United States Patent

Hutchins

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[54] ROTARY FLUID DEVICE WITH AXIALLY EXPANSIBLE VANE

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Related U.S. Application Data

[63] Continuation of Ser. No. 725,019, Apr. 29, 1968, abandoned.

[52] U.S. Cl. 418/111

[51] Int. Cl. F04c 27/00

[58] Field of Search 91/126, 135, 136, 137; 418/110, 111, 120, 123, 124, 267, 268, 269

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[57] **ABSTRACT**

A rotary device including a rotor turning in a fluid chamber and containing slots slidably receiving vanes which project into engagement with the walls of the chamber. Each vane includes at least two sections which are relatively axially movable to assure that the assembly occupies the full axial extent of the chamber, with one section having a tongue projecting axially into and slidable within a groove formed in the other section, and with pressure fluid being conducted through a passage which extends through the interior of the latter section and into its groove to urge the sections axially apart.

16 Claims, 6 Drawing Figures

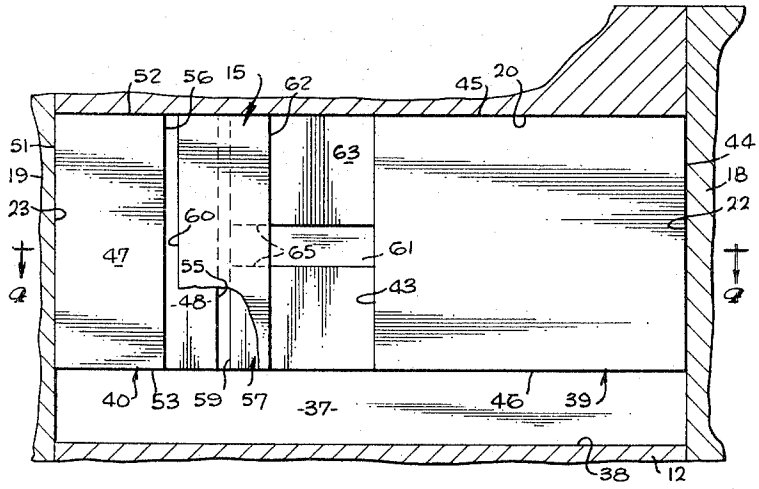


Fig. 1

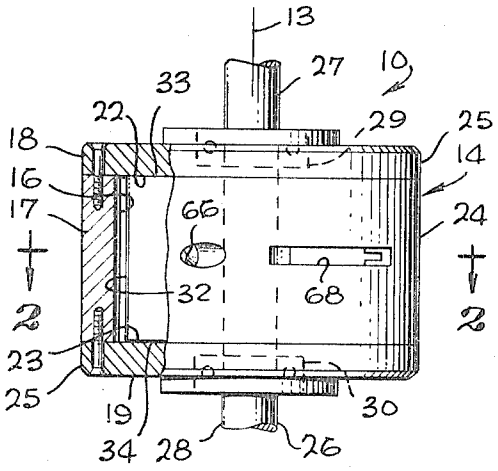


Fig. 2

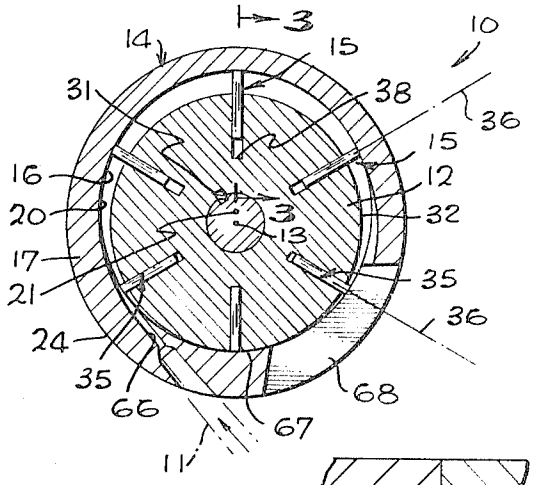


Fig. 3

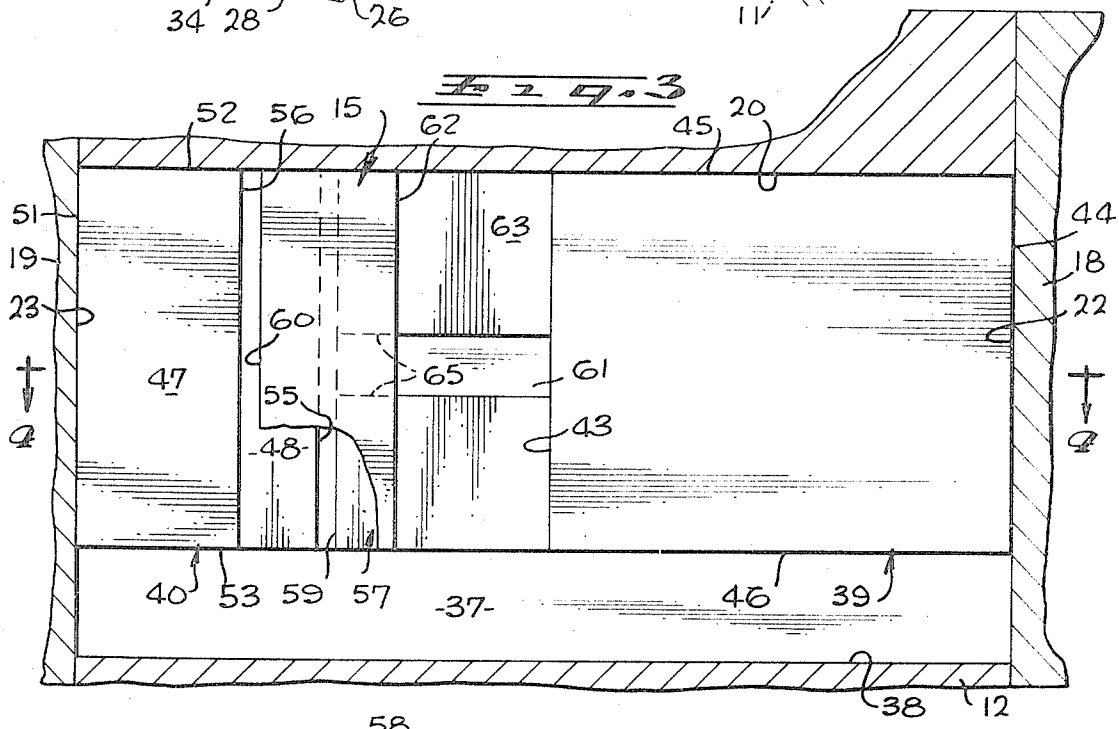


Fig. 4

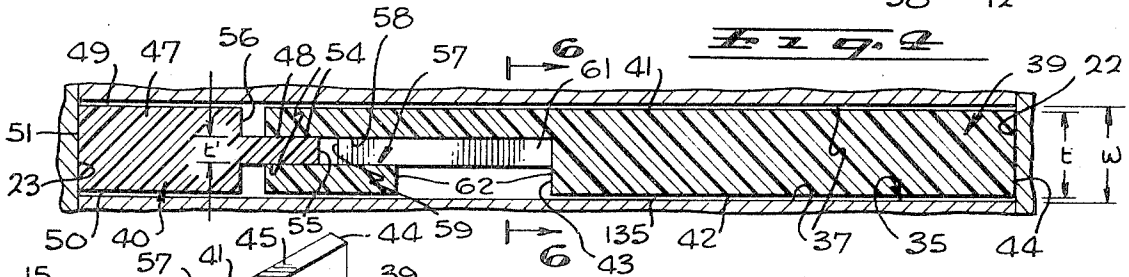


Fig. 5

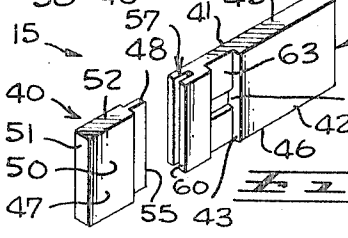
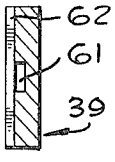


Fig. 6



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ROTARY FLUID DEVICE WITH AXIALLY EXPANSIBLE VANE

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of my copending application, Ser. No. 725,019 filed Apr. 29, 1968, and now abandoned, on "Rotary Fluid Device With Expansible Vane."

BACKGROUND OF THE INVENTION

This invention relates to rotary devices of a type having a vane, or more usually a series of vanes, coacting with a rotor and a stationary body to define a compartment or compartments which vary progressively in size as the rotor turns. Certain of the novel aspects of the invention may be applied to either a fluid-driven motor of the vane type, or a vane-type fluid pump acting to displace fluid in response to turning movement of the rotor. However, the invention will be described primarily as applied to motors.

One problem which has been encountered in many prior vane-type pumps and motors has been that of assuring maintenance of an effective fluid seal between the vanes and the engaged walls of the fluid chamber within which the vanes and rotor turn, and particularly preventing the development of leakage between the vanes and those walls as a result of wear and/or inaccuracies in manufacture. To prevent such leakage, some prior devices have included vanes formed of two adjacent plates, constructed to shift axially relative to one another in a manner altering the overall axial length of the vane in accordance with the length of the chamber which is to be occupied. However, these prior extensible vane arrangements with which I am familiar have not been capable of maintaining as effective a seal between the two vane sections, and between the vane sections and the other parts of the apparatus, as would be desired for optimum operational effectiveness, and therefore have not adequately solved the overall leakage problem.

SUMMARY OF THE INVENTION

In a device constructed in accordance with the present invention, I utilize an axially extensible vane assembly including two vane sections which are shiftable axially relative to one another in essentially the manner set forth above, but in which the construction of and relationship between the two vane sections is such as to assure an improved sealing effectiveness, both between these two sections themselves, and between the vane sections and the adjacent walls of the fluid chamber. As will appear, to attain these results, I provide one of the vane sections with a tongue which projects axially toward the other section, and is received slidably within a groove formed in that section, in a manner forming a very effective sliding essentially fluidtight joint. Preferably, fluid is directed from the higher pressure side of the vane assembly into the groove, at a location opposite the tongue of the other section, so that the pressure at this location urges the two sections relatively axially apart and toward or into proper sealing engagement with the chamber walls. The separating force exerted in this manner against the two sections is controlled very effectively and reliably by conducting the pressure fluid into the groove through a special passage of fixed dimension which extends through the interior of the section containing the groove, to automatically attain a spreading force sufficient to attain a proper seal and yet light enough to avoid excessive wear of the vane sections or engaged parts. Also, fluid from the high-pressure side is for best results conducted radially inwardly to the inner side of the vane, to conduct high-pressure fluid to that location in a relationship urging the vane radially outwardly to its active position of engagement with an outer wall of the fluid chamber.

BRIEF DESCRIPTION OF THE DRAWING

The above and other features and objects of the invention will be better understood from the following detailed description of the typical embodiment illustrated in the accompanying drawing, in which:

FIG. 1 is a side elevational view, partially broken away, of a fluid motor constructed in accordance with the invention;

FIG. 2 is a transverse section taken on line 2—2 of FIG. 1;

FIG. 3 is a greatly enlarged fragmentary section taken on line 3—3 of FIG. 2;

FIG. 4 is a section taken on line 4—4 of FIG. 3;

Fig. 5 is an exploded perspective representation of the two sections of one of the vane assemblies; and

FIG. 6 is a reduced section taken on line 6—6 of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIGS. 1 and 2, I have illustrated generally at 10 a vane-type rotary device, which may typically function as either a fluid pump or a fluid motor, but will be described primarily as the latter, having an inlet line 11 through which a pressurized fluid, such as compressed air, is introduced into the unit to drive its rotor 12 (FIG. 2) rotatively about an axis 13 relative to an outer stationary body or housing 14 of the device. The rotor slidably carries a series of circularly spaced vane assemblies 15 which are constructed in accordance with the invention.

The outer stationary body 14 of the device contains an inner cylindrical fluid chamber 16, and may be formed of an axially extending peripheral wall 17 closed at its opposite ends by two radially extending transverse end walls 18 and 19. More particularly, the peripheral wall 17 of body 14 may internally have an axially extending cylindrical inner surface 20 centered about an axis 21 which extends parallel to but is offset laterally with respect to the previously mentioned axis 13 of the rotor. The two end walls 18 and 19 have planar axially inner surfaces 22 and 23, which are disposed transversely of both of the axes 13 and 21, and therefore transversely of the cylindrical internal surface 20 of peripheral section 17 of the body, to define with surface 20 the cylindrical fluid chamber 16 in the body. Externally, section 17 may have an outer cylindrical surface 24 centered about axis 13 of the rotor, so that the radial thickness of the wall of section 17 varies progressively as that wall advances circularly about the axes 13 and 21, as seen in FIG. 2. End walls or plates 18 and 19 may have outer cylindrical surfaces 25 also centered about axis 13 and forming continuations of surface 24.

The rotor 12 is mounted rigidly to and turns with a typically externally cylindrical shaft 26 which is centered about and turns about axis 13, and whose opposite ends may project axially beyond the end walls or plates 18 and 19 for connection at 27 and/or 28 to a mechanism which is to be driven by the motor (or is to drive the shaft when the device 10 is to function as a pump). The shaft 26 may be mounted for its rotation by suitable ball bearings or other bearings illustrated at 29 and 30, and is keyed to rotor 12 for rotation therewith, as by a key represented at 31 in FIG. 2.

Rotor 12 is of cylindrical configuration, having a radially outer cylindrical surface 32 centered about axis 13, but of a diameter less than, and eccentric with respect to, the cylindrical surface 20 of fluid chamber 16 in the body. The opposite ends of the rotor are defined by two spaced parallel planar oppositely facing end surfaces 33 and 34, disposed transversely of the two axes 13 and 31, and positioned to substantially engage the opposite ends 22 and 23 of chamber 16 of the body. At a series of circularly spaced locations, rotor 12 contains a number of slots 35 which receive the vane assemblies 15, and lie essentially in planes 36 extending through and containing axis 13. More particularly, each of the slots is defined by two parallel planar opposite sidewall surfaces 37, disposed parallel to and at opposite sides of one of the planes 36, and continuing through the entire axial extent of the rotor, and extending radially inwardly from the peripheral surface 32 of the rotor to the location of an axially extending inner wall 38 of the slot disposed perpendicular to the sidewall surfaces 37.

As seen best in FIG. 5, each of the vane assemblies 15 includes two relatively axially shiftable vane sections 39 and 40, which are preferably formed of a suitable rigid resinous plastic material molded to the illustrated configuration. Section 39 may be longer axially than section 40, and has two parallel planar opposite side surfaces 41 and 42 (FIG. 4) which are spaced apart a thickness dimension t desirably slightly less than the width w of the individual slots 35 in the rotor, to occupy approximately the entire width of the slot while leaving only a small clearance space at 135 to assure free radial movement of the vane section 39 within the rotor slot. These surfaces 41 and 42 extend continuously along both sides of the vane except at the location of a radially extending groove or recess 43 formed in one side of the vane at a location interrupting surface 42. At one of its ends, section 39 of the vane assembly has a planar end wall surface 44 (FIGS. 3 and 4), which extends directly transversely of axes 13 and 21, and slidably engages inner end surface 22 of end wall 18 of the outer body of the device continuously over the entire extent of end surface 44 and through the entire radial extent of the vane. Along its radially outer edge, vane section 39 has an outer planar surface 45 disposed parallel to axis 13, and perpendicular to one of the previously mentioned radial planes 36 (FIG. 2), and which slidably engages inner cylindrical surface 20 of section 17 of the body continuously along the entire axial length of vane section 39, to form a fluid tight seal at that location. At the radially inner edge of section 39, a similar planar surface 46 may be formed (FIG. 3), extending parallel to outer surface 45 and parallel to axis 13.

The second section 40 of the vane assembly has a main relatively thick portion 47 and a thinner axially projecting tongue portion 48. The thick portion 47 of section 40 has two opposite side surfaces 49 and 50 which are planar and parallel to one another and are spaced apart the same thickness dimension t as are the two surfaces 41 and 42 of section 39, and are aligned with and lie in the same planes as those surfaces. Planar end surface 51 of section 40 is disposed parallel to surface 44 at the opposite end of section 39, and extends transversely of the two axes 13 and 21, and engages transverse end wall surface 23 of the fluid chamber in body 14 continuously over the entire radial extent and the entire thickness of the vane assembly. A radially outer surface 52 of section 40 is aligned with and lies in the same plane as outer surface 45 of section 39 (FIG. 3), and like surface 45 slidably engages surface 20 of the body, to form a seal therewith. A radially inner surface 53 of section 40 is aligned with and lies in the same plane as inner surface 46 of section 39.

The tongue portion 48 of vane section 40 has a thickness dimension t' which is substantially less than the thickness t of section 39 and the thicker portion 47 of section 40. This tongue is defined at its opposite sides by two spaced parallel planar surfaces 54, which are disposed parallel to but are spaced inwardly from the planes of surfaces 49 and 50. Surfaces 54 continue through the entire radial extent of the vane assembly, from radially outer surface 52 of section 40 to its radially inner surface 53, with those surfaces 52 and 53 continuing rightwardly in FIG. 3 to define the upper and lower ends of the tongue. The rightward extremity of the tongue is defined by a typically planar surface 55, disposed perpendicular to surfaces 54, and extending continuously from the radially outer surface 52 to the radially inner surface 53 of the vane section 40. Thus, tongue 48 and the remainder of section 40 both have a uniform cross section through their entire radial extent. At the juncture of the tongue and main portion 47 of section 40, the latter may have two narrow surfaces 56 aligned with one another and disposed in a plane which is perpendicular to the planes of surfaces 49, 50, and 54.

For coaction with tongue 48 of section 40, the section 39 has a radially extending groove 57, having a cross section (as viewed in FIG. 4) corresponding substantially to the cross section of tongue 48, to slidably receive that tongue in an interfitting sealing relation. More specifically, groove 57 has two opposite sidewall surfaces 58 which are parallel and planar and spaced apart a distance only very slightly greater than the thickness t' of tongue 48, to allow just sufficient clearance with respect to the tongue (desirably about one thousandth of an inch) to enable relative axial sliding movement of the sections. At its deepest portion, the groove 57 has an end wall surface 59 which is perpendicular to surfaces 58 and extends radially and parallel to end surface 55 of the tongue. Opposite surfaces 56 of section 40 of the vane assembly, section 39 has two aligned planar radially extending surfaces 60 disposed parallel to surfaces 56, and perpendicular to surfaces 41 and 42.

The recess 43 which is formed in one side of section 39 of the vane assembly continues through the entire radial extent of section 39, and except at the location of an increased depth portion 61 of the recess has a uniform cross section through that entire radial extent. This cross section will be apparent from FIG. 4, where the recess 43 is illustrated as having two spaced parallel opposite sidewall surfaces 62, extending radially, and extending perpendicular to surfaces 41 and 42 of section 39, with the inner wall of recess 43 being defined by a radially extending surface 63 disposed parallel to surface 42, but spaced inwardly therefrom, and lying in the same plane as one of the groove walls 58. The increased depth portion 61 of recess 43 takes the form of an axially extending groove, typically having the rectangular cross section illustrated in FIG. 6, and communicating with a correspondingly rectangular and aligned opening or passage 65 extending through the material of vane section 39 into the interior of groove 57 (through an opening in the center of inner end surface 59 of the groove).

With reference again to FIG. 2, the inlet line 11 introduces the actuating fluid, desirably compressed air, into the space radially between the rotor and body through a tangential inlet opening 66, located just circularly beyond the point of engagement 67 of the eccentric rotor 12 with the body wall 20. This air acts against the vanes to cause clockwise rotation of the rotor and vanes as viewed in FIG. 2, with the air ultimately discharging from the body or housing through an outlet slit 68. As the rotor turns, each of the vane assemblies 15, including its two sections 39 and 40, progressively advances radially outwardly with respect to the rotor 12, and then radially inwardly, to continuously slidably engage inner surface 20 of the body, and thus divide the chamber within the body into a series of successive compartments which change progressively in size as the rotor turns. The vanes are maintained against surface 20 by centrifugal force as the rotor turns. If the vane assemblies are in radially inwardly retracted positions upon the initial application of pressure through inlet 11, the pressure will itself act to force the vanes radially outwardly, by virtue of the delivery of some of the pressurized air radially inwardly through passage 43 (which is at the higher pressure side of the vane assembly) to the radially inner side of the assembly, so that the pressure may act radially outwardly against surfaces 46 and 53 of FIG. 3, to urge the vane assembly outwardly into sliding contact with body surface 20.

Some of the high-pressure air from within recess 43 flows through the increased depth portion 61 of that recess and through passage 65 into the groove 57 of section 39, to a location opposite the end of tongue 48, to thereby exert axial pressure against the tongue in a leftward direction as viewed in FIG. 4, and against section 39 in a rightward direction as viewed in FIG. 4, so that the two sections 39 and 40 are yieldingly urged axially apart and into tight sliding engagement with end wall surfaces 22 and 23 of the fluid chamber in body 14. Thus, very effective sealing engagement of the vane sections with walls of the chamber 16 in the body is assured, to prevent leakage of any of the air past the vane assembly during operation of the motor. The force with which the two vane sections are urged apart is regulated sufficiently by the fixed restriction afforded by passage 65 to assure against excessive wear which might result from too high a pressure between the sections, while at the same time maintaining a great enough pressure to attain an effective seal.

When the two vane sections **39** and **40** are formed of a resinous plastic material, as is preferred, this material will normally be subject to some expansion upon subjection to the humidity encountered in the driving air. The tongue **48** and groove **57** are in this case so dimensioned as to allow for expansion of the tongue to an increased thickness without development of too tight a binding engagement with the groove walls. Desirably, the tongue and groove have the previously discussed closely fitting relation in the ultimate expanded condition of the parts, with the tongue still being slidable in the groove in that condition, but being at the same time in sufficiently tight engagement with the groove walls to prevent the leakage of any substantial amount of air past the tongue. The overall thickness of the two sections **39** and **40**, between surfaces **41** and **42**, and surfaces **49** and **50**, is also small enough to assure effective reception of the vane assembly within the coacting slot **35** in the rotor body after any expansion of the vane which may occur due to moisture or the like, and still leaving sufficient clearance space between the vane surfaces and the slot walls **37** to allow for the desired continual radial movement of the vanes within the slots. For best results, the clearance between vane surfaces **41**, **42**, **49**, and **50**, and sidewall surfaces **37** of the slots, should be greater (in the expended or actual operating condition of the parts) than is any clearance between tongue **48** and the groove walls engaged thereby. In a preferred arrangement, the clearance between the vane sections and slot walls **37** (the difference between vane thickness dimension *t* and slot width *w*) is between about 0.003 and 0.005 of an inch, desirably about 0.004 of an inch; while the clearance between tongue **48** and groove walls **58** is desirably not greater than about 0.002 of an inch, and for best results is about 0.001 of an inch.

I claim:

1. A rotary device comprising a body containing a fluid chamber having a radially outer wall and two opposite end walls, a rotor mounted in said chamber to turn about a predetermined axis and containing a slot, and a vane assembly movably contained in said slot and projecting generally radially outwardly therefrom into engagement with said outer wall of the chamber and forming a side of a fluid compartment which varies in size as the rotor turns, said vane assembly being movable generally radially inwardly and outwardly within said slot as the rotor turns and in accordance with said variation in size of said compartment, said vane assembly including two sections which are relatively axially shiftable to assure occupancy by said assembly of the entire axial distance between said end walls, a first of said vane sections having a relatively thick first portion of a thickness occupying the major portion of the width of said slot and having a thinner tongue portion projecting axially from said first portion and of a reduced thickness substantially less than that of said first portion, the second of said vane sections having a portion adjacent said first section of a thickness corresponding substantially to that of said thick first portion of the first section and occupying the major portion of the width of the slot, said portion of the second section containing an axially facing essentially radially extending groove slidably receiving said tongue in relatively axially expansible relation, said portion of the second section forming two spaced projections defining said groove and extending essentially along opposite sides of the groove and along opposite sides of the tongue to slidably confine it therebetween, there being a fluid passage extending within the interior of said second section and having an end leading into said groove through an opening in a wall of the groove and conducting fluid from a pressure side of the vane assembly through the interior of said second section to a location within said groove and axially between the sections to yieldingly urge them axially apart.

2. A rotary device as recited in claim **1**, in which one of said sections is recessed at its pressure side in a relation to conduct pressure fluid to the radially inner side of said assembly to a location at which it urges the assembly radially outwardly.

3. A rotary device comprising a body containing a fluid chamber having a radially outer wall and two opposite end walls, a rotor mounted in said chamber to turn about a predetermined axis and containing a slot, and a vane assembly movably contained in said slot and projecting generally radially outwardly therefrom into engagement with said outer wall of the chamber and forming a side of a fluid compartment which varies in size as the rotor turns, said vane assembly being movable generally radially inwardly and outwardly within said slot as the rotor turns and in accordance with said variation in size of said compartment, said vane assembly including two sections which are relatively axially shiftable to assure occupancy by said assembly of the entire axial distance between said end walls, a first of said vane sections having a relatively thick first portion of a thickness occupying the major portion of the width of said slot and having a thinner tongue portion projecting axially from said first portion and of a reduced thickness substantially less than that of said first portion, the second of said vane sections having a portion adjacent said first section of a thickness corresponding substantially to that of said thick first portion of the first section and occupying the major portion of the width of the slot, said portion of the second section containing an axially facing essentially radially extending groove slidably receiving said tongue in relatively axially expansible relation, said portion of the second section forming two spaced projections defining said groove and extending essentially radially along opposite sides of the groove and along opposite sides of the tongue to slidably confine it therebetween, said second section containing a recess formed in a pressure side thereof into which pressure fluid can flow from said pressure side, there being a fluid passage extending within the interior of said second section, with the material of said second section extending entirely about and defining said passage, and with said passage having a first end opening into said recess and a second end opening into said groove for conducting fluid from the pressure side of the vane assembly through the interior of said second section to a location within said groove and axially between the sections to yieldingly urge them axially apart.

4. A rotary device as recited in claim **3**, in which said second end of said passage opens into the groove through an opening formed in an inner wall of the groove and entirely surrounded by the material of said second section axially opposite said tongue.

5. A rotary device as recited in claim **3**, in which said recess has a portion of increased depth formed in said pressure side of said second section and extending into the material of said second section farther than the remainder of the recess, said first end of said passage being positioned to open into said increased depth portion of the recess and receive fluid therefrom.

6. A rotary device as recited in claim **3**, in which said recess continues generally radially inwardly to a location at which it passes pressure fluid from said recess to the radially inner side of said assembly in a relation urging the assembly radially outwardly.

7. A rotary device as recited in claim **3**, in which said recess has a portion of increased depth formed in said pressure side of said second section and extending into the material of said second section farther than the remainder of the recess, said first end of said passage being positioned to open into said increased depth portion of the recess and receive fluid therefrom, said second end of the passage opening into the groove through an opening formed in an inner wall of the groove axially opposite said tongue.

8. A rotary device as recited in claim **3**, in which said recess extends generally radially in the pressure side of said second section and continues from the radially outer extremity of the vane to its radially inner extremity and acts to pass pressure fluid to the radially inner side of said vane assembly to urge it radially outwardly, said recess being located axially beyond said groove in a direction away from said first section, said recess having an axially extending portion of increased depth

formed in said pressure side of the second section and extending into the material of said second section farther than other portions of the recess both radially inwardly and radially outwardly thereof, said passage forming a continuation of said increased depth portion of the recess and extending axially therefrom into the groove through the interior of the second section and through an inner wall of the groove axially opposite said tongue.

9. A vane assembly to be mounted movably within a slot in a rotor of a rotary device, including two sections which are relatively axially shiftable, a first of said vane sections having a relatively thick first portion of a thickness to occupy the major portion of the width of said slot and having a thinner tongue portion projecting axially from said first portion and of a reduced thickness substantially less than that of said first portion, the second of said vane sections having a portion adjacent said first section of a thickness corresponding substantially to that of said thick first portion of the first section to occupy the major portion of the width of the slot, said portion of the second section containing an axially facing essentially radially extending groove slidably receiving said tongue in relatively axially expansible relation, said portion of the second section forming two spaced projections defining said groove and extending essentially radially along opposite sides of the groove and along opposite sides of the tongue to slidably confine it therebetween, there being a fluid passage extending within the interior of said second section and conducting fluid from a pressure side thereof through the interior of said second section to a location within said groove and axially between the sections to yieldingly urge them axially apart.

10. A vane assembly as recited in claim 9, in which said second section contains a recess formed in said pressure side thereof and leading pressure fluid from said pressure side into said passage for delivery therethrough into said groove.

11. A vane assembly as recited in claim 9, in which one of said sections is recessed at said pressure side in a relation to conduct pressure fluid to the radially inner side of said assembly and thereby urge it radially outwardly.

12. A vane assembly as recited in claim 9, in which said passage opens into said groove through an opening formed in an inner wall of the groove axially opposite said tongue.

13. A vane assembly as recited in claim 9, in which said second section contains a recess formed in said pressure side thereof and leading pressure fluid from said pressure side into said passage for delivery therethrough into said said groove, said recess having a portion of increased depth formed in said pressure side of said second section and extending into the material of said second section farther than the remainder of the recess and into which said passage opens.

14. A vane assembly as recited in claim 9, in which said recess continues generally radially inwardly to a location at which it passes pressure fluid from said recess to the radially inner side of said assembly in a relation urging the assembly radially outwardly.

15. A vane assembly as recited in claim 9, in which said second section contains a recess formed in said pressure side thereof and leading pressure fluid from said pressure side into said passage for delivery therethrough into said groove, said recess having a portion of increased depth formed in said pressure side of said second section and extending into the material of said second section farther than the remainder of the recess and into which said passage opens, said passage opening into said groove through an opening formed in an inner wall of the groove axially opposite said tongue.

16. A vane assembly as recited in claim 9, in which said second section contains a recess formed in said pressure side thereof and leading pressure fluid from said pressure side into said passage for delivery therethrough into said groove, said recess extending generally radially in the pressure side of said second section and continuing from the radially outer extremity of the vane to its radially inner extremity and acting to pass pressure fluid to the radially inner side of said assembly to urge it radially outwardly, said groove being located axially beyond said groove in a direction away from said first section, said recess having an axially extending portion of increased depth formed in said pressure side of the second section and extending into the material of said second section farther than other portions of the recess both radially inwardly and radially outwardly thereof, said passage forming a continuation of said increased depth portion of the recess and extending axially therefrom into the groove through the interior of the second section and through an inner wall of the groove axially opposite said tongue.

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