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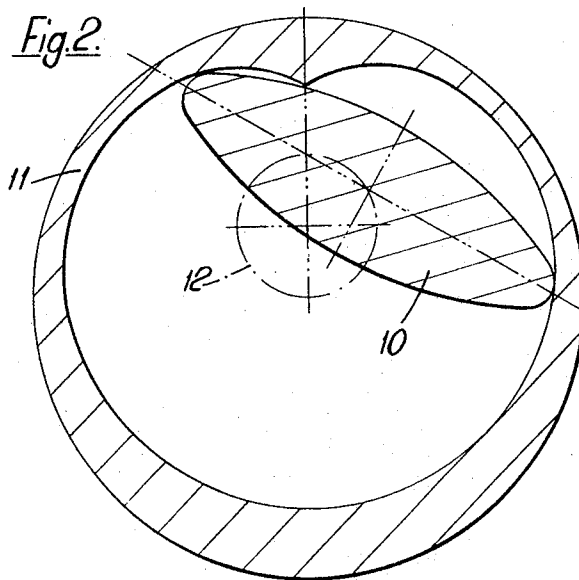
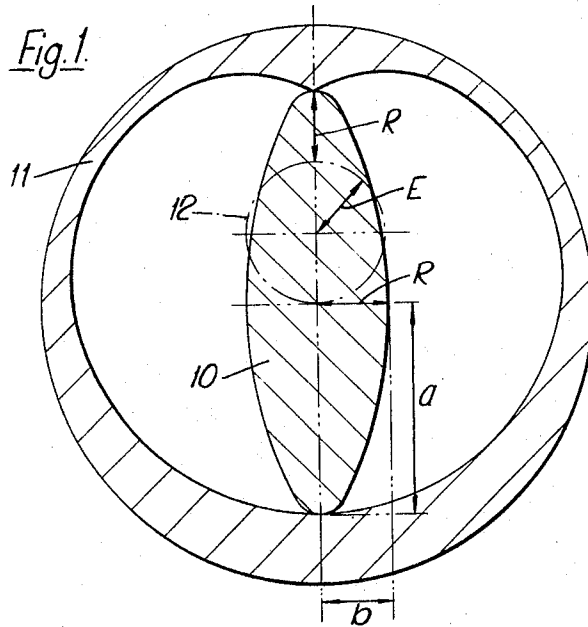
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3,299,822

HELICAL GEAR PUMP

Filed March 31, 1965

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

Fig. 3.

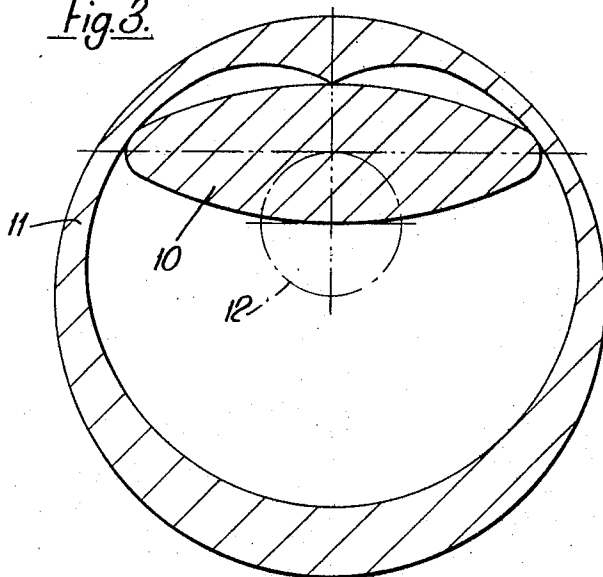
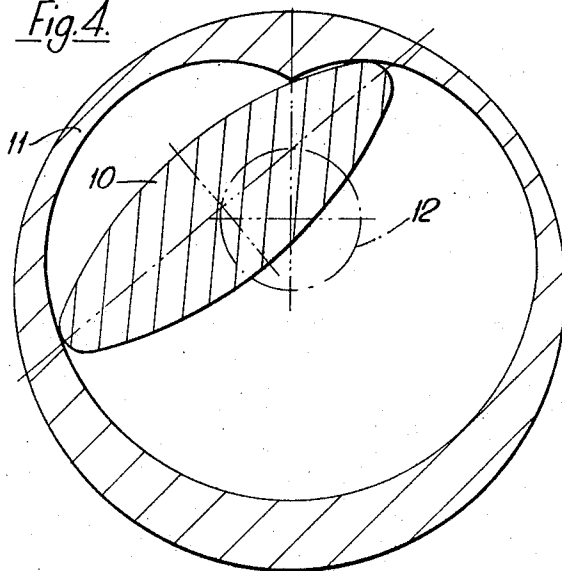


Fig. 4.



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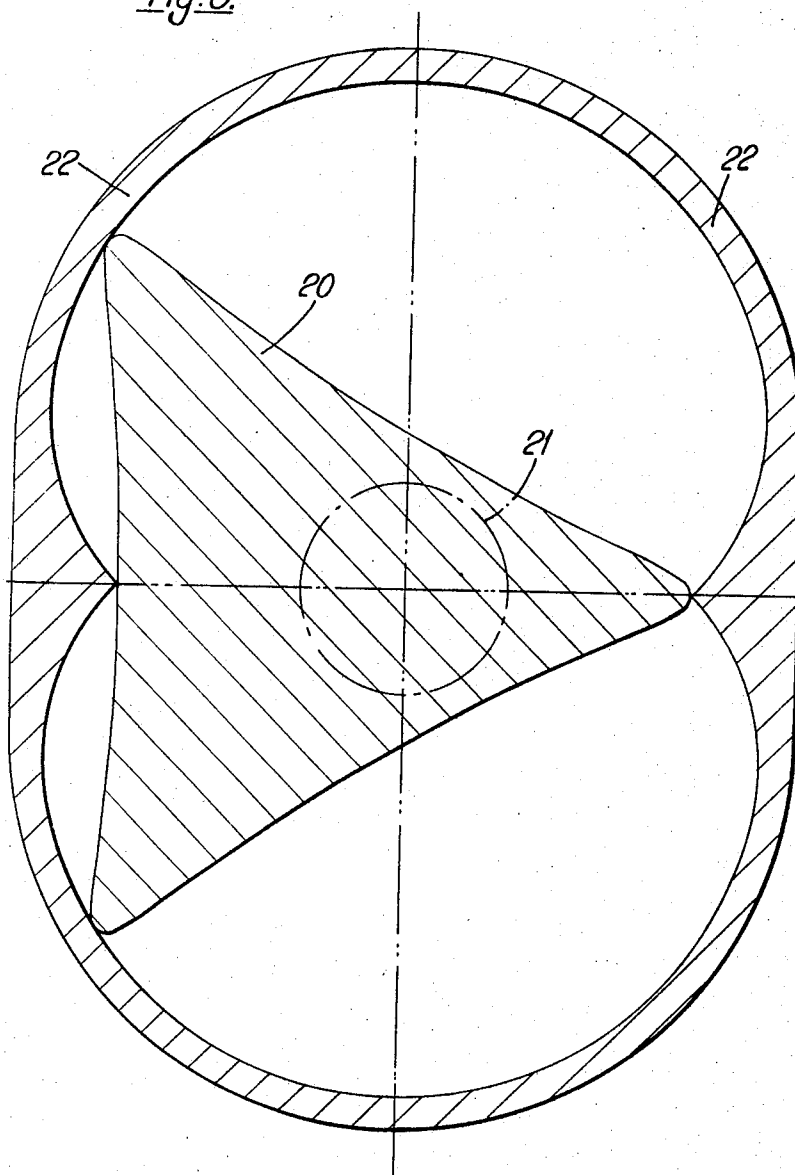
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4 Sheets-Sheet 3

Fig. 5



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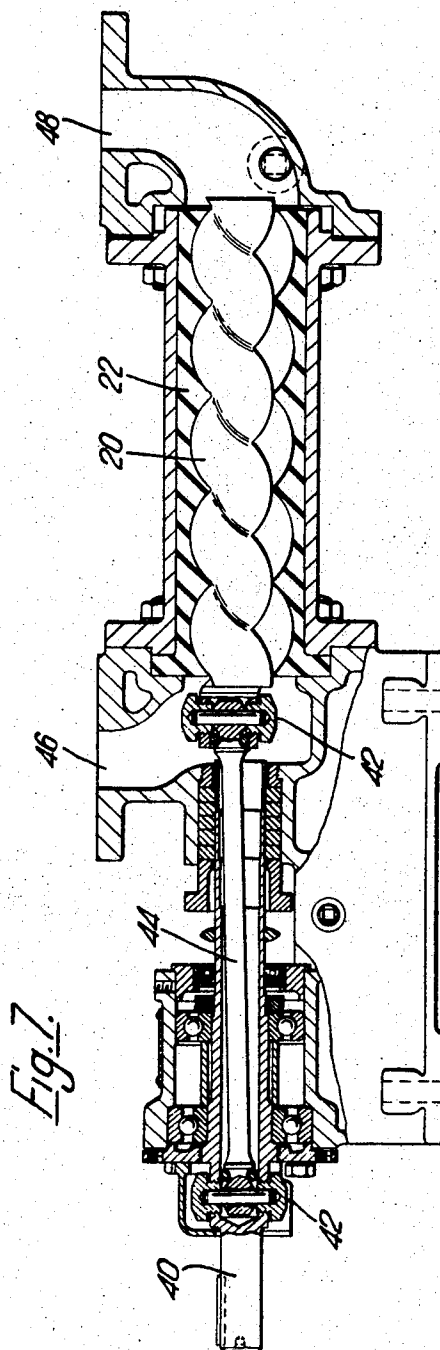
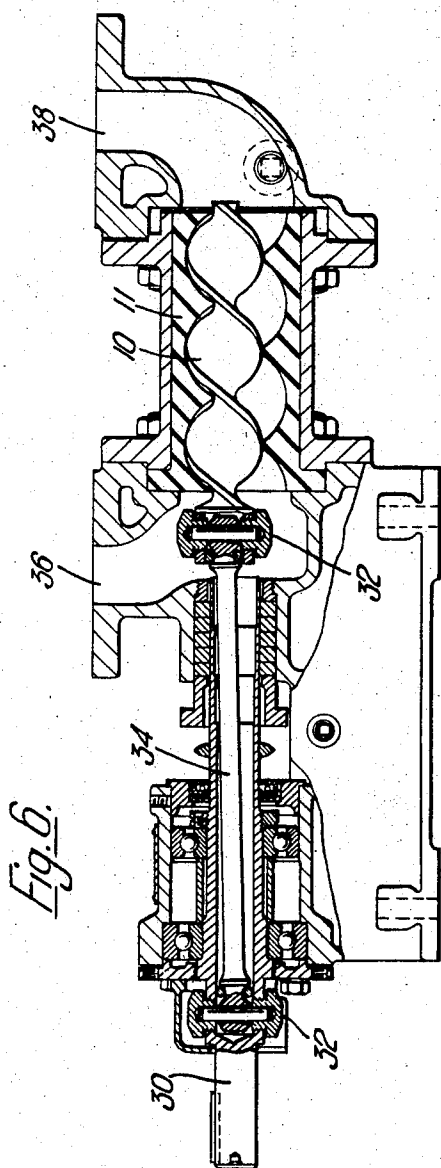
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4 Sheets-Sheet 4



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1

3,299,822

HELICAL GEAR PUMP

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5 Claims. (Cl. 103-117)

The present invention relates to helical gear pumps. Previously known helical gear pumps comprise an outer member, usually a stator, having a plurality of internal helical threads, and an inner member, usually the rotor, having external threads, the inner member having one less thread than the outer member. In operation, when the rotor is rotated in the stator, a point on the rotor axis describes a small circle in a direction opposite to the rotation of the rotor.

It is an object of the present invention to provide a new or improved helical gear pump.

According to the present invention there is provided a helical gear pump comprising an outer member having at least a one start internal helical gear formation thereon, an inner member mounted within the outer member, the inner and outer members being arranged to rotate sealing with respect to each other, the inner member having a plurality of starts of external helical gear formation thereon, the number of starts on the inner member being one more than that on the outer member and the pitch of the gear formations on the inner member being equal to that on the outer member, the shape of the internal and external teeth in any transverse section being such that the teeth on the inner member are always in contact with the outer member and the tooth or teeth of the outer member are always in contact with the inner member.

By way of explanation, the "pitch" is the axial distance between the corresponding points, for example the peaks of adjacent points on the helical gear form, the lead is the axial distance between corresponding points on the same helix after the latter has turned through 360° about its axis. Thus for a single thread the lead and the pitch are the same but for a double thread the pitch is half the lead.

In operation, when the inner member is rotated relatively to the outer member a point on the axis of the inner member orbits in a circular path at fixed eccentricity about the axis of the outer member in the same direction as the relative rotation of the inner member at $n+1$ times the relative rotational velocity when n is the number of teeth on the outer member. Thus if the outer member has only one tooth and the inner member therefore has two teeth the point on the inner member axis orbits at twice the relative rotational velocity.

The shape of the rotor and stator in any transverse section may be generated in any suitable way, for example as a hypocycloid. Such a shape is generated as the locus of a point on a generating circle which is orbited by rolling about a base circle, a circle of a different radius but having a common centre with the generating circle. Shapes approximating to such generated shapes work perfectly satisfactorily, for example in one particularly suitable form the inner member, which may be made from a non-resilient material such as steel or brass, has a cross-section in any plane transverse to the axis which is of elliptical form and the outer member, which may be made from a resilient material for example natural or synthetic rubber, has, in the same cross-section an internal shape generated by the inner member orbiting in a circular path the inner member rotating as it orbits at half the rate that the centre thereof orbits. With this arrangement if the minor radius of the inner member be represented by R , then the minor and major axes of the ellipse must be R and $2E+R$ respectively, if E is the eccentricity

2

of the axis of the inner member with respect to the axis of the outer member.

In order that the present invention may more readily be understood the following description is given of two forms of pumps according to the invention, reference being made to the accompanying drawings in which:

FIGURE 1 is a cross section through one embodiment of pump according to the invention having a two-toothed inner member and a one-toothed outer member;

FIGURES 2, 3 and 4 are views similar to FIGURE 1 showing the inner member in different relative positions;

FIGURE 5 is a view similar to FIGURE 1 illustrating a second form of pump having a three-toothed inner member and a two-toothed outer member;

FIGURE 6 is a longitudinal section through the pump of FIGURE 1 shown to a smaller scale; and

FIGURE 7 is a view similar to FIGURE 6 illustrating the second form of pump shown in FIGURE 5.

Referring now to the pump illustrated in FIGURES 1 to 4, the inner member 10 is of elliptical form having a major semi-cord a and minor semi-cord b . The form of the stator 11 surrounding the rotor 10 is such that when the rotor is rotated the centre thereof describes a circle 12 of radius E . Thus, if the length of the semi-cord b is given the dimension R , then the length of the semi-cord a is given by the expression $R+2E$.

As can be seen by comparing the relative positions of the rotor and stator in FIGURES 1 to 4 as the rotor 10 rotates about its own centre so this centre itself rotates about the centre of the stator at twice the rate and in the same direction. For example, as the stator moves from the position of FIGURE 1 to that of FIGURE 3 the rotor turns about its own centre through an angle of 90° while the centre of the rotor rotates round the circle of eccentricity 12 through an angle of 180°.

The form of the outer member of stator 11 is similar to that of a cardioid and is the locus of the furthest point of the rotor from the centre of the stator. This furthest point in the position of the rotor shown in FIGURE 1 is the tip or tooth of the ellipse i.e. the point of maximum curvature, but as the ellipse is rotated and as it orbits round the circle 12 the point furthest from the centre of the stator moves from the tip to a point spaced a small distance therefrom. It will be appreciated that this point is different for every relative position of the rotor. With this form of stator there is no possibility of the two members of the pump jamming against one another but there is always a free running relationship. It will be seen that, except in the extreme position shown in FIGURE 1, three points of the rotor will always be in contact with the stator and that the cusp or tooth of the stator is always in contact with the rotor. In the general case the number of contact points between the rotor and stator is equal to the number of teeth in the rotor plus the number of teeth in the stator although this is apparently less in some positions when such points on the rotor and stator coincide for example in the position shown in FIGURE 1.

The section shown in FIGURE 5 illustrates a pump in which the inner member 20 is provided with three points of maximum radius i.e. with three teeth and the outer member 22 is provided with two points of minimum radius i.e. with two teeth. When the two members move relatively to each other the axis of the inner member 20 describes a circular orbit about the circle of eccentricity 21, the inner member itself rotating about its own axis in the same direction at three times the speed of orbiting. It will be seen that the three members are normally in contact at five points but this reduces to four points when the points of minimum radius of the inner member coincide with the points of minimum radius of the outer member.

3

Both the pumps illustrated in the drawings are of helical form in an axial direction as illustrated in FIGURES 6 and 7, the pitch of the teeth of the inner member being equal to that on the outer member but the lead of the teeth on the inner member being greater than that on the outer member in the ratio of the number of outer member teeth to the number of inner member teeth. Thus in the pump of FIGURES 1 to 4 the pitch of the two gear forms is the same and the lead of the inner member is twice the lead of the outer member; in the construction of FIGURE 5 the pitch of the teeth of the inner and outer member is again equal while the lead on the inner member is greater than that on the outer member in the ratio of 3:2.

Conveniently the outer member 11, 22 is fixed against rotation and the inner member or rotor 10, 20 is rotated by a suitable flexible drive such as a driving shaft provided with a universal joint or other flexible coupling or by a Cardan shaft. In FIGURES 6 and 7 a drive shaft 30, 40 is illustrated as being connected to the rotor via two universal joints 32, 42 and on intermediate shaft 34, 44. The inlet to the pump is illustrated at 36, 46 and the outlet at 38, 48. However, equally, since the inner and outer members are symmetrical about their respective axes, and since the only eccentric motion is a rotation of the axis of the inner member about the axis of the outer member in the direction for relative rotation of the inner member, the use of a flexible drive may be dispensed with and the inner member may be mounted to rotate about its axis and the outer member allowed to rotate freely about its own axis. With such an arrangement the whole pump is perfectly balanced so that no further balancing is required. The outer member will be driven by the inner member and will rotate at a speed faster than the inner member, in the ratio:

$$\frac{\text{Number of inner member starts}}{\text{Number of outer member starts}}$$

When the inner and outer members are made of a substantially non-resilient material, for example, steel or brass the configurations of the two members must be kept to extremely fine limits to ensure that a substantially perfect seal is maintained. However, it is preferred that the outer member, which will normally be the stator, be made of a resilient material for example, natural or synthetic rubber, so that some tolerances in the actual dimensions are allowed. Equally the inner member which is normally the rotor may be made of a resilient material and the outer member made of a non-resilient material such as a metal.

I claim:

1. A helical gear pump comprising inner and outer relatively rotatable members meshing sealingly together and disposed one within the other; a single internal helical thread formed on said outer member to provide a tooth

4

in any transverse section on said other member; two external helical threads formed on said inner member to provide teeth in any transverse section on said inner member, said external thread having the same pitch as the internal helical thread of said outer member; a shape to said internal tooth and a shape to said external teeth, said shapes being such that in any transverse section the teeth on the inner member are always in contact with the outer member and the tooth on the outer member is always in contact with the inner member.

2. A helical gear pump as specified in claim 1, wherein the inner member is caused to rotate and the outer member is prevented from moving.

3. A helical gear pump as specified in claim 1, wherein the cross-section of the inner member in any transverse section is an ellipse; a centre and maximum and minimum cord lengths to said ellipse; a cross-section to said outer member in the same transverse section, of a form corresponding to the line roulette generated by rotating the centre of the ellipse in a circular orbit of a diameter equal to the difference of said maximum and minimum cord lengths, and rotating the ellipse in the same direction about its own centre at half the orbiting rate.

4. A pump according to claim 1, wherein one of said inner and outer members is formed of a resilient material.

5. A helical gear pump comprising inner and outer relatively rotatable members, meshing sealingly together and disposed one within the other; a plurality of internal helical threads formed on the outer member to provide teeth in any transverse section on said outer member; a plurality of external helical threads on said inner member to provide teeth in any transverse section on said inner member, said inner member having one more thread than the said outer member; a shape to said teeth on the outer member and a shape to said teeth on the inner member, said shapes being such that, in any transverse section, the teeth on the inner member are always in contact with the outer member and the teeth on the outer member are always in contact with the inner member.

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