May 2, 1944. E. FOWLER 2,347,944

ROTARY PUMP

Filed May 22, 1942 2 Sheets-Sheet 1

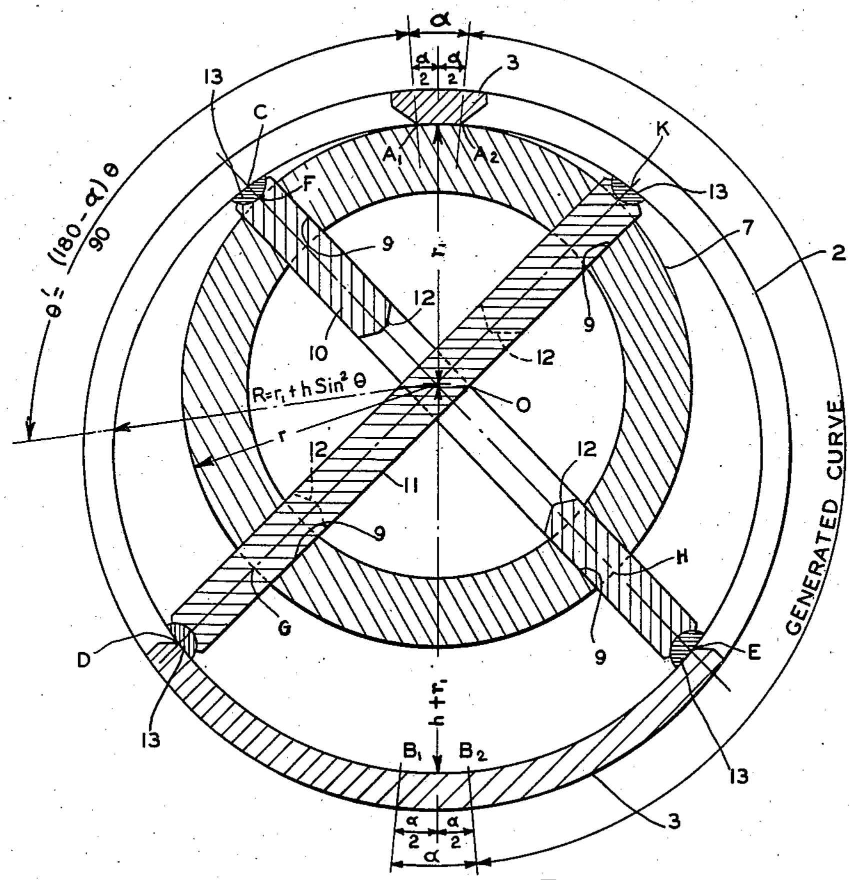

FIG.3.

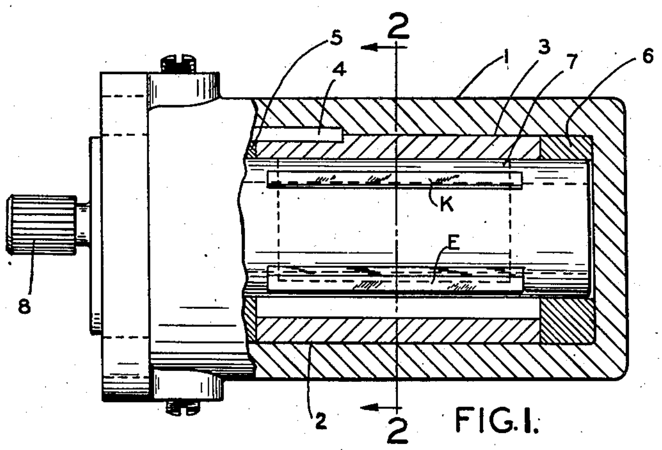

FIG.1.

INVENTOR.
ELBERT FOWLER

BY *Fay, Macklin, Golrick*
Williams, Chilton and Isler.
ATTORNEYS.

May 2, 1944. E. FOWLER **2,347,944**

ROTARY PUMP

Filed May 22, 1942 2 Sheets-Sheet 2

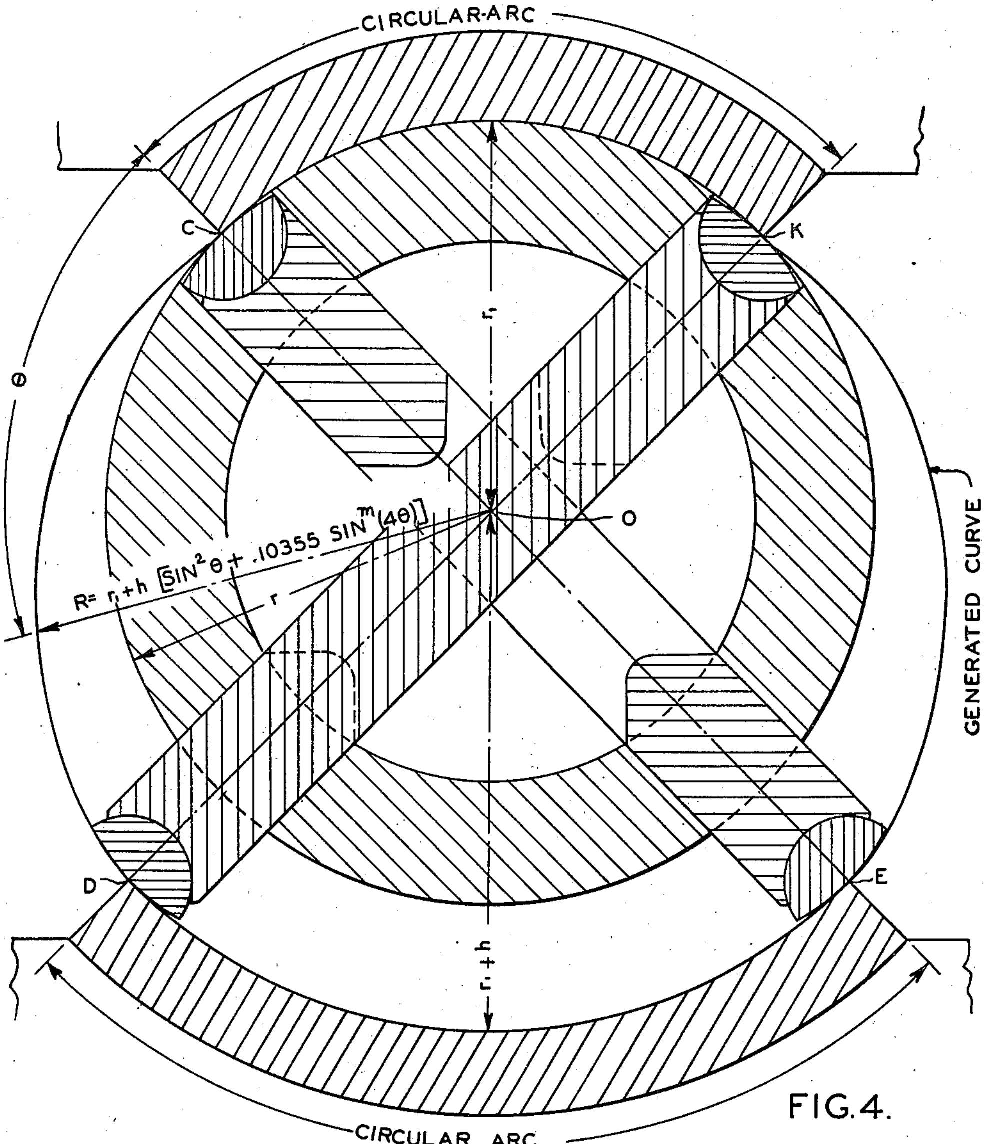

FIG. 4.

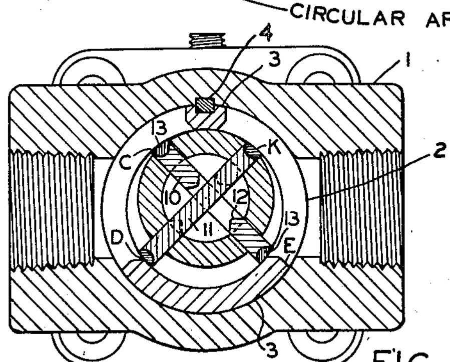

FIG. 2.

INVENTOR.
ELBERT FOWLER

BY *Fay, Macklin, Golrick, Williams Chilton and Osler.*
ATTORNEYS

Patented May 2, 1944 2,347,944

UNITED STATES PATENT OFFICE

2,347,944

ROTARY PUMP

Elbert Fowler, Elyria, Ohio

Application May 22, 1942, Serial No. 444,016

10 Claims. (Cl. 103—138)

This invention relates, as indicated, to rotary pumps, but has reference more particularly to rotary pumps of the sliding vane type.

It has heretofore been proposed to construct a rotary pump of this type with a bore comprising concentric arcs connected by means of curved sections in the form of portions of an Archimedean spiral. While such pumps have certain desirable operating characteristics, they will not produce an entirely smooth pulsationless flow, due to the fact that it is virtually impossible to join the ends of the non-arcuate curved portions thereof in such a manner as to avoid the presence of humps or cusps at or adjacent such junctures. This is a defect which is inherent in the use of Archimedean spiral portions for this purpose, and cannot be remedied by merely shifting such portions circumferentially of the bore in such a manner as to produce approximate tangency at one or the other of the junctures, since an attempt to remedy the defect at one juncture merely aggravates the condition at the other juncture.

I have discovered as the result of considerable experimentation and study of the conditions necessary to produce smooth pulsationless flow that I can best secure such flow by the use of a bore having non-arcuate portions in the form of a generated curve which deviates somewhat from an Archimedean spiral, and the juncture of which with the arcuate portions of the bore is characterized by a condition free from humps, cusps, or other protuberances or elements tending to interfere with smooth operation.

In one case, I employ a generated curve, which is suitable for air or gas compressors or vacuum pumps, in which smooth flow, while desirable, is not as essential as in a liquid pump. In another case, I employ a generated curve which is especially adaptable for liquid pumps for fuel and the like, in which smooth pulsationless flow is an essential consideration.

Inasmuch as the generated curve, in the second case, is derived from the equation of the first-named curve, a pump incorporating the first-named curve in the bore thereof will be first described, such pump being illustrated in Figs. 1, 2 and 3 of the accompanying drawings, wherein

Fig. 1 is a view, partly in elevation, and partly in section, of a pump incorporating the aforesaid first-named curve as a part of the bore thereof;

Fig. 2 is a transverse cross-sectional view, taken on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged cross-sectional view of the bore of the pump shown in Fig. 1, and

Fig. 4 is a view, similar to Fig. 3, but showing the modified pump incorporating the aforesaid second-named curve in the bore thereof.

Referring more particularly to Figs. 1, 2 and 3 of the drawings, it will be seen that a rotary pump constructed in accordance with the invention comprises a body 1 having a circular bore 2 into which the stator 3 is fitted and secured against rotation relatively to the body 1 by means of a key 4. The stator 3 is secured against endwise movement in the body 1 by means of thrust bearings 5 and 6, which bearings also serve as radial or journal bearings for the rotor 7 of the pump. The rotor 7 projects beyond one end of the pump body and is provided with a splined extension 8, whereby the rotor may be driven.

The rotor 7 is rotatable about the center O, which is also the center of the inside of the truly circular arcs A_1—A_2, B_1—B_2 of the stator 3. The rotor, moreover, is provided with slots 9 at right angles to each other and with vanes 10 and 11 which are slidable radially in these slots. The vanes 10 and 11 are cut away as at 12 to clear each other, the cut away portions being sufficient in length to permit the maximum radial movement of the vanes without interference with each other. The outer ends of the vanes are preferably fitted with rocker seals 13, the functions of which will be readily understood by those skilled in the art to which this invention relates.

The combined lengths of the vanes and rocker seals is greater than the external diameter of the rotor, and the "vanes," which term will hereinafter be used to include the rocker seals, therefore project radially from the rotor, the bore of the stator being so designed as to permit rotation of the vanes with the rotor. For convenience in describing the invention, the center lines of the vanes have been designated by the letters CE and DK, these letters also designating the points at which these center lines intersect the wall of the stator 3. Since both ends of a vane necessarily contact the stator at any point in the rotation of the rotor, the interior of the stator cannot be circular, but consists in fact, of several curves, designated respectively as A_1—A_2, B_1—B_2, A_1—B_1, and A_2—B_2.

The curves A_1—A_2 and B_1—B_2 are truly circular arcs having a common center O with the rotor and having radii respectively of r_1, equal to the radius of the rotor, plus running clearance of about .0005", and $h+r_1$, which is equal to the rotor radius plus the excess h of the vane length over the rotor diameter. The function of the arc A_1—A_2 is to improve the seal between the rotor and the stator at A_1—A_2, and this arc as well as the arc B_1—B_2 extends for a short distance equal to an angle which is designated α.

The curve A_1—B_1 is a generated curve, which is represented by the equation

$$R=r_1+h \sin^2 \theta$$

wherein R is the distance from the center O to the point on the curve A_1—B_1 whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, and θ is the angle determined from the equation:

$$\theta'=\frac{(180-\alpha)\theta}{90}$$

where θ' is the angle between OA_1 and a line drawn from the center O to the point on the curve A_1—B_1 whose position is to be determined.

Since CF varies as $\sin^2\theta$, since OC is 90° from GD, since $GD=HE$, since $\sin^2\theta+\cos^2\theta=1$, and since 1 is a constant, then CE is constant throughout the revolution of the rotor.

It will be apparent from the foregoing that the curve A_2—B_2, since it is symmetrically located relatively to the curve A_1—B_1, is determined or generated in the same manner as the latter.

A pump as described is particularly adapted for air or gas compressors, or as a vacuum pump, since smooth flow, while desirable in such pumps, is not as essential as in a liquid pump.

Referring to Fig. 4, wherein is shown a pump especially adapted for the smooth pulsationless flow of liquids, such as fuel for aeroplanes, and the like, it will be seen that the general constructional features of the pump are similar to those described in connection with the air or gas compressor pump.

In this case, however, the circular arcs CK and DE extend for 90 degrees and the curve CD is a generated curve which is represented by the equation:

$$R=r_1+h[\sin^2\theta+.10355 \sin^m(4\theta)]$$

wherein R is the distance from the center O to the point on the curve CD whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the difference between the radius of the arcs CK and DE, θ is the angle between OC and a line drawn from the center O to the point on the curve CD whose positions is to be determined and m is an exponent whose value may vary from ½ to 2. The constant, .10355 is the maximum deviation of the curve from the true Archimedean spiral, being expressed as a decimal of h. The exponent m is chosen arbitrarily, its value being influenced by whether more or less deviation from pulsationless flow is permissible. Obviously, the greater the deviation from pulsationless flow, the smoother the vane acceleration will be at the ends of the generated curve. A value of $m=1$ gives an excellent curve. The greater the value of m, the smoother will be the vane acceleration, but with greater departure from mathematically pulsationless flow. The curve EK is determined in the same way as the curve CD, and is, in fact, symmetrically disposed with respect to the latter.

If desired, the arcs CK and DE in the form of the invention shown in Fig. 4 need not extend 90 degrees, but may extend through smaller or greater angles, such as an angle α. In that event, the angle θ in the foregoing equation will be determined in the same manner as in the first form of the invention, i. e., from the equation

$$\theta'=\frac{(180-\alpha)\theta}{90}$$

Since the generated curves in all cases, are symmetrical about a vertical plane through the center O of the rotor, it follows that the pumps are reversible, insofar as the direction of rotation of the rotor is concerned.

Although I have shown and described pumps having two sliding vanes, it will be understood that this is the preferred number of vanes, although a single vane may be employed, if desired. A greater number of vanes than two is undesirable for a number of reasons, among which are the weakening of the rotor, due to the necessity of providing slots for the increased number of vanes, and the difficulty of providing sufficient vane rigidity or strength, where room must be provided for a large number of vanes.

I claim:

1. In a rotary pump of the sliding vane type, a rotor, a pump body having a stator therein, said stator having an internal cross-section defined by two opposite concentric arcs of unequal radii, and vane extending and retracting curves joining adjacent ends of said arcs, said curves being generated curves determined by the equation:

$$R=r_1+h \sin^2\theta$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, and θ is the angle determined from the equation

$$\theta'=\frac{(180-\alpha)\theta}{90}$$

wherein θ^1 is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined, and α is the angle subtended by said arc.

2. In a rotary pump of the sliding vane type, a rotor, a pump body having a stator therein, said stator having an internal cross-section defined by two opposite concentric arcs of unequal radii, and vane extending and retracting curves joining adjacent ends of said arcs, said curves being generated curves determined by the equation

$$R=r_1+h[\sin^2\theta+.10355 \sin^m(4\theta)]$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, θ is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined and m is an exponent whose value varies from ½ to 2.

3. In a rotary pump of the sliding vane type, a rotor, a pump body having a stator therein, said stator having an internal cross-section defined by two opposite concentric arcs of about 90 degrees, but of unequal radii, and vane extending and retracting curves, joining adjacent

ends of said arcs, said curves being generated curves determined by the equation

$$R=r_1+h[\sin^2\theta+.10355\sin^m(4\theta)]$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, θ is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined and m is an exponent whose value varies from ½ to 2.

4. In a rotary pump of the sliding vane type, a rotor, a pump body having a stator therein, said stator having an internal cross-section defined by two opposite concentric arcs of unequal radii, and vane extending and retracting curves joining adjacent ends of said arcs, said curves being generated curves determined by the equation

$$R=r_1+h[\sin^2\theta+K\sin^m(4\theta)]$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, θ is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined, K is a constant whose value varies from 0 to 0.200, both inclusive, and m is an exponent whose value varies from ½ to 2.

5. In a rotary pump of the sliding vane type, a rotor, a pump body having a stator therein, said stator having an internal cross-section defined by two opposite concentric arcs of unequal radii, and vane extending and retracting curves joining adjacent ends of said arcs, said curves being generated curves determined by the equation

$$R=r_1+h[\sin^2\theta+K\sin^m(4\theta)]$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, θ is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined, K is a constant whose value varies from 0 to .10355, both inclusive, and m is an exponent whose value varies from ½ to 2.

6. A pump of the sliding vane type comprising a body having a cavity therein, a rotor rotatably mounted in said cavity eccentrically thereof, said cavity having a cross-section defined by two opposite concentric arcs of unequal radii, and vane extending and retracting curves joining adjacent ends of said arcs, said curves being generated curves determined by the equation:

$$R=r_1+h\sin^2\theta$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, and θ is the angle determined from the equation

$$\theta'=\frac{(180-\alpha)\theta}{90}$$

wherein θ^1 is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined, and α is the angle subtended by said arc.

7. A pump of the sliding vane type comprising a body having a cavity therein, a rotor rotatably mounted in said cavity eccentrically thereof, said cavity having a cross-section defined by two opposite concentric arcs of unequal radii, and vane extending and retracting curves joining adjacent ends of said arcs, said curves being generated curves determined by the equation

$$R=r_1+h[\sin^2\theta+.10355\sin^m(4\theta)]$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, θ is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined and m is an exponent whose value varies from ½ to 2.

8. A pump of the sliding vane type comprising a body having a cavity therein, a rotor rotatably mounted in said cavity eccentrically thereof, said cavity having a cross-section defined by two opposite concentric arcs of about 90 degrees, but of unequal radii, and vane extending and retracting curves, joining adjacent ends of said arcs, said curves being generated curves determined by the equation

$$R=r_1+h[\sin^2\theta+.10355\sin^m(4\theta)]$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, θ is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined and m is an exponent whose value varies from ½ to 2.

9. A pump of the sliding vane type comprising a body having a cavity therein, a rotor rotatably mounted in said cavity eccentrically thereof, said cavity having a cross-section defined by two opposite concentric arcs of unequal radii, and vane extending and retracting curves joining adjacent ends of said arcs, said curves being generated curves determined by the equation

$$R=r_1+h[\sin^2\theta+K\sin^m(4\theta)]$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, θ is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined, K is a constant whose value varies from 0 to 0.2000, both inclusive, and m is an exponent whose value varies from ½ to 2.

10. A pump of the sliding vane type comprising a body having a cavity therein, a rotor rotatably mounted in said cavity eccentrically thereof, said cavity having a cross-section defined by two

opposite concentric arcs of unequal radii, and vane extending and retracting curves joining adjacent ends of said arcs, said curves being generated curves determined by the equation

$$R=r_1+h[\sin^2\theta+K\sin^m(4\theta)]$$

wherein R is the distance from the center of the rotor to the point on the curve whose position is to be determined, r_1 is the radius of the rotor plus running clearance, h is the excess of the vane length over the rotor diameter, θ is the angle between a line joining the center of the rotor and an end of the arc of smaller radius and a line joining the center of the rotor and the point on the curve whose position is to be determined, K is a constant whose value varies from 0 to .10355, both inclusive, and m is an exponent whose value varies from ½ to 2.

ELBERT FOWLER.