

Dec. 6, 1966

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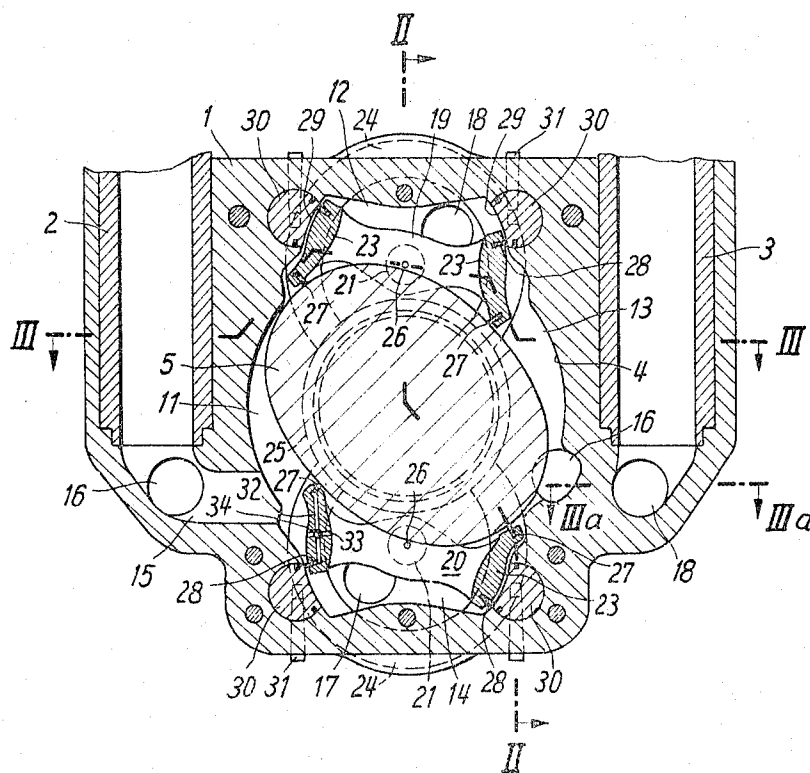
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ROTARY DISPLACEMENT MACHINE

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FIG. 1



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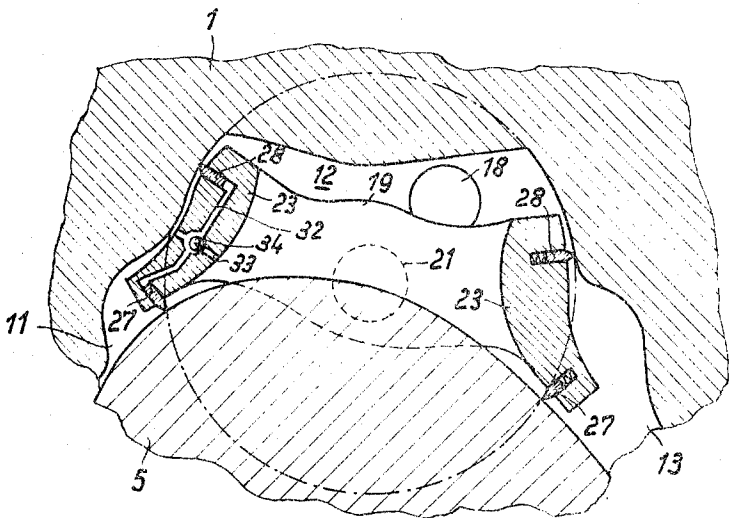
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FIG. 1a



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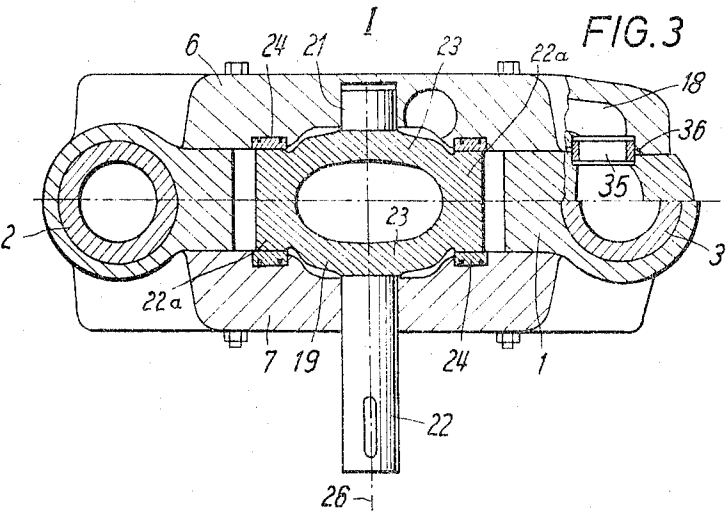
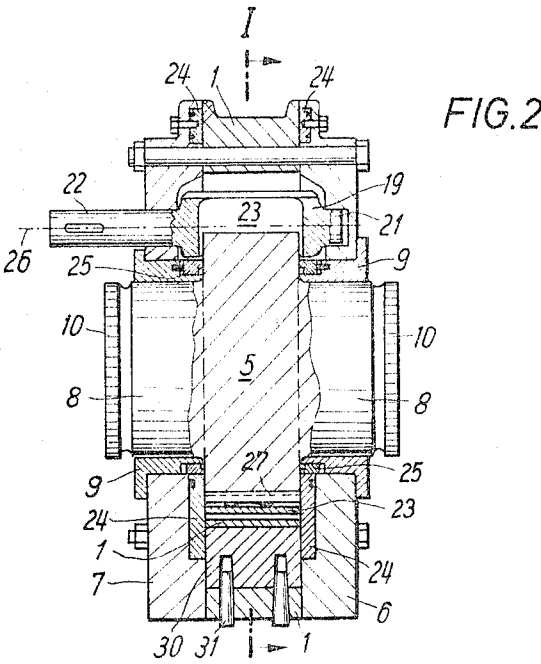
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FIG. 4

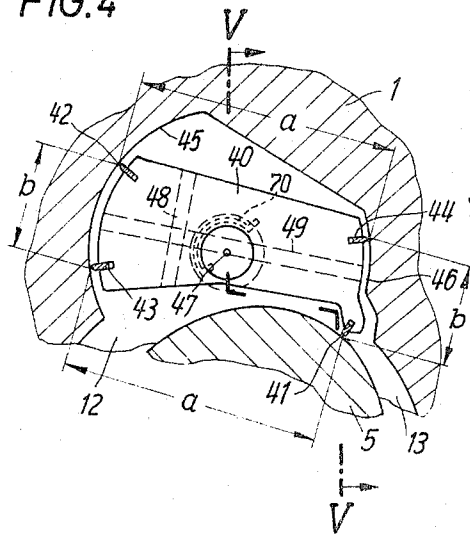


FIG. 5

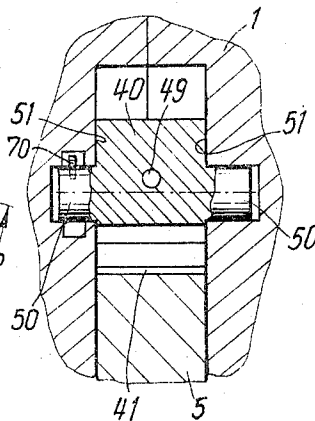


FIG. 6

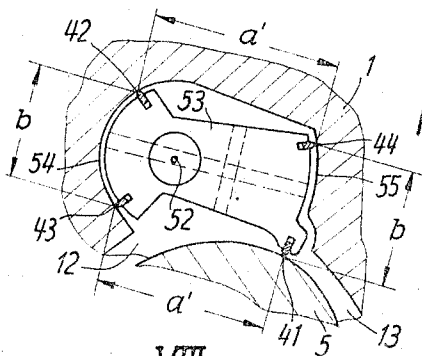


FIG. 7

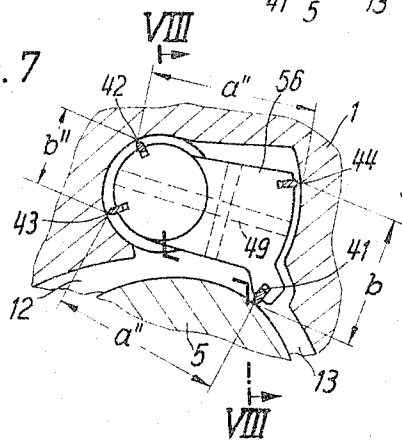
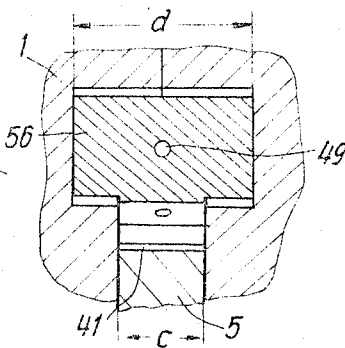


FIG. 8



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FIG. 9

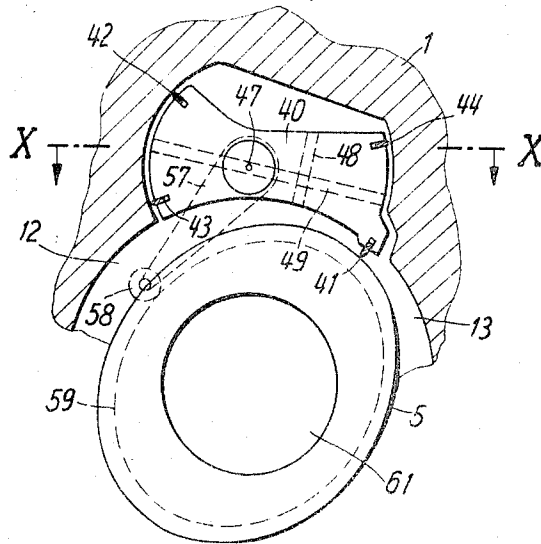
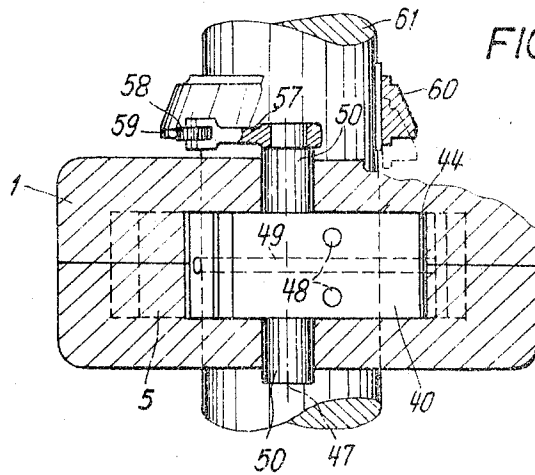


FIG. 10



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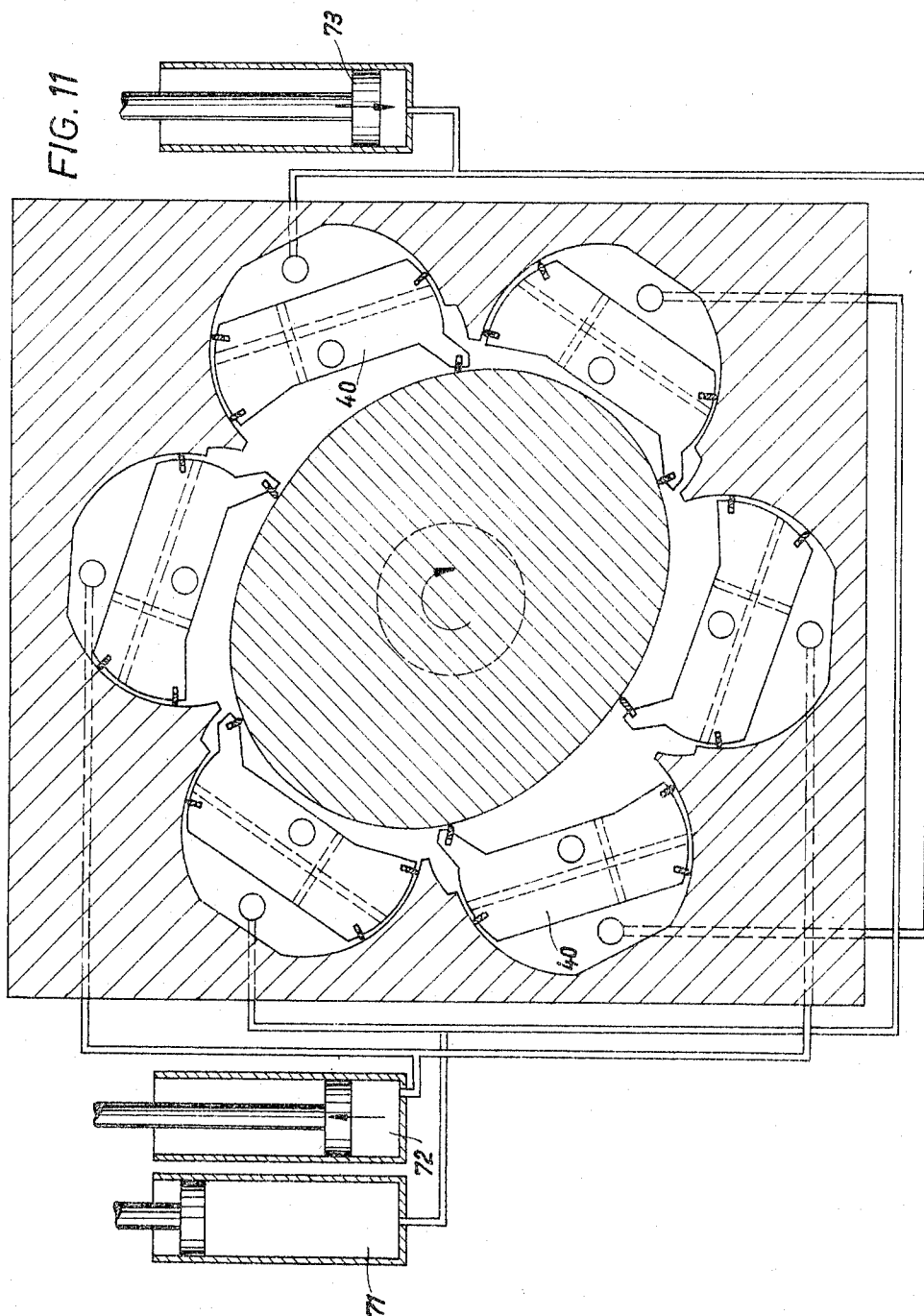
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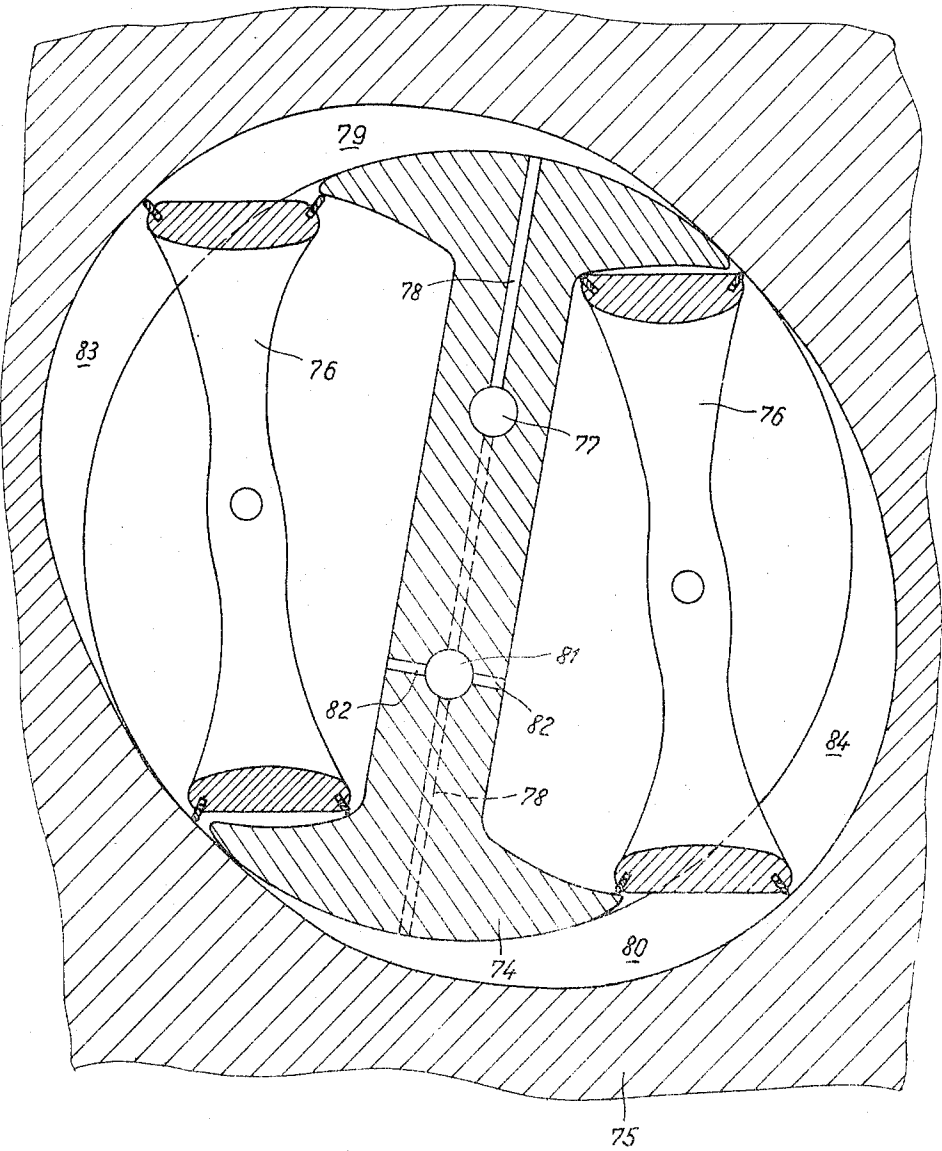
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FIG. 12



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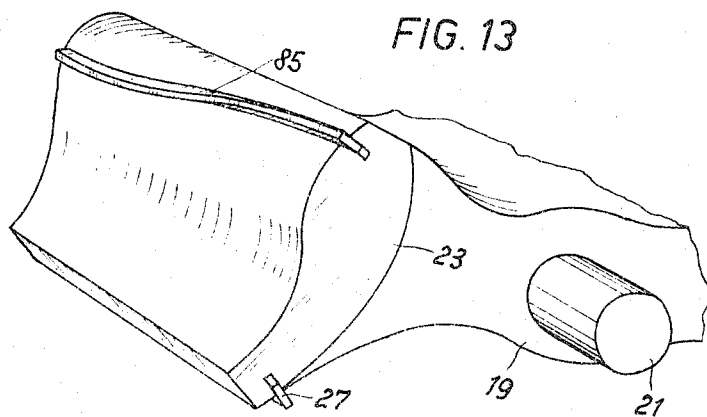
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ROTARY DISPLACEMENT MACHINE

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B 74,635

10 Claims. (Cl. 123—15)

The present invention relates to a rotary displacement machine one member of which has an oval or polygonal profile. The circumferential surface of said profile is provided with sealing elements guided in the other member of the displacement machine so as to be radially movable relative thereto. These sealing elements divide the space between the oval or polygonal member and the other member of the rotary displacement machine into at least four working chambers, the arrangement being such that in every other working chamber there will prevail a different phase of the fluid pressure condition than does prevail at the same time in the working chambers therebetween.

Rotary displacement machines of this type frequently together with reciprocatory piston displacement machines form movement converters for converting a reciprocatory movement to a rotary movement and vice versa. Movement converters in combination with oscillating fluid columns forming a hydraulic linkage, are employed to great advantage with internal combustion engines in substitution for customary crank drives.

Rotary displacement machines of the above-mentioned type have the drawback that the sealing elements during the operation of the machines have to move out of their slots to a considerable extent, so that great forces have to be transmitted in tangential direction and the respective displacement part in said slots as well as the sealing elements are subjected to great stresses and consequently are subject to rapid wear. In addition thereto, care has to be taken in order to prevent the sealing elements from being lifted by the fluid pressure off the circumferential surface of the displacement part.

It is, therefore, an object of the present invention to provide a rotary displacement machine which will overcome the above-mentioned drawbacks.

It is another object of this invention to provide a rotary displacement machine with sealing elements adjacent the periphery of the rotating member of the machine, in which the sealing elements will not be subjected to any high stress and thus will not be liable to wear rapidly.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIGURE 1 illustrates in section a movement converter with a rotary displacement arrangement according to a first embodiment of the invention, said section being taken along the line I—I of FIGURE 2;

FIGURE 1a is a section of a part of the movement converter according FIGURE 1 on a larger scale;

FIGURE 2 represents a section taken along the line II—II of FIGURE 1;

FIGURE 3 is a section taken along the line III—III and in part along the line III—IIIa of FIGURE 1;

FIGURES 4, 6, 7 and 9 illustrate in cross-section further embodiments of a rotary displacement machine according to the invention;

FIGURE 5 represents a section taken along the line V—V of FIGURE 4;

FIGURE 8 is a section taken along the line VIII—VIII of FIGURE 7;

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FIGURE 10 illustrates a section along the line X—X of FIGURE 9;

FIGURES 11 and 12 illustrate in cross-sections movement converters according to further embodiments of the invention;

FIGURE 13 shows a part of a rocker according to a particular construction, in a perspective view.

The present invention consists primarily in that with a rotary displacement machine of the above-mentioned type, rockers are employed for guiding the sealing elements, each rocker having at least one sealing element in engagement with the profiled structural surface of one rotary displacement member, whereas the remaining sealing elements engage cylinder surfaces of the other displacement member, said cylinder surfaces being concentric to the rocker axis. According to a further feature of the present invention, the edges of the sealing elements confine four surfaces perpendicular to which act the resultants of the liquid pressures prevailing between the respective edges. Of said four surfaces, each surface equals that of the respective oppositely located surface, and the pressure acting upon one surface equals the pressure acting upon the respective oppositely located surface. Preferably, the contacting edges of the four sealing elements of each rocker form a prism with rectangular base surface. In many instances, the arrangement is such that the edges of the four sealing elements of each rocker are located on one and the same circular cylinder coaxial to the axis of the respective rocker.

For instance, each rocker is equipped with two sealing elements engaging the profiled structural surface of a displacement member. In this instance, the oscillating movements of the rocker are effected positively in response to a rotation of one of said displacement members. In this connection, it is assured that the sealing elements cannot lift themselves off the profiled circumferential surface of one displacement member. However, there exists an interdependency between the profile of the above-mentioned circumferential surface on one hand and the distance between the sealing elements engaging said last-mentioned surface, and the location of the rocker axis on the other hand. However, to assure that the respective sealing elements safely engage the profiled circumferential surface, also additional auxiliary means such as springs may be employed.

For instance, the shaft of each rocker may form a chamber housing said rocker and pertaining to one displacement member extend to the outside of said chamber and may be provided with an arm the end of which may, for instance through the intervention of a roller carried thereby firmly engage a cam connected to the other displacement member. The said cam is so profiled that the respective sealing element will at all times engage the profiled structural surface of said other displacement member. In this way, the rockers are positively guided. This guided motion may be discontinued by causing the said cam disc to disengage the roller of the arm carrying the latter. This is effected, for instance with a hydraulic linkage replacing a mechanical crank drive, between a reciprocable displacement machine and a rotary displacement machine whenever it is desired to disconnect the respective output shaft.

Referring now to the drawing in detail and FIGS. 1 to 5 thereof in particular, the housing of the movement converter illustrated therein comprises a central member 1 which houses two cylinders 2 and 3 of a reciprocatory piston displacing machine. Provided between said two cylinders 2 and 3 there is a circular cylindrical chamber 4 for receiving a rotor 5. Each end face of said central member 1 has flanged thereto cover 6 and 7 respectively. Rotor 5 has an oval profile which is symmetrical with regard to two diameters arranged at a right angle with

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regard to each other. As will be seen from the drawing, rotor 5 is provided at each side thereof with a cylindrical extension 8 which extensions are by means of bearing boxes 9 journaled in the housing covers 6 and 7. Each extension 8 is provided with teeth 10 by means of which rotor 5 may be connected to rotors of movement converters.

The space confined by the circumferential surface of chamber 4 is by means of sealing elements to be described further below subdivided into four working chambers 11, 12, 13 and 14 each of which extends over a quarter of the circular circumference of chamber 4. Chambers 11 and 13 located diametrically opposite to each other communicate with cylinders 2 through passages 15, 16. The other two diametrically oppositely located working chambers 12 and 14 communicate with cylinder 3 through passages 17, 18.

Within the working chambers 12, 14 there are respectively provided rockers 19, 20. Each rocker is at opposite sides thereof journaled in bores of the housing covers 6 and 7. More specifically, the upper rocker 19 is journaled in covers 6, 7 by means of stud 21 and a shaft 22 protruding from cover 7. The lower rocker is similarly journaled. Each of the rockers 19, 20 has two lateral extensions 22a interconnected by a yoke 23. The said lateral extensions 22a have substantially the same width as the central member 1 (see FIG. 3) and have their end faces in close engagement with respectively adjacently arranged sealing rings 24 inserted in the respective adjacent surfaces of the covers 6, 7. The said sealing rings 24 are arranged coaxially with regard to the axis 26 of the rocker and have their inner ends in close engagement with sealing members 25 (see FIG. 1) which latter are provided in grooves of bearing bores or bushings 9.

Those marginal portions of yokes 23 of rockers 19, 20 which face rotor 5 are provided with grooves having arranged therein sealing strips 27 (FIG. 1) which are displaceable in radial direction to a slight extent. These strips 27 have their edges in engagement with the circumferential surface of rotor 5 and have their end faces in engagement with sealing rings 24.

Yokes 23 of rockers 19, 20 are furthermore provided with grooves having slightly displaceably guided therein sealing strips 28 (FIG. 1). Sealing strips 28 have their edges in engagement with surfaces 29 which are curved along the contour of a cylinder coaxial with the respective rocker axis 26. Said surfaces 29 pertain to rail bodies 30 which are inserted in transverse bores of the central member 1. The bodies 30 are secured against rotation by pins 31.

As will be evident from the above, sealing strips 27, 28 divide and separate the working chambers 12, 14 respectively containing rockers 19, 20 from the other working chambers 11, 13 which extend up to the sealing strips 28 in narrow gaps between yokes 23 and closure bodies 30. The arrangement of the sealing strips is such that the edge of each strip 27 is diametrically oppositely located with regard to a strip 28, and that the edges of all four sealing strips of each rocker are located on a circular cylinder (FIG. 1a) coaxial with regard to the axis of the respective rocker. Thus, the four points which in FIG. 1 represent the edges of the sealing strips 27, 28 are located in the corners of a right angle. Consequently, the forces exerted on each rocker on one hand by the liquid pressure in working chambers 11 and 13, and on the other hand by the liquid pressure in working chambers 12 and 14, balance each other. The bearings of rockers 19, 20 are, therefore, not under the load of liquid pressures.

Sealing strips 27, 28 may, if so desired, be pressed against the respective counter surfaces by springs (illustrated) in the grooves pertaining thereto. However, it is also possible to replace the thrust of the springs by hydraulic pressure. To this end, yokes 23 (as shown in FIG. 1 in the lower left-hand yoke) may be provided with bores 32, 33 which connect the grooves containing

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the sealing strips through a double-acting check valve 34 alternately with one or the other of the two adjacent working chambers, for instance 11, 14, and, more specifically, each time with that working chamber in which the higher pressure prevails.

Shaft 22 which pertains to rocker 19 and protrudes from the housing may serve for driving an auxiliary device, for instance an injection pump or discharge valves or a cooling pump. It is also possible, for installation purposes, to journal rockers 19, 20 unilaterally only in the housing.

As will be evident from FIG. 3, housing covers 6, 7 may be centered with regard to the central member 1 by means of sleeves 35 which are equipped with sealing rings 36 and at the same time serve as gap bridges, for instance for passage 18.

Referring now to FIGS. 4 to 10, each rocker, for instance rocker 40 of FIGS. 4 and 5, has only one sealing strip 41 for engagement with the circumferential surface of rotor 5, whereas the other sealing strips 42, 43 and 44 engage cylindrical surfaces 45, 46 the axes of curvature of which coincide with the axis of rocker 47. The edges of sealing strips 41, 42, 43 and 44 form the sides of a prism with a rectangular base surface. The large sides of the rectangle between the edges of strips 41, 43 and 42, 44 are designated with the letter *a*, whereas the small sides of the rectangle between the edges 41, 44 and 42, 43 have been designated with the letter *b*. Sealing strip 41 separates two working chambers 12, 13 of the rotary displacement device from each other. Working chamber 12 communicates through a passage 48 in rocker 40 with the oppositely located chamber in housing 1, whereas working chamber 13 merges with the narrow gap between the rocker and the cylindrical surface 46 and through a passage 49 in said rocker communicates with the oppositely located annular gap between sealing strips 42, 43.

Consequently, between strips 41, 44 and 42, 43 on one hand, and between strips 41, 43 and 42, 44 on the other hand through liquid pressures in working chambers 12 or 13 no moment acts upon rocker 40 so that a weak spring 70 will suffice to assure engagement of sealing strip 41 with rotor 5.

As will be evident from FIG. 5, rocker 40 is journaled in housing 1 by means of two studs 50 which are not loaded by the liquid pressure in chambers 12, 13. The end faces 51 of rocker 40 closely engage the end faces of the recess of housing 1 receiving rocker 40.

According to the embodiment of FIGS. 4 and 5, the rocker axis is located in the point of intersection of the diagonals of the rectangle *a, b*, or, differently expressed, the edges of the four sealing elements 41, 42 and 43, 44 are located on a circular cylinder coaxially arranged with regard to the rocker axis 47.

The embodiment according to FIG. 6 differs from that of FIGS. 4 and 5 merely in that the axis of rotation 52 of rocker 53 is not located in the point of intersection of the diagonals of that rectangle which in the illustrated cross-section is formed by the edges of sealing strips 41, 42, 43, 44. Instead, the radius of the cylindrical surface 54 engaged by sealing strips 42, 43 is with regard to rocker axis 52 considerably smaller than the radius of the cylindrical surface 55 engaged by sealing strip 44. However, rocker axis 52 is located in the rocker central plane which halves the arc of a circle between the sealing strips 42, 43 on one hand and the sealing strips 41, 44 on the other hand. (If axis 52 would be located outside said plane, the sealing strips 42, 43 would have to engage the cylindrical surface with different radii of curvature).

Consequently, the long sides *a'* of the rectangle defined by the strips 41, 42, 43, 44 are with the embodiment of FIG. 6 shorter than the corresponding sides *a* of the rectangle in the embodiments of FIGS. 4 and 5, whereas the short sides *b* of the rectangle may have the same

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size. Therefore, in order to house rocker 53 of FIG. 6 in housing 1, less space is required than is the case with the embodiment of FIGS. 4 and 5.

A further saving in space can be obtained when in conformity with FIGS. 7 and 8, the arc of a circle between the sealing strips 42, 43 is selected shorter than the distance between sealing strips 41, 44. In this instance, the four edges of the guiding strips are not located on a rectangle but on a quadrangle the short sides b'' of which between the edges of strips 42, 43 are shorter than side b located between the edges of strips 41, 44. In this connection, it should be noted that sides a'' pertaining to the quadrangle and located between the edges of strips 42, 44 and 41, 43 are shorter than the sides of a' of the rectangle according to FIG. 6. Thus, the chamber of housing 1 which receives the rocker 56 is shortened further. In order to assure that nevertheless the liquid pressures in chambers 12 and 13 will upon rocker 56 not exert any forces to be absorbed by the rocker bearings, the surface between sealing strips 42, 43 is made equal to the effective surface between sealing strips 41, 44. This is realized by making rocker 56 (see FIG. 8) within the range of sealing strips 42, 43 longer in axial direction than in the direction of strips 41, 44. The length of rocker 56 in the two mentioned ranges has been indicated by the letters d and c , respectively. Thus, $b'' \times d = b \times c$. With this design of the rocker, bearing studs corresponding to studs 50 in FIG. 5 become superfluous and may be omitted.

FIGS. 9 and 10 illustrate an embodiment according to which rocker 40 which, for instance is designed in the same way as the rocker according to FIGS. 4 and 5, is automatically during the rotation of rotor 5 so actuated that sealing strip 41 will always engage the circumferential surface of rotor 5. To this end, outside housing 1 and on one of bearing studs 50 (FIG. 10) extending through said housing and pertaining to rocker 40, there is provided an arm 57 one end of which carries a roller 58. Roller 58 engages the circumferential surface 59 of a cam 60 which latter is non-rotatably but axially displaceably mounted on an output shaft 61 carrying rotor 5. Surface 59 is similar to the circumferential surface of rotor 5, and the axes of symmetry of said surface have, with regard to the axis of rotation, the same location as the axis of symmetry of rotor 5. The effective lever length of arm 57 is, in view of the lever arm of the edge of strip 41 with regard to rocker axis 47 so dimensioned that during the rotation of rotor 5 and cam 60, sealing strip 41 will always be held in engagement with the circumferential surface of rotor 5. Inasmuch as the liquid pressures acting upon rocker 40 are at all times completely balanced, the members 50, 57 and 58, 60 have to convey only minor adjusting forces and consequently, can be of correspondingly light structure. Cam 60 may be adapted to any desired rotor shapes and may be exchanged for corresponding cams when other rotors are employed.

It is possible to displace cam 60 to the position illustrated by dot-dash lines in FIG. 10. If such a displacement takes place, roller 58 disengages cam surface 59 so that rocker 40 will no longer automatically be moved in conformity with the rotation of rotor 5. In this instance, rocker 40 may by means of a spring be tilted in such a way that sealing strip 41 disengages the circumferential surface of rotor 5. Consequently, it is at the operator's discretion to nullify the effect of the rotary displacement device so that it will not convey any torques. This is of importance above all when a hydraulic linkage of an internal combustion engine is involved because in this instance it is easier to interrupt the power transmission between a cylinder pair of the machine and the output shaft. As a result thereof it is possible, for instance to repair individual cylinders of a multi-cylinder internal combustion engine while the remaining cylinders continue in operation.

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The present invention also covers an arrangement according to which rockers with one sealing element each which engages the rotor—for instance in conformity with the embodiments of FIGS. 5 to 10—are distributed in such a number over the circumference of the displacement chamber housing the rotor as is required when more than two reciprocable piston displacement devices are connected to a rotary displacement device. This may be the case for internal combustion engines composed of a plurality of driving units in conformity with the building block principle, of which each driving unit consists of three or more cylinders and a rotary displacement device and also has a waste gas turbo-charger. Inasmuch as in this instance, three or more cylinders work upon a charger at a corresponding phase development of less than 180° , more favorable charging conditions are obtained. An embodiment with six rockers 40 and three reciprocable piston displacement devices 71, 72, 73 is illustrated in FIG. 11.

FIG. 12 shows a further embodiment with a rotor 74 of circle-cylindrical form whereas the housing 75 has an oval profile. Two rockers 76 are journaled within holes of the rotor 74. By means of conduits 77, 78 fluid is led to chambers 79, 80 and by means of conduits 81, 82 from chambers 83, 84, and vice versa. It is possible that the rotor 74 rotates and the housing 75 stands still or that the rotor 74 stands still and the housing 75 rotates.

Similarly, with an embodiment having an oval rotor and a circle-cylindrical housing the latter may rotate whereas the rotor stands still.

Furthermore, when more than two cylinders work on one rotary displacement device, a greater rotor diameter is obtained by the same output weight. As a result thereof, a greater flexibility is obtained with regard to the construction of the coupling elements which interconnect the rotors of the driving units. The sealing strips do not have to be rectilinearly parallel to the rocker axis but may also be helical. FIG. 13 shows a helical sealing strip 85 arranged in a nut of a rocker 19.

It is, of course, to be understood that the present invention is by no means limited to the particular constructions and arrangement shown in the drawings, but also comprises any modifications within the scope of the appended claims.

What I claim is:

1. In a rotary displacement machine, housing means comprising chamber means having at least four working chambers which are connected to the cylinders of reciprocating displacement means so that each working chamber at any one time is in a different phase of change in liquid pressure from the adjacent working chambers, rotor means rotatable in said chamber means, the peripheral surface of said rotor means having at least two planes of symmetry and having different radii in said planes of symmetry, certain of said working chambers having cylindrical wall surface portions, rocker means pivotally mounted in each of said certain working chambers on an axis concentric with said cylindrical surface portions and engaging said rotor means to separate its working chamber from an adjacent chamber, each of said rocker means having four sealing means, said sealing means being spaced about the periphery of said rocker means at points defining a quadrilateral, certain of said sealing means engaging the rotor means and the others engaging the cylindrical wall surface portions, said sealing means confining two pairs of substantially equal and opposite surface sections on said rocker means, the pressures on each pair of opposite surface sections being substantially equal and opposite so that the fluid pressure exerts a minimum force on the mounting of said rocker means.

2. In the machine defined in claim 1, in which a shaft is connected to said rocker means and extends through said housing means to the outside, cam means are arranged on the outside of said housing means and non-rotatably connected to said rotor means and means

are connected to said shaft and engage said cam means, said cam means being shaped to hold said sealing means positively in engagement with the respective surfaces to be engaged.

3. In the machine defined in claim 1, in which one of said rocker means is connected to a shaft extending through said housing means to the outside for connection with an auxiliary means to be driven by said rocker means and in which the surface sections of each pair of opposite surface sections are substantially the same size.

4. In the machine defined in claim 1, in which said housing means is formed by an annular central member and two cover means connected to opposite sides of said central member to form said chamber means and said rocker means are mounted in said cover means, and sealing ring means are supported by said cover means substantially coaxial with the axis of said rocker means for effecting a seal between said cover means and the respective adjacent sealing means.

5. A rotary displacement machine according to claim 1, in which at least some of said cylindrical wall surface portions are formed by wear elements inserted into said housing means.

6. In a rotary displacement machine, housing means comprising chamber means having at least four working chambers which are connected to the cylinders of reciprocating displacement means so that each working chamber at any one time is in a different phase of change in liquid pressure from the adjacent working chambers, rotor means rotatable in said chamber means, the peripheral surface of said rotor means having at least two planes of symmetry and having different radii in said planes of symmetry, certain of said working chambers having cylindrical wall surface portions, rocker means pivotally mounted in each of said working chambers on an axis concentric with said cylindrical surface portions and engaging said rotor means to separate its working chamber from an adjacent chamber, each of said rocker means having four sealing means, said sealing means being spaced about the periphery of said rocker means at points defining a quadrilateral, two of said sealing means engaging said rotor means and confining one surface section on said rocker means therebetween and two of said sealing means engaging said cylindrical wall surface portions and confining a surface section on said rocker means equal and opposite said one surface section therebetween, each pair of sealing means engaging with the rotor means and a cylindrical wall surface portion confining one of two equal and opposite surface sections on said rotor means, the pressures on each pair of opposite surface sections being substantially equal and opposite so that the fluid pressure exerts a minimum force on the mounting of said rocker means.

7. In a rotary displacement machine, housing means comprising chamber means having at least four working chambers which are connected to the cylinders of reciprocating displacement means so that each working chamber at any one time is in a different phase of change in liquid pressure from the adjacent working chambers, rotor means rotatable in said chamber means, the peripheral surface of said rotor means having at least two planes of symmetry and having different radii in said planes of symmetry, certain of said working chambers having cylindrical wall surface portions, rocker means pivotally mounted in each of said certain working chambers on an axis concentric with said cylindrical surface portions and engaging said rotor means to separate its working chamber from an adjacent chamber, each of said rocker means having four sealing means, said sealing means being placed about the periphery of said rocker means at points defining a quadrilateral, one of said sealing means engaging said rotor means and the others engaging the cylindrical wall surface portions, one pair of circumferentially spaced sealing means confining one surface section of said rotor means therebetween and the other pair of cir-

cumferentially spaced sealing means confining the equal and opposite surface section on said rotor therebetween, the sealing means forming each of the other two pairs confining one of two equal and opposite surface sections on said rotor means, the pressures on each pair of opposite surface sections being substantially equal and opposite so that the fluid pressure exerts a minimum force on the mounting of said rocker means.

8. In the machine defined in claim 7, in which one of the opposite surface sections confined by one of the last-named pairs of sealing means is of less width radially and greater length axially than the other of said pairs.

9. In a rotary displacement machine, housing means comprising chamber means the circumferential surface of which have at least two planes of symmetry and different radii in said planes of symmetry, rotor means having a cylindrical peripheral surface arranged within said housing means for relative rotation between said housing means and rotor means, said rotor means having a plurality of recesses open to said chamber means and equally spaced about said peripheral surface, each recess having two cylindrical wall surface portions, a plurality of rocker means each mounted within one of said recesses for rocking movement about an axis concentric with said cylindrical wall surface portions, each of said rocker means having four sealing means at least one of which is in engagement with said circumferential surface of said housing means and the others in engagement with the wall surface portions, so that said chamber means is divided into four working chambers, said working chambers being connected to the cylinders of reciprocating displacement means so that each working chamber is at any time in a different phase of change in liquid pressure from the adjacent chambers.

10. In a rotary fluid displacement machine having a housing means comprising a plurality of working chambers, and a rotor means in said housing means the peripheral surface of which has at least two planes of symmetry and different radii in said different planes, so that the volumes of said working chambers increases and decreases with rotation of said rotor means, cylindrical wall surface portions in one of said working chambers, a rocker means pivotally mounted in said one working chamber on an axis concentric with said cylindrical surface portions and engaging said rotor means to separate fluid in said one working chamber from an adjacent chamber, said rocker means having four sealing means engaging said rotor means and said curved surface portions, said sealing means being located at points at the corners of a quadrilateral which encloses said pivotal axis, the opposite sides of said rocker means between the pairs of sealing means at circumferentially spaced points being equal and subjected to the fluid pressure in said working chamber in opposite directions inwardly of said rocker means, and the opposite sides of said rocker means between the pairs of sealing means at radially spaced points being equal and subjected to equal fluid pressure in opposite directions from at least one adjacent chamber so that the fluid pressures are substantially equal and opposite on said rocker means.

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F. T. SADLER, *Assistant Examiner.*