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ROTARY PISTON MACHINE
Hanns-Dieter Paschke, Wilhelm-Leuschner Weg, Neckarsulm, Germany
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The present invention relates to a rotary piston machine capable of generating a variable volume, and thus it is capable of being employed as a pump or motor for liquid or gaseous media, as an internal combustion engine, or the like.

A primary object of the invention is to provide a rotary piston machine of relatively simple construction and possess relatively low tolerance requirements, and therefore is producible at low cost.

The rotary piston machine according to the invention consists of an outer member, and an inner member eccentrially arranged therein while mounted on a rotary shaft. At least one uni- or multi-partite annular sealing member is disposed in sealing contact with both of the members, which together define a working chamber whose volume varies in the course of relative motion of the two members. With respect to the cooperating surfaces of the sealing element and one of the members, one is spherical and the other is cylindrical; whereas the seal between the sealing element and the other member is annular. In addition, at least one of the members is provided with inlet and/or outlet apertures for the working medium.

Thus, the rotary piston machine according to the invention embodies only three principal parts, each of which are simple to manufacture. An additional important advantage of the machine resides in the fact that the major portion of the pressure of the medium acts directly and without an intermediary, upon the inner member, which functions as the power transmitting or receiving part.

The rotary piston machine according to the invention assumes one of a number of embodiments. According to one contemplated proposal, the outer member has at least one recess with a cylindrical inside wall, open towards the inner member and serving as a working chamber. The annular sealing element has a spherical outer surface cooperating with the cylindrical inside wall of the recess and slides on one of its annular faces over the periphery of the eccentric inner member.

According to another proposal of the invention, the outer member has at least one projection with a spherical outer surface extending towards the inner member. The annular sealing element has a cylindrical inner surface cooperating with the spherical surface and slides on one of its annular faces over the periphery of the eccentric inner member.

According to still another embodiment, the inner member has at least one radial recess with a cylindrical inside wall serving as the working chamber; and the outer member has an inner surface eccentric to the axis of rotation of the inner member. The annular sealing element also has a spherical outside surface cooperating in this instance with the cylindrical inside wall of the recess and slides on one of its annular faces over the inner surface of the outer member.

Further details and features of the invention will appear from the following description which is to be taken in conjunction with the drawings, in which some embodiments of the invention are represented, by way of example.

FIG. 1 shows a cross section of one embodiment of the invention with the working chamber in the outer member and with the inner member serving as a spherical eccentric;

FIG. 2 shows the same embodiment in longitudinal section;
FIGS. 3 to 8 show cross sections, similar to FIG. 1, of several more embodiments of the invention;
FIG. 9 shows an embodiment of the invention with five working chambers, in cross section taken along the line 9—9 in FIG. 10;
FIG. 10 shows a longitudinal section taken along the line 10—10 in FIG. 9;
FIG. 11 shows a longitudinal section of an embodiment of the invention with two working chambers in the outer member and with an inner member constituting a hollow sphere eccentric;
FIG. 12 is another longitudinal section with the working chamber in the outer member and with the inner member serving as a disc eccentric;
FIG. 13 shows a cross section along the line 13—13 in FIG. 12;
FIG. 14 shows a further embodiment of the invention in cross section; and
FIG. 15 shows a longitudinal section of an embodiment with the working chamber in the inner member.

Referring initially to the embodiment of FIGS. 1 and 2, the rotary piston machine consists of an outer member bearing the general designation 1, a housing 2 and cover 3 suitably secured to one another. A shaft 4 is rotatably mounted on bearings 5 by these parts and bears an inner member in the form of an eccentric 7 whose outer surface 8 is spherical. Housing 2 is provided with a recess 9 acting as a working chamber defined by a cylindrical inside wall 10. The recess 9 is closed off from the exterior by a cover 11 which is subject to the action of a spring 12.

Annular sealing element 13 is arranged between eccentric 7 and outer member 1. The sealing element 13 has a spherical outer surface 14 cooperating with the cylindrical inside wall 10 of the recess 9. Annular face 15 of sealing 13 slides over the spherical outer surface 8 of eccentric 7. In this connection, sealing element 13 is held in sealing contact with eccentric 7 by means of a spring 16 biased against cover 11. The interior 17 of outer member 1, in which eccentric 7 is arranged, has a connection 18 for supply of fluid medium. In the outer surface 8 of eccentric 7, an overflow pocket 19 is provided, and which periodically brings chamber 17 into communication with the interior 20 of sealing element 13 and hence with the working space 9. A fluid outlet 21 is provided in the housing 1 substantially as shown.

When the device is to act as a pump, shaft 4 will be driven. As the eccentric rotates, the volume of the working chamber 9 is varied periodically, while the sealing element 13 executes a reciprocating and at the same time a rocking motion in recess 9. Meanwhile, the annular face 15 is maintained in sealing contact with the spherical outer surface 8 of the eccentric; and in addition there is constant sealing contact of the spherical outer surface 14 of sealing element 13 with the cylindrical inside wall 10 of working chamber 9. Since a section of a sphere is always a circle, the seal with the eccentric outer face 8 is not impaired even when the face 15 wears down.

In the position of eccentric 7 shown, working chamber 9 has its greatest volume, and the medium previously delivered from chamber 17 through overflow pocket 19 into working chamber 9 is pressed upward. Further rotation of eccentric 7 in the direction of arrow D until the pressure built up overcomes the force of spring 12 and lifts the cover 11, whereupon the medium, now under pressure, can discharge through outlet passage 21. The cover 11 thus serves simultaneously as a pressure value. Since this cover presents a very large pressure area, the spring 12 admits of very wide tolerances. Since the cover affords a very large overflow cross section when the created pres-
sure overcomes the spring action, throttling losses are slight. The delivery rate of the pump can be changed in known manner by varying the eccentricity of eccentric 7 relative to the lengthwise centerline of working chamber 9.

The embodiment in FIG. 3 differs from that of FIGS. 1 and 2 essentially only in that the annular sealing element 13' has an annular groove 22 in its outer surface 14' in which the sealing ring 23 is imprisoned with radial clearance. The outer surface 24 of this sealing ring is likewise spherical and cooperates with the inside wall 10' of working chamber 9'. The purpose of this ring 23 is to achieve a double seal against the inside wall 16' of the working chamber 9', of value in high-pressure pumps. It may be possible for the sealing ring 23 to function as the sole seal with its outer surface. In other words, the outer surface 14' of sealing element 13' need not necessarily be in sealing contact with the inside wall 10' of working chamber 9'. Where appropriate, like numerals with accompanying primes will be used in the drawings for the parts of this embodiment corresponding with the embodiment of FIGS. 1-2.

Whereas in the preceding examples a spring holds a sealing element against an eccentric while being arranged in the working chamber, FIG. 4 shows an embodiment in which the spring is outside the working chamber. Here the sealing element 13' is provided with a recess 25, which receives a spring ring 26 embracing the eccentric 7 in spaced relationship by way of a slide ring 27. Thus, the face 15' of sealing element 13' is held in sealing contact with eccentric 7'. Inasmuch as the spring 26 for sealing element 13' is arranged outside the working space 9', this device may be used as a pump for hot or corrosive media to which the spring must not be exposed. The supply of medium to working chamber 9' is fed through a line 28 closed off by a suction valve 30 loaded with a spring 29; and the pressurized medium is delivered through a pressure valve 31 subject to the action of a spring 32 into an outlet passage 33. With respect to this embodiment the parts corresponding with the previous embodiments will be similarly numbered with accompanying double primes.

In the embodiment of FIG. 5, the annular sealing element 34 has a radially extending flange 35 presenting a shoulder for a spring 36 biased against outer member 1a exteriorly of the working space 9a. Here again, the spring 36 is arranged outside the working chamber 9a, so that this device may be employed for corrosive media. Supply of medium is through a passage 37 and a suction valve 39, subject to the action of spring 38, while the pressurized medium is discharged through a passage 40. This passage is controlled by a pressure valve 41 under the influence of spring 42 and is normally closed until the desired pressure is obtained. In this embodiment the subscript 1 will accompany like numeral designation of parts corresponding to the previous embodiments.

The embodiment of FIG. 6 differs from that of FIG. 1 essentially only in that the recess serving as working chamber is fitted with a liner 43 having a cylindrical inside wall 44. The terminal surface 45 of the liner 43 is perpendicular to the longitudinal axis of the liner 43. The annular sealing element 13b, whose spherical outer surface 14b cooperates with the cylindrical inside wall 44 of liner 43, may, when this liner 43 is employed, have a lesser wall thickness, as comparison of FIGS. 1 and 6 will show. This reduces firstly the area of sealing element 13b acted upon by pressure, and secondly its weight. Another advantage of the liner 43 resides in the fact that the wall of the recess, otherwise serving as bearing surface for sealing element 13b, need not be finished; besides in ease of wear, only the liner or the sealing element 13b need be replaced; and lastly, the sealing element 13b and the sleeve 43 may be selected in pairs for minimum tolerance before installation in the machine, thus affording a good seal with little expenditure of labor. The cover 11b serves to close off the working chamber 9b, and simultaneously functions as a pressure valve resting on a flange 46 of liner 43. This flange may likewise be finished before inserting the liner. Supply of medium in this embodiment is effected, for example, through a hole 47 in the shaft 4b of the eccentric 7b. Hole 47 continues in a passage 48 opening into the overflow pocket 19b. Parts of this embodiment corresponding with previous embodiments will be similarly numbered with an accompanying subscript b.

In the embodiment of FIG. 7, the liner 43b' is arranged displacable lengthwise in the recess 9b' serving as the working chamber. The liner 43b' includes at its outer end an inward flange 49 resting against the sealing element 50. Liner 43b' includes at its inner end an outward flange 51, serving to bias one end of a spring 52 also acting against the outer member 1b'. Accordingly, spring 52 urges liner 43b' towards eccentric 7b'. Sealing element 50 is carried along by flange 49 and held by its annular face 15b' upon the outer surface 6b' of eccentric 7b'. The inside wall 10b' of working chamber 9b' and the outer surface 53 of liner 43b' are cylindrical, and between the two surfaces a sealing ring 54 is arranged, for example, in the manner of a conventional piston ring. A subscript b with an accompanying prime and like numeral is employed to designate corresponding parts to previous embodiments.

This machine may be employed as a two-stroke internal combustion engine. For this purpose, the outer member 1b' is provided with an inlet passage 55 alternately closed and opened by a projection 56 of liner 43b', the form of a hollow spherical sector, in the form of longitudinal motion of the liner. The fuel-air mixture taken into the chamber 17b' of outer member 1b' passes through an opening 51a in flange 51 and an overflow passage 57 in outer member 1b' into the working chamber 9b' and expels the burned gases through an exhaust passage 59. The overflow passage 57 and exhaust passage 59 are controlled by the outer edge 58 of liner 43b'. A spark plug 60 is also schematically shown and serves its intended purpose.

FIG. 8 shows an embodiment employable preferably as a high-pressure compressor. In order to minimize the dead space, the sealing element 61 has the form of a spherical segment whose secant surface towards eccentric 7c has an annular edge 62 in sliding sealing contact with the outer surface 6c of eccentric 7c. The cover 11c' closing off the working chamber 9c from the exterior, has an inner surface 63 in the form of a hollow spherical segment. The leaf spring 64 holding the sealing element 61 against eccentric 7c rests in a recess 65 of sealing element 61. In the position shown, eccentric 7c is at top dead center, and manifestly the dead space is extraordinarily small. Sealing element 61 is provided with a passage 66 through which medium taken in through a filter 67 can enter the working chamber 9c when the overflow pocket 19c establishes communication between chamber 17c of outer member 1c and the space 68 between sealing element 61 and eccentric 7c. Cover 11c' serves, as in the embodiment of FIG. 1, simultaneously as a pressure valve; and in this respect, the subscript c subject to the action of spring 38, while the pressurized medium is discharged through a passage 40. This passage is controlled by a pressure valve 41 under the influence of spring 42 and is normally closed until the desired pressure is obtained. In this embodiment the subscript c and like numerals are employed for the parts of this embodiment corresponding with previous embodiments.

The embodiment of FIGS. 9 and 10 shows a pump with five working chambers arranged radially in outer member 1d. The outer member 1d again comprises a housing 2d and a cover 3d and defines a chamber 17d in which the spherical eccentric 7d, together with shaft 4 is rotatably mounted. In housing 2d, five radial recesses 9d each with cylindrical inner surfaces 18d serve as working chambers. Each is closed off from the outside by a spring-loaded cover 11d serving simultaneously as a pressure valve. An annular sealing element 13 is arranged in each recess to FIG. 1. The medium to be delivered enters
the chamber 17d though an inlet passage 70. Then it is conveyed through overflow pocket 19d in the outer surface 8d of the eccentric into the working chamber which is just being enlarged in volume. In FIG. 9, this is one of the two lowermost working chambers. Upon further rotation of eccentric 7d, the medium is pressurized until the pressure of spring 12f is overcome and cover 11d is lifted (as is just happening in FIG. 9 in the uppermost working chambers). The medium under pressure enters an annular space 71 in housing 2d which is made up by a cover 72 and communicates with an outlet connection 73. The arrangement with five working chambers achieves a substantially continuous flow pattern. Like parts corresponding to that of previous embodiments bear like numerals with an accompanying subscript d.

In the embodiment of FIG. 11, outer member 1e accommodates a floating shaft 4e bearing an inner member 74 in the form of a hollow sphere eccentric. Housing 2e of outer member 1e has two recesses 9e with cylindrical inside walls 10e, each serving as working chambers. In each working chamber 9e an annular sealing element 75 is arranged, having a spherical outer surface 76 cooperating with the cylinder inside wall 10e. In addition, eccentric 75 slides along on its annular face 15e on the hollow spherical inner surface 77 of eccentric 74. The working chambers of 9e are each in communication by way of a spring loaded pressure valve 78, with an outlet passage 79. Medium is supplied through a passage 80 opening into the chamber 17e of outer member 1e. Eccentric 74 is also provided with a slit 81 through which medium can pass from chamber 17e into the working chambers while their volume is increasing. Like parts corresponding to that of previous embodiments bear like numerals with an accompanying subscript e.

In the embodiments of FIGS. 1 to 10, the inner member is a spherical eccentric throughout. Alternatively, however, a disc eccentric may be employed instead of a spherical eccentric. One such embodiment is shown in FIGS. 12 and 13. Thus, an eccentric 82, mounted on a shaft 4f as in the preceding examples, has an outer peripheral cylindrical surface 83 on which the sealing element 13f slides. The construction of this device is otherwise the same as that of the device according to FIGS. 1 and 2 and consequently, like parts will be similarly numbered with an accompanying subscript f.

In the preceding examples, the sealing element has been shown as a closed ring. It is likewise within the scope of the invention, however, for this ring to be split, so that it can spread under the pressure of the medium and make sealing contact with the wall of the working chamber.

Whereas in the preceding examples the annular sealing element has a spherical outer surface cooperating with a cylindrical wall of the outer member, the outer member 1g may be provided with an inward-extending projection 85 having a spherical outer surface 86 as in the embodiments of FIG. 14. The sealing element 87 has a cylindrical inner surface 88 cooperating with the spherical outer surface 86. The sealing element 87 rests upon the inner member 7g, again in the form of a spherical eccentric, along an annular seal 89. A spring 90 presses sealing element 87 against eccentric 7g. As eccentric 7g rotates, the working chamber 9g varies in volume. While the volume is enlarging, working chamber 9g is in communication via overflow pocket 19g with the chamber 17g of outer member 1g, to which medium is being supplied through an inlet passage 91. Upon further rotation of eccentric 7g, the medium present in working chamber 9g is placed under pressure, and when a certain pressure is reached, the pressure valve 92 is opened against the bias of spring 93, and the medium can escape into the outlet passage 94. Subscript g with like numbers are employed to designate parts corresponding to the previous embodiments.

In the exemplary embodiment according to FIG. 15, the working chamber 96 is arranged in the inner member 95. It has a cylindrical inside wall 97 and contains an annular sealing element 98 whose spherical outer surface 99 cooperates with the cylindrical inside wall 97. The outer member 111 has an eccentric inner surface, eccentric to the axis of rotation of the inner member 95. This inner surface is of hollow spherical configuration and is followed by the sliding engagement of the sealing element 98 through its annular face 101. A spring to hold the sealing element 98 against the inner surface 100 of the outer member 111 is not required because the sealing element 98 is carried along by the inner member 95; and it is, therefore, held against the inner surface 100 by centrifugal force. Supply of medium to working chamber 96 is effected, and so is the removal of medium through a passage 102 in the shaft 103 of the inner member 95. The outer member 111 is provided with an inlet passage 104 and an outlet passage 105 which alternately come into communication with passage 102 as shaft 103 rotates.

Thus, among others, the several aforementioned objects and advantages are most effectively attained. Although several somewhat preferred embodiments have been shown and described herein, it should be understood that this invention is in no sense limited limited thereby but its scope is to be determined by the appended claims.

1. Claim:
   1. A rotary mechanism comprising: an outer body having a cavity, a rotary inner body having an outer peripheral spherical surface and being formed as a spherical eccentric and mounted eccentrically on a drive shaft within the cavity for rotation with respect to the outer body, the outer body comprising at least one working chamber with a cylindrical peripheral wall and openings towards the inner body for the working medium which working chamber varies in volume during rotation of the inner body relative to the outer body, a reciprocal annular seal element in sealing arrangement with both said inner and outer bodies and comprising a spherical outer peripheral surface for sealing cooperation with said cylindrical peripheral wall and an annular recess for sealing engagement with the outer peripheral spherical surface of said inner body, said annular seal element being reciprocally along an axis at an angle to the axis of rotation of the rotary inner body, spring means for urging said annular seal element against said outer surface of the inner body and cooperating to maintain the sealing cooperation of the annular seal element with the cylindrical peripheral wall and the sealing engagement of the annular seal element with the outer peripheral spherical surface of the inner body, and ports for the working medium in at least one of said bodies.
   2. A rotary mechanism as defined in claim 1 in which the end of the working chamber opposite to the inner body is closed by a spring loaded plate which at the same time serves as a pressure valve.
   3. A rotary mechanism as defined in claim 2 in which the means for urging said annular seal element against said outer surface is a spring which abuts against said plate.
   4. A rotary mechanism as defined in claim 1 in which the annular seal element comprising an annular groove in its outer surface, and a seal ring inserted with radial play within said groove having a spherical outer surface for sealing cooperation with the cylindrical peripheral wall of said working chamber.
   5. A rotary mechanism as defined in claim 1 in which said annular seal element is of a multipart construction, one of said parts engaging the outer body and another of said parts engaging the inner body.
   6. A rotary mechanism comprising: an outer body having a cavity, a rotary inner body having an outer peripheral cylindrical surface and being formed as a disc shaped
eccentric and mounted eccentrically on a drive shaft within the cavity for rotation with respect to the outer body, the outer body comprising at least one working chamber with a cylindrical peripheral wall and opening towards the inner body for a working medium which working chamber varies in volume during rotation of the inner body relative to the outer body, a reciprocal annular seal element in sealing arrangement with both said inner and outer bodies and comprising a spherical outer peripheral surface for sealing cooperation with said cylindrical peripheral wall and an annular end face for sealing engagement with the hollow-spherical surface of said inner body, said annular seal element being reciprocal along an axis at an angle to the axis of rotation of the rotary inner body, spring means for urging said annular seal element against said outer surface of the inner body and cooperating to maintain the sealing cooperation of the annular seal element with the cylindrical peripheral wall and the sealing engagement of the annular seal element with the outer peripheral cylindrical surface of the inner body, and ports for the working medium in at least one of said bodies.

7. A rotary mechanism comprising: an outer body having a cavity, a rotary inner body having a hollow-spherical surface and being formed as an eccentric part of a hollow sphere and mounted eccentrically on a drive shaft within the cavity for rotation with respect to the outer body, the outer body comprising at least one working chamber with a cylindrical peripheral wall and opening towards the inner body for a working medium which working chamber varies in volume during rotation of the inner body relative to the outer body, a reciprocal annular seal element in sealing arrangement with both said

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ROBERT M. WALKER, Primary Examiner.
WARREN COLEMAN, MARK NEWMAN, DONLEY J. STOCKING, Examiners.
W. L. FREEH, Assistant Examiners.