Oct. 12, 1965 O. E. ROSAEN 3,211,104

PUMPS

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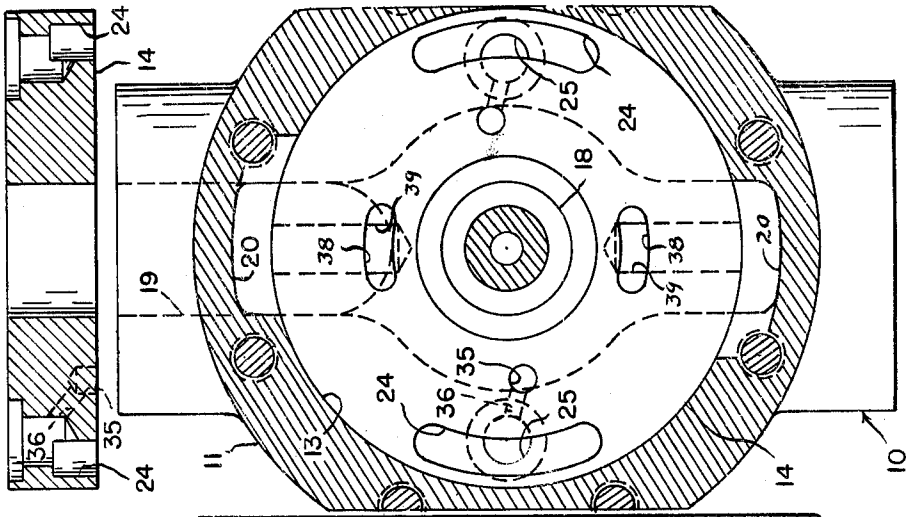

FIG. 3.

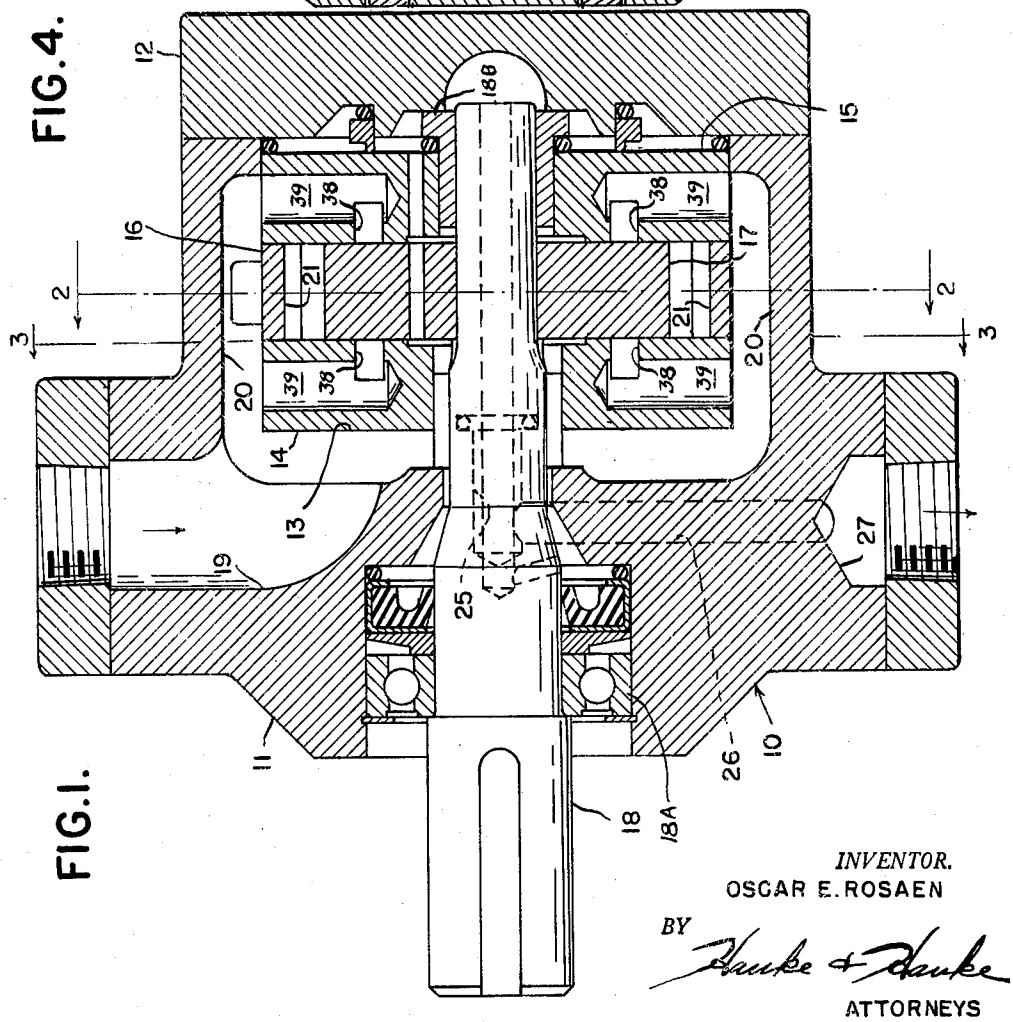

FIG. 4.

FIG. 1.

INVENTOR.
OSCAR E. ROSAEN

BY Hauke & Hauke

ATTORNEYS

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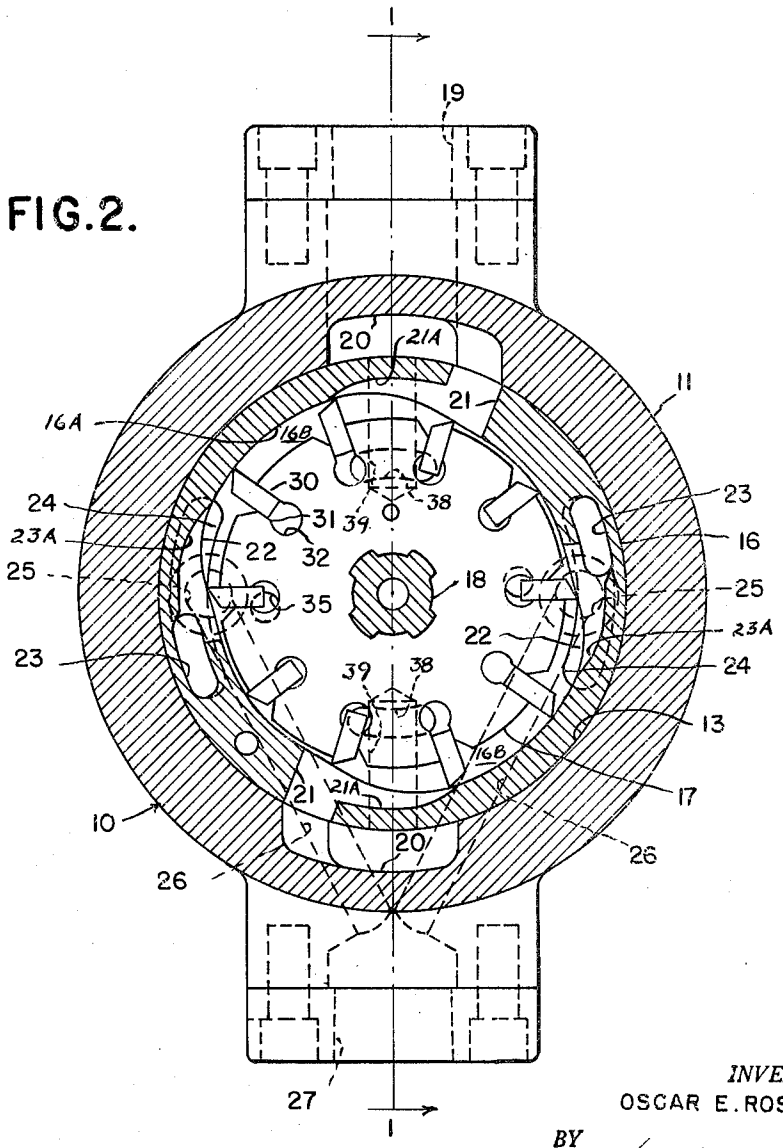
FIG.2.



INVENTOR.
OSCAR E. ROSAEN

BY Hauke & Hauke

ATTORNEYS

Oct. 12, 1965 O. E. ROSAEN 3,211,104

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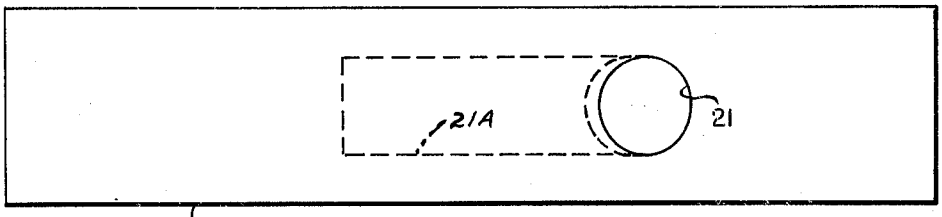

FIG.6.

FIG.5.

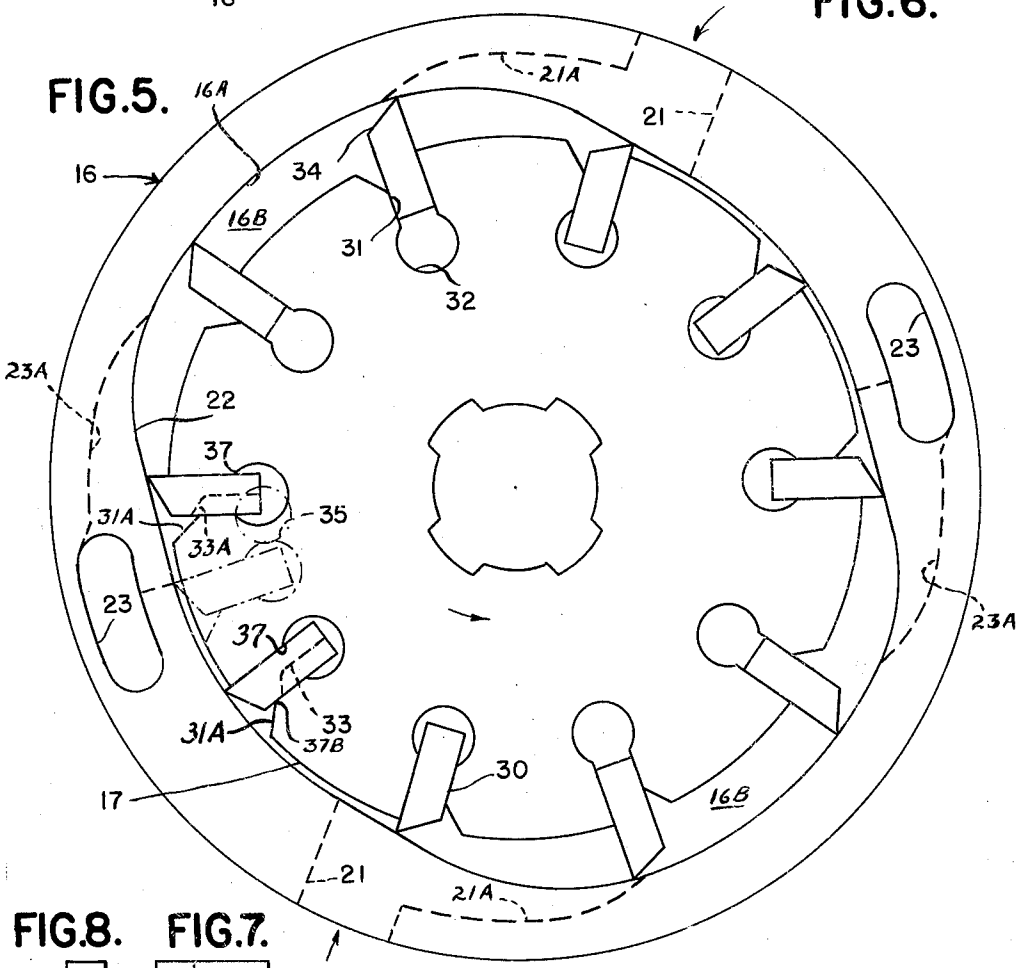

FIG.8.

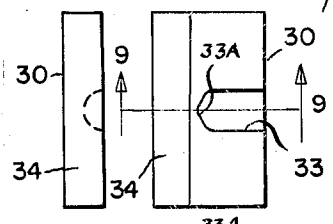

FIG.7.

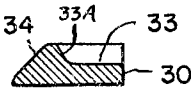

FIG.9.

INVENTOR.
OSCAR E. ROSAEN
BY
Hauke & Hauke
ATTORNEYS

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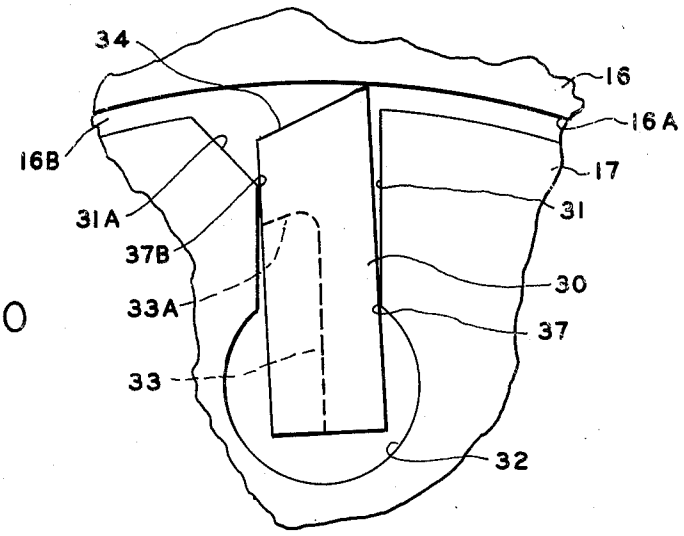

FIG. 10

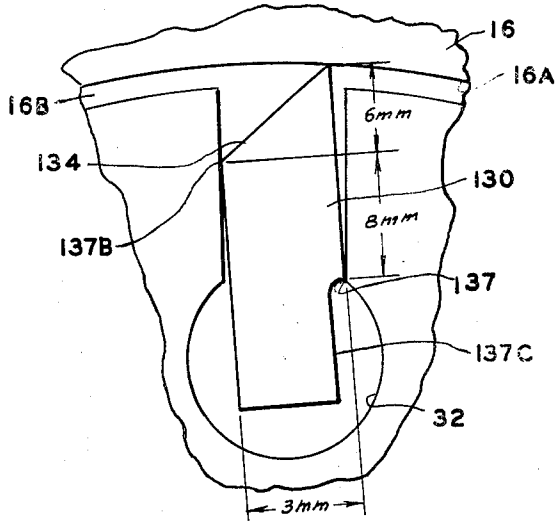

FIG. 11.

INVENTOR.
OSCAR E. ROSAEN

BY Dauke & Dauke

ATTORNEYS

United States Patent Office 3,211,104 Patented Oct. 12, 1965

3,211,104

PUMPS

Oscar E. Rosaen, Grosse Pointe, Mich.

Filed Aug. 2, 1963, Ser. No. 303,198
5 Claims. (Cl. 103—136)

The present application is a continuation-in-part of my copending application Ser. No. 90,294, filed Feb. 20, 1961, now abandoned.

The present invention relates to rotary vane type fluid pumps and more particularly to an improvement in pressure balancing of the vanes of such pumps as those I have disclosed in my copending application Ser. No. 765,605, filed Oct. 6, 1958 now Patent No. 3,000,324 issued Sept. 19, 1961 and Ser. No. 765,606, also filed Oct. 6, 1958.

U.S. Patents Nos. 2,612,114 and 2,612,115 issued to W. Ernst on Sept. 30, 1952 disclose and claim vane type pumps in which pressure balancing of the vanes is achieved by providing an axial bore beneath each vane element and by providing means for regulating the pressure in the axial bores to maintain contact between the ends of the vane element and the cam surface. It has been found that in pumps of the type disclosed in the aforementioned Ernst patents that as the vanes travel through the area between the outlet and the inlet of the pump the inlet suction pressure on the forward face of the vane element and the high outlet pressure on the rearward face of the element causes the element to move against the forward face of the vane slot. The fluid on the rearward side of the vane element then escapes beneath the vane element and because a sealing fit cannot be produced between the vane slot and the forward face of the vane element, fluid beneath the vane element will escape to the suction side of the vane element.

To overcome this problem many other types of pumps have been provided in which slipper elements or the like are provided to replace the vane elements. Such pumps are disclosed in U.S. Patents Nos. 3,009,420 and 3,009,421, issued to W. T. Livermore et al. on Nov. 21, 1961. Such pump utilize a portion of the pressure beneath the slipper elements to force the depending legs of the elements against the sides of the slots. In this way a seal is produced and the fluid beneath the element is prevented from escaping. Such pumps have the disadvantages that the slipper elements are difficult and expensive to manufacture and high pressures must be maintained beneath the element to insure the necessary contact between the end portions of the element and the cam ring because of the resistance to outward movement of the element produced by the sealing contact between the legs of the element and the sides of the slot.

In the pumps disclosed in my first mentioned copending applications the effectiveness of pressure balancing of the vanes is insured by using vane-like sealing elements positioned intermediate the pumping vanes. The sealing vanes contact the cam ring during travel through the critical area from the outlet or discharge port to the inlet area of the chamber and thus seal the rearward face of the pumping vanes from the high outlet pressure. Although the sealing vanes effectively eliminate the problem in this area of the pumping cycle, they are rather small and hence difficult to manufacture and handle and constitute an added expense in the manufacture of vane type pumps.

The present invention eliminates the need for such sealing vanes by providing a means of utilizing the differential in pressures in the area between the inlet and the outlet to tip the vane element and produce a sealing engagement between portions of the vane element and the walls of the slot. In this way pressure beneath the vane is sealed in and prevented from escaping.

One object then of the present invention is to maintain pressure balancing of the vane elements in all areas of the pumping cycle without the necessity of using sealing means.

Another object of the invention is to improve rotary vane pumps by providing vane elements which are ballanced by fluid pressures as nearly as possible in all directions to provide silent operation and elimination of pressure surges.

A further object of the invention is to simplify manufacture, handling and assembly of rotary vane pumps by providing passages for fluid pressure operative to maintain pressure balancing on the vanes at all times.

Yet another object of the invention is to improve rotary vane pump operation by providing pressure balanced vanes which in themselves act, during travel from the outlet areas to the inlet areas of the pumping chamber, to provide a sealing engagement with the sides of the slot to maintain a separation of the fluid pressures acting on the vane elements during such periods of travel.

For a more complete understanding of the present invention, reference may be had to the accompanying drawings in which like reference characters refer to like parts throughout the several views and in which

FIG. 1 is a longitudinal cross-sectional view of a preferred rotary vane pump embodying the invention and as taken substantially on the line 1—1 of FIG. 2.

FIG. 2 is a cross sectional view of the pump taken substantially on the line 2—2 of FIG. 1.

FIG. 3 is a cross-sectional view of the pump taken substantially on the line 2—2 of FIG. 1.

FIG. 4 is a cross-sectional view of a cheek plate portion of the pump on a plane normal to the plane of the cross-section of FIG. 1.

FIG. 5 is an axial elevational view of the rotor and cam components of the pump.

FIG. 6 is a side elevational view of the cam component shown in FIG. 5.

FIG. 7 is an elevational plan view of a vane embodied in the pump rotor.

FIG. 8 is an end elevational view of said vane.

FIG. 9 is a cross-sectional view taken substantially on line 9—9 of FIG. 7.

FIG. 10 is an enlarged fragmentary elevational view of structure shown in FIG. 5, and

FIG. 11 is a view similar to FIG. 10 but illustrating another preferred construction of the pump of the present invention.

Description

The preferred pump **10** comprises a housing structure **11** provided with an end plate **12** enclosing a substantially cylindrical pumping chamber **13**. An inner cheek plate **14** and an outer cheek plate **15** are disposed in the chamber **13** with an annular cam ring **16** disposed between them and having a cam surface **16A** forming the peripheral surface of a rotor chamber **16B**. A rotor **17** is rotatably carried in the chamber **16B** and is keyed to a drive shaft **18** supported by a bearing **18A** at one end of the housing **11** and a bushing **18B** mounted in the outer cheek plate **15**.

The housing **11** has a fluid inlet **19** connected with similar and diametrically opposite inlet grooves **20** in the sides of the chamber **13** to form passages extending axially between the wall of the chamber **13** and the outer surfaces of the cam ring **16**.

The grooves **20** admit fluid to intake openings **21** in the cam ring **16**, fluid thence entering the rotor chamber **16B** at what is for purposes of discussion herein called the inlet areas of the chamber **16B**. The openings **21** are elongated as at grooves **21A** shown in FIGS. 2 and

5 to provide inlet areas greater in annular length than the space between two adjacent rotor vanes.

Fluid will be impelled annularly around the spaces of the rotor chamber **16B** between the cam surfaces **16A** and the rotor **17** to an outlet area in the location of cam surface slopes **22**. A pair of diametrically opposite axially extending discharge openings **23** are provided in the cam ring **16** and are connected by grooves **23A** with the outlet areas of the rotor chamber **16B**. The grooves **23A**, like the grooves **21A**, are greater in annular length than the space between adjacent rotor vanes. Fluid from the discharge openings **23** is forced under pressure out through passages **24** provided in the inner cheek plate **14**, through discharge passages **25** and **26** in the housing **11** to a pressure fluid outlet **27**.

The pressure flow is produced by means of a plurality of axially elongated rotor vanes **30** radially slidably carried in a plurality of equally annularly spaced slots **31** provided around the periphery of the rotor **17**.

Each slot **31** communicates at its inner end with axially bored holes **32** as shown. In operation, as the rotor **17** turns, the outer edges of the vanes **30** are quided along the cam surfaces **16A**, the vanes **30** retracting in the slots **31** as they follow the cam slopes **22**. Fluid is thus impelled from the inlet to the outlet areas.

Each vane **30**, as shown in FIGS. 7, 8 and 9, is provided on its forward face with a radialy extending groove **33** and the forward outer edge is beveled as at **34** to provide substantially line contact between the vanes **30** and the cam surface **16A**, the vanes thereby being readily held outward by the pressure under the vanes as will be described, the outer end **33A** of the groove **33** being spaced slightly from the bevel **34**.

As shown in FIGS. 2 and 5, the forward outer edges of the slots **31** are beveled as at **31A**. When the vanes **30** are extended during travel from the inlet to the outlet areas of the chamber **16B**, the outer ends **33A** of the grooves **33** are radially outward of the slot bevel **31A**, the fluid presure is transmitted to the inner ends of the slots at the holes **32**, so that both ends of the vanes **30** are subjected to substantially equal pressures. Moreover, as the vanes move from the inlet to the outlet areas, pressure on the forward face is substantially balanced against the pressure on the rearward face, in the same fashion as that described in my prior patents. Thus, as pressure rises in the chamber **16B** ahead of each vane, the pressure also rises equally underneath the vanes **32**, providing for extremely silent operation with practically no pressure surges.

A difference occurs, however, as each vane **30** is retracted by the cam slope **22**. Then the groove **33** is closed off by the slot **31**, so that, as the vanes move from the outlet area to the inlet area, communication between the holes **32** and suction side of the vane **30** is substantially closed. Without more, however, the high pressure on the outlet side of the vane element **30** and the suction pressure on the inlet side of the vane element **30** would coact to press the vane element **30** against the forward face of the slot **31**. Outlet pressure would then enter the hole **32** and escape between the leading face of the vane element **30** and the wall of the slot **31** to the suction side of the element **30**. To prevent this, the slots **31** are beveled as at **31A**. As can best be seen in FIG. 10 the slot bevel **31A** provides a fulcrum at **37B** which permits the vanes **30** to tip. As the vane element **30** enters the area between the outlet and the inlet a pressure differential is produced across the extended end of the vane element **30**. The pressures between the faces of the vane element and the sides of the slot **31** as well as the pressure beneath the vane element **30** will vary but will be somewhat intermediate the suction pressure on the forward face of the extended portion of the vane element **30** and the high outlet pressure on the rearward face of the extended portion of the vane element **30**. For this reason the vane element **30** will be caused to tip forward as illustrated in

FIG. 10 and cause a substantially tight line contact between the rearward faces of the vanes and the inner edge of the slots **31** at the point **37** shown in FIGS. 5 and 10, and also between the forward faces of the vanes **30** and the outer edge of the slots **31** at the point **37B**, preventing leakage of pressure past the vanes **30**.

It is apparent that without the slot bevel **31A** not enough of the surface of the vane elements **30** would be exposed to the suction pressure and outlet presure to produce the tipping required to effectively seal the holes **32**. The slot bevel **31A** performs the dual function of promoting tipping of the vane element **30** by exposing a greater portion of the vane element to the pressure differential which produces the tipping and by providing the fulcrum point **37B** upon which the vane element **30** can tip as well as providing the closing point of the groove **33** below the halfway point of balance between the inner and outer ends of the slot **31**. In the embodiment illustrated in FIGS. 1–10 the beveled face **34** of the vane elements **30** provide substantially line contact between the vanes **30** and the cam surface **16A**.

In order to equalize the pressure on the outer ends of the vanes **30** with the pressure sealed behind the vanes **30** as the grooves are closed off on retraction and the vanes tip as described above, a port **35** is provided in the inner cheek plate **14** in a position to register momentarily with the holes **32** at the inner ends of the slots **31** as they successively pass from the outlet areas. The ports **35** are openly connected with the outlet passages **24** by means of passages **36**.

As the vanes **30** reach the inlet areas, and begin to extend the holes **32** move into registry, with elongated slots **38** provided in both inner and outer cheek plates **14** and **15**. These slots communicate with the housing inlet grooves **20** via radially extending passages **39**. This admits substantially atmospheric pressure to the inner ends of the vanes **30**, the outer ends thereof being subjected to the less than atmospheric pressure at the inlet areas of the chamber **16B**, causing the vanes **30** to extend.

FIG. 11 is a view similar to FIG. 10 but illustrates a preferred modification of the present invention. In FIG. 10, it will be noted the beveled face **34** of the vane element **30** is angled such that when the vane element **30** is in the retracted position, the edge of the bevel **34** and the leading face of the vane element is disposed above the line **37B**. In this way the edge of the slot bevel **31A** acts as the fulcrum upon which the vane element **30** is tipped. By extending the length of the bevel **134** of the vane element **130** as shown in FIG. 11, the fulcrum upon which the vane element **130** will tip becomes the edge **137B** formed by the bevel **134** and the leading face of the vane element **130**.

The vane **130** is provided with a recessed portion **137C** on the lower portion of the rearward face as shown in FIG. 11 so that a fulcrum point **137** is also provided on the rearward face of the vane **130**.

It is possible in either of the modifications described above to regulate the pressure permitted in the hole **32** before the vane elements **30** or **130** tips by changing the position of the fulcrum **37B**, **137B**, **137**. In this way, the force with which the vane **30** or **130** engages the cam surface **16A** can be regulated. The embodiment illustrated in FIG. 11 has the added advantage that this can be readily accomplished. All that is necessary is to replace the vane elements **130** with new vanes having the desired fulcrum point.

For example, if the dimensions shown in FIG. 11 are used, and the pump is operating at 1000 p.s.i., then the moment at point **137B** will equal the moment at point **137** less the unbalancing force on the forward side of the vane between the fulcrum points **137B** and **137**, or:

$$6 \cdot 1000 \cdot 3 \text{ equals } 8 \cdot 1000 \cdot 4 - (84\ P)$$

$$P \text{ equals } 437$$

Where P is the pressure in p.s.i. under the vane. The

force under the vane, which is one inch wide, urging it against the cam ring will thus be 51 lbs. since

3 mm. equals 0.117 in.

and

$0.117 \times 437 \times 1''$ equals 51

Therefore, it is clear that choosing the positions of the fulcrums actualy makes the vane itself regulate the effective pressure under the vane to whatever value is desired.

It is also apparent that although I have described but two modifications of my invention, many changes can be made without departing from the spirit of the invention as expressed by the scope of the appended claims.

I claim:

1. A rotary vane pump comprising
(a) a housing provided with a chamber having a peripheral wall,
(b) annularly spaced inlet and outlet ports connected respectively with suction and pressure portions of said chamber,
(c) a rotor rotatable in said chamber and having annularly spaced radially extending slots,
(d) vanes radially slidable in said slots and having outer ends guided in radial extension and retraction by said peripheral wall during rotation of said rotor,
(e) means providing a fulcrum line between the forward facing portion of said vanes and the adjacent face of said slot and a sealing line between the rearward facing portion of said vanes and the adjacent face of said slot, said fulcrum and sealing lines being at all times at fixed relative positions, whereby when pressure on the rearwardly facing side of said vane is greater than the pressure on the forwardly facing side thereof, said vane will be caused to tip on said fulcrum to produce sealing line contact at the fulcrum line and the sealing line with the faces of said slot.

2. A rotary vane pump comprising,
(a) a housing provided with a chamber having a peripheral wall,
(b) annularly spaced inlet and outlet ports connected respectively with suction and pressure portions of said chamber,
(c) a rotor rotatable in said chamber and having spaced radial slots,
(d) vanes radially slidable in said slots and having outer ends guided in radial extension and retraction by said peripheral wall during rotation of said rotor,
(e) means causing each vane to tilt in its slot to make line sealing contact therewith when pressure on the rearwardly facing side of the vane is greater than the pressure on the forwardly facing side thereof,
(f) said means comprising said slot having a radially outward rearwardly facing face portion beveled at an angle with respect to the radially inward portion to provide a fulcrum adjacent the forwardly facing side of said vane on which said vane is caused to tilt, and
(g) said slot having a shoulder providing an edge adjacent the opposite side of said vane with said line sealing contact being obtained at said edge.

3. The pump as defined in claim 2 and in which the inner end of the beveled portion of said slot is located about midway between the inner and outer ends of the slot.

4. A rotary pump comprising,
(a) a housing provided with a chamber having a peripheral wall,
(b) annularly spaced inlet and outlet ports connected respectively with suction and pressure portions of said chamber,
(c) a rotor rotatable in said chamber and having spaced radial slots,
(d) vanes radially slidable in said slots and having outer ends guided in radial extensions and retraction by said peripheral wall during rotation of said rotor,
(e) means causing each vane to tilt in its slot to make line sealing contact therewith when pressure on the rearwardly facing side of the vane is greater than the pressure on the forwardly facing side thereof,
(f) said means comprising said vane having a radially outward face portion beveled at an angle with respect to the radially inward portion to provide a fulcrum adjacent the rearwardly facing face of said slot on which said vane is caused to tilt, and
(g) said vane having a shoulder providing an edge adjacent the opposite face of said slot with said line sealing contact being obtained at said edge.

5. A rotary vane pump comprising,
(a) a housing provided with a chamber having a peripheral wall,
(b) annularly spaced inlet and outlet ports connected respectively with suction and pressure portions of said chamber,
(c) a rotor rotatable in said chamber and having spaced radial slots,
(d) vanes radially slidable in said slots and having outer ends guided in radial extension and retraction by said peripheral wall during rotation of said rotor,
(e) means causing each vane to tilt in its slot to make line sealing contact therewith when pressure on the rearwardly facing side of the vane is greater than the pressure on the forwardly facing side thereof,
(f) the inner end of said slots each having an enlarged portion defining an edge on the inner end of the forwardly facing face making line contact with the rearward face of the vane when it tilts, and
(g) said slot having a fulcrum on the opposite face making line contact with the forward face of the vane.

References Cited by the Examiner

UNITED STATES PATENTS

2,371,081	3/45	Tucker et al.	103—136
2,435,279	2/48	Hubacker	103—136
3,008,424	11/61	Roth	103—136
3,076,415	2/63	Farron	103—136
3,159,336	12/64	Paschke	230—145

FOREIGN PATENTS

30,312	10/59	Finland.

DONLEY J. STOCKING, *Primary Examiner.*

JOSEPH H. BRANSON, JR., *Examiner.*