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Airas

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[54] **EXTERNAL COMBUSTION SWASH PLATE ENGINE EMPLOYING ALTERNATE COMPRESSION AND EXPANSION IN EACH WORKING CYLINDER**

[76] Inventor: **Timo Airas**, Parkgatan 3A, Helsinki, Finland

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[51] **Int. Cl.** **F02g 3/02;** F01b 3/02

[58] **Field of Search** .... 60/39.6, 39.61, 39.62, 60/39.63, 39.43; 91/499, 476; 123/43 A, 43 AA

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Primary Examiner—William L. Freeh
Assistant Examiner—Robert E. Garrett
Attorney, Agent, or Firm—Elliott I. Pollock

[57] **ABSTRACT**

This invention relates to a combustion engine built up with a revolving cylinder group around a central crankshaft, carrying pistons via a wobble plate or the like, and rotating with a greater speed than the cylinder group. An external combustor for continuous combustion is connected via inlet ducts to a mutual sliding surface between a frame and said cylinder group. Ports for gas distribution are arranged in the frame portion and in the cylinder group portion of said surface. Other ducts on the frame side serve as exhaust means. Each cylinder alternatingly works as a compressor and as a motor by connecting the ports in the cylinder wall to different ducts.

4 Claims, 3 Drawing Figures

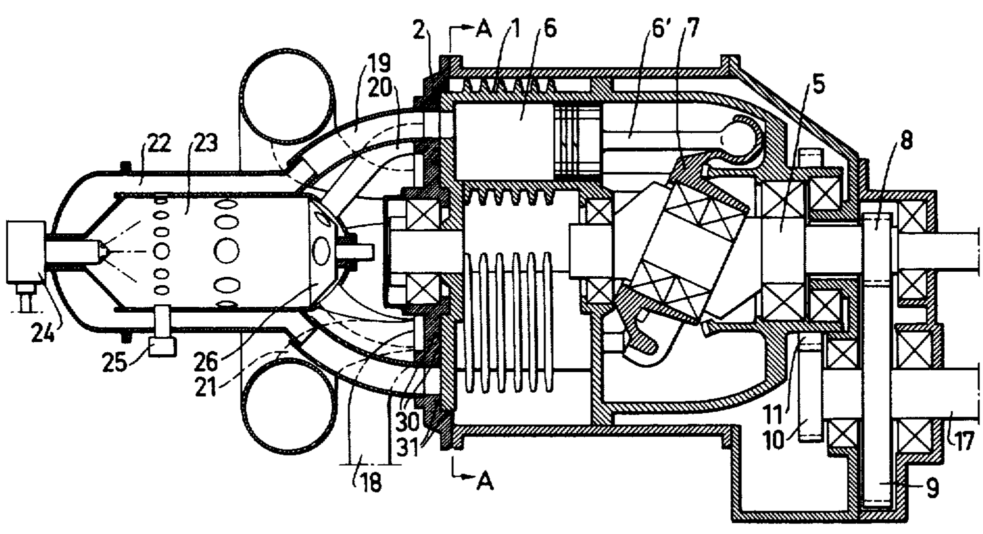
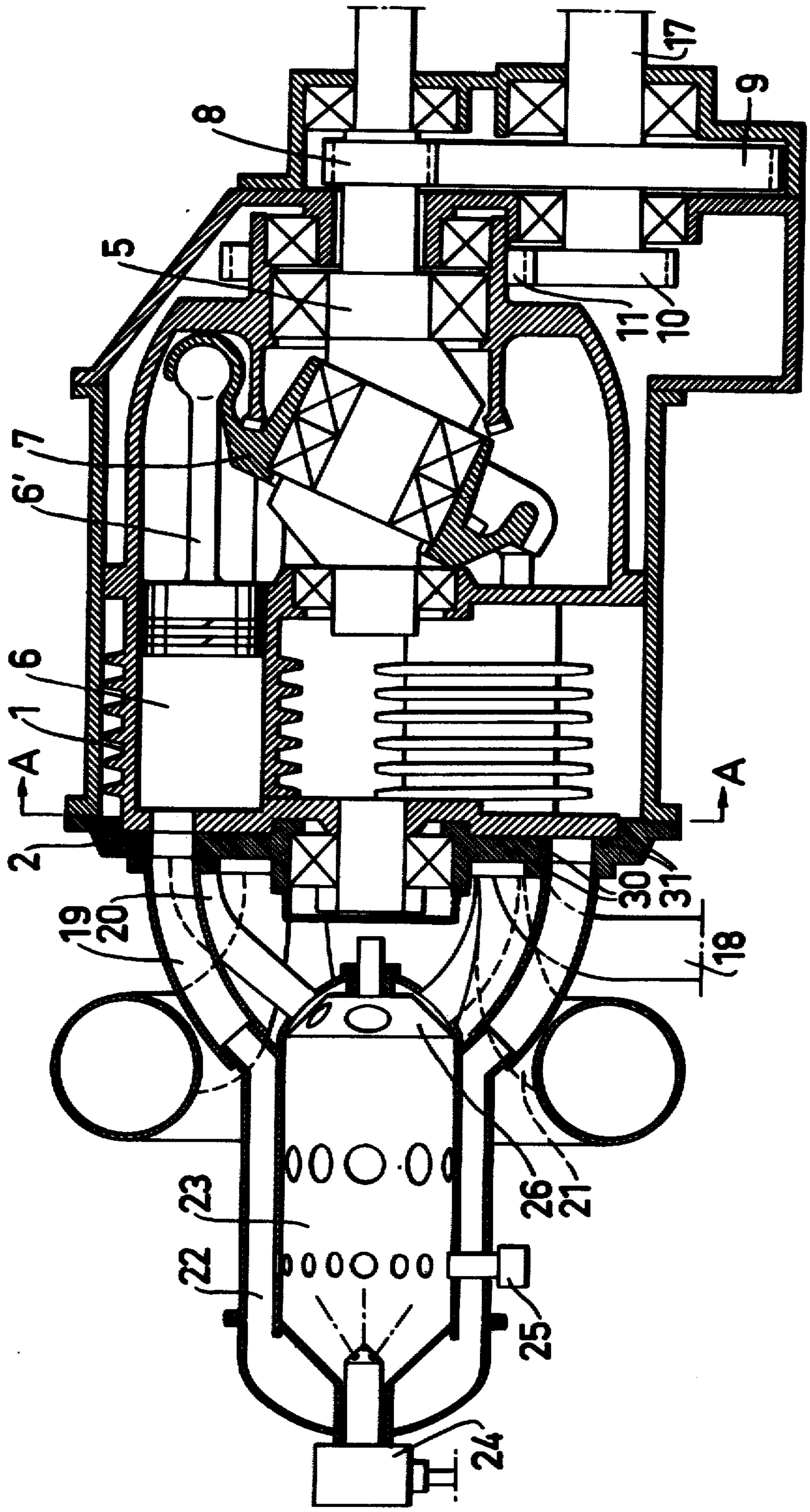


FIG. 1



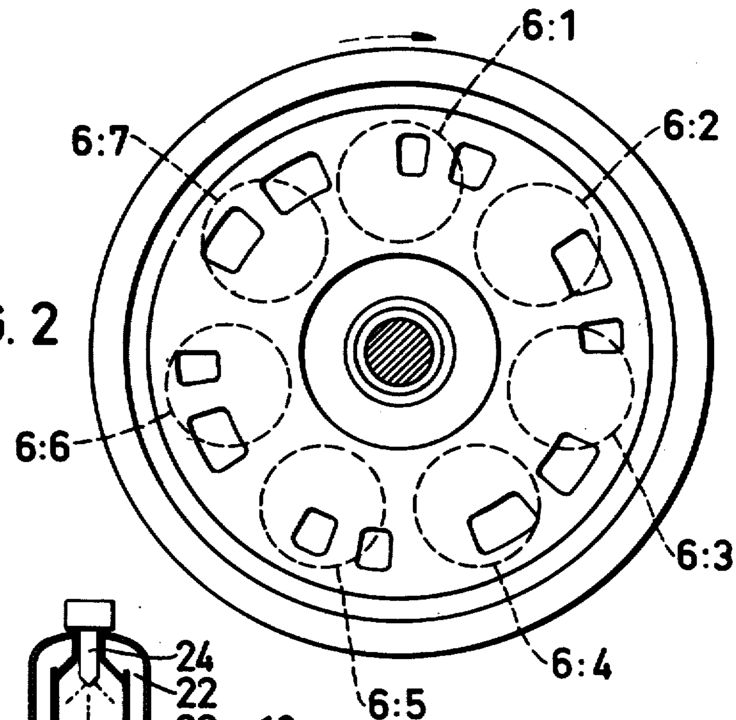
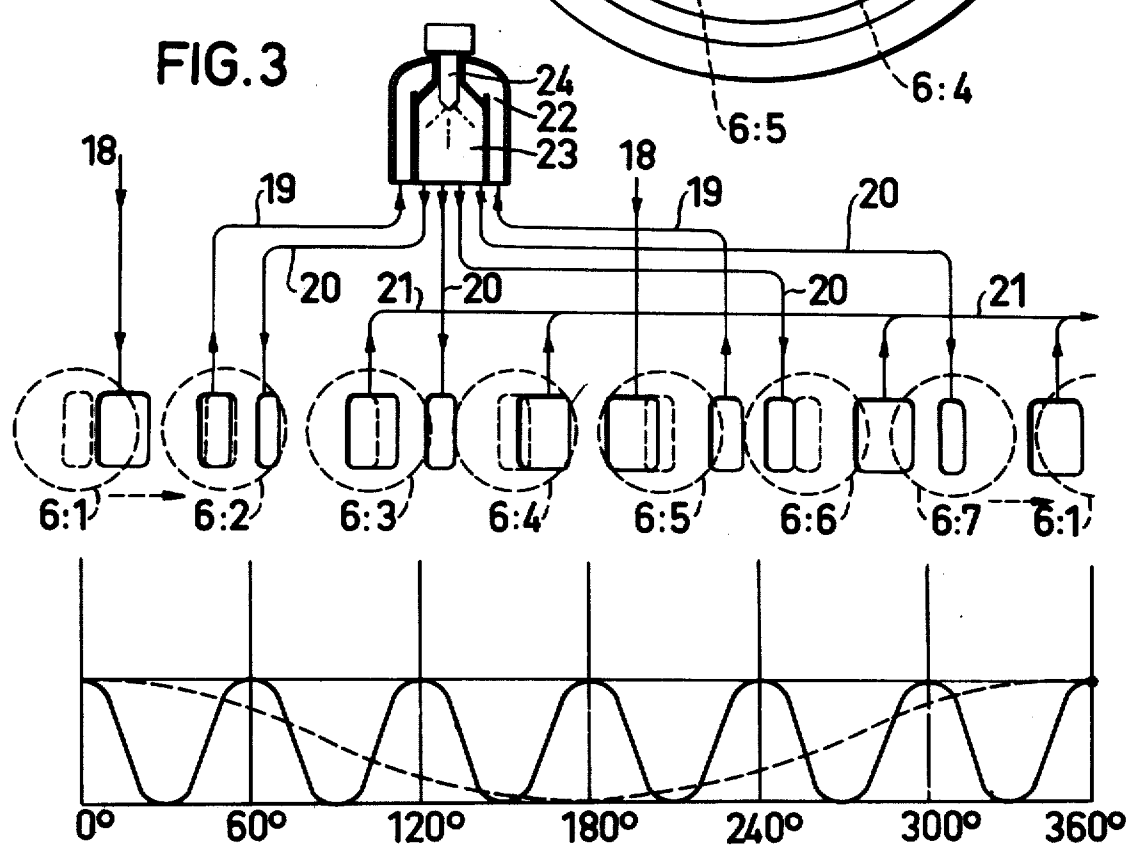

6:1
6:2
6:3
6:4
6:5
6:6
6:7

FIG. 2

FIG. 3


24
22
23
18
19
20
21
18
19
20
20
20
21
6:1
6:2
6:3
6:4
6:5
6:6
6:7
6:1
0°
60°
120°
180°
240°
300°
360°

EXTERNAL COMBUSTION SWASH PLATE ENGINE EMPLOYING ALTERNATE COMPRESSION AND EXPANSION IN EACH WORKING CYLINDER

The present invention relates to an internal (or external) combustion engine with continuous combustion and a revolving cylinder group. Such an engine is provided with a slide valve arrangement which is formed as a mutual slide surface between a frame of the engine and the cylinder group whereby openings are arranged in the frame at the sliding surface as well as in each cylinder of the cylinder group for controlling the gas distribution.

In the traditional internal combustion piston engine according to the Otto or Diesel principles, the combustion is effected intermittently and internally inside the cylinders. These principles, however, have several disadvantages, e.g., in form of harmful or poisonous exhaust emission, vibrations and high noise level. From an environmental point of view a better mode of function is obtained with the Stirling principle and the so called Rankin engine, the latter working with a steam cycle. These last-mentioned engines work with continuous, external combustion. They tend, however to be very expensive particularly in case of engines in the low power category.

Furthermore there are engines working according to the gas turbine principle, whereby the combustion occurs continuously, either externally or internally, in a combustion chamber placed between a compressor and a power producing turbine. According to this principle a number of so called free piston compressors have been used but they involve too great complication to be competitive in small units. The turbine itself is associated with some purely physical limitations. Thus, for instance, the slot losses grow, relatively, with reduced dimensions as well as the relative roughness in the turbine blade surface, all impairing rapidly the economy when the dimensions are reduced to be suitable for small-power units.

There are also proposals for piston and other displacement rotating engines which use a separate compressor but so far it has not been possible to produce a reliable motor part in such combination due to the high temperature of the working medium used and consequent lubrication difficulties.

To a great extent the present invention eliminates the main drawbacks in the engine types known so far and particularly in the region of low power units (below about 100 kW). The invention relates to an engine with continuous internal (or external) combustion. The engine consists of a multicylinder cylinder group having displaceable elements, for instance, pistons, the revolving cylinder group running on bearings in a stationary frame, a gear set and an outward combustion chamber. The gas distribution between the combustion chamber and the cylinders is governed in a mutual slide surface between frame and cylinder group where passageways to and from the combustion chamber end, and where ports are arranged for each cylinder in the cylinder group.

The invention thus constitutes a combustion engine of an entirely new type for continuous combustion with an external combustion chamber and is based on the so called double-rotation principle. The revolving cylinder group has pistons or other displaceable elements acting on a crankshaft, concentric with the cylinder group and having a rotational speed higher than that of the cylinder group. In a preferred embodiment the engine has a multitude of axial cylinders arranged around and mainly in parallel with said crankshaft, which is thus driven via a wobble plate, a swash plate of some other corresponding element in known manner.

Gas distribution between the outside combustion chamber and the revolving cylinders inside the engine frame is effected by a slide distributor at the mutual slide surface. In an engine according to this invention the use is made of an external combustion chamber with continuous, either direct or indirect combustion, combined with a double-rotating piston compressor motor, and additionally an arrangement of ducts between the slide surface and the combustion chamber in such a way that each cylinder works alternatingly as a compressor pumping air to the combustion chamber through certain ducts and as a motor with the working medium expanding from the combustion chamber through other ducts. Measures are also taken to avoid leakage of the working medium at said slide surface, a preferred means being circular sealing devices.

One embodiment of the invention is shown by the accompanying drawings.

FIG. **1** is a longitudinal section of the new engine.

FIG. **2** shows a cross section at the slide surface between the frame and the rotating cylinder group, and

FIG. **3** is a diagrammatical representation for explaining the working mode of the engine.

In the preferred embodiment according to FIG. **1** the engine is provided with seven cylinders **6** which are built together as a revolving cylinder group **1**, being arranged axially and concentrically around a crankshaft **5**. A double gear set **8, 9, 10** and **11** is coupled to the cylinder group, the last gear wheel **11** being fixed to the cylinder group. Each piston has the connecting rod **6'** joined to a swash plate **7** adapted on the shaft **5** in such a way that the reciprocating movement of the pistons is transferred to a rotational movement of the crankshaft. By means of the two step gear train of which the first step also can be used for reduction of the speed in the output shaft **17**, a suitable speed relation can be fixed between the crankshaft **5** and the cylinder group **1**.

This relation also determines the number of compressor and motor functions in the engine, i.e., the number of double strokes between the upper and the lower dead point of each piston, during a full working sequence, which is equal to a full revolution of the cylinder group. The total number of such functions f during one revolution of the cylinder group is, when the number of cylinders is z, given by $f = z \pm 1$. Since one such function, for instance inlet and compression, corresponds to one revolution of the crankshaft **5** (relative to the cylinder group) the same relationship is valid for the relative rotational speed, which also is the effective speed of the engine n_{eff}, and the speed of the cylinder group. When $f = z - 1$ the crankshaft and the cylinder group rotate in the same direction, and when $f = z + 1$ they rotate in the opposite direction.

According to one of possible embodiments of this invention it is suitable that the number of motor functions during a full working sequence is larger than that of compressor functions in order to obtain a motoring torque which is greater than that required for the compressor functions.

If, for instance, $z = 7$ and $f = 6$, the crankshaft **5** is rotating in the same direction as the cylinder group **1** and at $n_{eff} = 6{,}000$ r/m (100 r/s) the actual speed of the crankshaft will be 7,000 r/m and the speed of the cylinders 1,000 r/m (16 ⅔ r/s). This clearly shows that the sliding speed at the slide surface between the frame and the cylinder group will be very moderate, giving small losses and favourable conditions for the sealing function at the slide surface.

The function of the engine is determined by the slide distributor which is arranged at the said sliding surface between the frame and the cylinder group. FIG. **1** shows a combustor of a type known per se, consisting of a combustion space **23**, an injection device **24** for fuel, an ignition device **25** and an outer air space **22**. The combustor **22 – 25** is connected via ducts to that part of the frame **2** where the slide surface is situated. Thus the air space **22** communicates via ducts **19** with the slide surface, or with openings in the said surface. Other ducts **21** receive consumed working medium from the cylinders and are connected to an exhaust system. Still other ducts **20** connect the combustion space with ports in the slide surface. There are also ducts **18** serving as air intake to the engine. By means of a valve **26** inserted between the combustion chamber **23** and the ducts **20**, the working medium can be released, throttled or shut off in the direction towards the cylinder group.

The arrangement of the duct openings in the slide surface is illustrated in FIG. **2**, where the piston positions are indicated by dotted lines. This Figure is a section at A—A in FIG. **1**. In FIG. **3** again, the said duct openings are spread out along a straight line representing a full working sequence, for instance 0°–360°. This Figure also shows schematically with lines and arrows on the lines the connections of, and the transfer directions in the ducts **18, 19, 20, 21**. In FIG. **2** the cylinders are denoted **6:1** through **6:7** for the seven cylinders provided.

FIG. **3** also shows by means of dotted lines the positions of the cylinders **6:1** through **6:7** with their ports ending at the slide surface. The dotted curve in the lower part of FIG. **3** corresponds to the motion of the crankshaft **5**. During one revolution of the cylinder group each cylinder passes (according to the arrow between the cylinders **6:1** and **6:2**) in turn six zones in the slide surface, namely first a compressor zone, thereafter two motor zones, then one compressor zone and then again two motor zones. In FIG. **3** the piston in cylinder **6:1** is starting a stroke "downwards" from the upper dead point, starting the inlet of air through the duct **18** from an air inlet duct. In cylinder **6:2** the piston is on its way towards the upper dead point and is finishing compression of air into the outer air space **22** of the combustor via the duct **19**. The compressed air will be heated and thereby expanded in the inner space **23** of the combustor, where heat is taken over from the continuously burning burner **24** by means of delivered fuel. Via the valve **26** the heated working medium is passed through the ducts **20** to ports in the slide surface for action during the motorzones. In FIG. **3** the inlet of cylinder **6:7** is just going on, while the inlet is finished in cylinder **6:6** and the expansion is started in this cylinder. In the cylinders **6:3** and **6:4** the expanded working medium is being exhausted through further ducts **21** out to an exhaust system. In this case the crankshaft **5** is rotating in the same direction as the cylinder group but at a six times higher rotational speed n_5 in relation to the speed n_1 of the cylinders. The actual rotational speed of the crankshaft is thus $n_5 = 6\,n_1 + n_1 = 7\,n_1$. Due to the fact that the cylinders alternatingly perform motor and compressor functions there will regularly be inlet periods for cold air, during which the cylinder is internally cooled. Therefore the lubrication of the cylinders can be effected with conventional methods.

For this engine it is of essential importance how the sealing system at the slide surface is materialized. According to the preferred embodiment of the engine special seals are arranged on both sides (in FIG. **1** outside and inside of the gas port track proper) of the area which is occupied by the duct ports. It is also possible to arrange double seals and to force a neutral medium into them, for instance, oil or air, in order to prevent the leakage of the working medium from the port track. In FIG. **1** the seals at the slide surface are denoted with **30** inside the duct ports and with **31** outside the port area.

The mechanical realization is not limited to the axial cylinder type described having conventional, spherical or vane formed pistons. Alternatively the engine may be of radial type or be based on a rotating eccentric piston of epitrochoid type or vane type inside a revolving cylinder barrel on which the sliding surface of the slide distributor is situated.

In comparison with the conventional internal combustion engines the proposed engine is superior in respect of the purity of the exhaust gases, because the engine is working with a large excess of air and with a moderate temperature in the combustion. The continuous combustion further achieves extremely good reliability, allowing at the same time for a free choice of the fuel used. Furthermore the engine is much less sensitive to impurities in the working medium than is the case with, for instance, a gas turbine.

What I claim is:

1. A combustion engine, comprising a stationary frame, a cylinder block comprising a plurality of cylinders mounted for rotation as a unit in bearings in said frame, a reciprocable piston element axially movable in each cylinder, a crankshaft rotatably mounted in said frame along the axis of rotation of said cylinder block, gear means mounted in said frame and connected between the cylinder block and crankshaft for giving the crankshaft a higher rotational speed than that of the cylinder block, swash plate rotatably mounted on said crankshaft and connected in timed relationship to said cylinder block to effect a desired relative rotation therebetween, a connecting rod between each piston element and said swash plate for converting the reciprocating movements of the piston elements into rotational movement of the crankshaft, a slide distributor comprising a pair of relatively rotatable slidably engaged interface members connected respectively to said frame and to said cylinder block, first port means in said cylinder block member of said slide valve distributor, and in flow communication with each of said plurality of cylinders; second port means in said frame member of said slide distributor comprising, in circumferential sequential order, air inlet port means for supply of inlet air to a cylinder when said air inlet port means is in flow communication with said first port means, compressed air discharge port means for discharge of compressed air from a cylinder when said compressed air discharge port means is in flow communication with said first port means, combustion products inlet port means for supply of combustion products to a cylinder when said combustion products inlet port means is in flow communication with said first port means, combustion products discharge port means for discharge of combustion products from a cylinder when said combustion products discharge port means is in flow communication with said first port means; air duct means connecting said compressed air discharge port means to said combustor; and combustion products duct means connecting said combustor to said combustion products inlet port means, said slide distributor being operative, during rotation of said cylinder block and corresponding relative rotation of the said interface member, to cause each cylinder and its associated piston to operate alternatingly as a compressor pumping air into the combustor via said air duct means and as a motor utilizing the expanding heated working medium supplied to each cylinder via said

combustion products duct means.

2. The combustion engine of claim **1** wherein said combustion products inlet port means and said combustion products discharge port means both comprise plural ports disposed in alternating circumferential sequential order, thereby providing for plural motor expansion strokes of said piston elements for each compression stroke of said piston elements.

3. The combustion engine of claim **1** including a valve located between the outlet from said combustor and the combustion products duct means to enable the admission, throttling and shutting-off of the flow of working medium to the cylinders.

4. The combustion engine of claim **1** including sealing elements comprising twin groups of ring-shaped seals provided in the sliding interface on each side of the ducts in said interface.

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