United States Patent

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[54] **VANES FOR FLUID POWER CONVERTER**
9 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **418/221,** 418/267
[51] **Int. Cl.** **F01c 1/00**
[50] **Field of Search** 418/122, 123, 124, 143, 248, 249, 250, 251, 266, 267, 268, 175, 176, 177, 61, 221, 270

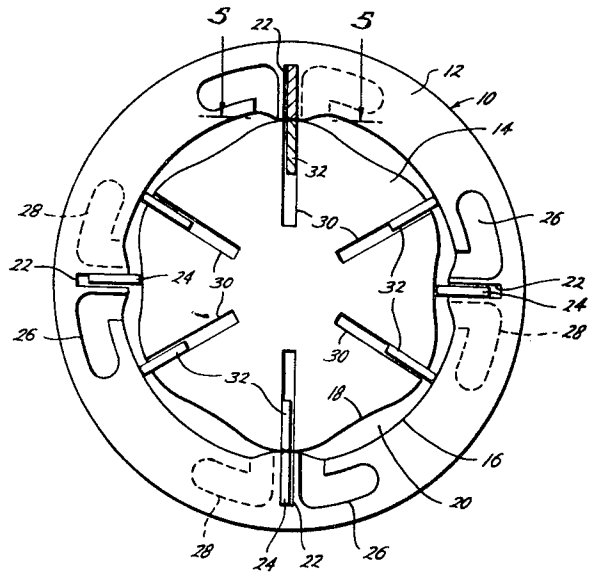
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ABSTRACT: A self-pressurizing reversible vane for use in a fluid pump or motor in which the width of the vane in a radial cross section is less than the width of the slot thereby allowing fluid pressure to flow into the vane-receiving slot and around the vane to act on the bottom of the vane to provide a self-loading action. The vane having sides contoured to coact with and seal with the sides of the slot and freely movable sideways in the slot thereby allowing the pump or motor to reverse. A vane being teardrop shaped in cross section and having straight sides with rounded ends with the small end extending out of the slot thereby reducing the friction of the pressure-loaded vane. In fluid motors and pumps having vane valve elements in both the stator and rotor interaction noise and interference between the vanes may be reduced by placing the longitudinal axis of the vanes on at least one of the rotor and stator at an angle to a radially extending plane through the axis.



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SHEET 1 OF 2

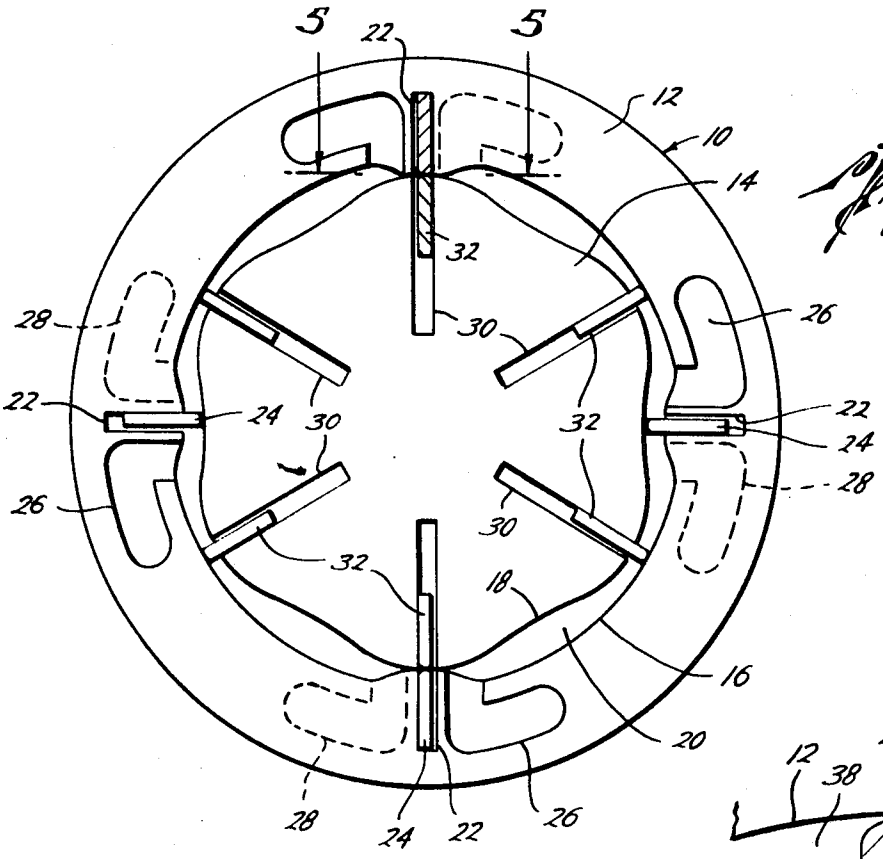


Fig. 1

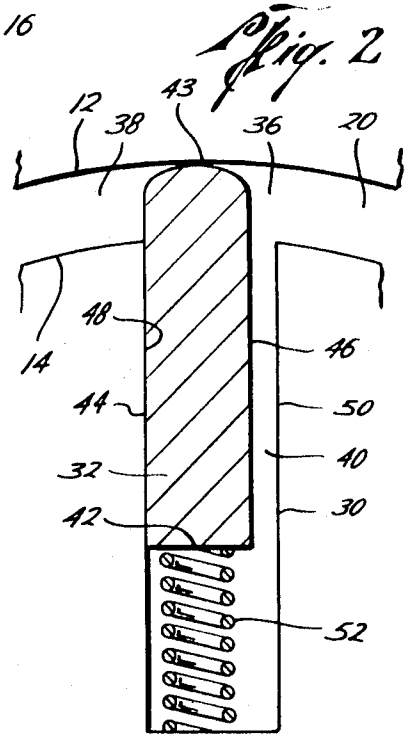


Fig. 2

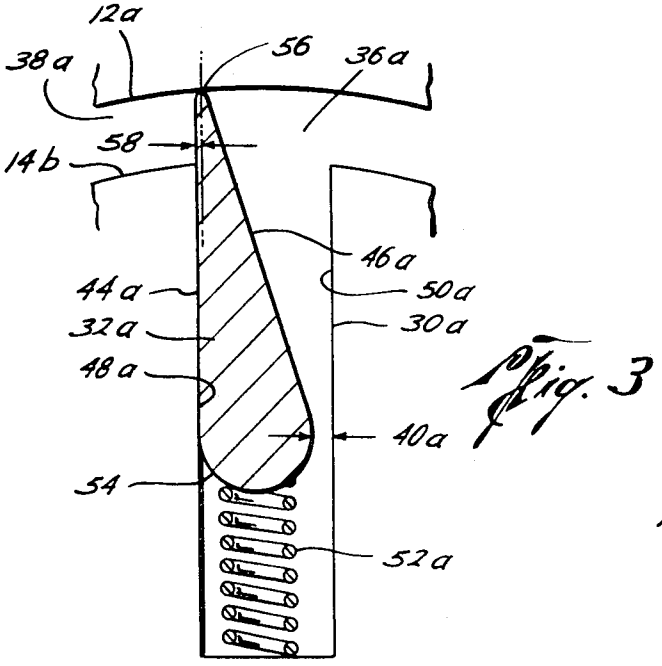


Fig. 3

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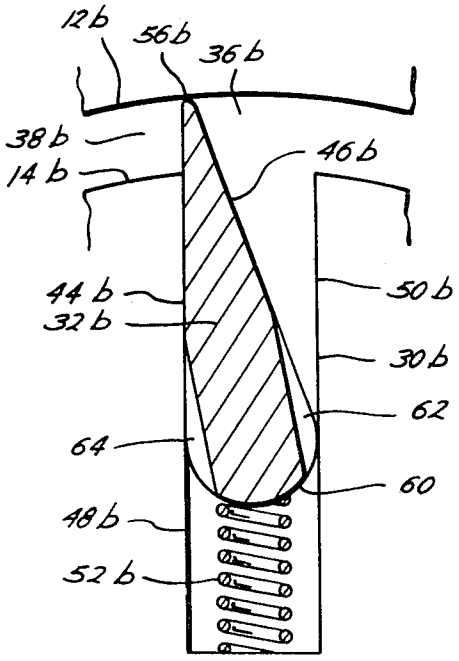


Fig. 4

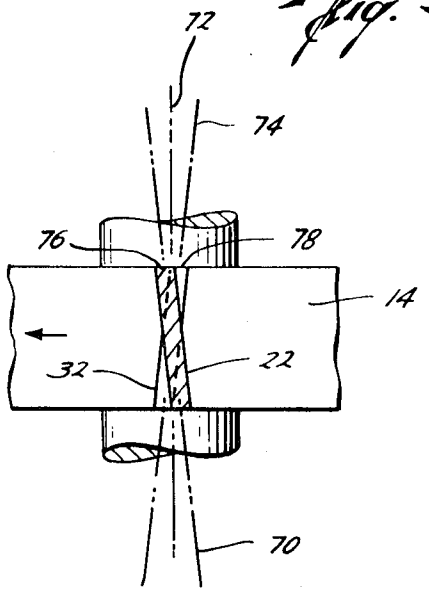


Fig. 5

Fig. 6

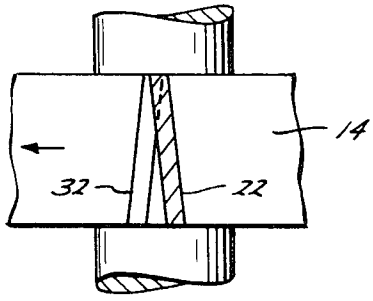
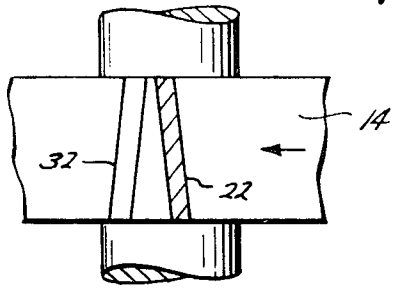


Fig. 7



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VANES FOR FLUID POWER CONVERTER

BACKGROUND OF THE INVENTION

The inventions herein described were made in the course of or under a contract or subcontract thereunder with the Department of the Army.

In existing vane-type hydraulic pumps and motors, the vanes are generally loaded against the stator, and sometimes against the rotor when the vanes are used on both the rotor and stator, by a combination of springs and fluid pressure. However, the vanes are generally closely fit into the vane-recieiving slots and in order to provide a vane which will seal, and at the same time be reversible, an expensive and special porting system must be provided. In addition, the action of the vanes creates friction resulting from the rubbing of the pressure-loaded vane elements against the rotor and/or stator decreasing the efficiency of the pump or motor. In addition, when a fluid power converter uses vanes in both the rotor and stator, the vanes on each member ride over the vane in the other member with a detent action and interaction noise. The present invention is directed to various improvements in vanes to overcome these problems.

SUMMARY

One feature of the present invention is to provide each vane with a sufficient side clearance between the side of the vane and the slot for allowing high-pressure fluid to flow into the slot and around the vane thereby acting on the bottom of the vane for providing an outward pressure loading, but with the vane being free to move in the slot in either sideways direction whereby either side of the vane may be brought into contact with a side of the slot for sealing thereby allowing the fluid converter to reverse.

Still a further feature of the present invention is the provision of a vane which in radial cross section is teardrop shaped by having straight sides and rounded ends in which the end extending out of the vane-receiving slot is small to reduce the friction as this small end contacts either the other member and in which the rounded end positioned in the slot is larger to provide a desirable vane strength. In addition, the teardrop-shaped vanes may be maintained with a running fit in the vane-receiving slots to keep them from flopping but receive and act as a self-pressurizing vane by providing one or more passageways in each side in the large rounded end to transmit high-pressure fluid to the underside of the vane.

Yet a still further object of the present invention is to prevent detenting or interaction noise between the vane valve elements on both the stator and rotor by positioning the longitudinal axis of the vanes in at least one of the rotor and stator at an angle to a radially extending plane through the axis of the fluid pump or motor, and preferably cocking the longitudinal axis of the vanes on both the stator and rotor, but in opposite directions, whereby the vanes on the rotor and stator ride over each other with less detent action and noise.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view in cross section of one type of fluid power converter having vane valve elements in both the rotor and stator,

FIG. 2 is an enlarged fragmentary cross-sectional view illustrating one type of vane of the present invention,

FIG. 3 is a fragmentary enlarged cross-sectional view illustrating a modified vane of the present invention,

FIG. 4 is a fragmentary enlarged cross-sectional view of a further modified vane of the present invention,

FIG. 5 is an enlarged cross-sectional view taken along the line 5—5 of FIG. 1 illustrating the feature of cocking the vanes on the rotor and stator relative to each other at one relative position,

FIG. 6 is a view similar to FIG. 5 illustrating the relative positions of the cocked vanes as they move further apart, and

FIG. 7 is a view similar to FIG. 5 showing the cocked vanes of the rotor and stator relative to each other in a yet further position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is directed to various improvements in vanes or vane valve elements in a fluid motor or pump and while the present invention will be described in connection with a particular fluid motor or pump shown in FIG. 1, for purposes of illustration only, the improved vanes of the present invention are equally useful in other types of fluid motors and pumps,

Referring now to the drawings, and particularly to FIG. 1, the reference numeral **10** generally indicates a fluid power converter, for example, a hydraulic motor or pump in which the member **12** may be the stator and the member **14** may be the rotor with the inner periphery **16** of the stator and the outer periphery **18** of the rotor **14** being suitably contoured to provide an annular fluid space **20** therebetween. The stator **12** includes a plurality of radially extending vane-receiving slots **22** each of which receive a vane or valve element **24** therein whose outer end contacts the outer periphery **18** of the rotor **14** as will be more fully described hereinafter. Fluid passageways **26** and **28** are provided on either side of the vane or valve elements **24** one of which such as passageway **26** may be a fluid outlet.

The rotor **14** may or may not also include vane elements, here shown as including radially extending vane-receiving slots **30**, which receive vane valve elements **32** therein the outer end **43** of which engages the inner periphery **16** of the stator **12**. Thus, assuming fluid comes in the fluid inlet passages **26** and out of the passageways **28**, the rotor **14** will rotate counterclockwise relative to the stator **12**.

The foregoing description of one type of fluid motor and pump in which the improvements of the present vanes may be used is more fully described in copending patent application Ser. No. 883,692 entitled Fluid Power Converter, filed Dec. 10, 1969.

Referring now to FIG. 2, an improved vane of the present invention is shown which provides self-loading and reversible features. While the present inventions and improvements may be applied to either the rotor or stator vanes, for purposes of illustration only, the rotor vanes **32** will be described, it being understood that the stator vanes **24** may be similarly constructed. An annular space **20** is divided by the vanes 32 into high-pressure passage portion **36** and low-pressure passage **38**. It is to be noted that the width of the vane **32** in a radial cross section, is sufficiently less than the width of the vane-receiving slot **30** thereby providing fluid passageway **40** between the side of the vane **32** and the side of the slot **30** to allow the high-pressure fluid in the passageway portion **36** of the annular space **20** to act on the end **42** of the vane **32** thereby providing an outward pressure loading against the stator **12** whereby the vane valve **32** prevents fluid communication between the high-pressure passageway **36** and the low-pressure passageway **38** of the annular space **20**. In addition, it is to be noted that the vane **32** has sides **44** and **46** contoured to sealingly coact with the sides **48** and **50** respectively of the slot **30** when engaged therewith. Thus, the high-pressure fluid in passageway portion **36** overcomes the low pressure in passageway portion **38** forcing the side **48** of the vane **32** against the slot side **48** and into a sealing relationship. And, of course, the vane **32** is then reversible, and in the event that the pressure in passageway portion **38** becomes the high pressure, as when the converter **10** is reversed, side **46** of the vane **32** will engage in a sealing relationship with the slot **30** and provide a side clearance passageway between side **44** of the vane **32** and side **48** of the slot **30** so that the high-pressure fluid can flow into the slot **30** and around the vane **32** to provide a self-floating vane. If desired, a spring **52** may be provided in the slot **30** to act against the vane **32** to keep the end **43** of the vane sealed against the stator **12** when the fluid power converter **10** is run at high speeds and light loads.

Of course, while it is desired that the pressure acting on the vanes **32** exerting them outwardly and into contact with the stator **12** be sufficient to keep the vanes sealed against the stator **12**, the rubbing of the outer ends **43** of the vanes **32** against

the stator 12 produces friction which decreases the efficiency of the fluid converter 10. Assuming that the ends 43 of the vanes 32 contact the stator at a vane midpoint and neglecting any pressure effect on the low-pressure side, the net radially outwardly acting force caused by the high-pressure fluid acting on one-half of the outer end 43 of vane 32 on all of the inner end 42 of the vane 32 would be proportional to one-half of the width of the vane 32. Therefore, by reducing the width of the vanes 32 and using thin width vanes the amount of friction of the outer ends 43 can be reduced. However, reducing the width of the vanes 32 causes a vane strength problem. Referring now to FIG. 3 a modified vane is shown wherein like parts utilize a suffix "*a*" for convenience of reference. Thus, the vane 32*a*, which is preferably teardrop-shaped in cross section will still be self-pressure-loading, may be used in a reversing motor or pump, and in addition will reduce the rubbing friction caused by the pressure loading and will allow the vane cantilever strength to be sufficiently maintained or increased as desired. Thus the vanes 32*a* may include straight sides 44*a* and 46*a* which are adapted to coact and seal with the sides 44*a* and 50*a*, respectively, of the slot 30*a* and are tapered relative to each other. In addition, the vane 32*a* includes a first large end 54, preferably rounded, and a small, preferably rounded, end 56. When the vane is pressure loaded from the high-pressure annular space passageway portion 36*a* against the stator 12*a*, the net loading force is proportional to the radius 58 of the rounded second end 56. Thus, by making the end 56 small, the friction force is kept small. However, the strength of the vane 32 is maintained because of the taper of the sides 44*a* and 46*a*, which can varied as desired. And, of course, the vane 32*a* may be made self-pressurizing by providing a sufficient side clearance or passageway 40*a* so that high-pressure fluid can readily pass around the side of the vane 32*a* and act on the rounded end 54.

However, because of the side clearance 40*a* in the embodiment of FIG. 3, and the resulting loose fit of the vanes in the slot 30*a*, there is a tendency for them to slap or flop against the sides of the slot 30*a*. Referring now to FIG. 4, a further modified vane is shown, wherein like parts to those of FIGS. 2 and 3 are designated by like numerals but using the suffix "*b*" for convenience of reference, which vane 32*b* maintains a closer fit in the slot 30*b* but still provides the features of self-pressurization and loading is adapted to be utilized in a motor or pump which is reversible, and which reduces rubbing friction, but still provides sufficient vane strength. Thus in the modification of FIG. 4, the vane 32*b* includes straight sides 44*b* and 46*b* to coact with the sides of the vane-receiving slot 30*b* and includes a first rounded end 60 which is sized to have a running fit between the sides 48*b* and 50*b* of the slot 30*b* thereby adding stability to the vane 32*b* but yet allowing the sides 44*b* and 46*b* to reverse. In order to provide fluid from the high-pressure annular passageway portion 36*b* fluid passage means such as fluid passages 62 and 64 are provided leading from sides 46*b* and 44*b*, respectively, to the underside of rounded end 60 to provide the self-pressure-loading as in the previous modifications. However, it is to be noted that the passageways 62 and 64 while allowing high-pressure fluid to flow around the vane 32*b* to the underside thereof do not interfere with the sealing of the sides 44*b* and 46*b* with the sides of the slot 30*b*, and therefore the vanes 32*b* may be used in a reversing pump or motor. Thus, as shown in FIG. 4, high-pressure fluid from annular passageway portion 36*b* will flow through passageways 62 to the underside of the vane valve element 32*b* to provide self-pressure-loading. And in the event that the motor or pump is reversed, so that the side 46*b* of the valve 32*b* is in contact with and sealing against side 50*b* of the slot 30*b*, then high-pressure fluid will flow from fluid passageway portion 38*b* through passageway 64 to the underside of the vane valve element 32*b*.

While the vanes shown in FIGS. 2, 3 and 4 may be used in a fluid motor or pump having vanes on only one of the stator and rotor, the vanes may be used in a fluid converter 10, as shown in FIG. 1, which employs vane-valving elements on both the stator and rotor. Ideally, the vanes on the stator 12 and the vanes on the rotor 14 are designed so that they ride over one another in a manner with no detent action and no interaction noise. However, because of wear of the vane tips, the ideal vanes would eventually begin to detent. Furthermore, the better vane configuration from a pressure-loading standpoint, as best seen in FIGS. 3 and 4, would not be as satisfactory from a detent standpoint as the vane configuration of FIG. 2.

Another feature of the present invention is to allow the vanes on the stator and on the rotor to wear against each other, but prevent them from detenting. This can be accomplished by cocking the longitudinal plane of the vane in either the stator and/or rotor, or both, at a small angle whereby the rotor and stator vanes are never totally riding upon one another and hence there can be no detenting. Thus the longitudinal axis of the vanes, in at least one of the rotor and stator, is cocked at an angle to a radial extending plane through the axis of the converter. Thus referring to FIG. 5 it is noted that the longitudinal axis 70 of the stator vanes 24 are at an angle to a plane through the axis 72 of the fluid converter 10. Preferably, the longitudinal axis of the vanes 32 on the rotor are also at an angle to a radial plane extending through the converter axis 72, but in the opposite direction to the angle of the longitudinal axis 70 of the stator vanes 24. Thus as shown in FIG. 5 the vanes 24 of the stator 12 and the vanes 32 of the rotor 14 after initially contacting each other at the ends 76 and 78, respectively, wipe across each other, as shown in progression in FIG. 5, 6 and 7. Thus, while the vanes will wear because of the interaction of the vane ends or tips, they will not wear in a manner to incur detenting.

Thus in use, the vanes of the present invention may be used in various types of fluid motors and pumps and provide a self-pressure-loading vane which may be used in a reversing motor or pump. In addition, the configuration may be such that the vanes have a reduced amount of rubbing friction, but with a sufficient vane strength. Also the teardrop configuration will provide a vane which may be maintained in the vane-receiving slot with a running fit to keep the vanes from flopping, and yet will still provide the advantages of self-pressuring, minimum friction, and use in a reversing fluid converter.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein.

What is claimed is:

1. In a fluid converter having a rotor member and a stator member, the members being rotated one with respect to the other with an annular fluid space therebetween, at least one of the members including a plurality of radially extending vane-receiving slots, the improvement in a vane positioned in each slot comprising,

said vane in a radial cross section being of a teardrop shape having straight sides tapered relative to each other and a large first end and a small second end, the first end being positioned in the slot whereby the vane is free to rotate about the first end in the slot to allow the straight sides to coact with the sides of the slot and seal in either direction to allow reversal of the power converter,

fluid passageway extending from the annular space on each side of the vane to the first end for providing radially pressure loading against the other member.

2. The apparatus of claim 1 including, spring means in each slot yieldably urging said vane radially out of said slot.

3. The apparatus of claim 1 wherein said fluid passageways are provided around the side of the vanes by providing a sufficient clearance between the vane and the side of the slot for passage of fluid.

4. The apparatus of claim 1 wherein said fluid passageways include at least one passageway through the vane from each straight side at a point spaced from the second end to said first end.

5. The apparatus of claim 4 including, spring means in each slot yieldably urging said vane radially out of said slot.

6. In a fluid power converter having a rotor member and a stator member, the members being rotatable one with respect to the other with an annular fluid space therebetween, both of said members including a plurality of radially extending slots each receiving a vane therein, the improvement in the vanes comprising,

the longitudinal axis of the vanes in at least one of the members being at an angle to the radial extending plane through the axis of the converter.

7. The apparatus of claim 6 wherein the longitudinal axis of the

slots in the rotor are at an angle to the radial extending plane of the converter, and

the longitudinal axis of the vanes in the stator are at an angle to the radial extending plane of the converter, but in an opposite direction to the angle of the rotor vanes.

8. In a fluid power converter having a rotor member and a stator member, the members being rotatable one with respect to the other with an annular fluid space therebetween, both of said members including a plurality of radially extending slot each receiving a vane therein, the improvement in said vane comprising,

said vane in a radial cross section being of a width sufficiently less than the width of the slot for allowing fluid pressure from the annular space to flow into the slot and around the vane and act on the bottom of the vane for providing radially outward pressure loading against the other member,

said vanes having sides contoured to coact with the sides of the slot to seal therewith when engaging,

said vane being free to move in the slot in either sideways direction whereby either side of the vane may be brought into contact with a side of the slot thereby allowing the converter to reverse, and

the longitudinal axis of the vanes in at least one of the members being at an angle to the radial extending plane through the axis of the converter.

9. The apparatus of claim 8 wherein

the longitudinal axis of the vanes in the second of said members are at an angle to the radial extending plane of the converter, but in an opposite direction to the angle of the first member vanes.