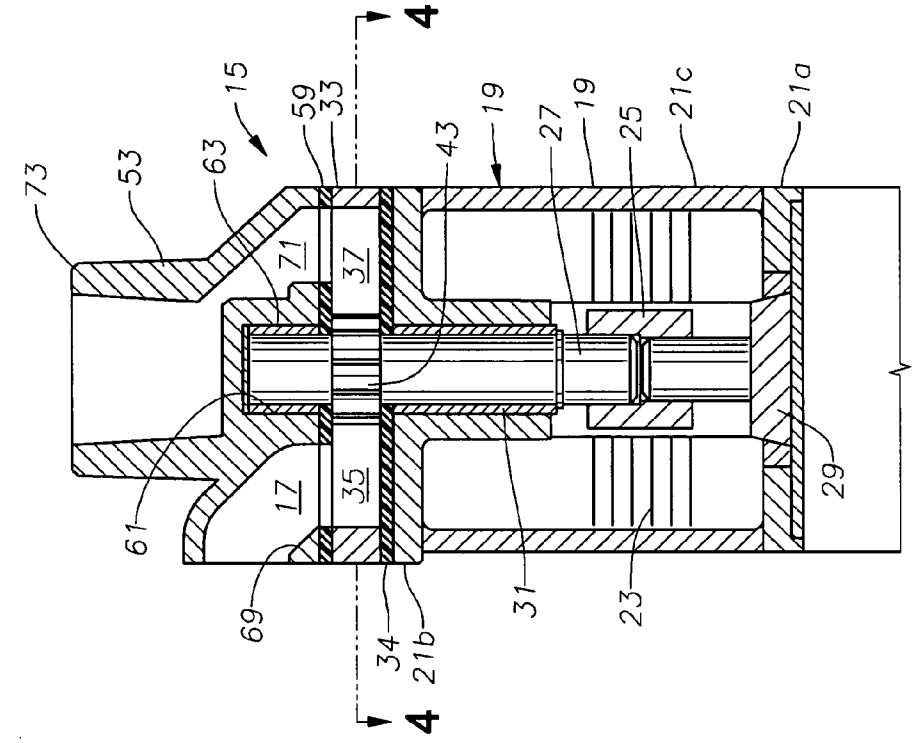

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21c
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21b
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23
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Fig. 2

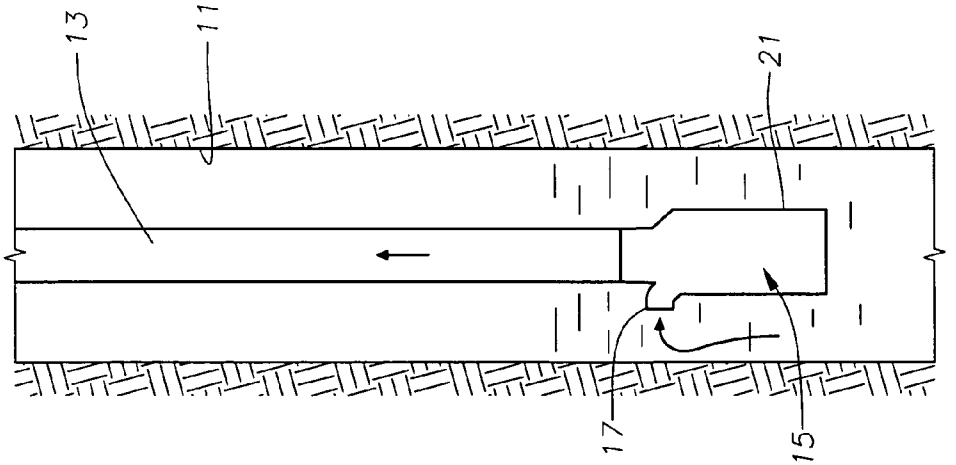

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11
21
17
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Fig. 1

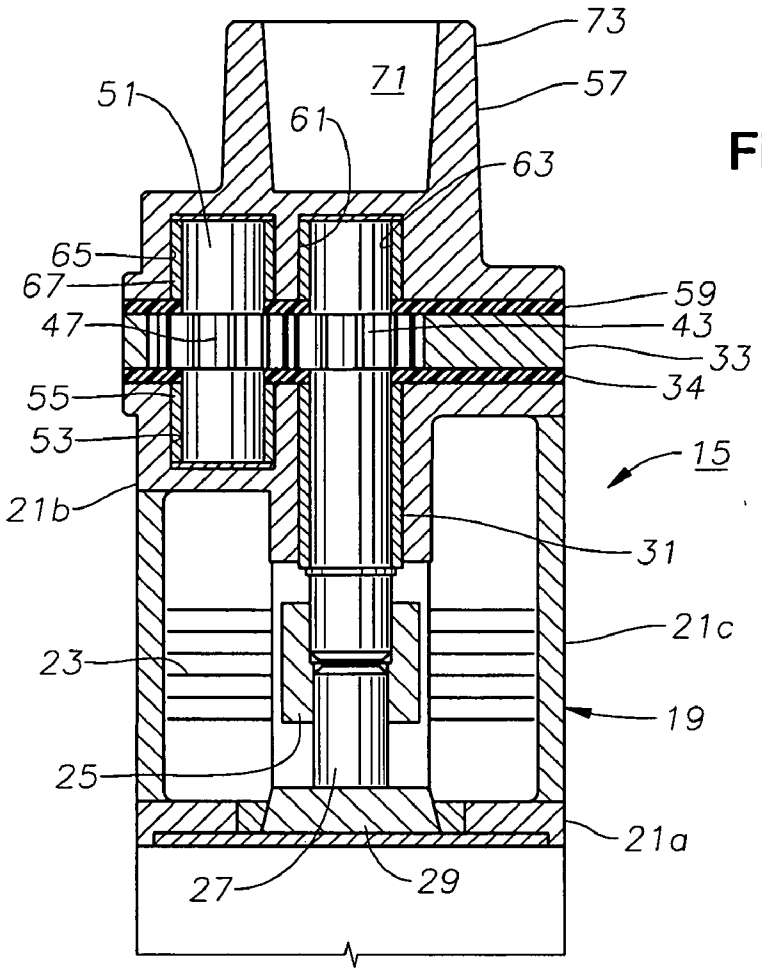

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21b
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21c
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21a
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Fig. 3

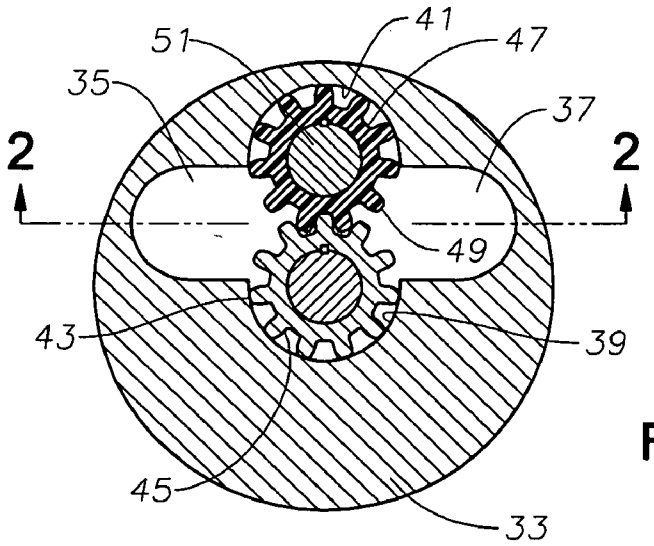

41
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2
49
43
39
45
33

Fig. 4

GEAR PUMP FOR PUMPING ABRASIVE WELL FLUID

FIELD OF THE INVENTION

[0001] This invention relates in general to well pumps, and in particular to a low volume positive displacement pump for pumping abrasive well fluid.

BACKGROUND OF THE INVENTION

[0002] Centrifugal pumps are commonly used in oil well production for producing large volumes of fluid. A centrifugal pump assembly comprises a downhole electrical motor, a pump made up of a plurality of stages, each stage having an impeller and diffuser, and a seal section located between the motor and pump. The seal section equalizes the pressure of lubricant within the motor with the hydrostatic pressure of well fluid on the exterior. If the well produces a significant amount of sand, to reduce wear, some of the thrust and radial bearings in the stages can be formed of a hard, wear resistant material, such as tungsten carbide.

[0003] Some wells require only fairly low flow rate pumps. For example, dewatering coal bed methane wells can be done with a small centrifugal pump but small centrifugal pumps are not particularly efficient. Also, if the well fluid contains abrasive particles, providing centrifugal well pumps with hard, wear-resistant components to resist the abrasive wear is expensive.

SUMMARY OF THE INVENTION

[0004] In this invention, a positive displacement pump is utilized for low volume wells having abrasive fluid. The positive displacement pump is preferably of a type having a driven member with lobes that intermesh with lobes of a drive member, such as a gear pump. An electric motor rotates the drive member, causing well fluid on an intake side to flow between the lobes of the drive and driven members to a discharge side. The intake leads to the exterior of the pump and is submersed in the well fluid. The discharge is connected to a conduit leading to the surface of the well.

[0005] To resist abrasive wear, one of the members has lobes or teeth formed of a hard, wear-resistant metal. The other member has lobes or teeth formed of an elastomeric material. The elastomeric material deflects when contacted by abrasives in the well fluid, reducing wear on the metal teeth. Preferably the drive and driven members comprise gear teeth.

[0006] In one embodiment, the drive and driven members are located within a cavity of a plate of a uniform thickness. The plate is sandwiched between a motor housing and a manifold housing. The thickness of the plate is the same as the thickness or axial dimension of each of the drive and driven members. The flow rate can be changed by increasing the dimension of the drive and driven members. The plate can be readily interchanged with a plate having a thickness to match the thickness of any drive and driven members selected. The motor and manifold are interchangeable with different thicknesses of plates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is schematic sectional view illustrating a gear pump constructed in accordance with this invention installed within a well.

[0008] FIG. **2** is an enlarged vertical sectional view of the gear pump of FIG. **1**, taken along the line **2-2** of FIG. **4**.

[0009] FIG. **3** is an enlarged vertical sectional view of the gear pump of FIG. **1**, taken along a vertical plane 90 degrees from the sectional plane of FIG. **2**.

[0010] FIG. **4** is a sectional view of the gear pump of FIG. **1**, taken along the line **4-4** of FIG. **2**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] Referring to FIG. **1**, a well having a casing **11** is illustrated. Well **11** is of a type that that requires pumping at a fairly low flow rate and may contain abrasive material within the well fluid. For example, well **11** may be a coal bed methane well that requires dewatering.

[0012] A string of conduit or tubing **13** is shown suspended within casing **11**. A positive displacement pump assembly, preferably a gear pump **15**, is suspended from the lower end of tubing **13**. Gear pump assembly **15** has an intake **17** submersed within the well fluid for pumping the well fluid up tubing **13** to the surface.

[0013] Referring to FIG. **2**, pump assembly **15** includes a submersible electrical motor **19**. Electrical motor **19** is located within a motor housing **21** that is sealed from the well fluid, and forms part of the housing assembly of pump assembly **15**. Motor housing **21** has a bottom **21** a, a top **21***b*, and a cylindrical sidewall **21***c*. Motor **19** may be of a variety of types but is preferably an AC motor with a stator **23** having a central opening for receiving a rotor **25**. Rotor **25** causes a drive shaft **27** to rotate when stator **23** is energized. Electrical power is supplied to motor **19** by a power cable (not shown) that extends downward from the surface. Drive shaft **27** is supported by a lower bearing **29** on motor housing bottom **21***a* and a radial bushing within a depending tubular portion of top **21***b*. In this embodiment, drive shaft **27** is located on the axis of motor housing **21**.

[0014] The housing assembly for pump assembly **15** also includes a pump base plate **33**, which is mounted on motor housing top **21***b*. Pump base plate **33** is preferably a solid, metal plate such as stainless steel, that has been hardened and is resistant to wear where exposed to the abrasive fluid well. Plate **33** has a flat lower side and a flat upper side, the sides being parallel to each other to define a uniform thickness for plate **33**. Plate **33** is separated from housing top **21***b* in this embodiment by a gasket **34** to prevent leakage.

[0015] As shown clearly in FIG. **4**, plate **33** has a closed cavity formed within it, the cavity having an intake portion **35**, a discharge portion **37**, a drive gear portion **39** and a driven gear portion **41**. Portions **35**, **37**, **39** and **41** join each other to form general cross shape with rounded ends. In this embodiment, intake cavity portion **35** and discharge cavity portion **37** are semi-circular. Similarly, drive gear cavity portion **39** and driven gear cavity portion **41** are semi-circular.

[0016] A drive gear **43** is rotatably mounted within drive gear cavity **39**. Drive gear **43** is a gear member that has a plurality of lobes or teeth **45** spaced around its circumference. Drive gear **43** is preferably formed of a hard wear-resistant metal, such as stainless steel. Drive gear **43** is rigidly secured to drive shaft **27** by a key for rotation therewith.

[0017] A driven gear **47** is located adjacent drive gear **43**. Driven gear **47** also has a plurality of lobes or teeth **49** spaced around its periphery. Teeth **45** intermesh with teeth **49** so that rotation of drive gear **43** causes driven gear **47** to rotate. Driven gear **47** is rigidly mounted to a driven shaft **51** that is free to rotate. As shown in FIG. **3**, driven shaft **51** has a lower end that rotatably fits within a receptacle **53** containing a bushing **55**. Bushing **55** seals drive shaft **27** and bushing **31** seals driven shaft **51**, preventing leakage of well fluid into motor housing **21**. Driven shaft **51** is parallel to drive shaft **21**.

[0018] In this embodiment, drive and driven gears **43**, **47** are identical in size, but driven gear **47** is formed of a resilient elastomeric material. Alternately, driven gear **47** could be formed of a hard, wear resistant metal and drive gear **43** formed of an elastomeric material. Moreover, both drive gear **43** and driven gear **47** could be formed of the same material, either elastomer or metal, particularly if the well fluid is not very abrasive.

[0019] Referring to FIGS. **2** and **3**, the housing assembly for pump assembly **15** also includes a manifold housing **57**, which fits on top of pump base plate **33** and is separated by a sealing gasket **59**. Manifold housing **57** has a drive shaft receptacle **61** that receives the upper end of drive shaft **27**. A bushing **63** is located within receptacle **61** to serve as a radial support bearing. Manifold housing **57** also has a driven shaft receptacle **65** that is adjacent and parallel to drive shaft receptacle **61**. Driven shaft receptacle **65** has a bushing **67** for rotatably receiving the upper end of driven shaft **51**. Bolts (not shown) extend from manifold housing **57** through base plate **33** and into threaded receptacles in motor housing **21**, clamping base plate **33** between manifold housing **57** and motor housing **21**.

[0020] As shown in FIG. **2**, manifold housing **57** has an intake port **69** that leads from the exterior of manifold housing **57** downward and inward into registry with intake cavity portion **35** (FIG. **4**). Manifold housing **57** has a discharge port **71** that leads outward and is in registry with discharge cavity portion **37** (FIG. **4**). Discharge port **71** preferably leads through an upper end **73** that contains threads or structure for securing pump assembly **15** to the lower end of tubing **13**.

[0021] In operation, electrical power is supplied to motor **19**, which causes shaft **27** to rotate drive gear **43** (FIG. **4**). Drive gear **43** rotates driven gear **47**, and the intermeshing engagement of gears **43**, **47** draws well fluid through intake port **69** into intake cavity **35** (FIG. **4**). The rotating engagement of gears **43**, **47** forces the well fluid into discharge cavity **37**, and from there through discharge port **71** up tubing **13**. Abrasive particles in the well fluid may temporarily embed in the resilient elastomeric driven gear **47**, thereby enabling the particles to pass through the pump without damage to either gear **43** or **47**.

[0022] The flow rate is a function of the axial dimension of drive and driven gears **43**, **47**. The flow rate increases as the axial dimension or thickness of gears **43**, **47** increases. In addition to making gears **43**, **47** with different thicknesses, stacking multiple drive gears **43** upon each other, and multiple driven gears **47** upon each other is another manner in which the thickness can be increased. Electrical motor **19** would have the capacity to accommodate gears **43**, **47** of various thickness. Also, motors of smaller and larger capacity could readily bolt to pump base plate **33**. Manifold housing **57** would be operable for a wide variety of flow rates. Pump base plate **33** should have a thickness that matches the thickness of drive and driven gears **43**, **47**, thus it would differ depending upon the flow rate of the pump.

[0023] Motor housing **21**, base plate **33** and manifold housing **57** are modular components fastened together by bolts. The modularity allows the manufacturer or a distributor to easily provide pump assemblies with different flow rates using the same motor **19** and manifold housing **57**, but different gears **43**, **47** and base plates **33**.

[0024] The invention has significant advantages. The downhole gear pump has a higher efficiency than a small centrifugal pump for low volume production. Using an elastomeric gear running against a hard metal gear reduces wear caused by abrasive particles in the well fluid. Expensive hardened components are not required for abrasive well fluids. The pump is modular and has components that can be readily interchanged to vary the capacity of the pump.

[0025] While the invention has been shown in only one of its forms, it should be apparent to those skilled in the art that it is not so limited but susceptible to various changes without departing from the scope of the invention.

1. A well pump apparatus for pumping abrasive fluids from a well, comprising:

a housing assembly for submersion in well fluid in a well;

an electric motor sealed within the housing assembly against the well fluid;

a drive shaft rotated by the motor and located within the housing assembly;

a drive member located within the housing assembly and operatively coupled to the drive shaft for rotation therewith, the drive member having a plurality of lobes spaced around an axis of the drive shaft;

a driven member rotatably mounted in the housing assembly next to the drive member, the driven member having a plurality of lobes that intermesh with the lobes of the drive member;

an intake chamber in the housing assembly leading from an exterior of the housing assembly to an intake side of the drive and driven members for flowing well fluid into contact with the drive and driven members;

a discharge chamber in the housing assembly extending from a discharge side of the drive and driven members to the exterior of the housing assembly for discharging the well fluid passing through the drive and driven members while rotating; and

the lobes of one of the members having metal surfaces, and the lobes of the other member having elastomeric surfaces to reduce wear due to abrasive particles in the well fluid passing through the drive and driven members;.

2. The apparatus according to claim 1, wherein the member having the lobes with elastomeric surfaces comprises an elastomeric sleeve mounted on a metal core.

3. The apparatus according to claim 1, wherein the lobes of the drive and driven members comprise gear teeth.

4. The apparatus according to claim 1, wherein each of the drive and driven members has an axial dimension that is the same, and wherein the housing assembly further comprises:

a base plate having a thickness that is the same as the axial dimension of the drive and driven members, the plate having cavities formed therein for defining the intake and discharge chambers.

5. The apparatus according to claim 1, wherein the housing assembly comprises:

a motor housing enclosing the motor;

a manifold housing having an inlet for the intake chamber and an outlet for the discharge chamber; and

a base plate sandwiched between the motor housing and the manifold housing, the plate having cavities formed therein for defining the intake and discharge chambers.

6. The apparatus according to claim 5, wherein each of the drive and driven members has an axial dimension that is the same, and wherein the plate has a thickness that is the same as the axial dimension of the drive and driven members.

7. The apparatus **6**, wherein the plate is releasably clamped between the motor housing and the manifold housing to enable the drive and driven members and the plate to be interchanged with drive and driven members of different axial dimensions and plates of different thicknesses.

8. The apparatus according to claim 5, wherein the plate is formed of a hard, wear-resistant material.

9. The apparatus according to claim 1, wherein the metal surfaces on the lobes of said one of the members comprises a hard, wear resistant material.

10. A well pump apparatus, comprising:

a string of conduit suspended in a well; and

a gear pump having a submersible electric motor, an intake leading to the exterior of the gear pump for drawing well fluid from the well and a discharge coupled to the conduit for pumping the well fluid through the conduit to the surface.

11. The apparatus according to claim 9, wherein the gear pump comprises:

a drive member driven by the electric motor and having a plurality of lobes;

a driven member having a plurality of lobes that intermesh with and are driven by the lobes of the drive member; and wherein

the lobes of one of the members are formed of metal and the lobes of the other of the members are formed of an elastomeric material.

12. The apparatus according to claim 11, wherein each of the drive and driven members has an axial dimension that is the same, and wherein the gear pump further comprises:

a plate having a uniform thickness that is the same as the axial dimension of the drive and driven members, the plate having cavities formed therein for defining intake and discharge chambers that receive the drive and driven members.

13. The apparatus according to claim 9, wherein the gear pump comprises:

a motor housing enclosing the motor;

a manifold housing defining the intake and discharge; and

a base plate of uniform thickness sandwiched between the motor housing and the manifold housing, the plate having cavities formed therein for defining intake and discharge chambers, the plate being interchangeable with plates of different thicknesses.

14. The apparatus according to claim 13, wherein the plate is formed of a hard, wear-resistant material.

15. A method of pumping well fluid from a well, comprising:

suspending a gear pump and submersible electric motor in the well; and

supplying electrical power to the motor to cause the gear pump to draw well fluid therein and pump the well fluid to the surface.

16. The method according to claim 15, further comprising:

providing the gear pump with drive and driven members having intermeshing lobes, the drive member being driven by the electric motor; and

wherein the lobes of one of the members are formed of metal and the lobes of the other of the members are formed of an elastomeric material.

* * * * *