United States Patent [19]

Powers

[11] **3,726,616**

[45] **Apr. 10, 1973**

[54] **FLUID ACTUATED ENERGY TRANSLATING DEVICE**

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[73] Assignee: **Northwestern University,** Evanston, Ill.

[22] Filed: **Jan. 11, 1971**

[21] Appl. No.: **105,430**

[52] **U.S. Cl.** **418/10,** 418/104, 418/195, 418/196

[51] **Int. Cl.**..........**F01c 1/08,** F03c 3/00, F01c 11/00

[58] **Field of Search**.........................418/195, 196, 10, 418/104

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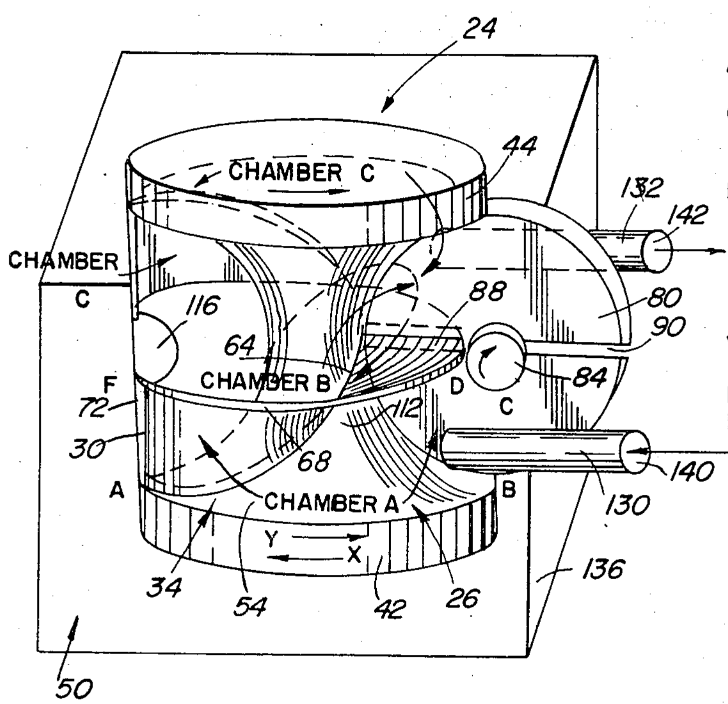
Assistant Examiner—John J. Vrablik
Attorney—Kegan & Berkman

[57] **ABSTRACT**

An energy translating device operative in response to fluid pressure and characterized by a novel and highly efficient intercoupling arrangement of its moving components. The elements of the device include a housing, a wasp-waisted spindle, a single turn mobius-type vane encircling the spindle and in fluid-sealing engagement with an annular wall of the spindle and with the housing, a rotatable slotted disc extending into a fluid cavity formed between the spindle and the housing and in fluid sealing engagement with the spindle and housing, the spindle-encircling vane passing slidably through a slot in the disc, and fluid input and exhaust passages extending through the housing and communicating with the interior cavity, on either side of the rotatable disc.

3 Claims, 16 Drawing Figures



A = EXPANSION CHAMBER (ROTATION X
A = COMPRESSION CHAMBER (ROTATION Y
CONFINING SURFACES CHAMBER A. DISC. B-C-D-E-B
SPINDLE: A-E-B-A
HOUSING CHAMBER WALLS A-F-D-C-B-A
VANE A-F-D-E-A
VANE SEAL AGAINST HOUSING BOSS: F-D
VANE SEAL AGAINST HOUSING WALL: A-F
DISC SEAL TO VANE: D-E
DISC SEAL TO HOUSING WALL: C-B

FIG-1

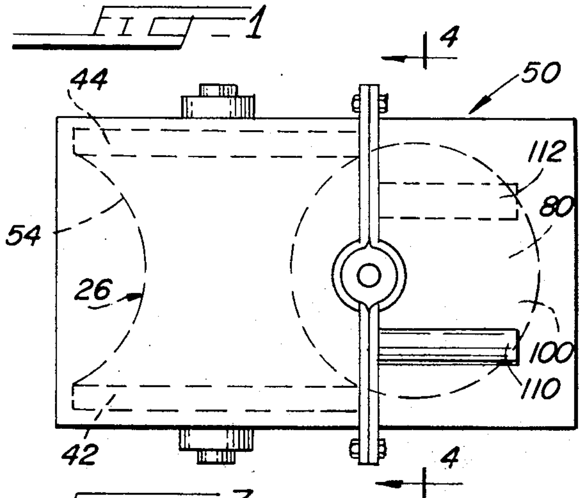


FIG-2

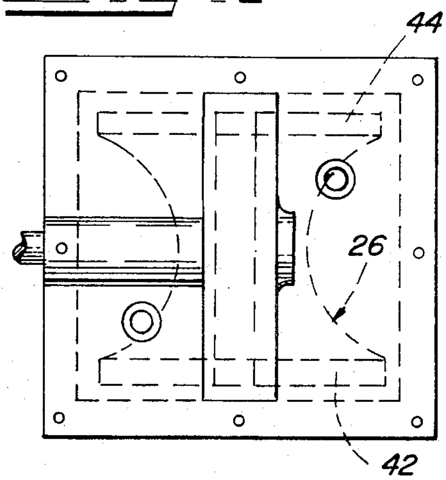


FIG-3

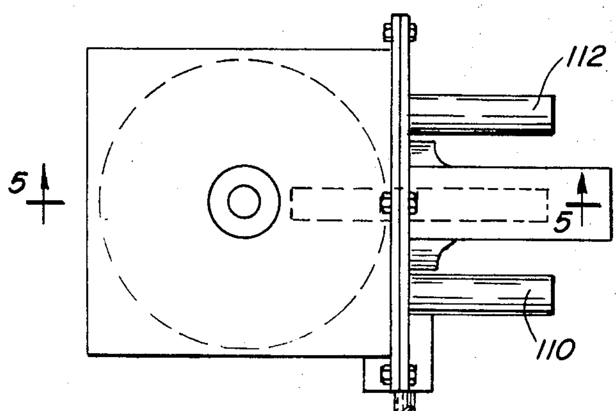


FIG-4

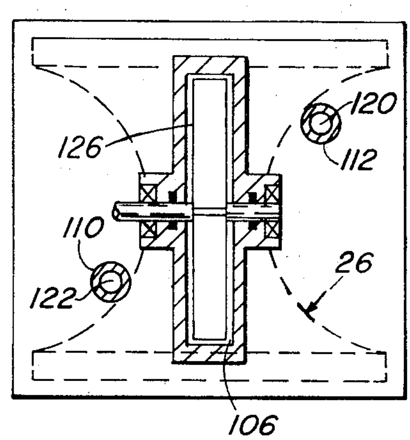


FIG-5

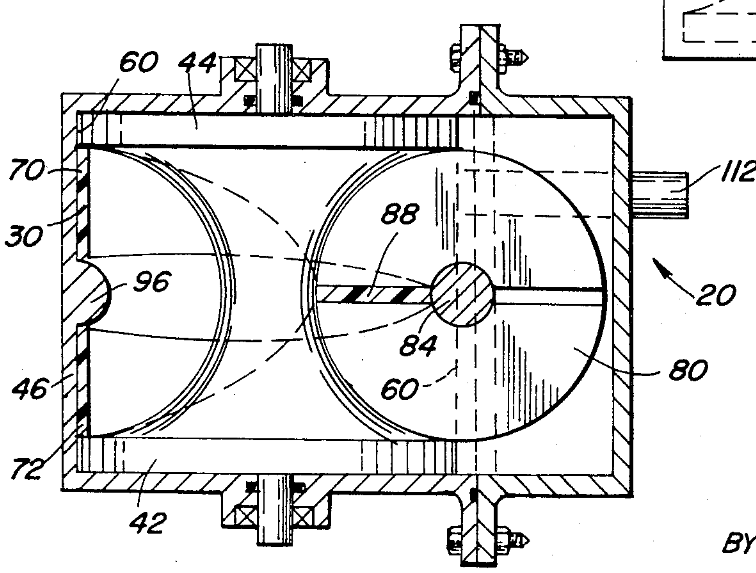


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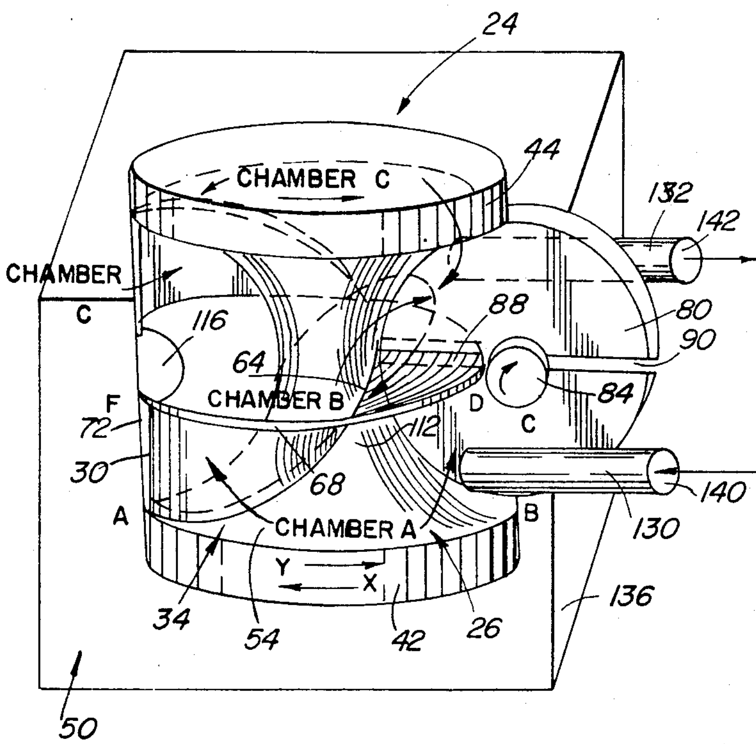
FIG. 6



A = EXPANSION CHAMBER (ROTATION X

A = COMPRESSION CHAMBER (ROTATION Y

CONFINING SURFACES CHAMBER A. DISC. B-C-D-E-B

SPINDLE: A-E-B-A

HOUSING CHAMBER WALLS A-F-D-C-B-A

VANE A-F-D-E-A

VANE SEAL AGAINST HOUSING BOSS: F-D

VANE SEAL AGAINST HOUSING WALL: A-F

DISC SEAL TO VANE: D-E

DISC SEAL TO HOUSING WALL: C-B

FIG. 7

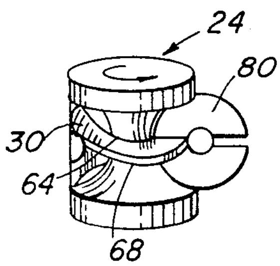


FIG. 8

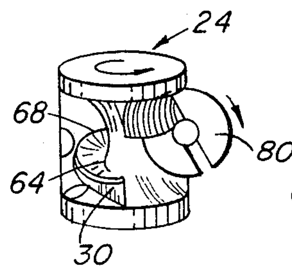


FIG. 9

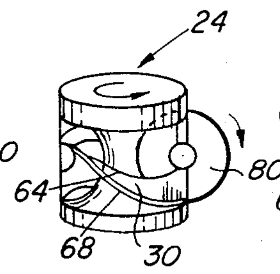


FIG. 10

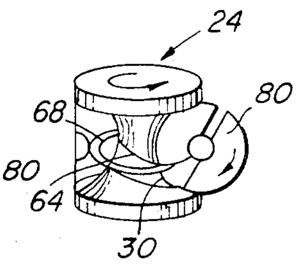


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FIG. 11

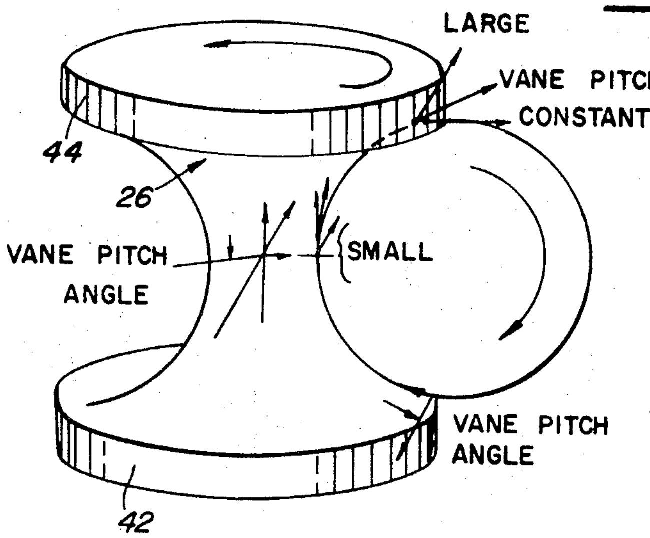


FIG. 12

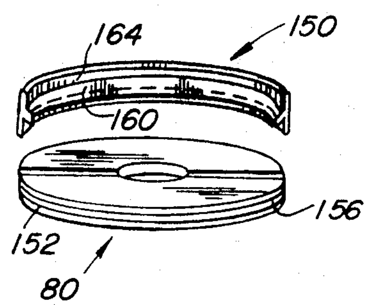


FIG. 13

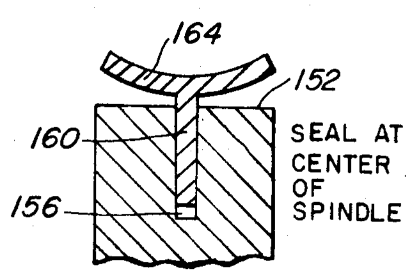


FIG. 16

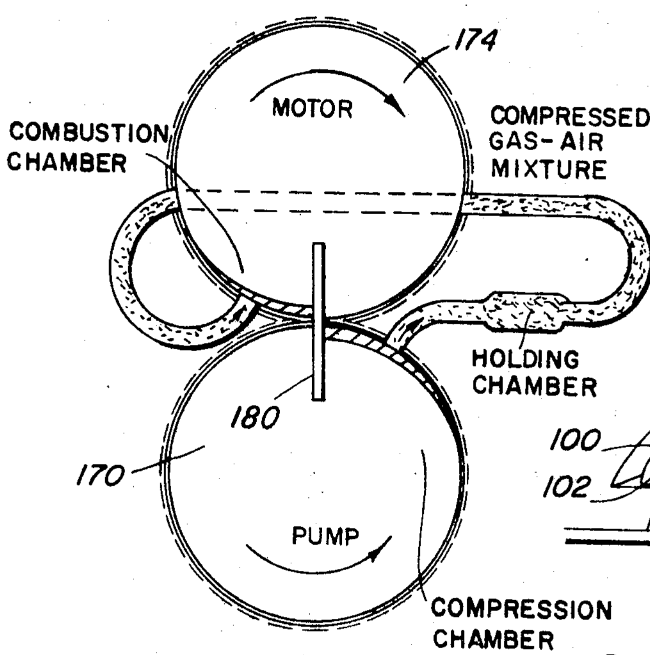
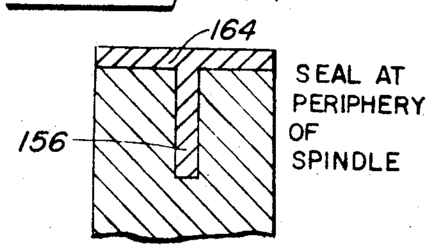


FIG. 14



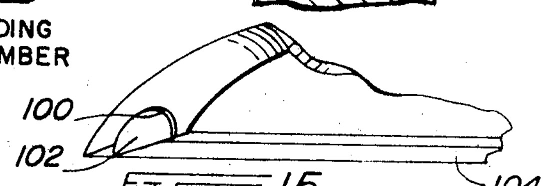


FIG. 15

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FLUID ACTUATED ENERGY TRANSLATING DEVICE

The invention relates to a fluid-actuated energy-translating device finding utility as a pump, motor, engine or other fluid pressure producing or responsive mechanism. More particularly, the invention is directed to a device utilizing rotary motion to produce substantially continuous torque under highly efficient operating conditions.

For illustrative purposes, and not by way of limitation, the present invention will be described in detail with reference to one preferred embodiment, a fluid motor.

A fluid motor embodying the present invention can be powered by gas or other compressible medium under pressure to generate continuous torque directly, without use of reciprocating motions. The basic device consists of a portion of a Mobius strip, formed as a vane mounted on a wasp-waisted spindle. This assembly, which is preferably all one unit, slips into a cylindrical cavity, the top and bottom rims of the spindle sealing the top and bottom of the cavity, and the edge of the vane forming a sliding seal against the walls defining the cavity.

The second, and only remaining, moving part of the motor is a disc with a hub, the disc being slotted in two places along a diameter. Either slot will slip over the vane so that the disc can fit in against the inner wall of the spindle forming a seal to the spindle and its attached vane. In a preferred embodiment of the invention the disc fits into the indented side of the spindle for half its diameter. The protruding half is accommodated by a slot machined into the inner wall of the housing defining the cavity. This slot cannot communicate with outside atmosphere, so it is dimensioned to fit the disc closely. To facilitate assembly, the housing is preferably fabricated in two parts. It will be appreciated that the slots in the disc must permit through passage of the vane with minimal friction. Techniques found suitable include forming the slots to include a "twist," radiusing the slots to make only a line contact with the vane, or employing flexible lining material in the region of contact.

The invention will be further described with reference to the accompanying drawings in which:

FIG. 1 is a side elevational view of an energy-translating device according to the invention and indicating, generally, the disposition of component parts in the housing;

FIG. 2 is an end elevational view of the structure illustrated in FIG. 1 and showing the projecting disc-enclosing chamber;

FIG. 3 is a top plan view of the structure of FIG. 1;

FIG. 4 is a cross-sectional view taken on the line 4—4 of FIG. 1;

FIG. 5 is a cross-sectional view, somewhat enlarged, taken on the line 5—5 of FIG. 3;

FIG. 6 is a diagrammatic, perspective view showing the mechanical relationship and the interengagement of parts of the mechanism of the invention, including the spindle, the casing, and the slotted disc;

FIGS. 7 through !0 are diagrammatic representations of stages in the sequence of spindle rotation in the motor of the invention;

FIG. 11 is a diagrammatic vector-like representation indicating the relative magnitudes and angular relationships of spindle and disc rotation as well as vane pitch in the motor of the invention;

FIG. 12 is a perspective view of a preferred embodiment of the spindle-engaging disc of the invention and a band for effecting a gas-tight seal between the disc and the spindle;

FIG. 13 is a cross sectional view of the sealing band of FIG. 12 seated in a cooperating annular disc-encircling groove formed in the periphery of the disc;

FIG. 14 is a cross-sectional view, similar to FIG. 13, but indicating schematically the limiting flattened disposition of the sealing band as assumed upon stressed engagement with the wall of the spindle of the device of the invention;

FIG. 15 is a fragmentary perspective view showing a preferred arrangement for sealing between the rotating disc and the spindle-encircling vane of the invention; and

FIG. 16 is a diagrammatic representation of the operation of the device of the invention as an internal combustion engine.

In the embodiment of the invention illustrated, the motor 20 includes a rotary assembly 24 consisting of a spindle 26 encircled by a convoluted open-ended vane 30. At its upper and lower extremities the spindle 26 is formed with end plates 42 and 44 the rims of which seal in bearing relationship against the surrounding wall 46 of a housing or casing 50 having a generally cylindrical bore, whereby the spindle 26 is rotatable within the housing 50. The exposed lateral wall 54 of the spindle 26 is a surface of revolution of a semi-circle, and the facing inner wall surface 60 of the housing 50 is preferably a right circular cylinder.

The vane 30, which takes the general form of a portion of a Mobius strip, executes only a single turn about the spindle 26. The physical orientation of the convoluted vane or strip 30 about the spindle 26 is such that one elongated edge 64 of the strip 30 is in fluid-sealing engagement with the concave surface 54 of the spindle 26. In a preferred form of the invention, the vane 30 itself is firmly fastened to the spindle 26 or is formed integrally therewith. The other elongated edge 68 of the strip 30 bears in fluid sealing engagement against the facing inner surface 60 of the housing 50. As seen most clearly in FIG. 6, in describing its path about the spindle 26, the strip 30 extends between the base plate 42 and the upper plate 44 of the spindle 26 to traverse the full longitudinal expanse or height of the arcuate wall 54. The upper and lower ends 70 and 72 of the strip 30 are in substantially vertical alignment, lie in substantially the same plane, and bear against the abutting wall 46 of the housing 50 in sliding, fluid-sealing engagement therewith.

Referring now to FIG. 6, the fluid motor embodiment of the invention illustrated includes an output disc 80 which is circular in form and has the same radius of curvature as the semi-circle which defines the surface contour of the spindle face 54, so that the longitudinal curvature of the spindle corresponds to the peripheral curvature of the disc. A hub 84 of the disc 80 serves conveniently as an output shaft. The disc 80 is formed with a pair of diametrically opposed slits 88 and 90 extending inwardly of its periphery and sized to receive the strip 30 therein for slidable passage therethrough and in fluid-sealing engagement therewith. The slits 88 and 90 are preferably radial but may be inclined at an angle to the radial direction provided that the angle of the convolute vane 30 is correspondingly arranged.

If the disc 80 is to rotate at constant angular velocity while the spindle 26 is also rotating at constant angular velocity, then the slits 88 and 90 in the disc cannot have a constant twist. This can easily be seen from the following:

At constant angular velocity, the periphery of the disc has a tangential velocity of a certain magnitude. Likewise, at the point where one radial element of the disc intersects or reaches the surface of the spindle, the spindle surface has velocity of its own at right angles to the disc tangential velocity. The local direction of the vane surface must lie along the resultant of these two vectors (FIG. 11). A pitch angle may be defined, at the root of the vane, as an angle which is maximum at this point and diminishes toward zero along the slot in the disc as the center of rotation of the disc, and the free edge of the vane, is approached.

As indicated schematically in FIG. 11, the tangential velocity of the spindle surface is least at the narrowest part of its waist, and greatest at the periphery. Hence, the pitch angle of the vane, measured from a normal to the plane of the disc, is greatest at the waist of the spindle and least at its periphery, if the tangential velocity of the disc is maintained constant relative to that of the spindle. A disc having appreciable thickness, therefore, cannot have its slots formed for a close sliding fit over the surface of the vane under the restriction of constant velocity, since the twist in this slot required for a close fit at one point would be correct only at one position between the center and the periphery of the spindle. Contact would have to be reduced to a line contact, with the thickness of the vane made variable in order to accommodate the varying pitch angle to the fixed slot width; the slot itself would preferably have rounded edges.

Included in the invention is a method of sealing effective to maintain a broad-area disc-to-vane seal under conditions of moderately varying pitch angle. Clearly, the less the ratio of maximum to minimum radii of rotation of the spindle surface, the less variation in pitch angle there will be, and the less stringent will be the requirements for flexible seals of the type described below.

In a preferred embodiment of the invention, the method of maintaining a disc-to-vane seal is to bond or apply a relatively soft compressible material to the inner faces of the disc slits, to take up variations in pitch angle while maintaining an area contact against the vane. A better method, though possibly of somewhat greater difficulty in execution, is to drill approximately radial holes into the disc so that when the slits are cut, each face of the slits will contain a groove 100 of round cross-section (See FIG. 15). Into this groove may be slid a straight round piece of flexible material 102 having a flat 104 along its entire length. The flat bears against the vane surface, and the cylindrical part bears against and rotates in the groove surface as the pitch angle and hence the twist of the slot is required to change. Just enough of the insert protrudes out of its groove to permit a flat contact surface to twist sufficiently to maintain area contact on the vane. This approach permits the use of flexible material of maximum strength for the insert, exposing a minimum of it to pressure from the working fluid. This insert may be a thin-walled metal extrusion if the changes in twist are not extreme. If preferred, softer material may be employed for greater flexibility. Bearing surfaces may be faced with metal.

As shown in FIG. 6, the disc 80 extends into the annular, generally semi-toroidal cavity or pocket 112 between the spindle 26 and the wall 46 of the housing 50, the peripheral arcuate edge of the disc 80 seating against the wall 54 in bearing relation therewith, whereby, upon rotation of the vane 30 and its passage through the slotted disc 80, the disc revolves about an axis tangent to the locus of the center of curvature of the abutting spindle wall 54, the rotation of the vane 30 being about an axis approximately at right angles to the axis of rotation of the disc 80. In the preferred form of the invention illustrated, the disc is disposed to present half of its diameter into the cavity 112. It will be appreciated that under such conditions a portion of the hub 84 will also extend into the semi-toroidal cavity 92. Accordingly the equatorial edge of the vane 30 cannot extend to the rotational axis of the disc 80 or to the cylindrical wall surface 60 of the casing 50. An annular boss 116 formed on the casing wall 46 and extending therearound ensures proper sealing between the vane 30 and the casing 50, the radial intrusion of the boss 116 into the cavity 92 corresponding to that of the disc hub 84. That half 120 of the disc 80 not in engagement with the spindle 26 and projecting generally radially outwardly therefrom extends into and is rotatably received in bearing and fluid-sealing engagement within a cooperating slot or groove 126 formed in the casing 50. Fluid input and exhaust passages 130 and 132 extend through the casing wall 136 and communicate with the interior cavity 112. The ports 140 and 142 opening into the cavity 112 are on opposite sides of the disc 80 and are displaced axially within the cavity 112, the positioning of the ports 140 and 142 being such that they are wiped by respective ends 70 and 72 of the strip 30 as the latter rotates within the housing 50.

A diagrammatic representation of the functioning of the rotating spindle and vane and its phased relationship with the slotted disc 80 is shown in FIGS. 7 through 10. As indicated, the spindle-vane assembly 24 is shown as turning counter-clockwise, as viewed from above. The disc 80 will then revolve clockwise.

When the spindle-vane assembly 24 turns once, the disc 80 will make half a revolution. As the disc slot 88 which has been engaged with the vane 30 and disappears into the housing 50 (FIG. 9), the other slot 90 appears and picks up the leading edge of the vane 30. Thus for nearly the entire revolution, one of the slots is engaged with the vane and the other is hidden in the recess 126 in the wall of the housing 50.

In FIG. 6 can be seen an area or zone in the lower foreground labelled "A." This represents a zone or chamber formed by the vane 30, the spindle 26 carrying the vane, the disc 80, and the cylindrical wall 46 of the cavity in the casing or housing 50. The chamber is roughly shaped like a pyramid with a triangular base and a chisel-shaped apex, bent around the spindle 26.

As the spindle 26 rotates in the direction shown by arrows, this chamber increases in volume for one full revolution. Therefore, a fluid under pressure introduced into this cavity near the disc will cause torque to be generated in the direction of the arrows.

At the end of one full revolution, the fluid in this chamber finds itself in a new chamber, sealed off when the trailing edge of the vane finally leaves the slot, chamber B. This chamber is bounded by the vane 30 and the walls of the housing 50, but now both ends are sealed off by the disc 80.

Chamber B will retain its identity for one full revolution, at which point it becomes the third chamber, which decreases in volume essentially to zero. The fluid in this third chamber is vented to external atmosphere by a hole through the housing just above the centerline and on the other side of the disc in FIG. 1, or else through the spindle. Alternatively, the fluid may be returned for re-use.

The establishment of a positive, effective seal between the disc 80 and the spindle wall 54 is important in ensuring efficient operation of the assembly. Several preferred sealing arrangements are set forth in detail below.

The surface of the spindle is convex at its narrowest point but essentially flat at its periphery. Hence the edge of the disc, if rigid, is restricted to a line contact with the spindle. In accordance with the seal embodiment illustrated in FIGS. 12 through 14, the effectiveness of the gas seal is enhanced through the use of bead, band or web 150 compressible or flexible material which automatically adapts or conforms its shape to maintain an area or zone of contact between the disc 80 and the spindle 26.

The outer edge 152 of the disc 80 is grooved 156, and the curved T-shaped bead is inserted into the groove 156 with the stem 160 of the T in the groove and the crossbar 164 of the T located between the disc edge 152, and the spindle face 54. The crossbar portion is preformed so as to be strongly concave at its face opposed to the stem 140. When pressed between disc 80 and spindle surface 54, the arcuate crossbar 164 will thus force itself into conformity with the spindle surface 54 anywhere between center (where the crossbar 164 will be curved) and periphery (where the crossbar 164 will be flattened), all as indicated schematically in FIGS. 13 and 14.

In particular special applications the sealing inserts or beads 150 are fabricated of hard, wear-resistant metal, too stiff to permit great degrees of flexing. In such cases the sealing insert 150 may consist of a plurality of generally flat rings (or half-rings) stacked or arranged like laminations, but formed independently, and inserted in place in the disc groove, each such insert being shaped to follow a natural radius of curvature somewhat longer than that of the disc edge so as to tend to spring resiliently outwardly against the spindle face. Each insert would make a line contact with the spindle face, and the multiplicity of such contacts would provide the necessary quality of gas seal. Each of the rings would occupy a position corresponding to that occupied by the stem 160 of the T-shaped bead 150 of FIG. 13 or 14 and would be retained by slightly deeper penetration into the disc of projections at each end of the semicircle.

There are two important factors which make the structure of the invention more efficient than other types of engines, particularly when the working fluid is steam. First, whether steam or some other gas is used, when the engine is operated by means of a compressed gas the work done near the end of the stroke is greater than that in a normal piston engine, because the area of the "piston" increases uniformly throughout the stroke. Assume that at the beginning of a revolution, a fixed quantity of compressed gas is introduced, which then expands for the remainder of the stroke. When the gas pressure is lowest, the area is greatest, so that useful work can continue to be extracted despite the drop in pressure. This means that the final temperature of the exhaust gases can be made lower, with a corresponding improvement in theoretical efficiency. The principle involved is the same as that in a multistage stream engine having high pressure and low pressure pistons, but the "staging" is continuous and occurs during a single stroke.

As a steam engine, this device can provide a portion of the ideal cycle that cannot be realized in a piston engine. After expansion of the steam in the first chamber, and a dwell-period of one revolution, the expanded steam can be compressed in a third chamber, being condensed under this pressure to the status of water droplets. This compression is powered (to the extent that power is required) by the power stroke which occurs in chamber A each revolution. After the midpoint of a revolution, the effective piston area of the inlet or power chamber is larger than that of the outlet chamber; hence, a continually increasing mechanical advantage than exists for efficient compression of the condensing vapor. Thus it appears feasible to do away with the separate condenser that is commonly employed, avoiding the need for a temperature drop that produces no useful work. Efficiency will further be improved by the fact that the final compression stroke will produce a rise in temperature in the third chamber, which will somewhat reduce the flow of heat through the vane from the expanding gases in the power chamber, heat which otherwise is altogether lost in an external condenser, and does not contribute to mechanical energy output.

For use as an engine with intermittent flow of gas into the power chamber, valving may be accomplished simply by placement of passageways in the spindle, in the housing, or in the shaft of the slotted disc. By this means both compression and expansion can be optimized.

The Mobius engine can be used as an internal-combustion engine by the simple addition of a spark-plug and valving, so that a gas-air mixture can be introduced into chamber A during the first few degrees of expansion, the chamber then being valved shut and the mixture ignited. Again the theoretical efficiency will be higher than that in an analogous ordinary piston engine because of the increase of piston area as the pressure drops. The fact that a power stroke lasts for one full revolution means that for a given engine speed the burning time allowed is four times as long as in a four-stroke cycle engine and twice as long as in a two-stroke cycle engine. The engine of the invention is essentially a one-stroke cycle engine, since exhaust and power strokes occur simultaneously. The operation of the engine of the invention as an internal combustion engine is indicated diagrammatically in FIG. 16.

For higher efficiency as an internal-combustion engine, the Mobius motor should be supplied with a pressurized and hot gas-air mixture. This is conveniently accomplished by using a second motor 170, geared to the first 174, as a pump. This pump 170 draws a mixture into chamber A, allows one rotation for mixing in chamber B, and then compresses the gas in the third chamber, raising pressure and temperature. Valving is used to release this compressed mixture into chamber A of the motor half for the proper portion of the cycle (so that ignition does not occur with this chamber at zero volume). Only one slotted disc 180 is required for the dual arrangement, since the unused half of the disc can be employed for the pump 170. The spindles are geared together through interengaging spur gears or other coupling means. Transfer of torque via the slotted disc would be inefficient, because of sliding friction.

The manufacture of the vane-spindle combination may be carried out starting either with a cylindrical workpiece or a rough casting. The principle of generating the vane and spindle as a single unit depends on using a tool which rotates in synchronism with the rotation of the workpiece through gearing or electronic control. The tool is placed on the same axis as the axis of the slotted disc, and as it rotates, a cutter is gradually extended radially from this axis, cutting deeper and deeper into the workpiece and making a helical slot. The workpiece and tool must be geared together, and the tool must be capable of allowing gradual extension of the cutting edge along a radius. The slot is then progressively widened to produce, finally, the vane, by altering the phase relationship of tool and spindle.

If the disc is to fit half its diameter into the spindle as it must if the vane is to be continually engaged in one or the other slot, then clearly, because of the need for a hub on the disc, the equatorial edge of the vane cannot be allowed to extend all the way to the axis of the disc, and hence cannot reach all the way to the wall of the cavity. Therefore, the cavity must have a boss around its middle, corresponding to the hub of the slotted disc, in order to maintain the necessary seal. The vane can be machined away to fit the boss properly by using a cutter of the same diameter as the disc hub, while the workpiece is spinning, or the required groove can be cut prior to machining the vane(and this will facilitate generating the vane).

The slotted disc bears all the reaction force from the motor torque, and must transmit this force to the housing. Therefore, the disc is preferably mounted on thrust bearings, which in turn can be mounted in a shaft from the hub of the disc.

This same mechanical arrangement can be made into a highly efficient right-angle drive with a reduction ratio of two to one. One of several possible configurations would involve only the mounting of conical rollers on ball bearings in the slots of the slotted disc. This would change the sliding friction to rolling friction, and power would be transmitted efficiently from the spindle to the shaft of the disc.

Power input and output from this device, whether used as a motor, right angle drive, or pump, would require a shaft through the spindle. Bearings on this shaft could be used to serve as locators for the spindle, the seal around the upper and lower rims of the spindle then being accomplished with inset material, metal or high-temperature compressible material. Friction at this seal will be reduced greatly by separate suspension of the spindle in bearings, since the torque is not balanced about the axis of the spindle. Changes in geometry can be made by increasing the radius of the spindle relative to that of the slotted disc; thus it would be possible to vary the torque obtained for a given disc size and inlet pressure, by moving the disc farther away from the axis of the spindle. The torque and speed of the motor can easily be tailored to different applications.

A Mobius strip is a topological form created by giving a strip of material a half-twist and joining its ends. Thus, a true Mobius strip has only one edge and one surface. In the subject invention the vane utilized in the apparatus described is referred to as a "Mobius-type" of surface because that surface has the same general or basic form of a Mobius strip, that is, a surface which is twisted about a curved line lying within a toroidal volume, the curved line being the mean major diameter of the toroidal volume. The vane utilized in the structure of the subject invention is not a true Mobius strip because the ends do not in fact join, and the amount of twist is not necessarily exactly one-half turn as it is in a true Mobius strip.

While preferred embodiments of the novel fluid actuated energy translating device of the invention have been illustrated and described, it is understood that the same is capable of modification and that such modifications may be made without departure from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A multi-chambered fluid-actuated engine comprising in combination, first and second motors and chamber end wall means common to said motors,

said first and second motors each comprising means defining an annular pocket encircling a rotatable spindle-shaped central axis and bounded by inner and outer wall surfaces that are surfaces of revolution,

one of said wall surfaces in each said motors being a surface of revolution of a semi-circle and the other of said wall surfaces being a right circular cylinder,

a Mobius-type vane in each said motors,

each said vane encircling a corresponding said rotatable spindle-shaped central axis and being in fluid-sealing engagement with corresponding said inner and outer wall surfaces bounding said annular pocket,

each said vane being firmly fixed to a corresponding central axis, whereby each said spindle-shaped axis turns when each said vane turns, in fixed relation therewith,

an annular boss in each said motors,

said boss being substantially semi-circular in transverse cross section and affixed to a corresponding said wall surface defining a right circular cylinder to extend therearound and inwardly thereof, each said annular boss being concentric with a corresponding said surface of revolution of a semi-circle and constituting a figure of revolution, each said boss ensuring fluid-sealing engagement between a corresponding vane and said wall surface defining a right circular cylinder,

said chamber end wall means common to said first and second motors comprising a circular disc,

said disc being of the same radius as the semi-circle wall surface and rotatable about an axis tangent to the locus of the center of curvature of each said wall surface of said first motor and of said second motor that is a surface of revolution of a semi-circle,

said disc having a radius matched to the radius of each said surface that is a surface of revolution of a semi-circle of each said first and second motors,

said disc being formed with a pair of diametrically opposed slits extending radially inwardly of a periphery thereof,

each said vane of respective said first and second motors projecting into a corresponding one of said pair of said diametrically opposed slits for sliding movement therethrough,

a fluid pressure inlet on one side of said disc,

a fluid pressure outlet on the other side of said disc, and

sealing means carried by said disc at a circumambient face thereof and adapted to abut, bear against, and to conform resiliently to an outer bounding wall of the central axis to establish a zone of sealing contact between said disc and the outer wall surface which is a surface of revolution of a semi-circle,

said sealing means consisting essentially of an arcuate bead substantially T-shaped in cross section and including a stem and a crossbar,

said stem being adapted to seat within a radial groove extending inwardly of a peripheral encircling edge of said disc, and said crossbar being adapted to abut, seal against, and conform to said outer bounding wall of the central axis of each said first motor and said second motor.

2. The structure as set forth in claim 1 and further comprising intercoupling means interconnecting a central axis of said first motor with a central axis of said second motor, said intercoupling means being operative to transfer torque forces between said first motor and said second motor.

3. The structure as set forth in claim 1 wherein said second motor constitutes a pump including a compression chamber and said first motor includes a combustion chamber, and further comprising fluid carrying conduit means communicating between and interconnecting said pump with said first motor.

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