Nov. 24, 1964 O. F. A. BIGINELLI 3,158,035

MULTI-BANK RADIAL TYPE MACHINE

Filed Sept. 9, 1960 2 Sheets-Sheet 1

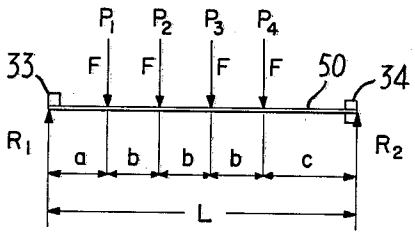

FIG. 1

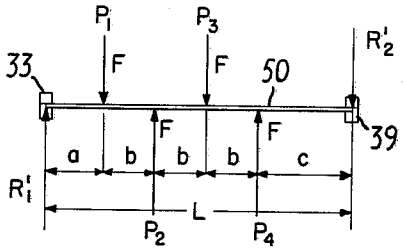

FIG. 2

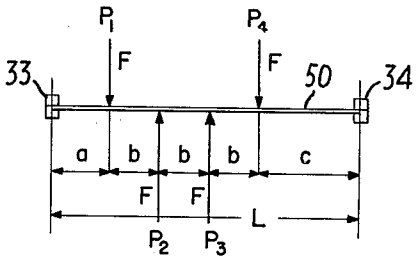

FIG. 3

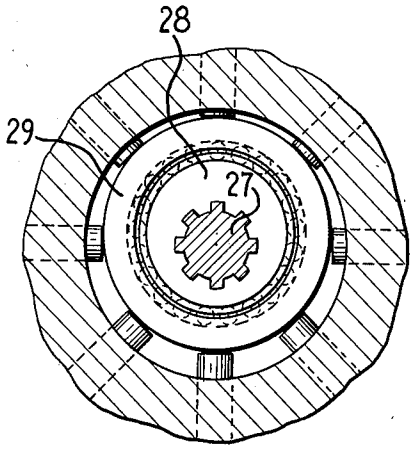

FIG. 5

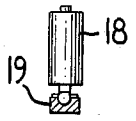

FIG. 6

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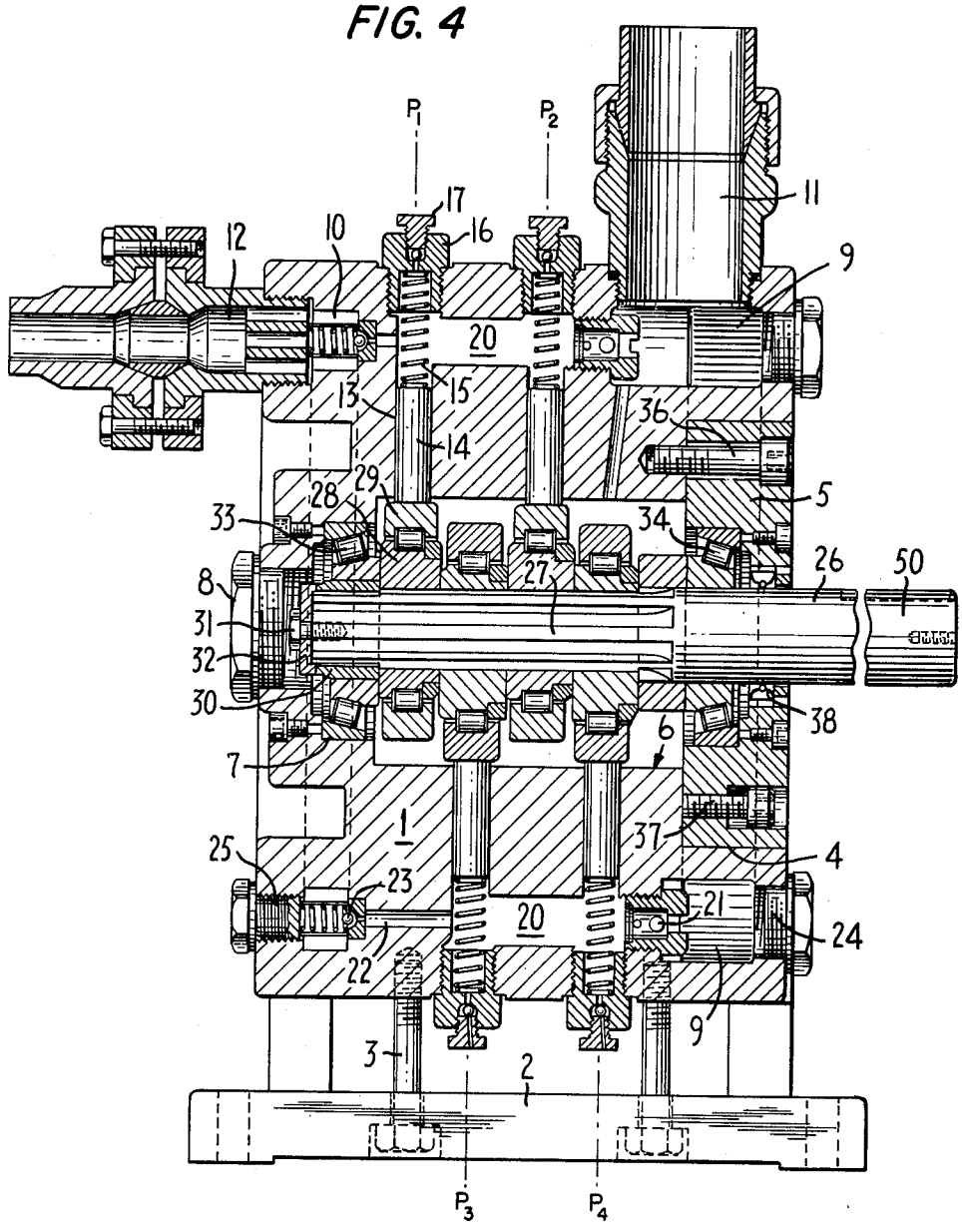
FIG. 4



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MULTI-BANK RADIAL TYPE MACHINE

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2 Claims. (Cl. 74—49)

Piston machines are already known, in which the pistons are actuated by an eccentric mounted on the shaft, the rotation movement of this shaft causing the rise and fall of the pistons by rotation of the eccentric.

In the case where the machine drives, the thrust of the pistons caused by the driving fluid effects the rotation of the shaft by acting on the eccentric.

In these known machines such as pumps, the shaft is generally formed as a crankshaft, and comprises a cylindrical part off-centered in relation to the rotation axis. Roller bearings are mounted on this off-centered part. Their external cages control the clearance in the radial direction of the pistons of the pump.

In pumps of this type with a considerable delivery, we are obliged to arrange the cylinders and pistons radially in several planes parallel banks perpendicular to the axis of the shaft. The single eccentric device then has the disadvantage that the pistons on one side of the shaft, at the moment of the compression stage, have a component action of the same radial direction on the shaft, the pistons on the other side are at the intake stage and have a zero component action on the shaft. Thus, the bearings receive the whole of the load due to half the pistons.

The present invention has more particularly the object of effecting an improved arrangement of the pistons and shaft of a multi-cylinder bank, radial type piston machine, the pistons of the various cylinder banks being placed in opposition so that the reaction forces of the pistons and shaft divide up into two groups of equal power, but opposed.

The invention enables the reduction, to a great extent, of the reaction support of the shaft by these bearings, and hence, to ensure longer and more efficient service of the bearings, particularly in the case of intensive use.

The invention possesses the advantage of being adaptable to any radial type of multiple bank piston machine. The invention especially relates to a machine in which a simple and efficient means of effecting the arrangement comprises roller bearings or ball bearings with an off-centered bore slipping on to the shaft with which they are rotatively integral, this arrangement affording an easy and speedy assembly of the machine.

Another advantage of the invention is the rotational integralization of the bearings and shaft ensured by longitudinal flutings or grooves of the shaft cooperating with complementary flutings provided in the off-centered internal ring of the bearings, enabling each bearing playing the part of eccentric to be fitted with any kind of orientation, without causing any difficulty in fitting. The grooves extend axially along a portion of a drive shaft and the bearings having an inner bore with projections extending radially inwardly for driving the bearings from the shaft. Moreover, the bearings can be slipped on or off the shaft at one end as described hereinafter.

The arrangement and the radial type multi-cylinder bank piston machine of the invention are shown, by way of example, in the particular application to a pump in the attached drawings, in which:

FIGURE 1 is a diagram showing the arrangement of the forces acting on the shaft and the reactions of support of the shaft in its bearings in the case of a single-eccentric pump.

FIGURES 2 and 3 show the arrangement of the forces acting on the shaft and the reactions of support of the shaft in its bearings according to two examples of application of the invention.

FIGURE 4 shows, in axial section, a pump in which the invention is incorporated.

FIGURE 5 shows a sectional elevation of the shaft and the arrangement of pistons around the eccentric.

FIGURE 6 shows an embodiment of the piston and its drive on the eccentric.

In the known single-eccentric pumps, we have stated that the bearings receive the whole of the load due to half of the pistons in their cylinders. In this case, the shaft 50 is subjected in the hypothesis of pistons of four cylinder banks to forces F separated by a distance b corresponding to the distance between the cylinder banks $P_1P_2P_3P_4$. The reactions of support of the shaft 50 on the bearings 33 and 34 are repsectively shown by the arrows R_1 and R_2; the distance between the bearing 33 and the force F of pistons of the first cylinder bank is denoted by a; the distance between the bearing 34 and the force F of pistons of the last cylinder bank is denoted by C. The total distance between the bearings 33 and 34 is denoted by L.

In these conditions, the computation of the reactions on the bearings gives:

$$R_1=\frac{2F(2c+3b)}{L}$$

$$R_2=\frac{2F(2a+3b)}{L}$$

We see that the reactions on the bearings are very considerable.

To obviate this disadvantage, according to the invention, an individual eccentric is used for each cylinder bank for putting the pistons of one cylinder bank, for example, successively in opposition to the pistons of the other cylinder bank.

In these conditions, FIGURE 2 shows the arrangement of the forces acting on the shaft 50 and the reactions of support of the shaft in its bearings 33 and 34.

The forces F acting on the shaft 50 of these the pistons of cylinders P_1 and P_3 are in opposition with the forces F acting on the shaft 50 due to the pistons of cylinder banks P_2 and P_4.

In these conditions, the computations of the reactions R'_1 and R'_2 on the bearings 33 and 34 give:

$$R'_1=-R'_2=\frac{2Fb}{L}$$

By considering that the value of the distance between the centers a and c is generally greater than that of the distance b, we see that the reactions R' have values at the most equal to ⅕ of the reactions R_1 and R_2 (the case of FIGURE 1).

It is also easy to see that the device according to diagram 1 involves a greater force exerted on the shaft to deflect it than in the device according to diagram 2.

Obviously, we can modify the arrangement of FIG. 2 without going outside of the scope of the invention for this purpose, by opposing the forces in pairs acting on the shaft 50. For example, FIGURE 3 shows an arrangement in which the reactions on the bearings 33 and 34 are zero.

The arrangement according to the invention and in particular that of FIGURES 2 and 3 thus enables the reducing of the forces on the bearings to ensure a more efficient use of the bearings.

In actual practice, the making of multiple eccentrics encounters difficulties. In particular, the machining of the shaft into a multi-eccentric crankshaft reveals a fitting

difficulty if it is required to retain the simple device of roller bearings as intermediary for the transmission of the eccentric movement to the pistons.

The machine according to the invention eliminates the above-mentioned difficulty by effecting an arrangement of the shaft and removable roller bearings controlling the pistons which enables various orientations of the eccentrics to be obtained from one cylinder bank to another, by means of a possible and easy fitting.

The principle of this device is as follows:

The shaft **50** of the machine does not comprise any eccentric, but a cylindrical part with longitudinal flutings. The various roller bearings corresponding to each cylinder bank are fitted on to this part of the shaft. These bearings have an internal ring whose bore is off-centered and machined into complementary shapes for engaging the flutings on the shaft. The internal ring is thus keyed on to the shaft and in the rotation movement of the shaft acts as an eccentric. Each bearing can thus be fitted with any kind of orientation of the eccentric, without any fitting difficulty arising therefrom.

In the machine, such as the pump shown in FIGURE 4, the pistons are arranged in four cylinder banks marked $P_1P_2P_3P_4$ in accordance with the structure of FIGURE 2.

In each cylinder banks, eight cylinders and thin pistons are arranged radially around the shaft **50** spaced 45° from each other.

The pump is formed by a special cast-iron body **1** of general cylindrical shape with horizontal axis mounted on a stand **2**, to which it is attached by bolts **3**. The body is bored successively along its axis at **4** for receiving the side plate **5** supporting the bearing on the drive side, at **6** for housing eccentrics fitted on the shaft **50** and at **7** for receiving the roller bearing on the opposite side to the drive. A screw plug **8** closes the end of the bore and is provided for facilitating disassembly. Two circular channels **9** and **10** are respectively reserved in the body at each end of the cylinder. The channel **9** acts as intake collector. The inlet nozzle **11** connected with the supply tank emerges in this collector. The channel **10** acts as delivery collector. The outlet nozzle **12** emerges in this collector. The four cylinder banks $P_1P_2P_3P_4$ normal to the axis, are each formed by eight radial borings, such as **13**, at angular intervals of 45°. This radial arrangement coincides in the cylinder banks P_1, P_3 on the one hand, and in the cylinder banks P_2, P_4 on the other.

For smoother running of the machine the pairs of cylinder banks can be staggered for

$$\frac{360°}{2n}$$

n being the number of cylinders, i.e., for 22°30′ in the case of FIGURE 4 with eight cylinders and pistons in each of the cylinder banks P_1, P_3 and P_2, P_4. FIGURE 4 exactly shows an upper half-section staggered by 22°30′ in relation to the lower half-section. In each of the bores **13** cylindrical pistons such as **14** can slide radially thrust towards the axis of the pump by a spring **15**, bearing, on the outer side, on a hollow plug **16** fitted with a ball air cock **17**. FIGURE 6 shows, as an alternative, a piston **18** provided with a swivel head **19**.

Each radial bore or cylinder **13** of the bank P_1 is connected with the corresponding radial bore of the bank P_3 by an aperture **20** drilled in the body normal to said bores of cylinders. This also applies to the radial bores of the cylinder banks P_2 and P_4. All these drillings emerge in the suction channel **9** and on this side are all fitted with suction valves **21**. On the opposite side, these drillings emerge in the delivery channel **10** through a smaller diameter hole **22**, which is provided with a delivery valve **23** at its end. Screw plugs **24** and **25** respectively afford access to the suction and delivery valves.

The driving shaft **50** comprises a cylindrical part **26** for coupling with the motor and a smaller diameter part **27** having longitudinal flutings. On this part of the shaft

(FIGURE 5) four roller bearings are slipped whose internal rings **28** are eccentrically bored and machined in this bore in the shape complementary to the flutings of the shaft **27**. By this means these internal rings are keyed on to the shaft and communicate an eccentric movement to the external cages **29**. The internal rings are successively fitted on in such manner that the eccentricity direction is in opposition alternately at 180° from each other. They are kept in position on the shaft by locking, on one side, between the shoulder due to the difference in diameter of the parts **26** and **27** of the shaft, and on the other, a ring **30** secured by the screw **31** and small plate **32**.

The shaft **50** is carried by two tapered roller bearings **33** and **34** mounted in opposition while forming plummer-blocks. The bearing **33** is mounted in the bore **7** of the body. The other bearing **34** is mounted in a side plate **5** housed in the bore **4** of the body and comprising fixing members (screw **36**) for adjustment (screw **37**) and fluid-tightness (ring **38**).

The shaft unit **50** and eccentric bearings together are so fitted that a bearing is arranged in alignment with the pistons of each of the cylinder banks $P_1P_2P_3$ and P4.

The machine thus made enables, in addition to the other advantages afforded by the invention, an easy and speedy assembly and disassembly of the control members formed by the shaft **50** and its bearings.

What I claim is:

1. In a machine having a plurality of cylinders and pistons reciprocable therein, said cylinders being arranged in separate planes, each plane having a plurality of cylinders arranged angularly disposed therein, the improvement which comprises means for reciprocably actuating said pistons and for balancing the reaction forces of said pistons, the last mentioned means comprising a driven shaft rotatably mounted, said shaft having a plurality of substantially linear, elongated, axially extending grooves disposed substantially parallel and angularly spaced in a circumferential direction thereon and terminating at one end of said shaft, a plurality of removable bearings having outer peripheral surfaces for reciprocably driving said pistons, said bearings having an inner bore having projections for complementary fitting into said grooves for rotatably driving said bearings with said shaft, said bearings being mountable on said shaft over said end of said shaft and slipped off therefrom, disposed in operation axially on said shaft with one bearing in each of said planes, said planes being disposed axially along said shaft, each passing through a respective bearing, said cylinders being further arranged and said bearings having their bores eccentric each in a direction for displacing the pistons radially in alternate ones of said planes in opposite directions to cause the reaction forces of one of said planes to compensate by opposite reaction forces generated in a next adjacent plane.

2. In a machine having a plurality of cylinders and pistons reciprocably therein, said cylinders being arranged in separate planes, each plane having a plurality of cylinders arranged angularly disposed therein, the improvement which comprises means for reciprocably actuating said pistons and for balancing the reaction forces of said pistons, the last mentioned means comprising a driven shaft rotatably mounted, said shaft havin a plurality of substantially linear, elongated, axially extending grooves disposed substantially parallel and angularly spaced in a circumferential direction thereon and terminating at one end of said shaft, a plurality of removable bearings having outer peripheral surfaces for reciprocably driving said pistons, said bearings having an inner bore having projections for complementary fitting into said grooves for rotatably driving said bearings with said shaft, said bearings being mountable on said shaft over said end of said shaft and slipped off therefrom, disposed in operation axially on said shaft with one bearing in each of said planes, said planes being disposed axially along said shaft, each passing through a respective bearing, said

cylinders being further arranged and said bearings having their bores eccentric each in a direction for displacing the pistons radially in one of two groups in opposite directions to cause the reaction forces of one of said groups of pistons to compensate by opposite reaction forces generated in the other of said groups of pistons.

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