July 8, 1947. G. W. HARDY 2,423,701

PUMP

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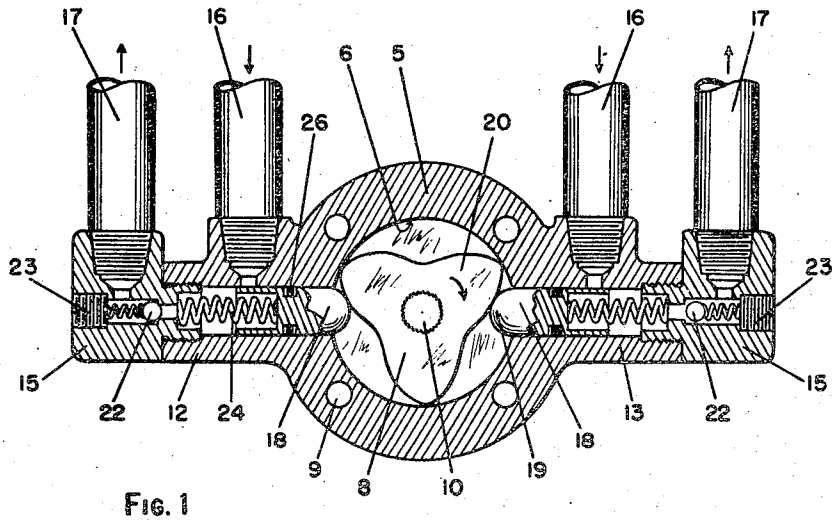

FIG. 1

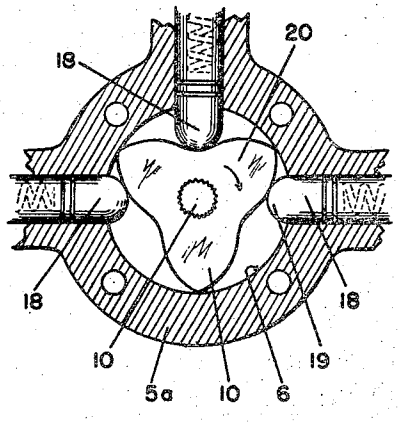

FIG. 2

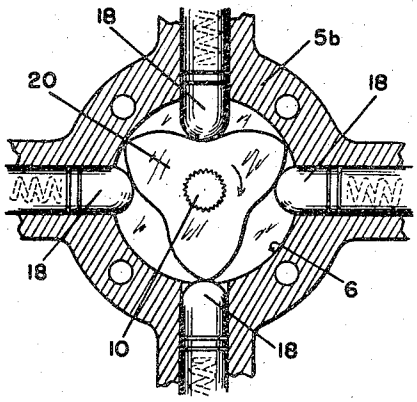

FIG. 3

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This invention relates to an improved pump mechanism of the type in which a plurality of pump pistons are driven by a single rotating driver member.

Mechanisms of this type are known in the art but have been subject to certain disadvantages. This has been particularly true in recent years and in the aircraft field. Pumps of this class as commonly used have not made efficient use of the driving power applied to the pump to reciprocate the pistons. This lack of efficiency is present in that known type of pump embodying one or more sets of opposed pistons driven by an eccentric or single crank which affords only one stroke per piston per revolution. Such pumps may have several pistons among which the peak driving power is divided at one time but this construction results in a proportionate increase in weight and driving power as the capacity is increased.

The present pump embodies a simplified construction by which a maximum volume of fluid is pumped with a construction of minimum weight; thus providing a compact unit for aircraft use where weight and volume are at a premium. A single driving cam with several lobes engages pump pistons in succession to effect the pumping action. The pistons and lobes are so formed and spaced with respect to each other to utilize most efficiently the pump driving force. The peak driving force applied to the cam is applied to only one piston at a time but to that piston several times per cam revolution.

Therefore, it has been the chief object of this invention to provide such a pump mechanism in which the peak driving thrust of the rotating cam or driver is applied to only one piston at a time but to that piston more than once per drive shaft revolution. A further object of the invention has been to attain maximum volume and uniformity in flow of the pumped fluid with a minimum number of pump pistons. Still another object has been to provide a simplified pump piston and valve construction.

Other objects of the invention will become apparent from study of this specification and the accompanying drawing. The novel features of the invention are summarized in the claims.

Referring now to the drawings:

Fig. 1 is a transverse section normal to the cam axis through a pump embodying my invention;

Fig. 2 is a section in a plane similar to Fig. 1 showing a modification employing three pump pistons, and

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Fig. 3 is a similar section illustrating a modification with four pistons.

In Fig. 1 there is shown a hollow pump case 5 provided with a cylindrical bore 6. A cam 8 is journalled in end caps (not shown) for rotation in either direction in the bore of the case. In the illustrations the cam is shown as rotating clockwise. The end caps are secured in place by bolts threadingly received in holes 9 in the cast case. A shaft 10 is driven from a suitable power source to rotate the cam.

A pair of opposed cylinders 12 and 13 are formed with their side walls integral with the case, although if desired they may be formed separately and bolted or otherwise secured thereto. The cylinders are in alignment with each other and their common axis is normal to and intersects the cam axis of rotation. Each cylinder is enlarged at its end and tapped to receive an end cap 15.

The fluid to be pumped by each piston is admitted to each cylinder by an inlet port 16 in the cylinder side wall and expelled by an outlet or discharge port 17 formed in a respective end cap.

Pump pistons 18 are carried in each cylinder and pump as they are forced outwardly by a lobe of the cam 8. Each piston is formed at its inward end with a semi-spherical surface 19 to insure uniform sliding engagement with the cam lobes irrespective of the rotated position of the piston in its cylinder. If desired a ball or roller may be carried by the piston to form an antifriction bearing with the cam face. If a roller is used the piston is restrained in any known manner against rotation in its cylinder.

Three symmetrical lobes 20 are formed on the cam as shown. The peripheral surfaces of each lobe are alike, symmetrical involute, as shown, and are formed to smoothly convert the power applied by rotation of the cam to the pistons to reciprocate them. There is no appreciable dwell at the peaks of the cams since it is desirable to have the suction strokes start as soon as possible after completion of the pressure or pumping strokes. The advantages in the use of the symmetrical involute shape of cam lobes are that the pistons move at a uniform speed both in and out if the cam is rotated at a uniform speed; the pump is reversible; the gradual return of the pistons on the suction strokes avoids shock, hence noisy operation and the tendency to starve which often characterizes the use of spring returned pistons when the return movement is unchecked by the cam. Such conditions obtain if the cam has a sudden drop-off or steep slope be-

yond the apex. It will be apparent that each lobe causes a power stroke of each piston once a revolution. Thus with the construction shown in Fig. 1 six power or pumping strokes take place for each cam revolution although there are only two pistons.

The spacing of the cam lobes and pistons is such that the peak driving force of the shaft is only applied to one piston at a time, insuring that the maximum power input is most efficiently used to move the pistons to pump fluid. Thus a minimum of driving force is applied to a single piston several times per cam revolution with the result that the input from the prime mover is most efficiently used and more even flow of the pumped fluid attained.

As each piston forces fluid through its outlet the fluid pressure opens a spring loaded ball check valve **22** formed in an end cap **15** (see right side Fig. 1). At the end of each pumping stroke the lobe **20** applying the force passes the piston end **19** which is then returned inwardly by a coil spring **24** seated at one end in the end cap and at the other end in a recess in the piston. The resistance to opening offered by the spring may be varied by adjusting the screw **23**.

A vacuum tends to be established between the piston and the end cap as the piston starts its return stroke because the check valve closes to prevent fluid from flowing from the outlet back into the cylinder (see left side Fig. 1). To relieve this the fit between the piston and cylinder side wall is of a calculated clearance to allow fluid from the inlet to be drawn ahead of the piston on its return stroke. This is an advantage as it effectively results in an increase in pressure in the fluid inlet line at the time the cylinder is charged. Leakage of fluid past the piston into the bore **6** is prevented by a linear seal **26** carried by the piston.

In certain cases it is desired to employ more than two pistons and this may be accomplished by the modifications of Figs. 2 and 3. In these figures all parts are labelled as in Fig. 1 except that the case is designated **5***a* in Fig. 2 and **5***b* in Fig. 3. The case of Fig. 2 has been formed to receive three cylinders and the case of Fig. 3 has been formed to receive four cylinders. Except for the cases and thus the number of cylinders, all parts of these two modifications are identical with corresponding parts of Fig. 1 and these modifications make use of the power input in the same efficient manner.

In the construction of Fig. 1 it will be seen that the arrangement of parts is such that at the time peak driving thrust is applied to the right hand piston the left hand piston is being returned by spring **24**. Hence, it requires no power from the shaft **10**. Referring to Fig. 2 and assuming that peak driving force is being applied to the right hand piston, it will be seen that the top piston is in a fully returned position and the left hand piston is being returned by its spring. In Fig. 3 if peak load is being applied at the right hand piston the left hand piston is being returned by its spring. The top piston is fully returned and the lower piston has just reached the end of its pumping stroke. If other positions of the cam are assumed for each figure it will be seen that maximum or peak driving force is applied to only one piston at a time. It is applied to each piston several times a revolution and thus makes most efficient use of the driver input to the pump.

I claim:

1. A pump comprising a hollow case, a plurality of piston cylinders rigid with said case and in communication therewith, a pump piston in each cylinder and a rotatable cam member with a plurality of equally spaced lobes of uniform shape to drive said pistons through a pumping stroke, said pistons and said cam lobes having such position and configuration that the cam applies peak driving force to only one piston at a time.

2. A pump comprising a hollow case, a plurality of piston cylinders rigid with said case and in communication therewith, an inlet port in each cylinder adjacent said case, an outlet port in each cylinder, a check valve to prevent travel of fluid from each outlet to each cylinder, a pump piston in each cylinder, and a rotatable cam member with a plurality of equally spaced lobes of uniform shape to drive said pistons through a pumping stroke, said pistons and said cam lobes having such position and configuration that the cam applies peak driving force to only one piston at a time.

3. A pump comprising a hollow case, a plurality of piston cylinders rigid with said case and in communication therewith, an inlet port in each cylinder adjacent said case, an outlet port in each cylinder, a check valve to prevent travel of fluid from each outlet to each cylinder, a pump piston in each cylinder with sufficient clearance between the piston and cylinder side wall to permit withdrawal of said piston from the outlet port without creating a vacuum adjacent said outlet port, and a rotatable cam member with a plurality of equally spaced lobes of uniform shape to drive said pistons through a pumping stroke, said pistons and said cam lobes having such position and configuration that the cam applies peak driving force to only one piston at a time.

4. A pump comprising a hollow case, two piston cylinders rigid with said case and in communication therewith, a pump piston in each cylinder, resilient means to urge each piston in one direction toward the center of said case and a rotatable cam member with a plurality of lobes to drive said pistons through a pumping stroke against said resilient means, said pistons and said cam lobes having such position and configuration that the cam drives only one piston at a time through a pumping stroke and simultaneously allows return of the other piston by its associated resilient means.

5. A pump comprising a hollow case, a pair of opposed piston cylinders rigid with said case and in communication therewith, an inlet port and an outlet port in each cylinder, a check valve to prevent return travel of fluid from each outlet to each cylinder, a pump piston in each cylinder with sufficient clearance between the piston and cylinder sidewall to permit withdrawal of said piston from the outlet port without creating a vacuum adjacent said outlet port, and rotatable means operable to drive only one of said pistons at a time through a pumping stroke.

6. A pump comprising a hollow case, a pair of opposed piston cylinders secured to said case and in communication therewith, an inlet port in each cylinder adjacent said case, an outlet port in each cylinder, a check valve to prevent return travel of fluid from each outlet to each cylinder, a pump piston in each cylinder with sufficient clearance between the piston and cylinder side wall to permit withdrawal of said piston from the outlet port without creating a vacuum adjacent said outlet port, resilient means to urge each piston in a return direction toward said case and a cam member with a plurality of lobes in

said case and rotatable in either direction therein to drive said pistons through a pumping stroke against said resilient means, said pistons and said cam lobes having such position and configuration that the cam drives only one piston at a time through a pumping stroke and simultaneously allows return of the other piston by its associated resilient means.

7. A pump comprising a hollow case, two oppositely disposed piston cylinders rigid with the case and in communication therewith, a pump piston in each cylinder and a rotatable cam member on an axis intersecting the cylinder axes and having three lobes of involute form operative on the opposed pistons alternately during rotation of the cam whereby the pistons are moved at a uniform rate and the cam applies driving force to only one of said pistons at a time.

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