May 7, 1968 J. VANSTEENE 3,381,583

VOLUMETRIC MACHINE

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Fig. 1

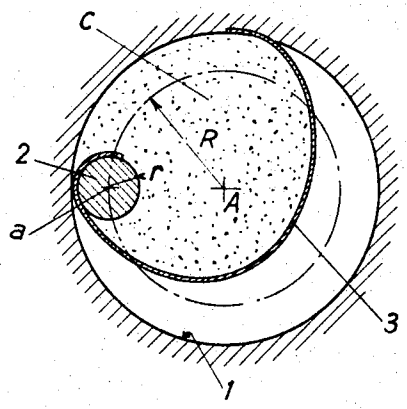



Fig. 2

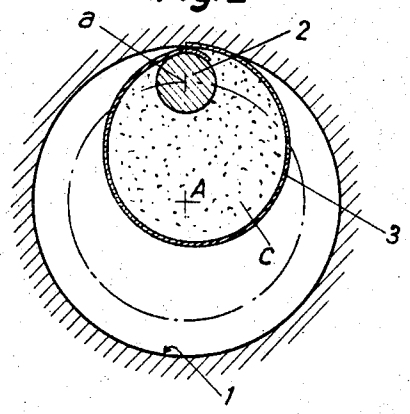



Fig. 3

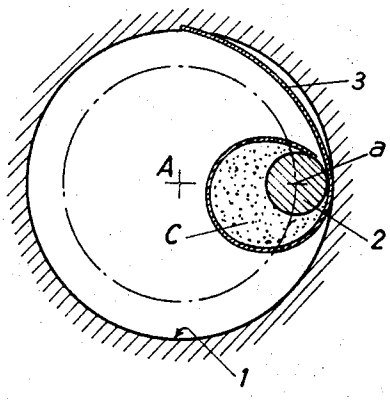



Fig. 4

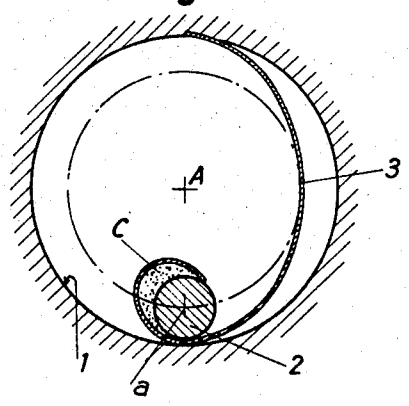
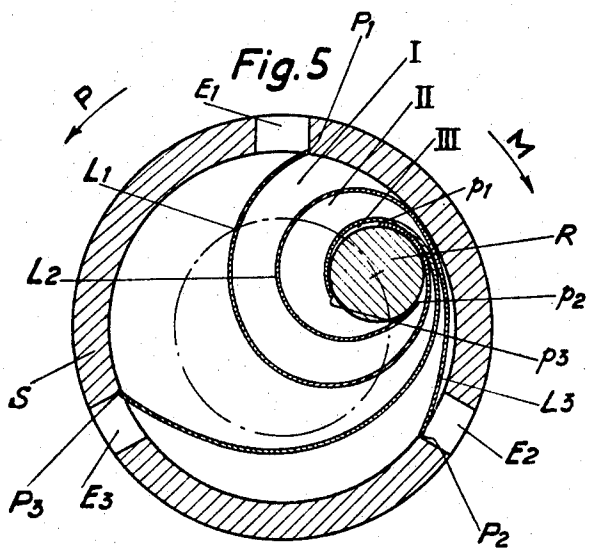



Fig. 5



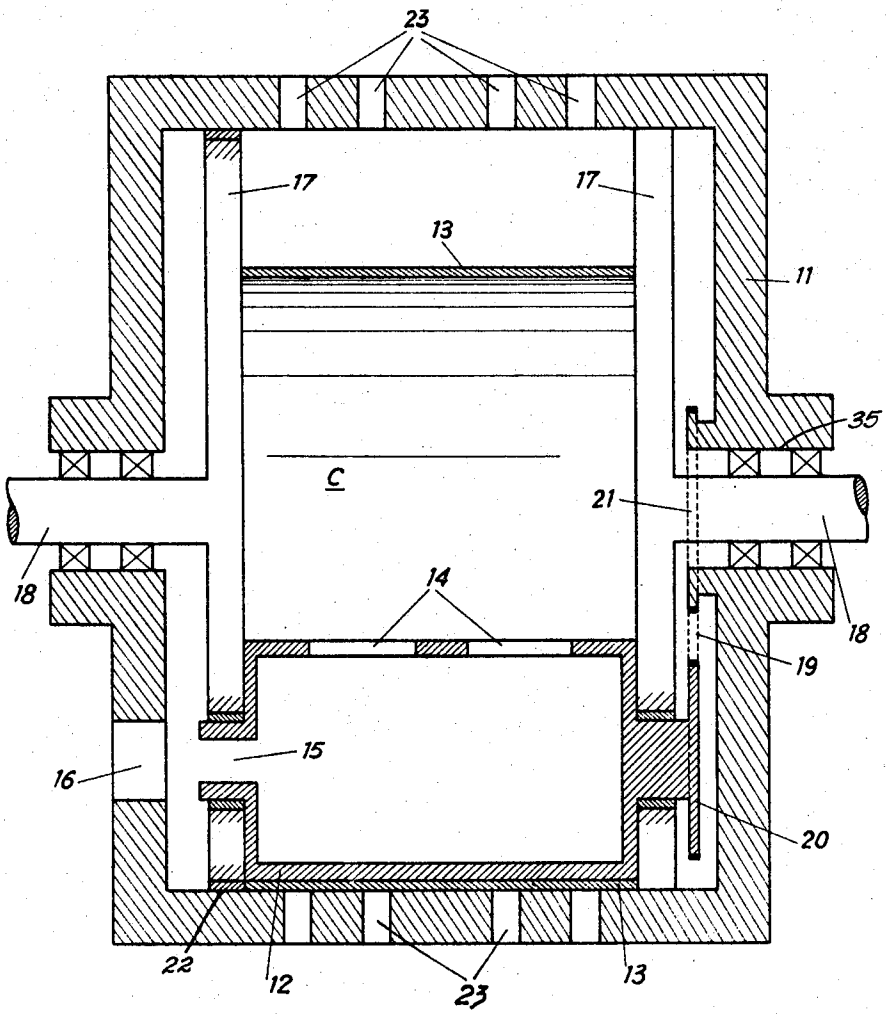

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Fig.6



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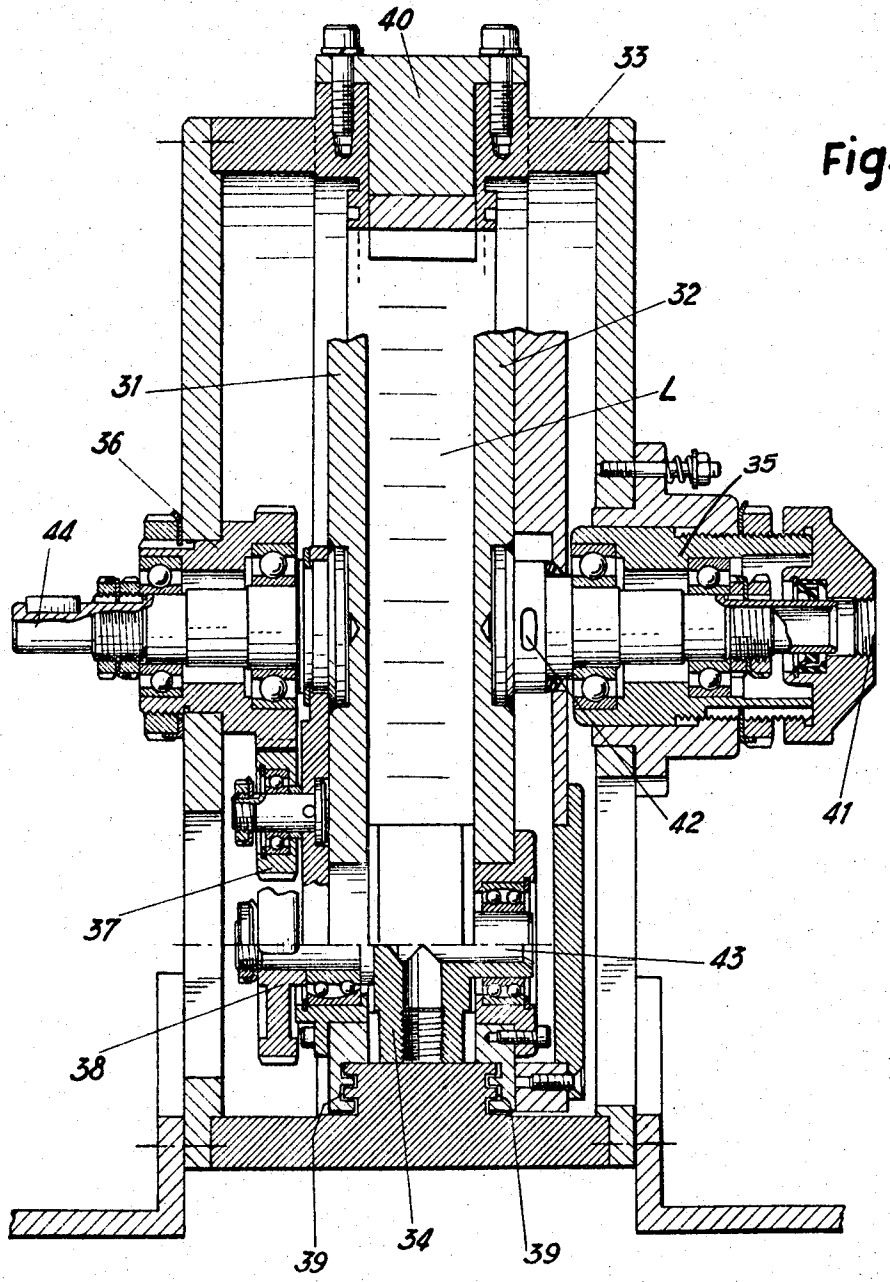



Fig. 7

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Fig. 8

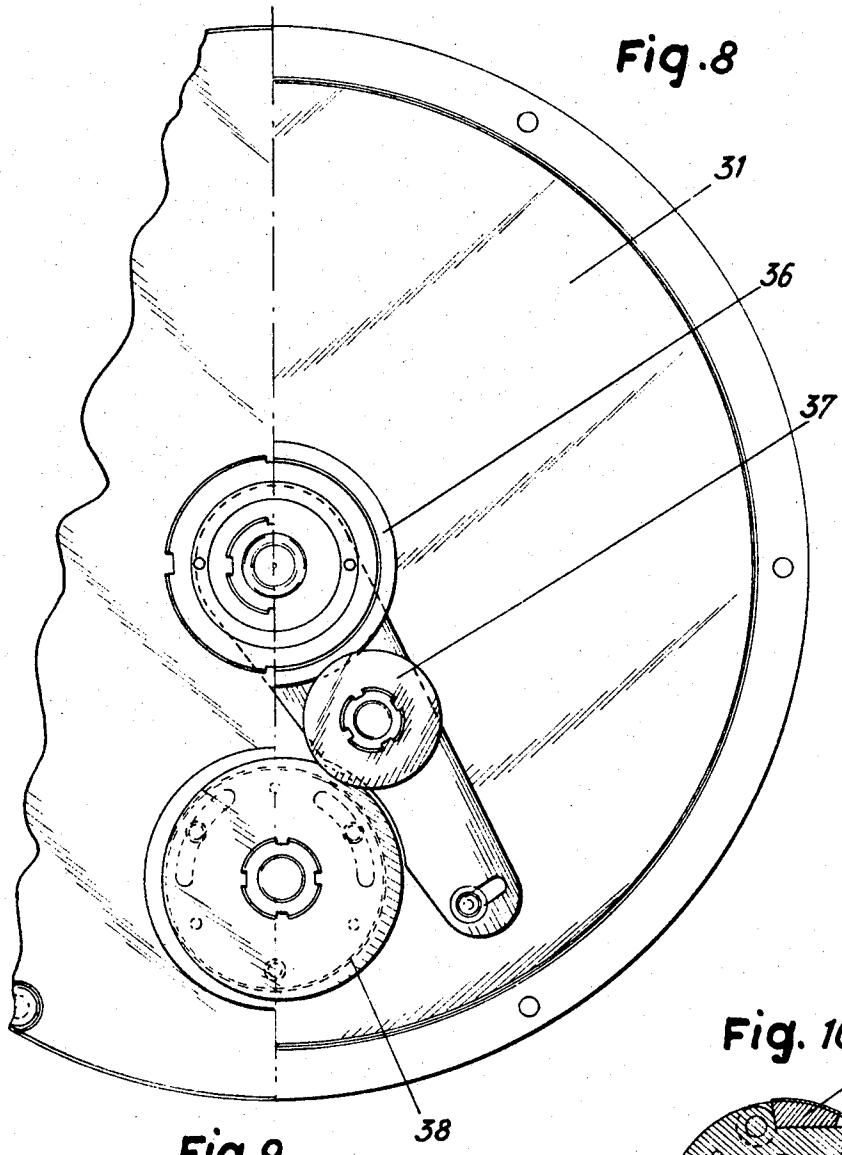



Fig. 9

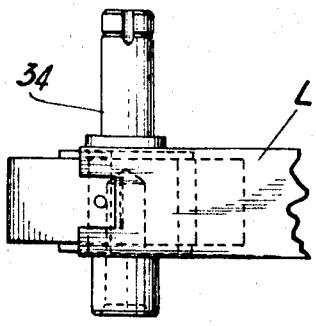
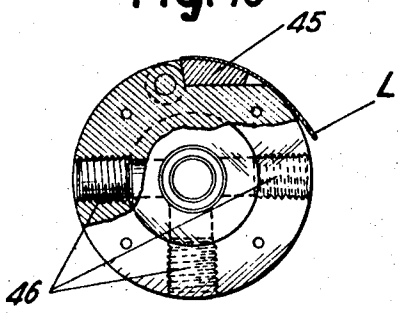



Fig. 10




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3,381,583

# VOLUMETRIC MACHINE

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Claims priority, application France, Nov. 20, 1964, 995,644
10 Claims. (Cl. 91—56)

## ABSTRACT OF THE DISCLOSURE

A fluid handling machine, such as a fluid motor or pump, has an inner member rotating with a pair of cheek discs within a housing and moving a flexible strip between the cheek discs so that a working chamber of varying volume is formed.

The present invention relates to a new hydraulic or pneumatic machine which may operate either as a motor or as a pump to transform the energy of a fluid-flow or pressure-into useful mechanical energy or, inversely, to use mechanical energy to modify the flow and/or the pressure of a fluid.

The machine in accordance with the invention is of the type in which the variation in volume of a fluid chamber is connected with the movement of a mechanical system.

More specifically, the present invention concerns a hydraulic or pneumatic machine capable of operating either as a pump or as a motor comprising essentially a fixed cylindrical enclosure, a cylindrical rotor capable of moving along the internal surface of the cylindrical enclosure in accordance with a cyclic law which makes a given orientation of the rotor about its axis correspond with its angular position relative to the axis of the enclosure; at least one flexible and substantially inextensible strip connected on the one hand to the internal surface of the enclosure and on the other hand to the rotor on which it is partly wrapped, the surface of this strip being parallel to the generatrices of the cylindrical enclosure and of the rotor; two transverse closure cheeks which make substantially sealing tight contact with the two edges of the sheet, a variable volume fluid chamber being thus defined by each sheet, the cheeks and the rotor, in the interior of the enclosure, the variation in volume of this chamber being connected with movement of the rotor; means for the admission and escape of fluid associated with the said chamber and mechanical transmission means associated with the rotor.

Preferably, but not necessarily, the law of movement of the rotor is as follows: It travels around the axis of the enclosure while always remaining parallel to it. Its movement is thus the product of a rotation about the axis of the enclosure with a rotation about its own axis with inverse angular speed.

For this purpose, the rotor is advantageously pivotally mounted between the two closure cheeks which are themselves fixed to a shaft mounted for rotation on the axis of the cylindrical enclosure, a coupling formed for example by an assembly of chain and sprockets or by a train of gears ensuring a mechanical transmission connection such that one turn of this shaft corresponds to one turn of the rotor about itself.

There could also be used a connecting means such that another law of relative displacement is given to the rotor and to the assembly of the two cheeks, for example by using a train of non-circular gears.

The sheet is preferably a flexible metal sheet, advantageously a steel sheet.

Furthermore, to ensure good sealing tightness of each chamber while avoiding too great friction of the strip



against the rotor and on the internal wall surface of the enclosure, of the strip on itself and of the edge of the strip against the moving closure cheeks, the strip may be covered on its two edges and possibly on its two faces with a substance of the Teflon type, such as tetrafluoroethylene.

Fixing of the strip onto the rotor and onto the internal wall surface of the cylindrical enclosure may be effected by any appropriate means such as welding, screwing, the strip being preferably inlaid into the surface of the rotor and of the cylindrical enclosure. The connection between the strip and the rotor and the interior of the enclosure is preferably tangential. A hinge may be used for the junction of the strip with the rotor.

Finally, several strips having points of attachment which are regularly spaced around the periphery of the rotor and along the length of the enclosure may be used, these strips defining several fluid chambers.

As for the admission and escape of fluid, this may be effected in different manners, particularly by openings or orifices provided in the cheeks or by one or several internal conduits formed in the rotor.

The following description and the accompanying drawings, given solely by way of non-limiting examples, will make better understood how the invention may be carried into effect.

In the drawings:

FIGS. 1 to 4 show diagrammatically in transverse section the machine in accordance with the invention, during four successive phases of operation, in one embodiment which has only a single strip,

FIG. 5 shows diagrammatically the machine according to the invention in an embodiment comprising three strips,

FIG. 6 shows diagrammatically in axial section a machine in accordance with the invention,

FIG. 7 is a corresponding sectional view of an actual prototype,

FIG. 8 is a partial side view of this prototype, and

FIGS. 9 and 10 show a view from above of a transverse section respectively of the rotor of the said prototype.

The machine shown in FIGS. 1 to 4 comprises a cylindrical enclosure or stator **1** having an axis A, a cylindrical rotor **2**, of radius *r*, a strip **3**, partially wrapped on the rotor **2** and connected tangentially at its two ends to the rotor **2** and the stator **1**. In cooperation with two cheeks parallel to the plane of these figures, this assembly creates a variable volume chamber C.

The rotor **2** is mechanically constrained to turn about A, the rotor **2** turning about itself about *a* at the same speed to remain parallel to itself.

During this movement, the volume of the chamber C varies cyclically.

If the rotor **2** turns about A clockwise, the chamber C passes through the successive states of FIGS. 1, 2, 3 and 4, starting from a maximum the chamber C decreases to nothing during one revolution.

The rotor continuing to turn, a new chamber C of maximum volume is formed and the cycle re-commences.

When the rotor **2** is driven mechanically as has been indicated above, a fluid is introduced into the chamber by suitably provided inlet openings and if the outlet orifices are also provided, the machine operates as a pump.

Inversely, if a motive fluid under pressure is admitted into the chamber C, the pressure in the latter causes tension in the strip **3**; this tension T generates a moment on the rotor **2** relative to the axis A causing rotation of the rotor anticlockwise. This motive couple is at least equal to $T \times R$, where R equals A*a*. The couple required to roll the strip on the rotor (resistive couple) is equal to $T \times r$. The motive couple finally developed by the machine operating as a motor is finally $T(R-r)$, neglecting friction.

The problems of sealing tightness, inlet and outlet are not complex. FIG. 6 shows, by way of example only and

for a better understanding of the operation of this kind of machine, a possible mechanical assembly.

There will be recognised, in FIG. 6, the three essential eelments: a rotor **12**, a tubular stator housing **11** and a strip **13**. The rotor is hollow permitting communication between the interior of the stator and an external conduit by means of orifices **14**, **15** and **16**. The rotor is carried by two cheeks or discs **17** which enable the rotor to be mechanically connected to the shaft **18**, these two discs moreover ensuring sealing tightness of the working chamber C by being applied against the sides of the strip **13**. The rotation of the rotor **12** about itself is ensured by a chain **19** connecting two sprockets **19**, **20** carrying the same number of teeth. One of these **20** is fixed to the rotor, the other **21** is fixed to the stator. The orifices **23** place the enclosure C in communication with the exterior at all instants. Sealing rings **22** ensure sealing tightness. FIG. 6 thus illustrates one mode of carrying the invention out in practice.

It should be pointed out that the length of the flexible strip which is wrapped about the rotor may be variable and that by wrapping several turns of the strip on the rotor, several sealed enclosures may be obtained which can be placed under successive pressures, thus for the same machine, there is obtained, in accordance with the length given to the strip and the number of turns thereof wrapped around the rotor, different relationships between the fluid pressure and the speed of rotation of the rotor. It is thus possible to make either the couple or the speed vary in the case of operation as a motor, or the pressure or the output in the case of operation as a pump. The relationship between the radii r and R affects the output and performance of the machine. The optimum arrangements are to be determined for each type of fluid, its pressure and the required results.

As has been indicated above, the skilled man has at his disposal numerous means for mitigating the harmful effects of friction of the strip on the cheeks and the stator and of the strip on itself while ensuring the sealing tightness of the enclosure. A preferred means consists in covering the strip with Teflon on its sides and its faces.

In the case of thermal motors (explosion and expansion of gas in the chamber C), there may be employed as lubricant a "calcium soap" of the type known and used in the field of artillery.

Moreover one cheek may advantageously be made displaceable relative to the other, particularly in the direction parallel to the shaft of the machine, to permit taking up of play as the strip wears.

The invention thus enables machines to be built having very simple structure operating as pump or as motor and of which the fabrication raises only a few machining difficulties. These machines may operate with high compression ratios and with a very large power/weight ratio.

One of the advantages of the machine in accordance with the invention is to permit a large expansion of the gases when it is used as a motor; similarly, if it is operating as a pump it can compress in a single revolution a large volume of gas.

This advantage no longer exists if the motive or pump fluid is a liquid. To one revolution there then corresponds a fixed output of liquid, the couple available or supplied to the motor shaft being directly connected to the pressure of this liquid. The couple is then besides not fixed and varies cyclically.

It would appear to be advantageous when the fluid is a liquid to connect the stator to the rotor not by a single strip but by several strips.

FIG. 5 shows the principal section of such an embodiment. In it will be recognised the stator S, the rotor R and three strips $L_1$, $L_2$ and $L_3$.

The rotor being constrained to turn about itself, and in the opposite direction for the same number of turns which it carries out about the centre of the stator cavity, it will be seen that the points $p_1$, $p_2$ and $p_3$ where the strips $L_1$, $L_2$ and $L_3$ respectively make contact during a cycle with the points $P_1$, $P_2$ and $P_3$ serving for the fixing of the strips on the stator. Thus there is always between the rotor R and the stator S three thicknesses of strip.



These strips determine between them and with the stator and the rotor the enclosures I, II and III.

With the machine operating as a motor and the sealing being provided between the rotor and the stator, in the case of the figure, the enclosures being at the same pressure, only the strip $L_1$ is subjected to a pressure difference between its two faces and it is subjected to a tension acting on the rotor. When the latter has carried out a rotation of 120°, the strip $L_2$ alone operates, the position of the strips having been permutated. It appears to be necessary that the inlet of fluid should be sequential so as only to act when the enclosures being supplied are closed. There are to be provided outlet openings $E_1$, $E_2$ and $E_3$ for each strip, in FIG. 5.

If there is no sealing between the rotor and the stator, the stator only then acts as a guide. Only those enclosures which are formed uniquely by a strip and the rotor in the case of the figure are then supplied with fluid.

Thus for the position of the rotor shown, only the enclosures II and III are supplied anl only the strip $L_2$ is under tension until the point $p_2$ comes into contact with the point $P_2$; at this moment, the motive tension is that in the strip $L_3$ and so on.

As can be seen, a single strip works at any moment, whatever the mode of operation. It does not seem to be useful to increase above three the number of strips.

The advantages of the "multi-strip" solution over the "single strip" solution are as follows:

More regular motor couple.

More regular pump output.

A large volume is placed permanently under a pressure exerting a force against the cheek which carries the rotor. It is more easy to supply in this way the interior of the rotor by placing the other face of the same cheek in communication with the fluid under pressure, this causing the cheek to be urged against the area of the strips for an assembly of the type of that in FIG. 6.

FIGS. 7, 8, 9 and 10 which will be briefly described, relate to a prototype of pneumatic motor which has performed satisfactorily. Intended for the verification of the principle and for the determination of some optimum arrangements, this prototype comprises many controllable or adjustable elements. Thus the whole arrangement of bearing **35** permits displacement of the cheek **32** parallel to its axis. The bearing **35** can turn about itself to cause the rotation of the rotor by the pinions **37** and **38**. The rotor **34** is mounted on two eccentric bearings which permit the rotor to be moved nearer or further from the internal surface of the stator **33**.

All these adjustments reacting on each other have complicated this experimental prototype.

The operational arrangements are as follows:

Two cheeks or discs **31** and **32** ensure the mechanical connection of the rotor to the output shaft **44** and the supply of the fluid into the space in the stator **33** through the hollow shaft **41**. These cheeks or discs also ensure the sealing off of the enclosure. Correct sealing tightness between the cheeks and cylindrical inner surface of the stator is ensured by the labyrinth formation **39**.

The strip L is fixed to the stator by the member **40** which holds it clamped. This strip is fixed to the rotor by a member **45**, see FIG. 10, forming a hinge with the rotor, this being for the purpose of simplification for this prototype, of the problem of fixing it on the rotor.

The rotor is constrained to turn about itself in the opposite direction to its rotation about the axis of the enclosure by means of the pinion train **36**, **37** and **38**, the latter being keyed to the rotor **34**. The pinions **36** and **38** have the same number of teeth. The pinion **36** is fixed to the stator, the pinion **37** being intermediate between **36** and **38**.

Inlet of fluid takes place through the hollow shaft **41**, the openings **42**, the hollow shaft **43** of the rotor **34**, and orifice **46**. The rotor is pierced with three threaded orifices **46**, which enables one or more of them to be blocked during experiments. These orifices connect the enclosed working chamber with the fluid under pressure.

The prototype operates in a satisfactory manner taking into account that to permit all the adjustments, its dimensions are large: internal diameter 300 mm.—width of the strip 50 mm., with a volume of nearly 4 litres.

I claim:

**1.** A rotary fluid handling machine, comprising, in combination, a tubular outer member having a first axis and a cylindrical inner surface; a pair of disc means mounted in said outer member for rotation about a first axis and having peripheral surfaces in sealing contact with said inner surface, said disc means being spaced from each other in the direction of said first axis and forming between each other and with said inner surface an inner space; an inner member located in said space and mounted on said disc means and having a second axis parallel with said first axis and radially spaced from the same; and at least one flexible strip having an outer end connected to said inner surface and an inner end connected to said inner member, and lateral edges in sealing contact with said disc means, said strip forming in said space a working chamber whose volume varies during relative rotation between said outer member and said disc means with said inner member; and means for supplying fluid to said working chamber and for discharging fluid from the same.

**2.** A fluid handling machine as claimed in claim **1** wherein said tubular outer member is a stationary housing; wherein said disc means include shaft means rotatably mounted on said housing and projecting out of the same so as to be adapted to be connected to another machine while said shaft means and disc means rotate with said inner member.

**3.** A fluid handling machine as claimed in claim **1** wherein said inner member is cylindrical.

**4.** A fluid handling machine as claimed in claim **1** wherein at least one of said disc means is mounted for axial movement; and including means for adjusting the position of said one disc means.



**5.** A fluid handling machine as claimed in claim **1** comprising a plurality of flexible strips each secured to said inner member and to said inner surface of said outer member at circumferentially spaced points.

**6.** A fluid handling machine as claimed in claim **1** wherein said disc means include shaft means for mounting said disc means on said outer member; and wherein said inner member has journal means mounting said inner member for rotation on said disc means.

**7.** A fluid handling machine as claimed in claim **6** wherein said inner member is hollow and has openings communicating with said working chamber; wherein at least one of said journals is tubular and communicates with an outer space formed outside of said disc means in said outer member.

**8.** A fluid handling machine as claimed in claim **6** comprising transmission means for rotating said shaft means and said journal means in opposite directions so that said inner member and said disc means rotate in opposite directions.

**9.** A fluid handling machine as claimed in claim **8** wherein said transmission means include a gear on said outer member coaxial with said first axis, a gear on said journal means, and chain means passing over said gears.

**10.** A fluid handling machine as claimed in claim **8** wherein said transmission means include a gear train connected with said journal means and having a ratio of 1:1, said gear train including a gear on said outer member coaxial with said first axis.


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