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(54) WOBBLE PLATE MECHANISM FOR A PISTON MACHINE

(57) Swash plate comprising : a substantially cylindrical element (48A1) adapted to be lodged within the central hole (47H) of the ring (47), and provided with a tubular protruding element (48A3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47).

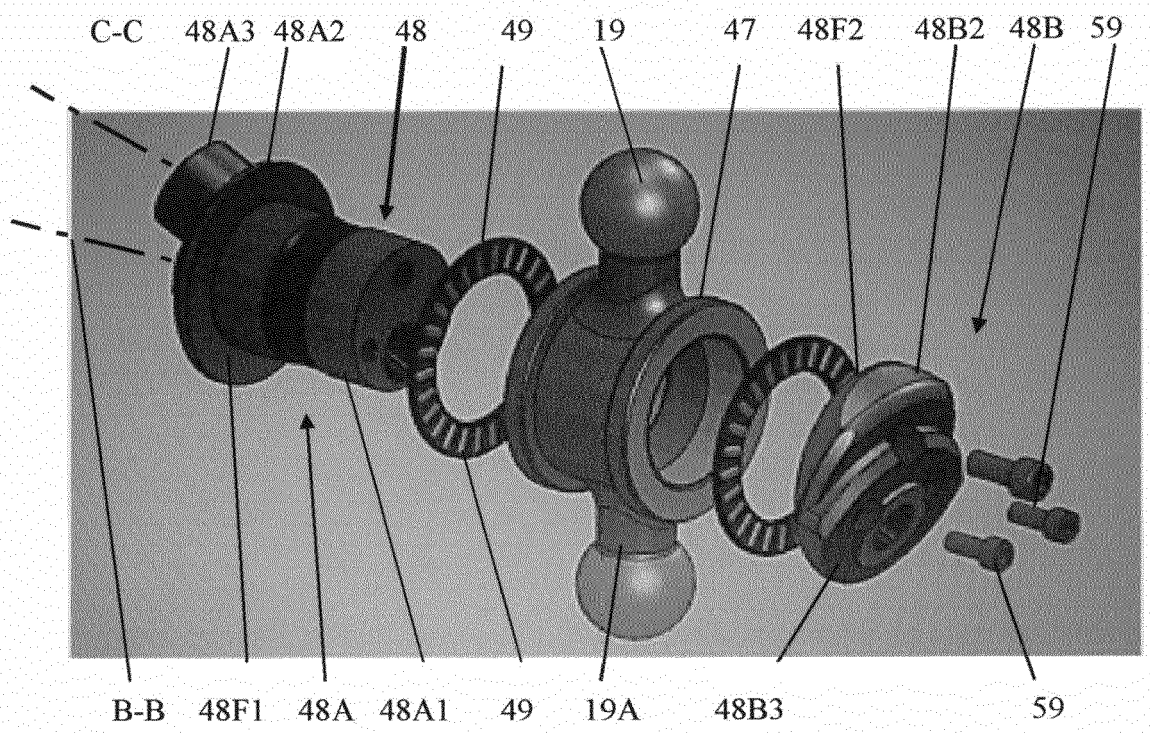

Figure 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a swash plate for a fuel engine, wherein the pistons are arranged to move linearly along axes parallel to the central axis of the drive shaft. The linear motion of a piston is converted into rotation by means of at least one swash plate. Advantageously, the heads of two pistons share the same combustion chamber. Thus, the engine is advantageously characterised by the opposing movements of pairs of pistons along axes parallel to drive shaft axis.

THE STATE OF THE ART

[0002] Engines, wherein the pistons are arranged to move linearly along axes parallel to the central axis of the drive shaft are known for example, from EP 0 052 387 and US 4,202,251.

[0003] The problems with known engines comprising parallel-aligned pistons lie in the wear of the swash plates. The swash plate comprises an outer ring and an inner boss, which is held and rotates within the ring on a set of bearings, that are usually needle bearings. The boss is attached to the drive shaft at an inclined angle, so that linear movements of the ring by the pistons cause the inner boss and shaft to rotate. The swash plate experiences high revolutions and peak pressures, and often insufficient oiling of the joints between the boss and ring, and between the ring and piston.

[0004] For solving at least partly said problems, it has been proposed by Applicant in WO2007/033441 a fuel engine comprising :

- a drive shaft having a central axis;
- at least one combustion chamber;
- at least a first piston and a second piston arranged each to move along axes parallel to the central axis of the drive shaft, in which said first and second pistons share the same combustion chamber,
- whereby the first piston is provided with a first piston rod adapted to rotate the drive shaft by means of a swash plate comprising a central assembly with a ring and at least one substantially spherical coupling element disposed on said ring, said coupling element on which the first piston rod or an element attached to the first piston rod is connected being distant from the central axis of a distance, while the second piston is provided with a second piston rod adapted to rotate the drive shaft by means of a swash plate comprising a central assembly with a ring and one or more substantially spherical coupling elements disposed on said ring, said coupling element on which the second piston rod or an element attached to the second piston rod is connected being distant from the central axis of a distance.

[0005] In said engine, the distance between the central axis of the drive shaft and the coupling element for the first piston rod is different from the distance between the central axis of the drive shaft and the coupling element for the second piston rod. By using such embodiment, it was possible to achieve a better linear motion with less vibration and noises.

[0006] While said fuel engine had alredy various advantages, namely a better burning efficiency, a better burning of the fuel while having less noxious gases, a better turbulence of the air or oxygen containing gas / fuel mixture in the combustion chamber, a better filling of the combustion gases and/or a better exhaust of combustion gases, improved wear of the swash plates, reduced vibrational noise, more efficient combustion and movement by the pistons, it has been observed that by using swash plate having a ring portion having a frusto-conical shape, various mechanical advantages could be achieved, enabling a further improvement of noice and vibration problems, especially after a few thousand hours running.

[0007] However, the swash plate was still critical, especially at high rotation speed of the driving shaft.

[0008] The swash plate of the invention is intended to solve this problem.

BRIEF DESCRIPTION OF THE INVENTION

[0009] The invention relates to a swash plate for a fuel engine, said fuel engine comprising at least:

- en enveloppe (7) defining at least space for combustion chambers;
- a drive shaft (29) having a central axis;
- a first combustion chamber (85);
- a first piston (2') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a second piston (2"), said optional second piston being arranged to move along an axis parallel to the central axis of the drive shaft, in which said first piston and said optional second piston (2', 2") share the first combustion chamber (85),
- a second combustion chamber (85');
- a third piston (3') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a fourth piston (3") arranged to move along an axis parallel to the central axis of the drive shaft, in which said third piston and said optional fourth piston (3',3") share the second chamber (85'),
- whereby the first piston and the third piston are provided respectively with a first piston rod (10) and a third piston rod adapted to rotate the drive shaft (29) by means of the swash plate (20),

said swash plate comprising a central assembly (48) associated to a ring (47) provided with at least two substantially coupling elements (19), a first coupling element (19) being connected to the first piston rod (10), while the

second coupling element is connected to the third piston rod, whereby the drive shaft (29) bears said central assembly (48), while the ring (47') is mounted rotative with respect to said central assembly so as to enable a relative rotation of the central assembly and the drive shaft with respect to the ring (47'),
at least one coupling element being provided with an extension adapted to follow a guiding means of the envelloppe,
said central assembly (48) comprising two parts (48A,48B) attached the one to the other, said parts having each a hole, said holes forming when the said two parts are attached together a passage through which the drive shaft (29) extends.

[0010] The swash plate of the invention has the following characteristics :

1. the first part (48 A) comprises :

(a) a substantially cylindrical element (48A1) adapted to be lodged within the central hole (47H) of the ring (47), said cylindrical element having an axis corresponding to the central axis of the central hole of the ring, said cylindrical element having a hole adapted for the passage of a portion of the drive shaft, said hole having an axis forming an angle comprised between 10° and 50° with the axis of the central hole of the ring (47),
(b) a substantially circular plate element (48A2) extending at least partly outside the central hole (47H) of the ring (47),
(c) a tubular protruding element (48A3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47), said protruding element (48A3) having advantageously a free end with a face extending in a plane perpendicular to the central axis of the hole, and
(d) an intermediate element (48A4) extending between the substantially circular plate element and the tubular protruding element, said intermediate element having fins;

2. the second part (48B) comprises :

(a) a substantially circular plate element (48B2) extending at least partly outside the central hole (47H) of the ring (47), and
(b) a protruding element (48B3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47),

3. the elements of the first and second parts are adapted so that the center of gravity of the swash plate is located on the axis of the hole for the drive shaft.

[0011] According to a preferred embodiment, the elements of the first and second parts are adapted so that the center of gravity of the swash plate is located at the intersection point of the axis of the hole for the drive shaft with the axis of the central hole of the ring.

[0012] According to details of preferred embodiments, the swash plate of the invention has one or more of the following characteristics :

1. the substantially circular plate element (48A2) of the first part (48 A) extending at least partly outside the central hole (47H) of the ring (47) has a face contacting an outer face of the ring (47) with interposition with a bearing (49).

2. the substantially circular plate element (48B2) of the second part (48B) extending at least partly outside the central hole (47H) of the ring (47) has a face contacting an outer face of the ring (47) with interposition with a bearing (49).

3. one single piece is formed by the following element of the first part:

the substantially cylindrical element (48A1) adapted to be lodged within the central hole (47H) of the ring (47), said cylindrical element having an axis corresponding to the central axis of the central hole of the ring, said cylindrical element having a hole adapted for the passage of a portion of the drive shaft, said hole having an axis forming an angle comprised between 10° and 50° with the axis of the central hole of the ring (47),
the substantially circular plate element (48A2) extending at least partly outside the central hole (47H) of the ring (47),
the tubular protruding element (48A3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47), and
the intermediate element (48A4) extending between the substantially circular plate element and the tubular protruding element, said intermediate element having fins.

4. one single piece is formed by the following element of the second part:

a substantially circular plate element (48B2) extending at least partly outside the central hole (47H) of the ring (47), and
a protruding element (48B3) having a hole adapted for the passage of a portion of the drive

shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47).

5. the coupling elements are each attached to the ring (47) by means of a radial arm, whereby the axes of said radial arms cross each other in a point located on the axis of the central hole (47H) of the ring (47).

6. the coupling elements are each attached to the ring (47) by means of a radial arm, whereby the axes of said radial arms cross each other in a point located on the axis of the hole of the tubular protrusion.

[0013] The invention relates also to a fuel engine comprising at least:

- en enveloppe (7) defining at least space for combustion chambers;
- a drive shaft (29) having a central axis;
- a first combustion chamber (85);
- a first piston (2') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a second piston (2"), said optional second piston being arranged to move along an axis parallel to the central axis of the drive shaft, in which said first piston and said optional second piston (2', 2") share the first combustion chamber (85),
- a second combustion chamber (85');
- a third piston (3') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a fourth piston (3") arranged to move along an axis parallel to the central axis of the drive shaft, in which said third piston and said optional fourth piston (3',3") share the second chamber (85'),
- whereby the first piston and the third piston are provided respectively with a first piston rod (10) and a third piston rod adapted to rotate the drive shaft (29) by means of the swash plate (20),

said swash plate comprising a central assembly (48) associated to a ring (47) provided with at least two substantially coupling elements (19), a first coupling element (19) being connected to the first piston rod (10), while the second coupling element is connected to the third piston rod, whereby the drive shaft (29) bears said central assembly (48), while the ring (47') is mounted rotative with respect to said central assembly so as to enable a relative rotation of the central assembly and the drive shaft with respect to the ring (47'),
at least one coupling element being provided with an extension adapted to follow a guiding means of the enveloppe,
said central assembly (48) comprising two parts (48A,48B) attached the one to the other, said parts having each a hole, said holes forming when the said two parts are attached together a passage through which the drive shaft (29) extends,
characterized in that the swash plate(s) is/are a swash plate according to the invention.

[0014] Advantageously, the enveloppe forms recesses for receiving tube elements intended to form the combustion chambers in which are moving the pistons. Said envelope has advantageously abutments for avoiding relative movements between the tube elements and the envelope during the movement of pistons inside the tube elements.

[0015] Preferably, the enveloppe is formed by two shells.

[0016] The envelope has advantageously two passages for receiving partly the end of the protruding element (48A3), advantageously with interposition of a bearing.

[0017] According to an embodiment, for each combustion chamber, the engine comprises a pair of pistons arranged to move along parallel axes or co-axially, and two swash plates according to the invention connected to pistons through piston rods, for driving into rotation the drive shaft.

[0018] The invention further relates to the use of an engine according to the invention for generating a power or a driving force.

[0019] Details and characteristics of preferred embodiments, given as example only,will appear from the following description, in which reference is made to the attached drawings.

BRIEF DESCRIPTION OF THE FIGURES

[0020]

Figure 1 is an exploded view of a swash plate of the invention ;
Figure 2 is another exploded view of the swash plate of figure 1 ;
Figure 3 is a perspective view of a swash plate with four coupling elements instead of two, as shown in figures 1 and 2 ;
Figures 4 to 16 are perspective views showing steps for the construction of an engine according to the invention ;
Figure 17 is a view of the engine of figure 16, after removing the upper shell of the envelope;
Figures 18 to 20 are views of a swash plate at different positions ;
Figures 21 to 23 are views showing the position of the two swash plate, but at different positions, and
Figure 24 is a cross section view.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0021] Unless defined otherwise, all technical terms used herein have the same meaning as is commonly understood by one of skill in the art. All publications referenced herein are incorporated by reference thereto. All United States patents and patent applications referenced

herein are incorporated by reference herein in their entirety including the drawings.

[0022] The articles "a" and "an" are used herein to refer to one or to more than one, i.e. to at least one of the grammatical object of the article. By way of example, "a channel" means one channel or at least one channel or more than one channel.

[0023] The recitation of numerical ranges by endpoints includes all integer numbers and, where appropriate, fractions subsumed within that range (e.g. 1 to 5 can include 1, 2, 3, 4 when referring to, for example, a number of pistons, a number of combustion chambers, and can also include 1.5, 2, 2.75 and 3.80, when referring to, for example, distances).

[0024] Fuel means any fuel suitable for engine combustion, including, but not limited to petrol, diesel, oil, gas, methane, propane, etc., and combinations thereof.

[0025] The present invention relates to an engine wherein the pistons are arranged to move along axes parallel to the central axis of the drive shaft,with one single piston moving in each combustion chamber, but preferably in which a pair of pistons share the same combustion chamber, and the linear motion of piston rods rotate the drive shaft by means of two swash plates. Such engines and variations thereof are known the art for example, from EP 0 052 387 and US 4,202,251 which are incorporated herein by reference. Such an engine is referred here as a "parallel piston engine" (PP engine), in view of the parallel arrangement of pistons with respect to the drive shaft.

[0026] For clarity, a technical description of a PP engine follows with reference to the figures. The figures are used only illustrate the description of the PP invention; other designs and configurations of PP engines that can be implemented by the skilled person are within the meaning of a PP engine.

[0027] The PP engine of the invention is advantageously a PP engine of the type disclosed in WO2007/033441, with combustion chambers having excentric portions or with combustion chambers having similar portions in which the pistons are moving. The PP engine of the invention can thus have one or more of the characteristics of the known PP engines.

[0028] The swash plate of figure 1 is a swash plate for a fuel engine, said fuel engine comprising as preferred embodiment, advantageously at least:

- en enveloppe (7) defining at least space for combustion chambers 8,9;
- a drive shaft (29) having a central axis A-A;
- a first combustion chamber (85);
- a first piston (2') moving along an axis parallel to the central axis of the drive shaft (29) and a second piston (2"), said second piston being arranged to move along an axis parallel to the central axis of the drive shaft (29), in which said first piston and said second piston (2', 2") share the first combustion chamber (85),
- a second combustion chamber (85');
- a third piston (3') moving along an axis parallel to the central axis of the drive shaft (29) and a fourth piston (3 ") arranged to move along an axis parallel to the central axis of the drive shaft, in which said third piston and said fourth piston (3',3") share the second chamber (85'),
- whereby the first piston 2' and the third piston 3' are provided respectively with a first piston rod (10) and a third piston rod adapted to rotate the drive shaft (29) by means of the swash plate (20),
- whereby the optional, but preferred second piston 2" and fourth piston 3" are provided respectively with a first piston rod (10) and a third piston rod adapted to rotate the drive shaft (29) by means of the swash plate (20'),

said swash plates 20,20' comprising a central assembly (48) associated to a ring (47) provided with at least two substantially coupling elements (19), a first coupling element (19) being connected to the first piston rod (10) or the second piston rod, while the second coupling element is connected to the third piston rod 10 or the fourth piston rod, whereby the drive shaft (29) bears said central assembly (48), while the ring (47) is mounted rotative with respect to said central assembly so as to enable a relative rotation of the central assembly and the drive shaft with respect to the ring (47),

at least one coupling element 19 being provided with an extension adapted to follow a guiding means 7G of the envelope 7,

said central assembly (48) comprising essentially two parts (48A,48B) attached the one to the other for example by mechanical means or bolts 59, said parts 48A,48B having each a hole, said holes forming when the said two parts are attached together a passage through which a portion of the drive shaft (29) extends.

[0029] The swash plate of the invention has the following characteristics :

1. the first part (48A) comprises :

   (a) a substantially cylindrical element (48A1) adapted to be lodged within the central hole (47H) of the ring (47), said cylindrical element having an axis corresponding to the central axis B-B of the central hole of the ring, said cylindrical element having a hole adapted for the passage of a portion of the drive shaft, said hole in the cylindrical element 48A1 having an axis C-C (when the swash plate is mounted on the drive shaft, the axis C-C corresponds to the axis A-A of the drive shaft 29) forming an angle comprised between 10° and 50° (advantageously between 20° and 40°) with the axis B-B of the central hole of the ring (47),

   (b) a substantially circular plate element (48A2) extending at least partly outside the central hole

(47H) of the ring (47), said plate element being provided with a hole for the passage of a portion of the drive shaft,
(c) a tubular protruding element (48A3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis C-C forming an angle with the axis B-B of the central hole of the ring (47), and
(d) an intermediate element (48A4) extending between the substantially circular plate element and the tubular protruding element, said intermediate element having fins 48A5; said intermediate element being provided with a hole for the passage of a portion of the drive shaft;
(e) the holes of the different elements 48A1,48A2,48A3 and 48A4 are co-axial, so that a portion of the drive shaft can extend through the first part 48A

2. the second part (48B) comprises :

(a) a substantially circular plate element (48B2) extending at least partly outside the central hole (47H) of the ring (47), said plate element being provided with a hole for the passage of a portion of the drive shaft, and
(b) a protruding element (48B3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis C-C forming an angle with the axis B-B of the central hole of the ring (47),
(c) the holes of the elements 48B2,48B3 being co-axial, so that a portion of the drive shaft can extend through the second part 48B.

3. the elements of the first and second parts are adapted so that the center of gravity CG of the swash plate is located on the axis C-C of the holes for the drive shaft.

[0030] Preferably, the elements of the first and second parts are adapted so that the center of gravity of the swash plate is located at the intersection point of the axis C-C of the holes for the drive shaft with the axis B-B of the central hole 47H of the ring 47.

[0031] According to details of preferred embodiments, the swash plate 20 of the invention has one or more of the following characteristics :

1. the substantially circular plate element (48A2) of the first part (48A) extending at least partly outside the central hole (47H) of the ring (47) has a face 48F1 contacting an outer face of the ring (47) with interposition with a bearing (49).

2. the substantially circular plate element (48B2) of the second part (48B) extending at least partly outside the central hole (47H) of the ring (47) has a face 48F2 contacting an outer face of the ring (47) with interposition with a bearing (49).

3. one single piece, for example one single casted piece is formed by the following element of the first part:

the substantially cylindrical element (48A1) adapted to be lodged within the central hole (47H) of the ring (47), said cylindrical element having an axis corresponding to the central axis of the central hole of the ring, said cylindrical element having a hole adapted for the passage of a portion of the drive shaft, said hole having an axis forming an angle comprised between 10° and 50° with the axis of the central hole of the ring (47),
the substantially circular plate element (48A2) extending at least partly outside the central hole (47H) of the ring (47),
the tubular protruding element (48A3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47), and
the intermediate element (48A4) extending between the substantially circular plate element and the tubular protruding element, said intermediate element having fins.

4. one single piece, for example one single casted piece is formed by the following element of the second part:

a substantially circular plate element (48B2) extending at least partly outside the central hole (47H) of the ring (47), and
a protruding element (48B3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47).

5. the coupling elements 19 are each attached to the ring (47) by means of a radial arm 19A, whereby the axes of said radial arms cross each other in a point located on the axis of the central hole (47H) of the ring (47).

6. the coupling elements 19 are each attached to the ring (47) by means of a radial arm, whereby the axes of said radial arms cross each other in a point located on the axis of the hole of the tubular protrusion 48A3.

7. the tubular protrusion has advantageously a length of at least 1cm, such as preferably comprised between 2 and 10cm.

[0032] The invention relates also to a fuel engine as disclosed here above, which can be of the type disclosed in WO2007/033441 or which can be of the type with pair of aligned pistons having co-axial rods.

[0033] Details and characteristics of the engine are for example these disclosed in WO2007/033441.

[0034] Advantageously, the envelope 7 forms recesses 7A,7B for receiving tube elements 85A,85B intended to form the combustion chambers 85',85" in which are moving the pistons 2',2",3',3".

[0035] The envelope 7 is formed by two shells 7E1, 7E2 which are attached together for forming inner chamber for receiving the tube elements, the pistons, the swash plates and the drive shaft, as well as for forming channels 7C for a cooling liquid, and channels for the passage of air into the combustion chambers or for the exhaust of combustion gases.

[0036] The PP engine according to the embodiment comprises an engine block 7 provided with two combustion chambers in each of which a pair of pistons are moving.

[0037] The wall of the combustion chamber or of the tubular elements 85A,85B can in an advantageous embodiment be coated with a ceramic layer or can be made in a ceramic material. Other material, such aluminium containing alloys are also suitable, even if ceramic is preferred. By using tubular elements, it is possible to use another alloy for the shells 7A,7B, than for the tubular elements 85A,85B.

[0038] The number of pistons in a PP engine according to the present invention is preferably a multiple of two e.g. 2, 4, 6, 8, 10, 12, 14 or 16 or even more (number of combustion chambers 1,2,3,4,5,6,7or 8, or even more). In the figures, reference is made to engine with four pistons and two combustion chambers.

[0039] Discussed further below is the PP engine as comprising 2 pairs of cylinders (i.e. 4 pistons).

[0040] The combustion of the fuel mixture in each combustion chamber 85',85" proceeds by known means and is not elaborated here. The ignition can be operated or controlled by a spark plug, by compression, and/or by any other means.

[0041] To transmit a linear movement of a piston to the swash plate, each piston 2', 2", 3' and 3", is rigidly connected to a piston rod 10. The piston rod 10 is associated to a slide block 11 connected to a coupling element 19.

[0042] The pistons 2',2",3',3" transmit force, via rods 10 and slide blocks 11 to the spherical coupling elements 19, pertaining to the swash plates represented by the general reference 20', 20".

[0043] The driving shaft 29 may be coupled to the end of the engine block distal to the flywheel by ball bearing coupling 30, and at the end proximal to the flywheel by means of a smooth bearing 32. The flywheel 33, attached to the latter end of the drive shaft 29 may comprise two coaxial elements 34 and 35 as disclosed in WO2007/033441.

[0044] The ends of the tubular elements 85A,85B are closed by a plug 85P with a central passage for the rod 10. The plug 85B is formed by two parts, which are advantageously identical.

[0045] The pistons 2', 2" and 3', 3" and the slide blocks 11 move in a linear mode, parallel to the central axis A-A of the shaft 29.

[0046] The tubular protrusion 48A3 of the swash plate 20,20' are advantageously associated to a bearing 20B placed in a recess of the envelope 7. This is quite advantageous for avoiding vibrations at high speed.

[0047] The bearing system 49 comprises bearing cylindrical or frustoconical elements having each an axis of symmetry forming an angle comprised between 75° and 105°, advantageously between 75° and 89° and between 91° and 115°.

[0048] For example, the bearing system 49 acting as abutment for the first end 47A of the ring has cylindrical or frustoconical bearing elements with an axis of symmetry forming a first angle y comprised between 75° and 89° with the axis of symmetry of the considered ring, while the bearing system 49 acting as abutment for the second end of the ring has cylindrical or frustoconical bearing elements with an axis of symmetry forming a second angle δ comprised between 75° and 89° with the axis of symmetry Y-Y of the ring, whereby said first and second angle are measured from the side of the axis of symmetry comprising a crossing point CP of the axis of symmetry YY with a line prolongating the frustoconical portion of the ring.

[0049] The ring 47 bears three spherical coupling elements 19 distant the one with respect to the other with an angle of 120°. Each coupling element is attached to the ring by a collar 22. Ring 47 is coupled to a central boss 48', 48" and is able to rotate relative to the boss 48', 48" by way of a first bearing 49 and a second bearing 50 disposed either side of said ring 47. Said first 49 and second 50 bearings are preferably needle bearings. The central boss 48 has a frustoconical portion maintained in position within opening of the ring 47 by a cap element 48A.

[0050] Where the bearings 49, 50 are needle bearings, the cylindrical or frustoconical elements can be made up of two or three coaxial elements. This provision is designed to take account of the variations in angular velocity which these elements undergo when one considers the rotation of the central boss 48 compared to the ring 47.

Wear to the swash plates

[0051] PP engines suffer from wear of the swash plate owing to the forces applied between the joints which translate the lateral movement of the pistons into rotational movement by the drive shaft. Improvements to the design of the swash plate by the present inventor have surprisingly lead to a better distribution of forces within the swash plate bearings, which improvements do not require more heavily engineered components, or more substantial bearings.

[0052] For a swash plate, the ring (47) is mounted rotative along an axis B-B with respect to the central assembly (48) and the drive shaft 29, by means of at least two bearings (49,50), whereby said axis forms an angle with the central axis of the drive shaft (29).

[0053] The axis of rotation B-B (also axis of symmetry of the opening) of the ring 47', 47" forms an angle comprised between 10° and 50°, advantageously between 15° and 40°, preferably about 20°-25° with respect to the central axis of the drive shaft (29).

Lubrication

[0054] The engine of the invention provides advantageously a lubrication system as a series of internal channels provided in the components of the most active joints.

[0055] In the preferred embodiment, the spherical coupling elements of a swash plate, the ring, the connected boss 48',48", the drive shaft 29, seating members 18', the connected piston rod 10, and the piston head comprise one or more internal channels for the passage of lubricating oil. The channels between at least two of the aforementioned components may be connected, where and when appropriate. Where two of the aforementioned components are cooperatively connected and move relative to each other during running of the engine, said components may be configured to temporarily connect where appropriate. Such temporary connection of channels may be achieved, for example, when the respective channels align momentarily as one component moves past the other (e.g. as seen in the movement of the spherical coupling element 19 across the seating member 18')

[0056] The use of ceramic coatings over the surface of joints is preferred, said ceramic coating being used in addition to oil lubrication or as an alternative to oil lubrication. Such coatings are known in the art, and allow reduced-friction movement of joints without the need for lubricant. Ceramics have properties of being hard wearing and resistant to heat, and as such are suited as coatings of engine parts.

Piston rings

[0057] The piston ring can be a piston ring as disclosed in WO2007/033441.

Point of fuel entry

[0058] It has been found that placing the point of entry of the fuel at the interface between the chamber portions facilitates the ideal of the stratified charge i.e. the fuel remains rich in the vicinity of the point of entry, and lean distal thereto; the explosion occurs while the fuel is locally rich, and burns outwards as distal oxygen in the chamber is consumed. The overall fuel mixture is lean, while the explosion is consistent with a rich fuel mix. Furthermore, because fuel is not dispersed, it is not deposited on the pistons so unburned fuel and/or charring are avoided.

Compressor

[0059] Advantageously the engine is provided with a mechanically driven compressor coupled to a ring of a swash plate. A compressor is disclosed in figure 6 of WO2007/033441, said compressor being suitable for injecting a gas mixture into the combustion chamber when required.

[0060] The compressed mix air/fuel of the compression chamber is, for example when reaching a sufficient pressure, then conducted towards a fuel injection point of a burning chamber.

Indented piston surface

[0061] In the preferred embodiments, the pistons have each a piston head surface provided with an indent which is deeper towards the centre of the piston head surface.

[0062] The indent changes the force-receiving characteristics of the piston head surface so that the energy generated by the explosion is more evenly distributed. There is a reduction in sideways knocking, and local wear.

Compression ratio.

[0063] As disclosed in WO2007/033441, the space 38 between elements 34 and 35 of the fly wheel 33 can be changed by the user. The element 34 can be provided with a set of bolts which are configured to move the element 34 away from element 35, so changing the volume of the space 38. By increasing the space 38, through the intermediary of a cylindrical body 39 attached to element 34, the position of the swash plate 20 proximal to the flywheel 33 can be adjusted. The boss 48 of swash plate 20 abuts the transverse face of the cylindrical body 39 which forms a unit with the element 35 of the fly wheel 33. By varying the volume of space 38, the swash plate 20 can be moved in the direction of the arrows 46' or 46" to vary compression between pistons 2,2' and 3, 3'. This adjustment allows the engine to be used with different types of fuel (e.g. petrol, diesel, ethanol, LPG etc).

Turbo pressure

[0064] The engine may be provided with a turbocharger. The turbo charger supplies additional air to the combustion chamber allowing a more efficient fuel combustion.

Cylinder advance

[0065] The timing of pistons can be set so that one piston in an opposing set moves in advance of another. For example, the advance of the piston 2" in the chamber disposed with exhaust ports is more than 0°, such as about 1°, 2°, 3°, 4°, 5°, 6°, 7°, 8°, 9°,10°,11°, 12°,13°,14°,15°,16°,17°,18°,19°, or 20° advanced.

Claims

1. A swash plate for a fuel engine, said fuel engine comprising at least:

    - en enveloppe (7) defining at least space for combustion chambers;
    - a drive shaft (29) having a central axis;
    - a first combustion chamber (85);
    - a first piston (2') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a second piston (2"), said optional second piston being arranged to move along an axis parallel to the central axis of the drive shaft, in which said first piston and said optional second piston (2', 2") share the first combustion chamber (85),
    - a second combustion chamber (85');
    - a third piston (3') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a fourth piston (3") arranged to move along an axis parallel to the central axis of the drive shaft, in which said third piston and said optional fourth piston (3',3") share the second chamber (85'),
    - whereby the first piston and the third piston are provided respectively with a first piston rod (10) and a third piston rod adapted to rotate the drive shaft (29) by means of the swash plate (20),

    said swash plate comprising a central assembly (48) associated to a ring (47) provided with at least two substantially coupling elements (19), a first coupling element (19) being connected to the first piston rod (10), while the second coupling element is connected to the third piston rod, whereby the drive shaft (29) bears said central assembly (48), while the ring (47') is mounted rotative with respect to said central assembly so as to enable a relative rotation of the central assembly and the drive shaft with respect to the ring (47'),
    at least one coupling element being provided with an extension adapted to follow a guiding means of the enveloppe,
    said central assembly (48) comprising two parts (48A,48B) attached the one to the other, said parts having each a hole, said holes forming when the said two parts are attached together a passage through which the drive shaft (29) extends,
    said swash plate being **characterized in that** the first part (48A) comprises : a substantially cylindrical element (48A1) adapted to be lodged within the central hole (47H) of the ring (47), said cylindrical element having an axis corresponding to the central axis of the central hole of the ring, said cylindrical element having a hole adapted for the passage of a portion of the drive shaft, said hole having an axis forming an angle comprised between 10° and 50° with the axis of the central hole of the ring (47),
    a substantially circular plate element (48A2) extending at least partly outside the central hole (47H) of the ring (47),
    a tubular protruding element (48A3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47), whereby said protruding element (48A3) has advantageously a free end with a face extending in a plane perpendicular to the central axis of the hole, and
    an intermediate element (48A4) extending between the substantially circular plate element and the tubular protruding element, said intermediate element having fins;
    in that the second part (48B) comprises :

        a substantially circular plate element (48B2) extending at least partly outside the central hole (47H) of the ring (47),
        a protruding element (48B3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47), said protrucing element having advantageously a length of at least 1cm, preferably comprised between 3cm and 20cm, and
        in that the elements of the first and second parts are adapted so that the center of gravity of the swash plate is located on the axis of the hole for the drive shaft.

2. The swash plate of claim 1, in which the the elements of the first and second parts are adapted so that the center of gravity of the swash plate is located at the intersection point of the axis of the hole for the drive shaft with the axis of the central hole of the ring.

3. The swash plate of claim 1 or 2, in which the substantially circular plate element (48A2) of the first part (48 A) extending at least partly outside the central hole (47H) of the ring (47) has a face contacting an outer face of the ring (47) with interposition with a bearing (49).

4. The swash plate of any one of the preceding claims, in which the substantially circular plate element (48B2) of the second part (48B) extending at least partly outside the central hole (47H) of the ring (47) has a face contacting an outer face of the ring (47) with interposition with a bearing (49).

5. The swash plate of any one of the preceding claims, in which one single piece is formed by the following element of the first part:

    the substantially cylindrical element (48A1) adapted to be lodged within the central hole

(47H) of the ring (47), said cylindrical element having an axis corresponding to the central axis of the central hole of the ring, said cylindrical element having a hole adapted for the passage of a portion of the drive shaft, said hole having an axis forming an angle comprised between 10° and 50° with the axis of the central hole of the ring (47),
the substantially circular plate element (48A2) extending at least partly outside the central hole (47H) of the ring (47),
the tubular protruding element (48A3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47), and
the intermediate element (48A4) extending between the substantially circular plate element and the tubular protruding element, said intermediate element having fins.

6. The swash plate of any one of the preceding claims, in which one single piece is formed by the following element of the second part:

a substantially circular plate element (48B2) extending at least partly outside the central hole (47H) of the ring (47), and
a protruding element (48B3) having a hole adapted for the passage of a portion of the drive shaft (29), said hole having an axis forming an angle with the axis of the central hole of the ring (47).

7. The swash plate of any one of the preceding claims, in which the coupling elements are each attached to the ring (47) by means of a radial arm, whereby the axes of said radial arms cross each other in a point located on the axis of the central hole (47H) of the ring (47).

8. The swash plate of claim 7, in which the coupling elements are each attached to the ring (47) by means of a radial arm, whereby the axes of said radial arms cross each other in a point located on the axis of the hole of the tubular protrusion.

9. A fuel engine comprising at least:

- en enveloppe (7) defining at least space for combustion chambers;
- a drive shaft (29) having a central axis;
- a first combustion chamber (85);
- a first piston (2') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a second piston (2"), said optional second piston being arranged to move along an axis parallel to the central axis of the drive shaft, in which said first piston and said optional second piston (2', 2") share the first combustion chamber (85),
- a second combustion chamber (85');
- a third piston (3') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a fourth piston (3") arranged to move along an axis parallel to the central axis of the drive shaft, in which said third piston and said optional fourth piston (3',3") share the second chamber (85'),
- whereby the first piston and the third piston are provided respectively with a first piston rod (10) and a third piston rod adapted to rotate the drive shaft (29) by means of the swash plate (20),

said swash plate comprising a central assembly (48) associated to a ring (47) provided with at least two substantially coupling elements (19), a first coupling element (19) being connected to the first piston rod (10), while the second coupling element is connected to the third piston rod, whereby the drive shaft (29) bears said central assembly (48), while the ring (47') is mounted rotative with respect to said central assembly so as to enable a relative rotation of the central assembly and the drive shaft with respect to the ring (47'),
at least one coupling element being provided with an extension adapted to follow a guiding means of the enveloppe,
said central assembly (48) comprising two parts (48A,48B) attached the one to the other, said parts having each a hole, said holes forming when the said two parts are attached together a passage through which the drive shaft (29) extends,
characterized in that the swash plate(s) is/are a swash plate according to any one of the claims 1 to 8.

10. The engine of claim 9, in which the enveloppe forms recesses for receiving tube elements intended to form the combustion chambers in which are moving the pistons, said envelope having advantageously abutments for avoiding relative movements between the tube elements and the envelope during the movement of pistons inside the tube elements.

11. The engine of claim 9 or 10, comprising for each combustion chamber a pair of pistons arranged to move along parallel axes or co-axially, and comprising two swash plates according to any one of the claims 1 to 8 connected to pistons through piston rods, for driving into rotation the drive shaft.

12. The engine of claim 9 or 10 or 11, in which the envelope has two passages for receiving partly the end of the protruding element (48A3), advantageously with interposition of a bearing.

13. Use of an engine according to any one of the preceding claims for generating a power or a driving force.

14. A fuel engine comprising at least:

- en enveloppe (7) defining at least space for combustion chambers;
- a drive shaft (29) having a central axis;
- a first combustion chamber (85);
- a first piston (2') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a second piston (2"), said optional second piston being arranged to move along an axis parallel to the central axis of the drive shaft, in which said first piston and said optional second piston (2', 2") share the first combustion chamber (85),
- a second combustion chamber (85');
- a third piston (3') moving along an axis parallel to the central axis of the drive shaft (29) and optionally a fourth piston (3") arranged to move along an axis parallel to the central axis of the drive shaft, in which said third piston and said optional fourth piston (3',3") share the second chamber (85'),
- whereby the first piston and the third piston are provided respectively with a first piston rod (10) and a third piston rod adapted to rotate the drive shaft (29) by means of the swash plate (20),

said swash plate comprising a central assembly (48) associated to a ring (47) provided with at least two substantially coupling elements (19), a first coupling element (19) being connected to the first piston rod (10), while the second coupling element is connected to the third piston rod, whereby the drive shaft (29) bears said central assembly (48), while the ring (47') is mounted rotative with respect to said central assembly so as to enable a relative rotation of the central assembly and the drive shaft with respect to the ring (47'),
at least one coupling element being provided with an extension adapted to follow a guiding means of the enveloppe,
said central assembly (48) comprising two parts (48A,48B) attached the one to the other, said parts having each a hole, said holes forming when the said two parts are attached together a passage through which the drive shaft (29) extends,
in which the enveloppe forms recesses for receiving tube elements intended to form the combustion chambers in which are moving the pistons, said envelope having advantageously abutments for avoiding relative movements between the tube elements and the envelope during the movement of pistons inside the tube elements.

15. The engine of claim 14, **characterized in that** the swash plate(s) is/are a swash plate according to any one of the claims 1 to 8.

16. The engine of claim 14 or 15, comprising for each combustion chamber a pair of pistons arranged to move along parallel axes or co-axially, and comprising two swash plates according to any one of the claims 1 to 8 connected to pistons through piston rods, for driving into rotation the drive shaft.

17. The engine of claim 14 or 15 or 16, in which the envelope has two passages for receiving partly the end of the
protruding element (48A3), advantageously with interposition of a bearing.

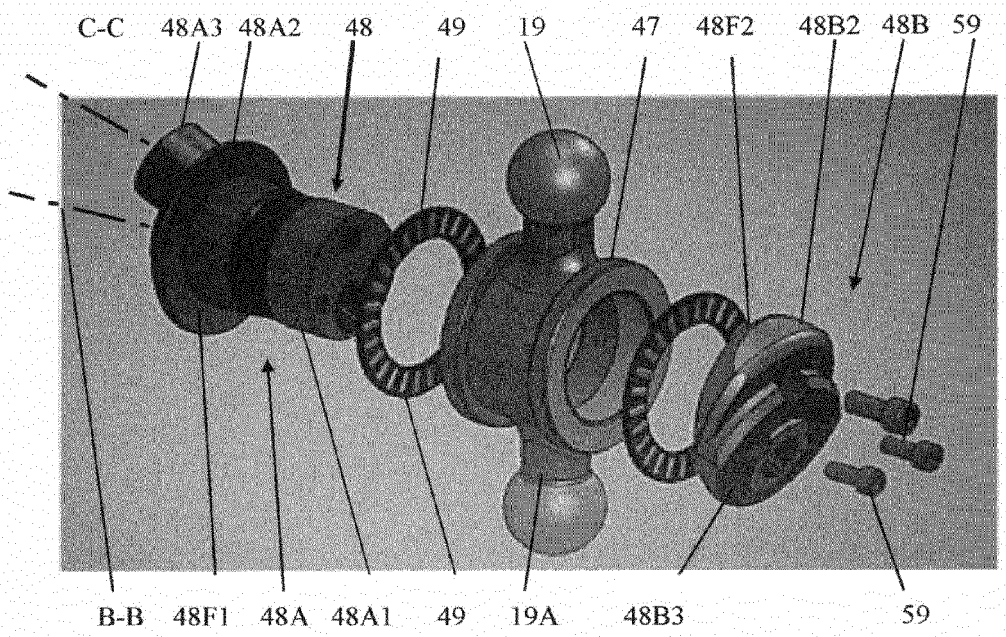


Figure 1

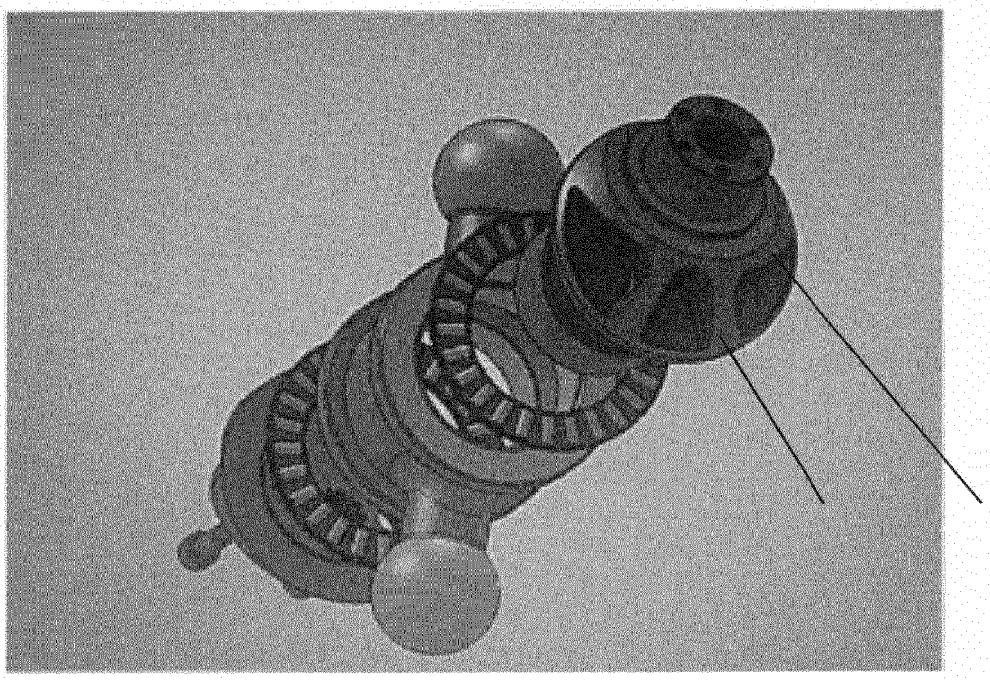
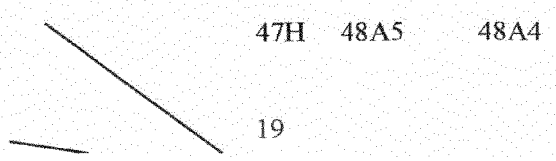
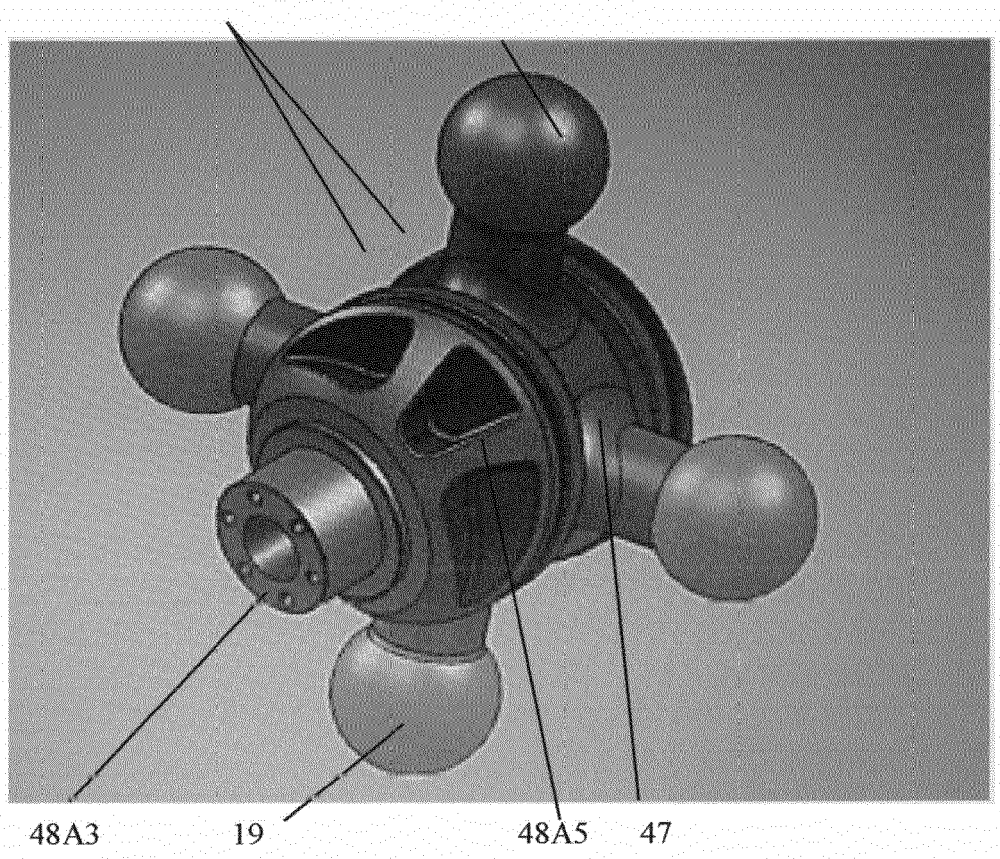


Figure 2





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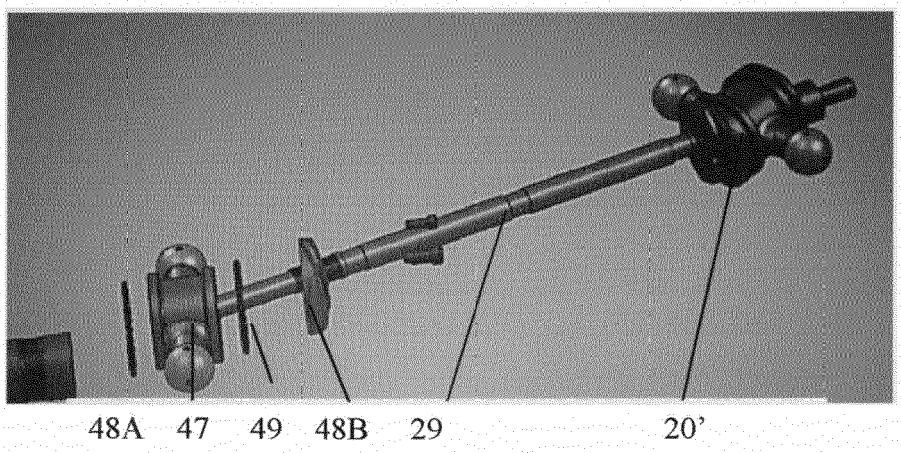

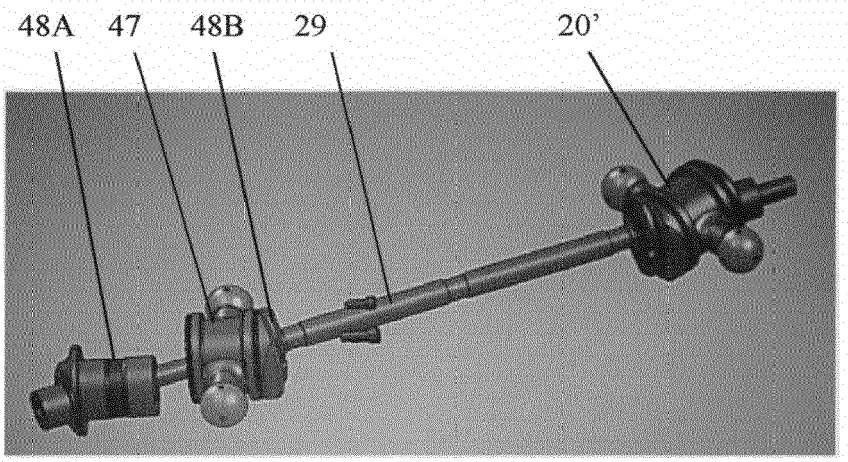

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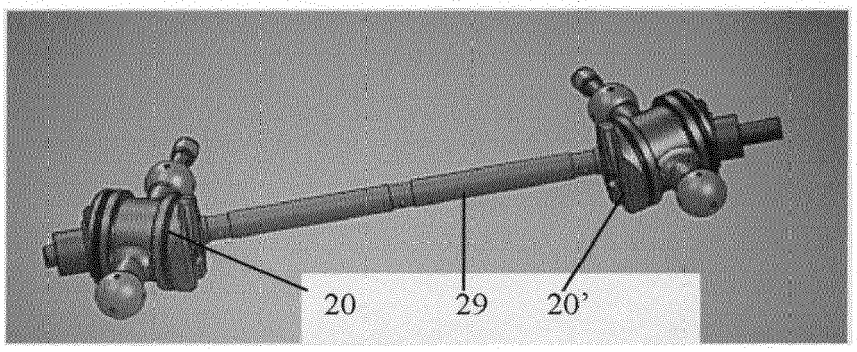

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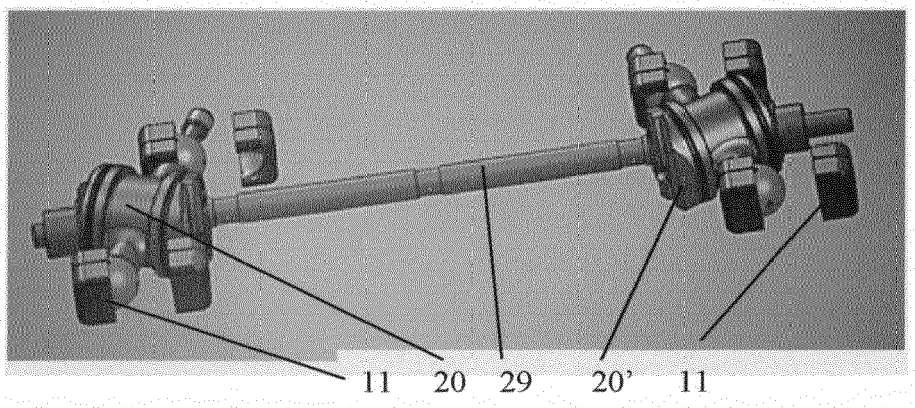

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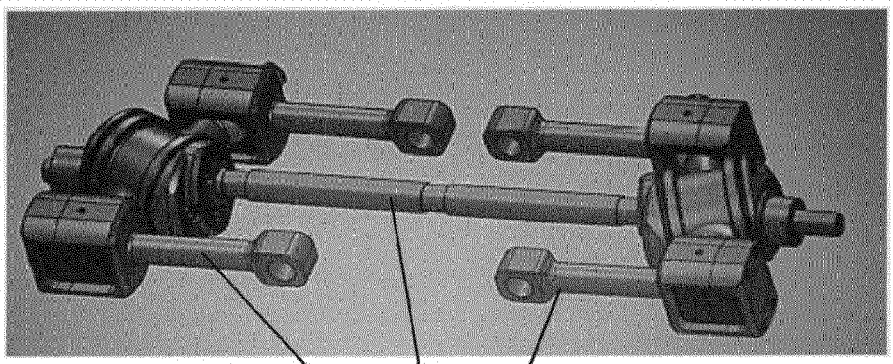

Figure 8

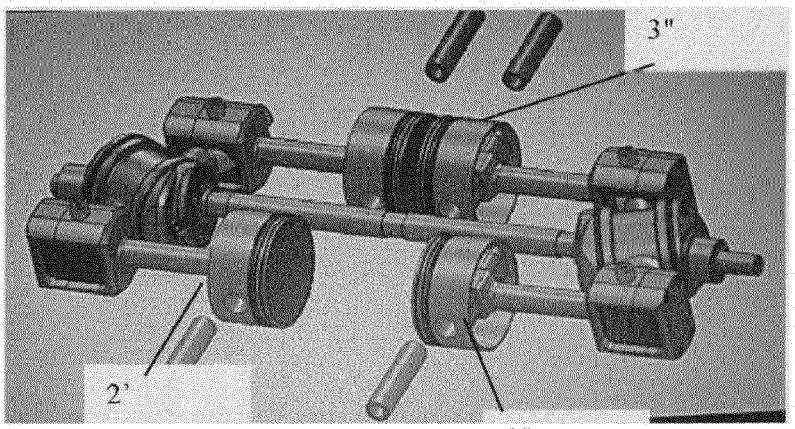

Figure 9

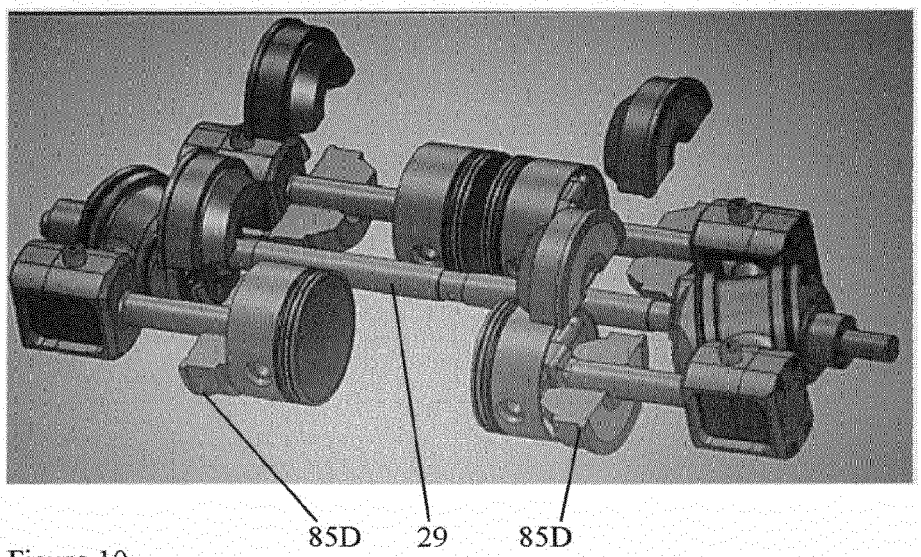

Figure 10

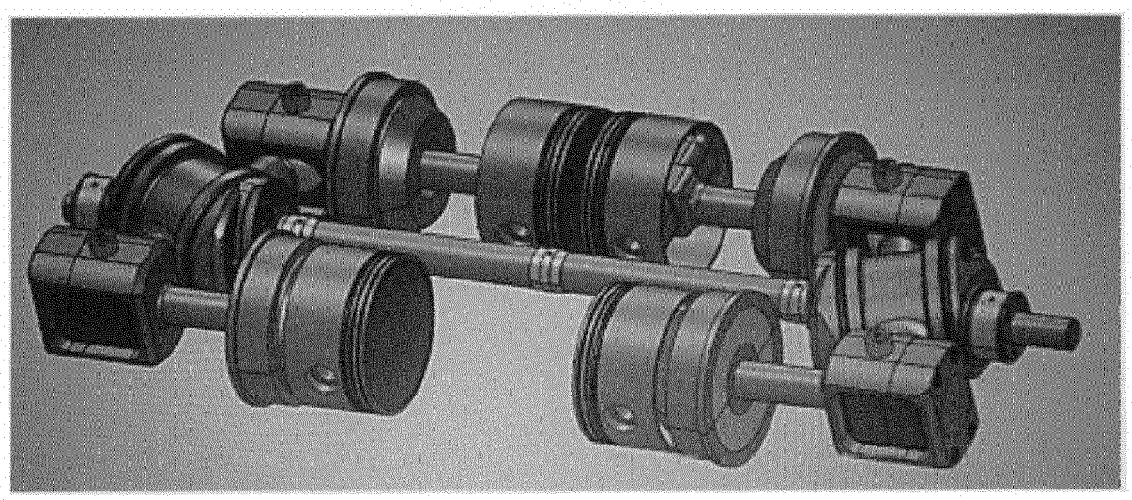

Figure 11

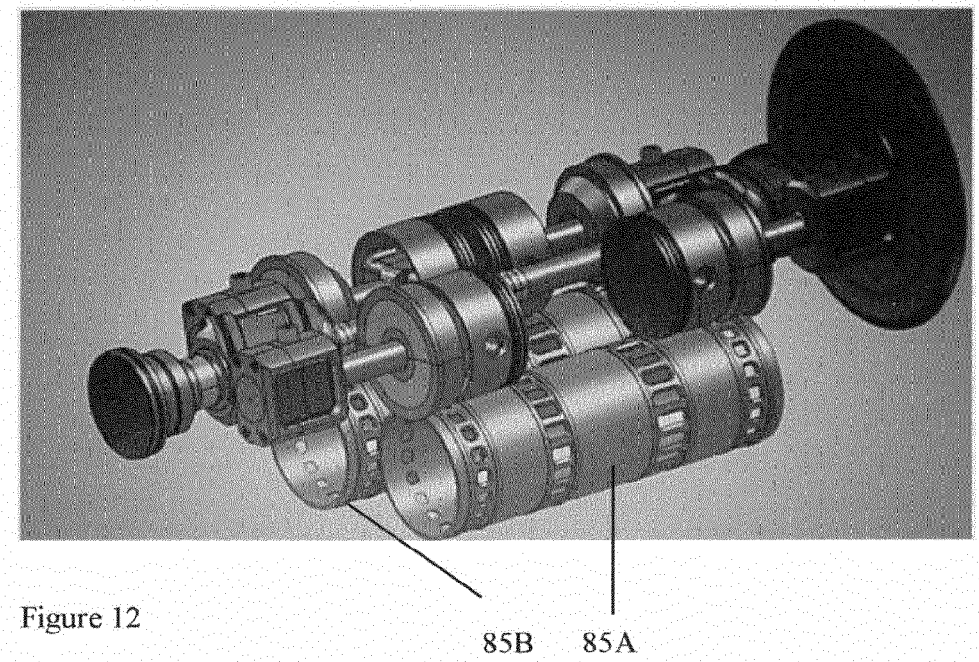

Figure 12

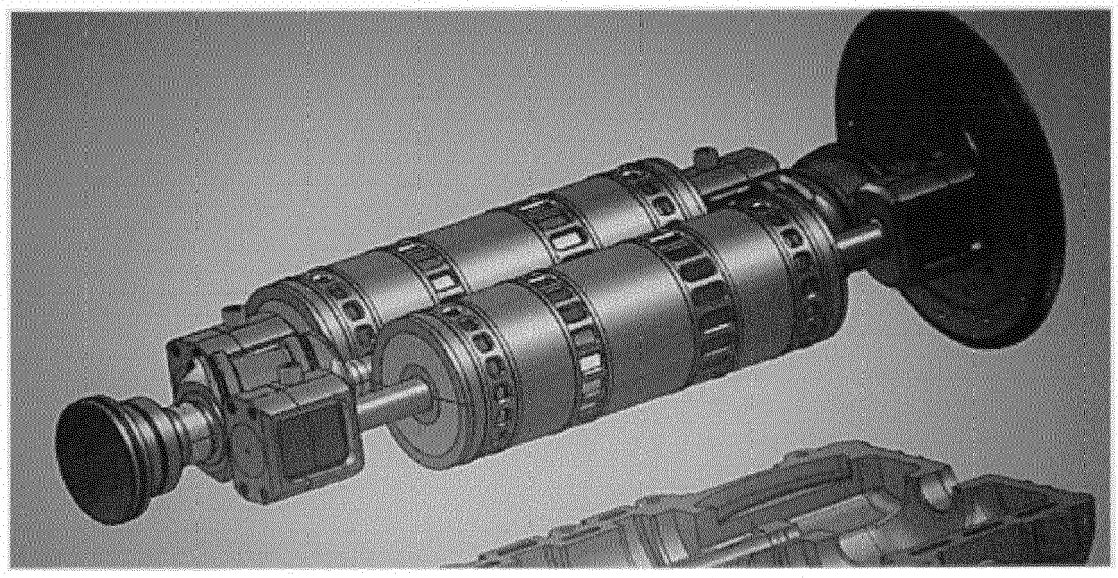

Figure 13

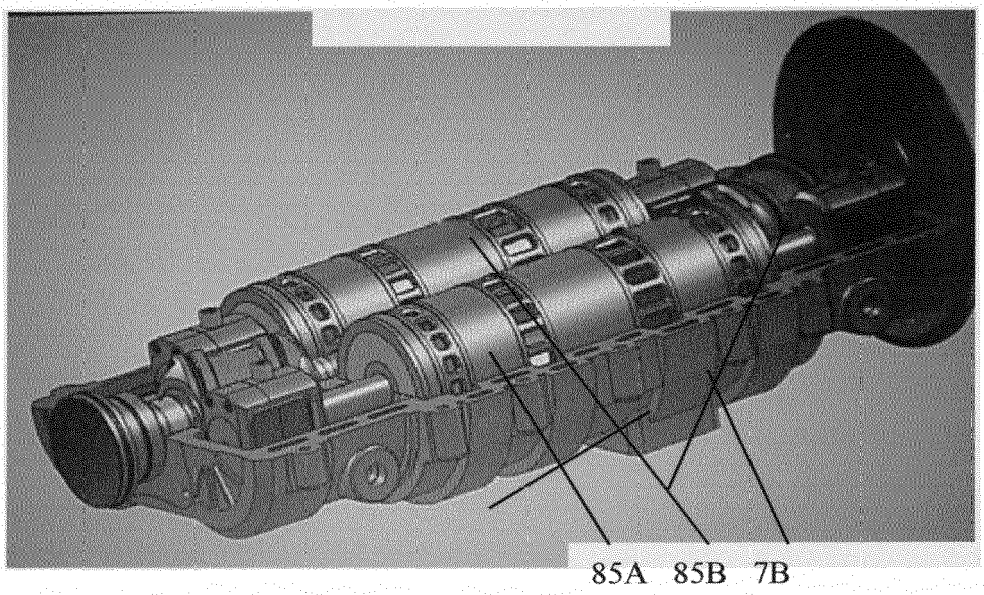

Figure 14

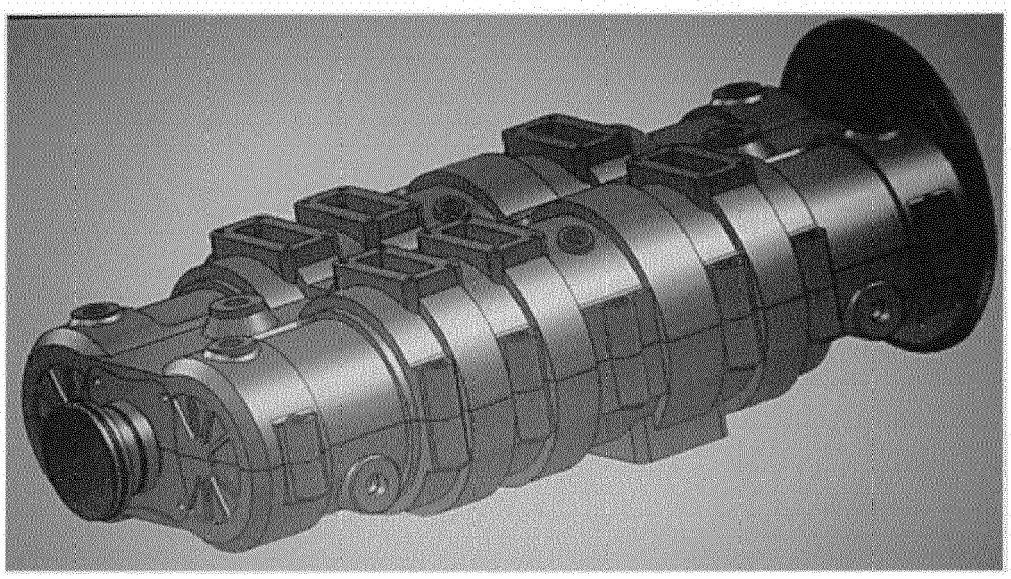

Figure 15

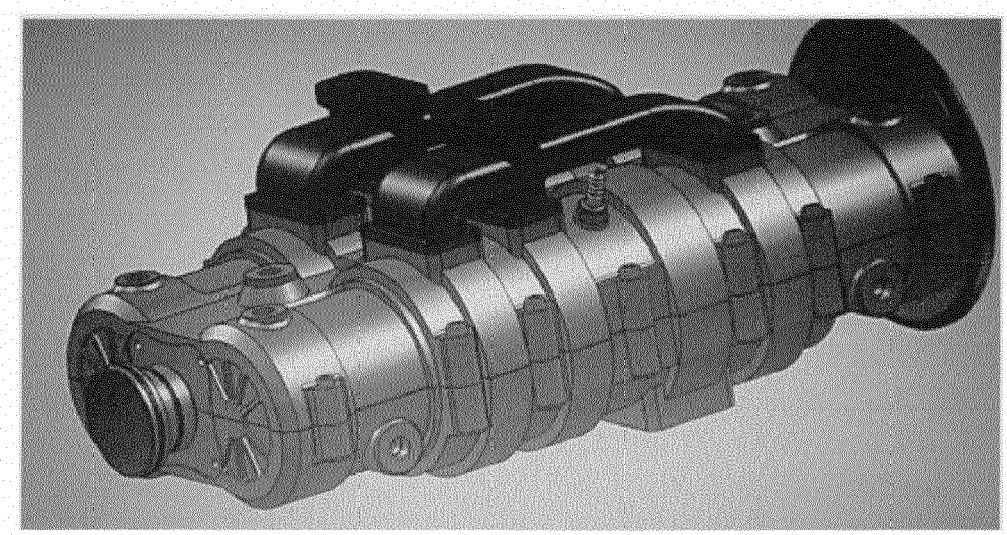

Figure 16

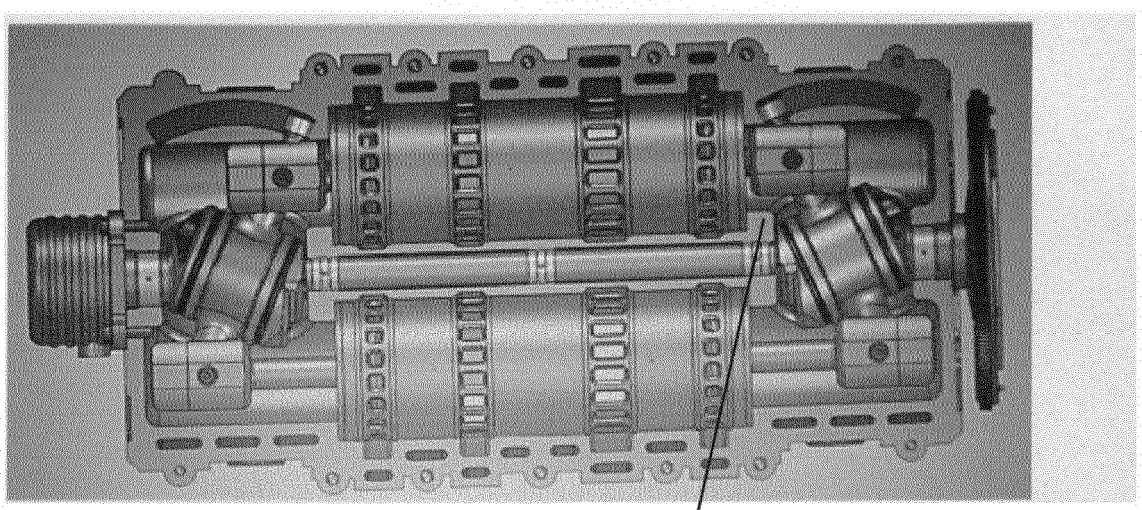

Figure 17

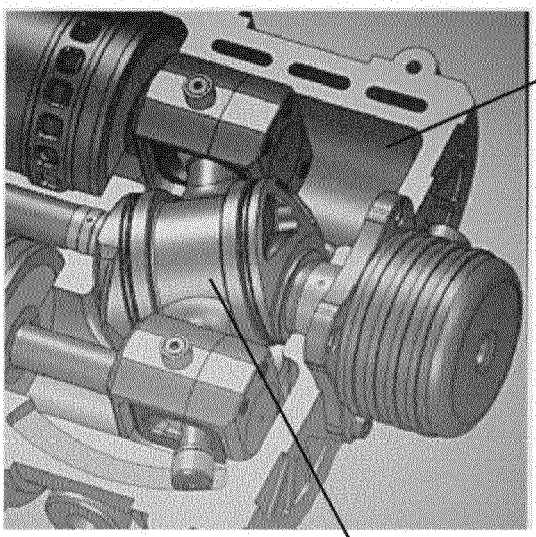

Figure 18

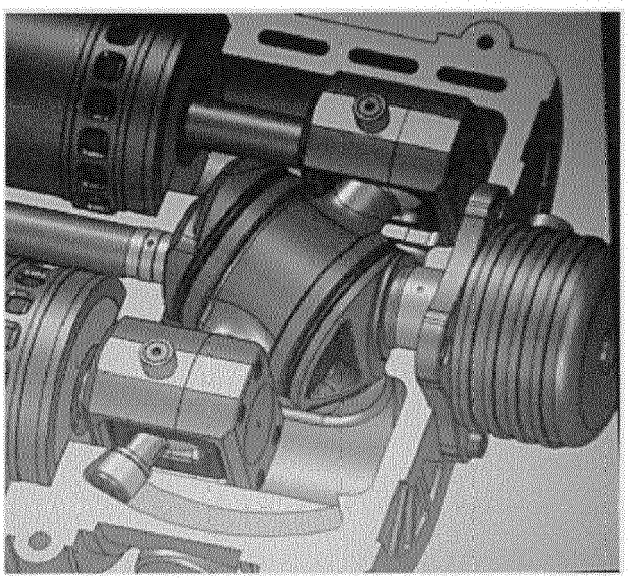

Figure 19

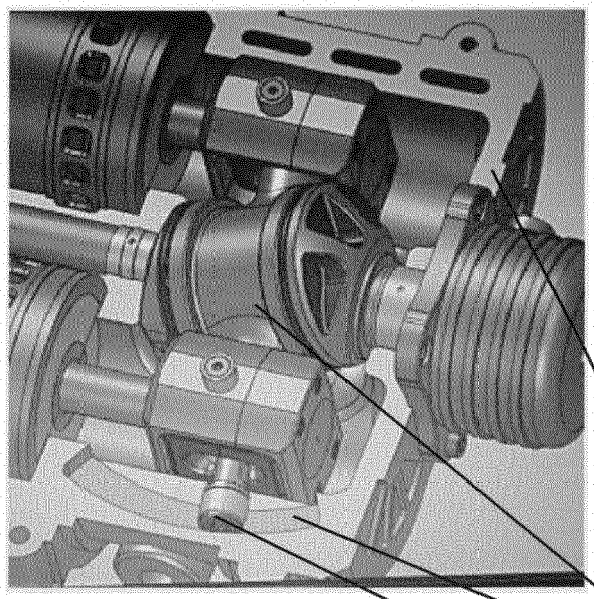

Figure 20

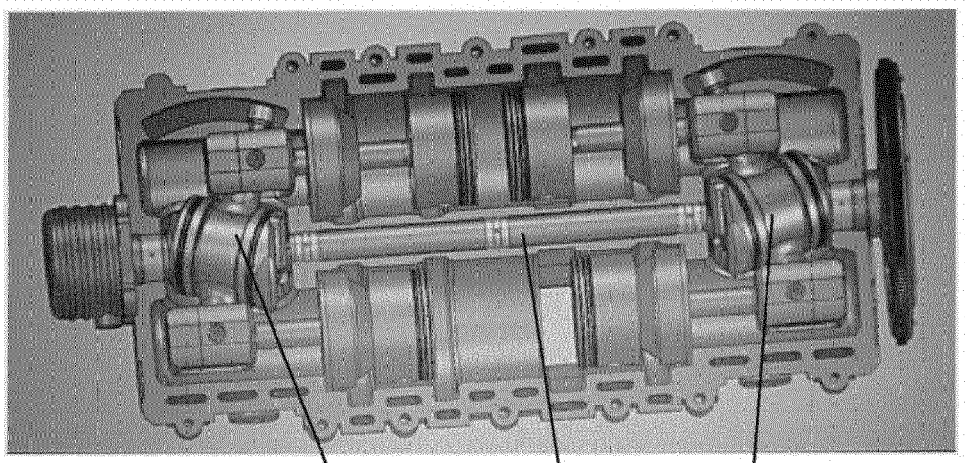

Figure 21

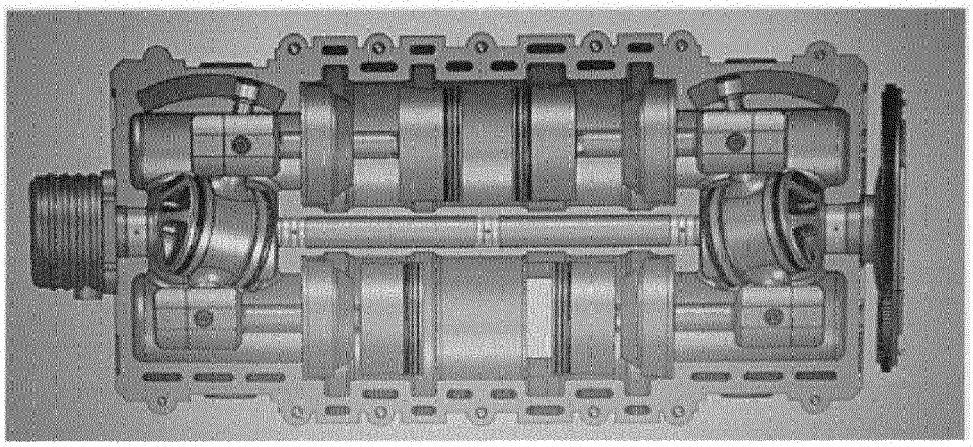

Figure 22

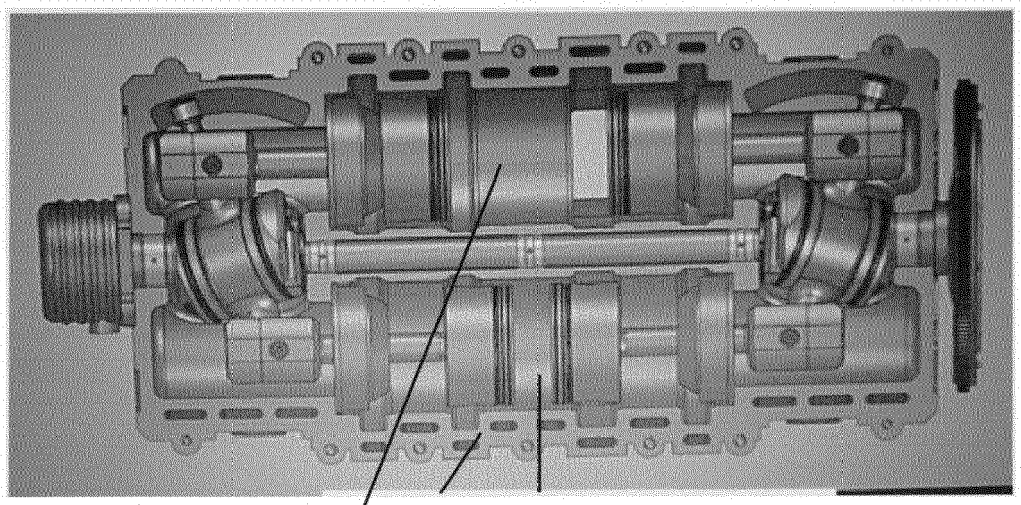

Figure 23

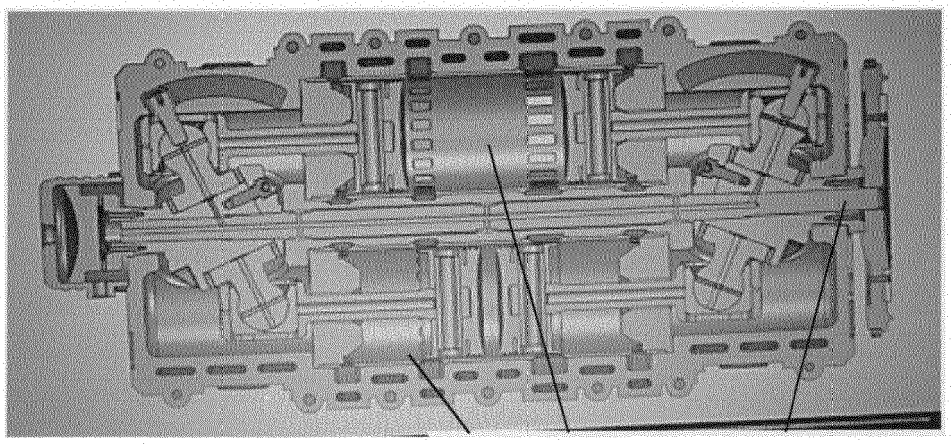

Figure 24

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EUROPEAN SEARCH REPORT

Application Number
EP 15 07 5001

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-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 July 2015	Paulson, Bo

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EUROPEAN SEARCH REPORT

Application Number
EP 15 07 5001

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 July 2015	Paulson, Bo

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L : document cited for other reasons

& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 07 5001

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23-07-2015

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