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54 **Rotary axial piston internal combustion engine.**

57 The present invention relates to an axial piston rotary internal combustion engine which comprises an engine casing (1), of cylindrical shape, able of rotating about its axis (a-a) and defining, in its inside, at least two cylindrical chambers (3) wherein respective pistons (4) can reciprocate, the piston rods (5) of the pistons (4) being operatively coupled to a rotary disk (7) which is slanted with respect to the engine axis (a-a) and is slidingly supported by a fixed disk (12) in turn coupled to a fixed shaft (13) projecting from the engine casing (1).

Ducts (25, 30) are moreover provided for the inlet and outlet of the fuel mixture into/from the combustion cylindrical chambers (3), as well as sparking plugs (22) for igniting the fuel mixture.

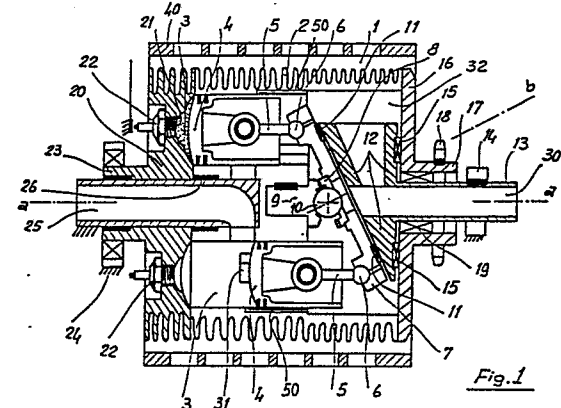


Fig. 1

Description

ROTARY AXIAL PISTON INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

The present invention relates to an axial piston internal combustion rotary engine, of the two-stroke Otto cycle type.

As is known, internal combustion engines and, in particular, the Otto cycle and Diesel internal combustion engines, generally comprise a fixed engine casing in the inside of which there are defined adjoining cylindrical chambers therein pistons are able of reciprocating, said pistons driving the engine crankshaft.

These conventional internal combustion engines have the drawback of generating great inertial reversing forces, because of the great moving masses which generate great vibrations and which, accordingly, must be properly balanced: this balancing operation, on the other hand, is a very complex job since it requires that counterrotating shafts or the like be used.

Moreover, a conventional internal combustion engine has a comparatively high size and weight, as well as a comparatively complex mechanical construction.

Another drawback of conventional internal combustion engines is that they have a low fuel efficiency with a consequent rather high operating cost.

SUMMARY OF THE INVENTION

Accordingly, the task of the present invention is to overcome the above mentioned drawbacks, by providing an internal combustion engine which operates in a very even way, without vibrations, independently from the engine RPM's and with very reduced discharging gas amounts.

Within the scope of the above task, a main object of the present invention is to provide an improved internal combustion engine which has a very simple and strong mechanical construction, with a very reduced weight and size with respect to a conventional internal combustion engine and which can be constructed by simple machine tools.

Another object of the present invention is to provide an internal combustion engine in which the distribution of the outlet gases can be easily controlled by easily and simply changing the angular position of the gas discharging duct, during the operation of the engine, with respect to its angular speed.

Still another object of the present invention is to provide an internal combustion engine comprising a scavenging supplying pump able of eliminating any outlet fumes.

Still another object of the present invention is to provide an internal combustion engine with very reduced transversal stresses and which, moreover, can be easily constructed starting from easily available components and materials and having a very reduced cost.

According to one aspect of the present invention, the above task and objects, as well as yet other

objects, which will become more apparent hereinafter, are achieved by an axial piston internal combustion engine having the features claimed in claim 1.

Other features of the subject internal combustion engine being defined in the sub-claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Further characteristics and advantages of the present invention will become more apparent hereinafter from the following detailed description of preferred, though not exclusive, embodiments of an axial piston internal combustion engine which is illustrated, by way of an indicative but not limitative example, in the accompanying drawings, in which:

Figure 1 is an axial cross-sectional view illustrating the internal combustion engine according to the present invention;

figure 2 illustrates a variation of the internal combustion engine of fig.1, provided with opposite cylindrical chambers;

figure 3 shows another possible embodiment of the invention, of improved efficiency, and including outwardly eccentrically directed combustion chambers;

figure 4 is a cross-sectional view taken along the line IV-IV of figure 3 and illustrating, in a detailed way, an engine casing provided with centrifugal fins;

figure 5 shows a piston rod element, included in the internal combustion engine according to the present invention, in which the piston is coupled to said piston rod element by means of an improved ball joint;

figure 6 is a detail view, in a broken away form, illustrating a possible arrangement of a piston ring included in the internal combustion engine according to the invention; and

figure 7 is a schematic view illustrating the general outline of an internal combustion engine according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the figures of the accompanying drawing, the axial piston internal combustion engine according to the present invention comprises an engine casing 1, of substantially cylindrical shape, which, on its side surface, is provided with cooling fins 2.

Advantageously, said cooling fins 2 are of the centrifugal type, as clearly shown in figure 3.

The engine casing 1 defines, in its inside, at least two cylindrical chambers 3 which, in the embodiment being disclosed, are symmetrically arranged with respect to the axis of the engine casing and are substantially parallel thereto.

Inside the mentioned cylindrical chambers 3 there are arranged respective sliding pistons 4, provided with respective piston rods 5 adapted to connect said pistons, through ball joints 6, to suitable seats

formed on a rotating disk 7 which is slanted with respect to the axis a-a of the engine casing 1.

More specifically, the rotary disk 7 is able of rotating about an axis b which, advantageously, forms with the axis a-a an angle from 20° to 25°.

The disk 7 rotates with the same angular speed as the engine casing, since it is coupled, by means of two bevel gears 8 and 9, having a like number of teeth (transmission ratio of 1:1) which are respectively rigid with the disk 7 and engine casing 1, and therebetween a coupling ball is arranged, indicated at 10.

In particular the rotary disk 7 is coupled, through a first thrust bearing 11, to a fixed slanted disk 12 the shaft 13 of which projects from the engine casing 1 and is connected to a fixed point of the frame, schematically indicated at 14.

Second thrust bearings 15 are moreover provided, which are arranged between the rear face of the fixed disk 12 and the cover member 16 which axially closes the cylindrical casing 1.

The cover member 16 defines a sleeve 17 therewith a gear 18 is rigid, said gear 18 providing a force takeoff for operating auxiliary members.

There is moreover provided a supporting bearing 19 arranged between the sleeve 17 and fixed shaft 13.

The engine casing is closed at the front by a cylinder head 20, which defines the mentioned combustion chambers 21, the number of which is obviously equal to the cylinder number, therein conventional sparking plugs 22 are arranged.

From the cylinder head 20 a front stub 23 projects, which is associated with a front fixed supporting member 24.

Through the front stub 23 a discharging duct 25 extends which, in the embodiment being disclosed, is fixed or stationary and is coupled to the engine casing 1 by means of bushings 26.

Likewise, the fuel mixture inlet duct, indicated at 30, is defined inside the shaft 13 of the mentioned fixed disk 12.

Transfer channels 31 are moreover provided which communicate the engine crankcase, defined by the region housing said fixed or stationary disk, with the top portion of the cylindrical chambers 3.

The disclosed embodiment of the internal combustion engine according to the present invention operates as follows, in a very simple way.

More specifically, as the engine casing is rotated about the axis a-a, the pistons 4, which are coupled to the slanted rotary disk 7, rotate about the axis b thereby performing a reciprocating motion with respect to their cylindrical chambers 3 in which the operating volumes varies in a conventional way, as in two-stroke combustion engine.

With reference to figure 1, as the piston 4 arranged at the top is at its top dead point, it will have compressed the fuel mixture which will be ignited by the spark plug 22: thus the expansion phase will start, with the lower piston 4 arranged at its bottom dead point position in which there are performed the fuel mixture discharging and filling phases, according to a conventional Otto cycle for a two-stroke engine.

The fuel mixture, in particular, is metered by a

conventional carburetor and is supplied, under a slight pressure, to the inlet duct 30 by means of a conventional positive displacement or centrifugal compressor, which has not been shown in the accompanying drawings.

The fuel mixture, through the inlet duct 30, enters the engine crankcase 32 and therefrom, through the transfer ducts 31, arrives at the cylindrical chambers 3.

It should be apparent that the piston 4 arranged at the top dead center will be displaced to the bottom dead center position, after a rotation through 180°, to return to the top dead center position again after a further rotation through 180°: in this way there is obtained an explosion of the mixture for each revolution of the engine, for each piston.

In this connection it should be apparent that the driving motion of the pistons is a rotary motion about the mentioned axis a-a: accordingly their absolute motion, that is the sum of the relative motion and driving motion of the pistons will be a rotary motion about the axis a. In this way the inertial forces will act on a constant plane which is perpendicular to the axis b, thereby said forces do not generate any objectionable moments, since they act according to the same direction (which is true for an even cylinder number); however, also in the case of an odd number of angularly equispaced cylinders a very satisfactory balancing will be obtained.

As a consequence, the vibrations, for all of the RPM's of the engine, will be completely absent for an even cylinder number, whereas in the case of an odd cylinder number an optimal dynamical balancing will be obtained.

With reference to figure 2 another embodiment of the internal combustion engine is herein shown, in which there are provided opposite cylindrical combustion chambers in which double acting pistons 4 reciprocate, said pistons being connected to the mentioned rotary slanted disk 7 so as to rotate about the axis b, through ball joint indicated at 6.

The inlet duct 30, in particular, extends through the overall axial extension of the engine casing 1, and outlet ports, indicated at 25', are provided through the engine casing and lead to the outlet manifold in such a way as to afford the possibility of controlling the outlet gases with an asymmetric outlet diagram; in this way the fresh outlet gas loss will be smaller than the fresh outlet gas loss of conventional two-stroke engines.

In this connection it should be moreover pointed out the longitudinal axis of the piston 4 is slightly displaced, by an amount e, from the longitudinal pivot axis of the ball joints 6, in order to prevent said piston from rotating about its longitudinal axis.

As shown in figure 1, an outer envelope is further provided, indicated at 40, which is provided with aerating holes to easily cool the engine which is further improved by the provision of the mentioned centrifugal fins 2 shown in figures 4 and 7.

As shown in figure 1, the internal combustion engine according to the present invention also includes a duct 50 for recovering the lubricating oil deposited on the inner walls of the cylindrical chambers 3; thus said lubricating oil will be

conveyed to the engine crankcase, thereby satisfactorily lubricating the engine, even with a reduced oil amount in the fuel mixture.

In this connection it should be apparent that a Pitot tube can be used for recovering the excess oil.

With reference to figure 3, another improved efficiency embodiment of the internal combustion engine according to the present invention is herein shown.

More specifically, this improved efficiency has been obtained by arranging the combustion chambers 21 of the engine at outward eccentric positions, as is clearly shown.

In this case, owing to the centrifugal force, the fuel mixture will be concentrated on the top portion, thereby automatically providing a "layered charge" effect, with a consequent improving with respect to a less emission of CO at the outlet; in this way a more ecologic engine is obtained.

With reference to figure 4, which is a cross-sectional view taken along the line IV-IV of fig.3, the outlet duct 25 provides "an asymmetric controlled outlet" since it, being suitably arranged on its axis a-a, prevents the fresh mixture from leaking at the outlet, with a consequent less consume.

Another feature of the invention is that it is possible to change the angular position of the outlet duct 25, during the operation of the engine, depending on the angular speed thereof, for example by means of a pneumatic system analogous to that for varying the spark advance angle in conventional engines or, preferably, by means of any known types of electronic systems.

Figure 5 shows a partial view of a piston rod member, included in the internal combustion engine according to the present invention, which piston rod member connects the piston to the slanted disk 7, by means of an improved ball joint assembly, indicated at GS.

As shown, the ball joint assembly of figure 5 comprises a ball member 61 which is peripherically provided with a recess 62 therein a pawl 60 engages, said pawl being rigid with the mentioned slanted disk 7.

Thus the pawl 60 will prevent the piston rod 5 from rotating about the longitudinal axis c-c; in this connection it should be pointed out that the pawl 60 is a conventional small roller of the type used in roller bearings.

At its other end the piston rod 5 is coupled to the piston (not specifically shown in fig. 5) by means of a further ball joint, the so-called "UNIBALL" joint 65, said ball joint also providing for the use of a pawl member 63 which, by coupling with the ball 64, prevent the piston pin from also rotating about the axis c-c.

In this connection it should be pointed out that the mentioned pawls 60 and 63 have their main axes which pass through the center of the respective balls 61 and 64.

Thus, in the above disclosed embodiment, the pistons cannot rotate, in an advantageous way, about their longitudinal axes and, accordingly, the piston rings will be safely protected against failure.

In order to prevent the piston from failing,

moreover, the invention provides for the use, as specifically shown in the detail view of figure 6, of specifically designed piston rings such as the piston ring shown in figure 6.

As is shown in this figure, the piston ring which has been represented by a broken away view and is indicated overall at ST, does not have as in conventional piston rings, a transversal cut with a hollow adapted to act as a stop element for the piston ring, but it is provided with a male/female flat type of coupling; thus the piston ring ST will be free of rotating in its seat about the longitudinal axis of the piston and it cannot be broken as the male/female coupling registers with the cylinder outlet or transfer ports.

Figure 7 shows a schematic view of the outer outline or configuration of the internal combustion engine according to the present invention.

In a really constructed prototype the engine had a swept volume of 250 cc, five cylinders and an outer diameter of 160 mm, a length of 230 mm and a weight of 6.5 kg.

From the above disclosure it should be apparent that the invention fully achieves the intended task and objects.

In particular the discharging fumes are completely absent since the lubricating oil included in the fuel mixture is centrifuged on the outer wall of the cylinders so as to lubricate the mantles of the pistons and is then automatically recovered, by a pressure differential, to the engine crankcase through the duct 50; accordingly the fuel mixture lubricating oil rate or amount will be very reduced.

Thus, the internal combustion engine according to the present invention is much more ecologic than the known comparable internal combustion engines.

This inventive engine, moreover, provides the following additional advantages: a complete absence of vibrations for any RPM's of the engine; an efficient control of the distribution of the discharged or outlet gases; a charge layering effect and, finally, a reduced work requirement for the positive displacement or centrifugal compressor or scavenging pump thereby improving the engine efficiency.

Also the engine fluodynamics is improved since the inlet fluid column A, for an even RPM condition, is not interrupted as in conventional 2-stroke engines.

Moreover the subject engine will operate in a very even way and one can change the speed of the compressor associated therewith since this engine operates with a very low pressure of 0.2-0.3 atm. with a consequent variable power outlet.

Finally, the transversal thrust forces on the cylinder, which are generated by a slanted piston rod in conventional engines, in this case are completely absent since the piston rod 5 of the engine according to the present invention will work in a nearly axial position, that is parallelly to the axis a-a.

Claims

1- An internal combustion engine, of the axial piston type, characterized in that it comprises an engine casing, of cylindrical shape, able of rotating about its axis and defining, in its inside, at least two cylindrical chambers therein corresponding pistons reciprocate, the piston rods of said pistons being operatively coupled to a rotary disk, slanted with respect to the axis of said engine casing and slidingly supported by a stationary disk, said stationary disk being coupled to a stationary shaft projecting from said engine casing, duct members being moreover provided for the inlet and outlet of the fuel mixture into/from said combustion chambers, said engine further including spark plugs for igniting said fuel mixture.

2- An internal combustion engine according to the preceding claim, characterized in that said pistons are coupled to said rotary disk by their piston rods, said piston rods being coupled to said rotary disk through a respective ball joint.

3- An internal combustion engine according to claim 2, characterized in that each ball joint comprises a ball having a peripheral hollow therein a pawl is engaged adapted to prevent said piston rod from rotating about its longitudinal axis.

4- An internal combustion engine according to claim 1, characterized in that the other end of each said piston rod is coupled to the piston body through a further ball joint including a pawl adapted to prevent the piston pin from rotating about said axis.

5- An internal combustion engine, according to the preceding claims, characterized in that said rotary disk is rotatively rigid with said engine casing through two bevel gears respectively coupled to said rotary disk and engine casing, a thrust ball member being arranged between said two bevel gears.

6- An internal combustion engine according to one or more of the preceding claims, characterized in that it comprises first thrust bearings arranged between said slanted rotary disk and said slanted stationary disk, as well as second thrust bearings arranged between said slanted stationary disk and a cover member closing said engine casing.

7- An internal combustion engine, according to one or more of the preceding claims, characterized in that it comprises, on said cover member closing said engine casing, a force takeoff gear.

8- An internal combustion engine according to one or more of the preceding claims, characterized in that said outlet duct axially extends at the from cylinder head of said engine and it is stationary and coupled to said engine casing through bushing members.

9- An internal combustion engine, according to one or more of the preceding claims, characterized in that said outlet duct is formed inside the shaft extending from said slanted stationary disk.

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10- An internal combustion engine according to one or more of the preceding claims, characterized in that said outlet duct has a variable angular position, said angular position being varied, during the operation of said engine, depending on the angular speed thereof, by a pneumatic system and/or an electronic system.

11- An internal combustion engine according to one or more of the preceding claims, characterized in that it comprises transfer ports formed in said cylindrical chambers communicating with the engine crankcase defined inside said engine casing at the region of said slanted stationary disk.

12- An internal combustion engine according to one or more of the preceding claims, characterized in that it comprises an outer envelope provided with aerating holes.

13- An internal combustion engine according to one or more of the preceding claims, characterized in that it comprises axially opposite combustion cylindrical chambers affecting a slanted rotary disk arranged at an intermediate position, said fuel mixture inlet duct axially extending through the overall length of said engine and outlet ports being formed through the side surface of said engine casing.

14- An internal combustion engine according to one or more of the preceding claims, characterized in that said cylindrical chambers extend in parallel relationship with the axis of said engine casing.

15- An internal combustion engine according to one or more of the preceding claims, characterized in that said chambers are arranged at outward radial eccentric positions.

16- An internal combustion engine according to one or more of the preceding claims, characterized in that with each piston there are associated piston rings which are free of rotating about the piston longitudinal axis.

17- An internal combustion engine according to one or more of the preceding claims, characterized in that it comprises a lubricating oil recovering duct for recovering lubricating oil deposited on the inner walls of said cylindrical chambers, said lubricating oil being conveyed to said crankcase so as to fully lubricate said engine.

18- An internal combustion engine according to any preceding claims, characterized in that it comprises centrifugal cooling fins.

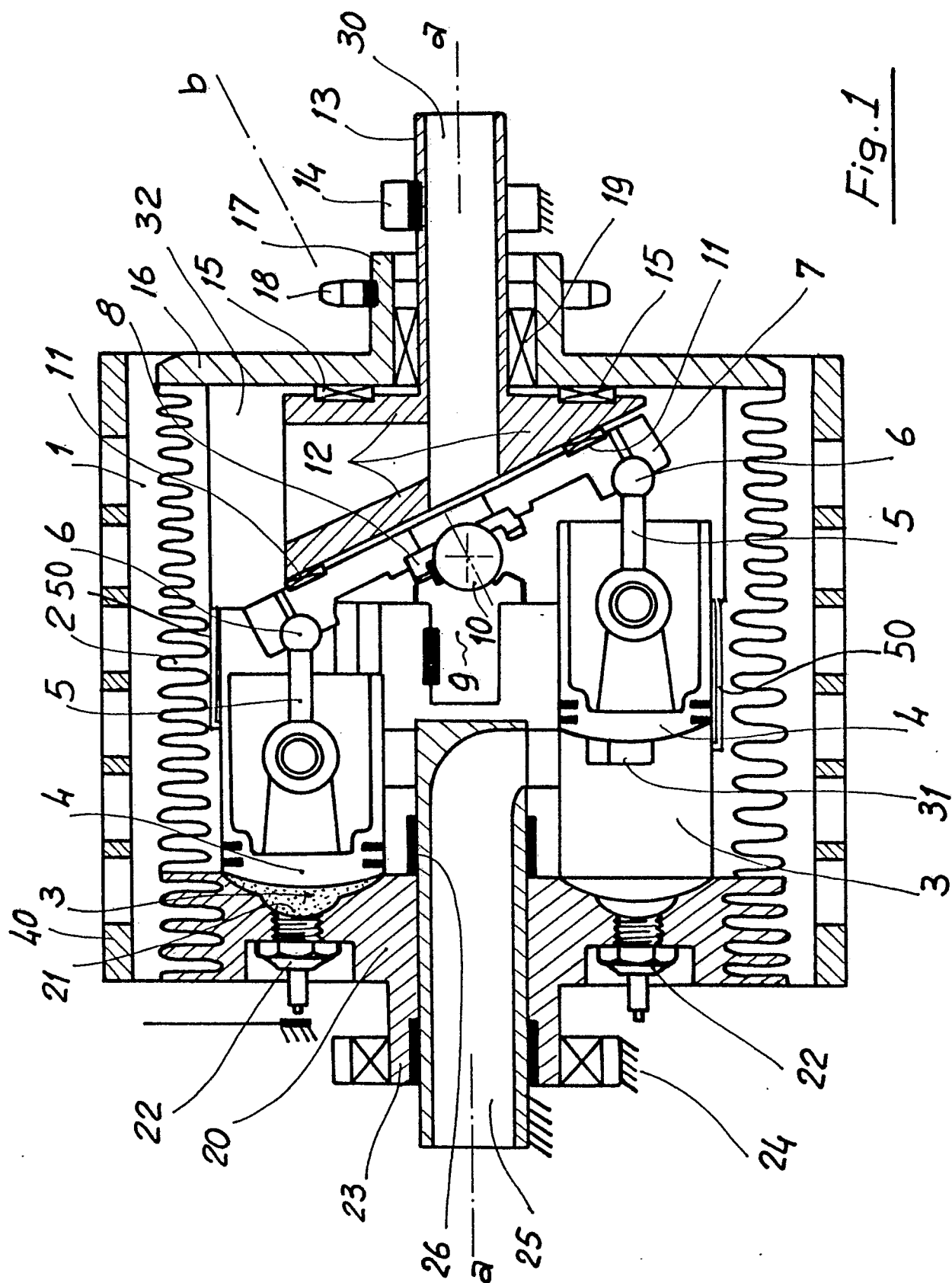
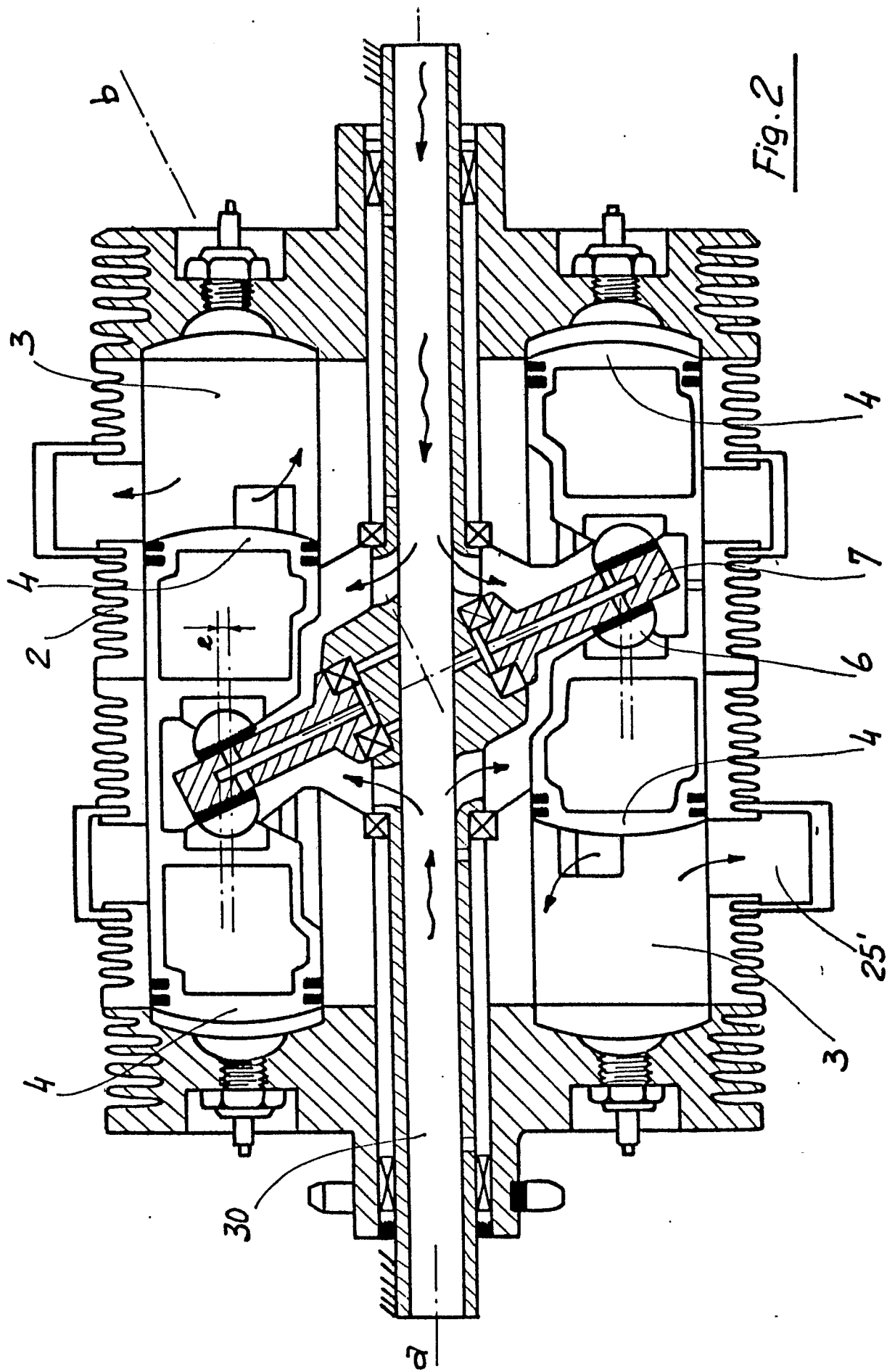
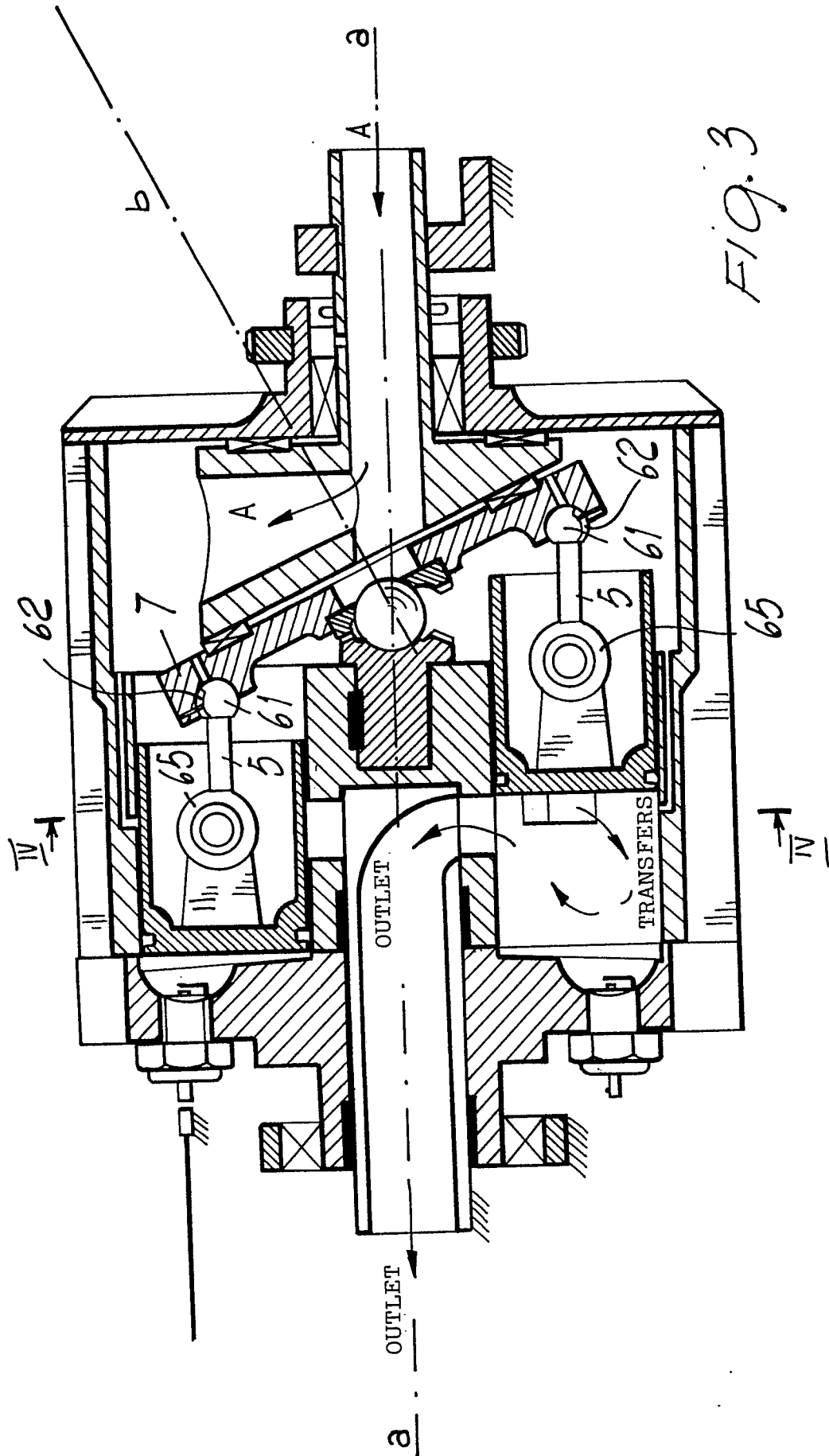


Fig. 1





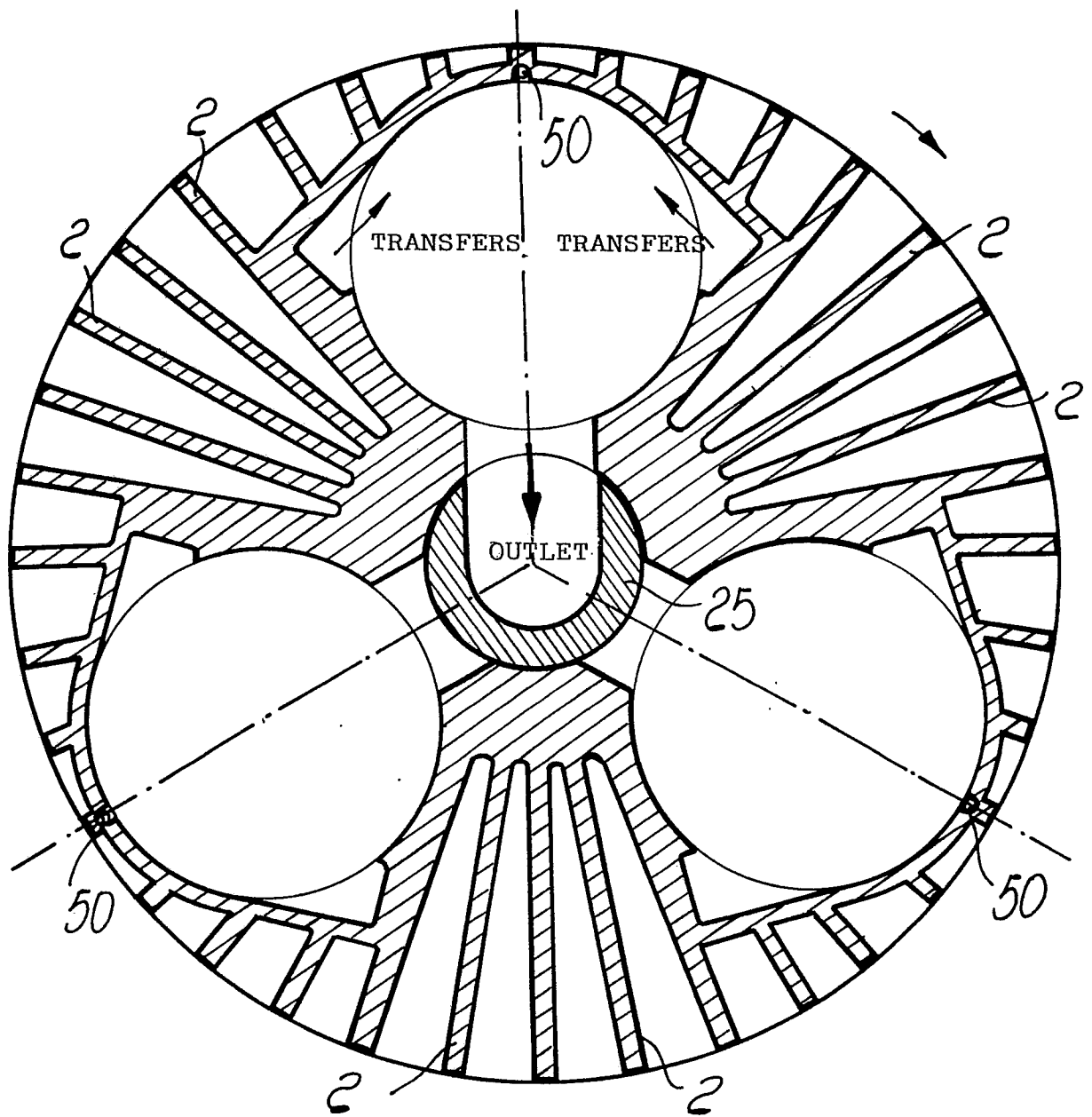


FIG. 4

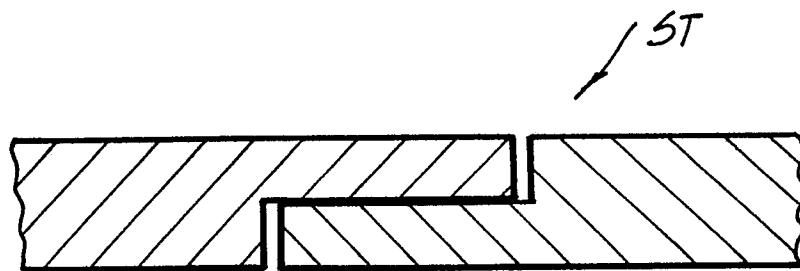


FIG. 6

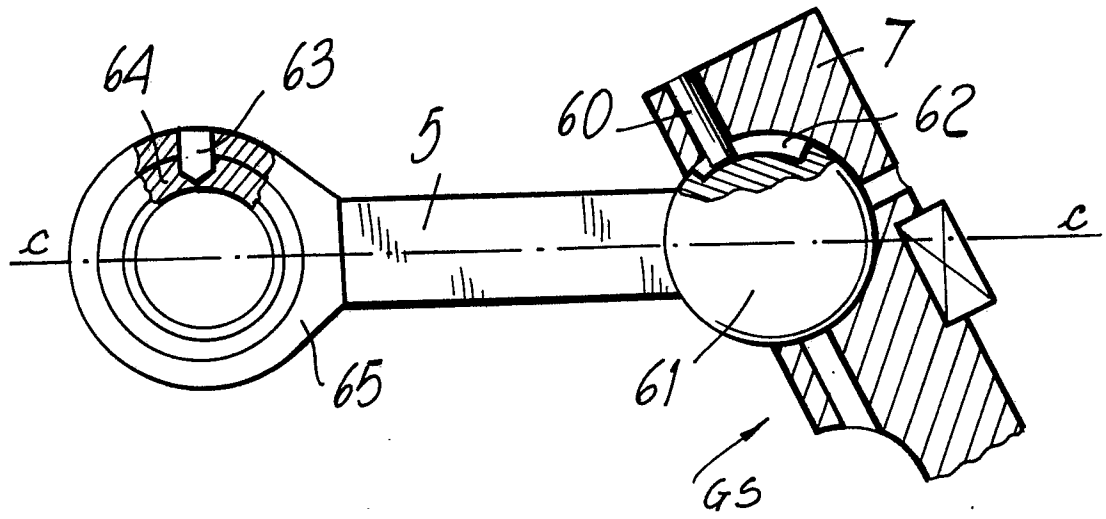


FIG. 5

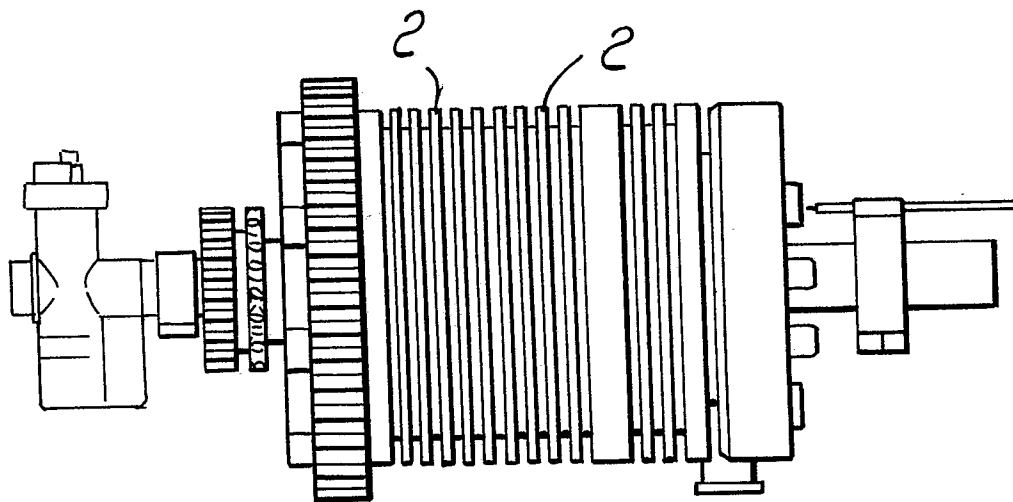


FIG. 7



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 83 0148

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	GB-A-2 027 122 (J. SEARLE) * page 1, line 48 - page 3, line 82; page 4, lines 20-29; figures 1-5d *	1,10,14 -16,18	F 01 B 3/00 F 02 B 75/26
X	FR-A- 582 878 (SUREL) * page 2, line 56 - page 5, line 76; figures 4-9 *	1,7,11, 14,15, 18	
Y	---	6,13	
X	CH-A- 66 925 (STATAX) * page 2, column 1, line 26 - page 4, column 1, line 16; figure 3 *	1,7,14, 15,18	
X	DE-A-2 707 163 (DAUBNER) * page 6, lines 4-36; page 10, lines 15-32; page 15, lines 1-25; page 17, lines 18-24; figures 1,2,23-25 *	1,2,12, 14,15, 18	
Y	---	5,8,9	
Y	GB-A- 590 800 (HAYTHORN et al.) * abstract; figure 1 *	8,9	
Y	AU-B- 59 178 (HART-SMITH) (1965) * page 18, line 22 - page 20, line 33; page 25, line 11 - page 26, line 5; figures 8,23-28 *	5,13	TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 01 B 3/00 F 02 B 75/00
Y	DE-C- 571 089 (VOITH) * page 2, lines 37-72; figure 1 *	6	
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 07-07-1988	Examiner NORDSTROEM U. L. N.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			