

May 25, 1954

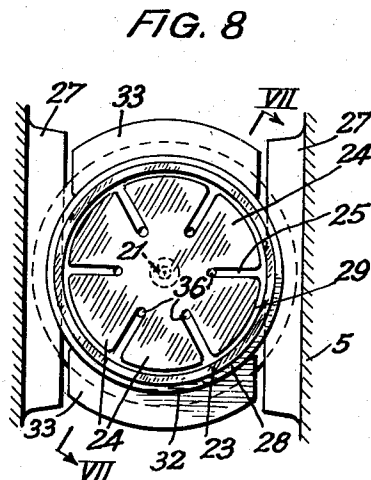
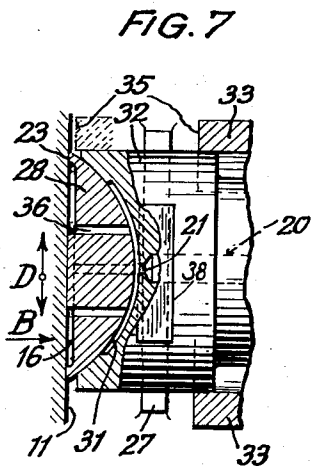
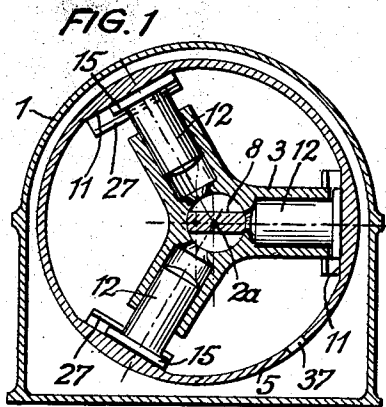
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EXPANSIBLE CHAMBER TYPE RADIAL PISTON ENGINE

Filed Sept. 14, 1948

2 Sheets-Sheet 1



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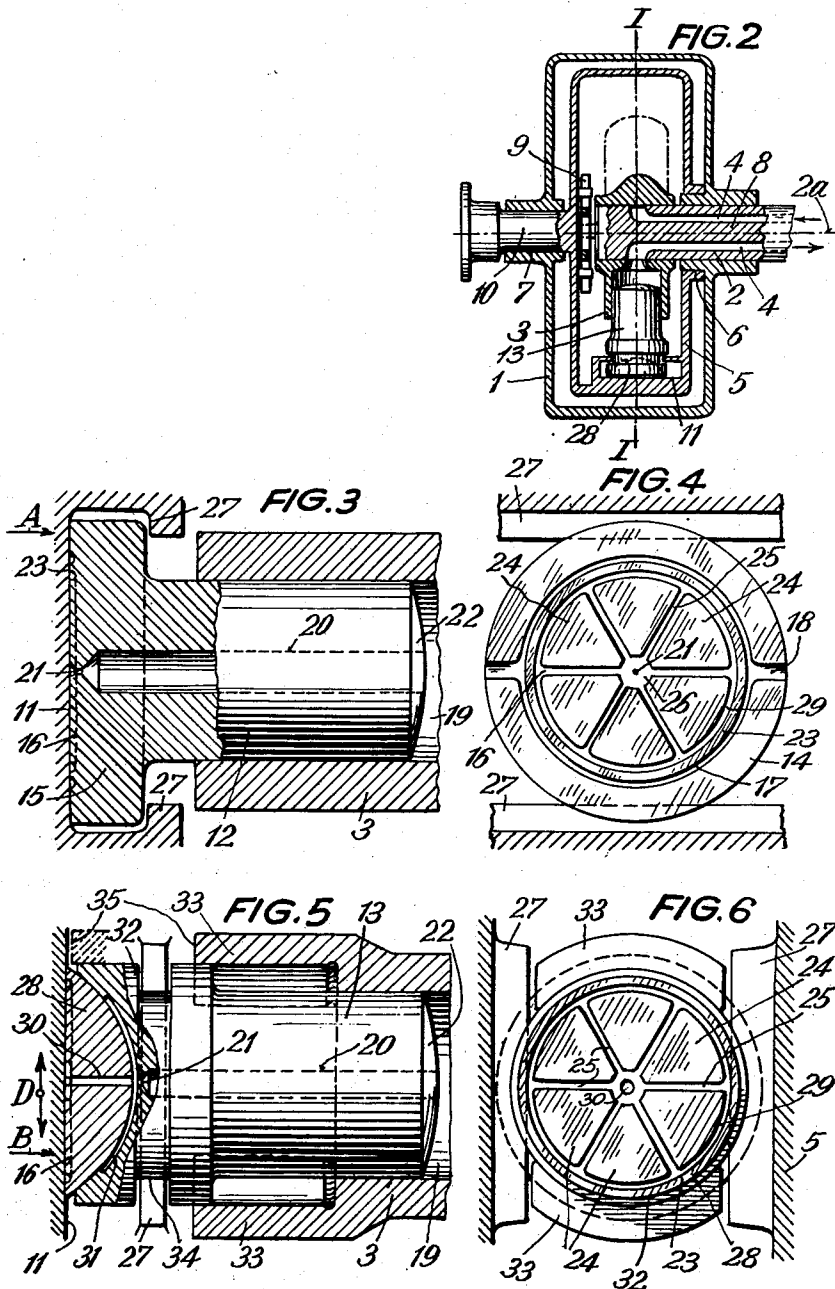
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EXPANSIBLE CHAMBER TYPE RADIAL PISTON ENGINE

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UNITED STATES PATENT OFFICE

2,679,210

EXPANSIBLE CHAMBER TYPE RADIAL
PISTON ENGINE

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Application September 14, 1948, Serial No. 49,140

Claims, priority, application Switzerland.
September 18, 1947

5 Claims. (Cl. 103—161)

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My present invention relates to improvements in expansible-chamber type engines of the type including a radiating cylinder, reciprocating pistons and an outside abutment; and in particular the construction of the relief chambers provided on the piston end-faces. The construction of the piston heads and of the extended cylinder walls in engines of such type, forms the subject matter of my copending application Ser. No. 49,139.

It is known in the art to definitely space the sliding surfaces of machine parts sliding upon each other, and thus to substantially reduce the friction; in that a pressure chamber is recessed from one of the said surfaces, which chamber is supplied through a throttling aperture with a pressure fluid.

It also is known in the art to use, in engines of the type described, pressure chambers supplied from the cylinder space. In such connection, however, certain difficulties arise, in that forces additional to the fluid pressure may arise on the pistons in their axial directions, such as accelerating or centrifugal forces which may be counteracted, during the pressure stroke, but not during the suction stroke by means of the pressure chamber recessed from the piston-head sliding-face, in that during the suction stroke the pressure-fluid supply to the pressure chambers from the side of the cylinder ceases. It is true that the pressure chamber could be kept under pressure also during the suction stroke, by means of a special pump which continuously produces pressure fluid, which arrangement, however, results in a complicated structure and additional manufacturing costs. But also when the piston engine runs idle or under a slight load, sufficiently high pressure also no longer is available in the working space of the engine cylinder during the pressure stroke, so that the slide-face portions adjacent the outside of the chambers are pressed against each other by these additional forces, thus giving origin to increased friction and perhaps pitting or wear.

In accord with my present invention such difficulties and disadvantages may be obviated by providing supporting faces inside the pressure chambers. As shown by tests, such provision does not in any way impair the effect of the pressure chambers of decreasing the friction. Such provision affords not only a lower weight of the entire pistons, but also the advantage that during the pressure period the high oil pressure is communicated, practically instantaneously, at least to the entire lubricating film on the support-

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ing faces disposed within the pressure chambers, so that the lubricating film during the suction period is displaced more slowly from the said faces. When the piston engine is so operated that also the suction space is under a certain slight pressure, e. g. 2-5 atm., there results the advantage that the faces at idling also still are lubricated by pressure oils, which is possible only at a less efficient degree when the supporting faces are arranged outside the pressure chambers. Further, the danger of pitting of the slide-faces when the throttling aperture is clogged, also is diminished.

Various forms of my present invention are illustrated in the accompanying drawings, in which:

Fig. 1 shows a section through a three-cylinder radial piston engine,

Fig. 2 is a longitudinal axial section through a three cylinder radial piston engine having pistons of modified design with respect to those shown in Fig. 1,

Fig. 3 shows in a larger scale, a piston according to Fig. 1 partly in longitudinal section,

Fig. 4 is a view of the piston head of Fig. 3, in direction of the arrow A in Fig. 3,

Fig. 5 is a longitudinal section through a piston of the type shown in Fig. 2,

Fig. 6 is a view of the piston head of Fig. 5 in direction of the arrow B in Fig. 5,

Fig. 7 is a fragmentary sectional view of a modified piston along the line VII—VII of Fig. 8,

Fig. 8 is a plan view of the piston end as seen in the direction of the arrow B in Fig. 7.

In Figs. 1 and 2, the cylinder block 3 of the engine, which may operate as pump or motor, is mounted rotatably on the control stud 2 which is rigidly secured to the casing 1, which block comprises three radially disposed cylinders. In the casing 1, further, the abutment 5 is rotatably mounted at 6 and 7 and eccentrically to the axis 2a of stud 2. The abutment 5 is so coupled to the cylinder block 3 through a follower 9, in form of a cross-loop coupling or universal coupling, that the block 3 and the abutment 5 always rotate at the same number of revolutions. On the inside wall of the abutment 5, which may be driven through the stub shaft 10, when the engine shall operate as pump, three plane faces 11 are provided for, against each of which the head of one piston 12 abuts by means of a slide shoe or piston head 15.

In the rigid control stud 2, two bores 4 are provided for supplying and delivering the working fluid, e. g. in the sense of the arrows shown

in Fig. 2. The cylinders situated above the horizontal median plane of stud 2, communicate with the upper one, and the cylinders below the said plane with the lower one of the said two bores 4. The web 8 separates the engine suction space from the pressure space.

The structure of piston 12, in which the piston and the head 15 are integral, is shown in a larger scale in Figs. 3, 4. A shallow chamber 16 is recessed from the end face of the head 15 abutting against the face 11, and is supplied with pressure fluid from the cylinder interior 19 through the bore 20 and the throttling aperture 21 of the piston. The chamber is confined by the narrow annular face 23. In the chamber 16, additional supporting faces in form of six ring sectors 24 are provided, which faces fill up the pressure chamber 16 with the exception of the six radial grooves 25, the central recess 26 and the circular groove 29. Outside the pressure chamber, the additional annular supporting face 14 is provided, which is separated from the chamber 16 through the annular groove 17.

Pressure fluid flows from the pressure chamber 16 or, respectively, the groove 29 through the narrow gap between the annular face 23 and the flattened face 11 into the annular groove 17 from which it may flow outwardly through the grooves 18 into the interior of abutment 5 and through an opening 37, back into the casing 1. The chamber pressure thus cannot propagate into the gap between the additional pressure face 14 and the flat face 11.

The piston is subject, in the direction from the cylinder space, to a fluid pressure, acting onto the piston face 22, of the magnitude F_k , as well as to an additional force C, e. g., as radially acting centrifugal force of the piston in the engine construction according to Fig. 1. The lubricating layer between piston head 15 and plate 11 should have a thickness, e. g., of approximately 0.01 mm. so as to ensure fluid friction and thus to keep the friction as small as possible. To such end, the sum of the fluid forces tending to push away the piston head 15 from the flat face 11—at a fluid pressure p_1 in the chamber 16—has to equal the sum of the forces tending to press the piston head 15 against the face 11. Fluid then will flow from the chamber 16 through the gap between the faces 11 and 23, so that the pressure p_1 therein, due to the throttling of the supply at 21, becomes less than the pressure p in the cylinder 19. Denoting the full circular area of the chamber 16 within the annular face 23 by F_1 , and that of the annular face 23 by F_2 , the requirement is:

$$F_1 p_1 + F_2 \frac{p_1}{2} = F_k \cdot p + C$$

The area F_2 is multiplied by only half the chamber pressure, since the pressure onto the face 23 drops, from the inside to the outside, approximately linearly from p_1 to zero. When $p_1 = p$, the oil flow in the lubricating layer ceases, and a semi-fluid friction occurs. The above equation, when dividing by p , then reads:

$$F_1 + \frac{F_2}{2} = F_k + \frac{C}{p}$$

In order to attain fluid friction in the case of full-load working-pressure, the sum of the chamber area and half the marginal area, therefore, must exceed the sum of the piston area and the quotient from the centrifugal force and full-load pressure. Advantageously measures are taken for attaining such ratio at the maximum additional force C occurring within the most common work-

ing range of the engine even at a pressure less than the full-load pressure.

During the pressure stroke, the piston pressure at the said dimensioning of the relief chamber area is slightly withdrawn from the face 11, ample oil flowing between the slide faces 11 and 23, 24 and, to a lesser extent, onto the face 14. During the suction stroke, the relief in chamber 16 is no longer effective, and the said faces 23, 24 and 14 intercept the non-compensated additional forces C. Oil then is squeezed from between the supporting faces 23, 24 and 14, and the oil layer becomes thinner until the pressure rise associated with the succeeding pressure stroke arrives in the chamber 16. In this manner, provision is made for sufficiently lubricating the faces of the piston head during the entire working period of the piston.

In order to ensure a sufficient lubrication of the piston-head faces also when the engine is slightly loaded and the pressure of the working fluid is low, the suction side of the piston engine advantageously also is held under a slight pressure of, e. g., from 2 to 5 atm. by means of a special pump. In this case, of course, a greater friction on the piston head than when the engine is more highly loaded has to be taken into account nevertheless. When the maximum additional force C occurs only at rare intervals in operation, the faces F_1 and F_2 also can be made smaller than according to the rule set forth above.

Ledges 27 provided on the abutment 5 prevent too great a rise of the piston heads 15 from the flat faces 11, in that these ledges engage the said heads from the rear. The groove 17 may be omitted, in which case the outside diameter of the head 15 and perhaps also that of the chamber 16 may be reduced somewhat, since then the annular face 14 also aids the action of the pressure chamber 16. In such case, however, when the chamber pressure is falling out, the outside supporting face 14 in particular is lubricated less efficiently through the oil bath which is always present in the rotor abutment space outside the pistons.

The structure of the piston 13 is more fully shown in Figs. 5 and 6. Such piston structure differs from the one described above, besides the adjustable spherical segment 28 inserted between piston and slide face 11, in that the enlarged piston head is guided on the cylinder, and in that additional supporting faces no longer are provided outside the annular face 23. The segment 28 permits balancing small deviations of the piston axis from the direction normal to the face 11. Its spherical seat on the piston may be relieved, at least partially, by means of a pressure chamber 31. The segment 28 is traversed by a bore 30 through which the pressure chamber 16 communicates with the oil supply bore 20—21 from the cylinder space 19.

The enlarged piston head 32 is guided, over the entire piston stroke, by means of the guide 33 rigidly secured to or integral with the cylinder block 3. In the inner dead-center position of the piston, the end face 35 of said guide is situated quite close to the slide face 11, as indicated in Fig. 5 by the dash line.

In order to energize the pressure chamber 16, the annular groove 29, which is supplied with pressure oil from inside through the radial grooves 25, should extend at least over 80% of the circumference. Under certain conditions it is of advantage to subdivide the sector-like supporting faces 24 by means of further smaller

grooves in order to facilitate a penetration of the pressure liquid between the said faces 24 and the faces 11.

In order to improve the bearing capacity of the lubricating layer of the pressure-chamber center, the radial grooves 25 may be extended only for a certain distance toward the center, as shown in Figs. 7 and 8. The said grooves 25 are supplied through a plurality of bores 36 from the chamber 31. The bores 36 may be interconnected through an annular groove (not shown).

With a given fluid pressure F_k and, if such is the case, a given additional force C , a gap of definite depth is established between the abutment face 11 and the annular piston end faces 14 and 23, which gap has to be only slightly deeper than the irregularities of the said faces in order to reduce the sliding friction practically to zero. The depth of said gap tends to be constant from the following reason. When, on one hand, the gap should increase in depth, the fluid flow through and from the chamber 16 is increased, and thus the pressure in the latter drops due to the throttle 21, whereby the forces acting on the piston depress the latter down to the original depth of gap. When, on the other hand, the gap is decreased and the pressure in chamber 16 increased over that acting on the piston through the cylinder, i. e. the original depth of gap again is re-established.

The use of pistons shown in Figs. 5 to 8 permits the adoption of the smallest diameter for the piston head abutting against the slide face 11, of all the forms of invention described.

The width of the marginal portion 23 may be held rather small, as has been proved by tests, and may preferably be made less than 15% of the chamber radius.

The guide ledges 27 provided on the abutment 5 are engaged in a recess 34 of the thickened piston and portion 32. The recess 34 may be provided in form of a circular turned-out groove, as shown in Fig. 5, or only in form of lateral milled grooves 38 as shown in Fig. 7.

The pistons suitably are made of light metal with a view of diminishing the inertia forces.

If the piston head 15 in Fig. 3 is made as long as in Fig. 5, it also may be better guided by means of guide lugs 33 disposed intermediate of the ledges 27.

In place of a liquid, one also may use a gas as working and pressure agent.

What I claim as new and desire to secure by Letters Patent is:

1. An expansible chamber type radial piston engine comprising a housing, a rotor movable in said housing, a cylinder block having radial cylinders eccentrically mounted in said rotor, reciprocating pistons in said cylinders, each piston having a longitudinal bore therein and being provided with a head at the outer end remote from the cylinder space, flat abutment faces on said rotor providing each for sliding engagement with one piston head, each piston head being recessed to form a pressure chamber between the head end face and the piston abutment face, said pressure chamber being supplied with pressure fluid from the cylinder space through said bore in the piston, a fluid throttling means in said bore near the end thereof at the piston head face, said pressure chamber being arranged in the form of a circular groove having a diameter approximately equal to the piston diameter, and a plurality of ducts establishing communication between said circular groove and the throttling

point of said pressure fluid supply bore, said ducts extending partially in the form of open radial grooves along the end face of the piston head whereby the areas of the piston head end face intermediate the annular groove and said radial grooves form piston head supporting faces acting as abutment pressure relief faces.

2. A fluid pump or motor as claimed in claim 1, wherein said pressure chamber is confined within an annular supporting face provided on said head end face, the radial width of said annular supporting face does not exceed 15% of the radius of said pressure chamber.

3. A fluid pump or motor as claimed in claim 1, wherein said pressure chamber is confined within an annular supporting face provided on said head end face, the sum of the area of the pressure chamber and one half the area of said annular supporting face are greater than the sum of the inner piston end area and the ratio between the centrifugal force acting on the piston during normal operation and a cylinder pressure which is smaller than the cylinder pressure at full load operation of the pump or motor.

4. A fluid pump or motor comprising a cylinder block having radial cylinders, a piston operating in each cylinder, each piston including a body portion and a separate end portion at the end thereof remote of the cylinder space, said end portion being in the form of a spherical segment having a spherical surface fitting a spherical recess in the piston body portion and a flat end face, a thrust member surrounding said cylinder block, said thrust member being provided with flat abutment faces each being in sliding engagement with the flat end face of a spherical segment of a piston end, each piston having a longitudinal bore therein extending through the piston body portion and said spherical segment, the end face of the spherical segment of each piston being recessed to form a pressure chamber between said end face and said abutment face on the thrust member, said pressure chamber being supplied with pressure fluid from the cylinder space through said bore in the piston, a fluid throttling means in said bore near the end thereof at the piston head face, said pressure chamber being arranged in the form of a circular groove having a diameter approximately equal to the piston diameter, and a plurality of ducts establishing communication between said circular groove and the throttling point of said pressure fluid supply bore, said ducts extending partially in the form of open radial grooves along the end face of the piston head whereby the areas of the piston head end face intermediate the annular groove and said radial grooves form piston head supporting faces acting as abutment pressure relief faces.

5. A fluid pump or motor as defined in claim 4, wherein a second fluid pressure chamber is provided between the spherical surface of said spherical segment and the surface of the spherical recess in the body portion of each piston.

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