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(54) Magnet assembly for a sputter ion pump

(57) The present invention concerns a sputter ion pump allowing attaining high pumping speeds even at low pressures, while keeping limited the size, weight and manufacturing cost of the pump itself. The sputter ion pump (1) in accordance with the invention has an improved magnet assembly comprising primary magnets (9a, 9b), disposed on opposite ends of the pump cells, and secondary magnets (11; 11', 11") disposed on one side only of said pump cells, whereby the assembly exhibits an asymmetrical configuration.

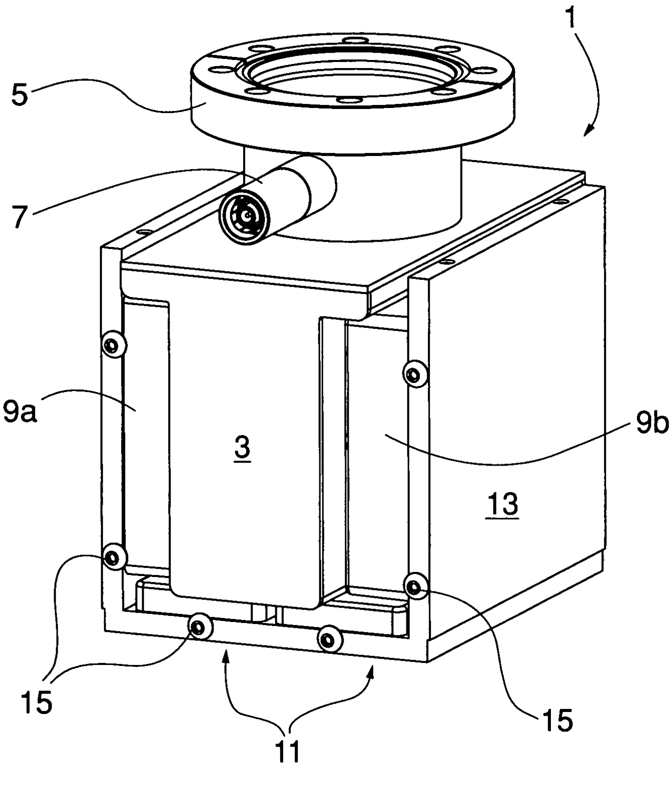

Fig. 2

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Description

[0001] The present invention concerns a sputter ion pump having an improved magnet assembly.

[0002] As known, and referring to Fig. 1, a sputter ion pump 10 is a device for producing high vacuum conditions. It comprises a vacuum enclosure 20 housing at least one anode 30 consisting of a plurality of hollow cylindrical pump cells 40, and a cathode 50 consisting of plates, e.g. made of titanium, located on opposite ends of cells 40. Pump 10 comprises means 60 for applying to the anode a higher potential than the cathode potential. Magnets 70 located external to enclosure 20, at opposite ends of pump cells 40, are further provided for producing a magnetic field oriented parallel to the axes of said pump cell.

[0003] During operation, when a potential difference is applied between anode 30 and cathode 50 (typically, 3 to 9 kV), a strong electric field region is generated between anode cells 40 and cathode 50, resulting in electron emission from the cathode, the electrons being then captured in the anode cells. Electrons collide with and ionise gas molecules inside pump cells 40. The resulting positive ions, because of the electric field, are attracted by cathode 50 and collide with the surface thereof. Ion collision with the titanium plates forming cathode 50 results in the "sputtering" phenomenon, that is, the emission of titanium atoms from the cathode surface.

[0004] The provision of magnets 70 for generating a magnetic field B allows imparting helical trajectories to electrons, so as to increase the lengths of their paths between the cathode and the anode and, consequently, the chances of colliding with gas molecules inside the pump cells and ionising such molecules.

[0005] A drawback of prior art ion pumps is the considerable decrease in the pumping speed at low pressures.

[0006] Different parameters exist that affect the pumping speed of an ion pump and that can be acted upon. One such parameter is the magnetic field strength.

[0007] In this respect, international patent application WO 2004/061889 discloses an ion pump in which the magnetic field strength is changed by providing additional magnets. More particularly, the ion pump disclosed in WO 2004/061889 includes primary magnets of opposite polarities disposed on opposite ends of the pump cells, and secondary magnets disposed on two opposite sides of the pump cells, perpendicularly to the primary magnets. Possibly, additional secondary magnets can be provided on two other opposite sides of the pump cells, perpendicularly to both the primary magnets and the other secondary magnets.

[0008] Use of magnetic assemblies including perpendicular pairs of primary magnets and secondary magnets in order to achieve a high strength magnetic field was already known, e.g., from US 4,937,545.

[0009] Yet, also the solution proposed in WO 2004/061889 has some non-negligible drawbacks, depending in particular on the considerable size and weight increase due to the provision of secondary magnets along two, or even four sides of the pump cells.

[0010] It is therefore an object of the present invention to overcome the drawbacks of the prior art, by providing a sputter ion pump capable of providing satisfactory pumping speeds even at low pressures, while having limited overall size and weight.

[0011] It is another object of the present invention to provide a sputter ion pump that is simple and cheap to manufacture.

[0012] Experimental studies carried out by the Applicant have surprisingly shown that providing secondary magnets disposed on only one side of the pump cells, even though it leads to an asymmetric configuration of the magnetic assembly, is sufficient to ensure an increase in the magnetic field strength and a corresponding increase in the pumping speed, even at low pressures.

[0013] Thanks to the above asymmetric configuration of the pumping assembly, an ion pump can be obtained that has reduced size, weight and manufacturing costs as compared to the pump disclosed in WO 2004/061889, which has a symmetric configuration of the magnetic assembly.

[0014] Further features and advantages of the sputter ion pump in accordance with the invention will become more apparent from the detailed description of some preferred embodiments of the invention, given by way of non limiting examples, with reference to the accompanying drawings, in which:

- Fig. 1 is a cross sectional schematic view of a prior art ion pump;
- Fig. 2 is a perspective schematic view of a ion pump according to a first embodiment of the invention;
- Fig. 3 is a schematic side view of the ion pump of Fig. 2;
- Figs. 4A and 4B are graphs showing the behaviour of the transversal magnetic field component in a longitudinal cross-section of a prior art pump and of the pump of Fig. 2, respectively;
- Fig. 5 is a graph showing the behaviour of the pumping speed as a function of pressure for a prior art ion pump and for the ion pump of Fig. 2;
- Fig. 6 is a perspective schematic view of a ion pump according to a second embodiment of the invention;
- Fig. 7 is a schematic side view of the ion pump of Fig. 6.

[0015] Referring to Figs 2 and. 3, there is shown a sputter ion pump according to a first embodiment of the invention.

[0016] Ion pump 1 comprises a vacuum enclosure 3 housing the plates forming the cathode and the pump cells forming the anode. Vacuum enclosure 3 and the components housed therein, which are made in accordance with the prior art shown in Fig. 1, will not be further described.

[0017] Vacuum enclosure 3 is connected to a connecting flange 5 for connecting pump 1 with a chamber to be evacuated and is provided with a high voltage electric feedthrough 7 allowing pump connection to a power supply.

[0018] Primary magnets 9a, 9b are located external to vacuum enclosure 3, at opposite ends of the cylindrical anode pump cells, for producing a magnetic field parallel to the pump cell axes.

[0019] In accordance with the invention, in order to achieve a high pumping speed even at low pressures, a secondary magnet assembly 11, comprising one or more magnets, is provided on one side only of pump cells 3 housed within enclosure 3. More particularly, in the illustrated example, secondary magnet assembly 11 is provided only on the bottom side of enclosure 3, opposite connecting flange 5.

[0020] The magnets in secondary magnet assembly 11 (or secondary magnets) are so arranged as to produce a magnetic field in orthogonal direction to the field produced by primary magnets 9a, 9b, thereby reducing the edge effects of the primary magnets.

[0021] Preferably, secondary magnets 11 are permanent magnets.

[0022] As shown in Figs. 2 and 3, pump 1 is equipped with a substantially U-shaped bearing structure 13 associated with enclosure 3, primary and secondary magnets 9a, 9b, 11 being secured to that structure by means of screws 15.

[0023] Referring in particular to Fig. 3, it can be appreciated that, in the illustrated embodiment, secondary magnet assembly 11 includes two secondary magnets 11', 11" arranged side by side and having opposite polarities.

[0024] Referring to Figs. 4A and 4B, there is shown the strength of the transversal magnetic field component (in Tesla) in a longitudinal cross-section respectively of a prior art pump made in accordance with the layout of Fig. 1 and of the pump in accordance with the invention, in the embodiment shown in Figs. 2 and 3. The dotted-line rectangle corresponds to the region occupied by the pump cells forming the pump anode.

[0025] As it is clearly apparent, the provision of secondary magnets 11 results in a considerable increase in magnetic field strength. More particularly, thanks to secondary magnets 11, there is a considerable increase in the region where the transversal magnetic field component exceeds a critical value (0.14 Tesla in the illustrated example), above which the maximum efficiency of the pump cells is achieved.

[0026] Actually, as known, two different pumping modes are associated with sputter ion pumps, namely a high magnetic field (HMF) mode and a low magnetic field (LMF) mode. If the magnetic field inside the ion pump falls below a critical value, the transition from HMF pumping mode to LMF pumping mode occurs, with a consequent reduction in the pumping speed. The critical value of the magnetic field is a function of pressure and, more particularly, it increases as pressure decreases, so that remaining above the critical value as pressure decreases is more and more difficult.

[0027] Thus, a stronger magnetic field (in particular above 0.14 Tesla, in the illustrated example) results in maintaining HMF pumping mode also at very low pressures, consequently improving the pumping speed.

[0028] In this respect, in Fig. 5, the behaviour of the pumping speed versus pressure for the ion pump of Figs. 2 and 3 is shown and compared to the behaviour of a prior art pump made in accordance with the layout of Fig. 1. It can be appreciated that both curves have substantially the same behaviour in the pressure range 10^{-6} to 10^{-8} mbars (10^{-4} to 10^{-6} Pa), even if the ion pump in accordance with the invention allows attaining pumping speeds exceeding by about 20% those of a pump without secondary magnets.

[0029] The main difference can however be appreciated in the pressure range 10^{-8} to 10^{-9} mbars (10^{-6} to 10^{-7} Pa). In the case of the pump in accordance with the invention, the pumping speed decreases as pressure decreases, but the pumping speed loss keeps limited. On the contrary, without secondary magnets, the pumping speed suffers from an extremely strong reduction. Consequently, at pressures close to 10^{-9} mbars (10^{-7} Pa), the pumping speed of a pump in accordance with the invention is about twice the pumping speed of a pump lacking secondary magnets, but otherwise identical.

[0030] Turning now back to Fig. 4B, it is interesting to note that the strength of the transversal magnetic field component exceeds the critical value in a larger portion of the region occupied by the pump cells as compared to the prior art solutions, and, in particular, that, notwithstanding the asymmetric arrangement of the secondary magnets in accordance with the invention, such a strength exceeds said critical value over the whole central area of said region and not only on the side closest to secondary magnet assembly 11.

[0031] Thus, as stated above, a sputter ion pump with satisfactory pumping speed even at low pressures can be obtained by using a reduced number of secondary magnets disposed on a single side of the pump cells and, consequently, by keeping the size, the weight and the manufacturing costs limited as compared to the ion pump disclosed in WO 2004/061889.

[0032] Thus, the pump in accordance with the invention attains the desired aims.

[0033] Turning now to Figs. 6 and 7, there is shown a second preferred embodiment of pump 1 in accordance with the invention.

[0034] In accordance with that second embodiment, a plate 17 is provided on the side of vacuum enclosure 3 opposite to secondary magnets 11 in order to confine inside the pump the magnetic field due to the provision of secondary magnets 11.

[0035] To this end, said plate 17 is made of a ferromagnetic material.

[0036] In Figs. 6 and 7, being secondary magnets 11 disposed on the bottom side of pump 1, plate 17 is located at the top side of the pump, is secured to bearing structure 13 through screws 19 and is so shaped as to allow the neck of connecting flange 5 to pass.

[0037] It is clear that the above description has been given by way of non-limiting example and that several changes and modifications can be included within the inventive principle upon which the present invention is based.

[0038] By way of example, a number of secondary magnets other than two could be provided, or the secondary magnets could be disposed on a different side of the vacuum enclosure, without departing from the scope of the invention.

Claims

1. A sputter ion pump (1) comprising:

- a vacuum enclosure (3) equipped with a connecting flange (5) for connecting the pump with a chamber to be evacuated;
- an anode, located inside said enclosure and consisting of a plurality of pump cells;
- a cathode, located inside said enclosure and consisting of plates located at opposite ends of said pump cells;
- primary magnets (9a, 9b), located on opposite ends of said pump cells, for producing a magnetic field coaxial with said pump cells;

characterised in that said pump (1) further comprises secondary magnets (11; 11', 11") disposed on one side only of said pump cells, so as to confer an asymmetrical configuration to the magnetic assembly consisting of said primary magnets (9a, 9b) and said secondary magnets (11; 11', 11 ").

2. The sputter ion pump (1) as claimed in claim 1, wherein said secondary magnets (11; 11', 11") are disposed on the side of said enclosure (3) opposite to said connecting flange (5).

3. The sputter ion pump (1) as claimed in claim 1, wherein two said secondary magnets (11; 11', ,11") are provided and are arranged with opposite polarities.

4. The sputter ion pump (1) as claimed in any preceding claim, wherein said secondary magnets (11; 11', 11 ") are permanent magnets.

5. The sputter ion pump (1) as claimed in any preceding claim, wherein said primary magnets (9a, 9b) and said secondary magnets (11; 11', 11") are housed within a substantially U-shaped bearing structure (13) secured to said enclosure (3).

6. The sputter ion pump (1) as claimed in any preceding claim, wherein said pump (1) further comprises a plate (17) located on the side of said enclosure (3) opposite to said secondary magnets (11; 11', 11").

7. The sputter ion pump (1) as claimed in claim 6, wherein said plate (17) is made of ferromagnetic material, so as to confine the magnetic field generated by said secondary magnets (11; 11', 11").

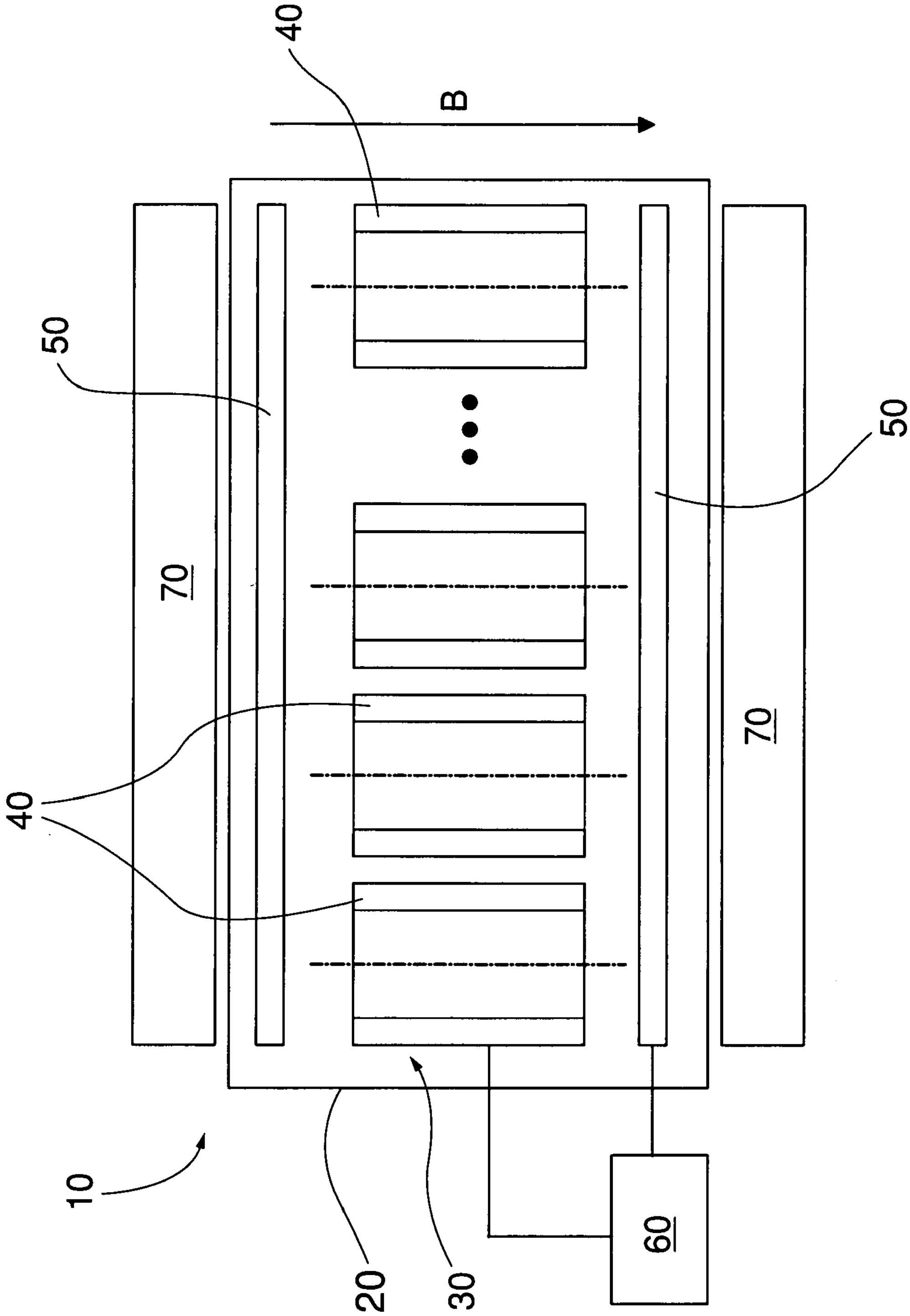

Fig. 1

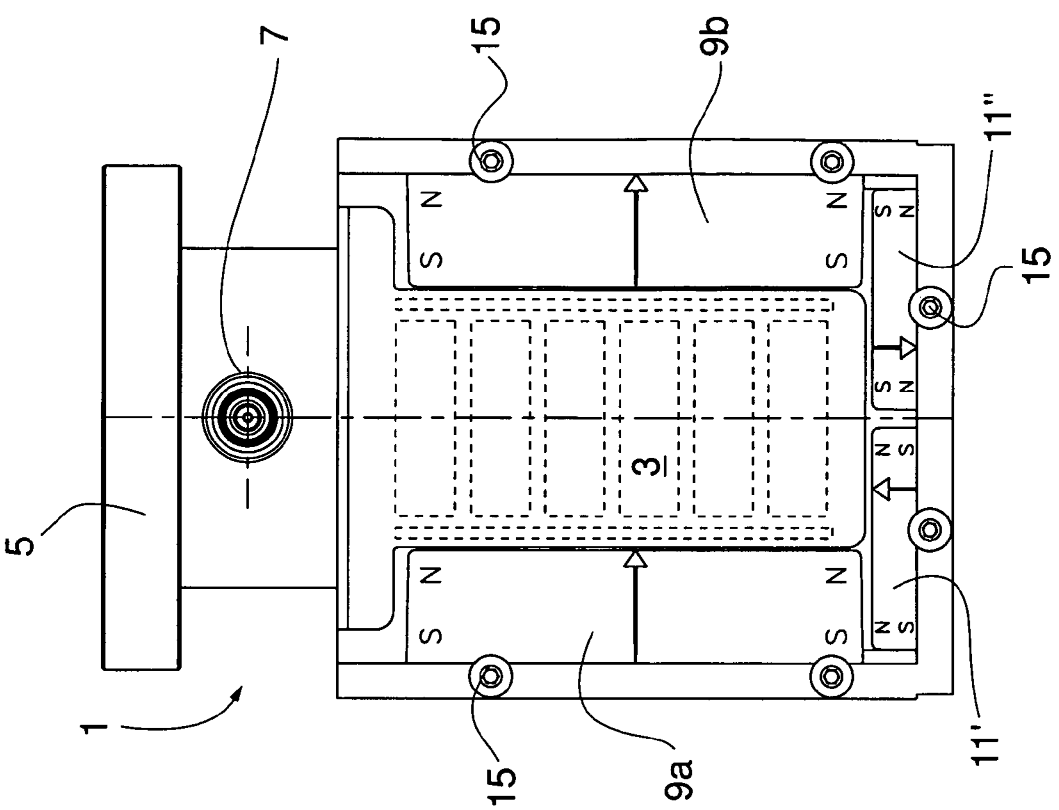

Fig. 3

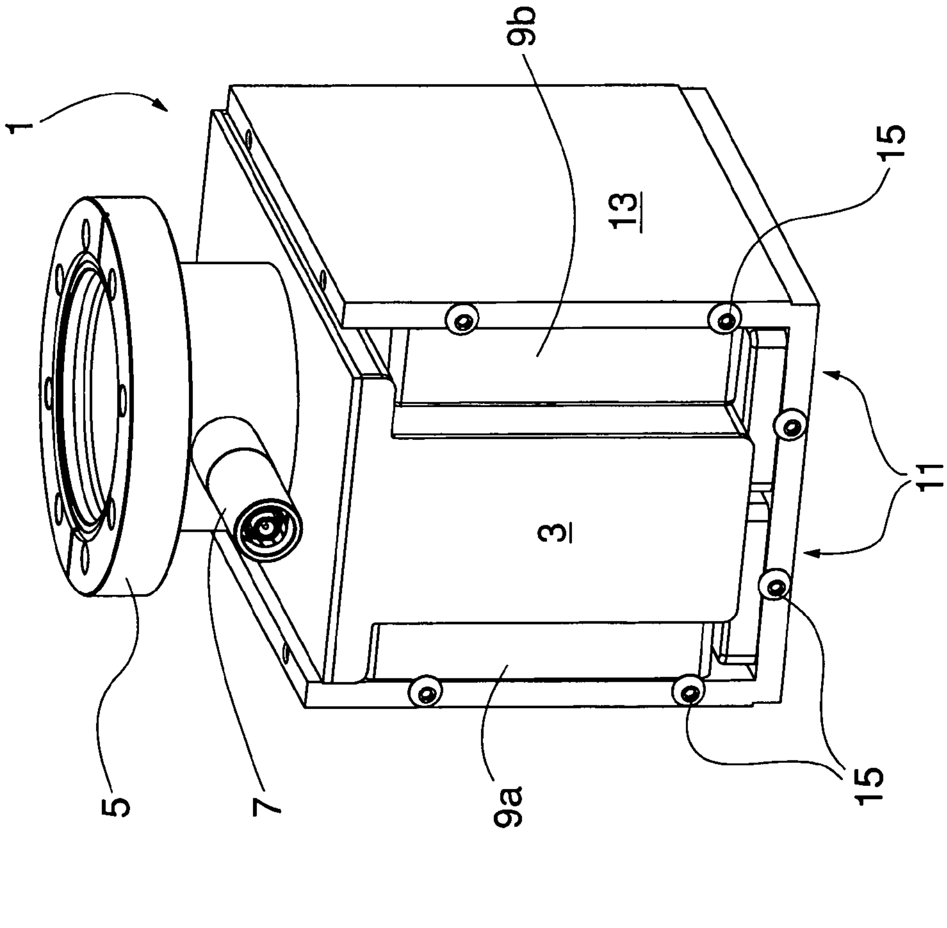

Fig. 2

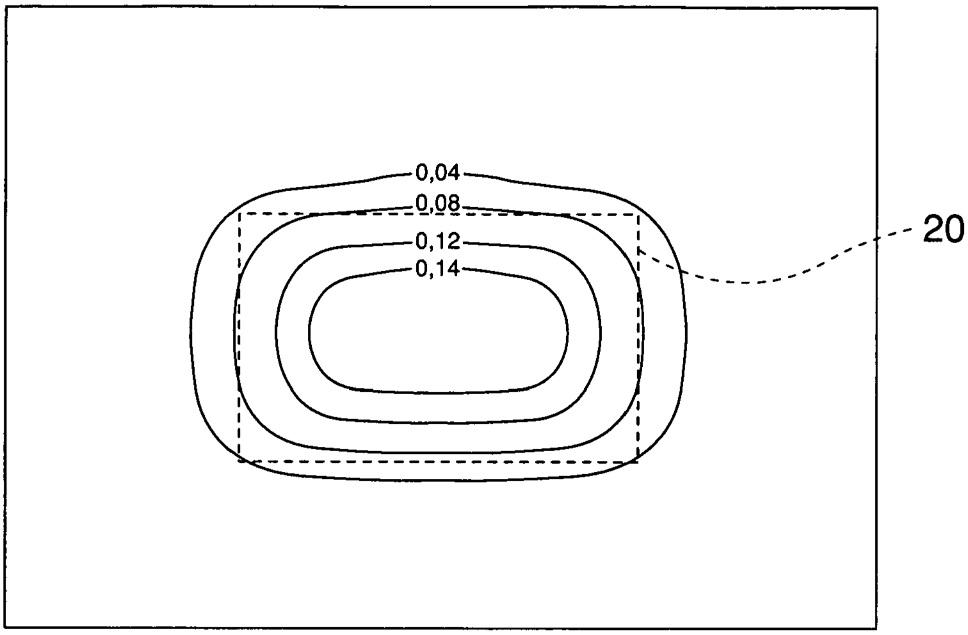

Fig. 4A

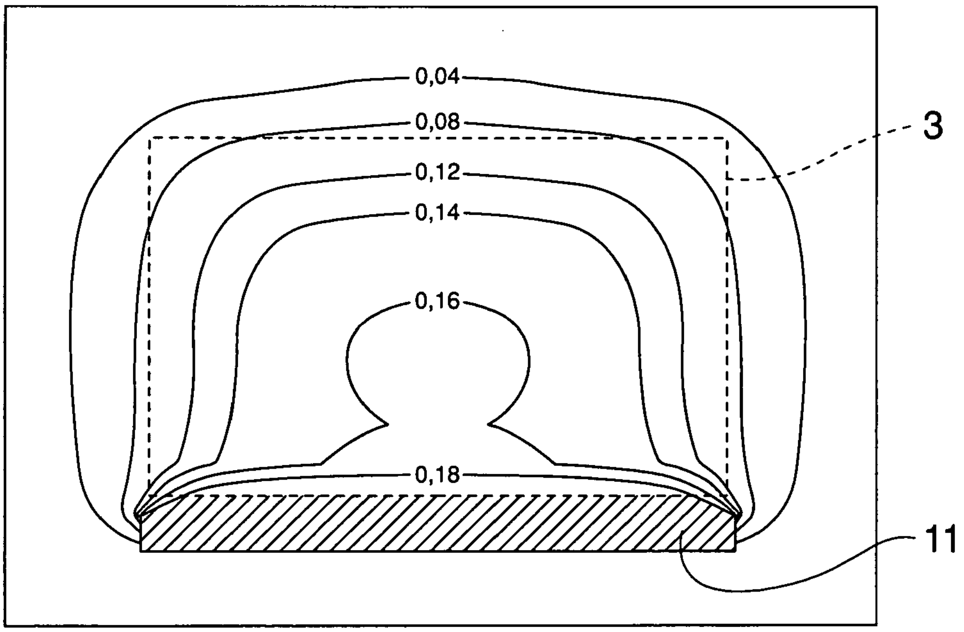

Fig. 4B

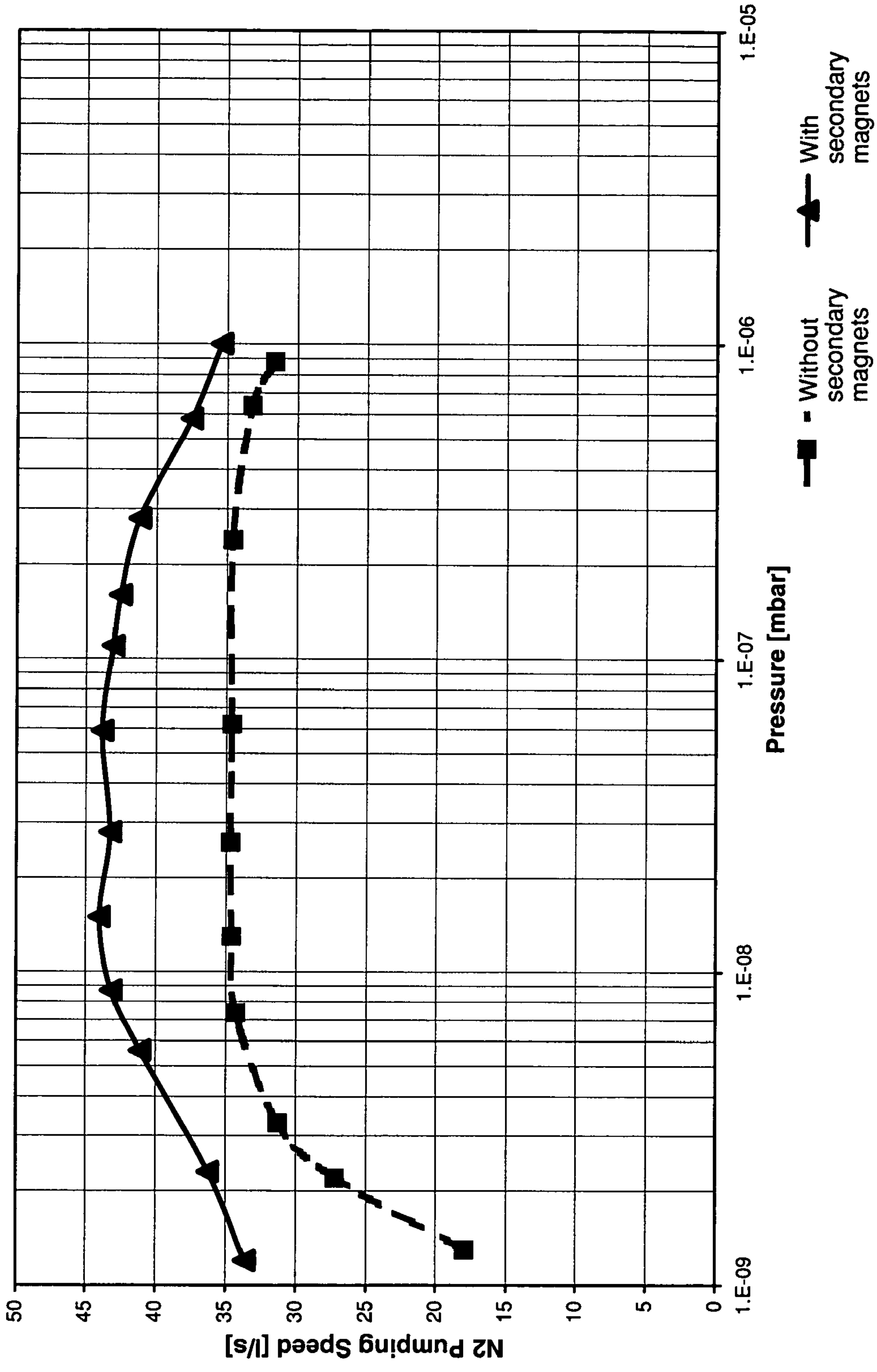
N2 Pumping Speed [l/s]
0
5
10
15
20
25
30
35
40
45
50
Pressure [mbar]
1.E-09
1.E-08
1.E-07
1.E-06
1.E-05
Without secondary magnets
With secondary magnets

Fig. 5

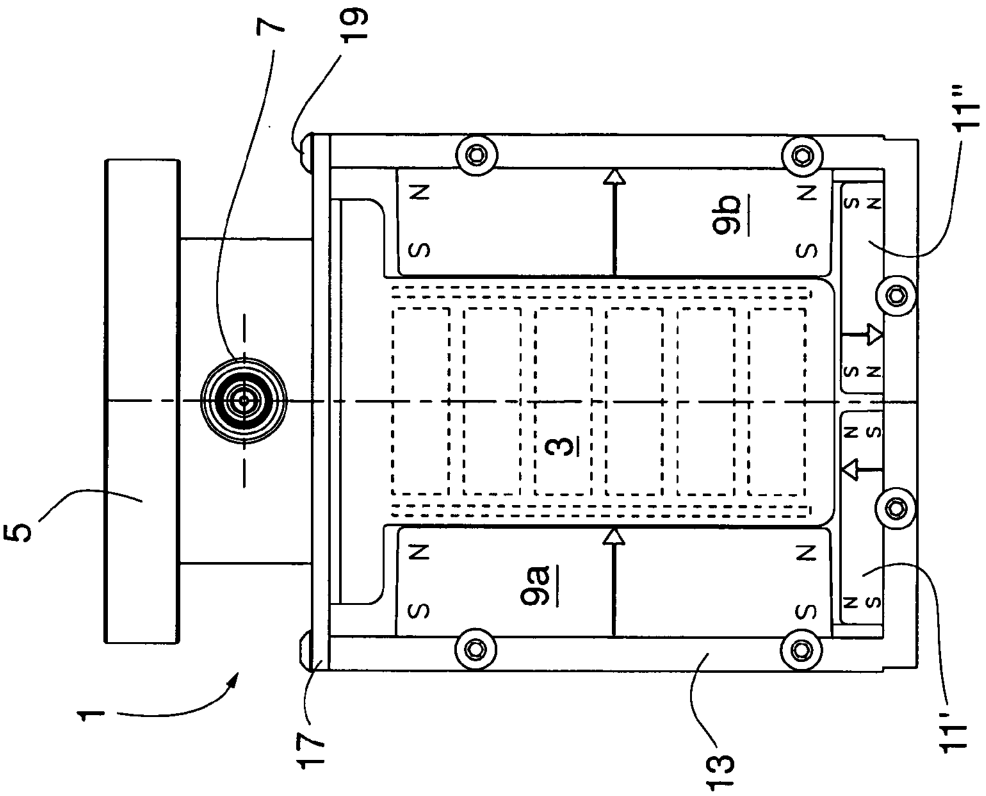

Fig. 7

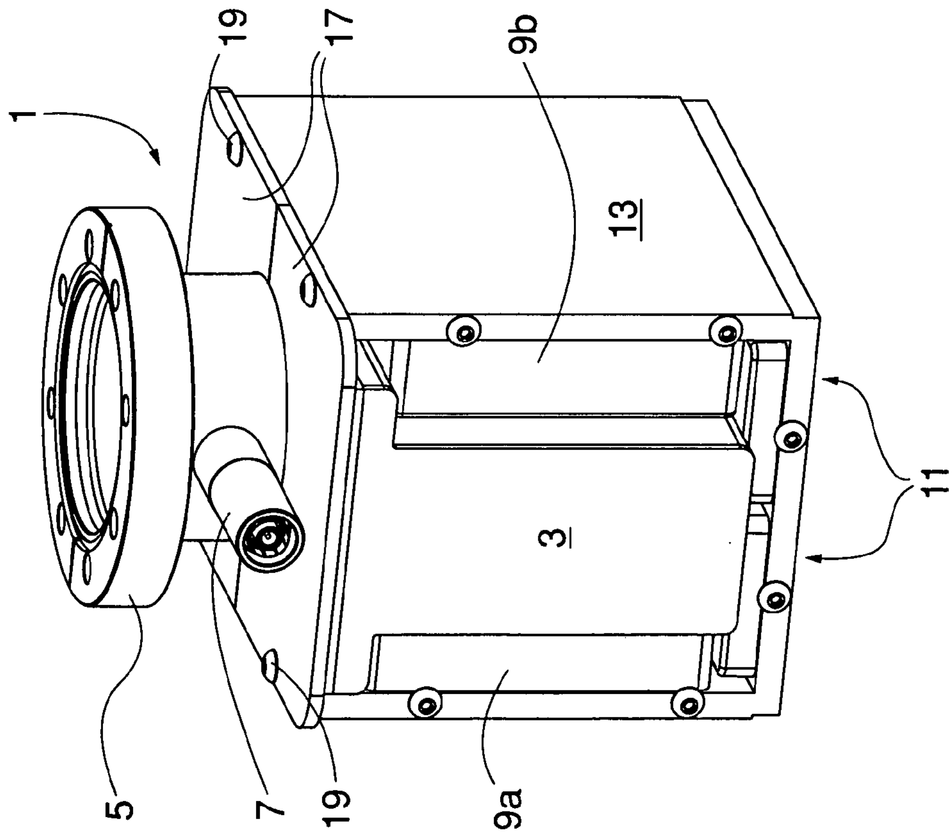

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 06 42 5377

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 November 2006	Hofmann, Kerrin

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CATEGORY OF CITED DOCUMENTS

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06-11-2006

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