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• **Miropolecs, Pavels**
2130 Dreilini (LV)

(72) Inventors:
• **Miropolecs, Stanislavs**
1084 Riga (LV)
• **Miropolecs, Pavels**
2130 Dreilini (LV)

(71) Applicants:
• **Miropolecs, Stanislavs**
1084 Riga (LV)

(74) Representative: **Fortuna, Jevgenijs**
Foral Patent Law Office
P.O. Box 98
1050 Riga (LV)

(54) **ROTARY PISTON PUMP**

(57) The invention relates to hydraulic and pneumatic pumps having a working rotor, which can be used for pumping liquid and gas between vessels or for supplying a working fluid for cooling, lubricating and hydraulic driving purposes, particularly in internal combustion engines.

An increase in capacity, performance and operating accuracy with minimal surge by comparison with other types of pumps of the same dimensions and mass is achieved in that a novel design of a working chamber inside a sleeve is used in the present pump.

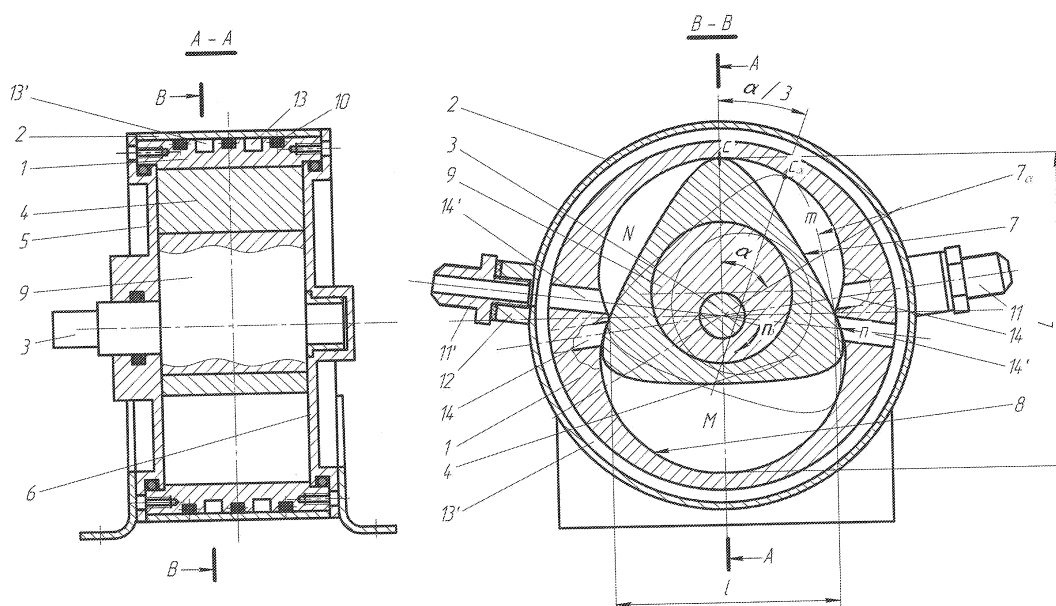


Fig.1

DescriptionField of Invention

[0001] The invention pertains to the machine building field and can be used for actuating systems, cooling and lubrication systems which are applied for different mechanisms where particular accuracy in feeding and pressure is required without substantial stream fluctuation, in particular in engines and devices for pumping liquids and gas between containers.

Prior Art

[0002] There is known a trochoidal pump according to the patent No. LV 15039 (WO/2015/104597), comprising a housing with two fittings, an internal pumping mechanism with a shaft and a piston, two vent caps for shaft bearing installed at the ends of the housing, where the caps are treated along their inner face for sliding contact with the piston, and there is a sleeve placed inside the housing which has surface grooves serving as connection channels, where channel apertures from the internal passage are made in the sleeve body, which cross profile is an epitrochoidal broken curve with the following formulae: $X = e/7(24\sin\tau + 25\sin3\tau)$, $Y = e/7(24\cos\tau + 25\cos3\tau)$, with the arbitrary parameter $\tau = 0, \dots, 2\pi$; and the shaft has a cylinder cam for running fit of the piston with the COG offset e to the shaft axis and a protruded part connected to a rotary actuator; and the piston has flat faces for sliding contact with faces of the caps, a central aperture for running fit with the shaft cam and the external surface formed by hypotrochoid with the following formulae in rectangular coordinates: $X = e(5\sin\tau - \sin2\tau)$, $Y = e(5\cos\tau + \cos2\tau)$, with an arbitrary parameter $\tau = 0, \dots, 2\pi$.

[0003] Due to availability of a slit caused by absence of contact between the epitrochoidal sleeve surface and the hypotrochoidal piston surface in some sections, a harmful overflow takes place, resulting in such deficiencies of a pump as fluctuation in feeding and pressure up to 15% and incapability to function at high pressures.

Disclosure of Invention

[0004] The goal of the invention is to increase the accuracy of functioning and efficiency of the pump disclosed in WO/2015/104597, when securing the maximally low fluctuation and capability of functioning at both low and high pressures.

[0005] The declared goal is achieved by using a sleeve with the newly developed internal surface. Such constructional improvement, in combination with the known structures, anticipate the following. The sleeve, from its edges, is closed by caps and is installed into a housing with inlet and outlet fittings. The caps provide support for the camshaft, and a shaft end portion extends through one of them, allowing rotation in either side to change the pumping direction. The processes of suction and feeding take place due to the fact that the contact lines of the piston and the sleeve divide the internal volume into four variable volume cavities. During rotation of the shaft and the piston with a suction fitting, the cavities are connecting at the time of their expansion, sucking a liquid or gas, and with a feeding fitting they are connecting at the time of their contraction, pumping out these substances. In such a manner stable pumping takes place.

Brief Description of Drawings

[0006] Fig.1 shows one embodiment of the pump design in longitudinal and cross-sectional plans.

[0007] The offered rotary piston pump contains:

a sleeve 1, having a through traversing pass 8, a housing 2, a shaft 3, a piston 4, a cap 5 with hole, a blind cap 6, a cam 9 of the shaft 3, a surface grooves 10 on the sleeve 1 for sealing, inlet and outlet fittings 11 and 11', socket 12, connection channels 13 and 13' on the sleeve 1 and/or on the housing 2, channel apertures 14 and 14'.

[0008] In accordance with the aforementioned design and functional principle, the major assemblies and parts of the pump can be arranged as follows.

[0009] The shaft 3, known from the cited above closest prior art solution (WO/2015/104597), has the following characteristics. The shaft 3 consists of sections with different sizes of external surfaces. The exit section bears on the cap 5 with hole through a bearing or flange. The middle section of the shaft 3 serves for stationary fit of the cam 9 on it. The internal end section of the shaft 3 bears on the central part of the blind cap 6 through a sliding or rolling bearing. The exit section of the shaft 3 serves for connection of a power actuator. The configuration of this section can be different depending on the known methods of connection. The shaft 3 must be equipped with the cam 9, which can have the form of a cylinder with a longitudinal aperture. The longitudinal axis of the aperture and the shaft 3 is off-axis of the large cylindrical surface by the COG offset e , which determines hypotrochoidal parameters of the piston 4 and the cross-section outline curve of the internal surface of the sleeve 1. The piston 4 is installed on the cylindrical surface of the cam 9. The length of the cam 9 must be less than the length of the piston 4.

[0010] The sleeve 1 serves as the main link of the pump, which secures the aforementioned advantages, and is a device where the pumping rotary mechanism is placed. With its external surface, the sleeve 1 is fixedly adjoined to the internal surface of the cover of the housing 2 and preferentially has five surface grooves 10: three for sealing and two are the connection channels 13 and 13' of the equal-pressure cavities inside the sleeve 1 through the four channel apertures 14 and 14'. Such grooves and paths may be done also on the housing 2. The distance between the connection channels 13 and 13' must be equal to the distance between the apertures in the housing under the fittings 11 and 11'. There are threaded holes at the ends of the sleeve 1 for fixing the caps 5 and 6. Inside the sleeve 1, there is the through traversing pass 8 made, which cross profile has two symmetry axes - the long one $L = 14e$ and the short one $l = 10e$, shown at section B-B of Fig.1. In contrast to the closest prior art solution (WO/2015/104597), the contour line of the cross section of the internal path is a new curve, which is developed for the given pump and which is to be used on other devices, being awarded the name the **Miropolets curve**, and it has the following formulae in rectangular axes:

$$X = e [5 \sin(\tau + \omega) - \sin(2\tau - \omega) + \sin 3\omega],$$

$$Y = \pm e [5 \cos(\tau + \omega) + \cos(2\tau - \omega) + \cos 3\omega],$$

$$\omega = \arctg \frac{5 \sin 2\tau + 2 \sin \tau}{5 \cos 2\tau - 2 \cos \tau},$$

where arbitrary parameter $\tau =]-22^\circ 8.54' \dots + 22^\circ 8.54' [$.

[0011] The curve secures the accurate contact with sliding and rolling of the piston in relation to the sleeve at all sections.

[0012] Other links, known according to the aforementioned prototype (WO/2015/104597), have the following characteristics.

[0013] The piston 4 has an axial longitudinal aperture for precise but movable mounting on the shaft cam 9 directly or through the slide or roller bearings. In the first case, the piston 4 or the cam 9 have to be made of the respective antifriction material, for example, bronze, etc. The curve contour of the cross section of the external surface of the piston 4 is a closed hypotrochoidal curve with three peaks and circumradius, equal to $6e$. Formulae of the curve in rectangular axes are $X = e(5 \sin t - \sin 2t)$, $Y = e(5 \cos t + \cos 2t)$, where the arbitrary parameter $t = 0, \dots, 2\pi$.

[0014] The housing 2 consists of the foliated cover, which caps the sleeve 1 externally, and two socket 12 sealed to the cover one by one over each connection channel 13 and 13' of the sleeve 1. The channel 13 and 13' may be made also on the housing 2. The socket has through threaded holes for connecting the fittings 11 and 11'. The distance between the axes of the holes must be equal to the distance between the connection channels 13 and 13' on the sleeve 1.

[0015] The caps 5 and 6 serve for the shaft alignment in relation to the sleeve 1 and restriction of longitudinal offset of the piston 4. The edge of the piston 4 must slide freely and contiguously along the internal edge of the caps 5 and 6. This internal part of the caps 5 and 6 penetrates into the front boring of the sleeve 1, by aligning it, and has a groove for sealing on the aligning surface. The caps 5 and 6 have ordinary fixation holes opposite the threaded holes on edges of the sleeve 1. The caps 5 and 6 differ only with their central part. The cap 5 has a central aperture for placing a bearing or a flange under the extending part of the shaft 3. The blind cap 6 has a central cavity under a sliding and rolling bearing of the shaft 3.

[0016] The device must be equipped with sealing rings made of a strong material resistant to the pumped substance.

[0017] Based on the comprehensively described structure of the device, the sequence of the pump functioning, for example when pumping a liquid, is provided below.

[0018] Let us take the position of the pump shown on Fig. 1 as initial, with account of the following conditions:

- one of the peaks C of the piston 4 is on the vertical in up position;
- the shaft 3 rotates at a constant speed n_3 clockwise;
- the ratio of rotation speeds of the piston 4 and the shaft 3 equals to $n_4/n_3 = 1/3$. At any point of time, in the cross section of the device, the piston 4 has four or three points of contact with the sleeve 1, which divide the area between the piston 4 and the sleeve 1 into sections with variable volumes.

[0019] When the shaft 3 with the cam 9 turns at the angle α clockwise, the piston 4, leaving the position 7, will take the position 7_α , shown in fine lines, having turned around its axis at the angle $\alpha/3$. Whereby, liquid is expelled from the cavities **M** and **m**, coming to the right feeding fitting 11 through the channel apertures 14 and the connection channel 13 (located behind the path 13'). Simultaneously, the cavities **N** and **n** are expanding, sucking the liquid through other channel apertures 14' and another connection channel 13' from the left suction fitting 11'. Further on, with rotation of the shaft 3 and the piston 4, this coming liquid is expelled to the right feeding fitting 11, as described above at the start

of the process. Such pumping of liquid takes place continuously with rotation of the shaft 3 in any position of the piston 4. When the shaft 3 is rotated in a different direction - counterclockwise, the aforementioned liquid stream changes its direction and the pumping will take place the other way round.

[0020] It is obvious that the presented pump sucks and further expels more liquid per one rotation than by using a gear rotary pump (about twice as much), conditionally put to the internal size at Fig. 1 (due to the limited height of the gears).

Claims

1. A rotary piston pump, comprising:

- (i) a housing (2) with two fittings (11 and 11');
- (ii) a shaft (3), equipped with a cam (9), with the eccentricity e with respect to the shaft (3) axis, and an external part made to allow attaching the shaft (3) to a rotary drive;
- (iii) a piston (4) with a central aperture for running fit on the cam (9) and the hypotrochoidal external surface;
- (iv) two caps (5 and 6), with an aperture under the shaft (3) support, installed at the edges of the housing (2) and treated along the internal edge for sliding contact with the piston (4);
- (v) a sleeve (1), placed inside the housing (2), having grooves (10) for sealing and grooves for the communication channels (13 and 13'),

characterized in that the body of the sleeve (1) is provided with two channel apertures 14 and 14' to each communication channels (13 and 13') from the internal passage, which cross profile is a curve with the following formulae in rectangular coordinates:

$$X = e [5 \sin(\tau + \omega) - \sin(2\tau - \omega) + \sin 3\omega],$$

$$Y = \pm e [5 \cos(\tau + \omega) + \cos(2\tau - \omega) + \cos 3\omega],$$

where e - the eccentricity with respect to the shaft (3),
 $\omega = \arctg \frac{5 \sin 2\tau + 2 \sin \tau}{5 \cos 2\tau - 2 \cos \tau}$, arbitrary parameter $\tau =]-22^\circ 8.54'; +22^\circ 8.54']$.

2. The pump according to claim 1, **characterized in that** the piston (4) has flat edges for sliding contact with edges of the caps

$$(5 \text{ и } 6)$$

and the external surface, which cross profile is hypotrochoid with the following formulae in rectangular coordinates:

$$X = e (5 \sin \tau - \sin 2\tau), \quad Y = e (5 \cos \tau + \cos 2\tau),$$

where arbitrary parameter $\tau = 0, \dots, 2\pi$.

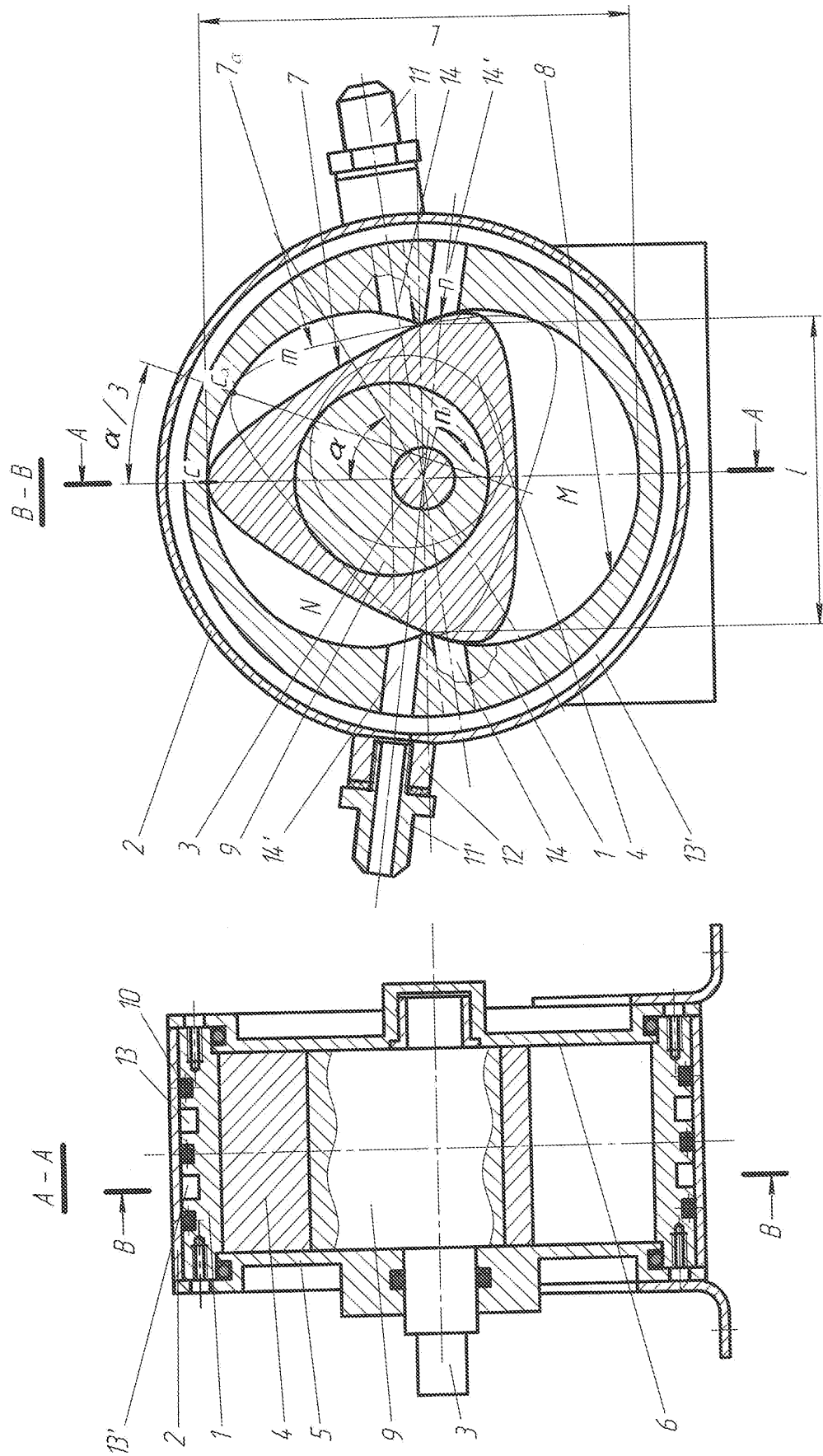


Fig.1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 2016/056247

5	A. CLASSIFICATION OF SUBJECT MATTER		
	F04C 2/22 (2006.01)		
	According to International Patent Classification (IPC) or to both national classification and IPC		
	B. FIELDS SEARCHED		
10	Minimum documentation searched (classification system followed by classification symbols)		
	F01C 1/00-1/28, 21/00, F04C 2/00-2/28, 15/00, 18/00-18/28, 29/00-29/04		
	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
15	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
	PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE		
	C. DOCUMENTS CONSIDERED TO BE RELEVANT		
20	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	X	WO 2015/104597 A1 (MIROPOLECS STANISLAVS et al.) 16.07.2015, p. 2, 3, fig. 1, 3	1-2
25	A	US 4296500 A (ANVAR) 27.10.1981	1-2
	A	EP 0799996 A2 (BERTOLI VITTORIO) 08.10.1997	1-2
30			
35			
40	☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
50	Date of the actual completion of the international search		Date of mailing of the international search report
	14 June 2017 (14.06.2017)		29 June 2017 (29.06.2017)
	Name and mailing address of the ISA/ RU		Authorized officer
55	Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- LV 15039 [0002]
- WO 2015104597 A [0002] [0004] [0009] [0010]
[0012]