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(54) **Title:** OIL-INJECTED VACUUM PUMP ELEMENT

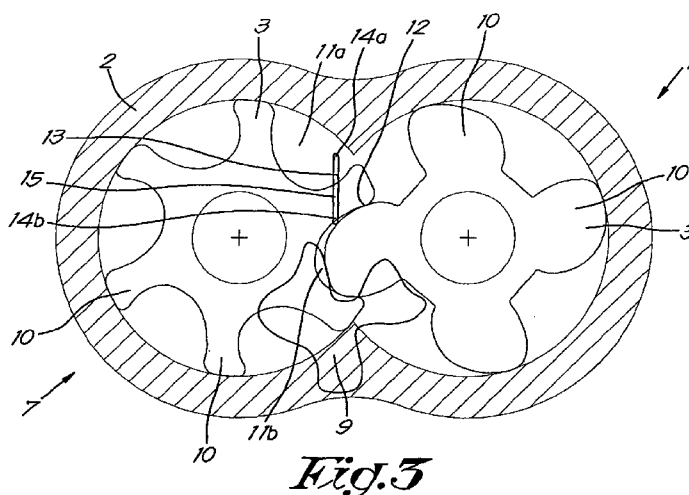


Fig. 3

(57) **Abstract:** Oil-injected vacuum pump element, whereby two cooperating helical rotors (3) are rotatably provided in a housing (2), whereby this housing (2) comprises an inlet port (8) and an outlet end face (6) with an outlet port (9), whereby compression chambers (11a, 11b) are formed between the helical rotors (3) and the housing (2), characterised in that the vacuum pump element (1) is provided with a connection that extends from a first compression chamber (11a) to a second smaller compression chamber (11b) at the outlet end face (6), whereby this first compression chamber (11a) is at a lower pressure than the second compression chamber (11b) and whereby this second compression chamber (11b) can make connection with the outlet port (9) upon rotation of the helical rotors (3), whereby the connection is such that a flow from the second compression chamber (11b) to the first compression chamber (11a) is possible, whereby the connection is not directly connected to the outlet port (9).



Oil-injected vacuum pump element.

The present invention relates to an oil-injected vacuum
5 pump element.

More specifically, the invention is intended for oil-
injected vacuum pump elements of the screw type, whereby
two cooperating helical rotors are rotatably provided in a
10 housing.

Chambers are defined between the lobes of the helical
rotors and the walls of the housing, that move from the
inlet side to the outlet side as a result of the rotation
15 of the rotors and thereby become increasingly smaller so
that the air trapped in these chambers is compressed.

It is known that oil is injected into the compression
chamber of such elements to remove the heat of compression,
20 to lubricate the helical rotors, to prevent corrosion and
to ensure a seal between the rotors.

This oil originates from an oil separator where the oil is
separated from the outlet air.

25

It is impossible for all air to be removed from the oil, so
that oil is injected that contains a certain amount of air.

This air content can be in the oil in the form of air
30 bubbles or dissolved therein.

As a result there is a risk of cavitation. In an oil flow there are two types of cavitation:

5 - cavitation whereby oil vapour bubbles are formed because the static pressure falls below the vapour pressure of the oil;

- cavitation whereby air bubbles are formed in oil flows that contain a certain quantity of air, because a reduction of the static pressure makes the solubility of air in the oil fall.

10

Depending on the type of cavitation, damage can occur when the air bubbles or oil vapour bubbles thus formed implode in the vicinity of (metal) components. This damage can be very extensive and can lead to the destruction of the machine.

15

Such cavitation can occur in an oil-injected vacuum pump element of the screw type under the influence of a fall of the static pressure, more specifically at the outlet of the vacuum pump in the last phase of compression.

20

In the last phase of compression, the volume of the compression chamber goes to zero, such that the pressure in this chamber can rise above the outlet pressure. As a result, large pressure differences occur between the

25

aforementioned chamber and the inlet, where the pressure can be 0.3 mbar(a) and below.

During the last compression phase, the aforementioned chamber is separated from another compression chamber that

30

connects to the inlet by only one single section of the rotor profiles.

In this section a type of channel forms between the profiles of the rotors or between the rotors and the outlet end face that first converges and then diverges to form a 'nozzle'.

A leakage flow of gas and oil is possible through this channel from the aforementioned chamber to the inlet due to the large pressure difference between the two, whereby due to the form of the channel and the rotors the speed of this leakage flow becomes so high that the static pressure becomes so low that gas bubbles can form.

Further in the channel the static pressure again increases, such that the bubbles formed implode, such that damage occurs to the rotors and the housing. As a result of this damage the vacuum pump element will no longer function or will do so less well.

The purpose of the present invention is to provide a solution to the aforementioned and other disadvantages.

The subject of the present invention is an oil-injected vacuum pump element of the screw type, whereby two cooperating helical rotors are rotatably provided in a housing, whereby this housing comprises an inlet port, an inlet end face and an outlet end face with an outlet port, whereby compression chambers are formed between the helical rotors and the housing that proceed from the inlet port to

the outlet port due to the rotation of the helical rotors and thereby become increasingly smaller, whereby the oil-injected vacuum pump element is provided with a connection that extends from a first compression chamber to a second smaller compression chamber at the outlet end face, whereby
5 this first compression chamber is at a lower pressure than the second compression chamber and whereby this second compression chamber can make connection with the outlet port upon rotation of the helical rotors, whereby the
10 connection is such that a flow from the second compression chamber to the first compression chamber is possible so that the pressure in the second compression chamber is reduced, whereby the connection is not directly connected to the outlet port.

15

Due to the rotation of the helical rotors the first compression chamber will become increasingly smaller and finally becomes the second compression chamber, whereby at this time a new first compression chamber is formed.

20

The second compression chamber is the compression chamber at the end of the compression cycle, in which there is compressed gas that can then leave the vacuum pump element via the outlet port. It goes without saying that this
25 second compression chamber is not connected to the inlet port.

An advantage of an oil-injected vacuum pump element according to the invention is that the pressure difference
30 between the inlet and the second compression chamber is reduced because a flow of gas and oil is made possible via

the connection from the second compression chamber at a higher pressure to the first compression chamber at a lower pressure.

5 As a result cavitation can be prevented because the flow via the channel between the profiles of the helical rotors or the flow between the rotors and the outlet end face in the section of the rotor profiles that separates the
10 aforementioned second compression chamber from the compression chamber that is connected to the inlet, will have a much lower speed.

Indeed, due to the reduced pressure in the second compression chamber, the pressure difference across the
15 aforementioned channel is too small to cause a flow through the channel that can give rise to cavitation.

The precise location of the connection and the design thereof will depend on the profile of the helical rotors
20 and the shape and location of the outlet port. Both can differ strongly depending on the vacuum pump element concerned.

In each case it must be prevented that the connection comes
25 into contact with the outlet port, i.e. the connection must not connect directly to the outlet port.

With the intention of better showing the characteristics of the invention, a few preferred embodiments of an oil-
30 injected vacuum pump element according to the invention are described hereinafter by way of an example, without any

limiting nature, with reference to the accompanying drawings, wherein:

5 figure 1 schematically shows an oil-injected vacuum pump element of the screw type;
figure 2 schematically shows a cross-section of the oil-injected vacuum pump element of figure 1 along the line II-II of figure 1;
figure 3 shows a similar cross-section to figure 2,
10 but of an oil-injected vacuum pump element according to the invention;
figure 4 shows the cross-section of figure 3, but in a different position of the helical rotors;
figures 5 to 7 show alternative embodiments of figure
15 3.

The oil-injected vacuum pump element 1 shown in figure 1 is an element of the screw type.

20 The element 1 essentially comprises a housing 2 in which two cooperating helical rotors 3 are rotatably provided.

The housing 2 comprises an inlet end face 4 on the inlet side 5 and an outlet end face 6 on the outlet side 7.
25

An inlet port 8 is affixed in the housing 2. This inlet port 8 is indicated by a dashed line in figure 1.

An outlet port 9 is affixed in the housing at the location
30 of the outlet end face 6. This is shown in figure 2.

Compression chambers 11a, 11b are formed between the lobes 10 of the helical rotors 3 and the housing 2. Due to the rotation of the helical rotors 3 these compression chambers 11a, 11b move from the inlet port 8 to the outlet port 9.

5

For as long as the compression chamber 11a, 11b makes contact with the inlet port 8, its volume will increase, so that a suction of gas is created.

10 When the compression chamber 11a, 11b is no longer in contact with the inlet port 8, the volume of the compression chambers 11a, 11b will decrease upon further rotation of the helical rotors 3 so that the gas, for example air, is compressed in these chambers.

15

Air that gets into a compression chamber 11a via the inlet port 8 in the first compression phase is transported to the outlet port 9 by the rotation of the helical rotors 3 and is thereby compressed to a higher pressure.

20

At a certain time during the rotation of the helical rotors 3 the compression chamber 11b will make contact with the outlet port 9 so that the compressed air in this compression chamber 11b can be removed during the last
25 compression phase.

The accompanying compression chambers 11a, 11b that belong to the two aforementioned compression phases, i.e. a first compression chamber 11a that makes contact with the inlet
30 port 8 and the outlet end face 6 and a second compression chamber 11b that only makes contact with the outlet end

face 6 but not with the inlet port 8 or the inlet end face 4, are indicated in figure 2.

As can be seen in this drawing these two compression
5 chambers 11a, 11b are separated from one another by one
single section of the helical rotors 3, whereby a channel
12 with a "nozzle" shape is formed between the profiles of
the helical rotors 3.

10 A flow of air and/or oil is possible via this channel 12 in
the direction from the second compression chamber 11b to
the first compression chamber 11a, whereby due to the form
of the channel 12 the flow speed becomes so high that
cavitation can occur.

15

In an oil-injected vacuum pump element 1 according to the
invention, as shown in figure 3, a connection is affixed in
the outlet end face, in this case in the form of a groove
13.

20

This groove 13 extends from the first compression chamber
11a to the second compression chamber 11b.

Hereby a first end 14a of the groove 13 will at least
25 partially overlap the first compression chamber 11a and a
second end 14b of the groove 13 will overlap the second
compression chamber 11b.

A flow of gas and/or oil from the second chamber 11b, at a
30 higher pressure, is possible via this groove 13 to the

first compression chamber 11a so that the pressure in the second compression chamber 11b is reduced.

In this way the pressure in the second compression chamber 11b can be prevented from becoming too high such that the flow of gas and/or oil will be slower via the aforementioned channel 12.

In this way cavitation, and the detrimental consequences thereof, is prevented.

Although in the example shown the groove 13 makes contact with a first compression chamber 11a that is connected to the inlet port 8, this is not necessarily the case. It is only necessary for the invention that the first compression chamber 11a concerned, to which the groove 13 is connected, is at a lower pressure than the second compression chamber 11b.

According to the invention the connection is designed such that the groove 13 is not directly connected to the outlet port 9.

This can clearly be seen in figure 3: the groove 13 stops at some distance from the outlet port 9 so that there is no contact with the second end 14b of the groove 13 and the outlet port 9.

This will ensure that a direct leakage flow is not possible from the outlet port 9 to the inlet port 8 via the groove 13 and the first compression chamber 11a, whereby this

leakage flow negatively affects the efficiency of the oil-injected vacuum pump element 1.

In the situation of figure 3 the second end 14b of the groove 13 is not in contact with the second compression chamber 11b. Upon further rotation of the helical rotors 3, whereby the second compression chamber 11b becomes increasingly smaller, this end 14b will increasingly overlap the second compression chamber 11b. As a result, the pressure increase in the second compression chamber 11b will be counteracted, because this chamber is still in contact with the first compression chamber 11a by means of the groove 13, so that a flow of gas and/or oil is possible from the second compression chamber 11b to the first compression chamber 11a.

Figure 4 shows the situation whereby the volume of the second compression chamber 11b has gone to practically zero. Hereby the second end 14b of the groove 13 is still connected to the second compression chamber 11b.

At this moment the pressure in the second compression chamber 11b can become very high, but the pressure in the second compression chamber 11b will be low enough to prevent cavitation through the connection to the first compression chamber 11a by means of the groove 13.

The location of the second end 14b, by which the groove 13 makes contact with the second compression chamber 11b, must be suitably chosen such that a connection to the second

compression chamber 11b is realised without coming into contact with the outlet port 9.

5 The final location of the groove 13, and in particular the second end 14b, will depend on the rotor profiles and the shape of the outlet port 9.

10 The final form and size of the groove 13 and thus the flow rate of gas and/or oil that can flow via the groove 13 will depend on two criteria:

- the flow rate must be high enough so that the pressure in the second compression chamber 11b can fall enough to prevent cavitation;

15

- the flow rate may not be too high because in this case the performance or efficiency of the oil-injected vacuum pump element 1 will fall.

20 The flow rate that can flow via the groove 13 will depend on the minimum cross-section of the groove 13.

25 Preferably this minimum cross-section of the groove 13 in mm^2 is between 0.01 and 0.04 times the maximum volumetric flow of the element 1 in litres per second.

30 However, it is not excluded that this minimum cross-section in mm^2 is between 0.01 and 0.1 or 0.01 and 0.08 or 0.01 and 0.06 times the maximum volumetric flow of the element 1 in litres per second.

A groove 13 with a smaller minimum cross-section will not be able to allow sufficient flow to let the pressure in the second compression chamber 11b fall enough to prevent cavitation.

5

A groove 13 with a larger minimum cross-section will allow through the large flows from the second compression chamber 11b to the first compression chamber 11a, such that the efficiency of the oil-injected vacuum pump element 1 will
10 fall by too much.

Preferably the end 14b of the groove 13 that is connected to the second compression chamber 11b at the outlet end face 6 is designed such that the maximum contact area
15 between the groove and the aforementioned compression chamber 11b has an area in mm² between 0.01 and 0.04 times the maximum volumetric flow of the element 1 in litres per second.

20 It is not excluded that the aforementioned maximum contact area is between 0.01 and 0.1 or 0.01 and 0.08 or 0.01 and 0.06 times the maximum volumetric flow of the element 1 in litres per second.

25 As it is possible that the contact area between the groove 13 and the second compression chamber 11b is less than the minimum cross-section of the groove 13 itself, preferably it is sufficient for the aforementioned contact area to be at the higher stated condition, in order to obtain the
30 desired effect.

Different options are possible with regard to the final design of the groove 13.

5 Preferably the groove comprises at least one slot-shaped section 15.

Slot-shaped 15 section here means a part of the groove 13 whose cross-section, viewed in the flow direction through the groove 13, does not change or practically does not
10 change.

This section 15 can be straight or curved.

15 In figures 3 to 6 the groove 13 only comprises a slot-shaped section 15.

As can be seen in these drawings, the slot-shaped groove 13 has different orientations.

20 It is also possible that the groove 13 connecting to this slot-shaped section 15 comprises a broadened section 16, whereby the groove 13 at least partially overlaps the first compression chamber 11a.

25 This is shown in figure 7, where it can be seen that the first end 14a of the groove 13 is formed by a broadened section 16 with a wider cross-section than the second end 14b that is formed by a slot-shaped section 15.

30 The precise shape of this broadened section 16 is of secondary importance.

The only condition for the first end 14a is that this end 14a extends far enough so that the groove 13 is always connected to the first compression chamber 11a.

5

Preferably the overlap between the groove 13 and the first compression chamber 11a is such that the connection between the first compression chamber 11a and the second compression chamber 11b is preserved by means of the groove
10 13 upon the rotation of the helical rotors 2 until the volume of the second compression chamber 11b goes to zero.

At this moment the pressure in the second compression chamber 11b is very high and the second compression chamber
15 11b is no longer connected to the outlet port 9, such that the high pressure in this second compression chamber 11b can only escape via the aforementioned nozzle-shaped channel 12.

20 In order to prevent this it is ensured that the second compression chamber 11b is connected to the first compression chamber 11a, and thus the inlet port 8, by means of the groove 13.

25 In this way the pressure in the second compression chamber 11b can be prevented from becoming too high during this phase at the time that the volume in this compression chamber 11b goes to zero and cavitation can be prevented.

30 Although in the examples shown above, the connection is always made by means of a groove 13 in the outlet end face

6, it is not excluded that the connection is realised by means of a groove part in the outlet end face 6 that at least partially overlaps the second compression chamber 11b and a channel or pipe connected thereto that leads to a first compression chamber 11a at a lower pressure than the second compression chamber 11b.

As already stated, this compression chamber 11a can be the compression chamber 11a that is connected to the inlet port 8, but this is not the necessary for the invention.

This channel or this pipe can be built in housing itself or otherwise, but of course can also be constructed on the housing.

15

In such an embodiment, preferably it must be ensured that the minimum cross-section of the groove part and the channel and the maximum contact area between the groove part and the second compression chamber 11b both satisfy the above-mentioned conditions, i.e. this minimum cross-section and this maximum contact area in mm^2 is between 0.01 and 0.1 times the maximum volumetric flow of the element 1 in litres per second, and preferably between 0.01 and 0.08 times, even better between 0.01 and 0.06 times, and even more preferably between 0.01 and 0.04 times.

The aforementioned groove part can take on the form of the slot-shaped section 15 of the groove 13 for example, as shown in figure 7.

30

Preferably it is also ensured that the channel or the pipe is such that the connection between the first compression chamber 11a and the channel or the pipe is preserved upon rotation of the helical rotors 3 until the volume of the
5 second compression chamber 11b goes to zero.

The present invention is by no means limited to the embodiments described as an example and shown in the drawings, but a an oil-injected vacuum pump element
10 according to the invention can be realised in all kinds of forms and dimensions without departing from the scope of the invention.

Claims.

1.- Oil-injected vacuum pump element of the screw type,
5 whereby two cooperating helical rotors (3) are rotatably
provided in a housing (2), whereby this housing (2)
comprises an inlet port (8), an inlet end face (4) and an
outlet end face (6) with an outlet port (9), whereby
compression chambers (11a, 11b) are formed between the
10 helical rotors (3) and the housing (2) that proceed from
the inlet port (8) to the outlet port (9) due to the
rotation of the helical rotors (3) and thereby become
increasingly smaller, characterised in that the oil-
injected vacuum pump element (1) is provided with a
15 connection that extends from a first compression chamber
(11a) to a second smaller compression chamber (11b) at the
outlet end face (6), whereby this first compression chamber
(11a) is at a lower pressure than the second compression
chamber (11b) and whereby this second compression chamber
20 (11b) can make connection with the outlet port (9) upon
rotation of the helical rotors (3), whereby the connection
is such that a flow from the second compression chamber
(11b) to the first compression chamber (11a) is possible so
that the pressure in the second compression chamber (11b)
25 is reduced, whereby the connection is not directly
connected to the outlet port (9).

2.- Oil-injected vacuum pump element of the screw type
according to claim 1, characterised in that the first
30 compression chamber (11a) makes contact with the inlet port
(9) and with the outlet end face (6).

3.- Oil-injected vacuum pump element according to claim 1
or 2, characterised in that the aforementioned connection
is realised by means of a groove (13) that is affixed in
5 the outlet end face (6), whereby this groove (13) extends
from the first compression chamber (11a) to the second
compression chamber (11b).

4.- Oil-injected vacuum pump element according to claim 3,
10 characterised in that the groove (13) at least comprises a
slot-shaped straight or curved section (15).

5.- Oil-injected vacuum pump element according to claim 4,
characterised in that next to the aforementioned slot-
15 shaped section (15), the groove (13) comprises a broadened
section (16) with which the groove (13) at least partially
overlaps the first compression chamber (11a).

6.- Oil-injected vacuum pump element according to claim 1
20 or 2, characterised in that the aforementioned connection
is realised by means of a groove part in the outlet end
face (6) that at least partially overlaps the second
compression chamber (11b), and a channel or pipe connected
thereto that leads to the first compression chamber (11a),
25 whereby this channel or this pipe is built in the housing
or otherwise.

7.- Oil-injected vacuum pump element according to any one
of the previous claims, characterised in that the minimum
30 cross-section of the connection in mm² is between 0.01 and
0.1 times the maximum volumetric flow of the element (1) in

litres per second, preferably between 0.01 and 0.08 times, even better between 0.01 and 0.06 times and more preferably between 0.01 and 0.04 times.

5 8.- Oil-injected vacuum pump element according to any one of the previous claims, characterised in that the end (14b) of the connection that is connected to the second compression chamber (11b) at the outlet end face (6) is designed such that the maximum contact area between the
10 connection and the aforementioned second compression chamber (11b) has an area in mm² of between 0.01 and 0.1 times the maximum volumetric flow of the element in litres per second, preferably 0.01 and 0.08 times, even better between 0.01 and 0.06 times and more preferably between
15 0.01 and 0.04 times.

9.- Oil-injected vacuum pump element according to any one of the previous claims, characterised in that the overlap between the connection and the first compression chamber
20 (11a) is such that the connection between the first compression chamber (11a) and the second compression chamber (11b) is preserved upon rotation of the helical rotors (3) until the volume of the second compression chamber (11b) goes to zero or practically zero.

25

30

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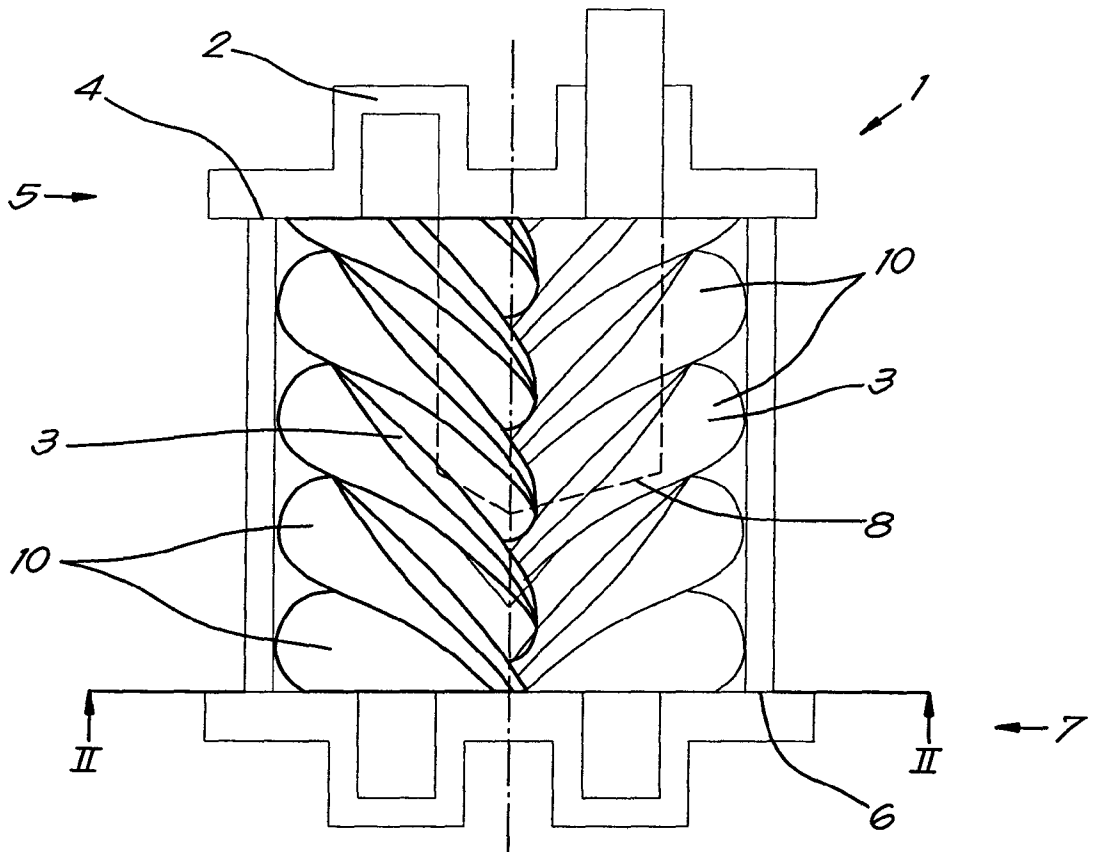


Fig. 1

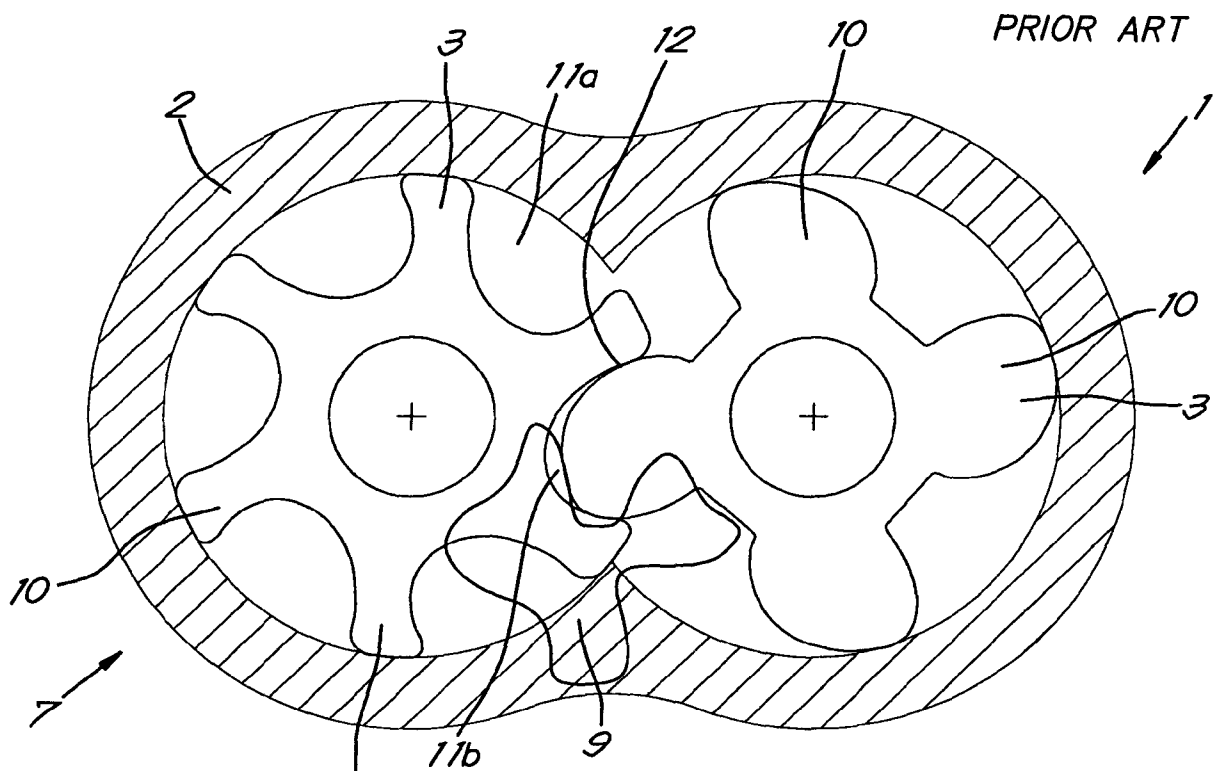


Fig. 2

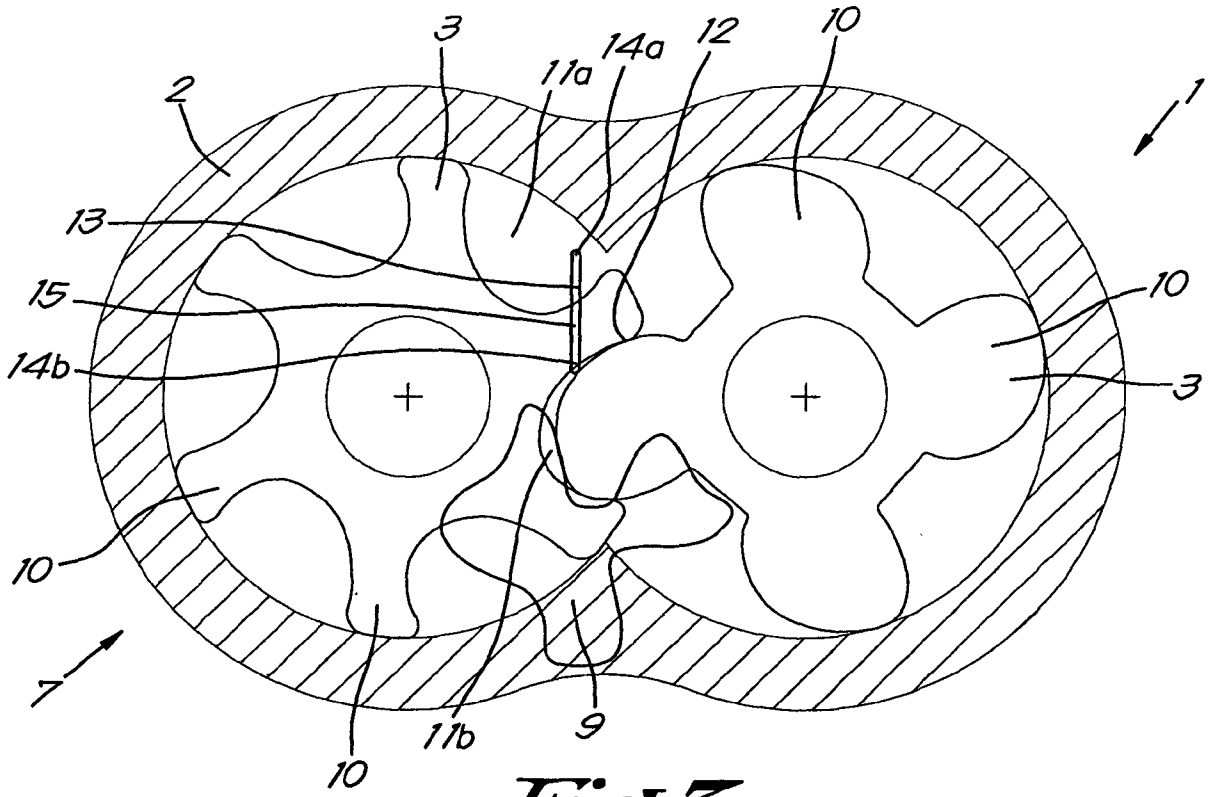


Fig. 3

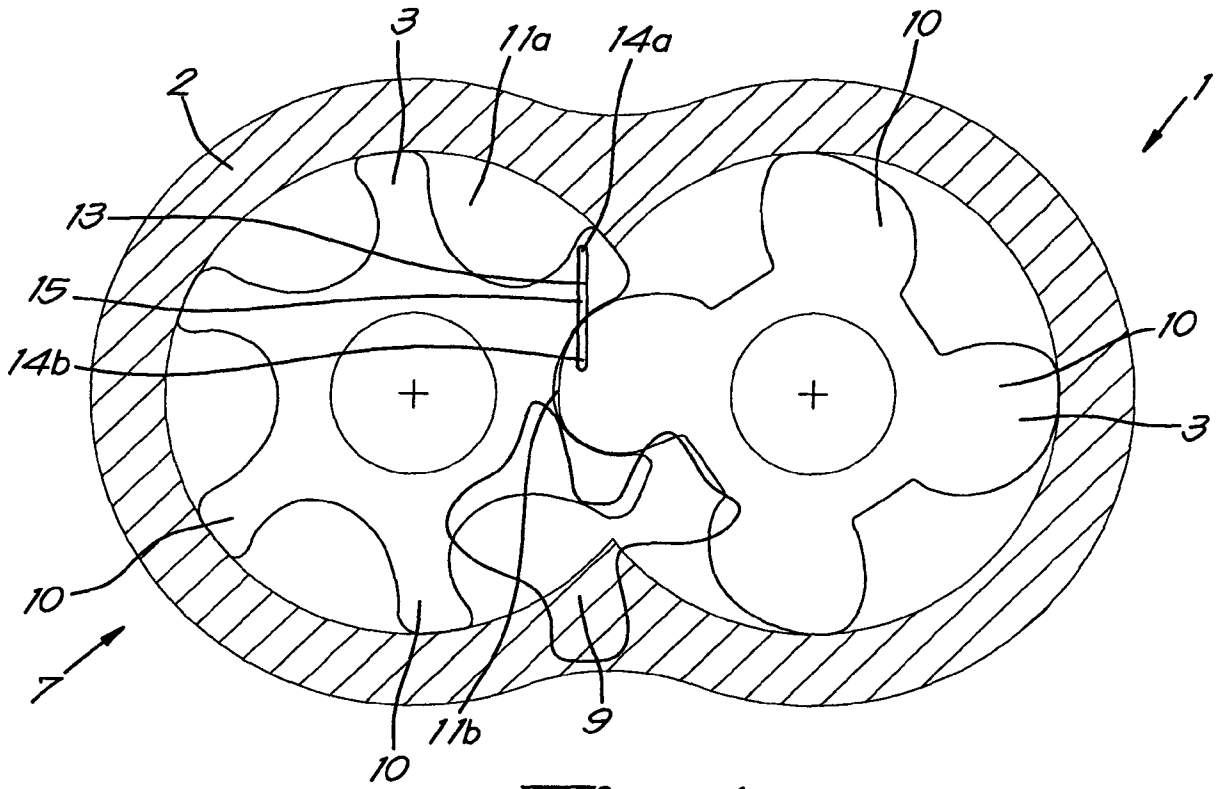


Fig. 4

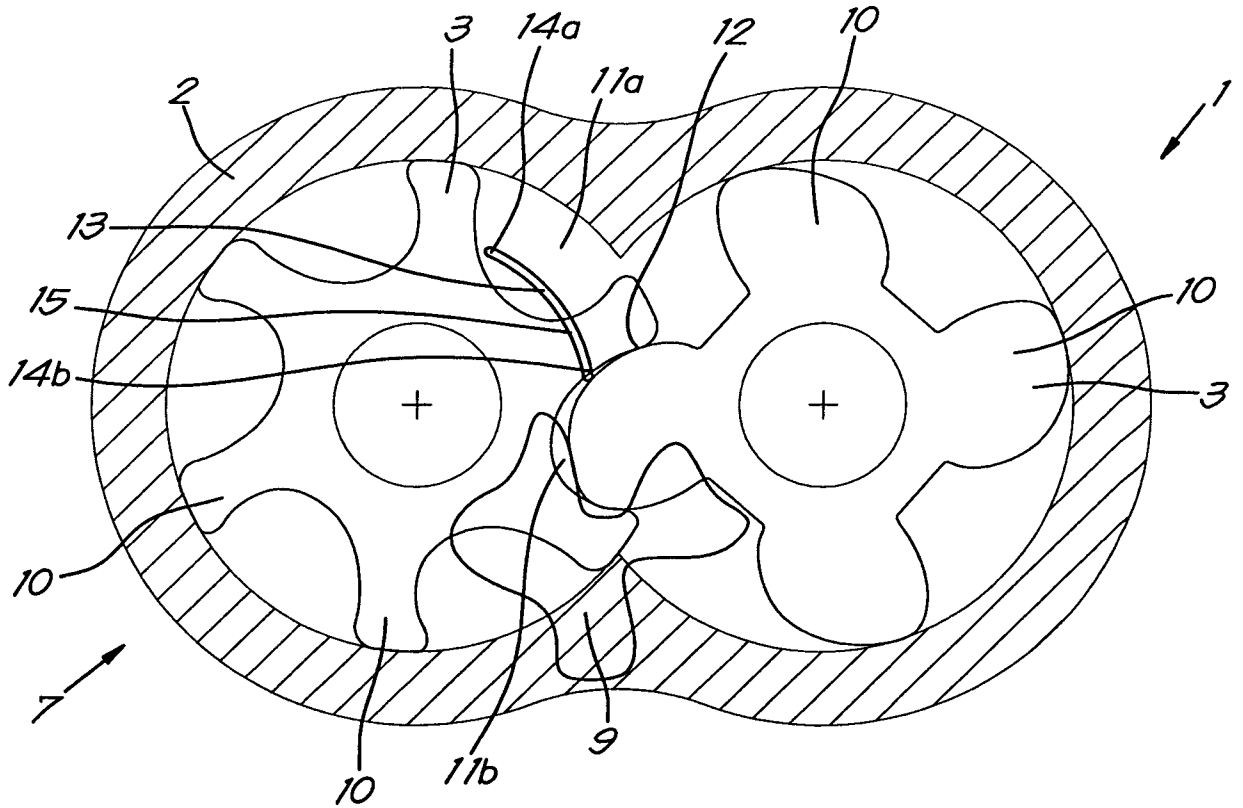


Fig. 5

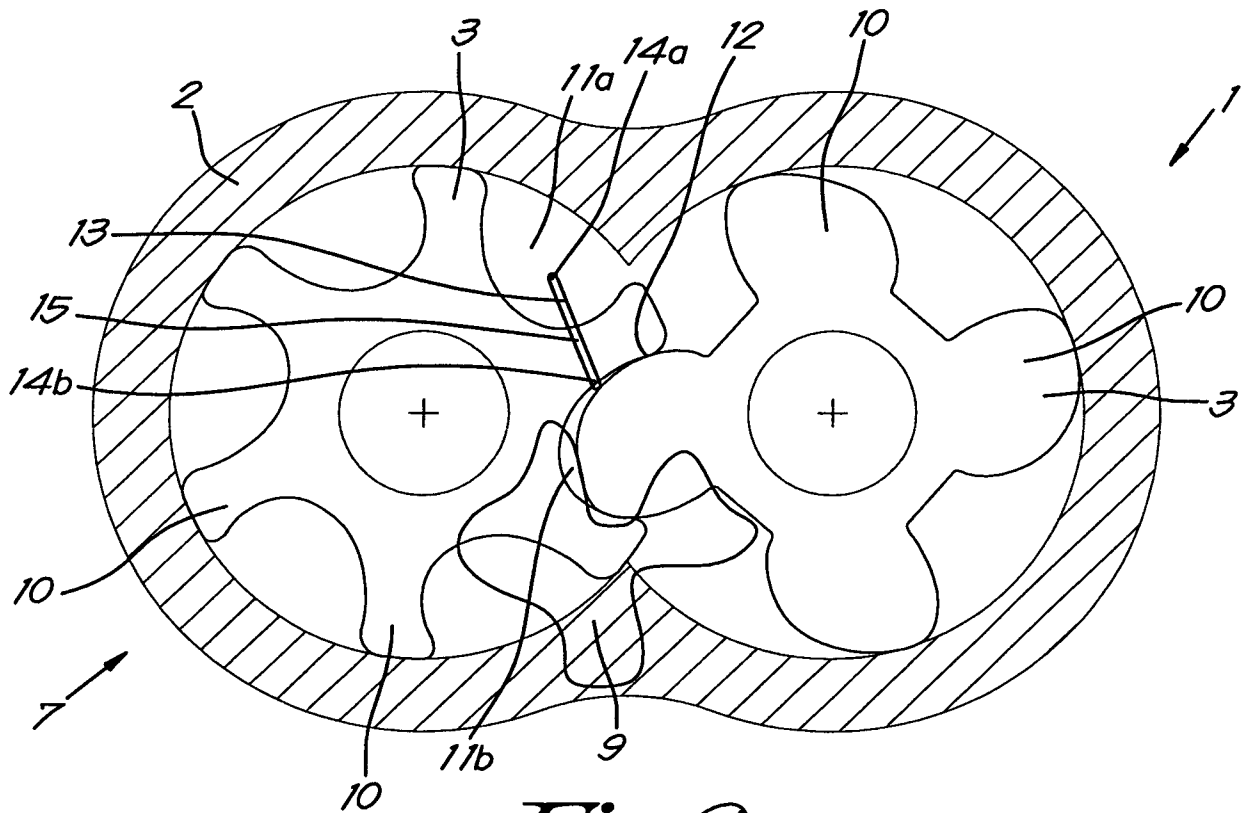


Fig. 6

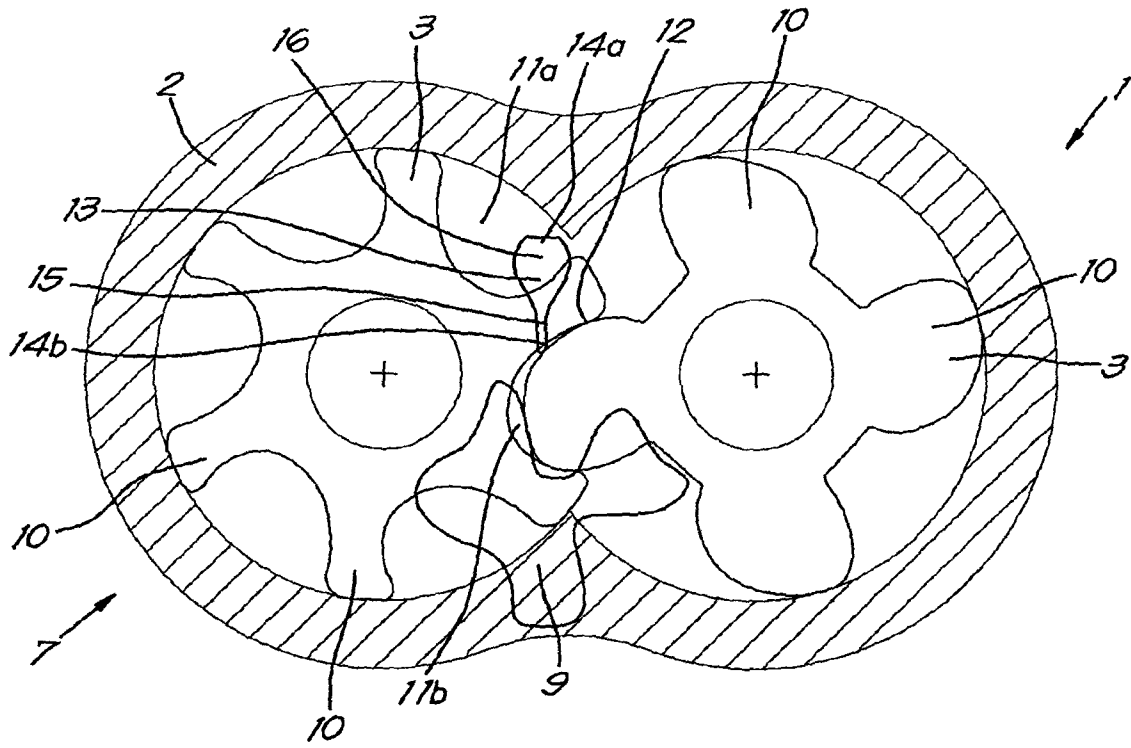


Fig.7

INTERNATIONAL SEARCH REPORT

International application No
PCT/BE2016/000002

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04C28/26 F04C18/14 F04C28/06
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
F04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/095364 A1 (ELGI EQUIPMETNS LTD [IN]; NAGESH RAJEPANDHARE [IN]; RAMESH PANDURANGAN) 14 September 2006 (2006-09-14) page 4, paragraph 4 page 10, paragraph 11 - page 11, paragraph 1 claim 1 figures 1,2	1,2
X	WO 89/12752 A1 (SVENSKA ROTOR MASKINER AB [SE]) 28 December 1989 (1989-12-28) page 5, line 21 - line 34 figure 1	1,2

Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search

9 May 2016

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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