July 7, 1964 JEANNINE MARIE SUZANE LARPENT BORN CORSET 3,139,871

FLUID MOTOR AND PUMP HAVING EXPANSIBLE CHAMBERS

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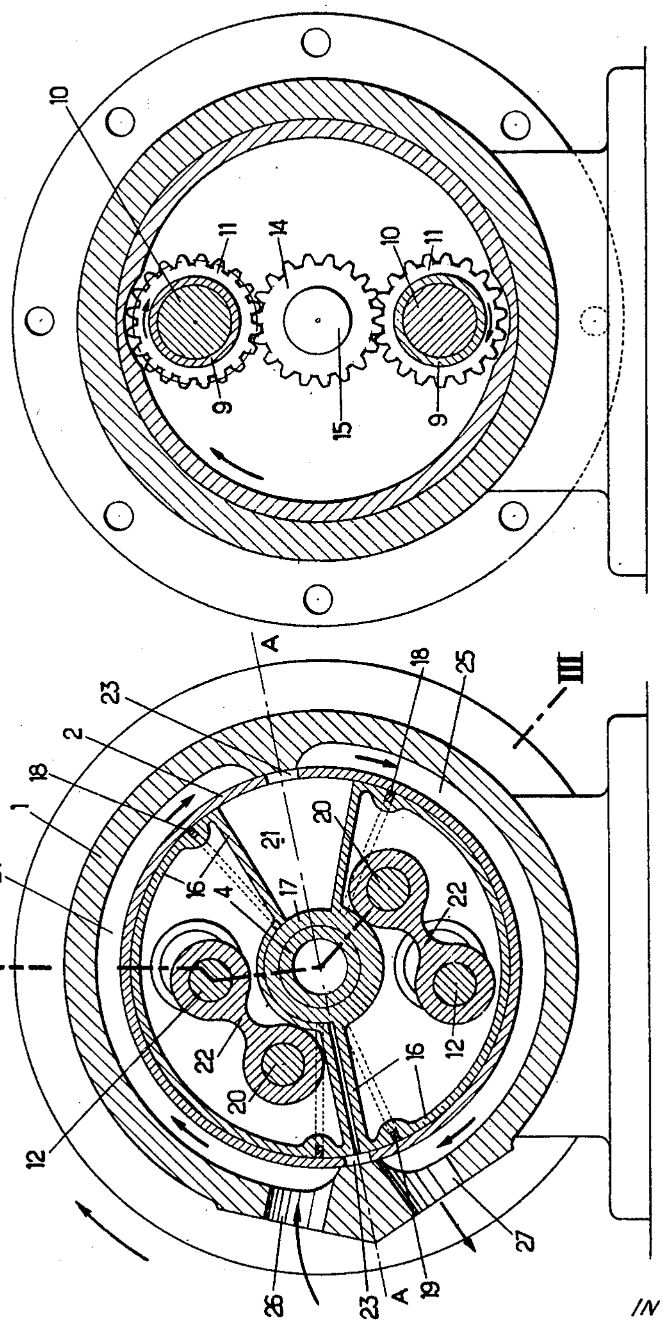
FIG.2

FIG.1



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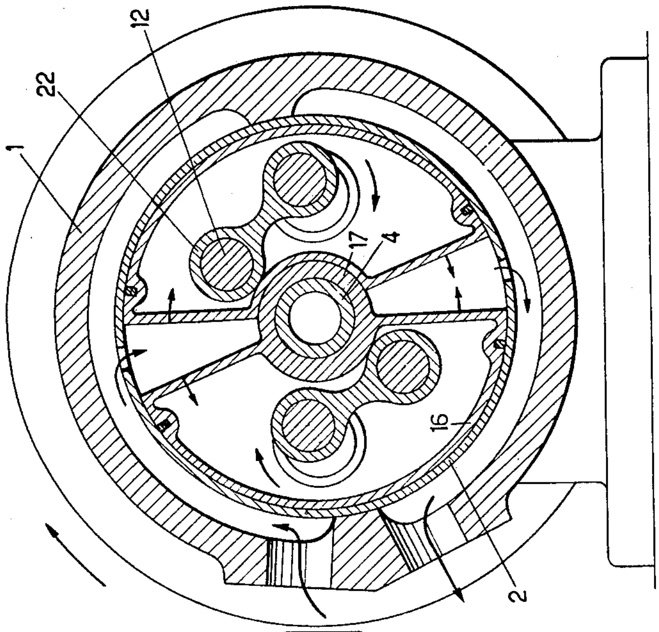

FIG. 4

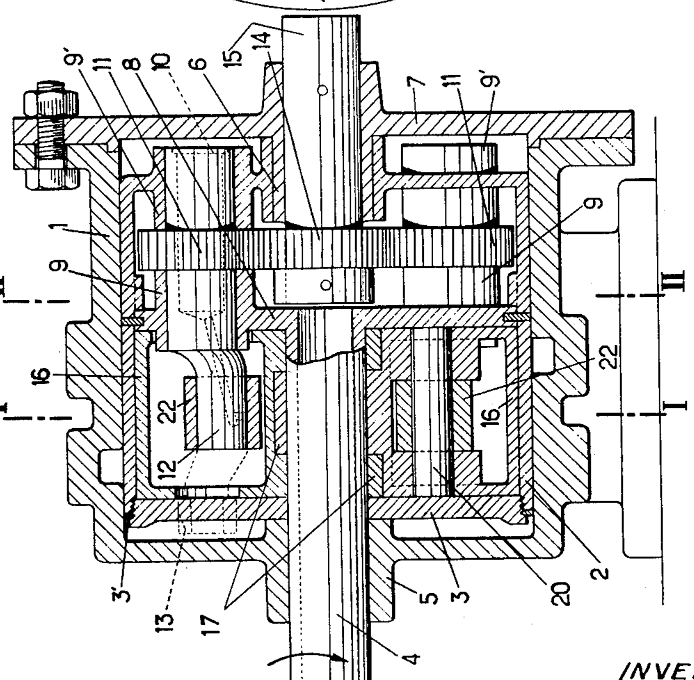

FIG. 3

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FIG.5

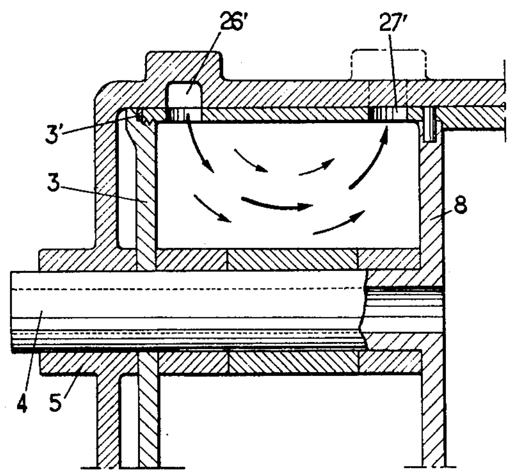
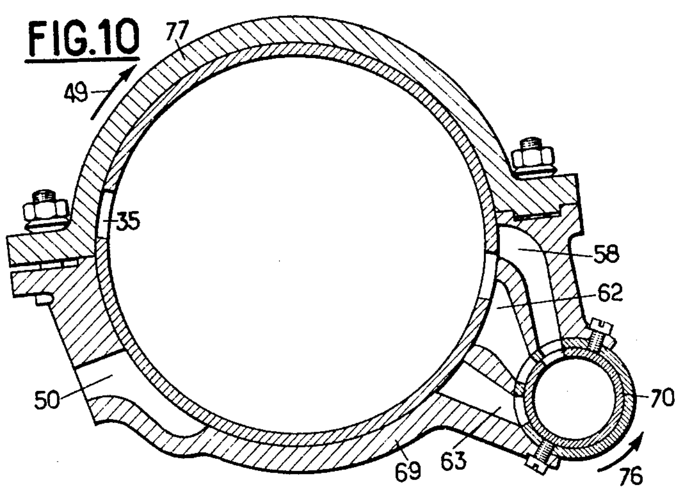


FIG.10



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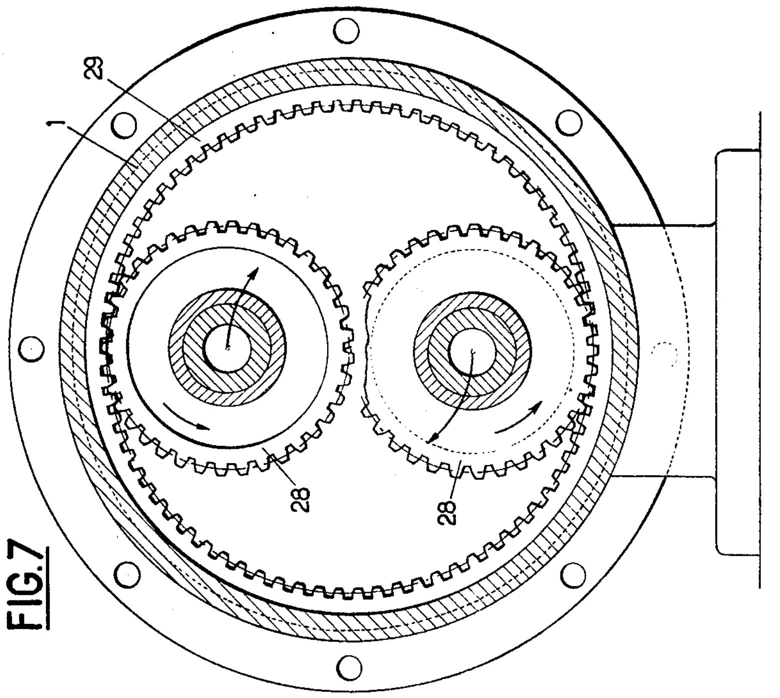

FIG.7

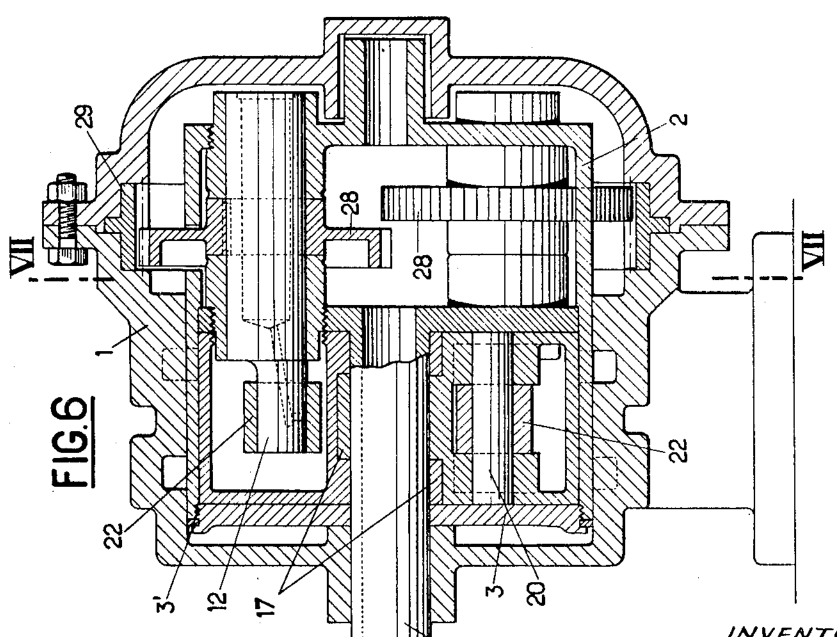

FIG.6

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FIG. 8

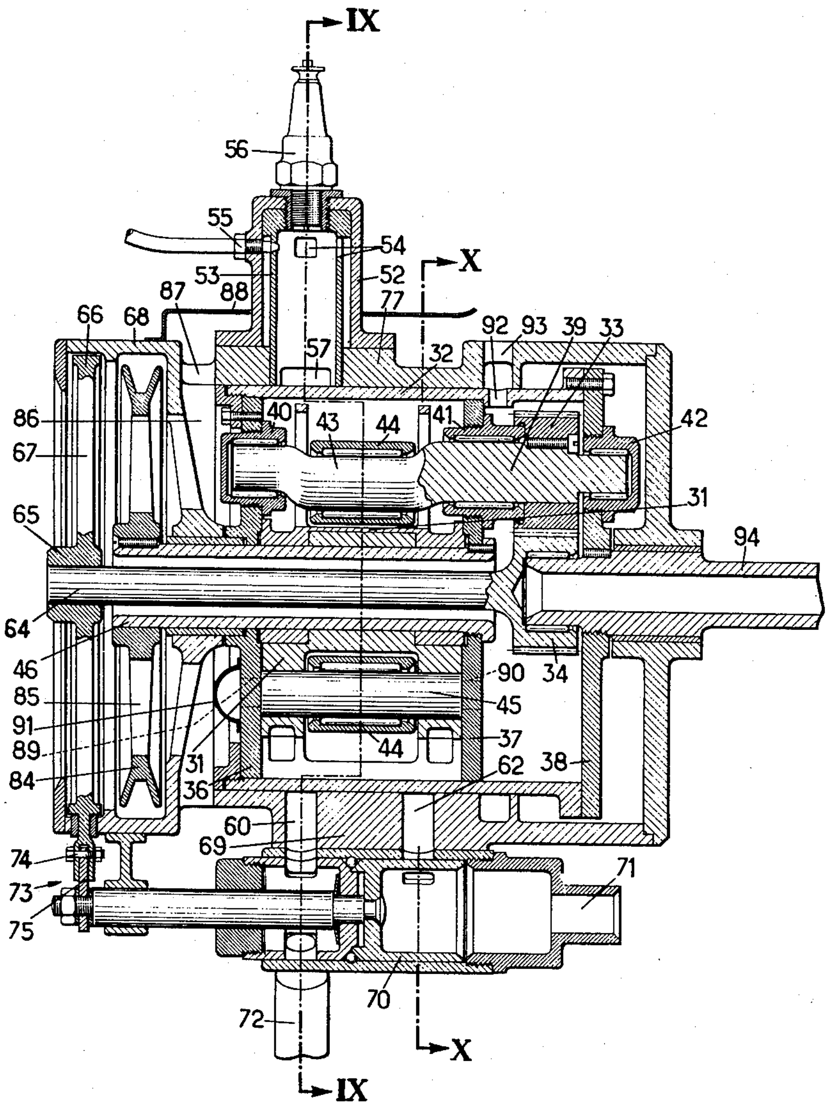

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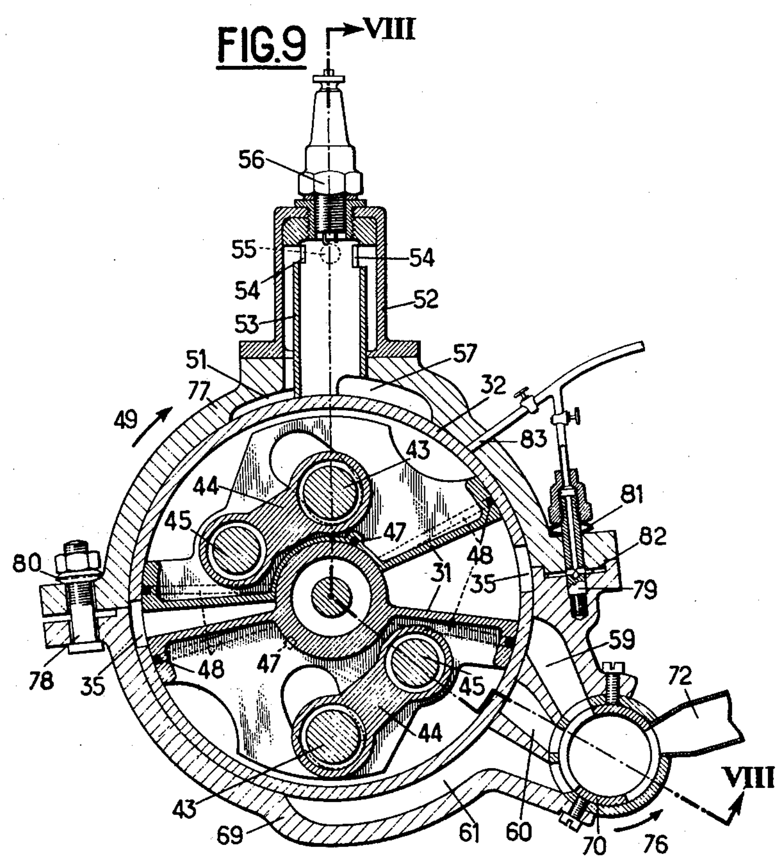
FIG. 9



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3,139,871

Patented July 7, 1964

3,139,871
FLUID MOTOR AND PUMP HAVING EXPANSIBLE CHAMBERS

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Filed Oct. 17, 1961, Ser. No. 145,601
Claims priority, application France Oct. 19, 1960
9 Claims. (Cl. 123—43)

This invention relates to a rotary motor having expansible chambers, the volume of which is periodically variable and controls, when placed in communication through special orifices with passages, reservoirs, or the atmosphere, certain movements of a liquid or gaseous fluid through the machine.

A great variety of such machines are already well known, and result from multiple geometrical and mechanical combinations of individually known elements, but their satisfactory operation is dependent upon the technical qualities of the combination adopted.

In the embodiments of these combinations numerous difficulties are encountered and certain of these combinations, which are very attractive at first sight, may give very poor practical results. These difficulties relate to: the regular flow of fluid, fluid tightness, friction, inertia at high speeds, and the fact that the dimensions of the parts, or their price is often times excessive.

The movements of fluid operated rotating machines are often based on the use of two principal shafts or supports, which are slightly eccentric with respect to each other and are mounted end to end and overchanging. One of these shafts drives vanes having a varied circular movement, either alternating or continuous, through a rotor or lateral partition. The fluid-tightness of these devices deteriorates rapidly under normal use and they are also unnecessarily cumbersome.

Other machines have vanes or sectors controlled by two shafts fixed to non-circular gears which provide for the necessary periodically varied movements, but these are difficult to manufacture and especially cumbersome.

The present invention falls within the category of gear-controlled machines but, as will be hereinafter seen, it does not have the disadvantages of the principal types just discussed.

The object of the present invention is to provide a rotary periodically expansible chamber machine comprising particularly a stationary cylinder pierced by suitably disposed orifices, a rotor fixed to a concentric shaft and turning freely in said stationary cylinder, two pistons in the form of more or less hollow sectors which oscillate inside the rotor during its rotation, as well as a device comprising connecting rods, crank shafts and gearing, which causes this oscillation, the connecting rods and the crank pins of the crank shafts being preferably mounted inside the rotor in the hollow portions of the pistons.

In a machine constructed in accordance with the invention, fluid tightness is easily assured, due to the fact that the entire rotating assembly is completely supported on a main shaft which is well supported by two bearings, positioned on opposite sides of the rotor, one of its ends being provided with wear-compensating automatic means. This assembly is moreover concentric with the stationary outer cylinder.

Since adequate play may easily be provided by utilizing normal tolerances in determining the diameters, friction is reduced to a minimum. Moreover, the strokes of the vanes or sector pistons are so short that the inertia does not exceed a reasonable value, thus permitting a relatively high speed of rotation and a high efficiency per unit of weight.

This machine may be driven from a source of mechanical energy and serve to move or apply pressure to any fluid. It may also be supplied by a fluid under pressure and deliver mechanical energy at its shaft. In the one case it serves as a pneumatic or hydraulic compressor and in the other as a pneumatic or hydraulic motor.

This machine may also be used in a heat engine, that is to say, a machine supplied with air at atmospheric pressure and a fuel, and which delivers resulting mechanical energy at its shaft by utilizing a work cycle comprising compression, explosion, and expansion. In particular, it is possible to construct two or four stroke motors, of the internal combustion type.

It is also an object of the present invention to provide improvements in said machine when used as a heat engine, these improvements consisting essentially in:

(1) The use of a particular operating cycle similar to the two stroke cycle but in which the compression step uses only part of the piston stroke, and in which the expansion step utilizes only a portion of the stroke independent in length of the foregoing. This permits a scavenging step to be inserted between the end of the expansion and the beginning of the next compression, by means of which the residual gases are swept out and the interior of the chamber incidentally cooled.

(2) To provide the motor with a single fixed combustion chamber periodically supplied with compressed air through a passage communicating with an orifice at the end of the compression and in which there is a direct fuel injection in a continuous or discontinuous manner, the gases under pressure from this chamber leaving through another passage through an orifice, at the beginning of the expansion.

(3) To make the central planetary gear about which the satellites turn capable of turning slightly on itself in response to the normal operating torque and being biassed in the reverse direction by a draw spring. This permits the ignition to be automatically advanced as a direct function of the cycle of rotation and compression of the motor. An auxiliary rotating slide-valve actuated by rotation of the same central gear permits the respective positions of the outlet and ventilating orifices to be compensated for, whereas the outlet for gas which is not under pressure, and which is positioned immediately in advance of the start of the compression, may be fixed and provided with a variable throttle so that the power may be regulated.

(4) To provide the motor with an automatic take-up to compensate for wear between the rotor and stator.

In order that the objects of the invention may be better understood, several specific embodiments of the invention will now be described in conjunction with the attached drawings, purely by way of example, and without limiting the scope of the invention to the specific details thereof.

In the drawings:

FIG. 1 is a transverse cross-section taken along the line I—I of FIG. 3, through the sector shaped pistons and connecting rods of a reversible fluid compressor.

FIG. 2 is a transverse cross-section taken along the line II—II of FIG. 3, of the same machine, through the auxiliary shafts. It shows a fixed central gear and two satellite pinions, all three of which have the same base diameter and consequently yield a ratio of 1/1.

If the diameter of each of the two satellite pinions is double that of said fixed central gear, there would be a ratio of 1/2.

FIG. 3 is a longitudinal section taken along the line III—III of FIG. 1.

FIG. 4 is a section similar to that of FIG. 1, but showing the movable parts in a different position.

FIG. 5 shows a specific arrangement of the fluid inlet and exhaust ports.

FIG. 6 is a longitudinal cross-section, showing an embodiment characterized by the presence of two satellite pinions of equal diameter, in engagement with a fixed ring gear having a basic diameter double that of the satellite pinions, thus yielding a gear ratio of 2/1.

FIG. 7 is a transverse section taken along the line VII—VII of FIG. 6, showing the same embodiment with a gear ratio of 2/1 between the fixed ring gear and each of the two satellite pinions.

With the structure shown in FIG. 7 it is possible to have a completely different ratio between the fixed ring gear and the two satellite pinions, such, for instance, as 3/1.

FIG. 8 shows in axial cross-section taken along the line VIII—VIII of FIG. 9, a machine of the heat engine type.

FIG. 9 is a section taken along the line IX—IX of FIG. 8.

FIG. 10 is a peripheral section taken along the line X—X of FIG. 8.

As seen on FIGS. 1, 3 and 4, the machine constituting the invention comprises a fixed cylinder **1** in which a rotor **2** turns freely, with a slight clearance and hence with but little friction. The rotor **2** is provided with an end **3** adapted to prevent longitudinal play (by means of thin removable rings **3′**, of foil for example) and is supported steadily and without play at one end on the shaft **4** and the bearing **5**, and at the other end in the socket **6** at the end of the cylinder **7**.

It will thus be appreciated that it is relatively easy to provide a rotor **2** and a fixed cylinder **1** which are exactly concentric, so that the rotor can turn with but little play and without effective contact with the cylindrical body, but without thereby substantially decreasing its fluid-tightness.

Inside the rotor **2** is a strong intermediate partition **8**, provided with two bearing sockets **9** in alignment with the bearing sockets **9′** of the rotor itself.

Two shafts **10** (FIG. 2), fixed to pinions **11**, are rotatably mounted in the sockets **9** and **9′**, and each of them carries an eccentric crank pin **12** (FIG. 3). If necessary, especially in the case of a longer cylinder **1**, the shafts **10** may take the form of crank shafts, the small ends of which are seated in the sockets **13** at the end **3**, as indicated in broken lines on FIG. 3. The shafts **10** are partially hollow in order to lighten them and also to serve as lubricant reservoirs.

A fixed central pinion **14**, fixed to a shaft **15** held without room for play in the end of the cylinder, engages the two pinions **11** which therefore act as satellites.

If the shaft **4** which controls the rotor **2** is turned, the wheels **11** and the shafts **10** are driven as a unit and these elements also have a secondary movement of rotation with respect to the rotor **2**.

According to an essential characteristic of the invention, these basic movements are applied to other elements designed to create or utilize the displacements of fluid under pressure.

As may be seen on FIG. 3, there is a rather large cylindrical space in the rotor **2** between the partitions **3** and **8**. This space is partially filled by two mutually independent sector shaped pistons **16**, the hubs of which are hinge shaped as shown at **17**, in a conventional manner, and which oscillate freely, but without play, about the central shaft **4** (see FIG. 1).

The two sector shaped pistons each have a volume less than that of a half-cylinder. They are hollow and carry, where fluid-tightness is not necessary, certain recesses not shown in detail on the drawings. Small sealing strips **18** and **19** freely seated in slots in the periphery and on the sides of the sectors insure the fluid tightness of the system.

There is inside each piston a free space which is utilized to hold a connecting rod which is pivotally attached at one end to the piston by means of the pin **20**, and at the other end to the shaft **10** by means of the crank pin **12** (see FIG. 1).

Since the open space **21** (FIG. 1) between the two sector-shaped pistons is judiciously calculated, it is easy to understand the operation of the entire assembly. It has already been seen that the shaft **10** is rotatable in the socket **9**. If it is to be supposed first, in order to simplify the explanation, that the rotor **2** is stationary, the rotation of the shaft **10** and the eccentric crank pin **12** produces an alternating movement of the connecting rod **22** and consequently an oscillation of the sector shaped piston **16** about the shaft **4**. The two connecting rods **22** act simultaneously in opposite directions, the radial walls of the pistons **16** approaching or moving away from each other at the same time, by reason of two explosions per revolution of the shaft **10**, on opposite sides of a plane of symmetry AA, which is approximate because the lines of centers of the connecting rods do not always remain parallel for a kinematic reason on which it is not necessary to linger.

If the orifices **23** of the rotor are placed in the plane of symmetry AA, they are always in communication with the variable chamber **21** between the radial faces of the sector-shaped pistons.

An intake and discharge of fluid thus takes place in each of the chambers **21** in response to a rather small relative displacement of the pistons **16** within the rotor **2** and about the central shaft **4**. This is very important from the point of view of friction and the saving of wear on the apparatus at high speeds, as will hereinafter appear.

But these relative and incomplete movements only produce pulsations, whereas the movement of the entire assembly permits the rotor to also serve as a distributor.

In effect, since the pinion **14** is fixed, if the shaft **4**, and the rotor **2**, which is fixed thereto, are turned, the pinions **11** and shaft **10** produce the relative movement just described and the sector-shaped pistons carry out their strokes within the rotor as a consequence of two impulses, (one forward and one return) for each revolution of the assembly, in the case of a gear ratio of 1/1.

A reduced pressure zone is thus created at each half revolution of the rotor (see FIG. 1) and a zone under compression after another half revolution for one or the other of the two chambers between the piston faces.

Then, as shown in FIGS. 1 and 4, two semi-circular grooves **24**, **25** and inlet and outlet ports (**26** and **27**) in the fixed cylinder, serve to permit movement of the fluid.

The space available for the ports in the cylinder **1** is rather large, so that they may be easily arranged in a single circular line, but when the space between the partions **3** and **8** is large enough, it facilitates high speed operation to improve the trajectory of the fluid by positioning one port **26′**) near the partition **3**, and the other (**27′**) near the partition **8** (see FIG. 5).

As has hereinbefore been pointed out, the ratio between the fixed gear and the satellite pinions may vary, for example, from 1/2 to 1/1 to 2/1 or 3/1 according to the cycle desired in relation to the speed of the shaft **4**, so as to obtain one, two, four or six strokes of the piston-shaped sectors per revolution of the shaft **4** and the rotor **2**.

FIGS. 6 and 7 show, by way of example, an embodiment of the invention in which two satellite pinions of the same diameter engage a fixed ring gear **29** having a base diameter twice that of the satellite pinions, thus yielding a ratio of 2/1.

Since this reversible machine may be driver or driven, and utilize either liquid or gas, a judicious choice must be made in each case.

For example, when used as a driving machine utilizing either liquid or gas, the 1/1 ratio permits the rotor **2** and shaft **4** to turn at an adequate speed, without requiring too rapid a movement of the sector-shaped pistons **16**.

A 3/1 ratio, on the contrary, permits a rather slow speed for the shaft **4** and a certain regularity in the driving torque, but is best suited to operation on liquids.

When used as a gas compressor or as a liquid pump, a 1/1 ratio permits direct control by an electric motor without excessive effects resulting from inertia.

When controlled by a slow motor and used as a gas compressor, a 3/1 ratio between the fixed gear and the satellites may be indicated.

The outlet ports in the rotor **2** and in the fixed cylinder **1** must obviously be related according to the ratio adopted for the gears.

It has already been pointed out that the pinion **14** (FIGS. 2 and 3) is fixed but, in the case of certain applications of the machine, it may be desirable (in order to provide an optimum fluid flow and improve the efficiency) to displace the shaft **15** relative to the pinion **14** through angular distance of 5° to 30° for example, by means of an exterior control member, fixed to the shaft **15**, which could then be called a semi-stationary shaft.

The same procedure may be applied to the ring gear **24**, which is then allowed a little freedom of movement but no play, within the cylinder **1** (FIGS. 6 and 7) and angularly displaced by means of an exterior control member.

The motor shown on FIGS. 8, 9 and 10 has the same general characteristics as the compressor and utilizes, as hereinbefore indicated, an operating cycle analogous to a two-stroke cycle, that is to say, the two pistons **31** complete a single movement forward and back for each rotation of the rotor **32**. This implies that the base diameter of the satellite gears must be equal to that of the planetary pinion **34**. The two periodically variable chambers positioned between said two pistons and diametrically opposite each other each cooperate with the two ports **35** in the rotor **32**. The immediate consequence of the adoption of this cycle is that the motor makes two explosions per rotation, which shows that with a single assembly such as that shown the same regularity of torque is secured as with a four-stroke motor of the conventional four cylinder type.

As shown on FIG. 8, the rotor has a cylindrical wall **32** and three circular partitions **36**, **37** and **38**, the first two of which enclose the volume within which the pistons are displaced, and the last of which encloses the compartment holding the gears **33** and **34**. Each of these gears **33** is mounted on a crank shaft **39** carried in three bearings constituted by roller bearings **40**, **41** and **42** mounted respectively in the partitions **36**, **37** and **38**. On the crank pin **43** of each of the crank shafts **39** is pivotally mounted a connecting rod **44**, the other end of which is pivotally attached to a shaft **45** extending through the associated piston.

The pistons **31**, as hereinbefore indicated, comprise a centrally positioned hinge arrangement, shown on the figures at **31** and **32**, through which passes a tubular member **46** fixed to the two partitions **36** and **37**. Fluid tightness between these pistons and the wall **32** of the rotor, and the walls **36** and **37**, and between one piston and the other at the center, is obtained by means of spring-biased segments of rectilinear sealing strips. FIG. 9 shows especially at **47** and **48** the mounting of these segments.

The motor shown on these figures is presumed to turn in the direction of the arrows **49** (FIGS. 9 and 10). It is also assumed that at starting the relative angular position of the planetary gear **34** is such that the periodically variable chambers have their minimum volume when the corresponding ports **35** pass to the upper part of FIGS. 9 and 10, and their maximum volume when these ports pass to the lower parts of said figures.

As seen best on FIG. 10, the stator is provided with a port **50** in communication with the atmosphere, so that compression of the air in one of the chambers does not begin until the cooperating port **35** has passed beyond the upper end of said port **50**. When these ports approach the upper part of the motor the air in the chamber reaches its maximum pressure and, as shown on FIG. 9, a port **51** directs this air under high pressure toward the combustion chamber, which comprises two concentric casings **52** and **53**. The air passing through the space between these two casings **52** and **53** enters through the ports **54** in the upper part of the casing **53**. A fuel injector **55**, shown on FIGS. 9 and 10, then sprays the fuel into the chamber where it is immediately ignited as a consequence of the temperature prevailing in the chamber as a result of the previous combustion. A spark plug **56** is provided solely in order to provide for the starting ignition.

While this explosion is taking place the port **35** moves until it is opposite the lower part of the casing **53** which terminates in a port **57**. During the entire displacement of the port **35** while it is in registration with the length of the port **57**, the variable chamber increases in size and consequently takes up a certain volume of the combustion gases under high pressure furnished by the explosion. Beginning at the end of the port **57**, the cut off of these gases continues until one of the ports **35** comes into registration with the outlet port **58** (FIG. 10).

As shown on FIG. 10, the outlet port **58** is positioned on the side of the partition **37**, while the inlet port **59** (FIG. 9) is near the opposite side of the rotor, and slightly spaced therefrom, so that when the pressure of the gases within the chamber has fallen, fresh air drawn in through the inlet port **59** by means of a fan, not shown, drives the residual combustion gases out of the chamber, this scavenging occuring from one end of the chamber to the other by reason of the location of the ports **58** and **59**, already described in the preceding example.

Then, when the ports **35** have passed beyond the positions in which they register with the passages **58** and **59**, the corresponding chamber continues to expand, and draws in fresh air through the passages **60** and **61** positioned beyond the passage **59**, the passages **62** and **63** positioned beyond the passage **58** being, on the contrary blocked for reasons which will be hereinafter set forth. Once the ports **35** have passed their lower position corresponding to a maximum chamber volume, one of these two ports again passes by the port **50** while the volume of the chamber begins to decrease and part of the air drawn in is ejected to the pressure free atmosphere through the port **50**. The volume of air drawn in through **61** and expelled through **50** has nevertheless served to cool the inner walls of the variable chamber.

The cycle thus described continues naturally and indefinitely, and the chamber diametrically opposite goes through the same cycle half a revolution later. In this way, twice a revolution, the combustion chamber receives compressed gas which mixes with the hot compressed gases remaining from the preceding combustion, then a new injection produces a new evacuation of gases at high pressure, as previously indicated. The combustion chamber thus functions like a pressure accumulator as well as a temperature accumulator, thus eliminating all operational shocks and even permitting in certain cases a continuous injection of fuel, or at least, a less sharply defined injection than in conventional motors.

According to another characteristic of the motor according to the invention, the planetary gear **34**, which has heretofore been fixed, is so mounted that it can turn through a certain angle while being biassed by a draw spring not shown. As seen on FIG. 8, this gear **34** is fixed to a central shaft **64**, the end of which is fixed to the hub **65** of a circular member having a rim **66** connected to its hub by the arms **67**. This member can turn within the casing **68** extending from the stator **69**. It is easy to see that the torque acting on this gear **34** tends to drive it in the same direction as the motor, that is to say, in the direction represented by the arrows **49**, and that this torque increases with the speed of the motor, due to the inertia of the pistons, and with the compression ratio by reason of the work done by these pistons, It is also seen that the rotation of the gear **34** in the direction of the arrow **49** shifts in the same direction the position corresponding to the minimum volume of the variable chamber, and which might be called by analogy with conventional motors "crank end dead center point." The immediate consequence is that the fixed combustion chamber is displaced in the opposite direction relative to this dead center point, which amounts to advancing the ignition, which is automatically balanced as a function of the speed of the motor, provided only that the draw spring is properly calibrated. Another consequence of this automatic relative displacement is that the displacement in the direction of the arrow **49** of the dead center point increases the angle subtended by the arc between the end of the port **50** and this dead center point, which amounts in the end to saying that this relative displacement increases the displacement volume of the motor as well as the compression ratio, while the physical volume remains constant.

It will thus be seen that, without any complicated mechanism, the motor achieves an automatic adjustment of the ignition advance, of the displacement volume, and the compression ratio, as a function of the speed of operation. This permits a substantial improvement in the efficiency at fractional power as compared with conventional motors which merely permit adjustment of the compression ratio by throttling the gases.

In practice, changes in the power of this motor may be obtained by varying the volume of the injection, and possibly by throttling, by means of a flutter-valve positioned over the orifice through which the port **50** opens into the atmosphere, but in this case the throttling works in a manner opposite to the conventional gas flutter valve since progressive closing of this valve corresponds to a simultaneous increase in the compression ratio and the displacement volume, and consequently in the power.

On the other hand, an undesirable consequence of relative displacement in the direction of the arrow **49** from the dead center position resides in the fact that the expansion stroke which does the work is shortened as the relative displacement increases, which should correspond to an increase in power. To compensate for this effect, the motor comprises, as shown on FIGS. 8, 9 and 10, a rotating double-acting slide-valve **70**, which when in one position, shown in section on FIG. 10 successively opens the passage **62**, closes the passage **58**, opens the passage **63** and closes the passage **62**, the passages thus opened being in each case connected to the outlet through the passage **71**. The position corresponding to injection, on the contrary, admits air under low pressure from the fan through the passage **72** and distributes it either to the three ports **59**, **60** and **61** as previously envisaged, or depending on its angular position, to the ports **60** and **61** alone, or even to the port **61** alone. As seen in FIG. 8, the rotation of this rotating distributor **70** is directly controlled by the rim **66** of the wheel shaped member fixed to the gear **34**, this control being effectuated, for example, by means of a mechanism **73**, comprising a pin **74** driving a fork **75**.

This mechanism turns the slide-valve **70** in the direction indicated by the arrows **76** on FIGS. 9 and 10 when the gear **34** and the member **66** turn in the direction indicated by the arrows **49** on the same figures. It is easy to see that this rotation effectively produces the desired result, that is to say the progressive retardation of the exhaust and scavenging actions, and this always in an absolutely automatic manner.

A final improvement in the motor consists in making the stator **69** in two parts, by separating the upper part **77** which is that against which the gas pressure is highest, and by providing this part **77** with automatic play taking up means. This means may be constructed as shown in FIG. 9 by joining the part **77** to the main body of the motor by means of screws **78** and **79** which pass through a stack of convex resilient washers **80** and **81** which have the effect of biassing the part **77** against the cylindrical portion **32** of the rotor. Moreover, between the members **77** and **79** on each side, or only on one side, it is possible to provide a sort of jack having a short stroke and comprising a piston and cylinder, or expansible bellows, this jack being concentric with one of the screws **79** or beside one or both screws. Oil under pressure, supplied by an auxiliary oil pump, supplies in parallel both this jack and an orifice **83**, positioned in the wall of the member **77**. This pressure serves to compress the Belleville washers **81** and separate the part **77** from the part **69**, that is to say, to increase the play between the part **77** and the rotor. But this play permits oil to escape through the orifice **83**, and thus reduce the pressure in the jack **82**. It is easily seen that a position of equilibrium is established in which the play between the rotor and the part **77** of the stator is constant and equal to an exactly determined value which may be regulated by controlling the supply of oil to the device. In like manner, compressed air could be used instead of oil under pressure.

Finally, a particularly useful characteristic of the embodiment in question resides in the fact that the tubular member **46** comprises a V-pulley **84** adapted, for example, to drive the dynamo, the arms **85** of this pulley being shaped into fan blades so as to draw air into the annular chamber **86**. This air escapes through the orifices **87** in a steel jacket **88** which encloses the part of the stator subjected to high temperature and cools its exterior. This stator may advantageously be provided with vanes. Moreover the partitions **36** and **37** of the rotor are provided with a certain number of orifices **89** and **90**, suitably positioned, so that they do not open into the expansible chambers, and the orifices **89** positioned in the partition **36** are covered by cup-shaped vanes which withdraw air from the annular chamber **86**, where it is already under pressure and force it through the orifices **89** to ventilate the interior of the rotor and pistons, said air leaving through the orifices **90**, thus ventilating the chamber containing the gears **33** and **34** and leaving through the orifices **92** in the rotor and **93** in the stator.

The motor is completed by the customary elements such as a flywheel mounted on the output shaft fixed to the rotor and adding to the inertia of said rotor, a starter, a dynamo, ignition means for the starter, a fuel injection pump, an exhaust silencer connected to the passage **71**, an air filter, and an auxiliary fan for drawing air into the passage **72**.

The motor so designed is, as has been seen, the equivalent of a four cylinder, four-stroke motor, and is relatively more efficient, especially by reason of the variation in swept volume and the use of direct injection, and is on the other hand much smaller and less expensive because of its smaller number of parts, despite its automatic operation.

On the other hand, it operates much more smoothly and regularly because of the reduction in alternating movements and is less subject to wear.

It will of course be appreciated that the above described embodiments, both the reversible compressor and the thermal motor, have been described purely by way of example and may be modified as to detail without thereby departing from the spirit of the invention.

In particular, the direct injection may be replaced by preliminary carburetion in the usual manner, and the cycle described may be replaced by a four stroke cycle by changing the ratio of the gears so as to have two explosions per revolution. In this case, the two explosions follow each other at a 90° interval, and it is preferable to join together two groups which are relatively displaced at 180° so as to have a regular torque like that of a conventional 8 cylinder, 4 stroke motor.

What is claimed is:

1. A rotating machine of the expansible chamber type

comprising a fixed cylinder pierced by inlet and exhaust ports, a hollow rotor mounted to turn within said cylinder on a shaft coaxial therewith, said rotor being provided with at least two ports, each of which is positioned to register successively with said inlet and exhaust ports during each revolution of said rotor, at least two part-cylindrical pistons mounted within said rotor, said pistons defining between them and the walls of said rotor at least two expansible chambers communicating with said rotor ports, crank means rotatably mounted in said rotor, said pistons being rotatably connected to the crank portion of said crank means, and means for causing said crank means to rotate in said rotor as said rotor itself turns, said crank means causing said pistons to oscillate relative to said rotor while turning about the axis of said rotor in the same direction and at the same average speed as said rotor, said oscillation of said pistons in said rotor bringing their ends towards and away from each other to expand and contract said chambers.

2. A machine as claimed in claim 1 comprising a combustion chamber in said cylinder outside said rotor, spaced ports in the wall of said chamber positioned to successively communicate with the ports in said rotor as said rotor turns in said cylinder, ignition means in said chamber, and means for introducing fuel into said chamber, one of said combustion chamber ports being positioned to receive compressed gas through said cylinder ports from said expansible chambers as said pistons contract them, and the other of said combustion chamber ports being positioned to lead combustion products from said combustion chamber into said piston chambers as they expand.

3. A machine as claimed in claim 2 in which said means for causing said crank means to rotate in said rotor comprises satellite gears mounted on said crank means and a central gear engaging said satellite gears, and said central gear is carried by and rotatable through only a limited angle with respect to said fixed cylinder, said machine also comprising means responsive to the torque exerted by said rotor for shifting said central gear through said angle, thereby effecting an advancement of the ignition, and resilient means biassing said central

gear toward a normal position relative to said fixed cylinder.

4. A machine as claimed in claim 3 comprising valve means actuated by rotation of said central gear, said valve means being movable to adjust the effective angular position of said exhaust port.

5. A machine as claimed in claim 3 in which the diameter of said central gear is equal to that of said satellite gears.

6. A machine as claimed in claim 2 in which said cylinder is provided with a pair of scavenging ports in addition to said exhaust and inlet ports, one of said scavenging ports being also connected to a source of cool air, said machine also comprising means for urging said cool air through said expansible chambers when the ports in said rotor are opposite said scavenging ports.

7. A machine as claimed in claim 2 comprising a further port in said cylinder which leads to the ambient atmosphere, said port being positioned at a point reached by said expansible chambers just after they have begun to contract, and adjustable throttling means for said port which serves to vary the compression ratio in said chambers and consequently the power delivered by the machine.

8. A machine as claimed in claim 1 in which said cylinder is made in a plurality of parts, said machine comprising pressure responsive fastening means connecting said parts and means for applying the pressure of fluid leaking between said rotor and cylinder to said pressure responsive means, so that any increase in the play between the rotor and cylinder results in an increase in the pressure exerted by said fastening means.

9. A machine as claimed in claim 1 in which said crank means lie mainly within said pistons.

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