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H. B. GREENING ET AL
INTERNAL COMBUSTION ENGINE

1,781,008

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2 Sheets-Sheet 1

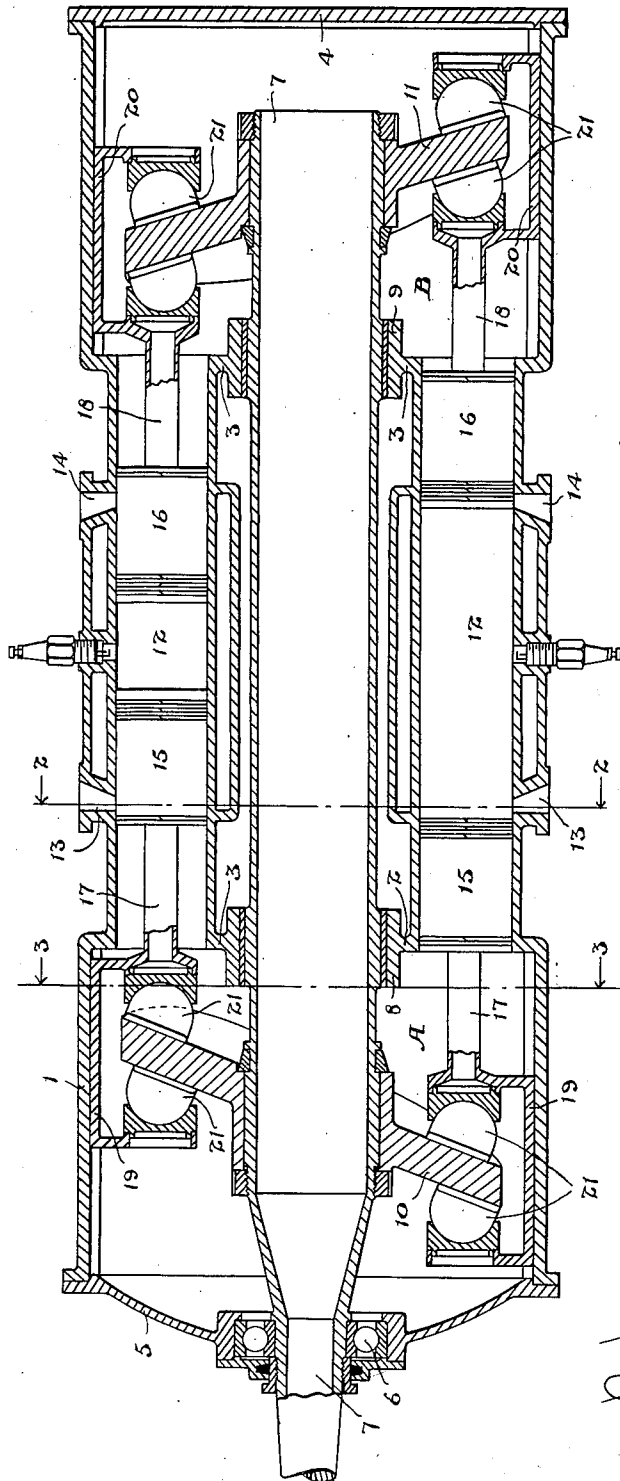


Fig. 1.

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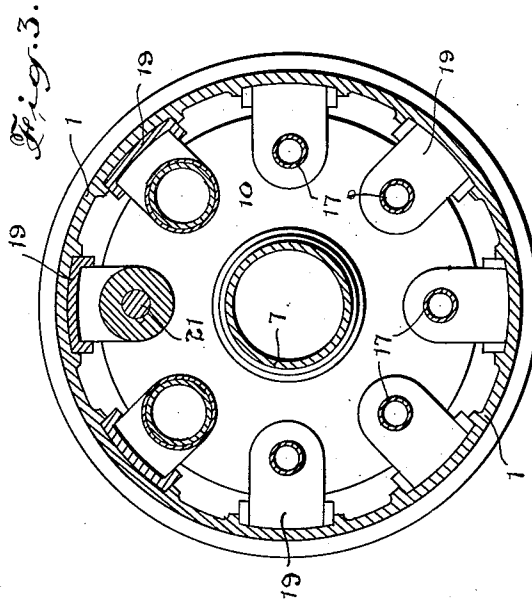
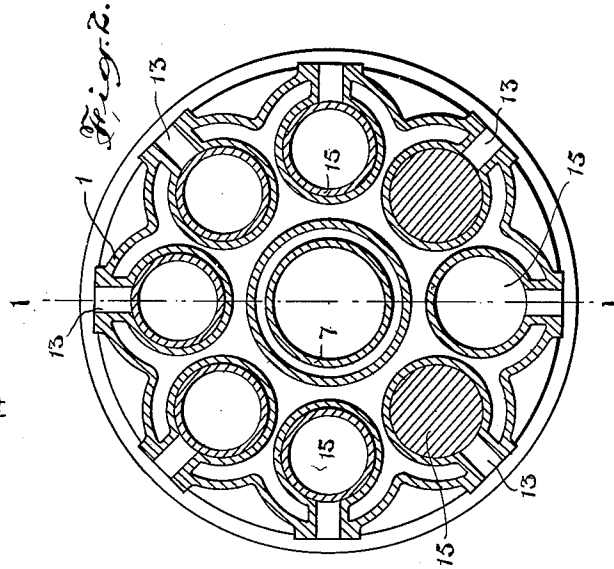
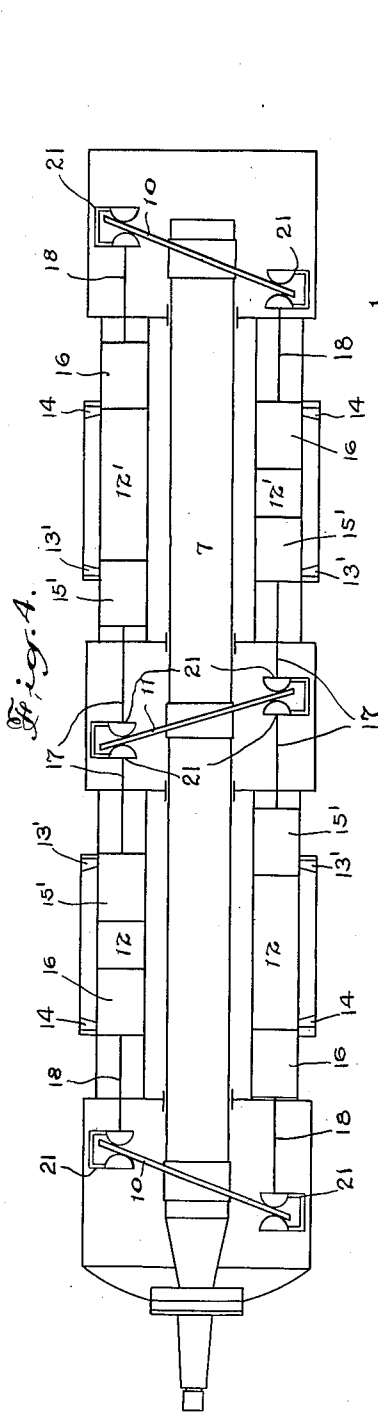
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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INTERNAL-COMBUSTION ENGINE

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The principal objects of this invention are to effectively reduce the weight and bulk per horse power in internal combustion motors, to devise a motor which will produce a remarkably uniform torque, and to produce an engine unit particularly adapted for aeroplane service which will present an extremely small frontal resistance area.

A further and important object of this invention is to devise a construction of motor in which the power units may be multiplied indefinitely and in which the moving parts are reduced to the minimum.

The principal features of the invention consist in the novel arrangement of a plurality of cylinders around a shaft upon which swash plates are mounted at each end of the cylinders and opposed pistons are arranged in each of said cylinders to cooperate with the angled faces of said swash plates.

In the drawings, Figure 1 is a longitudinal mid-sectional view of our improved type of motor.

Figure 2 is a cross section through the line 2—2 of Figure 1.

Figure 3 is a cross section through the line 3—3 of Figure 1.

Figure 4 is a diagrammatic longitudinal sectional view showing a multiplication of cylinders arranged longitudinally.

Internal combustion motors have been proposed in which the power thrust of the piston is applied to a rotatable "swash plate" carried by the shaft and in the present invention this principle is applied in a novel and efficient manner.

In the construction illustrated in Figures 1, 2 and 3, the engine casing 1 is of substantially cylindrical form and is provided with transverse webs 2 and 3 forming the chambers A and B respectively at either end.

A cap 4 closes the end of the chamber B and a cap 5 closes the end of the chamber A.

The cap 5 is provided with a ball bearing 6 in which one end of the hollow shaft 7 is journaled.

The shaft 7 is preferably flared to a considerably larger diameter within the casing and it is supported intermediate of its length by the bearing 8 carried by the web 2 and ad-

acent to its other end by the bearing 9 carried by the web 3.

A "swash plate" 10 is rigidly mounted on the shaft 7 between the bearings 6 and 8 and a similar "swash plate" 11 is rigidly mounted on the other end of the shaft adjacent to the bearing 9.

A plurality of cylinders 12 are arranged between the transverse webs 2 and 3 and may form an integral part therewith or they may be suitably secured thereto. Each of the cylinders 12 is provided with a port 13 arranged adjacent to one end and a port 14 adjacent to the other end. The ports 13 are here shown as the exhaust ports and are connected to a suitable exhaust manifold, not shown, and the ports 14 are connected to a suitable intake manifold, not shown.

Pistons 15 and 16 are arranged in opposed relation in the cylinders and the piston rods 17 and 18 extend into the chambers A and B and are connected to suitable cross heads 19 and 20 arranged in suitable guides in the casing 1. The crossheads are constructed to straddle the perimeter of the swash plates 10 and 11 and are provided with suitable swivel bearing blocks 21 which bear against the angled faces of the swash plates in opposed relation.

The swash plates are preferably arranged so that the "exhaust" plate 10 has a lead over the "intake" swash plate 11 consequently the pistons 15 will uncover the exhaust ports 13 slightly in advance of the uncovering of the intake ports 14 by the pistons 16 in their outward movement thus allowing the escape of combustion pressure from the cylinders prior to opening the intake. The exhaust ports are of course closed in advance of the intake ports as the pistons move inward.

It is preferable in this type of engine to use a "forced" intake to obtain the most efficient operation and the exhaust ports are closed before the intake ports. The continued inward movement of both pistons in each cylinder compresses the combustible charge and at the proper period ignition is effected. The expansion of the combustible mixture in the cylinders drives the opposed pistons outwardly and the connection between the pis-

tons and the swash plates effects the rotation of the plates and the shaft on which they are mounted.

The pistons of the diametrically opposed cylinders operate in the opposing cycles, that is, when the pistons of one cylinder are moving outward in the power stroke, the pistons of the diametrically opposed cylinder are being moved inwardly in the compression stroke. It will be readily understood that in a structure such as described when the power cylinders are arranged closely together the multiple arrangement of pistons are imparting power impulses to the swash plates in progression thus effecting a very uniform torque.

It will be seen that with a motor of this type all thrust loads are balanced.

The construction herein shown and described is adaptable to a great latitude of multiplication either in regard to the number of cylinders placed around the shaft or in the duplication of cylinders applying their power to the swash plates.

Referring particularly to the arrangement illustrated in Figure 4 of the drawings, the engine shaft 7 has rigidly secured thereto a pair of swash plates 10. The swash plates 10 are angularly arranged in relation to the shaft and spaced apart and are each disposed in a plane parallel to the plane of disposition of the other. Rigidly secured to the shaft 7 and spaced intermediately between the paired swash plates 10 is a swash plate 11. The swash plate 11 is angularly disposed with relation to the shaft and is disposed in a plane intersecting the planes of disposition of the swash plates 10.

Encircling the shaft 7 and parallel therewith and disposed between the swash plates 10 and the intermediate swash plates 11 are the groups of cylinders 12 and 12', such cylinders being preferably spaced equidistant in a path concentrically of the shaft 7.

Exhaust ports 13' are arranged at the inward end of the cylinders 12 and 12' and are adapted to be covered and uncovered by the groups of pistons 15' which pistons, it will be noted, are all controlled by the intermediate swash plate 11 in a very compact manner, the pistons 15' of the cylinders 12 operating against one side of the swash plate 11, while the pistons 15' of the cylinders 12' operating against the opposite side of the swash plate.

In the outer end of the cylinders 12 and 12' are arranged inlet ports 14 and these are adapted to be covered and uncovered by the groups of pistons 16, the movement of which are controlled by the paired swash plates 10.

The swash plate 11 is preferably arranged on the shaft 7 with a slight circumferential advance over the swash plates 10 so that the pistons controlled thereby will operate in a group in advance of the pistons controlled

by the swash plates 10, but it will be understood that the invention is not necessarily restricted to the arranging of the swash plate 11 in advanced relation to the plates 10, but considerable advantage is found in so doing and it will be understood that all of the exhaust pistons 15' in co-operating with a single swash plate 11 will be all accurately controlled thereby in a compact manner and any lead imparted to the swash plate 11 will influence each and all of the exhaust pistons 15' so that the exhaust ports controlled thereby will be all correspondingly opened and closed in advanced relation to the opening and closing of the inlet ports by the pistons 16.

A motor of this type may be used to advantage in marine work and in aeroplane service.

The invention is herein shown and particularly described as being used with two stroke cycle cylinders but it will be readily understood that the four stroke cycle type may be utilized in opposed relation operating against swash plates arranged as described without departing from the spirit of the invention.

What we claim as our invention is:—

1. An internal combustion engine comprising a rotatable shaft, a plurality of cylinders arranged around and parallel with said shaft, a pair of swash plates rigidly mounted on said shaft each disposed in angular relation to the shaft and in a plane parallel with the plane of disposition of the other, a swash plate mounted on said shaft between the aforesaid swash plates in angular relation to the shaft and being disposed in a plane intersecting the planes of disposition of the aforesaid swash plates, a plurality of cylinders arranged around and parallel with said shaft and disposed between the respective swash plates and opposed pairs of pistons arranged in each of said cylinders and co-operating with said swash plates to effect the rotation of said shaft.

2. An internal combustion engine comprising a rotatable shaft, a plurality of cylinders arranged around and parallel with said shaft, a pair of swash plates rigidly mounted on said shaft each disposed in angular relation to the shaft and in a plane parallel with the plane of disposition of the other, a swash plate mounted on said shaft between the aforesaid swash plates in angular relation to the shaft and being disposed in a plane intersecting the planes of disposition of the aforesaid swash plates, a plurality of cylinders arranged around and parallel with said shaft and disposed between the respective swash plates and opposed pairs of pistons arranged in each of said cylinders and co-operating with said swash plates to effect the rotation of said shaft, the intermediate swash plate being set in a circumferentially advanced position relative to the first-mentioned pair of swash plates whereby all of the pistons co-operating therewith operate

in a group in advanced relation to the remaining co-operating groups of pistons.

3. An internal combustion engine comprising a rotatable shaft, a plurality of cylinders arranged around and parallel with said shaft, a pair of swash plates rigidly mounted on said shaft each disposed in angular relation to the shaft and in a plane parallel with the plane of disposition of the other, a swash plate mounted on said shaft between the aforesaid swash plates in angular relation to the shaft and being disposed in a plane intersecting the planes of disposition of the aforesaid swash plates, a group of cylinders arranged circumferentially of said shaft between each of said pair of swash plates and the intermediate swash plate, exhaust ports arranged at the ends of said cylinders adjacent the intermediate swash plate, pistons in said cylinders co-operating with said ports and with said intermediate swash plate, intake ports in the other end of said cylinders, and pistons in said cylinders co-operating with said intake ports and with said pair of swash plates.

4. An internal combustion engine comprising a rotatable shaft, a plurality of cylinders arranged around and parallel with said shaft, a pair of swash plates rigidly mounted on said shaft each disposed in angular relation to the shaft and in a plane parallel with the plane of disposition of the other, a swash plate mounted on said shaft between the aforesaid swash plates in angular relation to the shaft and being disposed in a plane intersecting the planes of disposition of the aforesaid swash plates, a group of cylinders arranged circumferentially of said shaft between each of said pair of swash plates and the intermediate swash plate, exhaust ports arranged at the ends of said cylinders adjacent the intermediate swash plate, pistons in said cylinders co-operating with said ports and with said intermediate swash plate, intake ports in the other end of said cylinders, and pistons in said cylinders co-operating with said intake ports and with said pair of swash plates, the intermediate swash plate being set in a circumferentially advanced position relative to the first-mentioned pair of swash plates whereby all of the pistons co-operating therewith operate in a group in advanced relation to the remaining co-operating groups of pistons.

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