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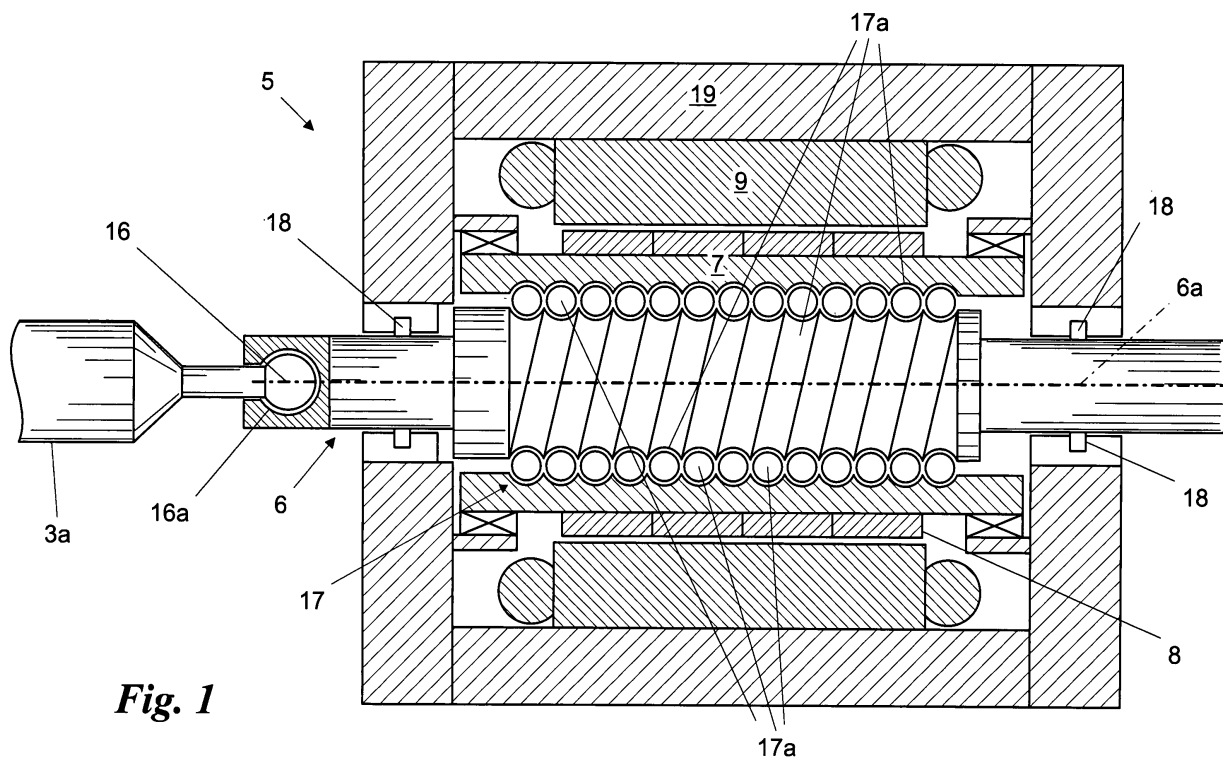
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(54) **Fluid handling apparatus**

(57) Fluid handling apparatus having at least a fluid handling device comprising: at least a piston movable with reciprocating translational motion and suitable to vary the volume of a transfer chamber to allow handling of fluids, and movement members (5) of the piston suitable to impart reciprocating translational motion thereto,

the movement members comprising a worm screw (6), an external guide (7) for this worm screw (6) substantially coaxial therewith and an electric motor (8) comprising a stator (9) and a rotor (10), the rotor (10) being integral with the external guide (7) and said worm screw (6) being suitable to transform the rotational motion of the external guide (7) into translational motion.



Description

[0001] The present invention relates to a fluid handling apparatus, in particular to a piston pump of the type specified in the preamble of Claim 1.

[0002] There are currently known reciprocating pumps for transferring fluids, in particular oils, petroleum and the like.

[0003] The most common reciprocating pumps act by means of at least a piston that moves with reciprocating motion inside a cylindrical chamber.

[0004] The cylindrical chamber is also in communication with two one-way valves and in particular a suction valve and a discharge valve.

[0005] Said piston determines a continuous and alternating variation of the volume inside the cylindrical chamber. Consequently, during increase of the volume of the chamber, fluid enters this chamber through the suction valve and, during decrease of the volume of the chamber, fluid exits therefrom through the discharge valve.

[0006] The reciprocating movement of the piston is generally activated by means of known crank-connecting rod mechanism.

[0007] Said piston is therefore normally connected to a crank substantially realized by a circular wheel that moves appropriately with a constant rotation speed.

[0008] The crank is then connected to a rotary electric motor and to appropriate mechanical connections, realized by speed reduction gears, drive belts and the like.

[0009] Said reciprocating pumps also comprise a lubrication system for the mechanical connections and for the crank mechanism described and a cooling system for these and for the electric motor.

[0010] The aforesaid prior art has some important drawbacks.

[0011] In fact, the crank mechanism described activates the piston with speeds and accelerations determined by the angular position of the crank, or wheel. In particular, when the crank is substantially parallel to the direction of movement of the connecting rod, this connecting rod is substantially stopped for an instant, while when the crank is substantially perpendicular to the direction of motion of the connecting rod, the latter moves at maximum speed.

[0012] The connecting rod therefore moves with a sinusoidally varying speed.

[0013] The speed variation of the connecting rod, or of the piston, therefore determines a variation of the transfer speed of fluids, or flow rate, which also occurs according to a sinusoidal curve.

[0014] Said continuous variation of the flow rate causes troublesome pressure pulsations inside the hydraulic pump, which have a negative effect in particular on the ducts that transfer the fluids and consequently on the entire system.

[0015] These vibrations can lead to undesirable noise, and above all to fatigue stresses that can determine the breakage of some portions of the pumps or of the ducts,

loosening of screws and bolts present on these pumps or ducts and yet other drawbacks.

[0016] Said drawbacks can only be partly solved by the use of reciprocating pumps utilizing several pistons simultaneously and moving these pistons by means of crank mechanisms having specific reciprocal angular phase differences, so that, when one piston is substantially stopped, the other moves at maximum speed and vice versa.

[0017] Other measures are also possible, such as the use of cranks realized by a non circular cam or the like.

[0018] However, these solutions can never completely eliminate said variations of the fluid transfer speed and moreover they form a further complication and make the structure of the hydraulic pump heavier.

[0019] A further drawback is realized by the fact that said reciprocating pumps, due to their complex crank mechanism and to the presence of various components, are very expensive, must be produced with reduced tolerances, require a specific lubricating and cooling apparatus and therefore continuous and costly maintenance.

[0020] Yet another drawback is realized by the fact that reciprocating pumps, and the apparatuses connected thereto, are very bulky and therefore large spaces are required to house them.

[0021] In this situation the technical aim underlying the present invention is to devise a fluid handling apparatus capable of substantially overcoming the aforesaid drawbacks.

[0022] Within the scope of said technical aim, an important object of the invention is to provide a fluid handling apparatus that allows the vibrations and noise of this apparatus to be decreased considerably.

[0023] Another important object of the invention is to obtain a fluid handling apparatus that is simple, inexpensive and requires little maintenance.

[0024] Last but not least object of the invention is to provide a fluid handling apparatus that is compact and occupies a small space.

[0025] The technical aim and the objects specified are achieved by a fluid handling apparatus as claimed in the appended Claim 1.

[0026] Preferred embodiments are highlighted in the dependent claims.

[0027] Other characteristics and advantages of the invention are further elucidated in the following detailed description of a preferred embodiment of the invention, with reference to the accompanying drawings, wherein:

Fig. 1 shows a section of a portion of the apparatus according to the invention;

Fig. 2 shows a further section of the apparatus according to the invention;

Fig. 3 shows an assembly view, in a particular configuration, of the apparatus according to the invention;

Fig. 4a shows a first graph of operation of the apparatus according to the invention;

Fig. 4b shows a second graph of operation of the apparatus according to the invention;

Fig. 4c shows a third graph of operation of the apparatus according to the invention.

[0028] With reference to the figures above, the fluid handling apparatus according to the invention is indicated as a whole with the number **1**.

[0029] It is suitable to handle fluids, in particular liquids and more in particular hydrocarbons and their derivatives.

[0030] The apparatus **1** comprises at least a fluid handling device **2**, comprising, briefly, at least a piston **3** movable with reciprocating translational motion, preferably of the plunging type, and suitable to vary the volume of a transfer chamber **4** that allows the handling of fluids, and movement members **5** of the piston **3** suitable to generate the reciprocating translational motion.

[0031] In more detail, the transfer chamber **4** is preferably realized by a cylinder **11** inside which the piston **3** moves with reciprocating translational, and preferably rectilinear, motion.

[0032] This transfer chamber **4** is also in fluid connection with a suction channel **12** through an inlet valve **13**, realized by a one-way valve suitable to allow fluid to enter the transfer chamber **4**, and with a discharge channel **14** through a discharge valve **15**, realized by a one-way valve suitable to allow fluid to exit from the transfer chamber **4**.

[0033] Alternatively, the transfer chamber **4** can be connected to the piston **3** by means of a membrane or can be of a different type.

[0034] The piston **3** is then mechanically connected to a drive shaft **3a**, in turn connected to the movement members **5** preferably by means of a ball joint **16** suitable to substantially cancel the undesirable effects caused by any misalignment between the movement members **5** and the drive shaft **3a**. Alternatively, the piston **3** is directly an integral part of the drive shaft **3a**.

[0035] The movement members **5** comprise a worm screw **6**, movable about an axis **6a** and an external guide **7** for this worm screw **6**, substantially coaxial therewith.

[0036] The external guide **7** is therefore rotatable about the axis **6a** and this rotational movement activates translation, substantially without rotation, of the worm screw **6** in a direction parallel to this axis **6a**.

[0037] In detail, the worm screw **6** is associated with a helicoid **17**, which substantially realizes the thread of the worm screw **6**, and this worm screw is preferably directly in contact with the external guide **7**. This helicoid **17** is also preferably realized by a plurality of balls **17a** suitable to roll along helical guides **17b** produced on the external surface of the worm screw **6** and of the external guide **7**, as shown in Fig. 1.

[0038] The external guide **7** is also provided with a recirculation channel for said balls, not shown in the accompanying figures, joining the opposite ends of the helicoid **17**.

[0039] It is therefore suitable to recirculate the balls **17a**, which due to their motion move to the outside of one of the ends of the helical guides **17b**, to return to the helical guides **17b** at the opposite end.

[0040] The worm screw **6** including in particular the helicoid **17**, and also said recirculating ball screw, allows helical movements to be performed with extremely low friction due to the presence of spherical elements that move through rolling friction.

[0041] The worm screw **6** is also preferably connected directly to the drive shaft **3a** and for this purpose comprises a spherical seat **16a** for the ball joint **16**. Moreover, each worm screw **6** can be connected to two pistons **3** and comprise a seat at each end, as shown in Fig. 3.

[0042] Finally, the worm screw **6** comprises at least a sliding block **18** suitable to allow translation in a direction parallel to the axis **6a** and to prevent rotation of the worm screw **6** about this axis **6a**.

[0043] The movement members **5** also comprise an electric motor **8** including a stator **9** and a rotor **10**, integral with the external guide **7**.

[0044] In particular, the rotor **10** is substantially integrated with the external guide **7** and is therefore coaxial with the axis **6a**.

[0045] Moreover, this rotor **10** is preferably realized by permanent magnets appropriately shaped as portions of cylindrical surface. This solution allows friction to be reduced, as no electrical connections are required between the rotor and the outside.

[0046] The stator **9** is instead appropriately realized by electrical windings connected to an alternating current power supply. It is preferably disposed on the outside of the rotor **10** and has a cylindrical shape coaxial therewith, as shown in Fig. 1. In detail, the stator **9** is appropriately connected to an inverter, known per se, connected to a power supply network.

[0047] Said inverter is suitable to allow variations of the power and of the frequency of the alternating current that supplies the electric motor **8**. It is also connected to specific control means preferably realized by an electronic processor.

[0048] Structurally, the device **2** is preferably supported by a single structure **19** suitable to support the various elements described, and in particular the transfer chamber **4**, the piston **3**, the connections of the suction **12** and discharge **14** channels including the specific valves **13** and **15** and the movement members **5**.

[0049] It is shown in particular in Fig. 2.

[0050] The structure **19** is also suitable to contain any leakages of fluids, so that they are not dispersed dangerously into the outside environment.

[0051] The device **2** can also comprise a lubrication system suitable to allow improved sliding of the worm screw **6** and of the other mechanical members.

[0052] A single fluid handling apparatus **1** also preferably comprises a plurality of fluid handling devices **2**.

[0053] In particular, between two and ten, and more preferably three, four or five fluid handling devices **2** are

preferably present, disposed in parallel as shown in Fig. 3 and all connected to unitary control means realized by a single electronic processor.

[0054] Movement of the pistons 3 belonging to a single apparatus 1 also occurs according to a new process.

[0055] In fact, said new process consists in moving the pistons 3 so that the suction volumetric flow rate and the discharge volumetric of the fluid are substantially constant.

[0056] Some examples of volumetric flow rates of apparatuses 1 according to the invention are shown in Figs. 4a, 4b and 4c. These figures show the volumetric flow rates of apparatuses 1 including three, four or five devices 2.

[0057] These flow rates are related with the volumetric flow rates of apparatuses according to prior art (dotted line) comprising three, four or five pistons moved by means of a crank-connecting rod mechanism.

[0058] These graphs show on the abscissa the volumetric flow rate, directly proportional to the movement speed of the pistons 3, as a function of the time indicated on the ordinate.

[0059] In more detail, the dashed lines represent the volumetric flow rates of each piston 3, while the solid lines represent the total suction and discharge volumetric flow rates of the apparatus 1.

[0060] In particular, the total discharge volumetric flow rate is attained by adding the positive flow rates, while the total suction volumetric flow rate is attained by adding the negative flow rates.

[0061] As can be observed in said figures, the pistons 3 move with non-null constant accelerations (inclined straight segments) in particular in proximity of the ends of stroke (corresponding to the points of the graph along the axis of the abscissae) or with constant and null accelerations and therefore constant speeds (straight segments parallel to the axis of the abscissae) in particular at a distance from the ends of stroke.

[0062] In more detail, if an even number of pistons 3 is present (Fig. 5a) it is possible always to have constant and non-null accelerations and decelerations, while if an odd number of pistons is present (Figs. 4a and 6a) it is also favourable to have sections with null constant accelerations.

[0063] Operation of a fluid transfer apparatus 1, described above in structural terms, is the following.

[0064] When it is activated, an electrical current passes through the electrical windings of the stator 9, creating a magnetic field which, interfering with the electrical field of the permanent magnets of the rotor 10, allows rotation thereof.

[0065] The rotor 10 is integral with the external guide 7, which by rotating activates translation of the worm screw 6.

[0066] The worm screw 6 in turn activates the reciprocating translational motion of one or two pistons 3, which by varying the volume of the transfer chamber 4, allow the transfer of fluids, and in particular of liquids, from the

suction channel 12 to the discharge channel 14.

[0067] The speed and direction of rotation are selected by means of the inverter and of the control means. It is therefore possible to easily select all the movement parameters of the apparatus 1 and in particular of the pistons 3: the stroke, speed and acceleration of the worm screws 6, thus promptly and precisely controlling each parameter of the apparatus.

[0068] The flow rates of each device 2 are therefore preferably selected according to the curves indicated in Figs. 4a, 4b and 4c.

[0069] The invention achieves important advantages.

[0070] In fact, the apparatus 1 allows a flow rate of fluid that is always constant to be produced and does not cause noise, vibrations or similar drawbacks.

[0071] The apparatus 1 therefore requires less maintenance than apparatuses according to prior art.

[0072] Moreover, due to its structure, this apparatus 1 is very compact and less bulky, as the crank mechanism, the speed reducer, the dampers, several joints, the motor and various gaskets are eliminated and moreover the lubrication and cooling devices are greatly reduced, or even completely eliminated.

[0073] Finally, as it has no structurally complex elements, it is simple and inexpensive.

Claims

1. Fluid handling apparatus (1) including at least a fluid handling device (2) comprising: at least a piston (3) movable with reciprocating translational motion and suitable to vary the volume of a transfer chamber (4) and to allow said handling of fluids, and movement members (5) of said at least a piston (3) suitable to impart said reciprocating translational motion on said piston (3), **characterized in that** said movement members (5) comprise: a worm screw (6) having an axis (6a), an external guide (7) for said worm screw (6), substantially coaxial with said worm screw (6) and suitable to take a rotational motion about said axis (6a), and an electric motor (8) comprising a stator (9) and a rotor (10), said rotor (10) being integral with said external guide (7) and said worm screw (6) being suitable to transform said rotational motion of said external guide (7) into translational motion.
2. Apparatus according to claim 1, wherein said worm screw (6) is associated with a helicoid (17), directly in contact with said external guide (7).
3. Apparatus according to claim 2, wherein said helicoid (17) is realized by a plurality of balls (17a) and wherein said worm screw (6) and said external guide (7) define helical guides (17b) in the area of interaction with said helicoid (17) suitable to house said balls (17a).

4. Apparatus according to claim 3, wherein said external guide (7) comprises a recirculation channel for said balls (17a), joining the opposite ends of said helicoid (17).
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5. Apparatus according to one or more of the preceding claims, wherein said rotor (10) is substantially integrated with said external guide (7).
10
6. Apparatus according to one or more of the preceding claims, wherein said rotor (10) is realized by permanent magnets.
15
7. Apparatus according to one or more of the preceding claims, wherein said worm screw (6) is connected to two pistons (3), one for each end.
20
8. Apparatus according to one or more of the preceding claims, wherein each said fluid handling device (2) comprises a structure (19) suitable to support at least: said transfer chamber (4), said piston (3) and said movement members (5).
25
9. Apparatus according to one or more of the preceding claims, comprising from three to five fluid handling devices (2).
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10. Process for activation of a fluid handling apparatus (1) according to one or more of the preceding claims, **characterized in that** it consists in moving said pistons (3) in a manner suitable to maintain the suction volumetric flow rate and the discharge volumetric flow rate constant.
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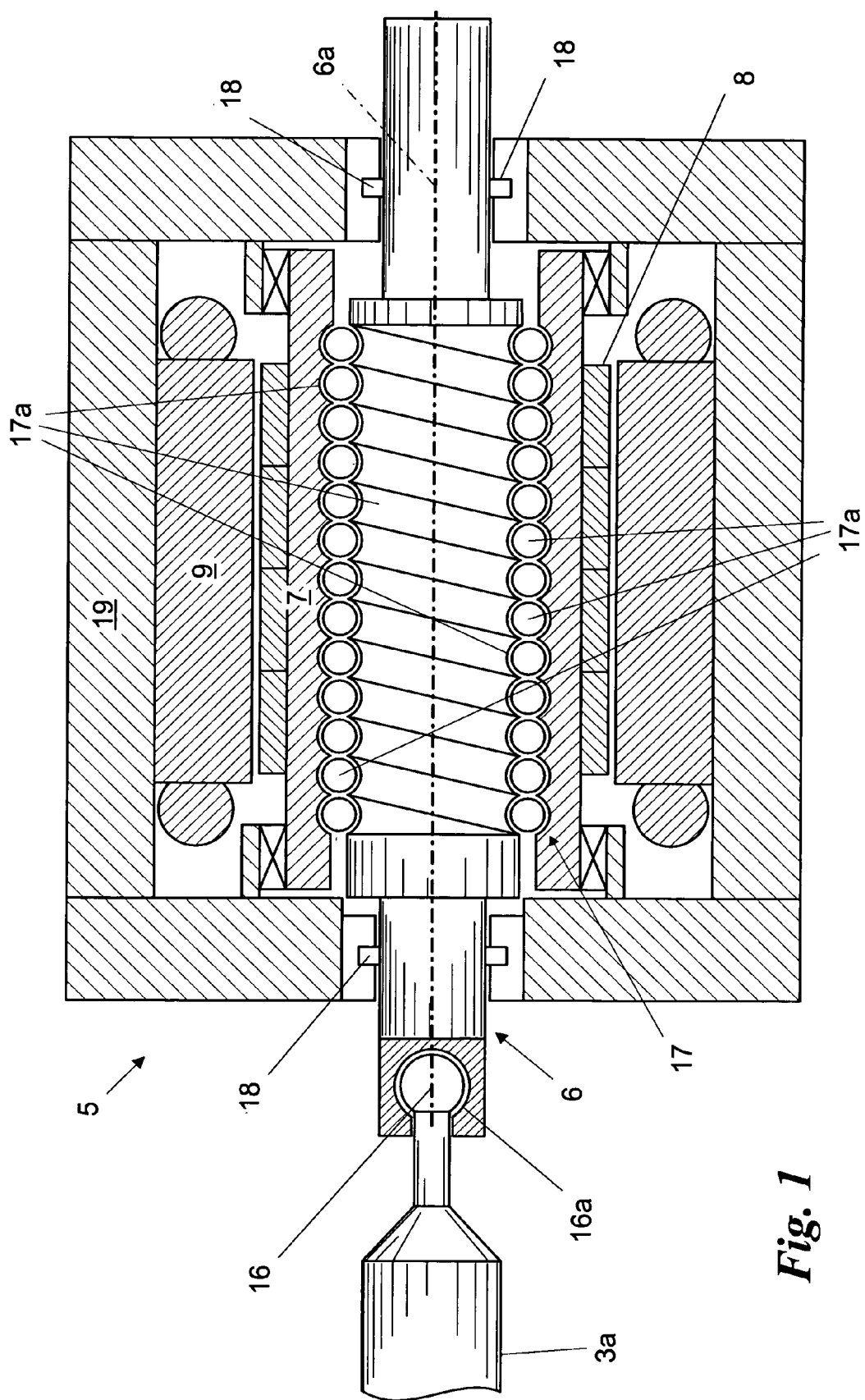


Fig. 2

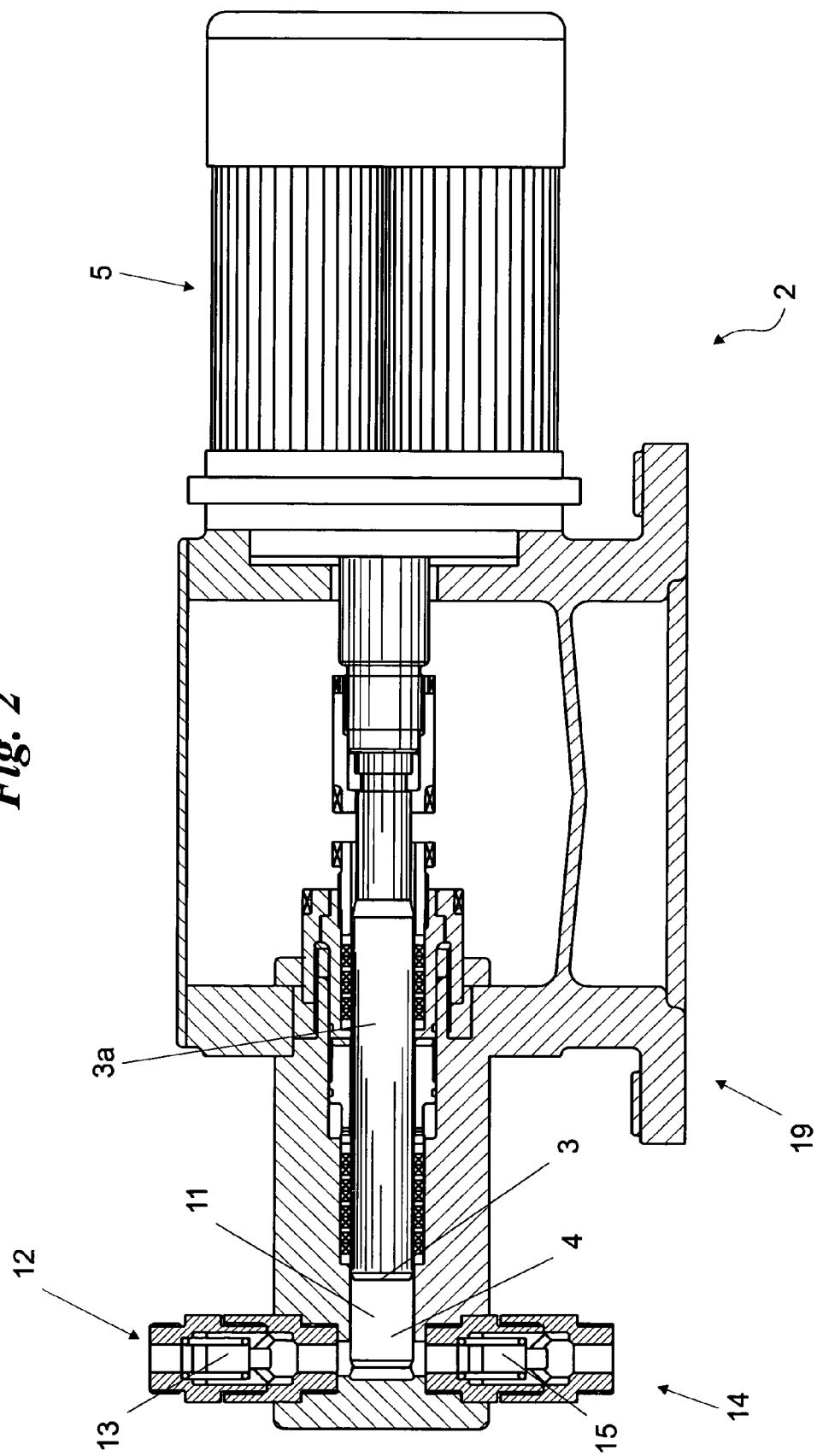


Fig. 3

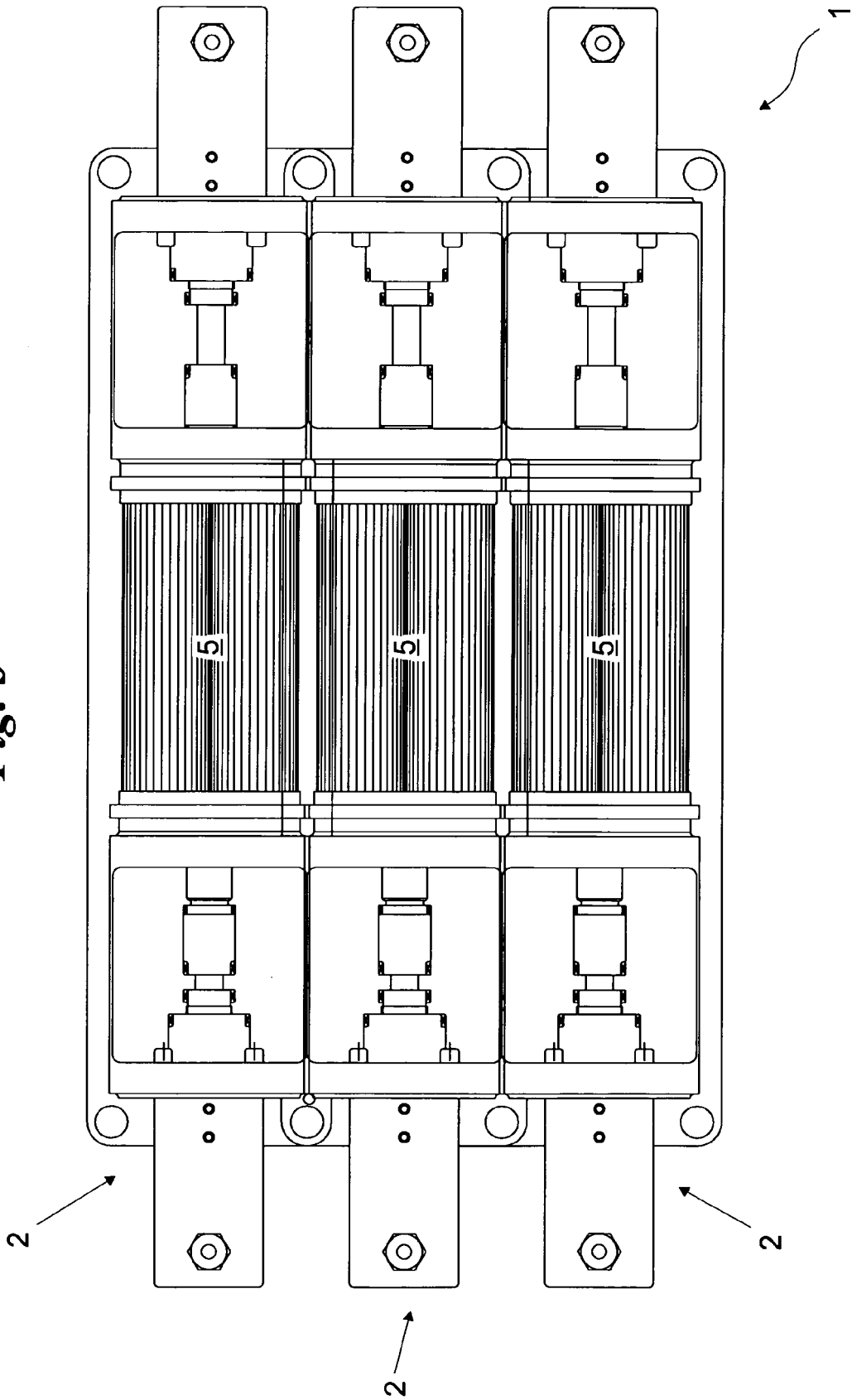


Fig. 4a

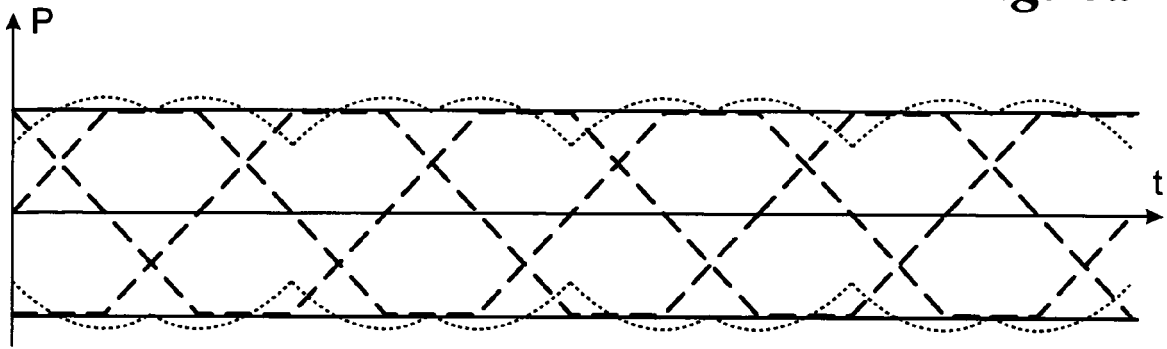


Fig. 4b

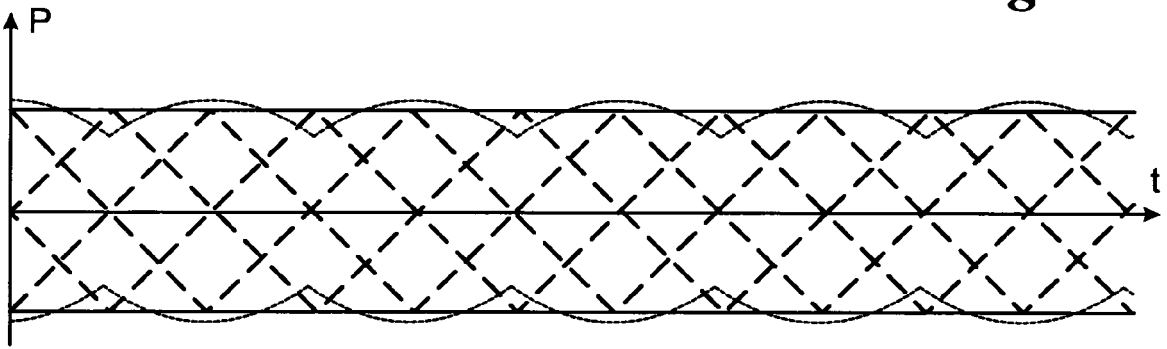
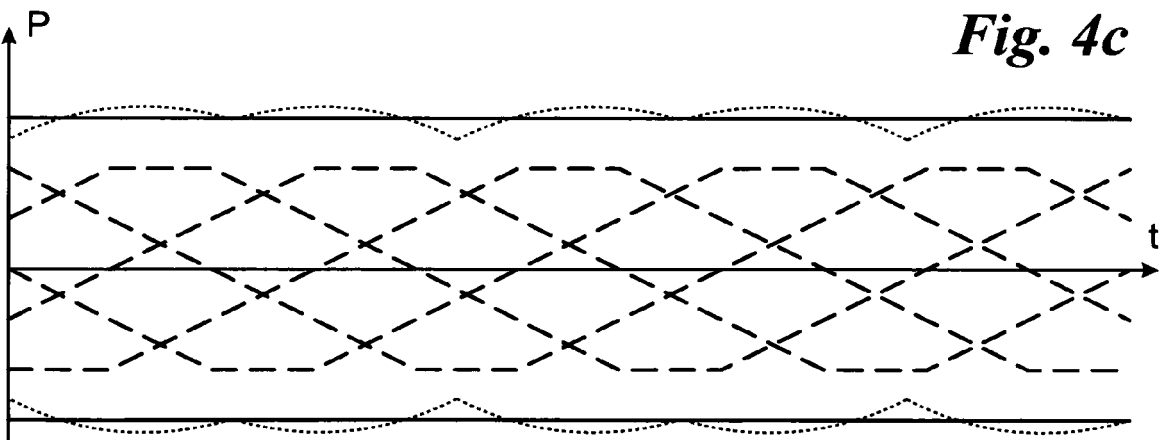


Fig. 4c





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 08 42 5036

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 276 003 A (PERKINS GERALD S ET AL) 30 June 1981 (1981-06-30) * column 2, lines 32-47; figure 1 *	1,2,5-10	INV. F04B17/03
X	US 4 856 967 A (JONES STANLEY C [US]) 15 August 1989 (1989-08-15) * column 5, lines 9-12; figures 1,5 *	1,4,8,10	
Y	* column 6, lines 31-49 *	2,3	
X	US 6 234 771 B1 (CAREY GLEN A [US] ET AL) 22 May 2001 (2001-05-22) * figures 2,5A-5C *	1,2,5,6,8	
Y,P	ANONYMOUS: "Ball screw" WIKIPEDIA, THE FREE ENCYCLOPEDIA, [Online] January 2008 (2008-01), XP002487369 Retrieved from the Internet: URL:http://en.wikipedia.org/wiki/Ball_nut> [retrieved on 2008-07-08] * the whole document *	2,3	
A	DE 100 32 793 A1 (INFINEON TECHNOLOGIES AG [DE]) 17 January 2002 (2002-01-17) * the whole document *	9,10	TECHNICAL FIELDS SEARCHED (IPC)
A	US 6 398 514 B1 (SMITH STEVE C [US] ET AL) 4 June 2002 (2002-06-04) * the whole document *	1-10	F04B
A	US 3 597 119 A (GRATZMULLER JEAN LOUIS) 3 August 1971 (1971-08-03) * the whole document *	1-10	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 8 July 2008	Examiner Olona Laglera, C
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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 42 5036

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08-07-2008

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4276003	A	30-06-1981	NONE	

US 4856967	A	15-08-1989	CA 1291368 C	29-10-1991
			GB 2210419 A	07-06-1989
			NL 8802328 A	17-04-1989

US 6234771	B1	22-05-2001	NONE	

DE 10032793	A1	17-01-2002	NONE	

US 6398514	B1	04-06-2002	NONE	

US 3597119	A	03-08-1971	BE 736533 A	26-01-1970
			DE 1937072 A1	29-01-1970
			GB 1249936 A	13-10-1971
			JP 49049122 B	25-12-1974

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82