Dec. 22, 1942. H. L. NASH 2,306,276

ROTARY PUMP

Filed June 6, 1940 3 Sheets-Sheet 1

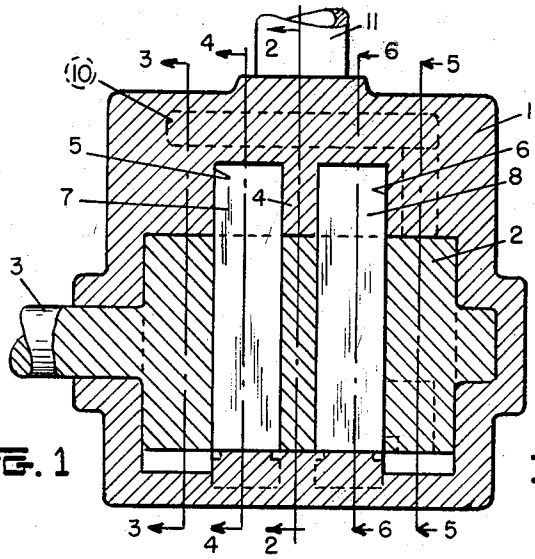


FIG. 1

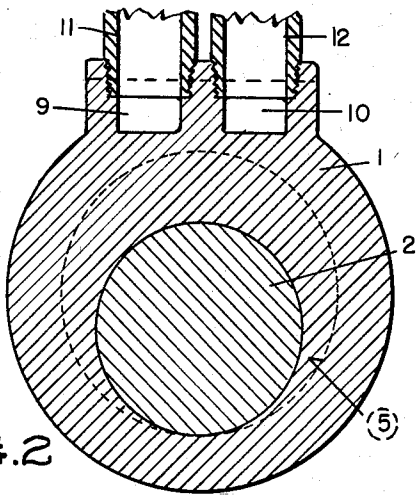


FIG. 2

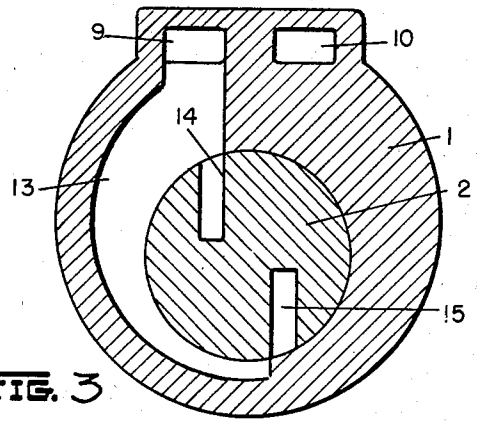


FIG. 3

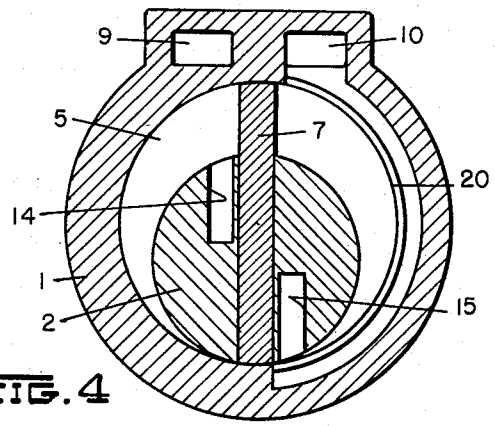


FIG. 4

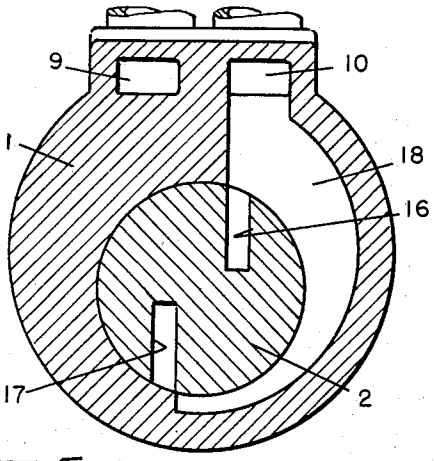


FIG. 5

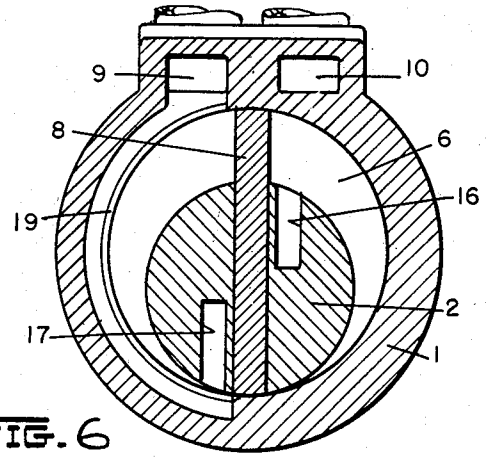


FIG. 6

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ROTARY PUMP

Filed June 6, 1940 3 Sheets-Sheet 2

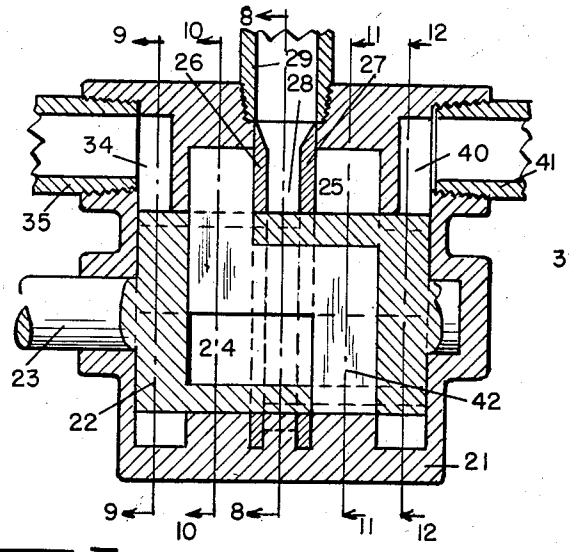


FIG. 7.

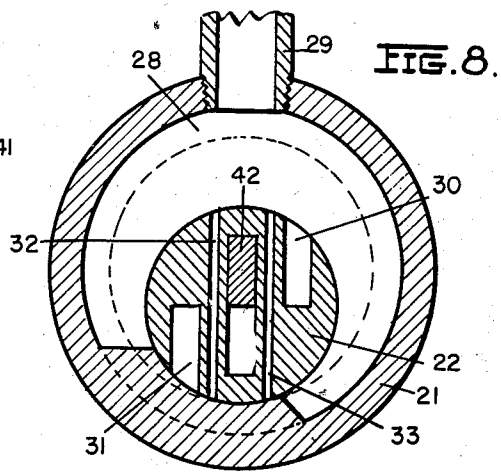


FIG. 8.

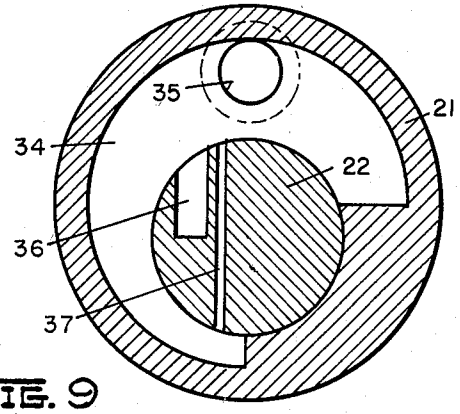


FIG. 9

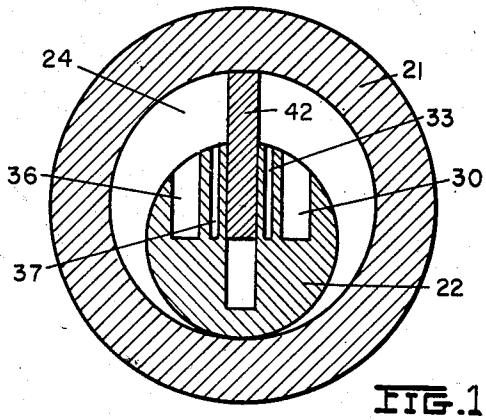


FIG. 10

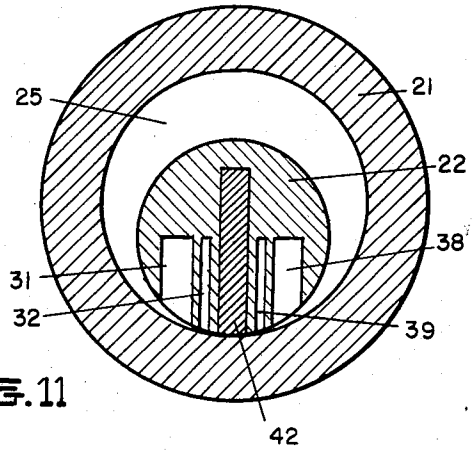


FIG. 11

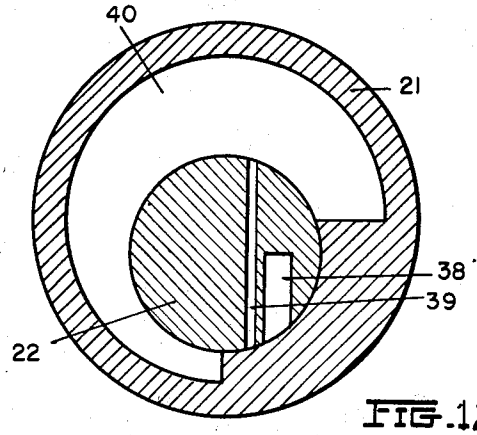


FIG. 12

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ROTARY PUMP

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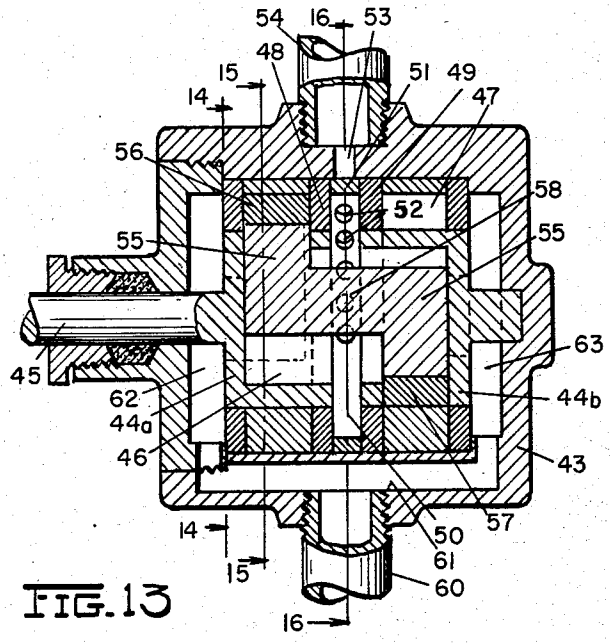


FIG. 13

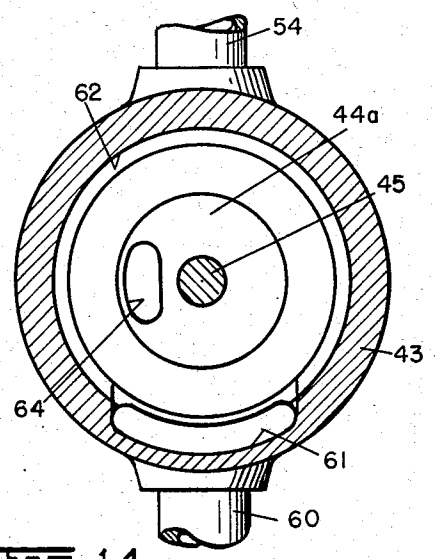


FIG. 14

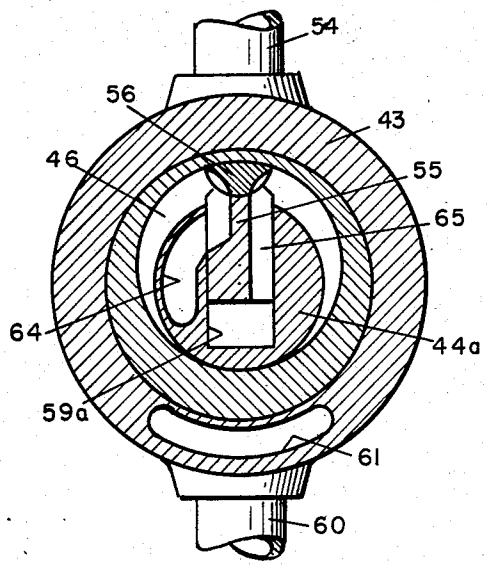


FIG. 15

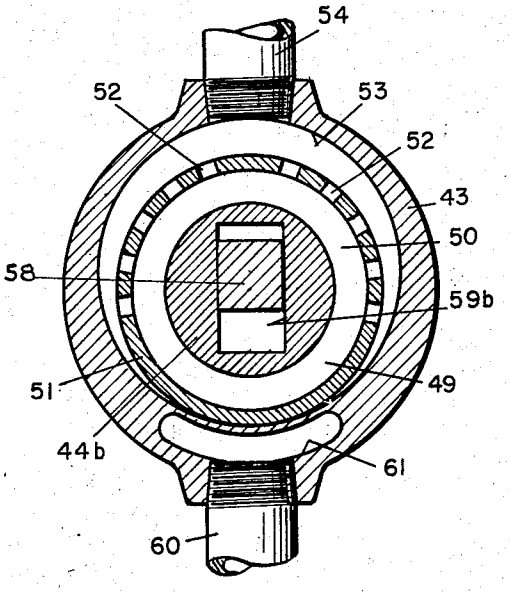


FIG. 16

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Patented Dec. 22, 1942

2,306,276

UNITED STATES PATENT OFFICE

2,306,276

ROTARY PUMP

Humphrey L. Nash, Shaker Heights, Ohio

Application June 6, 1940, Serial No. 339,154

11 Claims. (Cl. 103—137)

This invention relates as indicated to rotary pumps, and more particularly to vane type rotary pumps operative to provide non-pulsating delivery without at the same time occasioning mechanical shock to the vanes.

In modern carbureters for internal combustion engines, and especially airplane engines, it is becoming of more and more importance to provide a steady even flow of fuel under constant pressure thereto. As pointed out in Curtis Patent No. 2,165,963, prior art workers had not found it possible to construct a vane type rotary pump which would both provide non-pulsating delivery and yet be free from mechanical shock. Curtis then discloses one solution of this problem in which special cam guides are employed to conduct the vane tips from the arcuately curved pumping zone to the arcuately curved sealing zone, and vice versa. However, this type of pump chamber is somewhat complex of construction and does not permit the employment of less than six vanes, which fact, as when pumping a volatile liquid such as gasoline, may tend to cause vapor lock due to entrapment and violent working of a portion of such liquid.

It is therefore a primary object of this invention to provide a vane type rotary pump having a non-pulsating delivery and yet free from mechanical shock in operation.

Another object of this invention is to provide a pump of the type above indicated which will be simple and inexpensive to manufacture and efficient in operation.

Another object is to provide a non-pulsating rotary pump in which a single vane may be sufficient in a chamber.

Other objects of this invention will appear as the description proceeds.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims.

The annexed drawings and the following description set forth in detail certain mechanism embodying the invention, such disclosed means constituting, however, but one of various mechanical forms in which the principle of the invention may be used.

In said annexed drawings:

Fig. 1 is a cross sectional view axially of the rotor of one form of pump embodying my invention;

Fig. 2 is a sectional view through the casing and rotor of such pump taken along the line 2—2 on Fig. 1;

Fig. 3 is a sectional view of the intake valve of such pump taken along the line 3—3 on Fig. 1;

Fig. 4 is a sectional view taken through one chamber of such pump along the line 4—4 on Fig. 1;

Fig. 5 is a sectional view taken through the outlet valve of such pump along the line 5—5 on Fig. 1;

Fig. 6 is a sectional view of the other chamber of such pump taken along the line 6—6 on Fig. 1;

Fig. 7 is a sectional view taken axially of the rotor of another pump embodying my invention, such pump employing a unitary offset vane, each tip of which is reciprocable in one pump chamber;

Fig. 8 is a sectional view through the outlet valving means of such pump taken along the line 8—8 on Fig. 7;

Fig. 9 is a sectional view of the inlet valving means for one of such chambers taken along the line 9—9 on Fig. 7;

Fig. 10 is a sectional view through one pump chamber taken along the line 10—10 on Fig. 7;

Fig. 11 is a sectional view taken through the other pump chamber along the line 11—11 on Fig. 7;

Fig. 12 is a sectional view of the inlet valving means for such last named chamber taken along the line 12—12 on Fig. 7;

Fig. 13 is a sectional view axially of the rotor of another pump embodying my invention in which ports are provided through the vanes;

Fig. 14 is a transverse sectional view through such pump taken along the line 14—14 on Fig. 13;

Fig. 15 is a sectional view taken along line 15—15 on Fig. 13; and

Fig. 16 is a sectional view along the line 16—16 on Fig. 13 showing the discharge outlet.

Referring now more particularly to said drawings, and especially Figs. 1 to 6, the embodiment of my new invention there illustrated comprises a pump casing 1 in which is journalled a rotor 2 adapted to be driven through drive shaft 3. As shown in Figs. 1 and 2, a central wall 4 divides the interior of such casing into two pump chambers 5 and 6. In each of such chambers respectively and reciprocable in the rotor are unitary vanes 7 and 8, the bore of each of said chambers, i. e., the cam track followed by the vane tips, describing equal limaçon curves.

Also formed in said casing parallel to the axis of the rotor are two canals 9 and 10, the first communicating with inlet passage 11 and the latter with outlet passage 12. Canal 9 also com-

municates directly with chamber 6 and indirectly through passage 13 and port 14 or 15 in rotor 2 with chamber 5. Likewise, chamber 5 communicates directly with canal 10 (see Fig. 4) and chamber 6 indirectly thereto by way of port 16 or 17 in the rotor and passage 18. On the inlet side of chamber 6 and on the outlet side of chamber 5 cam guides 19 and 20 are provided respectively for the vane tips.

The operation of the above described embodiment of my new pump may now be explained. As rotor 2 turns in a clockwise direction, as view in Figs. 2 to 6, inclusive, liquid will be drawn in to chamber 5 through passage 11, canal 9, inlet passage 13 and either port 14 or 15 depending on which vane tip is passing through the pumping zone. As shown in Figs. 4 and 6, the lower ends of the vane tips are respectively just entering and leaving the pumping zone. As the vane tip moves through the pumping zone, the port in the rotor rearwardly thereof will be in communication with passage 13 and liquid will be drawn in behind such tip. Simultaneously, this vane tip will be discharging liquid from the pump chamber by way of canal 10 to passage 12. Referring now to Figs. 5 and 6, as the tips of vane 8 are reciprocated in chamber 6 by revolution of the rotor, liquid is drawn directly into said chamber from canal 9 and discharged through port 16 or 17, depending on which end of the vane is pumping, to passage 18 and thence to canal 10 and discharge passage 12.

Thus it will be seen that the path of the fluid being pumped is as follows:

It enters the casing 1 through inlet pipe 11 and flows into the passage 13, which is formed in the casing and is shown in Figures 3 and 1. The parts being in the positions shown, permit the fluid to pass through port 14 in rotor 2 and flow from port 14 out into chamber 5 as this port moves from the lower part of such chamber to the upper part of such chamber. The flow is occasioned by chamber 5 being evacuated, thus causing the liquid being pumped to flow upwardly out of port 14 into chamber 5 when the parts are in the position shown in Figure 4. Vane 7, as the rotor continues in a clockwise direction, now begins its pumping stroke and it forces the liquid out of chamber 5 and up through canal 10, because port 14 has been closed by the casing it being understood that the parts are slightly rotated in a clockwise direction from the position shown in Figure 4. As the vane 7 continues in a clockwise direction, the port 15 is placed in communication with the casing inlet passage 13, but the liquid being pumped cannot be forced into the port 15 since the port has passed the casing shoulder shown in the lower part of Figure 4. Obviously then, the liquid is forced out into the passage which lies radially outward of the cam track 20. It is to be noted that at this time, the port 14 does not communicate with the inlet passage 13 and that the opposite end of the vane is forcing liquid out of chamber 5 and that the only outlet is the canal 10. It is also to be remembered that the vane 7, as viewed in Figure 4, will begin to exert pumping action as the rotor revolves in a clockwise direction and that for all practical purposes, the upper end of the vane 7 performs no function as it continues downwardly. It does, however, perform a pumping action after it has reached its lowermost point.

From the foregoing it will be understood exactly how liquid being pumped passes from the inlet pipe or conduit 11 to the outlet pipe 12.

The previous operation in chamber 5 is just the reverse of the operation in chamber 6. In passing through chamber 5, liquid first entered in the passage 13 in the casing and left through the passage behind the cam truck 20 and thence outwardly through canal 10. In connection with chamber 6, the liquid being pumped passes from inlet canal 9 directly into the left-hand portion of chamber 6, as viewed in Figure 6. As the parts rotate in a clockwise direction, liquid is forced over into the right-hand part of chamber 6 as the lower end of vane 8 rises upwardly in the left-hand part of chamber 6, as shown in Figure 6. However, since the port 16 it is communication with outlet passage 18, the liquid passes from the right-hand portion of chamber 6 axially along port 16 and then through outlet passage 18 to outlet canal 10.

It is to be noted that perfect balance is obtained since there is a counterpart for every part and in each case, the action is opposite in effect and in volume.

It will thus be seen that the rate of change of fluid discharge from one chamber is always equal to but opposite in sign to that from the other chamber so that the combined discharge of passage 12 is always a constant. Since the bores or cam tracks of such chambers describe equal limaçon curves there will of course be no mechanical shock and unitary vanes may be employed, as well known in the art. By the employment of oppositely disposed pumping zones, which thus complement each other, and the provision of inlets and outlets respectively in communication, it is therefore possible to obtain the primary objects of this invention, namely constant non-pulsating delivery together with an absence of mechanical shock.

Another embodiment of my invention which has certain advantages over that just described is illustrated in Figs. 7 to 12 inclusive. As best shown in Fig. 7, this embodiment comprises a pump casing 21 in which is journalled a rotor 22 adapted to be driven through drive shaft 23. The interior of such casing comprises pump chambers 24 and 25 separated by partition walls 26 and 27 forming outlet valve 28 therebetween which communicates directly with outlet passage 29. As in the previouly described embodiment of the invention, the bore of each pump chamber describes an equal limaçon curve. However, there are neither direct inlets nor outlets to or from such chambers. Instead, outlet ports 30 and 31 are provided in the rotor as shown in Figs. 8, 10 and 11, such ports being in communication with passage 28 except for a portion of the revolution of the rotor during which period they are cut off, as shown in Fig. 8. Small auxiliary ports 32 and 33 are also provided in the rotor, such ports affording constant communication between passage 28 and chambers 24 and 25, even when primary outelt ports 31 and 30 are respectively sealed. Chamber 24 is in communication with inlet passage 34 and inlet conduit 35 by way of port 36 in the rotor. A small auxiliary port 37 is also provided which maintains constant communication between said chamber and said passage even when primary port 36 is sealed. A similar intake port 38 and an auxiliary port 39 connects chamber 25 with intake passage 40 and intake conduit 41. Reciprocably mounted in the rotor is an offset unitary vane 42 one end of which travels in contact with the peripheral

surface of chamber 24 and the other end in contact with the surface of chamber 25.

The operation of this embodiment of my invention may now be understood as follows. As rotor 22 revolves, vane 42 is reciprocated within said rotor, fluid being drawn in behind each vane end through intake passages 34 and 40 and intake ports 36 and 38 respectively, a portion of the intake of course also passing through auxiliary ports 37 and 39. When a vane end passes through the sealing zone, as illustrated in Fig. 11 and during a portion of the revolution immediately preceding this point, intake port 38 is closed, as shown in Fig. 12, and for a considerable portion of the revolution of the rotor the entire intake is through auxiliary port 39 which, however, quite suffices since the vane end during this portion of the revolution of the rotor is discharging a relatively small amount of fluid. Similarly the discharge from chamber 25 through port 31 to outlet valve 28 is cut off for a considerable period, as shown in Fig. 8, all fluid passing through auxiliary port 32. It is apparent, therefore, that there will be a very brief moment, defined by the thickness of the wall separating the primary and auxiliary ports, during which the auxiliary inlet port will be open to the inlet valve and the auxiliary outlet port simultaneously in communication with the outlet valve. However, due to the small size of such auxiliary ports and the extremely brief period during which they are in communication, any pulsation which might occur is so small as to be imperceptible.

It will of course be understood that inlet conduits 35 and 41 may be in direct communication with each other as by joining them to the same lead from a fuel tank or the like.

As described and explained above, a novel pump has thus been provided which is capable of constant non-pulsating delivery without mechanical shock to the mechanism, and, further, in which any possible loss of power due to the drag of a vane end through the discharge zone is avoided. It is also obvious that a plurality of more than two chambers might be employed without departing from the scope of this invention, and likewise, that my new pump may instead be employed as a motor. While the outlets from the pumping chambers must be in communication in order to provide non-pulsating delivery, it is not necessary that the inlets communicate, although such will generally be the case.

The embodiment of my invention illustrated in Figs. 13 to 16, inclusive, affords a number of additional advantages including simple valving means and an avoidance of ports in the rotor at points spaced from the vanes. As best shown in Fig. 13, this embodiment comprises a pump casing 43 in which is journalled a divided rotor 44*a* and 44*b* adapted to be driven through dive shaft 45. The interior of such casing comprises pump chambers 46 and 47 separated by partition walls 48 and 49 which form a discharge collecting cavity 50 therebetween circumferentially bounded by a spacer band 51 pierced by holes 52 affording communication between cavity 50 and outer chamber 53 to a common discharge passage 54. As in the previously described embodiments of the invention, the bore of each pump chamber describes an equal limaçon curve. Reciprocally mounted in the respective segments of said divided rotor is a unitary offset vane 55 having rocker tips 56 and 57 contacting the limaçon curve liners of said pump chambers 46 and 47. The intermediate portion 58 of said offset vane passes through openings 59*a* and 59*b* in the inner faces of said rotor segments, the vane serving to position such segments axially within the casing and also affording the means whereby segment 44*b* is maintained in driven engagement with segment 44*a*.

An inlet passage 60 communicates with a canal 61 in the casing which in turn connects with chambers 62 and 63 disposed axially of said rotor segments. In the outer ends of each of said rotor segments are inlet ports such as 64 in constant communication with chambers 62 and 63 respectively. The vane ends are partially cut away, as shown in Fig. 15, so that as the rotor revolves in a clockwise direction as viewed in Fig. 15 liquid may enter behind the vane through port 64 and pass into chamber 46. Liquid on the pressure side of the vane will be forced out of such chamber by way of the outlet port 65 in such vane and thence through opening 59*a* into cavity 50 from which it flows through holes 52 to chamber 53 and outlet passage 54. Of course as a vane end is forced into the rotor as the latter rotates, the rocker tip will gradually close both the inlet and the outlet ports in such vane end, until such ports are simultaneously completely closed. It will thus be seen that a pump has been provided in which but a single vane end is employed in a chamber, such vane end pumping continuously with rotation of the rotor except for the moment when it is entirely retracted in the rotor. Since each vane end is pumping in a complementary pumping zone, the joint discharge of the two chambers will be uniform and pulsationless. Since limaçon curve chambers are employed there will also be no mechanical shock. The segments of the rotor may be joined to form a unitary assembly, if desired.

In addition to the obvious advantages of the above described construction, it is apparent that such construction makes many other improvements possible. For instance, the intermediate portion of the vane may be formed as a separate element fitting in sockets in the two true vanes. The small amount of play therebetween would permit the automatic take-up of wear on the rockers.

When employing a plurality of limaçon pumping chambers in accordance with my invention it is apparent that various combinations are possible such as one large chamber and two small chambers, the vanes in the two small chambers pumping in zones complementary to the vane or vanes in the large chamber, the relative sizes of such chambers being so chosen as to provide pulsationless delivery. Generally, however, the simplest form comprising two equal chambers with vanes in complementary zones and outlets in communication will be preferred. If the vanes are not quite oppositely disposed in relation to the respective limaçon curve liners there will be a degree of pulsation although, of course, not as serious as in a pump not having even partially complementary pumping zones. Unless the vane ends are directly opposed, unitary vanes cannot be employed and spring backed vanes or the like must be used.

In the past, the method most generally employed to reduce pulsation was to provide a large number of vanes with resultant increase in assembly difficulties and wear in use. As above explained, a pump may be constructed in accordance with my invention employing only one vane, such pump being well-balanced, long-wear-

ing and efficient in operation. One end of such vane pumps in one chamber, the other end in the other chamber. It is, of course, possible to employ a plurality of such unitary vanes if desired.

While it is believed that those skilled in the art will have little difficulty in understanding the above explanation of my invention, a brief summary of the mathematics involved may be helpful. The formula for a limaçon curve is

$$r=a-b\cos\theta$$

where a is a constant, b is less than a, and r is the distance from the point from which the curve is generated to any point on such curve (such point also being the center of rotation of the rotor). Such curve is well known and has long been employed in rotary pumps since it is the only curve permitting the use of unitary vanes passing through the center of the rotor. However, due to the shape of such curve, the volume of liquid being discharged by any vane end during a stated degree of angular rotation will vary radically with consequent pulsation in the discharge line. While this situation may be somewhat ameliorated by the provision of a larger number of vanes, other complications then arise without having obtained truly pulsationless delivery. Prior art workers, such as Curtis, therefore turned to other curves and combinations of curves to attack the problem. But by employing my invention absolutely pulsationless delivery may be obtained without abandoning the other known advantages of limaçon curve pumps.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the mechanism herein disclosed, provided the means stated by any of the following claims or the equivaent of such stated means be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In a vane type rotary pump, at least two limaçon pump chambers, a rotor in each of said chambers, a vane in each of said rotors and reciprocable therein, the corresponding ends of said vanes being disposed 180° apart relative to the respective limaçon curves engaged thereby so that the sum of the effective pumping areas of said vanes is at all times a constant, fluid inlet means communicating with said chambers rearwardly of such vane ends, fluid outlet means communicating with each of said chambers forwardly of such vane ends, said outlet means being in communication with each other, and means operative to synchronize the rotation of said rotors.

2. In a vane type rotary pump, a plurality of limaçon pump chambers, rotors therein, a vane in each of said rotors and reciprocable therein, the ends of said vanes in certain of said chambers being disposed 180° apart relative to the corresponding ends of the vanes in the other said chambers in relation to the respective limaçon curves engaged thereby and the size and number of said chambers being so chosen that the sum of the effective pumping areas of said vanes is at all times a constant, fluid inlet means communicating with said chambers rearwardly of such vane ends, fluid outlet means communicating with each of said chambers forwardly of such vane ends, said outlet means being in communication with each other, and means operative to synchronize the rotation of said rotors.

3. In a vane type rotary pump, at least two limaçon pump chambers, a rotor in each of said chambers, a vane in each of said rotors and reciprocable therein, the ends of said vanes in certain of said chambers being disposed 180° apart relative to the corresponding ends of the vanes in the other said chambers in relation to the limaçon curves engaged thereby so that the sum of the effective pumping areas of said vanes is at all times a constant, fluid inlet means passing through said rotors and entering said chambers rearwardly of such vane ends, fluid outlet means passing through said rotors and communicating with said chambers forwardly of such vane ends, said outlet means being in communication with each other, and means operative to synchronize the rotation of said rotors.

4. In a vane type rotary pump, at least two limaçon pump chambers, a rotor in each of said chambers, a vane in each of said rotors and reciprocable therein, not more than one vane end in each chamber being operative as a pumping element at any one time, the ends of said vanes in certain of said chambers being disposed 180° apart relative to the corresponding ends of the vanes in the other said chambers in relation to the limaçon curves engaged thereby, fluid inlet means passing through said rotors and entering said chambers rearwardly of such vane ends, fluid outlet means passing through said rotors and communicating with said chambers forwardly of such vane ends, and means operative to synchronize the rotation of said rotors.

5. In a vane type rotary pump, a plurality of limaçon pump chambers of equal bore, a rotor in said chambers, vanes in said chambers and reciprocable in said rotor, the ends of said vanes operative as pumping elements at any one time in certain of said chambers being oppositely disposed to such ends in the other said chambers in relation to the limaçon curves of said respective chambers, inlets to said chambers, and outlets from said chambers in communication with each other.

6. In combination, two limaçon pumps respectively comprising casings of equal limaçon bore in axial alignment, rotors in said casings, a unitary vane slidably mounted in said rotors, one end of said vane engaging the inner surface of one of said casings and the other end of said vane engaging the inner surface of the other of said casings at a point diametrically opposite on the limaçon curve thereof, inlet ports through said rotors communicating with the interior of said casings rearwardly of said vane ends, and outlet ports through said rotors communicating with the interior of said casings forwardly of said vane ends, said outlet ports being in communication with each other.

7. In a vane type rotary pump, adjacent paired limaçon pump chambers in axial alignment, a rotor revoluble therein, a unitary offset vane reciprocable in said rotor with one end of said vane in sliding engagement with the surface of one of said chambers and the other end in sliding engagement with the surface of the other of said chambers at a diametrically opposite point thereon, inlet ports through said rotor and cut-away portions of the suction sides of said vane ends, outlet ports through cut-away portions of the pressure sides of said vane ends and through said rotor, and rocker tips for said vane ends operative to seal said respective inlet and outlet ports when said vane ends are fully retracted, the dis-

charge from said outlet ports being conducted to a common passage.

8. In a vane type rotary pump, two similar pump chambers, rotors eccentrically disposed in said chambers, the inner peripheries of said chambers comprising curves in which the sum of the lengths of the opposite polar coordinates is a constant, the poles of such curves being the centers of rotation of said rotors, a vane in each of said rotors in sliding engagement with the inner peripheries of said respective chambers, only a single vane end being operative as a pumping element in each of said chambers at any one time, such operative vane ends being oppositely disposed relative to the curves of the inner peripheries of said respective chambers, inlets to said chambers, outlets from said chambers in communication, and means operative to synchronize the rotation of said rotors.

9. In a vane type rotary pump, two similar pump chambers, a rotor eccentrically disposed in said chambers, the inner peripheries of said chambers comprising curves in which the sum of the lengths of the opposite polar coordinates is a constant, the poles of such curves being the center of rotation of said rotor, an offset unitary vane in said rotor, one end of said vane being in sliding engagement with the surface of one of said chambers and the other end in sliding engagement with the surface of the other of said chambers at a diametrically opposite point on the curve thereof so that the sum of the extension of the vane ends from the rotor is at all times a constant, inlet ports through said rotor on the suction sides of said vane ends, and outlet ports through said rotor on the pressure sides of said vane ends, said outlet ports being in communication.

10. In a sliding vane type rotary pump, two similar pump chambers, rotors eccentrically disposed in said chambers, the inner peripheries of said chambers comprising curves in which the sum of the lengths of the opposite polar coordinates is a constant, the poles of such curves being the centers of rotation of said rotors, a vane reciprocable in each of said rotors in sliding engagement with the inner peripheries of said respective chambers, the corresponding ends of said vanes being disposed 180° apart relative to the respective curves engaged thereby so that the sum of the effective pumping areas of said vanes is at all times a constant, fluid inlet means communicating with said chambers rearwardly of such vane ends, fluid outlet means communicating with each of said chambers forwardly of such vane ends, said outlet means being in communication with each other, and means operative to synchronize the rotation of said rotors.

11. In a sliding vane type rotary pump, two similar pump chambers, rotors eccentrically disposed in said chambers, the inner peripheries of said chambers comprising curves in which the sum of the lengths of the opposite polar coordinates is a constant, the poles of such curves being the centers of rotation of said rotors, a vane reciprocable in each of said rotors in sliding engagement with the inner peripheries of said respective chambers, the corresponding ends of said vanes being disposed 180° apart relative to the respective curves engaged thereby so that the sum of the extension of the operative vane ends from the rotors is at all times a constant, fluid inlet means communicating with said chambers rearwardly of such vane ends, fluid outlet means communicating with each of said chambers forwardly of such vane ends, said outlet means being in communication with each other, and means operative to synchronize the rotation of said rotors.

HUMPHREY L. NASH.