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(54) Title: SINGLE-VANE PUMP

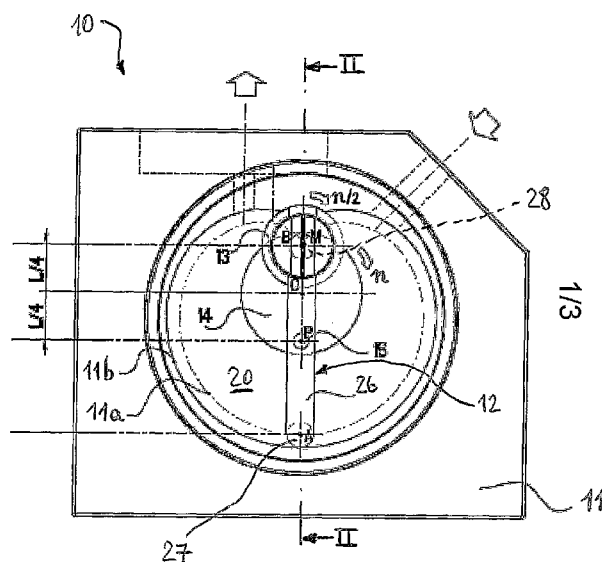


Fig.1

(57) Abstract: The invention relates to a single-vane pump comprising a stator (11), a first rotor (13) mounted in the chamber (20) of the stator and capable of rotating around an axis (M-M) and a vane (12) slidably mounted in a diametric groove (30) of the rotor (13) and having a rectilinear portion (26) having a predetermined length (L) and opposite free ends (22, 24) in contact with a perimetric surface (lib) of the chamber (20). A second rotor (14) is mounted in the chamber (20) and is capable of rotating around an axis (O-O) which is parallel to the axis (M-M). The vane (12) is pivoted to the rotor (14), at a longitudinal middle area thereof, on an axis (P-P) parallel to the axis (M-M). The distance between the axis (M-M) and the axis (O-O) and between the axis (P-P) and the axis (O-O) is equal to a fourth of the length (L) of the rectilinear portion (26) of the vane (12). The perimetric surface (lib) of the chamber (20) has, in a plane perpendicular to the axis (M-M), a cardioid shape that coincides with the cardioid defined by the ends (22, 24) of the vane (12) during the rotation of the rotors (13, 14).

Single-vane pump**DESCRIPTION**

The present invention relates to a single-vane pump.

5 In particular, the invention relates to a single-vane vacuum pump for a motor vehicle engine, such a vacuum pump being intended to create a predetermined depression for activating and operating specific devices provided in the motor vehicle, like for example the servo-brake of a brake system.

10 Throughout the present description, reference will be made, in particular, to a vacuum pump. However, it should be understood that what is said also applies, more generally, to different types of pumps.

15 A single-vane vacuum pump generally comprises a stator, a chamber defined inside the stator, a rotor mounted inside the chamber and a vane mounted on a diametric groove of said rotor and free to slide in such a groove.

20 The rotor is mounted eccentrically in the chamber and it is tangent at one point to the perimetric surface of the chamber. Such a perimetric surface has - in a plane perpendicular to the rotation axis of the rotor - a substantially elliptical shape.

25 The rotation of the rotor causes the vane to move in rotation around the rotation axis of the rotor and to translate inside the diametric groove, so that the opposite free ends of the vane are in slithering contact on the perimetric surface of the chamber, typically with a very high load factor. The value of the load factor is high even with low values of the rotation speed of the rotor, due to
30 the high value of the instantaneous working radius of the vane.

Therefore, a single-vane vacuum pump configured in the way

schematically described above has the drawback of not being very suitable for operating at high rotation speeds, because of the high wearing at the opposite free ends of the vane. In other words, the reliability of the single-
5 vane vacuum pump described above becomes critical when the rotor is made to rotate at a high rotation speed. The Applicant has found that the aforementioned drawback occurs in particular in single-vane vacuum pumps in which the rotor is dragged directly by the drive shaft of the engine
10 of the motor vehicle. Such a drawback substantially prevents the rotor of the aforementioned single-vane vacuum pump from being dragged by a counter-rotating balance shaft of the engine of a motor vehicle, because there would be a further multiplication of the number of revolutions of the
15 engine.

The technical problem at the basis of the present invention is that of overcoming, or at least minimising, the drawbacks mentioned above with reference to the prior art.

The present invention, therefore, relates to a single-vane
20 pump, in particular a vacuum pump for a motor vehicle engine, having the features recited in claim 1.

Preferred features are recited in the other claims.

In the present patent application, "cardioid" is used to indicate the mathematical curve described by a point of a
25 circumference which rolls without slithering outside a second circumference having the same radius. Being R the radius of the circumference, the equation of the cardioid in polar coordinates (ρ, θ) is:

$$\rho = 2R (1 + \cos \theta).$$

30 Advantageously, the Applicant has found that the single-vane pump according to the invention can be used without drawbacks in those applications in which the rotor is dragged at high rotation speeds, since the opposite free ends of the vane always remain tangent to the perimetric

surface of the chamber without slithering on said surface. Consequently, the problem correlated to the wearing of the ends of the vanes is extremely reduced, this problem being on the contrary always present, to a greater or lesser extent depending on the specific solution which is implemented, in single-vane vacuum pumps of the prior art.

Further characteristics and advantages of the present invention shall become clearer from the following detailed description of a preferred embodiment thereof, given with reference to the attached drawings and as a non limiting example. In such drawings:

- figure 1 is a schematic plan view from above of a single-vane vacuum pump according to the present invention, without an upper cover so as to show the chamber of the stator;

- figure 2 is a top side schematic view of a section, taken at the plane II - II, of the vacuum pump of figure 1 provided with the aforementioned upper cover;

- figure 3 is a schematic drawing of a segment AB the ends of which describe a cardioid;

- figure 4 is a schematic plan view from above of the single-vane vacuum pump of figure 1, wherein it is highlighted a comparison between the displacement of a single-vane vacuum pump according to the prior art (area with single broken line) and of the displacement of the vacuum pump according to the invention (area with a single broken line and area with a double broken line);

- figure 5 is an exploded schematic perspective view of the single-vane vacuum pump of figure 1.

With initial reference to figures 1, 2, 4 and 5, a single-vane vacuum pump in accordance with the invention is shown. This pump is wholly indicated with reference number 1 and, in particular, it is suitable for being used in a motor

vehicle engine.

The vacuum pump 10 comprises a stator 11 in which a chamber 20 is defined. A rotor 14 is mounted in the chamber 20 and is capable of rotating around a first rotation axis O-O. A
5 vane 12 is mounted on the rotor 14 and has opposite free ends 22, 24 which are in contact with a perimetric surface 11b of said chamber 20.

The perimetric surface 11b has, in a plane perpendicular to the first rotation axis O-O, substantially the shape of a
10 cardioid defined as described below.

The vane 12 comprises a rectilinear portion 26 having a predetermined length L (line A-B in figure 1) and opposite end portions 27, 28 having a substantially semi-circular section, with a predetermined radius r and respective
15 centres in A and B. In the example of the figures, the rectilinear portion 26 of the vane 12 has a thickness equal to twice the predetermined radius r of the portions 27, 28.

The vane 12 is rotatably connected to the rotor 14 at the longitudinal middle area thereof through a pin 15 which has
20 a pivot axis P-P parallel to the rotation axis O-O. The distance between the pivot axis P-P and the rotation axis O-O defines an eccentricity equal to a fourth of the length L of the rectilinear portion 26 of the vane 12.

The vacuum pump 10 comprises a further rotor 13 also housed
25 inside the chamber 20 and having a diametric groove 30 for the sliding of the vane 12. The rotor 13 is capable of rotating around a rotation axis M-M parallel to the rotation axis O-O. The distance between the rotation axis O-O and the rotation axis M-M is equal to the
30 aforementioned eccentricity, i.e. equal to a fourth of the length L of the rectilinear portion 26 of the vane 12.

The rotor 14 and the rotor 13 are selectively drivable in rotation. The rotor that is driven in rotation drags in rotation the other rotor.

The kinematism of the single-vane vacuum pump 10 described above is schematised in figure 3. In such a figure, the segment AB (that corresponds to the rectilinear portion 26 of length L of the vane 12) is hinged in the point P, at the middle of the segment AB, and is forced to slide inside a slide S (which corresponds to the diametric groove 30 of the rotor 13) rotating around M (corresponding to the rotation axis M-M of the rotor 13).

If the point P (corresponding to the pivot axis P-P of the vacuum pump 10) is driven in rotation around O (corresponding to the rotation axis O-O of the rotor 14) on a circumference with radius OP, it is geometrically demonstrated that the two ends of the segment AB describe a cardioid 11a when the following dimension ratios are respected:

$$L = AB$$

$$OM = OP = L/4$$

$$PA = PB = L/2$$

Being $\rho = MP + PA = MA$ and θ the angle formed between a vertical axis Y and the segment MA, it results that:

$$\rho = L/2 (1 + \cos\theta)$$

which indeed is the mathematical expression of a cardioid in polar coordinates (ρ, θ) .

The end portions 27, 28 with a substantially semi-circular section of the vane 12 correspond, in the schematic drawing of figure 3, to the two circumferences with radius r and centre A and B. When the points A and B describe the cardioid 11a, the aforementioned circumferences with radius r and centre A and B remain tangent, in all the points, to an outermost homothetic cardioid. The peripheral surface 11b of the chamber 20 of the vacuum pump 10 has the profile of this last homothetic cardioid. Figure 1 indicates the

cardioid 11a as well as the cardioid of the peripheral surface 11b.

In other words, the two circumferences with radius r and centre A and B, during the rotation of the segment AB with
5 the geometrical constraints indicated above with reference to figure 3, always remain tangent to a cardioid (indicated with 11b in figure 1) that is obtained by homothetically translating the cardioid 11a by an amount equal to r , such an amount being taken on the perpendicular to the tangent
10 in each point of the cardioid 11a.

As far as the rotors 13, 14 of the vacuum pump 10 are concerned, the schematic drawing of the kinematism of figure 3 shows that, by imposing to the segment OP (which corresponds to the radius of the rotor 14 of the vacuum
15 pump 10) a rotation speed of n revolutions, the slide S (which corresponds to the diametric groove 30 of the rotor 13 of the vacuum pump 10) is driven in rotation - through the segment AB - with a rotation speed equal to $n/2$.

Vice versa, by imposing to the slide S a rotation speed of
20 n revolutions, the segment AB is driven in rotation and the segment OP rotates with a speed equal to $2n$.

Moreover, in the vacuum pump 10 according to the invention, the vane 12 generates - during its rotation - a variable volume having a predetermined displacement, in the case in
25 which the motion is driven by the rotor 14, and having double displacement, in the case in which the motion is driven by the rotor 13.

The specific displacement (i.e. the displacement per unit of height) of the vacuum pump 10 according to the invention
30 is greater by about 50% with respect to the specific displacement of a single-vane vacuum pump of the prior art having the same external overall dimension.

The comparison between the displacement of the vacuum pump of the invention and that of a single-vane vacuum pump of

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the prior art having the same external overall dimension is represented in figure 4, in which the area J with double broken line indicates the gain (about 50% more) in specific displacement of the vacuum pump of the invention with
5 respect to that of the vacuum pump of the prior art (which corresponds to the area K indicated with a single broken line).

As can be seen in figure 4, an important advantage of the vacuum pump of the invention is related to the fact that
10 the second rotor 13 is extremely smaller with respect to the single rotor of the single-vane vacuum pump of the prior art, making available almost the entirety of the chamber of the vacuum pump for the displacement.

Another advantage of the vacuum pump of the invention is
15 that, in operation, since the pin-vane peripheral slithering speed is extremely low (the diameter of the pin 15 is indeed very small), all the dynamic loads are discharged onto the kinematic pair formed by the pin 15 and vane 12 with an extremely low load factor.

Moreover, the vacuum pump of the invention can
20 advantageously receive motion from either the rotor 14 and the rotor 13, generating the predetermined displacement or a double displacement, respectively, and therefore it is perfectly suitable for either application with a high
25 number of revolutions and application with a low number of revolutions, by respectively taking the motion from the rotor 14 or from the rotor 13.

A further advantage of the vacuum pump of the invention is related to the fact that, having a specific displacement
30 which is greater than that of conventional vacuum pumps, when the motion is provided by the second rotor 13, the vacuum pump can have a smaller overall dimension, being equal the displacement.

Of course, a man skilled in the art, with the purpose of

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satisfying specific and contingent needs, may apply numerous modifications and variants to the single-vane vacuum pump described above, all of these being anyway covered by the scope of protection of the present invention

5 as defined in the following claims.

CLAIMS

1. Single-vane pump (10), in particular for a motor vehicle engine, comprising:

- a stator (11) in which a chamber (20) is defined;

5 - a first rotor (13) mounted in said chamber (20) and capable of rotating around a first rotation axis (M-M);

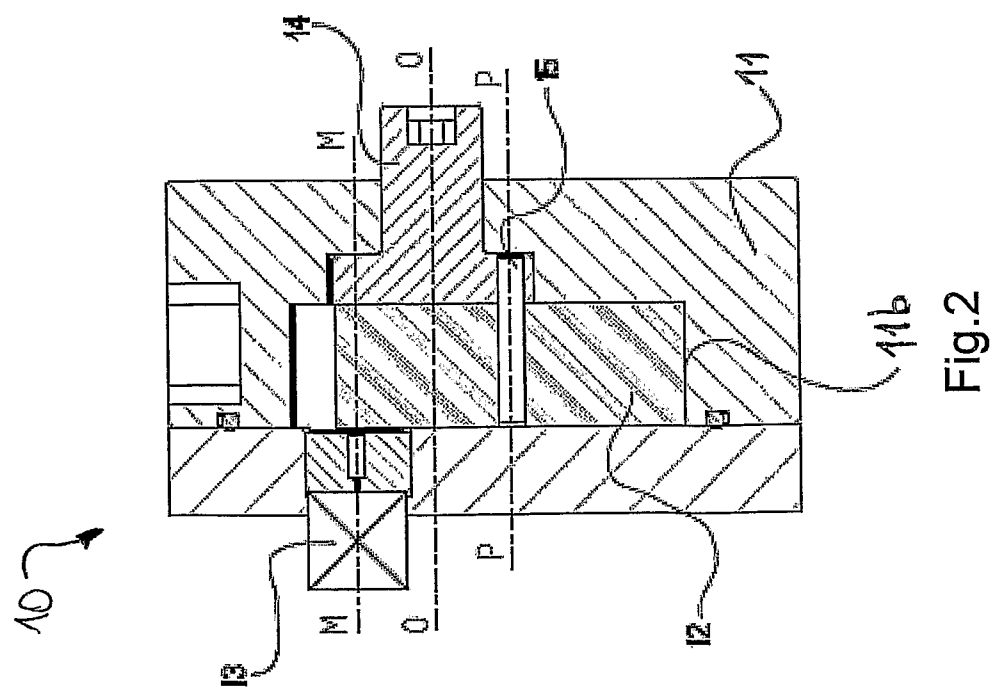
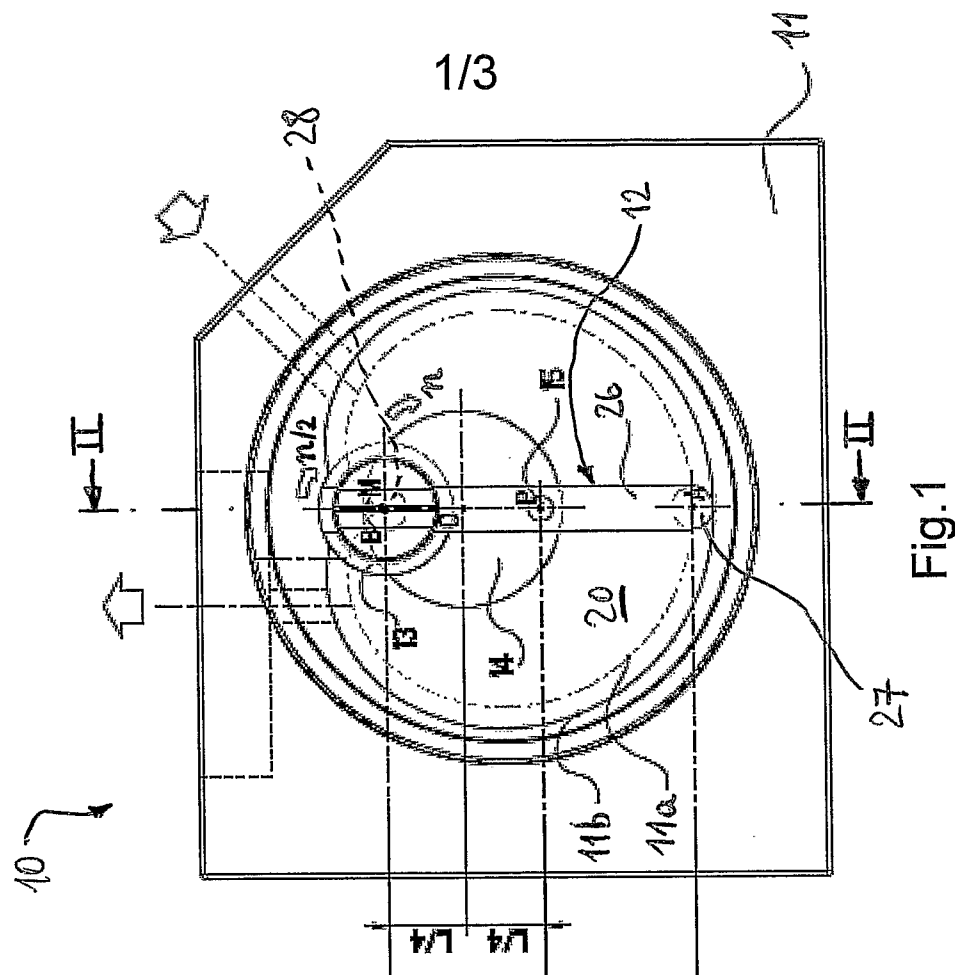
- a vane (12) slidably mounted in a diametric groove (30) of said first rotor (13) and having a rectilinear portion (26) having a predetermined length (L) and opposite
10 free ends (22, 24) in contact with a perimetric surface (11b) of said chamber (20);

characterized in that the pump comprises a second rotor (14) mounted in said chamber (20) and capable of rotating around a second rotation axis (O-O) parallel to the first
15 rotation axis (M-M), the vane (12) being connected to the second rotor (14) at a longitudinal middle area thereof and being capable of rotating around a pivot axis (P-P) which is parallel to the first rotation axis (M-M), the distance between the first rotation axis (M-M) and the second
20 rotation axis (O-O) and between the pivot axis (P-P) and the second rotation axis (O-O) being equal to a fourth of the predetermined length (L) of the rectilinear portion (26) of the vane (12), the perimetric surface (11b) of said chamber (20) having, in a plane perpendicular to the first
25 rotation axis (M-M), a cardioid shape which substantially coincides with the cardioid defined by the opposite free ends (22, 24) of the vane (12) during the rotation of the first rotor (13) and of the second rotor (14).

2. Single-vane pump (10) according to claim 1, wherein
30 the opposite free ends (22, 24) of the vane (12) are defined on opposite end portions (27, 28) having a substantially semicircular section with a predetermined radius (r).

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3. Single-vane pump (10) according to claim 1 or 2, wherein the first rotor (13) and the second rotor (14) are selectively drivable in rotation, the rotor driven in rotation dragging in rotation the non-driven rotor.
- 5 4. Single-vane pump (10) according to any one of the previous claims, wherein said pump is a vacuum pump (10).



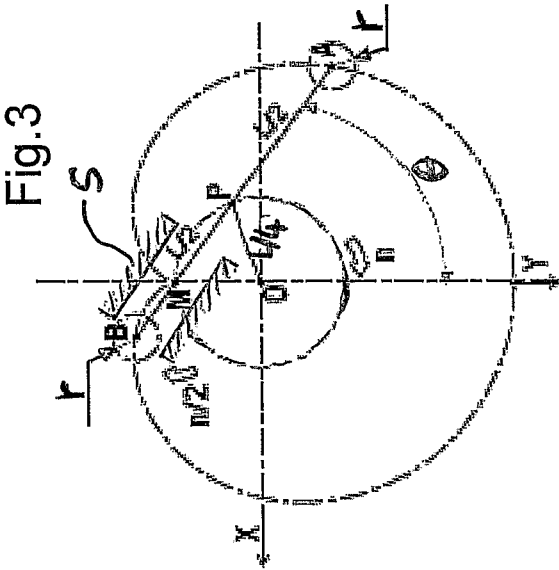
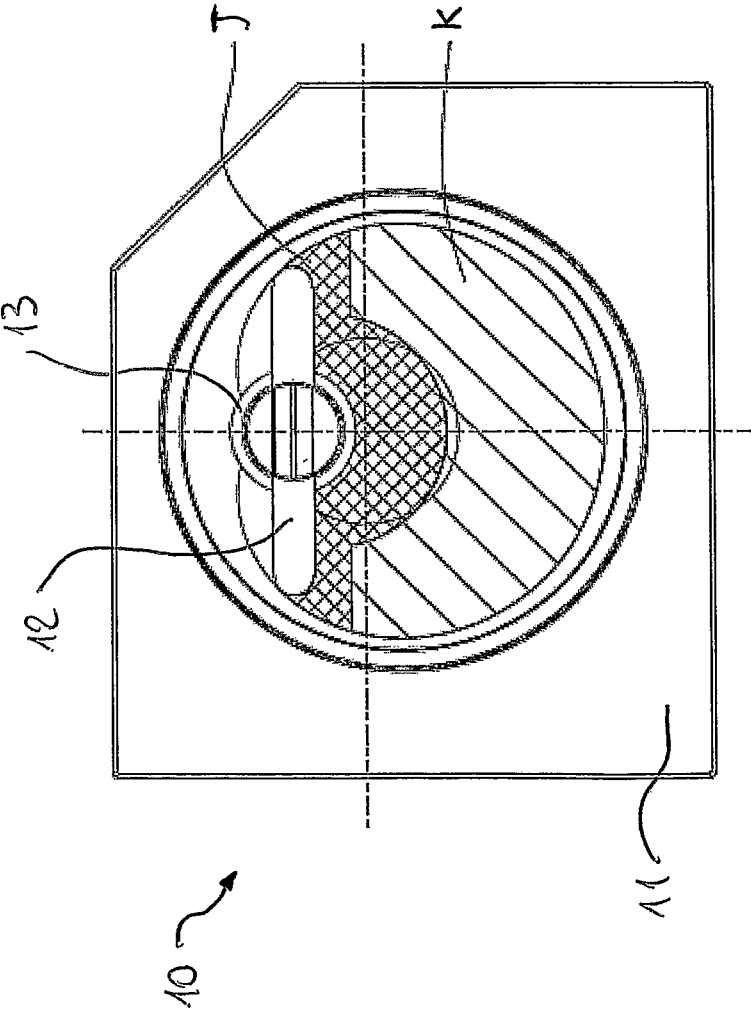


Fig. 4

Fig. 3

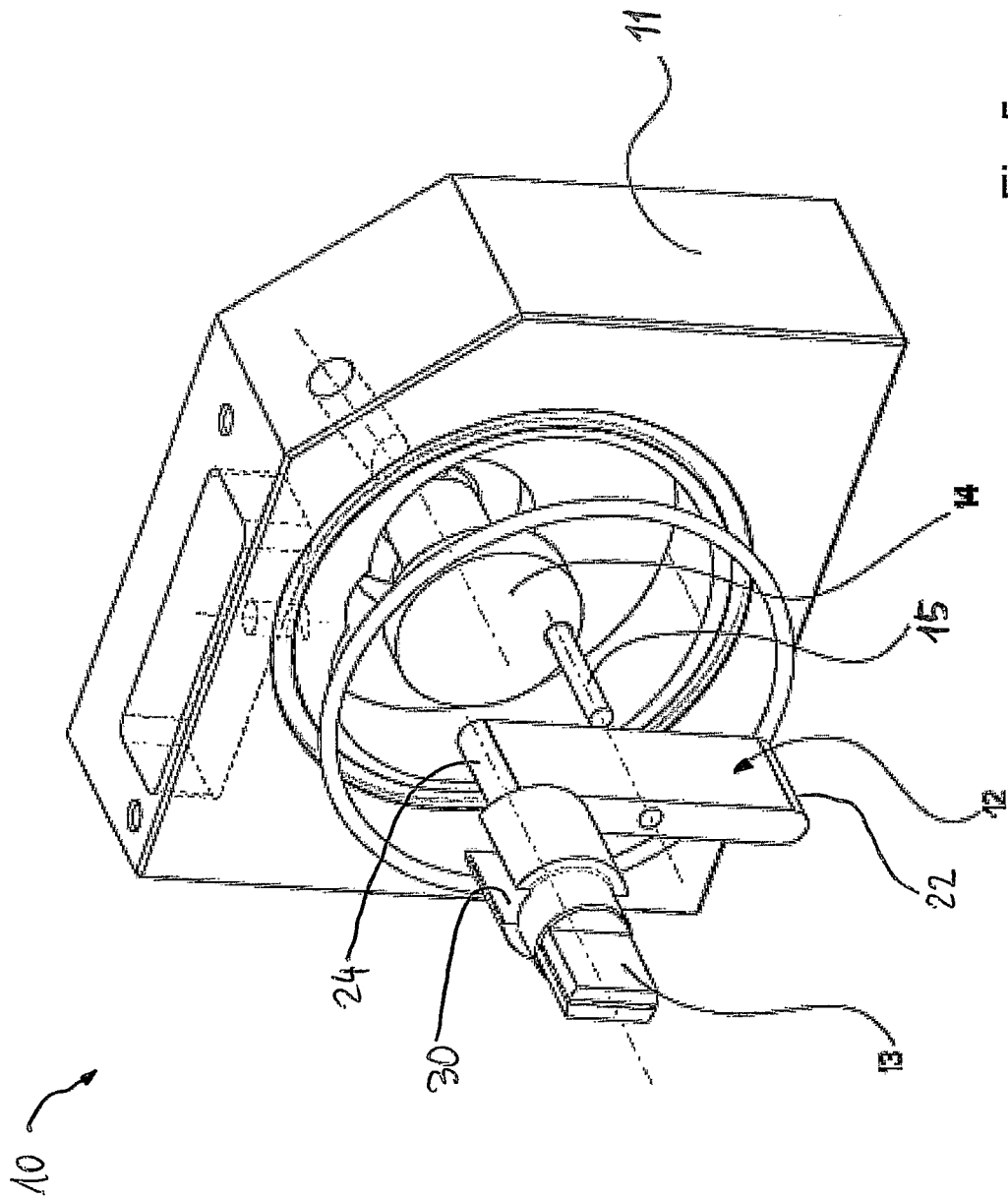


Fig.5