United States Patent

Airas

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[54] AXIAL CYLINDER ROTARY ENGINE

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **123/43 A**, 91/499, 123/58 B, 417/461

[51] **Int. Cl.** **F02b 57/04**

[58] **Field of Search** ..... 123/45 R, 45 A, 44 D, 55 R, 123/55 SR, 58 B, 58 BA, 58 BB, 43 A, 43 R; 91/499; 417/461

[56] **References Cited**

UNITED STATES PATENTS

3,535,984	10/1970	Anderson	91/506
1,405,224	1/1922	Kenmonth	123/43 A
1,219,377	3/1917	Davidson	123/43 A
2,280,669	4/1942	Sklenar	123/44 D
2,234,187	3/1941	Meyer	123/44 D

FOREIGN PATENTS OR APPLICATIONS

450,661	4/1913	France	123/43 A

OTHER PUBLICATIONS

Hall, E. S., " Engines Having The Cylinders Parallel to The Shaft."

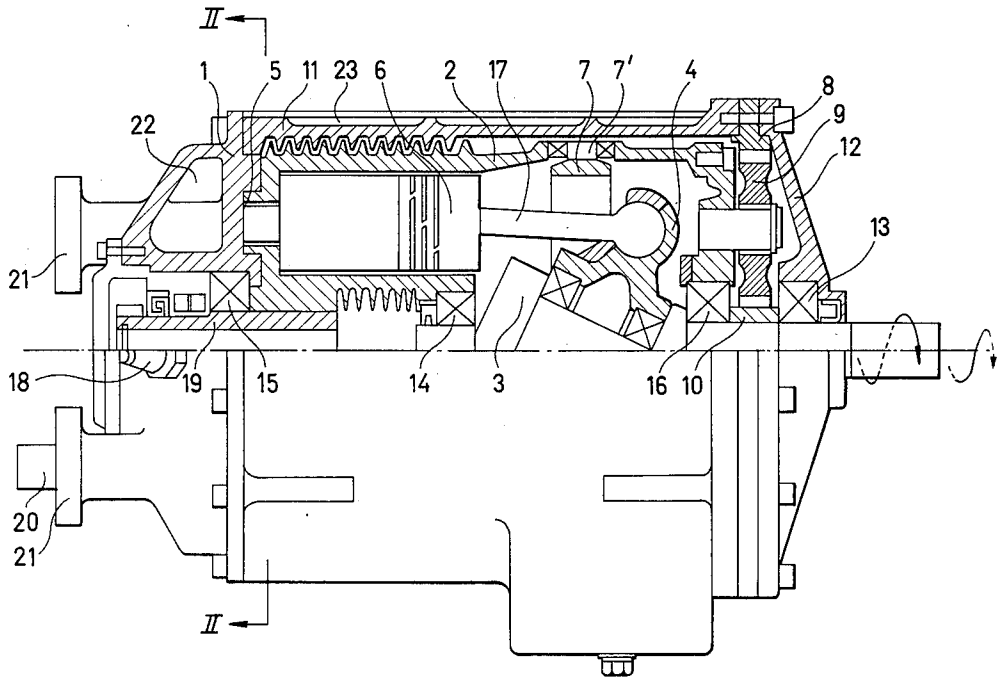
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[57] **ABSTRACT**

An internal combustion engine has a rotating group of axial cylinders around a swash plate driven crankshaft. Each cylinder has only one port for intake and exhaust this port ending directly at a sliding seal against a plain or substantially plane distributor surface on the gable of the stationary engine frame. This stationary distributor surface is provided with a least two sets of intake and exhaust ports as well as ignition devices so arranged that during a full revolution of the cylinder group two full series of four-cycle sequences occur in each cylinder. The cylinder group and crankshaft rotate at different speeds and the relation between these speeds to each other and to the stationary frame, are determined by a gear. The gear arrangement and ratio is depending of the number of cylinders and the number of four cycle sequences per cylinder group revolution.

3 Claims, 5 Drawing Figures



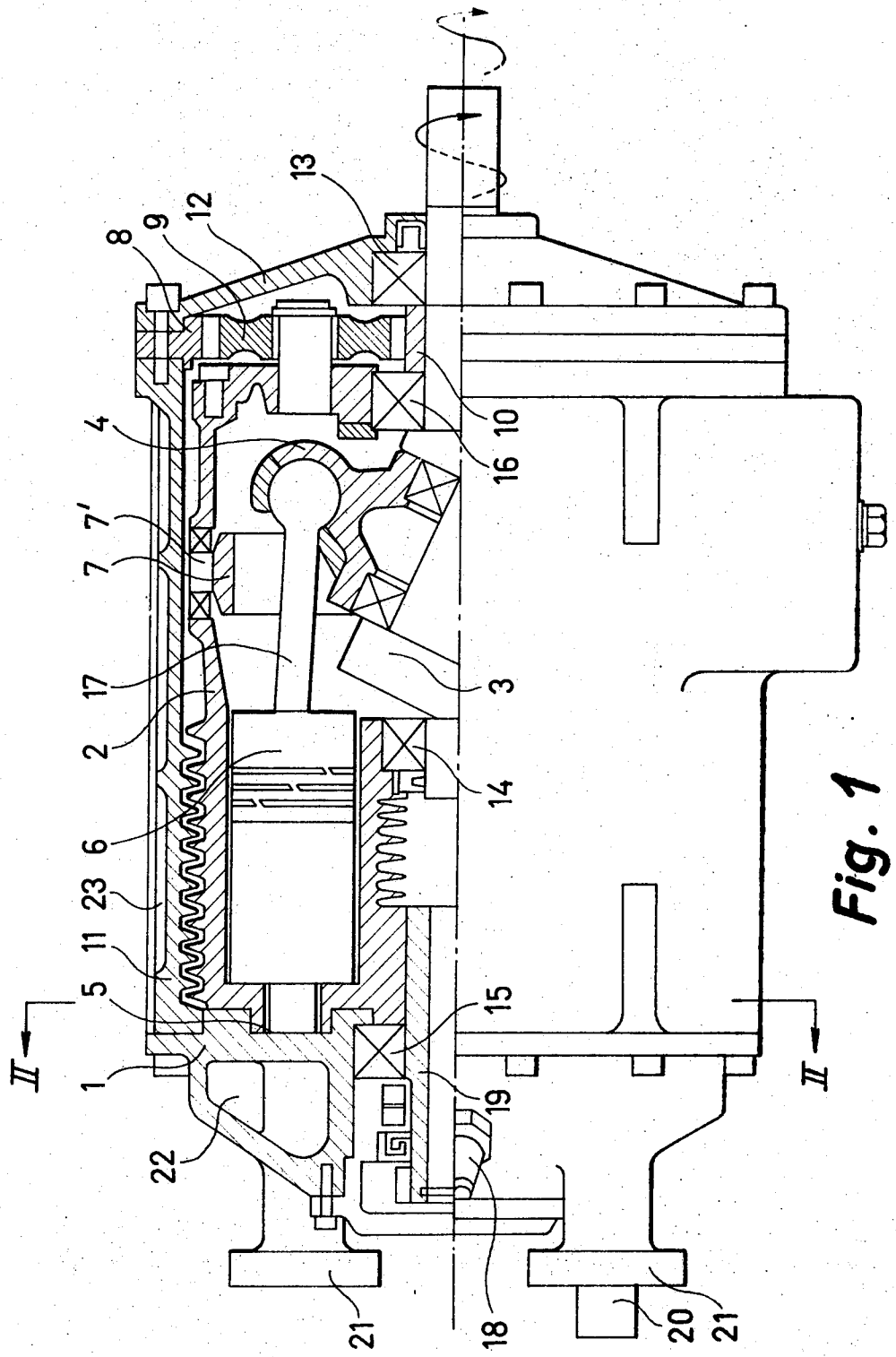


Fig. 1

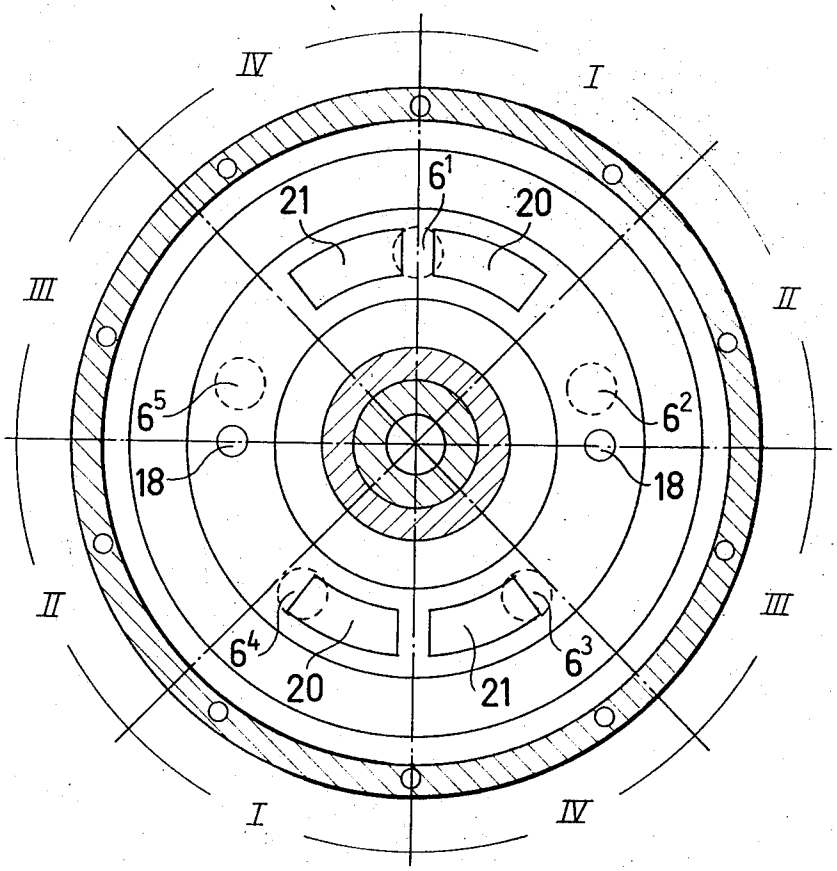

IV
I
III
II
II
III
I
IV
6^1
21
20
6^5
6^2
18
18
6^4
20
21
6^3

Fig. 2

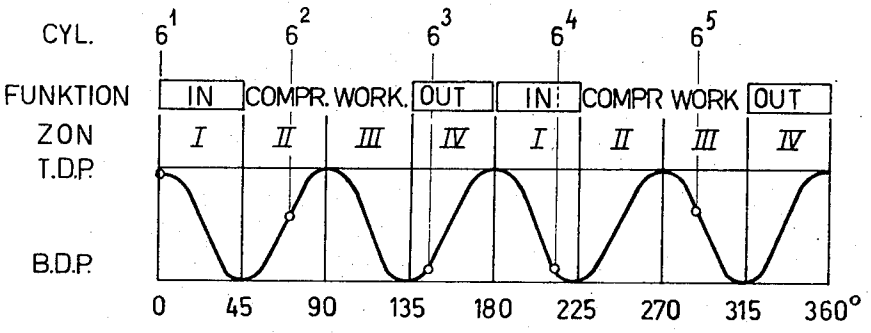

CYL.
6^1
6^2
6^3
6^4
6^5
FUNKTION
IN
COMPR.
WORK.
OUT
IN
COMPR
WORK
OUT
ZON
I
II
III
IV
I
II
III
IV
T.D.P.
B.D.P.
0
45
90
135
180
225
270
315
360°

Fig. 3

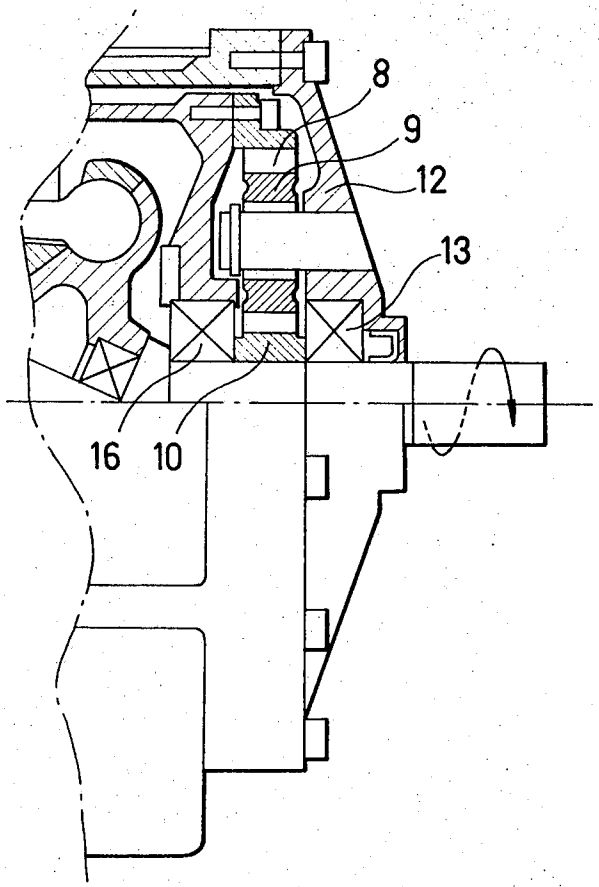


Fig. 4

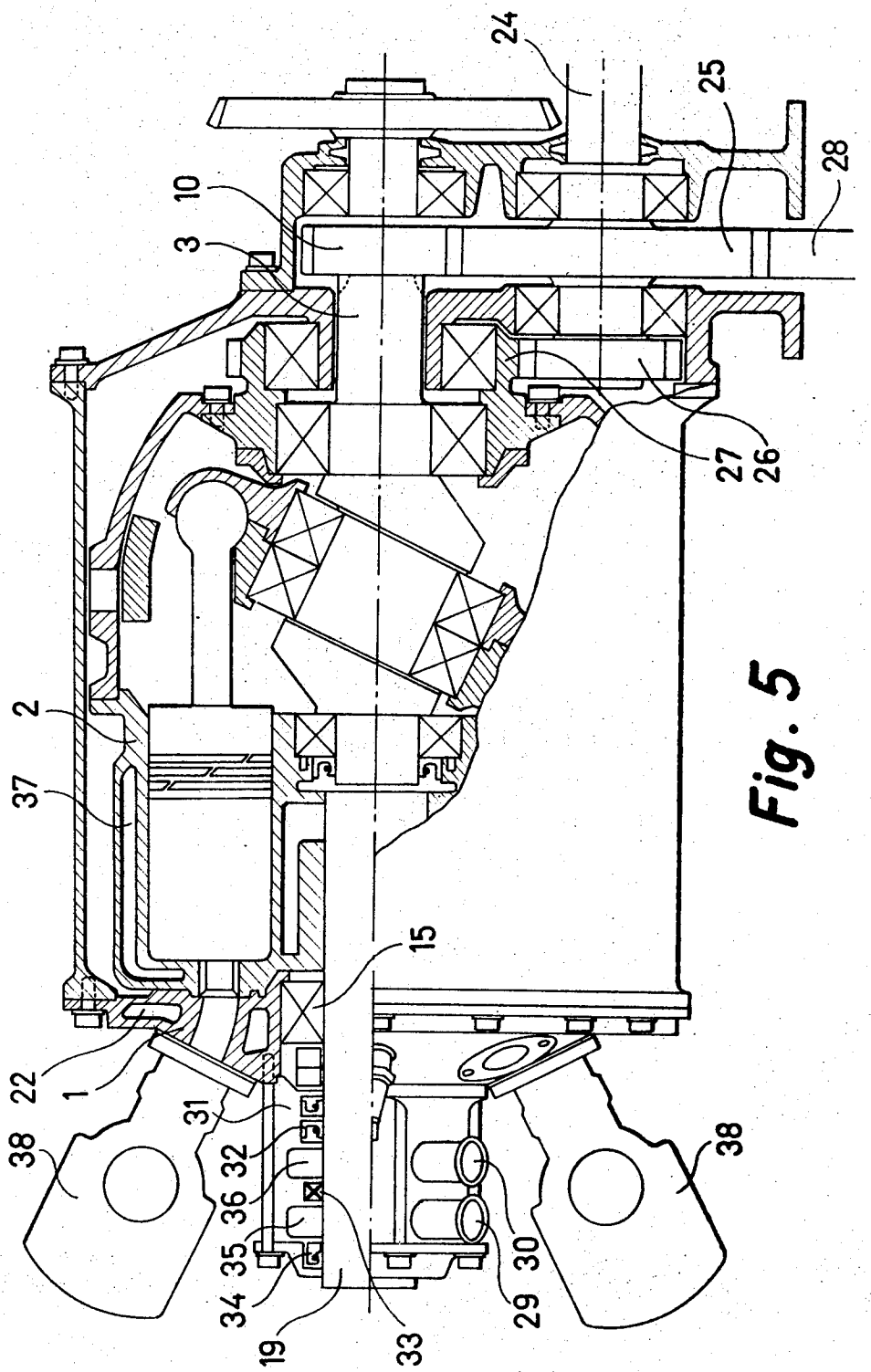


Fig. 5

AXIAL CYLINDER ROTARY ENGINE

BACKGROUND OF THE INVENTION

Various axial cylinder engines are known which comprise two main types, viz, engines having a stationary cylinder block and engines having a rotary cylinder block. It has been proposed to use in the last mentioned type a stationary crankshaft together with a specific crank mechanism comprising rocker arms each of which is common for two cylinders. It has further been proposed to use a rotary crankshaft which is driven by a swash plate or a sloping plate. These prior known engines have been designed with various objects in mind but the proposed solutions have generally rather complicated.

SUMMARY OF THE INVENTION

The present invention relates to a four-cycle engine with rotating, axial cylinders. Engines of this type have been designed with various objects in mind. The object of the present invention is to produce an engine with a simple rotation slide distributor or valve system. This object is quite new and it is realized by a substantially plain slide distributor surface between the cylinder group and a stationary gable and by keeping the sliding speed low by means of different and reduced speed of the cylinder group in relation to the swash plate driven crankshaft.

Furthermore the engine according to this invention has an other unique feature in the referred class of engines having the ignition devices in the stationary gable. Among other advantages this feature gives the possibility of using a continuously or periodically acting ignitor which makes possible the use of slower igniting fuels.

The simplicity of the design makes it particularly attractive in a small size engine. These can be economically made with three or more cylinders, which with the fully balanced transmission mechanism ensures a reliable and extremely smooth running. A simple planetary or two plane gear used for determining the speed ratio and can simultaneously be used for speed reduction from crankshaft to a separate output shaft. This output shaft can alternatively consist of the axle on the slowly running cylinder group.

SHORT DESCRIPTION OF THE DRAWING

FIG. 1 is a sectional view of an engine with five cylinders and two sequences per cylinder group revolution according to the invention.

FIG. 2 is a section at the plane II—II in FIG. 1 showing the slide distributor surface.

FIG. 3 is a schematic illustration of the working mode of the engine according to FIG. 1.

FIG. 4 shows the planetary gear modified for contrarotating cylinder group and crankshaft for three- or seven-cylinder design.

FIG. 5 is a liquid cooled embodiment of a five-cylinder engine with a combined reduction and distributing gear.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1 the stationary engine frame consist of mantle 11 and gables 1 and 12. In the gable 12 there is a bearing 13 for a crankshaft 3. A cylinder group 2 runs on bearings 15 in the gable 1 and 16 on the crankshaft 3 respectively of which the inner end runs in a bearing 14 in the cylinder group 2. Thus the crankshaft 3 and the cylinder group can rotate separately and their rotational speed and direction is determined by a planetary gear consisting of a sun wheel 10 on the crankshaft 3, planetary wheels 9 on the crankcase end of the cylinder group whilst the outer wheel 8 is fixed to the engine frame 11 and 12. In this case (five cylinders) the crankshaft 3 and cylinder group 2 are rotating in same direction. With Z teeth on the sun wheel 10 and $4 \times Z$ teeth in the outer wheel 8 the speed relation between crankshaft and cylinder group is as five to one. The speed difference is thus four, i.e., the crankshaft makes four revolutions in relation to the cylinder group during one revolution of the latter in the stationary frame and against the slide distributor surface 5.

In this way two complete four-cycle sequences are effected in one cylinder as described more in detail below. A swash plate 4 on the crankshaft 3 gives via connecting rods 16 the necessary reciprocating movement for pistons 6. As embodied in the FIG. 1 the rotational movement of the swash plate is coupled to the cylinder group by means of a ring 7 which is carried by two opposite bearings in the crankcase part of the cylinder group and connected to the swash plate by one or two swiveling pins (not shown in the figure) at 90° angle to said bearings. Alternatively the syncronization can be effected by, e.g., a pair of matching bevel gear rings.

The channels 5 in each cylinder 6 are sealed against the slide distributor surface in gable 1 by means of whatever known sealing arrangement. Thus this seal can be, e.g., a tube ring or plate made of metal or plastic material. In the gable 1 there are ports 20 for intake of fuel and air (the port 20 is in the sectional upper part of FIG. 1 not visible) and ports 21 for exhaust. The gas distribution is effected by the slide valve action arising from the rotary motion of the cylinder group 2 where the ports 5 pass the openings for ports 20 and 21 in the slide distributor surface.

The ignition is effected by igniting devices at two diametrically located sites 18.

The operation of the engine according to the invention can be described with the air of section II—II from FIG. 1 as shown in the FIG. 2, i.e., against the slide distributor surface in the gable 1.

Due to the rotation of the cylinder group 2 each cylinder 6 and its port 5 are successively passing four zones in the gable 1 during one complete four-cycle sequence. These zones are marked by I, II, III, and IV in FIG. 2 and their divisions is given by radial dotted lines. There are two sets of such zones each covering in the figure 180°. The locations of the cylinders are marked by dashed circles and ordinal numbers 6^1–6^5.

When the cylinder group is rotating clockwise, e.g., the cylinder 6^1 passes at first the zone I which is an intake zone with opening to the intake port 2 and thereafter the zone II during compression cycle whereby the port 5 runs against a closed face. At the end of zone II the one ignition device 18 initiates the working cycle in zone III.

The cylinder then passes an exhaust opening in 21 in the zone IV thus completing one four cycle sequence. The same functions are then repeated during the second half turn back to the initial position.

The diagram in FIG. 3 is a schematic illustration of the movement of piston 6^1 between top (TDP) and bottom dead point (BDP) during a full 360° revolution of the cylinder group. The figure also shows the initial locations of the other cylinders 6^2–6^5.

In an engine thus described the gas distribution is effected through the movement of the cylinder group in relation to the gable 1. An extremely simple and reliable distributor action is obtained without valves and practically no additional parts. Due to the reduced speed at the cylinder group which is one-fourth or less of the effective speed of the crankshaft good sealing and wearing properties are obtained as well as moderate frictional less in the slide surface.

FIG. 4 shows a detail of a different arrangement of the gear suitable for, e.g., three or seven cylinder embodiment of the invention with contrarotating crankshaft and cylinder group. For the function described above with two working cycles (ignitions) per cylinder group revolution in this embodiment the speed relation shall be as 3:1 between the crankshaft and cylinder group. This is obtained by means of a planetary gear where the outer wheel 8 is mounted on the cylinder group 2 crankcase part and the planet wheels 9 are running on bearings fixed to the stationary gable 12. For Z teeth in the sun wheel 10 the outer wheel shall have 3Z teeth. In other respects the operation of this embodiment is equal to that of the described engine according to the FIGS. 1 to 3.

The other parts as fuel, ignition, and lubricating systems can be of conventional type and are therefore not described here. As, however, the ignition timing can be determined by the position of ignition device in the distribution surface this device can be of continuously or periodically acting type as, e.g., a glow-plug. This allows for the use of a wide variety of fuels. Similarly the fixed position for other "strokes" gives the possibility of using the compression for, e.g., fuel injection. Air or gas starting is also possible without complicated valve arrangements.

Alternative cooling systems with air, water, oil, or other fluids can be used. A combination of air and liquid cooling is indicated in FIG. **1** with fluid cooling space **22, 23** in the gable **1** and in the mantle **11** respectively. FIG. **5** shows an alternative with fluid cooling through ports in the slow running shaft **19** fixed to the cylinder block. The cooling agent is taken into the shaft via a casing **31** fixed to the gable **1**. Fluid from and to cooler is conducted via ports **29** and **30** to two toroidal chambers **35** and **36** which again communicate directly with ports in the axle **19** and thus with the cooling space **37** in the cylinder block. Alternatively the stub **30** may be placed on the gable **1** in order to direct the cooling agent directly from the chamber **32** inside the casing **31** into the cooling space **22** in the gable **1** or vice versa. The chambers **35** and **36** are sealed mutually by the seal **33**, outward by seal **34** and towards the lubricated bearing **15** by a double seal **32**.

The right hand side of FIG. **5** illustrates a possible arrangement of cylindrical or helical gear consisting of a primary transmission **10–25** to an output shaft **24** and a secondary gear **26–27**. Alternatively the output can be taken via a gear wheel **28** in the secondary gear **26–27**. The wheel **27** is fixed to the crankcase part of the cylinder group **2** thus determining the speed ratio between the cylinder group **2** and crankshaft **3**. This gear arrangement is suitable for, e.g., five cylinders (with two ignitions per revolutions) or seven cylinders (with three ignitions per revolution) embodiments.

In the FIG. **5** there are shown two carburators **38** which in an practical application will be placed in a horizontal plane,

i.e., in a plane in right angle to the sectional plane of the gear of the FIG. **5**.

Having thus described my invention and in what manner the same is to be performed I declare that what I claim is:

1. An internal combustion engine comprising a stationary engine frame including a cylindrical mantle between two gables, a cylinder block rotatable within said frame and comprising an odd number of at least three cylinders extending in the axial direction of said mantle, a piston in each of said cylinders, a crankshaft in the center of and rotatable with respect to said frame and said cylinder block, first bearing means rotatably supporting said crankshaft on said frame and second bearing means supporting said cylinder block for rotation relative to said crankshaft at a slower speed than the later, a swash plate rotatable on said crankshaft and connected to said pistons for rotation with said cylinder block, a substantially planar distribution surface on one of said gables of said frame, at least two sets of intake and exhaust ports and igniting devices in said distribution surface, a port in each of said cylinders adjacent to and sealing against said distribution surface for co-operation with said intake and exhaust ports and said igniting devices, said cylinder ports each having a diameter less than that of said cylinder and a gear means coupled between said crankshaft, said cylinder block and said frame respectively for determining such relative rotational speeds of said crankshaft and said cylinder block with respect to said frame that each cylinder passes at least two complete four stroke sequences during a full revolution of said cylinder block.

2. An internal combustion engine as in claim **1**, wherein said gear means determining the rotational speeds of said cylinder block and said crankshaft comprises a two plane cylindrical gear the first plane of which forms a speed reduction transmission between said crankshaft and a separate output shaft.

3. An internal combustion engine as in claim **1** comprising ignition devices for each of said cylinders, said ignition devices being of a periodically acting type.

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