May 6, 1958 W. L. CABLE 2,833,465

MULTI-VANE POSITIVE DISPLACEMENT PUMP

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FIG. 1

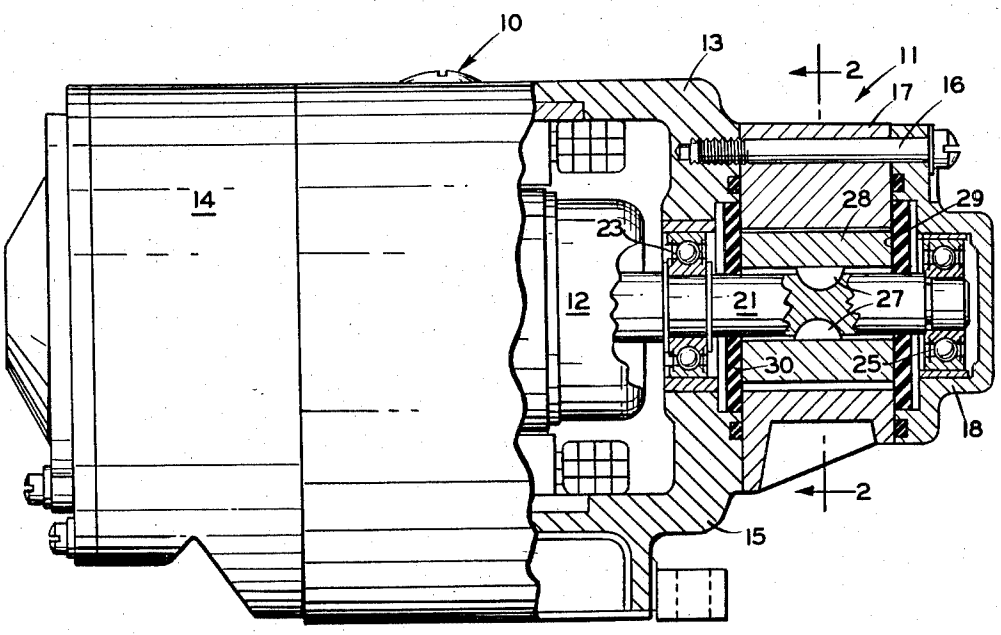
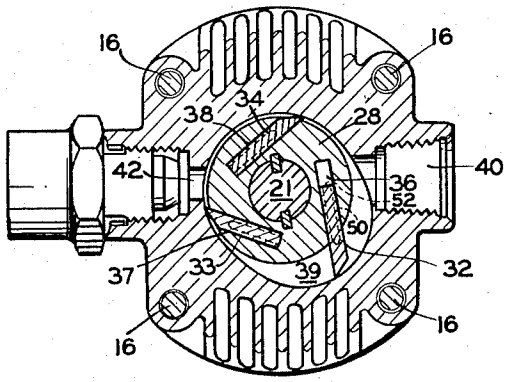


FIG. 2



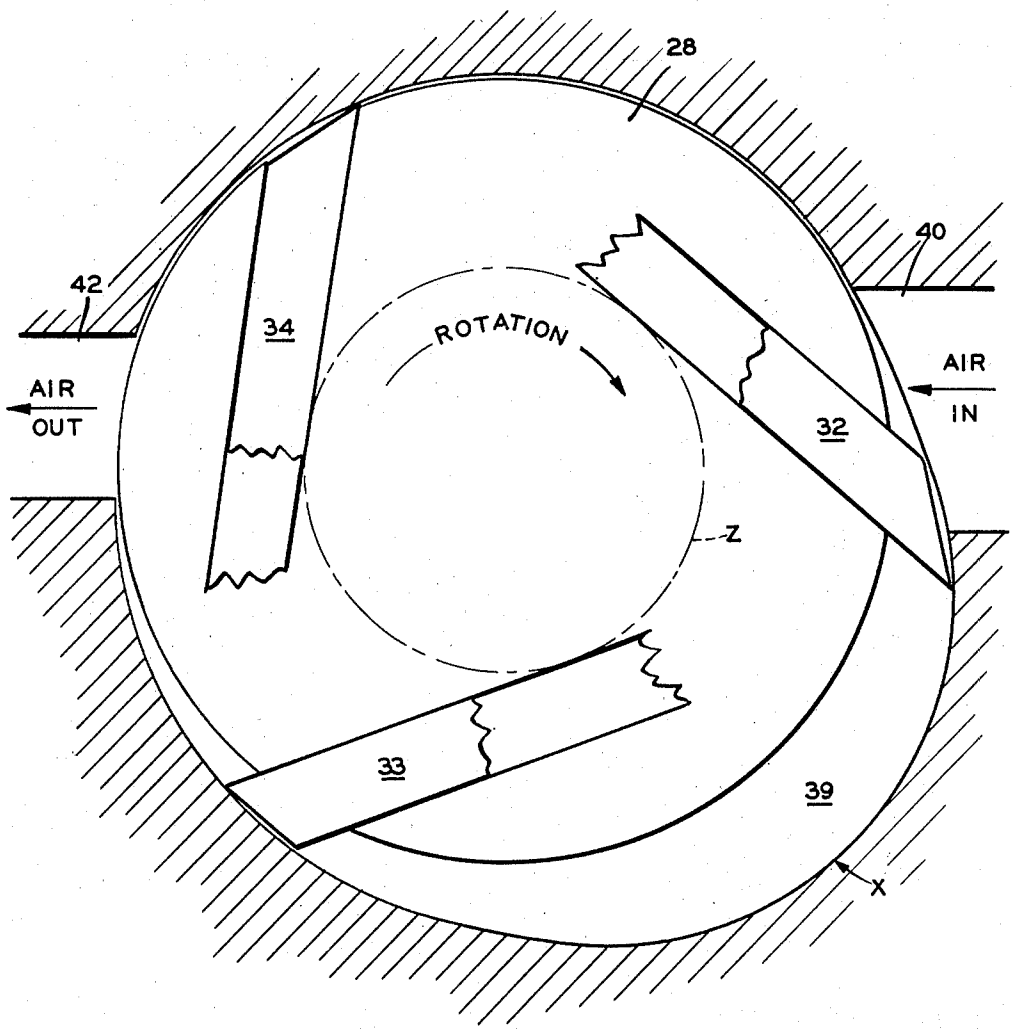
INVENTOR.
WALTER L. CABLE
BY Herbert L. Davis
ATTORNEY

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FIG. 3



INVENTOR.
WALTER L. CABLE
BY Herbert L. Davis
ATTORNEY

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FIG. 4

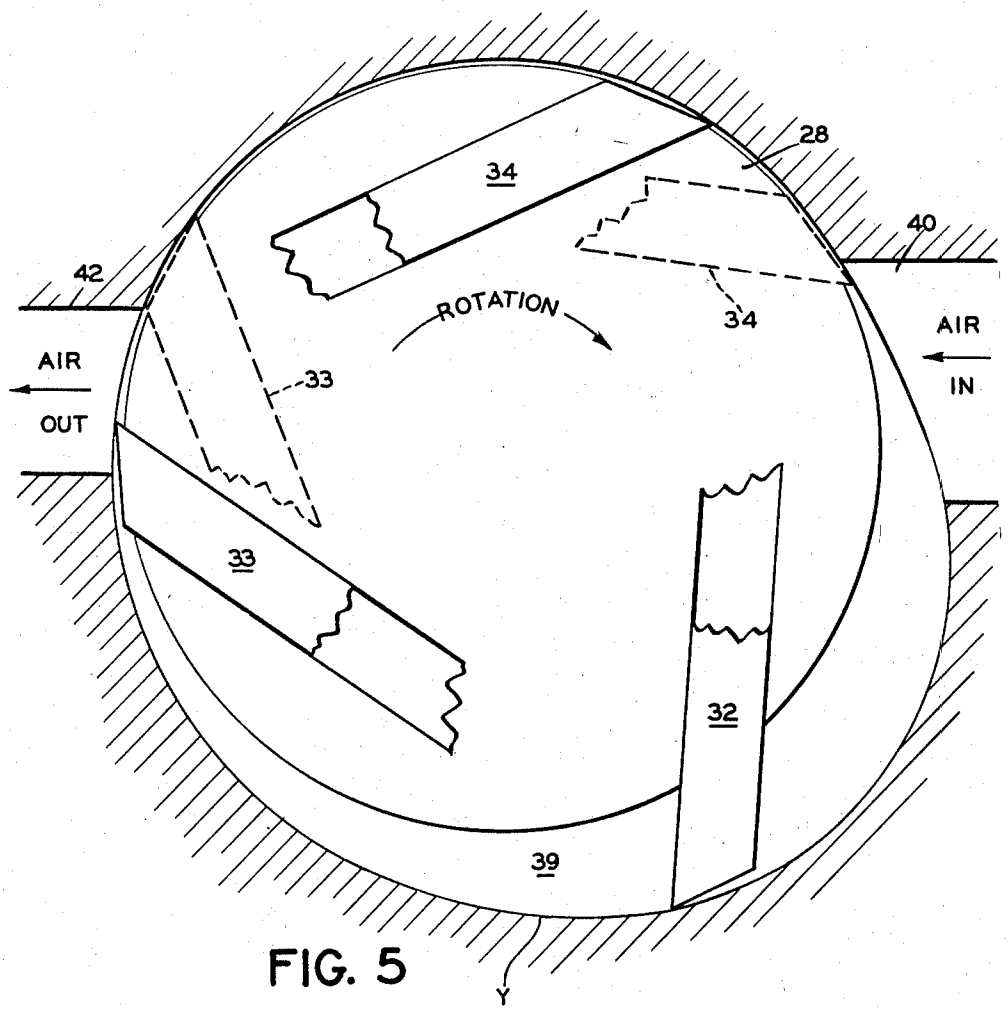
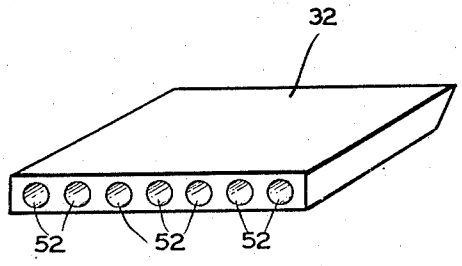


FIG. 5



INVENTOR.
WALTER L. CABLE
BY Herbert L. Davis
ATTORNEY

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MULTI-VANE POSITIVE DISPLACEMENT PUMP

Walter L. Cable, New Milford, N. J., assignor to Bendix Aviation Corporation, Teterboro, N. J., a corporation of Delaware

Application August 2, 1955, Serial No. 525,846

2 Claims. (Cl. 230—152)

This invention relates to an improved rotary multi-vane positive displacement pump of a type disclosed and claimed in a copending application Serial No. 526,032, filed August 2, 1955, by Edward C. Breinig and Edward V. Manning, and more particularly to the structure of the vanes of such pump.

In multi-vane pumps of the aforenoted type, pumping vanes of the conventional solid type slidably fitted with close tolerance within corresponding rotor slots have certain disadvantages in that as each vane slides from its innermost to its extreme outward position, a suction force is created in its rotor slot at the inner end of the solid type vane which tends to retard the vane from moving outwardly under centrifugal force to contact the pump housing surface at its vane tip. This lack of proper contact between the tips of the solid type vanes and the inner pump housing surface would result in a loss in pumping or volumetric efficiency in allowing the pumped air or gaseous medium to leak between the vane tips and the pump housing instead of the respective pump vanes containing the pumped air or gaseous medium as a slug and moving it towards the pump discharge port after the trailing pump vane has passed the inlet port.

An object of the invention is to avoid these disadvantages incident to such solid type vanes by providing a relieved section or volume in each vane in the vane surface facing the bottom of the rotor slot in which the vane is slidably mounted so as to minimize this suction effect and avoid the leakage paths aforenoted.

Another object of the invention is to provide in the inner end surface of each of the aforenoted vanes a series of holes having openings facing the bottom of the rotor slot in which the vane is slidably mounted so as to provide a relief volume, which volume built into the vane causes the air or gaseous medium entrapped therein and between the vane and inner end of the rotor slot to act as a variable rate spring which can adjust itself to particular inlet and outlet conditions of operation so as to provide the following improvements over the conventional solid type vane: (1) a much higher outlet flow of the pumped gaseous medium at a particular operating condition, (2) a higher pump suction under no flow conditions, and (3) less vane wear at the tips of the vanes due to the decrease in weight of each vane obtained by including the relief volume in the vane itself.

A further object of the invention is to provide a compact air pump of great efficiency in comparison to its size and of such simplicity in construction as to adapt it for manufacture and installation at low cost.

Other objects and advantages of this invention are set forth in the following description, taken with the accompanying drawings; and the novel features thereof are pointed out in the appended claims. The disclosure, however, is illustrative only and there may be changes in detail, especially in matters of shape, size and arrangement of parts within the principle of the invention to the full extent indicated by the broad and general meanings of the terms in which the appended claims are expressed.

In the accompanying drawings which form a part of this specification, like characters of reference indicate like parts in the several views wherein:

Figure 1 is a fragmentary side view, partially in section, of a rotary multi-vane positive displacement pump in which there may be embodied the novel features of the present invention;

Figure 2 is a sectional end view of Figure 1 taken along the lines 2—2 and showing the relationship of the rotor and vane assembly in the pump cavity and by dotted lines in the pump vanes the relief section or excess volume built into the vanes;

Figure 3 is a diagrammatic view illustrating the manner in which the gaseous medium or air entering through the pump inlet is entrapped between vanes of the pump at substantialy the same pressure as that entering the inlet port of the pump;

Figure 4 is a diagrammatic view illustrating the manner in which the air entrapped in the pump cavity may be compressed between the pump vanes and the decreasing contour of the pump chamber, and also showing by dotted lines that there is provided a minimum of at least one vane in contact with the cavity contour between the inlet and outlet ports at all times so as to prevent leakage of the relatively high pressure air from the discharge port back to the inlet port;

Figure 5 is an enlarged perspective view of a novel pump vane showing a series of holes therein having openings in the bottom surface of the vane.

Referring to the drawing of Figure 1, there is shown a rotary air pump of a type disclosed and claimed in the aforenoted copending application and including a power unit **10** and a pumping assembly **11** constructed and arranged to be mounted and driven by the power unit **10**.

In the last-mentioned type of pump, the power unit 10 comprises an electric motor **12** suitably mounted and enclosed within a hollow housing or casing **13**, an end wall **14** closing one end of the housing **13**, while the air pump unit **11** is suitably fastened to an opposite end wall **15** of housing **13** by bolts **16**.

The pump assembly **11** comprises a casing **17** and a head wall **18**. Head wall **18** is secured to the casing **17** and the end wall **15** of the casing **13** by the bolts **16** which pass through tubular openings in the head **18** and casing **17** and screw-threadedly engaged in the wall **15**.

Motor **12** is provided with a shaft **21** rotatably mounted in bearings **23** and **25** carried by the end wall **15** and the head **18**, respectively. Secured to the shaft **21** by keys **27** for rotation therewith is a rotor member **28**. End plates **29** and **30** are provided in the end wall **15** and head **18**, respectively to sealingly engage the side of the rotor member **28** and rotor vanes **32**, **33** and **34** slidably mounted therein, as best shown in Figure 2.

The cylindrical rotor **28** has formed therein suitable longitudinal slots **36**, **37** and **38** each extending, as indicated in Figure 3, tangent to a circle Z having a common center to that of the rotor **28** and, as shown in Figure 2, in spaced relation to and in a plane at one side of the shaft **21** and center of rotation of the member **28**. Slidably mounted in the slots **36**, **37** and **38** and extending from the rotor member **28** at an acute angle to the circumferential surface thereof and in a direction corresponding to the direction of rotation of member **28** are the vanes **32**, **33** and **34**, respectively. The outer edges of the vanes make contact with a profile of a pump cavity or chamber of oval cross-section formed within the casing **17** and act to seal at all times the pump inlet **40** from the pump outlet **42** so as to prevent back rush of high pressure gaseous medium from the outlet to the inlet through the pump cavity, as shown diagrammatically by Figures 3 and 4. It is to be noted that about

one-half of the rotor is uniformly closely-spaced to one end of the oval shaped cavity and that a compression chamber of extended crescent-like cross-section results.

Further, the profile of the cavity has a predetermined contour so designed as to progressively decrease the volume of a portion **39** of the cavity between the inlet **40** and the outlet 42 so that upon rotation of the element **28** gaseous medium drawn into the portion **39** may be entrapped between successive vanes **32**, **33** and **34** and pre-compressed prior to release of the gaseous medium through outlet **42**.

The contact between the vanes and the profile of the cavity within the casing **17** is maintained by the radial component of the centrifugal force acting on the vanes during rotation of the rotor element **28** so as to maintain the outer edges of the vanes in contacting relation with the profile of the cavity without excessive friction and load at high speeds of rotation, as distinguished from vanes of the true radially extending type in which the centrifugal force applied at high speeds may cause an excessive wear, friction and load to be applied to the outer edges of the vanes increasing with the speed of rotation.

Thus, as the shaft **21** is rotated, gaseous medium such as air may be drawn into the pump cavity and between the vanes, such as **32** and **33**, through the pump inlet port, indicated in Figure 2 by the numeral **40**, and thereby pre-compressed and finally delivered to the pump outlet port **42** under the compression force thereof.

Referring to the diagrammatic drawing of Figure 3, a charge of air or gaseous medium is entrapped in the portion **39** of the cavity between the vanes **32** and **33** at substantially the same pressure as that entering the inlet port **40** so as to occupy a volume designated in the drawing of Figure 3 by the letter X.

Now referring to the drawing of Figure 4, it will be seen that the gaseous medium or air charge between vanes **32** and **33**, and indicated by the letter Y, has now been rotated to a location just prior to its discharge through outlet port **42** and, because of the predetermined non-symmetrical profile of the portion 39 of the pump cavity of progressively decreasing volume, the charge of gaseous medium Y has now been compressed between the vanes **32** and **33** with a consequent increase in pressure. Theoretically, the charge between the vanes 32 and **33** has been precompressed adiabatically in accordance with a predetermined relationship.

Again referring to the schematic drawing of Figure 4, it can be seen that the relationship of the distance between the inlet port **40** and the outlet port **42** and the distance between any two vanes (indicated by dotted lines in Figure 4) is arranged to provide a minimum of at least one vane in contact with the contour of the pump cavity between the ports **40** and **42** at all times. The importance of this feature is to prevent a direct leak of relatively high pressure air from the discharge port 42 back to the inlet port **40** without the necessity of maintaining any rubbing contact by the rotor **28** and the non-symmetrical cavity surface and, further, without the necessity of maintaining even a critically close clearance between the surfaces of the rotor and housing cavity.

Thus, in multi-vane positive displacement pumps of the aforenoted type, the gaseous medium or air is squeezed or compressed between vanes of the rotor moving in the portion **39** of the pump cavity prior to the discharge of the air or gaseous medium through the exhaust conduit **42**. This is shown by Figures 3 and 4 wherein the air or gaseous medium between the vanes **32** and **33** of the rotor **28** is shown in the process of being compressed. Since the volume of the portion **39** of the pump cavity progressively decreases in volume from the inlet 40 to the outlet **42**, it will be seen that prior to release, the pressure of the gaseous medium or air compressed through the above means is increased to such a degree that upon release of the same, as shown in Figure 4, by the dotted line vane **33**, there is no backing up or back rush of air, instead the compressed gaseous medium carried in the cavity space **39** separating the vanes **32** and **33** passes directly out the exhaust conduit **42** under the compression force thereof.

Through the use of built-in precompression in a pump of the type described herein, there is provided a pump with relatively constant input torque or power requirements so as to make these pumps ideally suited for use with various driving means, particularly when used under a wide range of operating conditions.

The multi-vane pump so far described, as to Figures 1–4, is claimed in the copending application Serial No. 526,032, filed August 2, 1955, by Edward C. Breinig and Edward V. Manning, and assigned to Bendix Aviation Corporation, assignee of the present application. The present invention is directed to an arrangement in such a multi-vane pump of the vane structure described and claimed herein.

In the present invention, the vanes are formed of carbon or other suitable material and, as shown in Figure 5, have provided a series of longitudinal holes **50** having openings **52** in the bottom surface of the vane facing the inner end of the rotor slot in which the vane is slidably fitted, as indicated in Figure 2, with a close tolerance between the surfaces of the slot and vane to maintain a minimum leakage path between the slot and vane surfaces.

Upon rotation of the rotor **28**, each of the vanes **32**, **33** and **34** is forced outwardly into contacting relation with the inner surface of the pump housing causing an increase in the volume of the space at the bottom of the slot between the end of the vane and the inner end of the slot as the vane under centrifugal force moves to its outermost position, as indicated in Figure 4 for example by the vane **32**.

In the case of a conventional solid type vane, this volume would normally be negligible if the vane be in its innermost position, as indicated for example by vane 34 of Figure 4, with no additional volume provided at the bottom of the vane or slot of the rotor so that in going from a zero volume to the maximum volume position, a suction would be created under the vane which would tend to retard a conventional solid type vane from moving out and properly contacting the inner pump housing surface. Such lack of proper contact of the solid type vane would result in a loss in pumping or volumetric efficiency due to leakage in the pumped air between the vane tip and the profile of the pump cavity in the pump housing.

However, by designing a relief section or volume into the vane by the provision of the holes **50**, this suction effect can be minimized. Thus, in effect, the volume built into the vane acts as a variable rate spring which can adjust itself to particular inlet and outlet conditions of operation. This phenomena is particularly effective under low flow conditions in which high pump suction is desired, since it allows a greater efficiency of operation under such conditions than that achieved in a pump of the aforenoted type having conventional type vanes lacking the relief section or excess volume provision.

The advantages of the arrangement with the vane structure illustrated at Figure 5 resides in the fact that such vane structure in minimizing the suction effect on the vanes gives to the pump (1) a much higher flow characteristic under particular operating conditions, (2) a higher pump suction under no flow conditions, and (3) less vane wear due to the decrease in weight obtained by including the relief section or excess volume in the vane itself.

Although only one embodiment of the invention has been illustrated and described, various changes in the form and relative arrangement of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference

is, therefore, to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. In a rotary multi-vane positive displacement pump of the type including a housing having a cavity, a rotor member rotatably mounted in said cavity, an inlet conduit for a gaseous medium opening into said cavity, an outlet conduit for said gaseous medium opening from said cavity, a plurality of slots in said rotor member; the improvement comprising a separate vane slidably fitted in each rotor slot with a continuous close tolerance, each vane having an inner end surface and an outer end edge surface, said housing cavity having a surface of predetermined contour cooperating with the outer end edge surfaces of said vanes so that upon rotation of said member the outer edge surfaces of said vanes continuously contact the surface of the cavity, each of said vanes having a plurality of closely-spaced holes opening at said inner end surface to the inner end portion of the slot in which the vane is slidably mounted and extending more than one-half the length of said vanes, said holes being substantially uniformly spaced from the sides of said vanes and from each other whereby the weight of the vane is reduced, said vanes being free of any passage between said holes and said outer end edge surface, means at both ends of said rotor arranged to prevent fluid communication with the space defined by said slots and the inner ends of said vanes, and the space defined by said slots and the inner end of said vanes being free of spring means.

2. A rotary multi-vane positive displacement pump comprised of a housing having a central cavity of oval cross section; a cylindrical rotor member rotatably mounted in said cavity; said cylindrical rotor member and said oval-shaped cavity being constructed and arranged so that about one-half of the cylindrical surface of said rotor member is uniformly closely-spaced to the surface of one end of said oval-shaped cavity and so that an extended crescent-like compression chamber is formed; an inlet opening into one end of said compression chamber; an outlet connected, adjacent the other end of said chamber, to the space between said rotor member and said cavity where closely-spaced; three equi-spaced longitudinal slots in said rotor member; each of said slots extending tangentially to a circle having a center common to said rotor; three vanes slidably mounted in said slots with a continuous close tolerance and extending from the rotor member at an acute angle to the circumferential surface of the rotor member and in a direction corresponding to the direction of rotation of the member; each of said vanes having a plurality of closely-spaced holes opening into said slots and extending from the inner end of said vanes over one-half the length of said vanes; said holes being substantially uniformly spaced from the sides of said vanes and from each other whereby the weight of the vane is reduced, said vanes being free of any passage from said holes to the outer end surfaces thereof; means at both ends of said rotor arranged to prevent fluid communication with the space defined by said slots and the inner ends of said vanes, and the space defined by the surface of said slots and the inner ends of said vanes being free of any spring means.

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