July 5, 1966 H. ERDMANN 3,259,074

RADIAL-PISTON MACHINES

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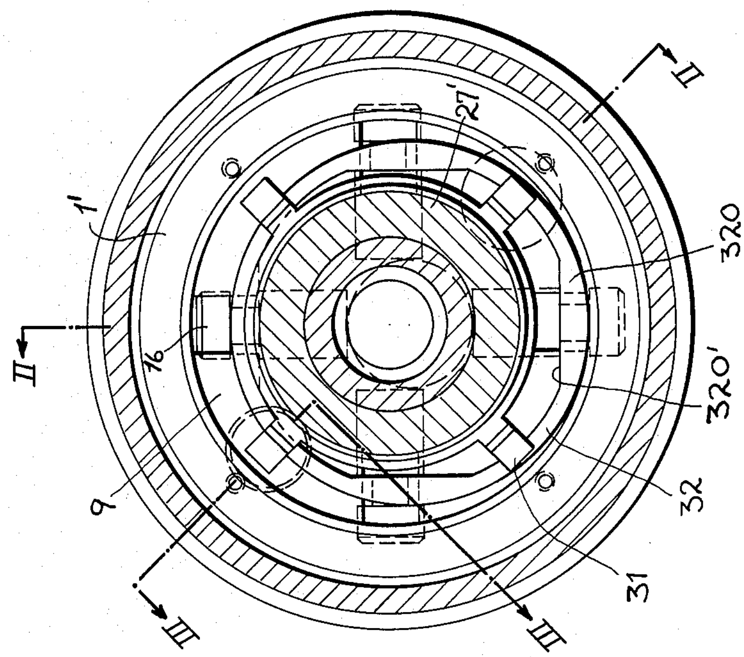

Fig.1

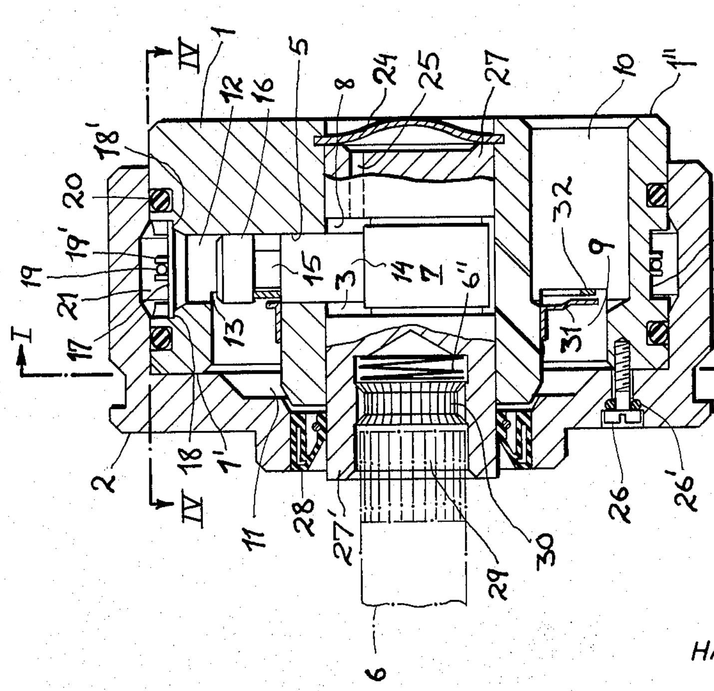

Fig.2

HANS ERDMANN
INVENTOR.

BY Mestern, Ross & Mestern

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Fig.3

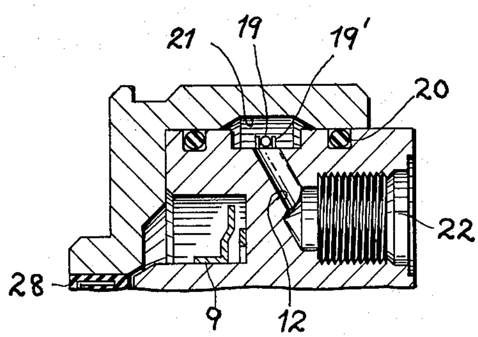


Fig.4

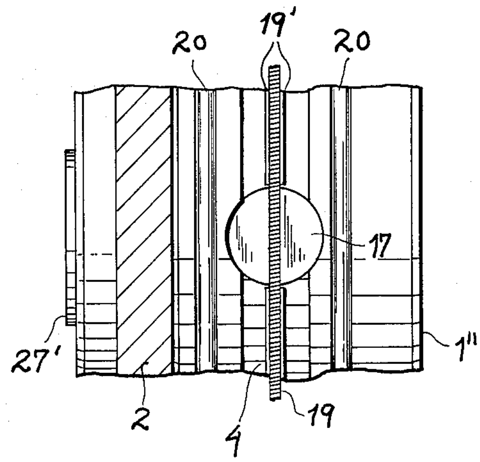
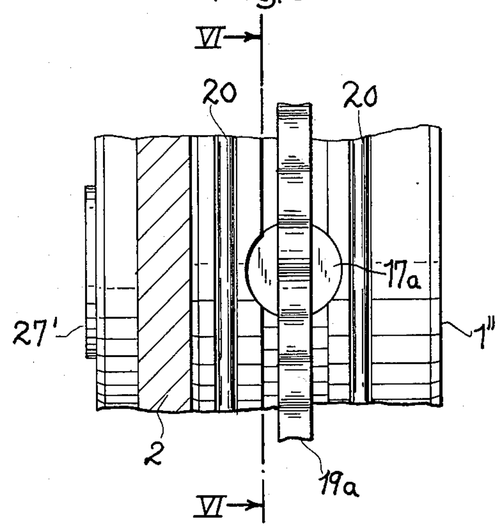


Fig.5



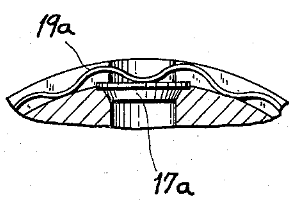


Fig.6

HANS ERDMANN
INVENTOR.

BY Mestern, Ross & Mestern

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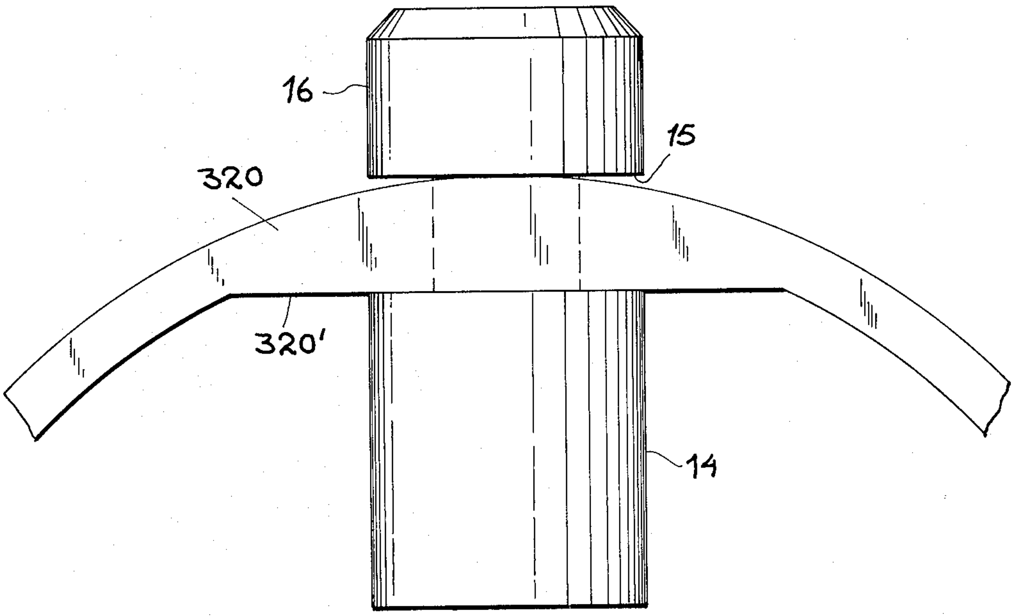

Fig. 7

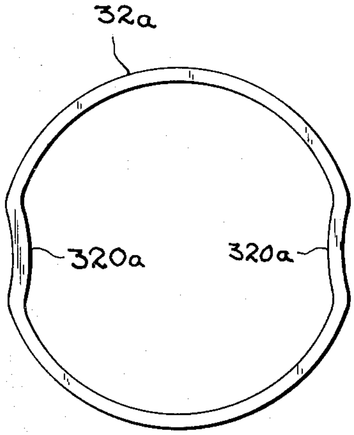

Fig. 8

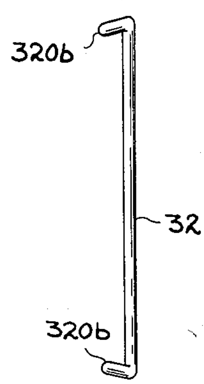

Fig. 9

HANS ERDMANN
INVENTOR.

BY Mestern, R... & Mestern

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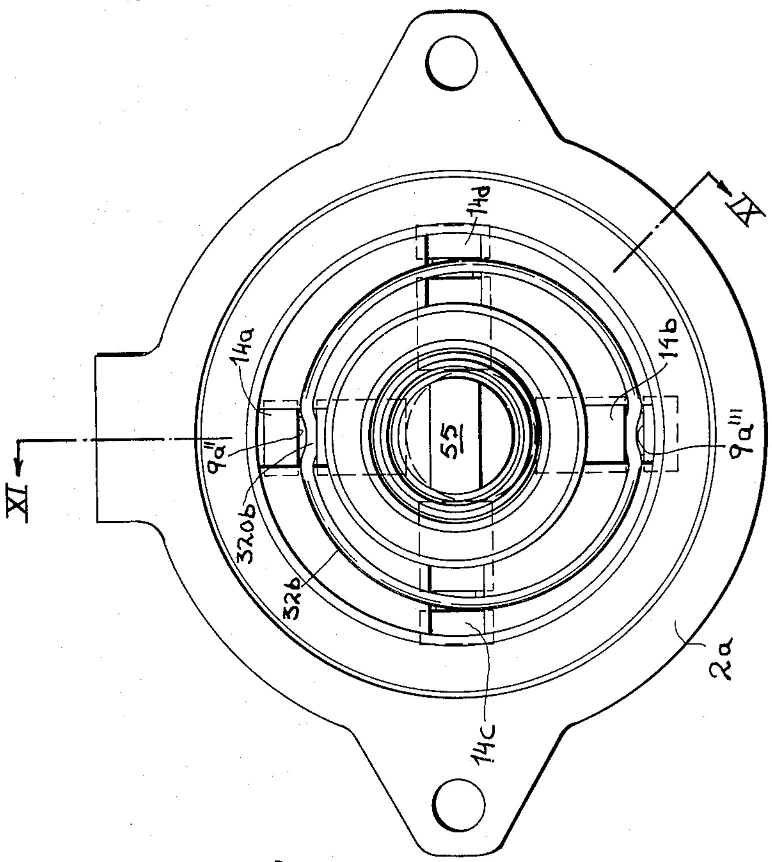

Fig.10

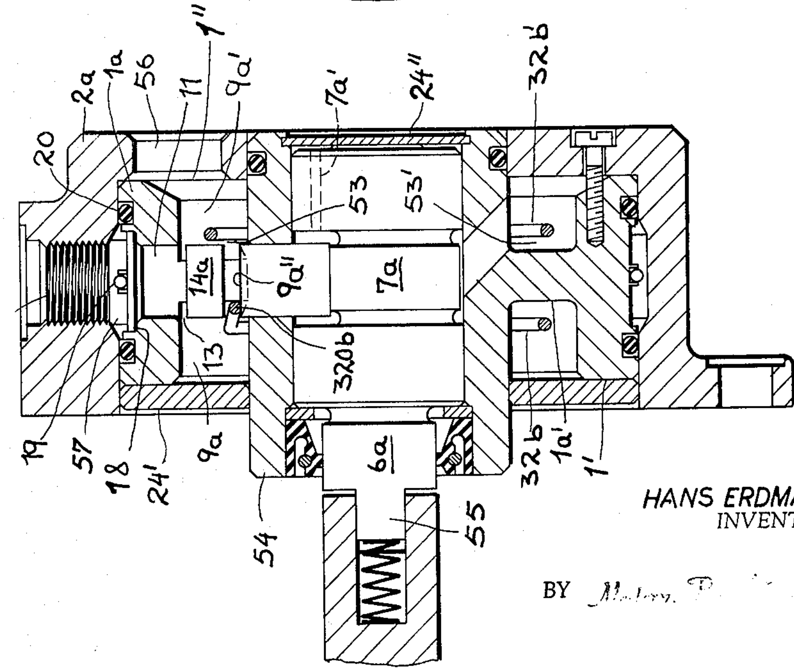

Fig.11

HANS ERDMANN
INVENTOR.

BY

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Patented July 5, 1966

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RADIAL-PISTON MACHINES

Hans Erdmann, Frankfurt am Main, Germany, assignor to Alfred Teves Maschinen- und Armaturenfabrik Kommandit-Gesellschaft, Frankfurt am Main, Germany, a corporation of Germany

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Claims priority, application Germany, Feb. 16, 1963, T 23,484, T 23,485
12 Claims. (Cl. 103—174)

My present invention relates to radial-piston machines and, more particularly, to radial-piston pumps and the like wherein at least one and preferably a plurality of radially reciprocable pistons are operated by an eccentric shaft in order to displace a fluid.

Heretofore, radial-piston pumps of the character described comprised cylindrical sleeves, which were received in bores provided in a cylinder block, adapted to house the pistons which were radially reciprocable within these sleeves. For the most part, the flow of fluid to and from the cylinder bores provided by the sleeves was controlled by means of slits or other openings formed in the sleeves and co-operating with means for selectively admitting fluid to the bores and presenting reverse flow of the fluid. In order to permit the fluid to pass through these openings, it was necessary to provide further bores in the cylinder block which were in alignment with the openings in the sleeves. Since exact alignment of the two sets of openings was essential, the production of pumps of this nature was relatively costly and time consuming. Additionally, such pumps were frequently provided with means linking two or more pistons for joint reciprocation, such means including slide blocks co-operating with the pistons so that, when one of the interconnected pistons is subjected to a compression stroke, another piston or other pistons are engaged in the fluid-charging stroke. Such slide blocks or glides on the tie rings are costly and the blocks are, moreover, subject to considerable wear and are capable of giving rise to many servicing problems.

It is the principal object of the present invention, therefore, to provide an improved radial-piston machine, such as a pump or motor, of relatively simple and inexpensive construction.

A further object of this invention is to provide an improved radial-piston pump having the characteristics of low wear, ease of servicing, and all-around high efficiency in operation.

These objects, and others which will become apparent hereinafter, will be attained, in accordance with the present invention, by providing a radial-piston machine (e.g. a pump adapted to displace a fluid medium or a motor operable by such medium) which comprises a housing having an axially extending cavity in which generally annular cylinder-block means is disposed, this cylinder-block means being provided with at least one circumferential groove and at least one axially extending groove, both open in the direction of the housing means, which define with the walls of this cavity a first channel lying generally in a plane transverse to the axis of the housing means and cylinder-block means as well as a second channel spaced from the first channel. Fuid-inlet and fluid-outlet means can then be provided in either the housing means or the cylinder-block, although preferably in the latter, so as to communicate with the aforementioned grooves and thereby deliver fluid medium to or remove it from the first and second channels. The cylinder-block means can then be provided with at least two angularly spaced, generally radial cylinder bores lying substantially in the plane of the first-mentioned groove with the cylinder bores communicating with both said channels. A radially reciprocable piston is then slidably disposed in

each of the bores and cooperates with an eccentric shaft rotatable coaxially with the cylinder-block means and disposed therein for operation by the fluid-pressure differential across the pistons when the machine is a motor and for compressing fluid when it operates as a pump. The eccentric shaft, which is in force-transmitting relationship with the pistons, can be rotated by a drive element (e.g. a further shaft) connectable to the eccentric shaft internally or externally of the housing means.

According to a more specific feature of this invention, each of the pistons is provided with an outwardly open circumferential recess lying in a respective plane transverse to the respective cylinder bore, two or more of the pistons being interconnected for joint movement by a coupling ring lying generally in a plane perpendicular to the axis of the housing and the cylinder-block and disposed in the axially extending second channel mentioned above; the coupling ring is then received in the recesses of the pistons interconnected thereby and oscillates slightly to effect the joint movement of the pistons. It has also been found desirable, in some circumstances, to provide two sets of jointly movable pistons with these circumferential recesses so that two coupling rings, of the character described, can be disposed on axially opposite sides of the pistons for respective engagement with the sets thereof.

I have found that a radial-piston pump of the type referred to above can efficiently include respective unidirectional valve means at the junction of each cylinder bore with the circumferential channel for admitting fluid medium from the bores to this channel under the pressure of the pistons. The valve means thus can include a radially movable plate in annular contact with a valve seat formed by the cylinder-block around a respective cylinder bore and an annular resilient member, e.g. an endless coil spring, disposed in the peripheral groove in the cylinder block and urging all of the valve plates radially inwardly.

The central cylinder passage of the cylinder-block means can be of substantially uniform cross-section for receiving the eccentric shaft which may have an eccentric intermediate portion radially aligned with the pistons and a pair of bearing portions axially offset from the intermediate portion on opposite sides thereof. These bearing portions, which can be of a diameter proximal to that of the passage, are rotatably mounted in this passage so as to support the eccentric. It has been found that excellent results are obtained when, by virtue of the uniform diameter of the passage, the shaft is axially shiftable in the passage and the cylinder-block means is provided with an abutment, e.g. a plate closing one end of the passage, for limiting axial displacement of the shaft, resilient means being provided for urging the shaft axially into engagement with the abutment means. To lubricate the contact between the shaft and the abutment and to prevent unidirectional loading of the shaft by hydraulic pressure, a small passage can interconnect the opposite sides of the bearing portion of the shaft engaging the abutment so as to conduct oil or the fluid medium to a compartment formed between the shaft and the abutment means. The resilient means can be a spring bearing axially on the eccentric shaft and urging it away from the dry element to which the eccentric shaft is connectable. In general, the housing means should be provided with a wall extending perpendicular to its axis for defining the second channel together with the axially extending groove of the cylinder-block means. This wall can be integral with a sleeve portion of the housing means surrounding the cylinder block or provided as a separate cover plate removably connectable with the housing. According to a more specific feature of this invention, the cylinder block can project axially, at least partly, through the plate. The coupling ring or rings interconnecting the pistons of each set can, moreover, be provided with angularly spaced enlargements received in the annular recesses of the pistons or with angularly spaced projections extending transversely to the plane of the ring for engagement with the recesses.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a transverse cross-sectional view through a radial-piston pump, according to the invention, exposing the interior thereof through the fluid-inlet channel;

FIG. 2 is a cross-sectional view taken along the line II—II of FIG. 1;

FIG. 3 is a cross-sectional view taken along the line III—III of FIG. 1;

FIG. 4 is a cross-sectional view taken along the line IV—IV of FIG. 2;

FIG. 5 is a view similar to FIG. 4 of a modification of the pump-valve structure;

FIG. 6 is a cross-sectional view taken along the line VI—VI of FIG. 5;

FIG. 7 is a detail-view, drawn to an enlarged scale, of the piston assembly of the pump of FIGS. 1 and 2;

FIG. 8 is a plan view of a coupling or tie ring adapted to be used in conjunction with the pump of FIGS. 1 and 2;

FIG. 9 is a side-elevational view of another tie ring;

FIG. 10 is an end view of a modified pump with its cover plate removed; and

FIG. 11 is a cross-sectional view taken along the line XI—XI of FIG. 10;

In FIGS. 1 and 2 I show a multiple-piston pump incorporating my invention. An annular cylinder block **1**, having a front face **1'** and a rear face **1''**, is receivable in a housing **2** which is open on one side. Block **1** incorporates an axially extending main passage **3** running from face **1'** to face **1''** transversely thereto; another passage aligned with that in block **1**, is provided in housing **2**. From an annular groove **4** in the circumference of block **1** a plurality of cylinder bores **5** (one shown) extend inwardly and intersect bore **3**. A shaft **6**, having an intermediate eccentric portion **7**, is so received within bore **3** that the eccentric portion is rotatably positioned in the chamber **8** created at the intersection of bores **3** and **5** and is coplanar with the pistons. An axially extending second groove **9** is provided in the front face **1'** of block **1** and communicates with fluid-intake **10**. Together with housing **2**, groove **9** defines a fluid channel **11** which communicates with the compression manifold **12** via the opening **13**, permitting the flow of fluid into the manifold. A piston **14**, having an annular recess **15** below the piston head **16**, is slidably received within the bore **5**. A unidirectional check valve **17** rests on annular valve seats **18, 18'** along circumference of block **1** and is maintained in closed position by a spring **19** which is held between the ridges **19'**. A gasket **20** seals the junction of block **1** and housing **2** and prevents an escape of fluid. Annular notch **4**, together with housing **2**, forms a pressure chamber **21** into which valve **17** opens; in turn this pressure chamber communicates with outlet **22** through a channel **23**. Bore **3** is closed off at rear face **1''** with a cap **24** which serves the purpose of limiting the axial movement of shaft **6** by the force of spring **6''**. Block **1** and housing **2** are joined by a plurality of screws **26**, sealed with O-rings **26'** and the shaft **6**, which is supported by bearing portions **27, 27'**, is provided with a sealing collar **28** against leakage of fluid. A blind bore **29** in the projecting end of shaft **6** has axially extending splines **30** and is adapted to receive a splined drive shaft **6''** having complementary serrations to permit relative axial displacement of shaft **6**. The tie ring **32**, finally, is rotatably received in the second channnel **9**, where it is held against axial movement by retaining ring **31** and serves to couple the pistons of the pump for joint operation by engaging the annular recesses **15** of pistons **14** (one each shown) with its formations **320** (see FIGS. 2 and 7).

Upward movement of the piston **14** under the pushing action of eccentric **7** causes the fluid present in the corresponding cylinder bore to be displaced and to be ejected under pressure through the valve **17** into the pressure chamber **21**, from where it travels to the outlet **22**. The tie ring **32**, in its eccentric rotation slides slightly in the piston recesses **15** and forces the piston **14** to travel downwardly. The pressure reduction in manifold **12** causes fluid from the conduit **11** to flow into the manifold through the opening **13** and the process is repeated. It must be remembered here, of course, that the pistons are connected for joint movement by the coupling ring **32**.

FIG. 2 illustrates this point more clearly. Four pistons **14** are shown to be arranged symmetrically within block **1** and to have recesses **15** below the heads **16**. Eccentric **7** is positioned on shaft **6** and is rotatable in a plane with the pistons' longitudinal axes. The tie ring **32** is received in groove **9** of the front face **1'** and is secured there by retaining ring **31**. The inner diameter of tie ring **32** is decreased at spaced locations by the projections **320** (FIG. 7) whose undersides **320'** engage the recesses **15**. Movement of any given pistons thus will cause slightly eccentric movement of the tie ring **32** and the resulting travel of formations **320** through the recesses **15** will, in turn, coordinate the movements of the remaining pistons with those of the first. The valve is held radially inwardly by the endless coil spring **19**. FIGS. 5 and 6 show a valve arrangement wherein the plate valve **17*a*** is held resiliently against displacement by undulating band **19*a***.

FIG. 8 is a detailed view of a ring **32*a*** in an alternate construction. The guide formations **320*a*** in this embodiment are here created by concave deformation of the ring in the direction of its axis at spaced locations. Furthermore, unlike the ring shown in FIGS. 2 and 7, this embodiment comprises only two guide formations **320*a*** and is therefore suitable for the coordination of two pistons only.

Still another modification of the tie ring is shown in FIG. 9, where the peripheral portions of the ring are bent at spaced locations **320*b*** at an angle substantially transverse to the ring's plane and are inclined toward its axis. This construction is particularly useful where it is desirable to have the body of the ring itself remain outside the piston head recess **15**, that is, in cases where different combinations of pistons are to be linked and consequently more than one ring is being used.

In FIG. 7 I show a detail of the piston **14** having its recess **15** below the piston head **16**. The ring **32** engages recess **15** with guide face **320'** of its formation **320** and during its eccentric rotation causes the piston to oscillate in a rhythm determined by the speed of the ring's oscillation and the number and location of formations **320**. A modification of the pump in FIGS. 1 and 2 is shown in FIGS. 10 and 11. The cylinder block **1** in this case is provided with not one, but two axial grooves **9*a*, 9*a'*** in faces **1'** and **1''**, respectively. Two tie rings **32, 32'** are housed in the channels defined by the respective grooves and are adapted to rotate somewhat therein, as illustrated in FIG. 11. Housing **2** is closed on one side by a cap **24** through which flange **54**, integral with face **1*a'*** of block **1*a***, projects. The shaft **6*a***, carrying the eccentric **7*a***, is adapted for coupling to a drive shaft at the formation **55**. Fluid intake **56** and pressure chamber **57** in this modification are partly defined by the housing **2*a***.

As evident from FIG. 11 the tie rings **32*b*, 32*b*** in this case are designed each to control the operation of a respective set of pistons. The rings shown are those of the embodiment of FIG. 9. It will be understood from FIGS. 10 and 11 that the guide formations **320*b*** on both rings may be angularly staggered relative one to another, that is, while ring **32*b*** operates, say, pistons **14*a*** and

14*b*, ring 32′ may actuate pistons 14*c* and 14*d*. The advantage of this arrangement is the ability to balance the cycle of operation more precisely and to achieve a smoother run. It is clear, of course, that each ring must be so offset from the recesses 9*a*, 9*a′* of the pair of pistons not assigned to it by the angled guide formations 320*b* at the points 53, 53′ as to prevent the formations 320*b* from engaging these and from interfering with their proper regulation by the other ring. The cylinder block 1*a* extends axially through the cover plate 24′ of housing 2*a* while the shaft 6*a* is axially displaced and is held by a spring against the abutment plate 24′. In both embodiments an oil-leak passage is provided (7*a′*) to lubricate the abutment.

The invention described and illustrated is believed to admit of many modifications within the ability of persons skilled in the art, all such modifications being considered within the spirit and scope of the appended claims.

I claim:

1. A radial-piston machine comprising:
housing means having an axis and provided with an axially extending cavity;
cylinder-block means received within said cavity and defining with said housing means an annular first channel lying generally in a plane transverse to said axis and an axially extending second channel spaced from said first channel;
fluid-inlet means and fluid-outlet means formed in at least one of said cylinder-block means and said housing means, each of said fluid-inlet means and said fluid-outlet means communicating with a respective one of said channels;
an eccentric shaft journaled in said cylinder-block means, said cylinder-block means being provided with at least two angularly spaced generally radial cylinder bores lying substantially in said plane and communicating with said channels at spaced locations along said bores;
a radially reciprocable piston slidably disposed in each of said bores and in force-transmitting relationship with said eccentric shaft; and
respective unidirectional valve means at the junction of each of said cylinder bores with said first channel for admitting said fluid medium from said bores to said first channel under the pressure of said pistons, each of said valve means including a respective valve seat surrounding each of said bores; a respective radially movable plate in annular contact with said cylinder-block means around the respective cylinder bore at the respective valve seat, said pump further comprising an annular resilient member surrounding said cylinder-block means and urging both said plates radially inwardly.

2. A radial-piston pump comprising:
housing means having an axis and provided with an axially extending generally cylindrical cavity;
elongated cylindrical tubular cylinder-block means received within said cavity and provided with a peripheral groove and with an axially extending groove at one end of said cylinder-block means, said grooves opening toward said housing means and respectively defining therewith an annular first channel lying generally in a plane transverse to said axis and an axially extending second channel spaced from said first channel;
fluid-inlet means and fluid-outleet means formed in said cylinder-block means, and communicating with said second and first channels, respectively;
an eccentric shaft journaled in said cylinder-block means, said cylinder-block means being provided with at least two angularly spaced geenrally radial cylinder bores lying substantially in said plane and communicating with said channels at spaced locations along said bores;
a radially reciprocable piston slidably disposed in each of said bores and in force-transmitting relationship with said eccentric shaft for reciprocation thereby, said pistons each being provided with an outwardly open circumferential recess lying in a respective plane transverse to the respective cylinder bore;
a coupling ring lying generally in a plane perpendicular to said axis and disposed in said second channel while being received in both said recesses for connecting said pistons for joint movement in said bores;
a pair of axially-spaced annular sealing members bearing upon said cylinder-block means and said housing means in all-around contact on opposite axial sides of said first channel; and respective unidirectional valve means at the junction of each of said cylinder bores with said first channel for admitting said fluid medium from said bores to said first channel under the pressure of said pistons, each of said valve means including a respective valve seat surrounding each of said bores, a respective radially movable plate in annular contact with said cylinder-block means around the respective cylinder bore at the respective valve seat, said pump further comprising an annular resilient member surrounding said cylinder-block means and disposed in said peripheral groove while urging both said plates radially inwardly.

3. A radial-piston pump as defined in claim 2 wherein said member is an endless helical spring, said cylinder-block means comprising a pair of axially spaced ridges in said peripheral groove maintaining said spring in engagement with said plates.

4. A radial-piston pump as defined in claim 2 wherein said cylinder-block means is provided with an axially extending central cylindrical passage of uniform cross-section receiving said shaft, said shaft comprising an eccentric intermediate portion of relatively small diameter radially aligned with said pistons and a pair of bearing portions of relatively large diameter axially offset from said intermediate portion on opposite sides thereof and rotatable in said passage while being of a diameter close to that of said passage.

5. A radial-piston pump as defined in claim 4 wherein said shaft is axially shiftable in said passage, said cylinder-block means being provided with abutment means at one end of said passage for limiting axial displacement of said shaft, said passage being open axially at its opposite end, said pump being further provided with resilient means urging said shaft axially into engagement with said abutment means.

6. A radial-piston pump as defined in claim 5 wherein said abutment means is a plate received in said passage and said shaft is provided with an opening at said opposite end of said passage for receiving a drive element, said shaft being formed with engagement means in said opening for rotatably interconnecting said shaft and said element, said resilient means including a spring mounted in said opening and bearing axially upon said element.

7. A radial-piston pump as defined in claim 2 wherein said housing means includes a sleeve portion surrounding said cylinder-block means and at least one annular end plate connected to said sleeve portion and defining said second channel with said cylinder-block means, said end plate extending perpendicularly to said axis and said cylinder-block means at least partly projecting axially through said end plate.

8. A radial-piston pump as defined in claim 2, further comprising means for retaining said ring in said recesses.

9. A radial-piston pump as defined in claim 2 wherein said ring is provided with angularly spaced enlargements received in said recesses.

10. A radial-piston pump as defined in claim 2 wherein said ring is provided with angularly spaced portions projecting transversely to the plane of said ring and engaging said recesses.

11. A radial-piston pump comprising:

housing means having an axis and provided with an axially extending generally cylindrical cavity;

elongated cylindrical tubular cylinder-block means received within said cavity and provided with a peripheral groove and with an axially extending groove, said grooves opening toward said housing means and respectively defining therewith an annular first channel lying generally in a plane transverse to said axis and an axially extending second channel spaced from said first channel;

fluid-inlet means and fluid-outlet means formed in said cylinder-block means, and communicating with said second and first channels, respectively;

an eccentric shaft journaled in said cylinder-block means, said cylinder block means being provided with at least two pairs of angularly spaced generally radial cylinder bores lying substantially in said plane and communicating with said channels at spaced locations along said bores;

a radially reciprocable piston slidably disposed in each of said bores and in force-transmitting relationship with said eccentric shaft for reciprocation thereby, said pistons each being provided with an outwardly open circumferential recess lying in a respective plane transverse to the respective cylinder bore;

a pair of coupling rings lying generally in respective planes perpendicular to said axis and disposed in said second channel on opposite sides of said bores while being received in both said recesses of the pistons of each pair, respectively, for joint movement of each pair of pistons in said bores;

a pair of axially-spaced annular sealing members bearing upon said cylinder-block means and said housing means in all-around contact on opposite axial sides of said first channel; and

respective unidirectional valve means at the junction of each of said cylinder bores with said first channel for admitting said fluid medium from said bores to said first channel under the pressure of said pistons, each of said valve means including a respective valve seat surrounding each of said bores, a respective radially movable plate in annular contact with said cylinder-block means around the respective cylinder bore at the respective valve seat, said pump further comprising an annullar resilient member surrounding said cylinder-block means and disposed in said peripheral groove while urging both said plates radially inwardly.

12. A radial-piston machine comprising:

housing means having an axis and provided with an axially extending cavity;

cylinder-block means received within said cavity and defining with said housing means an annular first channel lying generally in a plane transverse to said axis and an axially extending second channel spaced from said first channel;

fluid-inlet means and fluid-outlet means formed in at least one of said cylinder-block means and said housing means, each of said fluid-inlet means and said fluid-outlet means communicating with a respective one of said channels;

an eccentric shaft journaled in said cylinder-block means, said cylinder block means being provided with at least two angularly spaced generally radial cylinder bores lying substantially in said plane and communicating with said channels at spaced locations along said bores;

a radially reciprocable piston slidably disposed in each of said bores and in force-transmitting relationship with said eccentric shaft, said cylinder-block means being provided with an axially extending cylindrical passage of uniform cross-section receiving said shaft, said shaft comprising an eccentric intermediate portion of relatively small diameter radially aligned with said pistons and a pair of bearing portions of relatively large diameter axially offset from said intermediate portion on opposite sides thereof and rotatable in said passage, said shaft being axially shiftable in said passage;

abutment means at one end of said passage for limiting axial displacement of said shaft; and

resilient means bearing upon said shaft for urging same axially into engagement with said abutment means, said coupling ring being provided with angularly spaced enlargements received in said recesses.

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DONLEY J. STOCKING, *Examiner.*

R. M. VARGO, *Assistant Examiner.*