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(54) **PROGRESSIVE CAVITY PUMP WITH FLEXIBLE COUPLING**

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(52) **U.S. Cl.** **417/410.3**; 417/360; 418/48; 166/107

(58) **Field of Search** 418/48, 182; 417/360, 417/424.2, 424.1, 410.3, 319; 166/107

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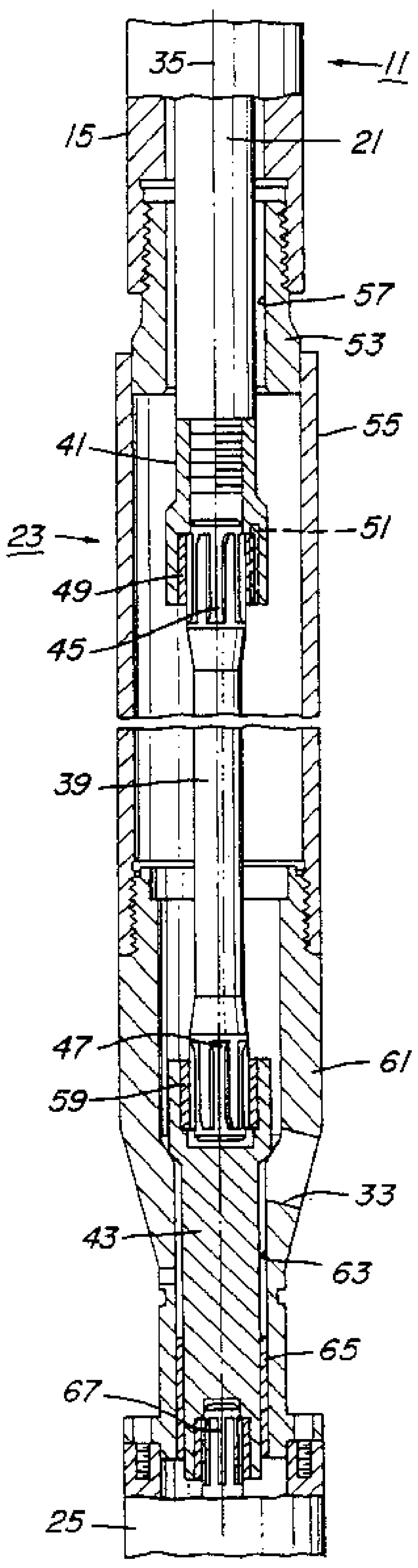
(57) **ABSTRACT**

A progressive cavity pump located in a well and driven by a downhole electrical motor. A connector locates between the drive shaft of the motor and the rotor of the pump. The connector includes a connector shaft which has a lower end restrained on a longitudinal axis. The upper end orbits with the lower end of the rotor. The connector shaft has splined ends that are received in couplings. The connector shaft flexes during the orbiting movement.

12 Claims, 2 Drawing Sheets



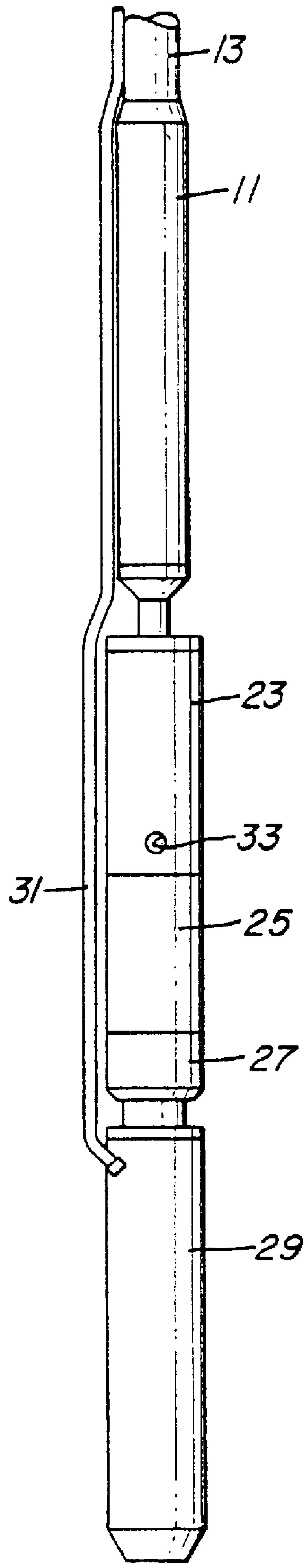


Fig. 1

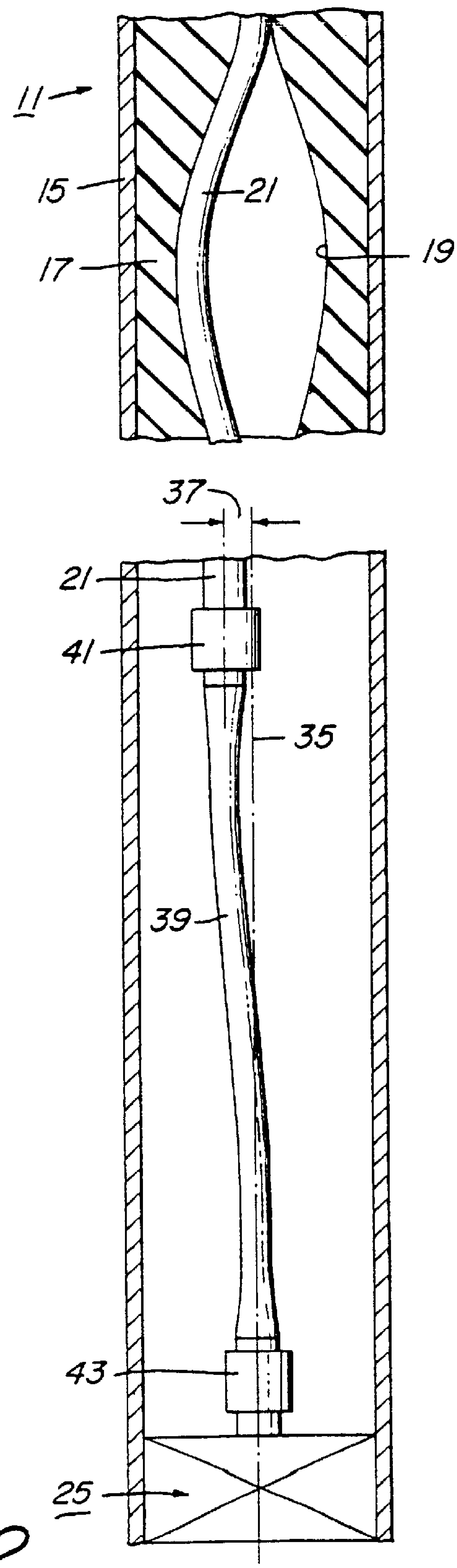


Fig. 2

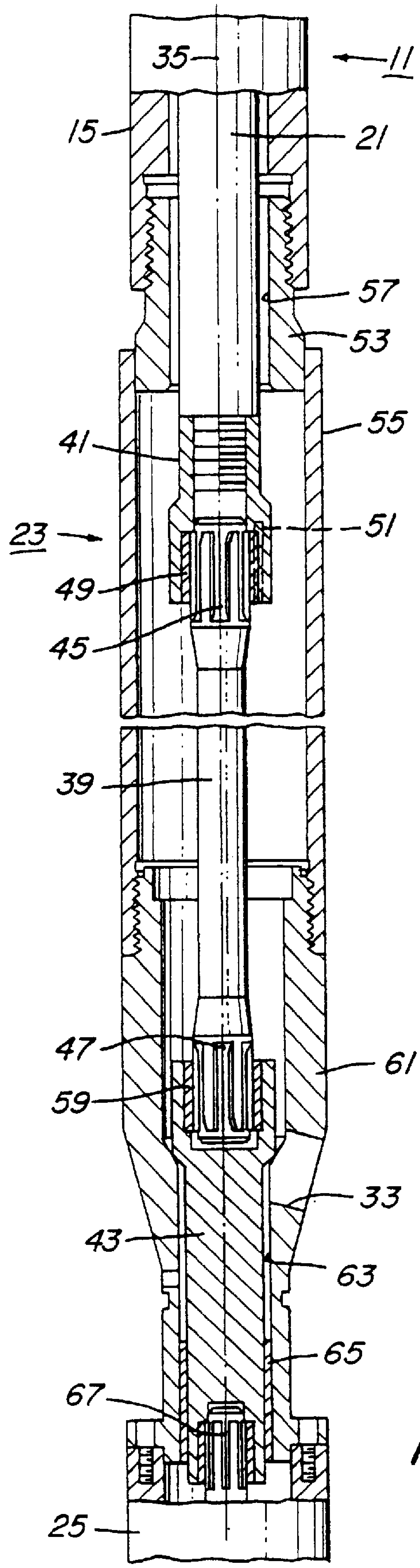


Fig. 3

PROGRESSIVE CAVITY PUMP WITH FLEXIBLE COUPLING

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to well pumps of a progressive cavity type using a downhole electric motor, and in particular to a flexible connector for connecting the rotor of a progressive cavity pump to the drive shaft of the motor.

2. Description of the Prior Art

A progressive cavity pump is a type of pump that has a helical metal rotor that is rotated within an 11 elastomeric stator that has double helical cavities. Rotating the rotor forces the liquid from an intake end to an output end.

The rotor will rotate in an eccentric or orbiting motion. This complicates the means for driving the rotor. In one type of assembly, a downhole electric motor is installed with the pump. Electrical power is supplied to the motor for rotating the pump. The motor has a drive shaft that rotates on an axis, not eccentrically. Various connector assemblies have been devised to accommodate the orbiting movement of the lower end of the rotor. One type employs U-joints on ends of a connector shaft. The U-joints allow the rotor end to orbit while the drive shaft end remains on the axis. The connector shaft remain straight and inflexible during operation. While workable, U-joints wear.

SUMMARY OF THE INVENTION

In this invention, a connector assembly is provided for a progressive cavity pump that uses a connector shaft that flexes. The rotor end and the drive shaft end of the connector shaft are splined. A rotor coupling connects the splined rotary end to the connector shaft. A drive shaft coupling connects the splined drive shaft end to the drive shaft. A guide bushing restrains the drive shaft coupling from orbiting. The shaft is a solid metal member, such of as steel. Its length and diameter are selected so that it will flex and accommodate the orbiting movement of its rotary end. The length and diameter is also selected so that the downthrust transmitted along the shaft to a thrust bearing in a seal section below the connector will not cause the shaft to buckle.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view illustrating a progressive cavity well pump assembly.

FIG. **2** is a schematic sectional view illustrating portions of the pump and a connector assembly for the pump assembly of FIG. **1**.

FIG. **3** is a sectional view illustrating the connector assembly for the pump assembly of FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, the downhole pump assembly includes a pump **11** which is suspended on a string of tubing **13** in the well. Pump **11** is of a progressive cavity type. Referring to FIG. **2**, pump **11** has a tubular housing **15** which contains an elastomeric stator **17**. Stator **17** is a stationary elastomeric member having double helical cavities **19** throughout its length. A rotor **21** of single helical configuration extends through the cavities **19**. Rotor **21** is a solid steel member that is rotated for causing pumping action.

Referring again to FIG. **1**, a connector **23** is located at the lower end of pump **11**. Connector **23** is secured to the upper end of a seal section **25**. Seal section **25** is a conventional member which has a thrust bearing and a pressure equalizing section. Seal section **25** in the embodiment shown secures to a speed reduction transmission **27**. Transmission **27** is mounted to the upper end of electrical motor **29** for reducing the speed of an output drive shaft. A power cable **31** extends from the surface for supplying electrical power to motor **29**. Intake **33** is located in connector **23** for supplying well fluid to pump **11**.

Referring to the schematic illustration in FIG. **2**, connector **23** has a longitudinal axis **35** that coincides with the longitudinal axis of pump **11**. The upper end of rotor **21** will orbit eccentrically relative to axis **35**, as indicated by the numeral **37**. The amount of lateral deviation from the axis **35** is typically about ⅛ to ¼ inch. Rotor **21** is connected to a connector shaft **39** by a rotor coupling **41**. Rotor coupling **41** forms a rigid connection which causes the upper end of connector shaft **39** to orbit in unison with the lower end of rotor **21**. The lower end of connector shaft **39** connects to a drive shaft coupling **43**, which is also a rigid coupling. Drive shaft coupling **43** rotates concentrically on the longitudinal axis **35**. The numeral **25** in FIG. **2** indicates schematically the seal section, which includes a thrust bearing which absorbs downthrust on connector shaft **39** due to the pumping action of rotor **21** of pump **11**.

Connector shaft **39** will flex along its length because of the orbiting movement of its upper end. Connector shaft **39** is a solid steel member with a diameter and length selected so as to allow the flexing action to occur without any permanent deformation. Shaft **39** is designed so that neither the yield strength, fatigue life, nor buckling design load is exceeded by the flexing due to the lateral movement of its upper end.

Referring to FIG. **3**, connector **23** is shown in more detail. The connector shaft **39** has a splined upper or rotor end **45**. Similarly, the lower end or drive shaft end **47** of connector shaft **39** has identical splines to rotor end **45**. The splines of rotor end **45** extend longitudinally in a conventional manner in an upset section of the upper end of connector shaft **39**. The splines of rotor end **45** are parallel to the longitudinal axis and evenly spaced apart circumferentially around connector shaft **39**. The splined rotor end **45** locates within a cavity formed in the lower end of rotor coupling **41**. Preferably, a sleeve **49** is secured by key **51** in the cavity of rotor coupling **41**. Sleeve **49** has splines that mate with the splined rotor end **45**.

The rotor coupling **41** extends downward from the lower end of rotor **41** through an adapter **53**. Adapter **53** connects a tubular connector housing **55** of connector **23** to pump **11**. Pump end adapter **53** has an axial bore **57** extending through it. Bore **57** has a greater diameter than the outer diameter of rotor coupling **41** by a sufficient amount so as to allow a clearance for the eccentric movement.

The splined drive shaft end **47** of connector shaft **39** inserts slidingly into a splined sleeve **59**. Splined sleeve **59** is secured by a key to drive shaft coupling **43**. Drive shaft coupling **43** extends through a seal section adapter **61**, which secures connector housing **55** to seal section **25**. Seal section adapter **61** has an axial bore extending through it. Guide means comprising a guide bushing **65** is located within seal section adapter **61** for maintaining drive shaft coupling **43** in coaxial rotation. Guide bushing **65** serves as a radial bearing to provide radial support for the drive shaft coupling **43** and prevent any orbiting movement of drive shaft coupling **43**. Guide bushing **65** is mounted in bore **63** stationarily, and rotatably and slidably receives a lower portion of drive shaft coupling **43**. The lower end of drive shaft coupling **43** is a splined cavity for coupling to a drive shaft **67** which is driven by motor **29** (FIG. **1**).

By way of example, in one embodiment, the thrust load requires a motor **29** of approximately 20–30 horsepower. The connector shaft **39** is about 1¼ inches in diameter and approximately 7½ feet long.

In operation, the pump assembly will be assembled as shown in FIG. **1** and lowered into a well on a string of tubing **13**. Electrical cable **31** will be strapped to tubing **13** as the assembly is lowered into the well. Once in place, electrical power is supplied to motor **29**. This causes drive shaft **67** (FIG. **3**) to rotate, which in turn rotates connector shaft **39** and rotor **21** (FIG. **2**). The drive shaft **67** speed is lower than the speed of motor **29** because of transmission **27**. Well fluid will be drawn in through intake **33** (FIGS. **1**, **3**), flowing through connector housing **55** into pump **11**. Pump **11** will discharge the fluid out the upper end into tubing **13**, where it flows to the surface. Rotor **21** will orbit in an eccentric fashion as indicated by numeral **37**. The rotor end **45** will orbit in unison with the lower end of rotor **21** while the drive shaft end **47** will remain coaxial with longitudinal axis **35**. Drive shaft **39** will flex along its length.

The invention has significant advantages. The splined ends on the connector shaft provide an economical type of attachment between the drive shaft and the rotor. The connector shaft is allowed to flex to accommodate the orbiting movement. The splined ends and splined couplings are less expensive than prior art U-joint types.

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 is susceptible to various changes without departing from the scope of the invention.

We claim:

1. In a pump assembly having a progressive cavity pump with a stator and a rotor, a motor which rotates a drive shaft for rotating the rotor in orbiting motion, an improved coupling between the motor and the pump, comprising:

- a connector shaft having a splined rotor end and a splined drive shaft end;
- a rotor coupling connected to the rotor for orbiting movement therewith and having an internal splined receptacle which slides over the rotor end of the connector shaft to cause the rotor end of the connector shaft to orbit in unison with the rotor;
- a drive shaft coupling connected to the drive shaft and having an internal splined receptacle which slides over the drive shaft end of the connector shaft; and
- a guide means for restraining the drive shaft from orbiting motion, the connector shaft having sufficient flexibility to accommodate the orbiting movement of its rotor end.

2. The pump assembly according to claim **1**, wherein the connector shaft is a solid steel member.

3. The pump assembly according to claim **1**, further comprising:

- a connector shaft housing which encloses the connector shaft, and wherein the guide means comprises:
  - a radial bearing mounted in the housing in engagement with the drive shaft coupling.

4. The pump assembly according to claim **1**, further comprising:

- a connector shaft housing which encloses the connector shaft, and wherein
- the pump has a well fluid intake which is located in the connector shaft housing.

5. In a pump, comprising in combination:

- a progressive cavity pump having a stator, and a rotor which rotates eccentrically;
- a solid steel connector shaft having a splined rotor end and a splined drive shaft end;
- a rotor coupling connected to the rotor for eccentric movement therewith and having an internal splined receptacle which slides over the rotor end of the connector shaft to cause the rotor end of the connector shaft to rotate eccentrically in unison with the rotor,
- a motor assembly which rotates a drive shaft which has a splined end;
- a drive shaft coupling having internal splines which slide over the drive shaft end of the connector shaft and splines which connect to the splined end of the drive shaft;
- a connector housing which encloses the connector shaft and the couplings and which is connected between the pump and the motor assembly;
- the connector housing having an intake port for admitting well fluid to the interior of the connector housing which flows into the pump housing; and
- a bushing sleeve in the connector housing which rotatably engages the drive shaft coupling to prevent eccentric movement of the drive shaft coupling, the connector shaft having sufficient radial flexibility to accommodate the eccentric movement of its rotor end.

6. The pump according to claim **5** wherein the motor assembly comprises:

- an electric motor; and
- a seal section located between the connector housing and the motor for sealing well fluid from the motor, equalizing well fluid pressure with lubricant contained in the motor and for absorbing pump thrust.

7. In a pump assembly having a progressive cavity pump with a stator and a rotor, a motor which rotates a drive shaft for rotating the rotor in orbiting motion, an improved coupling between the motor and the pump, comprising:

- *a connector shaft having a rotor end and a drive shaft end, wherein at least one of the ends is splined;*
- *a rotor coupling connected to the rotor for orbiting movement therewith and having an end which mates with the rotor end of the connector shaft to orbit in unison with the rotor;*
- *a drive shaft coupling connected to the drive shaft and having an end which mates with the drive shaft end of the connector shaft; and*
- *a guide mounted in engagement with the drive shaft coupling for restraining the drive shaft from orbiting motion, the connector shaft having sufficient flexibility to accommodate the orbiting movement of its rotor end.*

8. The pump assembly according to claim 7, wherein the connector shaft is a solid steel member.

9. The pump assembly according to claim 7, further comprising:

- *a connector shaft housing which encloses the connector shaft; and wherein the guide comprises:*
  - *a radial bearing mounted in the housing in engagement with the drive shaft coupling.*

10. The pump assembly according to claim 7, further comprising:

a connector shaft housing which encloses the connector shaft; and wherein

the pump has a well fluid intake which is located in the connector shaft housing.

11. A pump assembly, comprising in combination:

a progressive cavity pump having a stator and a rotor which rotates eccentrically;

a solid steel connector shaft having a rotor end connected to the rotor for eccentric movement therewith and a splined drive shaft end containing a plurality of splines;

a motor assembly which rotates a drive shaft;

a drive shaft coupling connected to the drive shaft and having a splined end which mates in sliding engagement with the splines of the drive shaft end of the connector shaft to cause the rotor to rotate;

a connector housing which encloses the connector shaft and the couplings and which is connected between the pump and the motor assembly;

the connector housing having an intake port for admitting well fluid to the interior of the connector housing which flows into the pump; and

a bushing sleeve in the connector housing which rotatably engages the drive shaft coupling to prevent eccentric movement of the drive shaft coupling, the connector shaft having sufficient radial flexibility to accommodate the eccentric movement of its rotor end.

12. The pump assembly according to claim 11 wherein the motor assembly comprises:

an electric motor; and

a seal section located between the connector housing and the motor for sealing well fluid from the motor, equalizing well fluid pressure with lubricant contained in the motor and for absorbing pump thrust.

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